SAVING LIVES AND REDUCING INJURY THROUGH ADVANCED VEHICLE DESIGN AND TECHNOLOGY

VISION ZERO INTERNATIONAL

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JUNE 2011

Sven Beiker

The former BMW man on CARS' future vision for the automobile

WiFi or sci-fi?

Why Ford's Mike Shulman thinks 5.9GHz is the next big safety breakthrough

Watch and learn

The world's leading authorities on eye-tracking technology debate its potential as a solution to distracted driving

David Strickland

NHTSA's administrator talks distraction, impaired driving, new legislation and the Toyota recalls

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Test pilot

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Foreword

Six months is a long time in the world of auto safety. Back in November 2010, there was a definite air of doom and gloom around. I've never heard some of my usually positive contributors so downbeat about the state of play, perhaps reflected in a few of the articles published in the January 2011 edition.

Undoubtedly 2010 was a challenging period for our industry, particularly on the back of the safety recalls saga. And regardless of the decision reached by the US Supreme Court in the Williamson vs Mazda case, heard 3 November, either way the result was going to be pivotal for the ambitious goals of Vision Zero. It turned out to be excellent news for consumers (*see page 12*). Automakers cannot now expect pre-emption from liability if their vehicles merely meet the minimums required by the FMVSS. The decision will spur innovation and safer cars, particularly if vehicle-makers continue to promote safety for a competitive edge. I'm sure we'll see the effect of this decision in the years to come – and we'll chip away at those traffic fatalities and serious injuries one by one.

And if it has to be one by one, so be it – the end justifies the means. In the USA during the 1970s and 1980s, there was a general acceptance that between 700 and 800 burn-deaths would result every year from rear-end crashes. Those deaths are now down to about 100 a year, primarily due to a simple design change – moving the fuel tank forward of the rear axle.

Whether or not you believe zero accidents and fatalities is feasible, when you strip Vision Zero down to its bare bones, it's simply a numbers game – cause and cure. You only have to look at NHTSA's 2010 fatality statistics to see this in effect – down by 3% on 2009 figures to 32,788 yet by an astonishing 25% since 2005. Even considering the vehicle-miles-travelled impact of a weaker economy throughout this period, it's significant progress. Continuing on that same curve, the USA might be looking at fewer than 20,000 killed in traffic accidents by 2020. But I think we can all do better…

Over the course of the next decade, who knows what impact the mandating of technologies such as ESC, lane-keeping assist, blind-spot detection and even forward collision mitigation systems could have? Suppliers are working hard to bring the cost of these technologies down. Even during the short time since we launched this magazine, advanced safety systems are now being made available for mid-range cars and not just premium models. Safety will soon be a luxury everyone can afford – even in low- and middle-income countries, where admittedly the scale of the problem is an altogether different challenge, although not an insurmountable one.

And what effect could C2X have? According to Ford's Mike Shulman, vehicles and infrastructure outfitted with a low-cost, safe-and-secure WiFi-based system – similar to that in our smart phones – could reduce up to 81% of all vehicle-to-vehicle crashes involving unimpaired drivers. This isn't *The Jetsons*, Shulman told me when discussing the safety potential of 5.9GHz (*p54*). So, can we get to zero? Perhaps not in my lifetime, but we can get pretty damned close to it! I hope you'll find something in this issue to help you on your way.

Nick Bradley, editor, *Vision Zero International*

Contributors to this issue…

Byron Bloch

An auto safety expert for 40 years, Byron's vast safety-related archives include many thick volumes of the International ESV Proceedings, of which he reports in this issue. He also writes about how the recent US Supreme Court decision will help stimulate vehicle safety, as well as about the Smithsonian's new exhibit and website on the history of auto safety.

Saul Wordsworth

"Living in traffic-clogged central London means that a motorcycle would be an ideal mode of transportation. However, the thought of riding on today's roads terrifies me," says Saul. "Reporting on the latest safety advances for PTWs has given me hope that soon, PTWs will be given as much consideration as their larger counterparts. I may even apply for my bike license!"

Louise Smyth

Distracted driving is something Louise recently realised she was guilty of while driving home in a state of distress after a garage had just issued her with a huge bill. "It's an issue that affects all of us at times. Interviewing practioners on whether eye-tracking technology could help us keep our minds and eyes on the road has been both thought-provoking and reassuring," she says.

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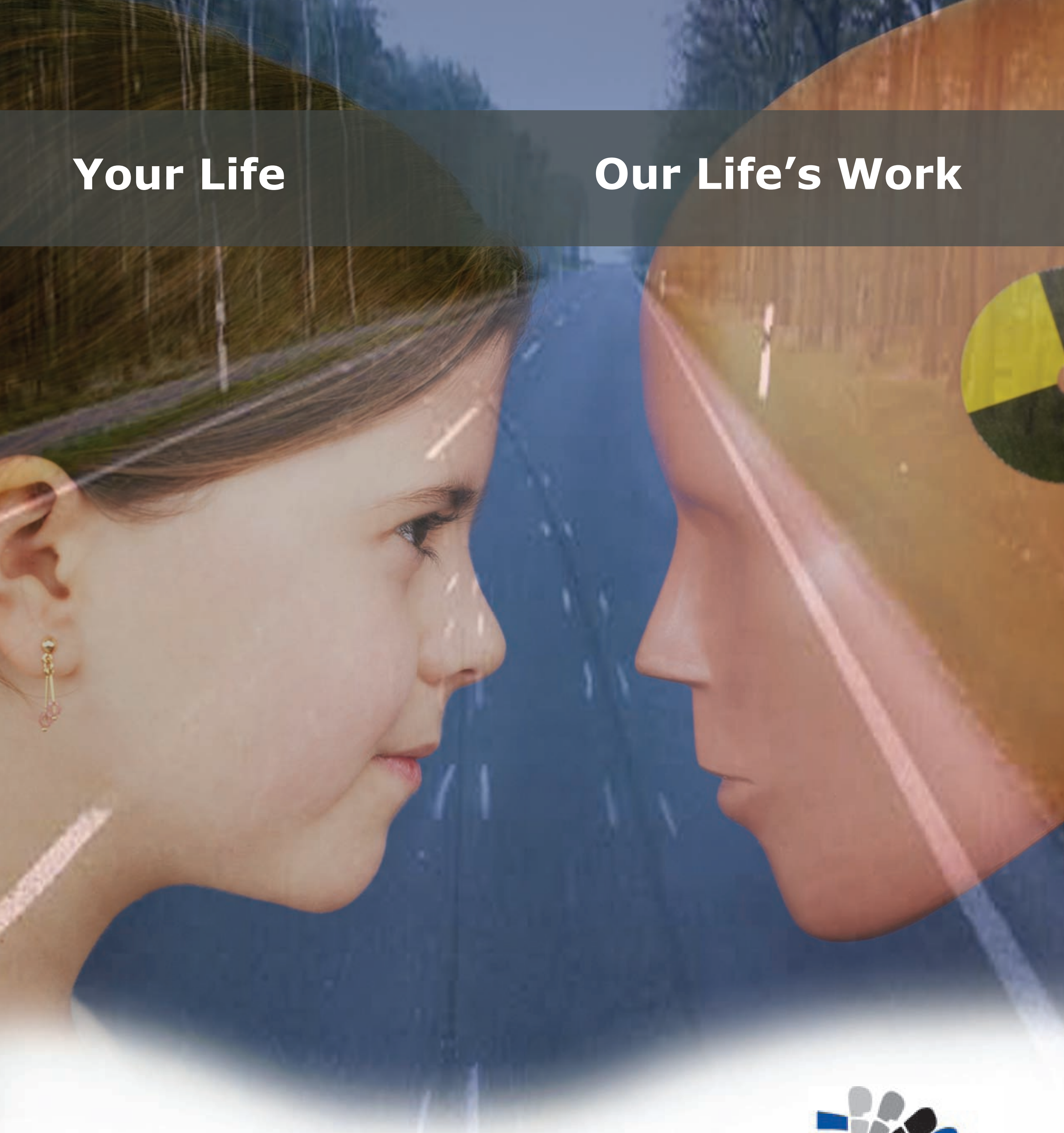

Your Life
Our Life's Work

The camera never lies

With distracted and drowsy driving currently high on the auto industry agenda, we assess the potential of eye-tracking technology as a means to tackle this dangerous behaviour and improve road safety

AUTHOR LOUISE SMYTH
IMAGES COURTESY OF MIT, TOBII & VOLVO TECHNOLOGY

The continued development of eye-tracking systems is big news in the auto industry. Moving beyond the detection of simple head movement, actually following a driver's eye gaze is a key piece of the inattentive driving jigsaw. Trent Victor from Volvo Technology is a world-renowned expert in the field. A senior researcher specialising in analysis of human factors, he has worked on eye-tracking systems since he started at Volvo in 1996. Today, he also works with the SAFER – Vehicle and Traffic Safety Centre at Chalmers University of Technology in Sweden, as well as being a board member of Australia's Seeing Machines. Asked how a typical eye-tracking system works, Victor's response highlights the complex issue that it is: "There are really two separate parts of that question," he says. "One relates to the eye-tracker technology and the other is functionality. Some of the latter you can achieve by just using head movement, or you can measure eye closure, which is how drowsiness detectors work. Both are intertwined as the requirements for functionality depend on the maturity of the eye tracker. Much of my efforts have been focused on the premise that

Could camera-based eye tracking solutions prove to be the ultimate solution to distracted driving?

"WITH EYE TRACKING, I THINK THE AUTOMOTIVE REQUIREMENTS ARE JUST EXTREMELY HARD, WHICH IS THE MAIN IMPEDIMENT TO THE TECHNOLOGY"

these systems *do* work effectively. Accepting that basis as a fact, you ask yourself what would I use them for and how can they help?"

Perhaps as so much of his job is at this 'what-if' level, Victor is keen to differentiate between research and commercial systems: "There are two manufacturers, Seeing Machines and Transecurity, offering market-mature systems – i.e. they are selling them as safety systems to real customers," he reveals. Below that line, there are a number of other competing companies, the first of which that springs to mind is Smart Eye."

Naturally, all of the big automotive Tier 1s are also working on solutions. But Victor has watched the same story unfold time and time again, reflecting his point about the need for mature offerings. "In 1992, Siemens VDO published a report discussing a system that it said worked to detect drowsiness, suggesting it would be introduced on a vehicle within the next few years. That never happened. Delphi was heavily into this work, too, but it was the same scenario. Drumming up business based on prototypes is just smoke and mirrors.

"With eye tracking, I think the automotive requirements are just extremely hard, which is the main impediment to the technology. The fact that these things have to be so 'simple', cheap and small is difficult. To achieve that – especially at the right price – the functionality has to be there. Tell me what your system does. Does it beep at you? Does it provide data to the back-office, or does it get integrated into a collision-warning system? How do we know it works and that customers actually want it?"

Victor cites Seeing Machines as having the right approach. Although its system is not embedded technology – it relies on a rugged PC – it has

Line of sight

In March 2010, Miao Wang and David Latotzly from the Department of Computer Science at the Free University of Berlin, published a paper entitled *Driving an autonomous car with eye tracking*. The vehicle used was the university's Spirit of Berlin, an autonomous car that competed in the 2007 DARPA Urban Challenge.

The report makes an important point about bridging the gap between manned and unmanned vehicles: "Between human driving and unmanned driving, there lies an area in which human behaviour can be used as a guideline for autonomous control."

The eye-tracking control was a hardware and software set-up called eyeDriver. The system works by tracking the driver's iris with an infrared camera built onto an HED4 interface by SensoMotoric Instruments. Iris position data is then transmitted by eyeDriver to control the steering wheel.

The HED4 unit is a helmet construction that incorporates two cameras and an infrared spotlight. The paper describes the set-up as follows: "The spotlight and one camera are aligned to illuminate and capture the operator's eyes and the captured grey images can be used to track iris movement. The other camera is aligned to the operator's viewing direction, providing a coloured image of the user's field of view. The iris positions are mapped to the *x* and *y* coordinates of the front image and transformed into steering wheel commands."

Two methods of sending these commands were explored. The first was direct transformation, which enabled the operator to lock onto an object in the distance with his eyes in order to head towards it. The second, which proved less intuitive, was to use steering windows where if the driver looked to the left, the car would drive to the left.

However, the issue of requiring a helmet to steer his car casts some doubt as to whether applications such as this can move beyond the research arena. But the report stresses that eye control has potential: "We see our work as a proof-of-concept upon which more applications can be built."

already found a niche as an aftermarket system in the mining sector. Fatigue and distraction in mining is more costly than most other areas of transport, so it's natural this sector would spend an initial outlay to prevent work from grinding to a costly halt. And Victor predicts that fleet vehicles in other fields will follow this lead. "You have to find the customers. Currently it's mining, but next will be vehicles that transport hazardous or expensive materials."

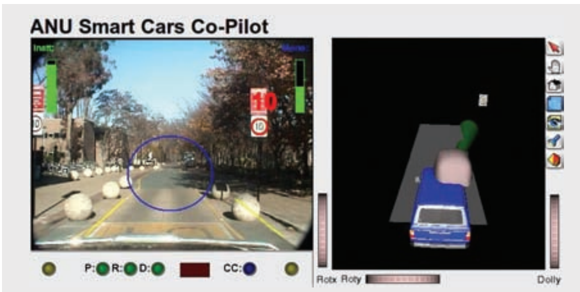
Victor also envisages that a luxury car-maker will eventually start offering eye-tracking systems, ideally ones that can be used to boost the functionality of other ADAS such as lane-departure warning or forward-collision systems. But he offers a note of caution about walking before we can run: "Right now, the thing we need more than anything is to prove the safety benefits of the different solutions. One function I've been involved with is visual distraction alerts – i.e. providing some kind of a warning when a driver is looking away for too long or too often from the road. That is just a very simple function but there are some major results coming out of Seeing Machines – for both trucks and the mining market – that show a major reduction in incidents and a big reduction in distraction. One trial showed an 80% reduction in distraction events. This is real progress!"

Talking technology

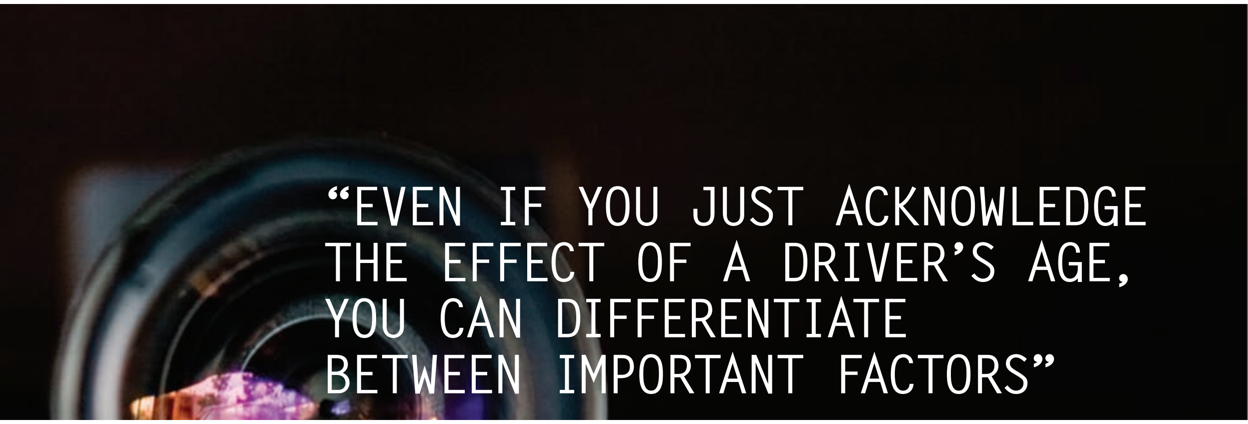
Dr Riad Hammoud is a research scientist and author who has published swathes of work in this sector, including his ground-breaking book *Passive Eye Monitoring*. When he was working on pilot fatigue, he became interested in eye tracking's potential as a non-invasive answer to this problem. While working for Delphi he immersed himself in developing solutions for the automotive world. "There are two parts to an eye-tracking system: the hardware and the algorithmic or software part," he states. "In terms of hardware, the most important part is the optics – the camera resolution, near infrared sensitivity and image quality. "These live images of the driver's eyes are processed in real-time in the central unit – in the automotive industry usually a Texas Instruments DSP unit. The processing routines give you the results. If we're talking about fatigue in particular, we're interested in eye-closure rate, where you would compare the percentage of eye closure in real-time to a predefined threshold until you can say 'eye closure or drowsiness level is above the threshold so we must warn the driver'."

"TO ISSUE A WARNING AT THE ONSET OF FATIGUE (I.E. BEFORE A DRIVER FALLS ASLEEP), A SYSTEM HAS TO BE REAL-TIME OR IT'S USELESS"

To a layperson this sounds deceptively simple, although Hammoud is quick to point out the challenges to getting a system to work effectively. "To issue a warning at the onset of fatigue – i.e. before a driver falls asleep – a system *has* to be real-time or it's useless. Another challenge to writing robust image-processing algorithms is that they have to handle different lighting conditions, eye squinting, different eye colours, etc, so the vision algorithm needs to be adaptive. Finally, we have to find the balance between a small amount of missed fatigue detection while keeping the false alarm rate low. You don't want the system itself to become a distraction."



Establishing what a driver has or hasn't seen is a critical part of eye tracking



"EVEN IF YOU JUST ACKNOWLEDGE THE EFFECT OF A DRIVER'S AGE, YOU CAN DIFFERENTIATE BETWEEN IMPORTANT FACTORS"

From robot to real-world

The use of eye-tracking systems links into the whole debate on autonomous technologies. Luke Fletcher, a research scientist in robot vision and sensor networks at MIT's Computer Science and Artificial Intelligence Lab is a notable expert in this particular field. "The path to realising a car where you can pretty much throw away the steering wheel and it'll take you to work autonomously relies on getting driver support systems into vehicles," he feels. Fletcher has followed these issues for many years and once he'd observed Seeing Machines spin off as a commercial enterprise from Australia's national university, ANU, he decided to look into bundling eye-gaze tracking with road scene computer vision "to see if we could determine what the driver was looking at, what they were not seeing, and so on". This is where his efforts have been most recently focused.

Fletcher explains that the best eye-tracking systems contain a combination of both video cameras and infrared technology: "The common approach is to use corneal reflection or to use an infrared camera – that makes it easy to track somebody's eyeball. You need accurate head pose and eyeball orientation to offer a good estimate as to what the driver is looking at."

Fletcher's thesis in this field concentrated on driver distraction. "It was about real-time direction estimation, which is about inattention. You need to be able to determine whether someone actually looked in a particular direction at a particular time, as opposed to just calculating an average of when someone's got their eyes open or closed," he reveals. "All work in this field comes with a notable caveat – the issue of looking but not seeing. You can never say that somebody saw something – even when they are staring right at it – so we had to take the converse approach to only ever show that somebody missed a piece of information."

Fletcher's passion for these systems was truly ignited when he worked with MIT on 2007's DARPA Urban Challenge. "Following that, we had spin-off projects with Ford to look at using some of the autonomous technologies in driver safety systems."

Standard industrial-grade cameras are used in most eye-tracking research projects

In Fletcher's opinion, demonstrating the safety value of these systems to consumers is what will help drive market demand: "We need to create systems that people actually want to use. You can portray these technologies as assuming a 'nannying' type of role but why not turn that idea on its head? Although I cringe to say it, think of them more as a *Knight Rider*-type of concept. You've then got cars that are cool and smart with truly intelligent safety technologies. Systems that offer feedback on the accelerator and steering wheel, for instance, are a natural interface for the driver – and you can use eye gaze to cancel false positives. Seeing what the driver has seen eliminates many false alerts and makes the related safety systems more useful."

(Above) Hardware from an ANU eye-tracking project

(Right) Seeing Machines equipment in an MIT research vehicle

The human factor

The future potential of eye-tracking systems doesn't however rest solely on commercial systems becoming cheaper, smarter and more desirable. No matter how sophisticated the technology becomes, how we humans interface with it is just as crucial. Bryan Reimer at MIT's AgeLab has a wealth of experience in assessing eye-gaze allocation and driver attention. He is particularly knowledgeable about psycho-physiological meaures, such as heart rate and skin conductance and how they respond to different levels of demand in the vehicle, but suggests we're still a way off from deploying non-invasive versions of such systems in cars. Instead he feels eye-gaze systems do have a lot of potential in the shorter term. "If you're looking for something that is implementable in a vehicle today, eye tracking or visual attention monitoring is very powerful."

He does, however, feel that many people disregard the previously mentioned 'looking but not seeing' theory and vastly underestimate the issue of cognitive distraction. "There are an alarming number of researchers and practitioners in the automotive field who are really focused on the idea of 'Well, if the eyes are on the road, the driver's paying attention' and I think that's partially incomplete. Cognitive demand or distraction – the stress, the emotion we bring into the vehicle – is really affecting our ability to drive safely. We also need to consider all of the interfaces and information that we are now providing to the driver. How much of these are drivers really cognitively capable of managing?"

Reimer also raises another point that seems to be woefully neglected by other practitioners: all drivers are individuals. "Even if you just acknowledge the effect of a driver's age, you can differentiate between important factors," he says. "Young adults today are growing up in a multi-tasking world in which they're splitting their attention among too many electronic devices, and they come into the vehicle needing a level of sustained attention that they just have no experience with. Conversely, the older generation is blessed with the fact that they've had this focused experience in the vehicle for a number of years. But now we have a number of in-vehicle safety systems that are providing them with information that's not well grounded in their experiences."

Reimer also cites the need to train drivers how to react to warnings: "Providing warnings is all well and good, but when an alarm goes off, we end up searching for the alarm itself as opposed to reacting to it. How to educate people to react to warning systems – yet keep their eyes on the road – is a significant matter."

His research has shown that cognitive distraction is a measurable attribute through a driver's eyes. In a situation where a driver has a moderate level of cognitive demand, there is more scanning of the road. As that level of demand increases, scanning decreases. Reimer's research has been conducted using commercial eye-tracking systems such as those from Seeing Machines and he believes that derivatives of these systems will prove to be successful in the wider market: "The basis of the technology to solve the problem is there – i.e. detecting from a visual distraction perspective when the eyes are on and off the road – but we're not going to have perfect information in first-generation products. To move forward, we need to focus on developing models that learn and adapt to the driver's individual charcteristics. Eye-tracking systems are great technologies, but just as important is how we provide feedback to the driver and integrate it with other vehicle systems. If we want to make serious strides in safety, detection systems have to be tailored to the driver. Some will argue that one day cars will not crash, and I'd like to think that will be the case. But for the foreseeable future at least, automation will have to be overseen by a driver. And as long as the driver is in the loop, the driver will make mistakes." ‹

Eye witness

John Elvesjö, CTO and founder of Swedish company, Tobii, says eye-tracking technology has a healthy future

What eye-tracking technology are you offering for the automotive market?
It's a new infrared-based system that combines two patented LEDs with two miniature cameras. This combination allows us to determine the driver's gaze point and eye position, as well as the openness of the eye. It's a very small, remote system that's hidden away in the dashboard, behind what we call 'black windows'.

We've been supplying disabled people with a way of interaction using gaze point for several years, so we've learned how to filter out background signals (such as any kind of visible light) so that we have a system that has zero-dependence on the rest of the environment, making it perfect for automotive applications. Whether it is direct sunlight or pitch black, the system doesn't detect a difference.

How do you make sure the system itself is not a distraction and how do you prevent false alarms?
So far we haven't seen any false alarms at all. There are two main categories of dangerous driving that the system would alarm for – distracted behaviour and drowsiness. For drowsiness, we measure a raw signal that corresponds to the general alertness of the eye, the openness and rate of movement. Then we take different types of values from that and set different thresholds for what is dangerous – and there are quite a few things that have to happen in the system for it to sound the alarm. With regard to issuing that alarm, the most effective method we've found so far is to present the alarm as a short vibration from the steering wheel, because that generates an immediate change in eye behaviour without requiring the driver to look around for the source of the alarm.

What sort of vehicles is the system installed in?
Automotive customers are quite secretive so I'm limited to what I can say. But there are a host of automotive OEMs we are working with, either in the research stage or at prototype level. Our initial plan is to target a wider market with a retrofitted product for different types of fleet vehicles, such as trucks and buses. It will take a longer development cycle to get OEMs to integrate a version of the system at the design stage for personal vehicles.

Could eye-tracking systems be the optimum solution to distracted and drowsy driving?
I think they could. Typically, these optical systems look at something more than just one single value. They can provide a great deal of data about how you behave and how you move. There is no better way to tell if somebody is falling asleep than by simply looking at their face and eyes, and I really don't see any other way to measure drowsiness in-vehicle. Simply monitoring head movement, for instance, will never tell the full truth. And eye-tracking systems are becoming cheaper every day, so the cost will not be a prohibitive factor for the automotive market. We're also tackling the size issue, which is always a factor for OEMs. It's taken some time but today there is no reason for an eye tracker to be any larger than the camera in a decent mobile phone.

"THERE'S NO REASON FOR AN EYE TRACKER TO BE ANY LARGER THAN THE CAMERA IN A MOBILE PHONE"

Step-by-step guide

Here are some key points made in the Supreme Court opinion, which can affect vehicle manufacturers and auto safety equipment suppliers and test facilities. The US product-liability laws not only serve to compensate victims who were severely injured by needlessly unsafe or defective designs, but also serve as an incentive for automakers to make continuously safer vehicles that will prevent those injuries – which thereby also reduces the automakers' potential liability.

Point 1: Designs that exceed the minimal compliance requirements will prompt progressively greater actual safety benefits.

Point 2: Extra cost cannot be considered as an excuse to preclude a safer design.

Point 3: A cost-effectiveness rationale conflicts with the statutory 'savings clause' (in the Federal Law) that foresees the likelihood of a continued meaningful role for State tort law.

Point 4: The Court affirmed that such State lawsuits did not stand as an obstacle to Federal law merely by potentially imposing a more stringent requirement on vehicle safety design and performance.

Sense and liability

A recent US Supreme Court decision is good news for auto safety and will help to stimulate new developments in this sector, says our man on the scene, Byron Bloch

There is good news for auto safety after the US Supreme Court issued its unanimous eight-to-zero opinion on 23 February, 2011 in the case of Williamson versus Mazda. The issue was whether compliance with a permissible option in Federal Motor Vehicle Safety Standard 208 should pre-empt the automaker from any liability for their choice. The focus here was on whether providing a permissible lap belt only for a second row seat position in a 1993 Mazda MPV minivan was sufficient for pre-emption.

The US Supreme Court opinion reaffirms that compliance with the minimum requirements or permissible options of a FMVSS does not entitle the automaker to preemption from potential liability. So, severely injured crash victims can continue to pursue justice and compensation in the courts, alleging the vehicle at issue was needlessly unsafe and defectively designed, despite the fact that it may have complied with the often weak 'safety standards'.

Automakers should make the safest vehicles that are feasible, rather than ones that barely comply with the safety standards. This ruling will therefore stimulate automakers and suppliers and testing facilities to do more to advance safety, to go well beyond the minimums, meaning fewer accidents, and fewer deaths and serious injuries.

The civil case will now be allowed to proceed to a jury trial in California State Court. Mazda will have to defend why it did not also provide a shoulder belt, which arguably would have prevented the passenger from fatal internal injuries when she jack-knifed over the lap belt in a front-impact accident. NHTSA had encouraged automakers to install combination lap-and-shoulder belts as a more crashworthy design, and it was perfectly feasible for Mazda to have done so. When automakers lose such product-liability court cases, often with verdicts and settlements in multimillion dollar amounts, that also creates an incentive to eliminate those defects and make their future cars safer.

Justice Sonia Sotomayor and Chief Justice John Roberts outside the US Supreme Court

The US Federal Law that created NHTSA and the FMVSS explicitly states: "Compliance with any Federal motor vehicle safety standard under this title does not exempt any person from any liability under common law." The law unequivocally states that exemption or preemption from liability is therefore not an option. Further, by law, the FMVSS only establishes the minimum requirements, leaving automakers free to integrate safety technology that exceeds those minimums and to produce and market safer vehicles than their competitors.

A number of constructive measures could (and should) now be implemented to meet these goals: *For FMVSS 214 on side-impact protection*: Stronger side structures to minimise intrusion, plus use of interior padding, wrap-around seats, improved side-curtain and between-passenger airbags, and laminated glass for side windows. Upgraded testing should include shaped-moving-barriers into vehicles, vehicle impacts into poles,

"WHEN AUTOMAKERS LOSE SUCH PRODUCT-LIABILITY COURT CASES, IT CREATES AN INCENTIVE TO ELIMINATE THOSE DEFECTS AND MAKE THEIR FUTURE CARS SAFER"

Was a shoulder belt, as shown above, also feasible for the aisle seat of a 1993 Mazda minivan?

and car-to-car tests (including override of the rocker section), with instrumented dummies in all seating positions. Impact speeds should be at +50mph to simulate real-world accidents.

For FMVSS 216 on roof crush resistance: Stronger roof structures need a strength-to-weight ratio (SWR) of at least 5.0 – versus the newly upgraded SWR of 3.0 as too minimal and already exceeded by many production vehicles. Roof designs should include box section headers and pillars with full-length internal reinforcements, plus rigid foam filling and composite material strengtheners. Dynamic rollover tests at +50mph with instrumented test dummies in all seating positions will simulate real-world rollovers, to validate seatbelt performance, maintenance of survival space, and elimination of head and cervical vertebrae injuries.

For FMVSS 226 on ejection mitigation: More robust side-curtain airbags are needed, plus laminated side window glass and wrap-around seats with integrated seatbelts. Testing must go beyond minimal lab impacts of a 40 lb head-shaped impactor at 12.5 and 10mph, and include both side-impact and dynamic rollover testing at +50mph to ensure partial or complete ejection of the full-size test dummies does not occur.

For FMVSS 223-224 on rear-impact guards: For truck underride protection, it means stronger, lower rear guards that are full-width with attachments at the corners. Strong side guards will be necessary on all trailers and large trucks. Validation should include car-into-truck tests at +50mph, including offset and angular crashes – and perpendicular crashes into side guards – to ensure that deadly underride is prevented.

The ongoing product-liability risk for automakers, with costly verdicts and settlements, will encourage development of safer designs and technology to help prevent accidents, and more crashworthy vehicles that will prevent serious and fatal injuries. The US Supreme Court should be saluted for helping stimulate such developments. ‹

Political ambitions

Claes Tingvall

Countries such as Sweden, Norway and Australia have already decided to build their traffic safety ambitions and actions around Vision Zero. In October 2008, the OECD recommended that a 'Towards Zero' approach should be used by jurisdictions striving for good management principles. Meanwhile, the forthcoming ISO 39001 – the standard for traffic safety – is to be used by those who wish to eliminate deaths and serious injuries resulting from traffic crashes within their organisation. This is all great and progressive, but the next major step is just around the corner.

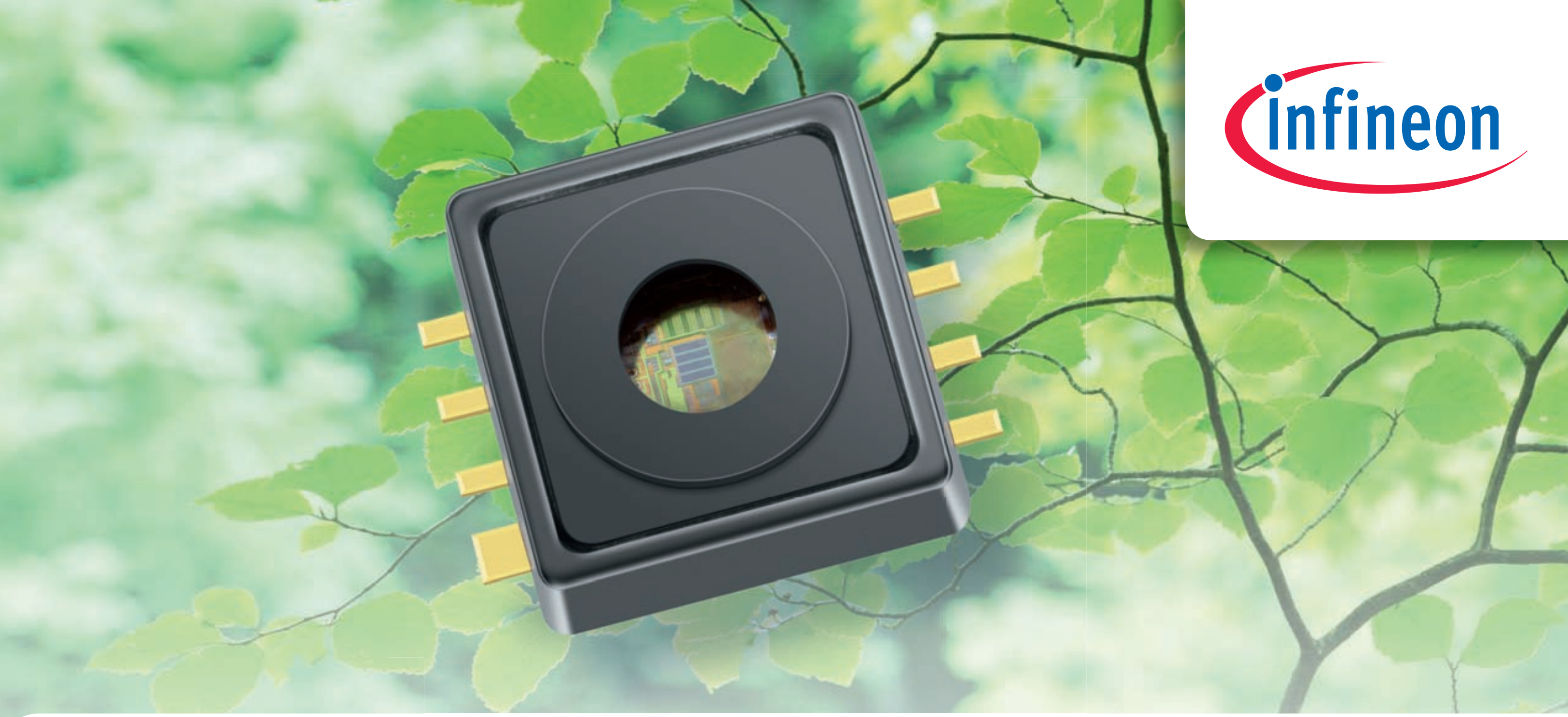
In December last year, ministers from the Council of the European Union reached an historical traffic safety milestone in Brussels by adopting a number of conclusions, not least the following: "…*Considers* that the level of road fatalities remain unacceptably high and *stresses* the importance of adapting motorways, roads, streets and vehicles to human capacity; thereby *aiming* towards the long-term 'vision zero' for European road transport safety". Continuing, the ministers stated: "…*Considers* that infrastructure, vehicles and road users should be seen as a system in which human error and inappropriate behaviour should always be taken into account. Infrastructure and vehicles should be designed as to prevent and limit consequences of such failures". Another conclusion was also interesting: "…*Encourages* a strong cooperation between the bodies responsible for the infrastructure in the Member States and the vehicle industry to support the deployment of promising in-vehicle systems that contribute to saving lives on the European road network. New technologies of which effect is proven can contribute to make it possible to deal with problems such as speeding and impaired driving (such as under the influence of alcohol, drugs and fatigue)".

Such expressions are Vision Zero in a nutshell, and this is the first time that we've seen a major political decision taken based on its principles. The EU Parliament rapporteur also expressed a strong support for Vision Zero in his report, stating explicitly that long-term policies should be based on the ethos.

And it goes on… In early April this year, the EU Comission's *2011 White Paper* was released. This document is, of course, merely a proposal but a very important step in decision-making in Europe. The first ever political long-term target for traffic safety is listed within its pages, suggesting we should be "close to zero" by 2050. This must be seen as a major breakthrough, when the vision is broken down to a numerical target. Of course, we could always ask ourselves what "close to zero" actually is. But even if it's something like 10% of the number of fatalities, it really is a realistic target – meaning halving the numbers every 10 years. We know this is possible if we are all ambitious. With policies that view road transport as a system – and basing safety developments on eradication – it's a start. If we can for the first time see that we should support sober driving and safe speed with technology, we are tackling areas that have a major potential.

So, in summary, we can see the political support growing fast, and with the upcoming UN Decade of Action, the future of traffic safety looks better than ever. And with Vision Zero as the basis for it all, the interest for new, innovative solutions is greater than ever.

• Claes Tingvall was recently appointed professor of Global Road Safety Research at the Monash University Accident Research Centre, Australia. He has also been director of traffic safety in Sweden since 2001



Boosting High Efficient and Safe Mobility

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Infineon's integrated pressure sensor family uses a unique design of multiple surface micro-machined capacitive sensor cell arrays, that allows to implement powerful features like the sensor self diagnoses. The monolithic integration onto one chip allows a state-of-the-art production using a standard automotive qualified BiCMOS process. The combination of sensor cell design with a fully digital signal conditioning and processing with the methods of a high volume standard production flow ensures a superior quality over lifetime. Today's automotive applications are side crash detection, pedestrian protection, engine management (BAP, MAP, Turbo MAP, secondary air valve), fuel vapour and seat comfort. The next generation powertrain sensors will offer in addition digital interfaces like SPI, SENT&SPC and will support the Power-train PSI5 interfacing standard as well as a safe communication between sensor and ECU.

Infineon Pressure Sensor portfolio at a glance

- World leading supplier in side crash detection and body comfort pressure sensors
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Hall of fame

A new collection of exhibits at the Smithsonian offers a tangible record of how American lives have been saved over 75 years of automotive safety development

Automotive safety has found its way into the American hall of fame at the Smithsonian National Museum of American History. "The Smithsonian owns 73 automobiles and many objects that show how Americans transformed communities, travel, family life, commerce and the landscape by owning and using automobiles," reveals Roger White, associate curator, Road Transportation – Work & History, at the museum. "Several years ago, I began collecting objects that show how Americans have dealt with automobile safety hazards and the historically high fatality and injury rate," he continues. "For more than 75 years, there has been a struggle to separate the promise of personal mobility from the seemingly inevitable accidents, injuries and fatalities that power, speed and inadequate safety designs (both in cars and on roads) brought to everyday life."

The 'Inventing Automobile Safety' exhibit mentions some of the auto safety advocacy work conducted by *Vision Zero*'s Byron Bloch, and includes two historic car models and a sketch from his efforts in the 1970s regarding the Pinto fuel tank court cases and the need for fuel tanks to be safely mounted forward of the rear axle, as he showed in the Ford Taurus model (pictured right).

The exhibits are divided into driver education, publicity campaigns, unsafe designs and protective safety hardware. "We received as gifts driving instruction books of the 1930s from the American Automobile Association, costumes from the Vince and Larry crash dummy commercials of 1985-88, and a 1967 Chevrolet energy-absorbing steering column. Also on display is a custom-designed dashboard pad of the 1940s, an add-on lap belt from the 1960s, and a 1987 breath analyser that disabled a car until the driver passed a blood alcohol test. We hope to prepare a larger exhibition in the future with other safety objects, including crash test dummies from the 1970s

and 1980s, and a 1961 Volvo seat with an early three-point seatbelt."

White, a safety enthusiast, suggests the historical lessons of this collecting and exhibiting programme are threefold. First, he says, automobiles had to change greatly to become truly useful without imposing a safety risk. "Second, for decades, there was disagreement about the causes of accidents, injuries and fatalities. The auto industry and some safety advocates insisted that automobiles were safe and driver error caused all problems, with accident prevention emphasised." But crash testing – which began at universities in the 1950s – established they should become the first line of defence in a collision with the addition of seatbelts, padded dashboards, stronger door locks and seat anchors, and other hardware. "The third lesson is that no single factor – driver competence, automobile design or highway design – governs driving safety. It's a combination of all three factors." ‹

The Smithsonian Museum's website has recently launched Demand for Safer Cars, Drivers, and Highways *with 20 sections tracking a century of progress in auto safety – http://americanhistory.si.edu/onthemove/themes/story_86_1.html*

The crash and burn epidemic

The fire hazard of Ford's popular compact Pinto, and upgrade to safer fuel tanks, is featured in the Inventing Automobile Safety exhibit at the Smithsonian. At issue was the easily crushed fuel tank near the rear bumper, and filler tube that easily pulled out.

What prompted safer tanks? First, the 1978 Grimshaw versus Ford Pinto trial resulted in US$125 million punitive damages… and headlines. Second, Mother Jones magazine exposed that Ford knew of the Pinto's hazard. Third, America's first 'reckless homicide' trial in 1980 in Indiana alerted the public about the epidemic of fiery crashes. Auto safety expert Byron Bloch testified, urging that tanks be safely located forward of the rear axle… noted in the exhibit's text and by the later Taurus model. With adoption of such safer designs, the fiery epidemic has thankfully tapered off.

An IIHS study has shown that thousands of pedestrian fatalities might be avoided each year if detection technologies were fitted to vehicles. Researchers estimated that 2,932 fatalities – around 75% of the current annual total – and 39,000 injuries could be prevented by fitting pedestrian-detection systems.

In a bid to improve the safety of electric vehicles, Continental has developed a sensor that shuts off the high-voltage battery in the event of a collision while the vehicle is in charge mode. The evSAT detects accidents and shuts off batteries, allowing emergency services teams to recover cars without risking electric shock.

NHTSA has released projected figures that show US traffic fatalities in 2010 dropped to the lowest level in recorded history. NHTSA's early projections show that the number of fatalities fell 3% from 2009 to 2010 from 33,808 to 32,788. Fatalities have dropped 25% since 2005's total of 43,510. The estimated figures also project that the current fatality rate will be the lowest since records began in 1949, with 1.09 fatalities per 100 million vehicle miles travelled, which is down from 2009's 1.13 fatality rate. It is noteworthy that the decrease in fatalities during 2010 occurred despite an estimated increase of vehicle miles travelled of nearly 21 billion miles.

Toyota is launching a collaborative safety research centre (CSRC) in the USA, bringing together universities, hospitals, research institutions, federal agencies and other organisations to collaborate on projects aimed at reducing KSIs. The CSRC is based at the Toyota Technical Center in Ann Arbor, Michigan.

Follow the leader

The SARTRE autonomous road train project has taken a big leap forward from the simulation labs to the real world with tests taking place in Gothenburg

Autonomous driving has seemingly been a few decades away since the dawn of the modern automobile. It therefore comes as no surprise to hear that is what the brains behind SARTRE are predicting if the 'Safe Road Trains for the Environment' vehicle platooning project yields the kind of results its research team anticipates.

With similar intentions to initiatives such as Prometheus, PATH and KONVOI, SARTRE does, however, boast some notable distinctions. "We don't have any dedicated lanes, such as PATH," says Dr Erik Coelingh, technical leader, Active Safety Systems at Volvo Cars – one of the seven partners in the consortium. "We don't need to make any alterations to the existing infrastructure either. We're also mixing the autonomous road train with other traffic on public roads, and vitally we're doing this using sensors such as cameras, radars and LIDAR. What's central is to take a production-ready vehicle and adapt it as little as possible."

SARTRE is thought to be the ideal way to take Volvo's safety technologies such as ACC and emergency braking to the next level. Coelingh says: "We believe that autonomous driving is on the horizon. Our core vision is for an accident-free future. At Volvo, we asked ourselves, 'Where do we now require knowledge?' We agreed on platooning – but not platooning that necessitates an overhaul at the roadside, or where all vehicles drive autonomously. We instead thought about a scenario in which a lead vehicle is driven by a professional driver, similar to a bus – you get on, pay for your journey, the driver takes responsibility for you, and you just hop on and off when and where you want."

The SARTRE proposal was submitted to the EU in May 2008 and funding was secured under the EU's Seventh Framework Programme.

The SARTRE system would see eight-car road trains linked and led by a professional driver

Ready to roll

According to Erik Coelingh, there is nothing magical about the technology being employed in the SARTRE platoon vehicles – a mixture of standard radar, camera and LIDAR sensors, as well as 5.9GHz 802.11p DSRC communications – although that does perhaps oversimplify what's being achieved. "We want to make the platooning a kind of extension of ACC," he says. The main challenge technologically is that the vehicles are travelling so close to one another that the sensors cannot see the lane markers. So instead of using the lane as a reference, we're using the lateral position to the vehicle in front as the reference.

"Communications between all vehicles is also a challenge," Coelingh adds. "We're continuously transferring information about accelerations, velocities, data relating to longitudinal and lateral motion, curvature, and more.' The V2V communication module, currently an ALIX 3D3 embedded PC, connects to the vehicle CAN interface, although a backup communication channel may also be needed.

The VTT Technical Research Centre of Finland and Mercedes-Benz are leading a project to build a test area in Tampere, which will be used to create a transport system of the future. The new centre will test systems in which vehicles communicate with each other, receive real-time information about traffic, and also gather and forward information themselves. The tests will be on cooperative systems in which vehicles will exchange location based real-time information with other vehicles (V2V) and infrastructure (V2I). This would make it possible to warn a driver about an approaching emergency vehicle or a slippery curve ahead, for example.

Delphi has announced that it has developed two new vehicle sound generators, which can help OEMs warn pedestrians of approaching hybrid and electric vehicles. Without sound generators, such vehicles are nearly silent. Delphi's first Vehicle Sound Generator will be introduced by a leading European OEM in mid-2012.

From 7 February 2011, all new cars and light vans being produced in European automotive factories must now be equipped with automatic daytime running lights (DRL) in a bid to raise road safety. The European Commission says the DRL – which automatically switch on when the engine starts – are expected to increase road safety as they raise the visibility of vehicles for other road users. New trucks and buses will be equipped with the daytime lights in August 2012. The commission said road users (including pedestrians and cyclists) detected vehicles using DRL more clearly and quickly than those equipped with dipped beam headlights.

"WHAT'S CENTRAL IS TO TAKE A PRODUCTION-READY VEHICLE AND ADAPT IT AS LITTLE AS POSSIBLE"

Officially starting on September 1, 2009, it will all come to an end on August 31, 2012.

Research throughout 2010 was confined mostly to the virtual world, where a great deal of simulation work was conducted. SARTRE took a major step forward in January 2011 when all of the systems were brought together for the very first real-world test near Gothenberg in Sweden. "Our main goal was to make sure that everything mirrored the simulations," Coelingh says. "We've all developed different parts of the system so this was the first time we connected everything up to see if the car, in this case a Volvo S60, could operate entirely autonomously. We wanted to see if it would steer, brake and accelerate in the way we wanted and we're pleased to say the test was highly successful."

Coelingh was one of the first to get behind the wheel. "It's somewhat unusual at first, but you get used to it," he says. "It's reminiscent of the first time you drive with ACC. Once you realise it works perfectly, you end up adjusting your driving style to one that embraces ACC. It's the same with autonomous driving."

NEC Europe has designed and implemented an innovative vehicle-to-infrastructure (V2I) communication system that allows vehicles and roadside infrastructure to talk to each other and exchange real-time information. The system allows traffic light controllers to transmit their current signal phase of red or green and time changes to approaching vehicles, warning of potential red lights and aiding safer and more efficient driving. The system is currently being evaluated as part of the EU's INTERSAFE-2 project, which is financially supported by the European Commission.

The Father of Passive Safety

Béla Barényi

When you consider that he was born well over 100 years ago, it's a measure of Béla Barényi's ingenuity to discover that many of his patented inventions are still to be found on vehicles today. Widely accepted as the 'Father of Passive Safety', with 2,500 patents to his name, Barényi is however barely known outside of auto circles. Yet if you lined up the all the people whose lives his inventions have saved, they'd probably stretch around the world.

Born in Austria-Hungary in 1907, as a child he suffered from inflammation of the hip, which limited his mobility. He told various people throughout his life that his condition may have shaped his career, as his time as a boy was spent scouring highly technical literature. He would later study mechanical and electrical engineering in Vienna, before working for Austria-Fiat, Steyr and Adler automobile companies before joining Daimler-Benz in 1939, although the onset of the Second World War halted his career – but not his ideas.

Following the War, in 1948, he was reinstated by Daimler-Benz and given the freedom to express his engineering creativity. A few of his concepts were on the Mercedes-Benz 180 (W 120 series), with floor assembly designed and dimensioned so that it provided improved protection, mostly in side impacts.

His 1951 concept of dividing cars into three collision zones – a soft front section, a rigid passenger cell and a soft rear end – was among his most significant contributions, however, and was eventually used on all Daimler-Benz vehicles and adopted by the auto sector as a whole. In 1953, this safety body/crumple zone as well as a patented safety steering wheel concept would make it into the W 111 series.

Barényi fine-tuned the latter over several years. It was initially a steering wheel with generously sized padded boss and a deformable linkage between impact absorber and the end of the steering column, relocated towards the front. Incorporated into the 1959 series 'Fintail' W 111, in 1965 he introduced a steering system with telescopic steering column to the W 108 series. Barényi himself was not satisfied with the design, though, as he believed it could lose its flexibility when subjected to lateral pressure in a crash. A newer version was based on a steering column in the form of a corrugated tube, which allowed the steering to give way in several directions in the event of a crash. This collapsible system was first installed in the 123 series in 1976.

After 33 years with Daimler-Benz, Barényi retired in 1972, and in 1994 he was inducted into the Detroit Automotive Hall of Fame and as a nod to his contribution, a Mercedes-Benz advertisement featuring Barenyi's image proudly stated: 'No one in the world has given more thought to car safety than this man'. He died in 1997 aged 90.

Reversing role?

A new NHTSA regulation mandating rearview cameras in all new vehicles sold by 2014 means some terrible tragedies could be averted in the future

According to estimates from the USA's NHTSA, every year there are an average of 292 fatalities and 18,000 injuries resulting from back-up accidents. Of these, 228 deaths involve light vehicles weighing 10,000 lbs or less. Although a small proportion of the 32,000 or so people killed on US roads annually, it's still a huge concern for the agency, which is introducing a new regulation to help tackle the issue resulting from the Cameron Gulbransen Kids Transportation Safety Act of 2007.

The intention is to expand the field-of-view for all passenger cars, pickup trucks, minivans, buses and low-speed vehicles with a gross vehicle weight rating of up to 10,000 lbs so that drivers can see directly behind the vehicle when the vehicle's transmission is in reverse.

NHTSA believes the best way to meet the proposed standards will be rear-mounted cameras and in-vehicle displays, which prompted resistance on the part of some OEMs who were concerned the hardware necessary could add hundreds of dollars to vehicle cost. Industry insiders believe this could be around US$159-US$203 per car for those without a pre-existing satnav screen or US$53-US$88 for cars with a screen. NHTSA estimates the new regulations will cost the auto industry between US$1.9 and US$2.7 billion annually once they kick in, far outstripping the costs associated with lives saved by the law based on NHTSA's own cost-benefit analysis standards (US$6.1 million per life saved).

In March 2011, a hearing was held to provide an opportunity for safety advocates, victims, industry groups and other interested parties to voice their opinions on the back-over problem directly to NHTSA's David Strickland, who feels mandatory backup cameras "may change the face of safety around the world".

Gentex's RCD mirror uses a liquid crystal display that works with a video camera mounted at the rear of the vehicle

"Backovers impact two segments of the population: children and the elderly," he said. Around 100 of the nearly 300 fatalities in backup crashes each year involve children aged five or younger. One-third of the deaths involve people 70 and older.

Eventually the plan is to get automakers to have 10% of vehicles with rearview cameras by 2012, approximately 40% by 2013 and 100% of new vehicles by 2014. Several OEMs are ahead of the game and are offering rearview systems already, some such as Nissan (on its 2011 X-Trail) and Lexus (on the CT 200h hybrid) incorporated into the rearview mirror.

In both of the above cases, the Rear Camera Display (RCD) Mirrors are supplied by Gentex, which senior vice president, Enoch Jen, says is an easily adaptable method to display the output of a rear camera, which satisfies NHTSA's preliminary interpretation. ‹

Mirror image

Gentex feels it's resolved the issue of where to locate a rear camera display in-vehicle by incorporating it in the rearview mirror. "It's a logical, intuitive and ergonomic location for drivers," suggests senior vice president Enoch Jen. "Where else but the rearview mirror would you expect to find information about what's behind you?"

Other displays, such as satnav screens, are well suited to deliver vehicle infotainment, diagnostic and operational information. The rearview mirror, though, allows OEMs to locate rear visibility and driver safety information exactly where the driver expects to find it. They also avoid the costs associated with integrating an RCD in other areas of the vehicle.

The system comprises a high-resolution LCD that works with a video camera to provide a view of the blind zone directly behind the vehicle. The display appears through the auto-dimming mirror's reflective surface, made possible by utilising Gentex's 'transflective' coating and lighting techniques, and the display only appears when the vehicle is shifted into reverse. Other ADAS functionality can also be displayed, such as alerts for tyre pressure, lane departure, traffic sign recognition, as well as vehicle and pedestrian detection.

Following a collaboration between West Nexco and Nissan, a wrong-way alert system has been developed. Using GPS data, it offers information about road and traffic conditions, as well as wrong-way driving alerts. The system will be deployed in the navigation systems of Nissan's Fuga Hybrid.

Toyota Motor Corporation has created the post of chief safety technology officer (CSTO) and appointed Moritaka Yoshida to the role. The post has been designed to help coordinate Toyota's safety technologies and will speed up decision-making and communication in the vehicle safety technology development arena.

A new system that combine Adaptive Cruise Control with braking and collision mitigation technologies has hit the North American market. Bendix Commercial Systems recently launched its Wingman Advanced collision mitigation technology. A radar sensor on the front of the vehicle is used to provide both warnings and active interventions in a bid to help avoid rear-end collisions. When the ACC with braking feature is in use, the system intervenes to help drivers maintain a safe following distance by reducing throttle, engaging the engine retarder or applying the brakes. The collision mitigation feature alerts the driver and applies the brakes when the system senses a rear-end collision is imminent.

A 32-bit MCU family designed to make ADAS more affordable has been launched by Freescale. The Qorivva microcontroller range has been designed to help reduce the need for additional external signal processing components. It offers high throughput, a dual-core architecture and high-density on-chip memory.

DECADE OF ACTION FOR ROAD SAFETY 2011-2020

Seven-time Formula 1 World Champion, Michael Schumacher supporting the Decade of Action for Road Safety

Seven-time Formula 1 World Champion, Michael Schumacher, and the President of the European Parliament, **Jerzy Buzek**, will be the key speakers at an event organised by the eSafety Challenge project (funded by the European Commission, eSafetyAware, FIA, and the FIA Foundation) in the **European Parliament in Strasbourg on 11th May 2011** to mark the launch of the UN Decade of Action for Road Safety. eSafety Challenge will support the Decade of Action's pillar on Safer Vehicles. Those interested in attending the event on 11th May can register by sending a mail to info@esafetyaware.eu.

Formula One World Champion Sebastian Vettel to join the eSafety Challenge 2011 in Vienna

The eSafety Challenge is an annual event that promotes and highlights the life-saving potential of advanced vehicle safety technologies. In its continuous efforts for eSafety deployment, the third edition of the eSafety Challenge will take place at the **ÖAMTC Safe Driving Centre Teesdorf, close to Vienna, on 30 & 31 May 2011.**

An array of activities is being prepared to show delegates the potential of eSafety systems to save lives on the roads. A point of attraction will be again the technology demonstrations opened by celebrity drivers, including **Formula 1-Champion Sebastian Vettel, 8-time 24h Le Mans Winner Tom Kristensen,** and racing driver **Alexander Wurz**.

To register, visit: www.eSafetyChallenge.eu/registration

www.eSafetyChallenge.eu

FIA Foundation for the Automobile and Society

Life in the balance

With motorcyclists disproportionately represented among fatalities, moves are afoot to apply some of the ADAS innovations used in the automotive world for use on powered two-wheelers in a bid to reverse the trend

AUTHOR SAUL WORDSWORTH
IMAGES COURTESY OF BMW, HONDA, ROSA & SAFERIDER

Between 2003 and 2009, the number of drivers killed on Europe's roads fell by 25%. During that same period, motorcycle fatalities rose by a shocking 18%. Similarly, while all OECD members bar one witnessed falls of between 17 and 55% in road fatalities from 2000 to 2009, half saw motorbike fatalities rise during the same period. PTWs may equate to only 1% of vehicles, but they account for 20% of road deaths.

"Motorcyclists have traditionally been ignored in debates on safety," says Aline Delhaye, general secretary of the Federation of European Motorcyclists' Associations (FEMA). "It is not on purpose; they're easy to forget. Almost everyone is a car driver. With no political focus, everything was blocked, unimportant, not a priority. Recently, however, the political focus has shifted towards the safety of powered two-wheelers. Now that the doors have opened, everything is easier."

Before considering ways in which motorcycle safety can be enhanced, it's perhaps wise to examine the most far-reaching European PTW research project to date. "Without much precedent we had a fairly broad objective," suggests Tim Edwards, senior engineer of advanced technologies at research body MIRA, one of the key partners in the SAFERIDER project. "By looking at technologies already in existence

A BMW 7 Series car and BMW K 1300 S motorcycle have been fitted with innovative V2V communications technology

in the automotive domain, we analysed what could work for PTWs."

SAFERIDER was an EU-sponsored consortium project that ran from 2007 until December 2010. Its uniqueness lay in its blend of participants, from users (FEMA) and the motorcycle industry (Yamaha, Piaggio), to subsystems suppliers and academia. "Fitting automotive safety solutions onto a PTW is a major challenge," Edwards reveals. "A bike also has dynamic movement; it pitches and rolls around every corner and bend. This means if you install radars or video cameras, all of the data must be adjusted to account for the movement of the bike before you can use it. Not only is there a sensing challenge in monitoring the bike accurately, there's also a computing challenge in processing the data via a Human Machine Interface (HMI)."

SAFERIDER featured the use of three simulators for early HMI evaluation, plus eight trial bikes that were constructed and ridden around Europe. As part of the process, ADAS was renamed ARAS (Advanced Rider Assistance Systems) and charged with finding five different solutions – frontal collision warning, speed limit warning, curve warning, intersection support and lane-change support. Meanwhile, IBIS was rebranded OBIS (On-Bike Information Systems) and tackled navigation and route guidance, weather and traffic information, black-spot warning, telediagnostic services and eCall. HMI elements such as a vibrating seat, smart helmet, feedback throttle plus haptic (i.e. vibrating) handle and glove were among the solutions used to relay information to the rider.

Two of the most important ARAS trial solutions were the curve warning and intersection support. The former compared the actual rider manoeuvre with a safe reference manoeuvre. If the rider doesn't follow the calculated deceleration plan, a two-level warning is generated and relayed to the HMI manager in order to alert the rider.

For intersection support (IS), Edwards picks up the story: "Accident statistics show they're one of the most dangerous places for PTWs, especially when there is a non-visible hazard. IS aims to warn the rider against possible collisions with fixed or moving obstacles at intersections and has been fully tested on a riding simulator by reproducing a number of the cases defined using haptics and other HMI. Although some parts of this solution were beyond our technological capabilities, my feeling is that with V2V and V2Infra technology (see *Honda speaks* sidebar), there's nothing stopping the next rider research programme looking at intersection safety for PTWs."

One of the main OBIS solutions trialled as part of SAFERIDER was eCall. Already a well-known automotive solution, to date eCall has not been incorporated into PTWs. On the prototypes, a measurement sensor was embedded under the seat of the bike (and in some cases within the helmet) to detect the impact of a crash and trigger an automatic emergency call through the pairing of mobile device and GPS navigation system.

The navigation unit itself was devised specifically for the riding task and integrates information about possible hazardous weather, potential traffic jams and accident black spots.

Hope in helmets

First developed back in 2005 but having recently passed the European ECE-ONU 22-05 homologation standard for road use, the Reevu rearview helmet allows wearers to clearly see what is behind them without having to turn their head. Already fairly popular across Europe, the UK-designed helmet uses a set of bullet-proof coated optics and is the culmination of 10 years of privately funded research. Its current retail price is €285.

Meanwhile, a €227 brain-cooling helmet called ThermaHelm developed in the UK at Sussex University's Innovation Centre is already making its mark. Head injuries occur in 80% of all motorcyclist fatalities. A key factor in these injuries is the brain swelling inside the helmet and the response time to address it. A standard motorcycle helmet is the perfect energy absorber but also acts like an oven to an already hot head, causing post-accident brain temperatures to potentially reach fatal levels. To survive, rapid treatment is required and ThermaHelm's system instantly cools the head on impact, limiting neurological damage and increasing chances of recovery.

Reevu's helmet allows riders to maintain awareness of traffic conditions behind them in the same way as a car's rearview mirror

ThermaHelm's ThermaPak system instantly cools the head on impact, limiting neurological damage and increasing your chances of recovery

Research results

"Some of the systems we worked on could soon be developed individually by OEMs and Tier 1s," states Edwards. "A speed-limit warning system would integrate neatly into an aftermarket satnav and is potentially quite close to market. The same is true of a bike-specific satnav as well as possible helmet sensors for eCall, as they could both exist as standalone products. We like to think the technologies developed in SAFERIDER could be used in the future, though we don't think it's solved the problem by any stretch."

Others are of the opinion that this technology has a long way to go before it's ready to use. "In my opinion, the majority of products that came out of SAFERIDER are not at all ready," says FEMA's Delhaye. "Before these products go to market, much more research is required. Often the ideas for ITS come from the auto industry – people think it's a good idea and try to develop it. But we're lacking knowledge about what the motorcyclist needs in terms of assistive systems. We know little about PTW accidents and what exactly the motorcyclists are doing when they're trying to avoid them. A lot of research is based on statistics, but the in-depth data on PTW accidents is limited. Mobility patterns and safety issues vary from region to region. Of course, it is great that any solutions are being worked on as we are far behind in that regard, but we need a lot of extra research and more importantly to know where and why an accident happens."

Aki Lumiaho is chief consultant at Ramboll Finland for the Infrastructure and Transport Business Division, and is a leading light in PTW safety. He, too, feels that not all automotive ADAS systems transfer to a PTW environment. "It is a question of riding dynamics and vehicle characteristics," he says. "Some systems simply do not fit to PTWs. Collision avoidance, for example, may have automatic actions on speed, acceleration, brakes and engine revs, which would have an immense impact on riding stability. However, the likes of adaptive cruise control, blind spot monitoring, collision warning, black-spot warning, remote service and maintenance and incident warning are all highly adaptable and could make for a more informed and safer rider with less stress and distraction."

SAFERIDER studied the potential of ADAS/IVIS integration on motorcycles for riders' comfort and safety

Legislation

In July 2010, the EC unveiled its Road Safety Action Plan. Aside from its latest target of halving road deaths by 2020, it included a new focus on motorcyclists through "encouraging research and technical developments aimed at increasing PTW's safety and reducing the consequences of accidents, such as standards for personal protective equipment, airbags, the use of relevant ITS applications (e.g. eCall) and progressive installation of advanced braking systems".

The EC also proposed to extend PTWs' existing EU legislation concerning Periodical Technical Inspections (PTIs) and to better adapt road infrastructure. More recently, the EU announced plans to make ABS for PTWs above 125cc compulsory from 2017 and the Bill is currently going through European parliament.

A triggering algorithm enables D-Air to operate without any physical connection to the motorcycle

Protect and serve

The concept of a PTW airbag was demonstrated as part of Piaggio's Safety in Motion scheme (2006-2009), both on-vehicle and as an inflatable wearable device. The former was developed by Dalphimetal (now part of TRW). Italian supplier Dainese has spent a number of years developing a jacket called Intelligent Protection System – or D-Air.

"We are working on both a racing and street solution," says Alessandro Bellati, principal D-Air technician at Dainese. "The racing version inflates to prevent typical racing injuries – collar bone and shoulder, etc. D-Air Street focuses more on road user vulnerabilities such as the thorax, back and neck. We are at the homologation phase for both and close to market."

The extra material and electronics add 650g to the D-Air Racing jacket – and up to 1kg for the Street version (to protect a larger area) – yet it could still be lighter than a standard leather riding jacket, which can vary in weight from 3-5kg.

"FEMA is not in favour of anything being mandatory as we don't believe the technology element is the key priority," Delhaye says. "Unproven and expensive measures such as ABS add to cost and the technology still needs improving. That is not to say we do not believe ABS is a good system – it is, but it should remain the choice of the rider. Overall, too much of the Commission's plan is based on vehicle technology. For instance there is no proven link between accidents and PTIs. Human behaviour is the main issue. We need to address this through training, awareness, attitudes and infrastructure. If you want to improve PTW safety, you need to add elements of PTW into the car driving curriculum. When you look at in-depth accident analysis, technical elements are a small part of the problem. In 66% of PTW fatalities, the other vehicle is responsible."

Human behaviour

One project that seeks to look beyond the bike and more at rider psychology is 2BESAFE. Engaging 29 partners across 14 mainly European countries, it is targeting behavioural and ergonomic investigations to develop measures for enhancing safety based on research into crash causes and human errors.

"2BESAFE is the first large-scale PTW study designed to analyse rider behaviour at both a motor and cognitive level," says Stephane Espie, senior researcher at INRETS, a leading French transport research body, and scientific coordinator for 2BESAFE. "The core of the project is an in-depth study of rider behaviour. In order to design countermeasures for PTW safety, we first require knowledge based on scientific evidence."

This innovative programme is designed to examine PTW riders' perception and acceptance of risk, to complete in-depth research on factors underlying driver failure to see PTWs and their riders, to develop recommendations for safety countermeasures and to realise the world's first naturalistic riding study involving instrumented PTWs.

"We have motorbikes in four European countries that are used in everyday life," Espie says. "We are currently collecting and collating the data. For in-depth analysis using self-confrontation techniques, I have a concurrent project in France in which we use more in-depth interview techniques to let the rider express the

Honda speaks

Honda's Dave Hancock talks about the company's ongoing commitment to improving PTW safety standards

"BY MOVING THE INSTRUMENT PANEL FURTHER UP, THE RIDER ONLY HAS TO MOVE HIS EYES AND NOT HIS HEAD"

Would you say Honda is at the forefront of PTW safety?
Very much so. In 2006, Honda publicly stated it would sign up to the European Road Safety Charter requiring all motorbikes above 250cc to offer ABS. This we achieved. In 2008, we were the world's first PTW manufacturer to develop an Electronically Controlled Combined ABS. This was introduced specifically for sports bikes. They tend to have a shorter wheelbase and on braking have a tendency to pitch. The public was initially very sceptical as they feared it would take away rider feel and input, but within six months the general consensus was 'Why buy a sports bike without it? You don't even know it's on the bike until you need it'. In addition, the Honda Goldwing was the first PTW to include an airbag.

I believe Honda is big on improving visibility?
Yes, we continue to research in the field of conspicuity. All too often, an incident occurs because another vehicle misjudges the distance and speed of a PTW. Our research has shown that this is improved if the front of the bike looks more like a human face. If you see normal headlights, they tend to be concentrated in one area. On some of our more recent bikes, such as the VSR1200, the front lights are arranged in a type of cross-shape, spread out across the front of the bike, and with more of them. This gives great visibility, which helps other road users to judge the speed. Even using seven LEDs instead of five makes a big difference.

What other safety features is Honda currently working on?
We are investigating other areas of a bike where an airbag could be fitted. The legs are vulnerable targets. Would it be possible to equip airbag technology to protect a rider's legs? The challenge is working the dimensions without compromising other areas of the vehicle.

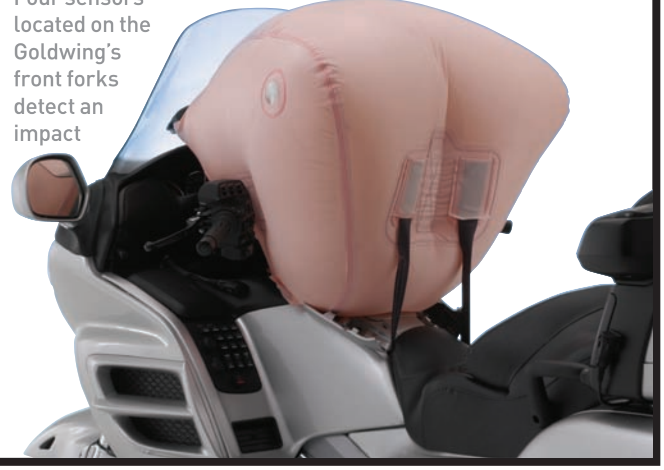
Honda is one of the only PTW manufacturers to be involved in the research and development of car-to-car systems. This will enable cars and bikes to communicate and flag up potential hazards, for instance at cross-sections, which can be so dangerous for PTWs.

We have also raised the instrument panel on the newly launched Crossrunner. Traditionally, the panel requires the rider to put their head down then up again, which means taking their eyes off the road momentarily. Just by moving the whole instrument panel further up, the rider only has to move his eyes and not his head.

Finally, where traditionally on the left handlebar the horn is on the bottom and the indicators on the top, we have switched them around on the VFR1200 and will look to integrate this into future models. Based on our research, we found this to be a more natural design, especially since the thumb rests next to the indicators, which are used more frequently than the horn. Once riders understand the psychology, they quickly get used to the change.

What are the specific challenges regarding PTW safety?
In the UK, the two main challenges are the poor public perception of motorbike riders, and the behaviour of the bikers themselves. In mainland Europe, PTWs are embedded into the culture. People don't look at them and say 'They're dangerous and unsafe'. In the UK, people who don't ride believe that bikes are dangerous. The challenge is to overcome this misconception.

Rider behaviour is the other challenge. Although the majority of riders are sensible, there are some in the UK that have a propensity towards risk-taking. For themselves, other road users and the general public this is the great challenge.



Four sensors located on the Goldwing's front forks detect an impact

(Above) Norway's Vision Zero road for riders
(Left) The *Good Practices Handbook* has been published as a result of the ROSA Project

motives that underlie their decision making. Technology is vital for safety – ABS may assist in up to 20% of accidents – but so does rider psychology, driver attitudes and road infrastructure."

Tailored infrastructure

"All too often when it comes to safety infrastructure, motorcyclists are ignored," Delhaye believes. "Motorway guardrails are not tested to factor in cyclists who can slide and hit them, and roads rarely take account of how paint on the road is slippery when wet."

If Delhaye – or indeed the European Commission – wanted an example of the benefits of tailored infrastructure, they need look no further than Norway. Back in 2006, the Norwegian Road Authority selected the scenic and twisty Highway 32 near the city of Skien as the world's first road-safety audit focusing on motorcycles. Despite its popularity among riders, it was also one of the 10 most dangerous routes in the country. Previously littered with rocks, lighting columns and siding posts on the outer curves, all were removed and where necessary re-established on the inner curves. Sub-rails were installed below ordinary guard rails, thereby protecting the motorist from a collision with the posts behind them. The remoulded nine-mile section of road, which was developed with feedback from local riders, was officially opened in 2008. "We have not had a single fatality on this stretch since its alteration," says Jan Petter Lyng, one of the original engineers on the scheme. "The feedback from riders is that they are very happy with it. It has been so successful that we are about to launch a similar project on nearby Highway 36."

Final thoughts

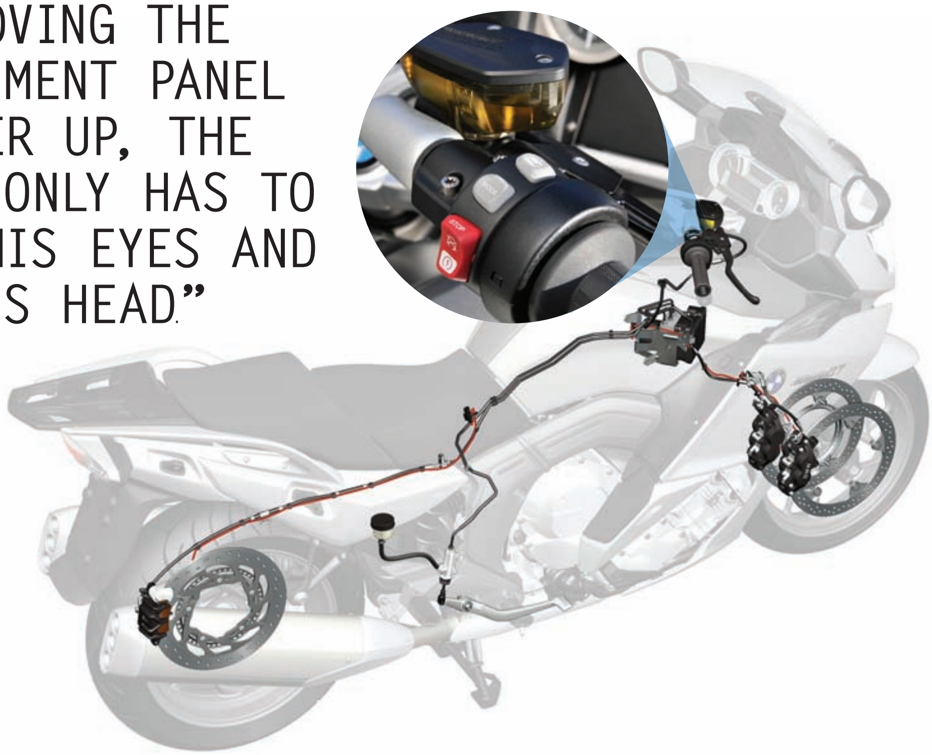
SAFERIDER may be the largest and most high-profile EU-sponsored PTW safety project of recent years, but it is by no means the only one. Coordinated by Italy's Piaggio, Safety in Motion (SIM) ran to November 2009 and had similar objectives to SAFERIDER. ROSA (ROad SAfety for motorcyclists), meanwhile, was devised to reduce European PTW fatality rates via the creation and dissemination of a handbook of best practices for PTW safety.

Alongside such projects, many commercially available bikes already feature an array of highly advanced safety features (see *Honda speaks* sidebar). For instance, BMW Motorrad today offers ABS as an option on all of its bikes, something no other manufacturer does. In addition, some models present switchable power modes that allow the rider to adapt the machine to the weather conditions and reduce the chance of losing traction, plus Adaptive Headlights complete with a gyro-stabilised dipped beam that remains horizontal at all times. In the near future, the German giant will launch its own vehicle-to-vehicle communications technology to assist with warnings regarding bad weather, obstacles, an emergency vehicle approaching, or a braking manoeuvre by a vehicle ahead. BMW is just one of a number of OEMs that is releasing such systems, alongside an increasing array of standalone products currently being brought to market (see *Hope in helmets* and *Protect and serve* sidebars).

"There is a lot taking place, both commercially and in the field of research," Delhaye says. "Not everything is perfect but we are definitely on the right track. We need to look at what accidents are made of, which is being done but it takes time. Still, we are far better placed now than in the past. For the first time, every part of the industry is truly talking about the issues."

"Not all makes and models are targeting safety improvements," concludes Ramboll's Lumiaho. "For years ahead there will be some designed purely for pleasure and excitement. I myself am not sure whether Vision Zero is achievable with PTWs, mainly as a result of their unique riding dynamics. However, in five years' time we will be further along than we were five years ago." ‹

"BY MOVING THE INSTRUMENT PANEL FURTHER UP, THE RIDER ONLY HAS TO MOVE HIS EYES AND NOT HIS HEAD"



BMW's power switch mode softens power delivery and, when in rain mode, reduces overall output, allowing riders to adapt the bike to the weather, which reduces the chance of losing traction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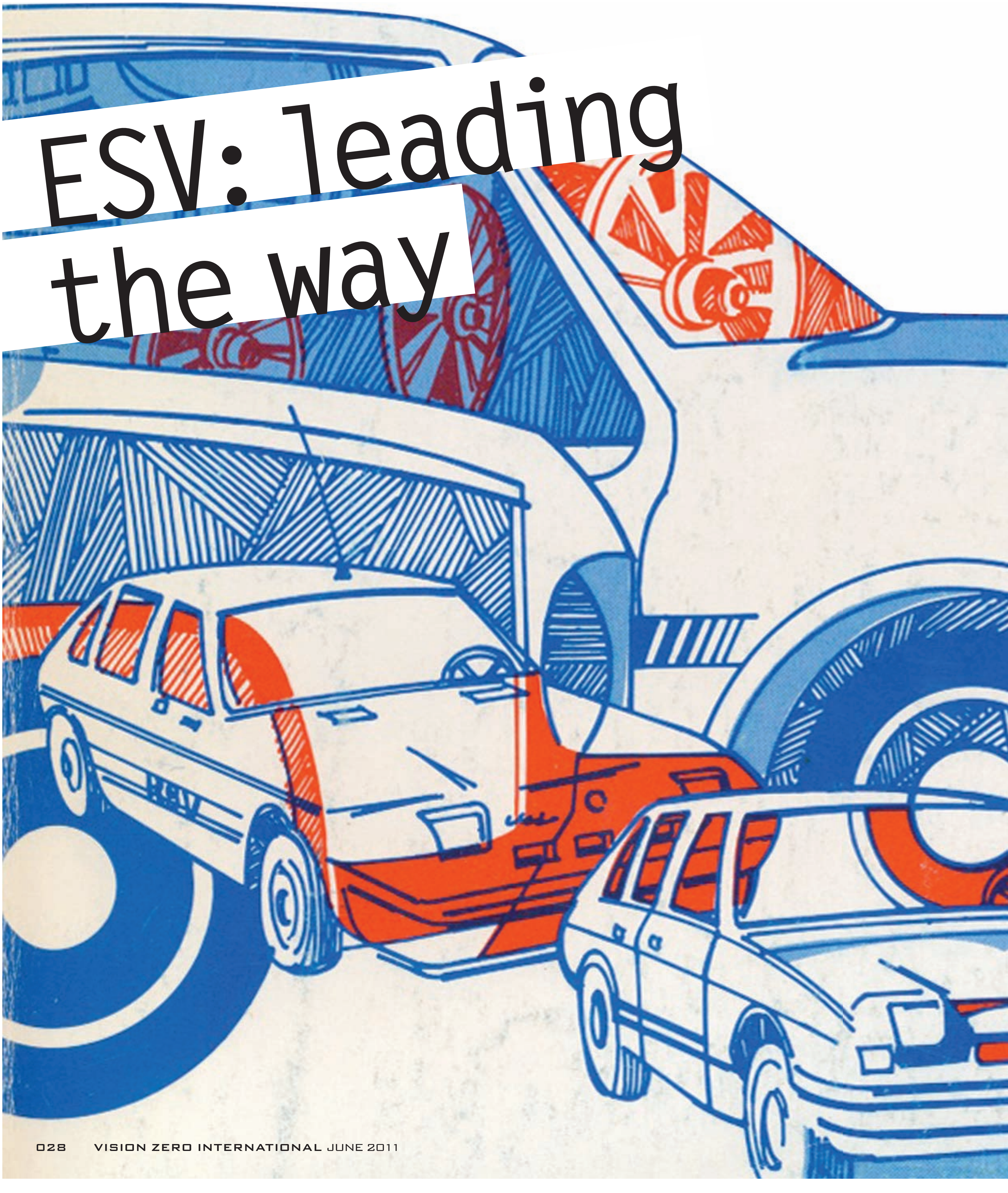
ESV: leading the way



The ESV proceedings have traditionally been published in large, bound volumes and are a vital reference of auto safety developments

Vision Zero's resident auto safety expert reflects on the history of the ESV Conferences and their innovations leading to safer vehicles

AUTHOR BYRON BLOCH, AUTO SAFETY EXPERT, USA **IMAGES** COURTESY OF CANDICE BLOCH

The International Technical Conferences on the Enhanced Safety of Vehicles, or simply the ESV Conferences, have become the preeminent vehicle safety research conferences in the world. Held typically every two years, they enable safety professionals, OEMs and government officials to present the latest results of their ongoing efforts towards safer vehicles. And they're often catalysts for advances that go from innovation and experiment to development, testing, prototype and ultimately into production.

The ESV proceedings (published initially as large reference books and more recently on DVD) document the amazing potential of improving vehicle safety, and are full of technologies, tests and assessments that show in detail what we could do towards developing increasingly safer cars, motorcycles, heavy trucks and buses.

Saving lives for 40 years

When launched, ESV originally stood for Experimental Safety Vehicle as the initial focus was to encourage automakers to develop advanced-design technical vehicles to demonstrate what could be done. A name change in 1991 to Enhanced Safety of Vehicles better reflected a more expansive spectrum on the many ways that all vehicles could be improved or enhanced, from accident prevention to crashworthiness.

Participants at the first conference held in France in 1971 included individuals from Germany, Australia, Belgium, France, Italy, Japan, the Netherlands, Sweden, the UK and the USA. Among the highlights was a discussion of the performance requirements for 4,000 lb ESVs.

The initial ESV designs demonstrated crashworthiness survivability in car-to-car front and rear crashes at 75mph, side impacts at 30-40mph (with intrusion limits of 3-4in), and rollovers at 60-70mph (with an intrusion limit of 3in). All in all, the first ESV was off to an ambitious start!

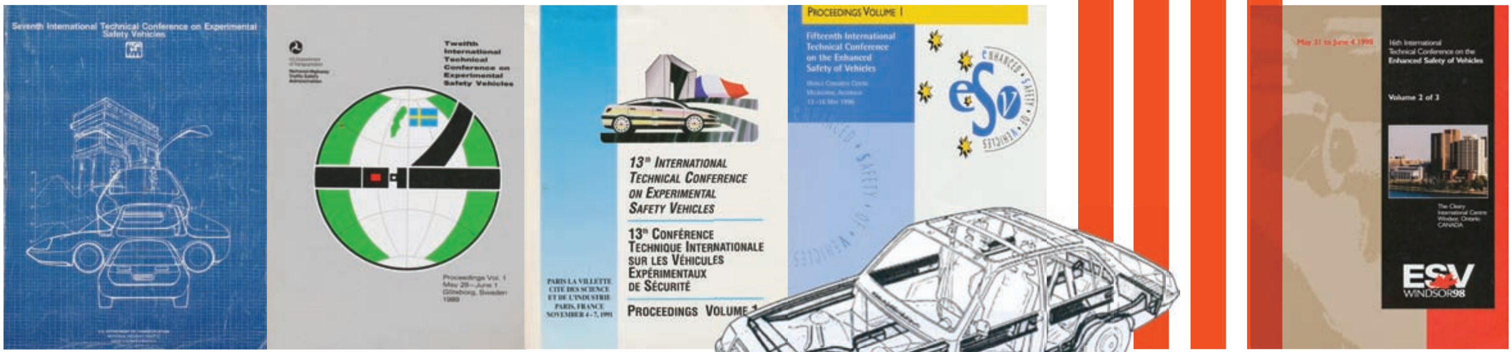
> "THE ESV CONFERENCES ARE OFTEN CATALYSTS FOR SAFETY ADVANCES IN VEHICLES"

The second conference was held later that same year in Germany. Participation swelled and technical presentations were made by automakers and government agencies from nations all over. In addition to progress with 4,000 lb ESVs, there were now reports on developments of smaller, lighter four-door sedans weighing 2,500 lb or less. Smaller ESVs were in development by Toyota, Nissan, Honda, Fiat, VW and Peugeot. Evolving principles included frontal crush zones, survival space maintenance, inclusion of airbags and rollover testing.

The third event was held in Washington, DC in 1972 in conjunction with TRANSPO '72 – a major display of ESVs and technology at Dulles International Airport. Presentations included crash tests of early ESVs, plus seatbelts that automatically fastened around you when you entered the car. In the 3,200 lb category, VW showed its ESVW while Volvo described roof strength tests of an inverted vehicle drop from eight feet and a rollover test at 70mph.

At the Fourth ESV Conference in 1973 (Japan), ESV cars of smaller sizes and weights were demonstrated by Nissan, VW and British-Leyland, as well as larger ESVs by GM and Ford. Development and testing of sophisticated vehicle body designs showed how frontal crush zones enabled safer ride-down deceleration, and how interconnected structural members helped maintain the survival space in frontal and side impacts.

Automakers worldwide presented the design details of their safety



vehicles at the fifth instalment held in London in 1974, often based on modifying a production car. The Renault BRV, Opel OSV, Volkswagen ESVW II, British-Leyland Safety Cars from mini to saloon, Toyota ESV, Nissan ESV and Ford UK ESV were all presented. Other highlights included the GM-NHTSA development of the GM-ATD 502 biofidelic test dummy, and development and testing of GM's Air Cushion Restraint System.

Back to Washington, DC in 1976, topics at the Sixth ESV Conference expanded, including accident analysis, accident avoidance (handling, braking, vision), biomechanics and pedestrian protection. Vehicle weight-reduction techniques, airbags and automatic seatbelts were also explored, while the Calspan-Chrysler Research Safety Vehicle (RSV) and Volvo ESV were presented. The gap between ESV innovations and production vehicles was clearly closing.

Highlights at the Eighth ESV Conference held in Wolfsburg in 1980 included refinements to airbag systems, automatic seatbelts, biofidelic dummies, side-impact protection and pedestrian protection mechanics. Safety car progress was shown by the testing of the Minicars RSV and the Calspan-Chrysler RSV.

The US NCAP (New Car Assessment Programme) reported its first results at the Ninth ESV Conference back in Kyoto in 1982, with presentations made about how to communicate a vehicle's crashworthiness to the public.

There was renewed emphasis surrounding motor vehicle safety for children and the elderly at the Twelfth ESV Conference held in 1989 in Sweden. Accident investigations focused on the precise mechanisms of injury, while there were also presentations on the need for international harmonisation.

The Calspan-Chrysler RSV (left) and (above) Opel's OSV

Lucky for some

The 13th ESV Conference was held in Paris in 1991 – the 20th anniversary of ESV. Major topics included safety improvements from advanced vehicle/highway technology, crash avoidance, side-impact protection and rollover injury analysis. Crash simulations, the upgrading of airbag performance and heavy truck safety were also examined.

I presented three papers at the 16th ESV Conference, held in 1998 in Ontario: *Improved Crashworthy Designs for Truck Underride Guards*, *Advanced Designs for Side Impact and Rollover Protection*, and *The Coming Revolution in Airbag Technology*. It was good to meet with other auto safety professionals from all around the world, and concur that we could all do so much more to advance vehicle safety.

40 years of International ESV Conferences

1st ESV – January 1971	Paris, France
2nd ESV – October 1971	Sindelfingen, Germany
3rd ESV – May 1972	Washington, DC, USA
4th ESV – March 1973	Kyoto, Japan
5th ESV – June 1974	London, England
6th ESV – October 1976	Washington, DC, USA
7th ESV – June 1979	Paris, France
8th ESV – October 1980	Wolfsburg, Germany
9th ESV – November 1982	Kyoto, Japan
10th ESV – July 1985	Oxford, England
11th ESV – May 1987	Washington, DC, USA
12th ESV – May 1989	Goteborg, Sweden
13th ESV – November 1991	Paris, France
14th ESV – May 1994	Munich, Germany
15th ESV – May 1996	Melbourne, Australia
16th ESV – May 1998	Windsor, Ontario, Canada
17th ESV – June 2001	Amsterdam, the Netherlands
18th ESV – May 2003	Nagoya, Japan
19th ESV – June 2005	Washington, DC, USA
20th ESV – June 2007	Lyon, France
21st ESV – June 2009	Stuttgart, Germany
22nd ESV – June 2011	Washington, DC, USA

And now onto 2011… We're at the threshold of the 22nd ESV Conference, to be held in Washington, DC, from 13-16 June 2011. More than 1,000 attendees are expected from all over the world, representing automakers, Tier 1 suppliers, government officials and safety professionals. As the predominant forum for the advance of vehicle safety and the vast wealth of emerging information, the ESV Conferences are highly beneficial for all nations and vehicle-makers. But it's time for countries with high traffic death tolls – such as China, India, Russia, Brazil, etc – to join in and actively participate.

Motor vehicles continue to be a vital and integrated transportation and socio-economic component in all nations. But with the terrible worldwide toll of 1.3 million fatalities every year in vehicle accidents, plus millions of debilitating injuries, renewed efforts must be made to enable the rapid transfer of safety knowledge into the vehicles and roads so as to prevent the continuing carnage. If you are reading this article, you are likely involved somewhere in that worthwhile process of enabling safer vehicles. I hope you join us in working towards the goal of attaining Vision Zero – the compassionate vision of zero fatalities in vehicle-related accidents. ❮

• Byron Bloch has been a US auto safety expert in design and crashworthiness for about 40 years. His extensive archives include the ESV Conferences published proceedings. Log on to his website at www.autosafetyexpert.com for more details

Back to the future

As we haven't quite achieved the automated highways vision depicted in previous Futurama-type scenarios, we speak to a man who has his own idea of how roads in the future will look

AUTHOR LOUISE SMYTH **PORTRAIT PHOTOGRAPHY** COURTESY OF RAMIN RAHIMIAN

Sven Beiker has always been fascinated by automobiles, so it's perhaps fate he's ended up working at a facility whose acronym is CARS. And although the Center for Automotive Research at Stanford University is a far cry from Beiker's previous base in his home of Germany, the move to California from Munich has proved extremely worthwhile.

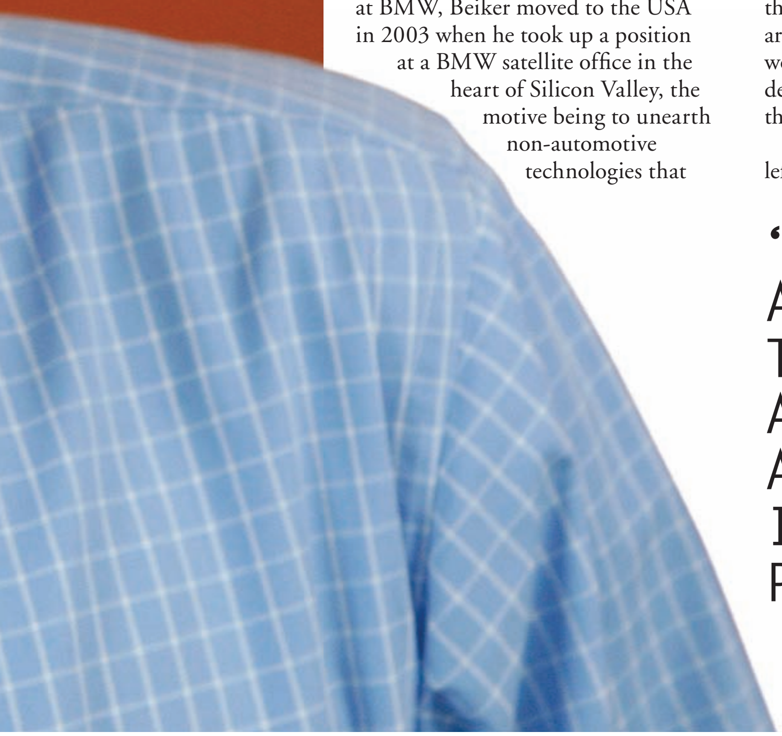
Following a history of academic and commercial work in vehicle dynamics, primarily in innovation management at BMW, Beiker moved to the USA in 2003 when he took up a position at a BMW satellite office in the heart of Silicon Valley, the motive being to unearth non-automotive technologies that could be considered for automotive use. "Working at BMW taught me about the differences between the wonderful dreams that engineers have and the reality of taking those dreams and creating products that will work and be desirable to consumers," he says.

Executive director of CARS since 2008, Beiker remains true to the idea of never allowing fantasy to get in the way of reality: "I'm responsible for operations, which means working to bridge the gap between industry and academia." Broadly speaking, this means that any research projects he sanctions are not simply pie-in-the-sky ideas that won't ever make it to the roads. His desire is to see tangible progress within the industry – and within his lifetime.

"There are still so many challenges left and I think the 21st century, which I usually call the second century of the automobile, is where we really need to address these challenges," he says. "It's not only about safety but efficiency, pollution and more. What gets me excited about the automobile is that it's a very complex and technologically advanced system, yet can be operated by pretty much everybody. It gives people such freedom in their mobility. It's not just a machine; it's intertwined with society and culture, too. The automobile has never become boring. In a way it's now reinventing itself – or being reinvented – yet you can also say that it hasn't really changed that much at all in the past 125 years. It's so many things to so many people."

Obviously a car nut, Beiker comes across as passionate about all modes of transport, however, listing his hobbies

"WHAT GETS ME EXCITED ABOUT THE AUTOMOBILE IS THAT IT'S A VERY COMPLEX AND TECHNOLOGICALLY ADVANCED SYSTEM, YET IT CAN BE OPERATED BY PRETTY MUCH EVERYBODY"



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as cross-biking ("It's beautiful here in the mountains between Stanford University and the Pacific") and also sailing. But time doesn't allow for him to be in perpetual motion, so these days he's more likely to be found at CARS working on ideas that have inspired him for years. He cites automotive heroes such as Béla Barényi (*see page 17*), who Beiker says "did so many inspiring things with crumple zones and safer vehicle structures" and Ulrich Seiffert from VW, who lectured Beiker back at the Technical University of Braunschweig. "They really got me fascinated with safety and what's possible to enhance auto safety."

Autonomy rules

Placing safety in the realms of autonomous driving has been a particular interest since Beiker helped to form CARS. "A lot of this goes back to what was happening in the early 2000s at Stanford – a great deal of work on automotive controls, autonomous driving and human factors," he explains. "The DARPA Grand and Urban Challenges got Stanford very visible, which attracted more industry interest. It wasn't long before people were saying, 'Hey, you guys should really get serious about automotive future thinking.' This was basically the starting point for what is now CARS – primarily an industry/academic partnership programme."

Beiker also took the lead to ensure everything CARS was involved with was firmly located in the bigger societal picture: "I wanted to broaden the horizon to look at the future of the automobile in terms of how ADAS, autonomous driving and automotive control theory all fit into the wider ideas of connected and efficient vehicles, and generally how we consume mobility."

So what is Beiker's future vision for the automobile? This is not a straightforward question for the 42-year-old to answer. "I am following a lot of forecasts and publications and trying to create my own scenario," he says. "I'm not quite sure how far we'll get with autonomous driving as there are so many challenges – many non-technical – but we will see more evolution in driver assistance. Functions such as lane departure warning will merge with heading control, so it's not just warning, it's interacting with the steering.

"However, it's one thing to have warning systems in-car, but to have them highly integrated with the vehicle control system so they're able to take action is a whole different story. This is connected to another point – what a consumer is willing to accept and use in their car. It goes back to innovation management: it might be a great technology in the car and great engineering work, but if consumers don't get it, they're not going to use it and we might end up with a situation where someone is less safe. If we go to market with assistance systems that are imperfect, with people arguing they're more of a distraction, there could be a huge backlash against them."

Beiker is at pains to not be seen as painting a bleak picture of the future – it's just that he's seen too many examples of great ideas not working out as predicted: "Look at contemporary driver assistance systems – ACC is a very good example. It's a great, established technology that prevents you from running into the car in front and it's been around for about 15 years – yet the market penetration is not that high. Compare that to ESC, which had a great penetration even before it was mandated. Also, all of these kinds of systems act on one level – essentially vehicle dynamics. They look at velocities – a car might be running, sliding or skidding too fast. But other systems such as lane-departure warning or lane-change assistance are all based on the absolute position on the road – and that is just a very different level. An accident essentially happens if two positions overlap – it doesn't happen just because a velocity is too high or too low. With the latest ADAS, you're dealing with these different positions and that's a very tricky problem."

Trickiness aside, Beiker is not discounting a future featuring truly autonomous vehicles, however, and says that the fact that in 95% of accidents human error is a contributing factor tells us exactly how much can be done to eliminate this problem. "It's already technically possible today to have a completely automated traffic situation, but it requires two things – a huge amount of infrastructure (V2V and V2I communications) and the transition to an entirely autonomous fleet. Even if we tackle the infrastructure issue, the second aspect is harder. It's impossible to change the whole fleet overnight, yet a mix of autonomous and non-autonomous vehicles is unlikely to work. Just hearing the stories of how people are behaving when they spot the Google

"I'M NOT QUITE SURE HOW FAR WE WILL GET WITH AUTONOMOUS DRIVING AS THERE ARE SO MANY CHALLENGES – MANY OF THEM BEING NON-TECHNICAL"

One of Beiker's automotive heroes – Daimler's great Béla Barényi

Matter of communication

"If there are two vehicles both transmitting their location, direction of travel and velocity, you can tell if an accident is apparent or not," Beiker says. "But to have this infrastructure – to instantly have a high enough penetration of vehicles in the system so you can *really* use it – is quite a step. Even before that, to deploy all the communication nodes is a big deal, and this is where we are stuck at the moment."

Beiker regards the use of DSRC as having an obvious pitfall: "The clue is in the name – it's dedicated short-range communication. It's great, but the whole problem is that it's dedicated, only for this purpose and nothing else. It therefore costs an immense amount of money and if it's used solely for V2V communications, it doesn't generate any money. In the end, are people willing to pay for the V2V infrastructure? The answer today is 'no'."

Beiker often corresponds with people involved in IntelliDrive and similar programmes, and says they are putting in a great deal of work to develop a more viable business case and to see if a dedicated frequency spectrum could be used to make money as well as save lives. He has also noted a less costly but more basic idea that could be used as part of the solution: "We could use an existing frequency spectrum, which is where GSM technology comes in. Latency and coverage is a problem, although I know some researchers are looking at some basic safety systems that could rely on mobile phones. This could be a simple warning that's generated when you're approaching a congested area. It doesn't have to be accurate down to a centimetre – all it needs to do is allow the driver time to react."

car – trying to jump out in front of it or deliberately change lanes to see if the car reacts – tells us a lot about how that mix might pan out!"

The German also raises an interesting point about autonomous vehicles needing to obey existing traffic rules at all times, which from a traffic management perspective he feels would just be a nightmare: "Just consider the four-way stop we have here in the USA. This wouldn't work in an autonomous car. The theory is that everyone has to stop at the sign, but the reality is that barely anyone comes to a full stop – they all retain marginal velocity. It might not be legal but it works. In an autonomous car, though, a 'stop' would probably be defined as at least 0.5 seconds of zero velocity in front of a stop bar. To code something into a vehicle, you need to code 'OK, you need to be standing still for at least 0.5 seconds, wait for everyone else to stop, then you can drive off'. Well, guess what: your autonomous car would sit there forever! You simply can't revolutionise the fleet quickly, which is why a lot of the R&D is being spent on the transition – what happens if we have a mix of human-driven and autonomous cars on the road."

(Above) **'Stanley' was Stanford's 2007 entry into the DARPA Urban Challenge** (Right) **The Google autonomous car**

Pedestrian issues

Beiker is also keen to emphasise that autonomous vehicles must be considered with regard to other road users too – notably pedestrians. Stanford itself is conducting considerable research in the field of pedestrian detection, partly as a spin-off of work that originated from the DARPA Challenges. "We're going beyond just recognising 'that's a pedestrian and not a light pole' at Stanford and looking into analysing pedestrian intent," he says. "What direction is the pedestrian walking in and where might they be once the vehicle gets to the same position? It's great that OEMs are picking up on this. Pedestrian detection is a valuable thing. I also admire those working in automated parking – where you can just press a button and the car finds its parking spot perfectly. Although it's not necessarily a safety function, it's that sort of application that will encourage the public interest in autonomous systems."

Engaging the public is something Beiker feels strongly about and he thinks that how the public feels about autonomous cars relates in part to cultural differences. "Here in the USA, many people expect an autonomous car already safely waiting outside their doorstep – the high profile of DARPA and the Google cars means that people expect to be able to buy an autonomous car soon," he explains. "There is also a strong consumer pull. I hear all the time that people want the machine to do everything for them so that they can do something else. In Europe, though, people are all in favour of assistance (particularly in challenging conditions), but there's more concern about automation taking over all control."

"I LIKE THE VISION ZERO PHILOSOPHY BUT ZERO IS HARD TO ACCOMPLISH. AS A TARGET IT'S A GOOD POINT, BUT HOW DO WE GET THERE?"

The defining factor in the success of autonomous cars will of course be their ability to save lives. Here, Beiker cautions that even with an all-autonomous fleet, zero accidents is out of the question, citing recent events in Japan to demonstrate that nature alone can interject. "I really like the Vision Zero philosophy but zero is very hard to accomplish. As a target it's a good point, but how do we get there? The answer lies in accident prevention – keeping the car safe in terms of stability control, warning systems, perhaps even centrally controlling the speed. But I think the vehicle completely taking over is a long shot. All existing and forthcoming driver assistance systems are truly great but they do make the vehicle an increasingly complex environment for drivers. The task of driving a car is changing: you are not controlling the distance to the car in front – you're now monitoring a system that is controlling the distance to the car in front. There are so many issues like this that tend to be non-technical, which we need to consider. But I think we're moving in the right direction, so let's get back to work and make sure we get as close as possible to zero!" ‹

Breaking convention

» The journey towards autonomous highway systems could be thwarted by non-technical issues such as legislation. The Vienna Convention – with its oft-quoted rule that 'a driver needs to be in control of his vehicle or animal at all times' – is merely one challenging hurdle to overcome. "We are just starting a new research programme called Legal Aspects of Autonomous Driving, focused on refining the legal aspects, such as what happens if something goes wrong? It's also assessing and devising policies and advocating them to governments, as well as looking at how we can prepare the public and the traffic rules for autonomous vehicles."

Beiker says that part of the legislative problem is that an autonomous vehicle means that it is not the driver (or indeed animal) who's deciding on the path of the vehicle. "Some people will say that the driver has to be in complete control at all times – end of discussion. Others just say that the whole point of an autonomous car means this 43-year-old law is no longer valid. We need to have this discussion now. What I'm hearing from many researchers in the field is that there might end up being a huge amount of hype about autonomous driving again, yet we never bridge the gap between the research and the actual application of it. I don't want this to become a flash-in-the-pan as we can greatly reduce accidents through autonomous technologies."


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Behavioural therapy

Is there a danger that as we adapt to driving with ADAS, driver behaviour and performance may take a turn for the worse? Behavioural analysis conducted in Germany reveals some interesting findings that might be alarming

AUTHORS ANGELA MAHR & CHRISTIAN MÜLLER, DFKI, GERMANY
ILLUSTRATION COURTESY OF FLATLINER

One of the big German carmakers uses the following slogan to advertise its advanced driver assistance systems: 'It's cold, it's slippery, it doesn't matter.' The message implies a powerful system that helps the driver to overcome traditional safety concerns. Enhancing traffic safety and efficiency are the main benefits of ADAS portrayed by the automotive industry. But many researchers observe that the numerous benefits ADAS may appear to offer at first sight shouldn't prevent a closer look at the behavioural consequences that can result when a human being comes into the equation. In other words, any gains in terms of safety may be countered by an adverse effect ADAS might have on driver behaviour.

A subset of driver assistance systems – which focus mainly on the manoeuvring side of driving – ADAS are designed to support the driver with warnings and information. They provide feedback on drivers' actions and aim to reduce their workload and increase comfort. According to the Code of Practice, they must support drivers in the primary driving task, provide active support for lateral and/or longitudinal control with and without warnings, and detect and evaluate the vehicle environment. They also use complex signal processing and provide direct interaction between driver and system.

Behavioural effects

But any interactive system that provides information through warning messages potentially leads to a scenario where the driver's attention is diverted from the road, which must be taken into account when designing in-vehicle systems. In the case of systems that offer warnings about imminent hazards, for instance, those alerts can be given via different modes (vision or speech) or coding (text or symbols). This should not be viewed as a long-term behavioural consideration, though, as it represents an immediate reaction to the system rather than a side-effect of taking control of parts of the driving task.

Long-term behavioural changes

Using an ADAS over a longer period of time can result in a reduction of the driver's level of attention or encourage them to engage in some other unrelated task, such as selecting music. This is known as 'attention decrease/shift'. Due to this shift, the driver might not become aware of a sudden hazard with enough time to react adequately. If there is a sudden change between easy and difficult driving conditions, there might be a 'transition problem', meaning the driver is unable to deal with the sudden shift between cognitive underload (easy driving conditions with help from the system) to cognitive overload (difficult conditions without help from the system).

Another potentially negative effect of ADAS is that they can tempt drivers to take risks that they wouldn't necessarily take without the systems in place. The likelihood and magnitude of this risk adaptation depends on certain conditions and there are five general criteria that influence the occurrence of this phenomena. These comprise: how much the driver interacts with the system; how quick the feedback is; the degree to which the system widens the driver's scope for action; how much it increases subjective safety; and how much the system superimposes 'acting-out' tendencies.

A number of ADAS have been researched in order to rate their impact on safety. A study by M. Gründl on behalf of the University of Regensburg analysed more than 300 accidents by interviewing the drivers and technically reconstructing the incidents. The study found that automatic emergency braking systems are only slightly prone to risk adaptation effects as they are virtually unnoticable to the driver, apart from in near-crash situations, and don't play any role in normal driving. Whereas systems such as night vision and adaptive lighting have a far higher likelihood of risk adaptation. The effects of these kind of systems are permanently visible to the driver and the enhanced vision they provide offers an increased scope for driver action. For instance, drivers who used to avoid driving at night may no longer avoid it, while others may think it's safe to drive much faster than usual.

As a result of the various possible negative effects that ADAS can have on safety, there is likely to be a trade-off between risk adaptation and attention decrease/shift in the sense that if drivers take higher risks, they will not be simultaneously less attentive and vice versa. However, over-estimating the functionality or reliability of an ADAS might increase the effects of both risk adaptation and the attention decrease/shift. That means that the driver's trust in the system – even if not fully justified – might make them drive more dangerously or be less attentive.

"ADAS CAN TEMPT DRIVERS TO TAKE RISKS THEY WOULDN'T NECESSARILY TAKE WITHOUT THE SYSTEMS"

Addressing malfunction

In cases of system malfunction, the basic assumption about over-reliance is supported by signal detection theory – i.e. the relationship between a system's false alarms/missed detection and the interacting human's dependence. It has been demonstrated that an increase in false alarms decreases the driver's compliance, resulting in a longer reaction time to alerts, and in some cases the driver may even ignore those alerts.

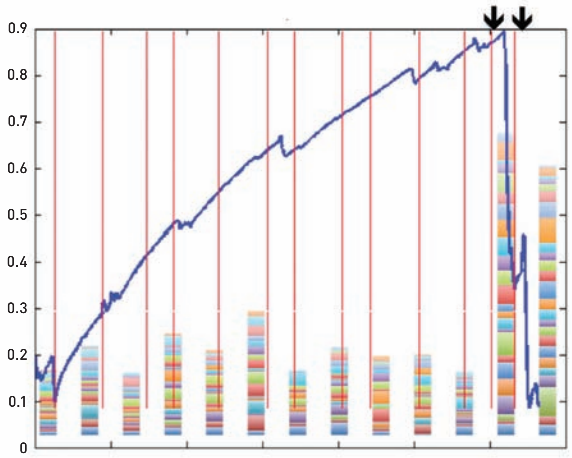
An increase in the system's miss rate, on the other hand, means the driver will become less reliant on the system and will pay more attention to traffic conditions. If only a small percentage of failures occur, drivers might start to trust the warning system excessively, resulting in them paying less attention to their surroundings or even relying on the system completely. This demonstrates the importance of reliability, which ADAS designers can improve by using threshold settings for the decision criteria, allowing them to trade false alarms against misses. Research has shown that false alarms can be more detrimental to a driver's performance than misses. A high false alarm rate also depends on the base rate of situations – i.e. whether or not the system should warn the driver. In ADAS, non-warning situations are more common than those that warn and accordingly the likelihood

A driving simulator study provided insight into how drivers react and respond to unanticipated ADAS system failures of false alarms is higher than with an equal base rate. This might lead to annoyance, distrust or even ignorance relating to valid system outputs. On the flipside, though, in certain miss situations, automation can still be beneficial, especially in a demanding multi-tasking situation. If users are aware of possible but relatively rare misses, they are more likely to stay vigilant and to successfully detect dangerous situations.

System failures

When talking about system failures, it is important to note that for humans, these failures need to be defined in a more detailed way than they do in the technical domain. There are a number of factors that can cause a failure to occur: technical factors such as when there is no warning from the system because danger is not detected; psychophysiological factors when drivers fail to notice warnings; misinterpretation factors such as when the driver confuses the nature of the warning with the situation, or misunderstands the purpose of the ADAS. Sometimes, drivers ignore warnings intentionally as a result of previous experiences. People may even be driving vehicles unequipped with the ADAS they are used to, and some drivers may choose to disable certain ADAS altogether.

It's difficult to determine the exact overall rates of system failures that



Small downward slopes in the blue temperature curve indicate stress that occurs immediately after an obstacle appeared. The two right-most drops show stress after an unexpected system failure. Red vertical lines are obstacles; arrows are unwarned of obstacles; the *x*-axis is time

a driver notices during system use. This also raises the point that a user interacting with a system will hardly ever perceive a miss rate of 0% when considering usage over a longer period of time – even if the technical miss rate was actually 0% or close to it.

Local danger alerts

Research has been carried out to examine the behavioural effects of local danger alerts in ADAS, which play an important role in improving driving safety. As well as directly monitoring the environment to detect danger, recent advances in inter-vehicle communication technology, such as wireless car-to-car communication, allow increased exchange of information between vehicles. This enables a much wider application of local danger warnings, as drivers can be alerted to approaching danger that is not yet visible. These tests focused on a scenario where drivers are warned about road obstacles that are a short distance ahead but yet not visible (e.g. a bend in the road or a vehicle ahead), and therefore require an immediate reaction. (See *Put to the test...* sidebar).

Conclusion

ADAS technology is susceptible to behavioural impacts such as attentional decrease/shift and over-reliance.
A system's reliability and sensitivity can be viewed in terms of false alarm rate and miss rate. By varying the threshold settings for the decision criterion, designers are often able to trade one against the other, as previous research has stated that false alarms could be more harmful to a user's performance than miss rate, while on the other hand a certain level of miss rate is tolerable, especially in demanding multi-tasking situations. Therefore the decision criterion for warnings should be set conservatively so users are aware of the possible (but relatively rare) miss rate and will therefore stay vigilant on the road.

It was suggested that system reliability levels of 70% to 75% represent an optimum threshold for imperfect reliability assistance. Accordingly, a 75% reliable system would be better for the use on the road than one with 99% reliability. No technical system will be 100% failure-free – especially when taking into account driver failures. Even a technically perfect system would most probably result in a critical miss rate that is only close to 0%, leading to very rare misses that are particularly dangerous. Research tends to support this, as rare misses potentially lead to severe performance decline accompanied by rising stress levels.

All in all, behavioural factors must be taken into account when setting the decision criterion of any ADAS and engineers must ensure drivers are always aware the system may fail. ‹

• *Angela Mahr is a researcher at the German Research Center for Artificial Intelligence (DFKI) in Saarbrücken. Christian Müller is the DFKI's head of automotive IUI group, Intelligent User Interfaces Department. His research focus is in the field of user-adaptive multimodal Human-Machine Interfaces*

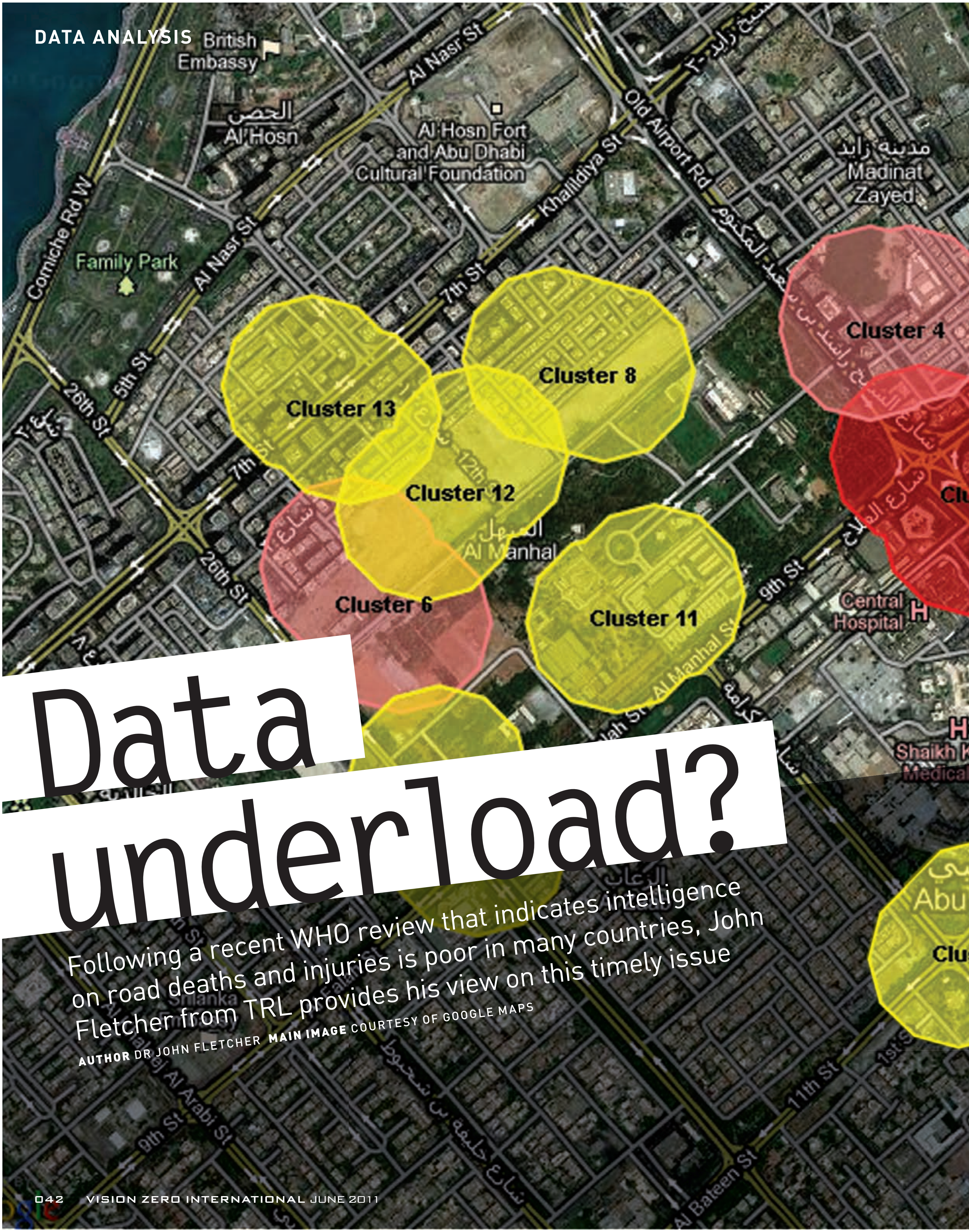
Put to the test...

» A driving simulation study was conducted on the effects of unanticipated system failures due to over-reliance on driving performance and the effect of such incidents on physiological measurements. The reaction times and stress levels of 32 drivers were compared while they encountered obstacles on a track in three different situations. First, driving without ADAS and the subject being aware of this. Secondly, with the help of a working ADAS. And finally, in a situation where an unanticipated ADAS failure occurs.

Results showed that after repeatedly experiencing local danger alerts during an hour of driving (correct alarms and some false alarms, but no misses), the subjects' driving performance was severely affected by a sudden system failure (miss). The ability to effectively react to suddenly appearing obstacles in the unanticipated failure scenario was significantly lower (no reaction or late reactions) than in the scenario where there was no ADAS at all.

A high-resolution skin temperature sensor revealed that sudden unwarned obstacles resulted in significant temperature increases after the encounter, indicating higher driver stress levels. Interestingly, quite a few drivers mentioned in the questionnaire said that they doubted their own perception rather than that of the warning system. This finding was supported by some drivers checking the warning display rather than reacting immediately to the obstacle in the miss case.

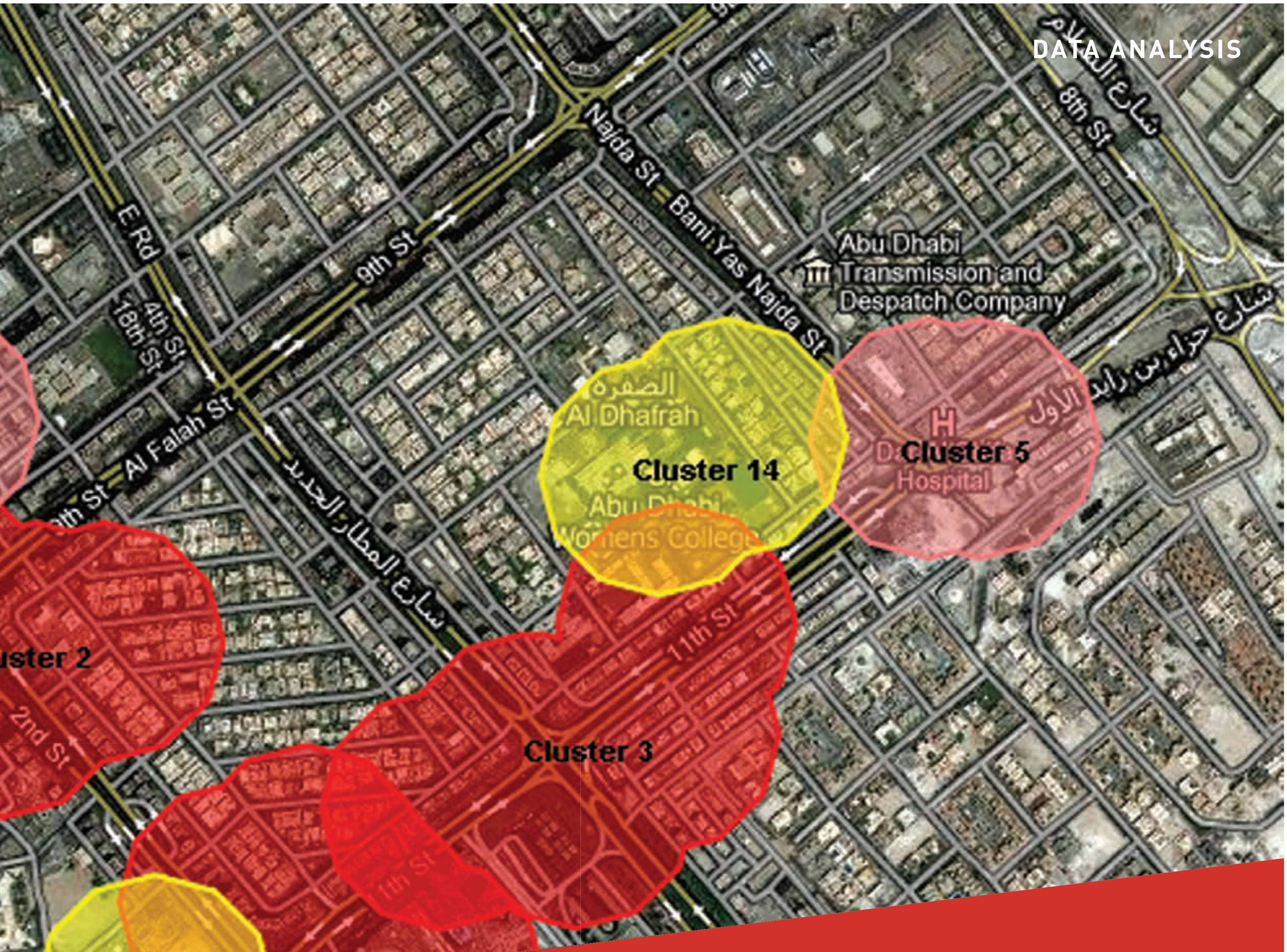
Although the results of a simulation study cannot be exactly transferred to real driving situations, they support the widely assumed behavioural effects of ADAS and can be useful in future system designs.



Data underload?

Following a recent WHO review that indicates intelligence on road deaths and injuries is poor in many countries, John Fletcher from TRL provides his view on this timely issue

AUTHOR DR JOHN FLETCHER **MAIN IMAGE** COURTESY OF GOOGLE MAPS



To successfully reduce KSIs requires accurate data collection to generate information that can be used proactively

Data from reports on individual crashes and casualties is widely acknowledged as critical to successful efforts to improve road safety. Setting up a good data collection and analysis system is recommended as one of the very first actions that a country should take to really start tackling its road safety problem – but it is a task that is extremely deficient in many countries. Data collection is often worse in poorer countries that very much need accurate information to determine the nature of their road safety problems.

The lack of good quality data, user-friendly analytical tools and analysis knowhow makes it very difficult for road safety practitioners to identify specific problems and to come up with appropriate and effective, value-for-money solutions. As well as having a direct 'local' impact, the paucity of the data on fatality numbers has also meant that the best estimate of the global death toll is fairly inexact, and almost certainly underestimates the scale of the problem. Etienne Krug clearly summarised the scale of the challenge that road safety poses in the June 2010 issue of this publication.

There is no way that the issue can in any sense be trivialised for richer countries, but the clear consensus is that road deaths and injuries are a far more pressing problem and also more difficult to treat in low- and middle-income countries (LMICs). All of the evidence indicates that, journey for journey, roads in poorer nations are far more hazardous than those in high income countries.

In high-achieving countries, data is used to set targets and to evaluate the effectiveness of national strategies, and to direct and evaluate localised measures such as engineering treatments or enforcement activities. To develop effective, evidence-based approaches to reduce the problem of road injuries, crash data is vital. In fact, if there was no data collected on road fatalities and serious injuries, there could be no Vision Zero!

The *World Status Report* (WHO, 2009) sought to compile the best available data from police or health sources on road fatality and injury numbers from member countries. The results of the survey were concerning. It was clear that in many countries, significant numbers of road deaths are not being reported in official statistics, and this problem was especially acute in (although not limited to) LMICs.

The World Bank, UN, WHO and other international stakeholders give the issue of setting up good quality crash data collection systems a very high priority, being the first or second recommended action for countries starting to seriously address road safety. The collection of quality information on collisions and casualties is inherent in the Safe Systems approach to improving safety. The Decade of Action also gives the setting up of data systems a high profile in its proposals, and the recent *WHO Good Practice Manual (2010) on Data Systems* should give the issue renewed focus.

TRL's experience with accident data

TRL has been heavily involved in efforts to improve data collection for more than three decades. As one of the first organisations to identify the significance of road fatalities and injuries as a serious development issue, TRL recognised that the problem was obscured by a lack of data.

In almost all countries, police forces collect data on road crashes reported to them, but in general this information is not usually in a format that is easy to analyse. Based on experience from a number of LMICs, TRL developed a simplified crash report form with a series of short (mostly coded) questions, adaptable for local conditions, that police could complete quickly alongside their longer case reports. The MAAP (Microcomputer Accident Analysis Package) software was developed to make computerised storage and analysis of the data more widely available to a range of personnel.

MAAP focused on improving the location information for incidents, which is particularly important to engineers and for targeting police enforcement efforts effectively. Past versions have had link-node and kilometre-marker-post systems to assign crashes to networks, and the ability to plot crashes on scanned maps. Recent versions can handle GIS mapping, which is more versatile and provides powerful ways to plot and analyse crashes spatially. MAAP has been supplied in different language versions, including Russian, Spanish, Bahasa Indonesia, Serbian, and Arabic.

Getting it right

At face value, the proposition of collecting data from crash scenes, gathering it together and getting it into a computer sounds straightforward. However, the reality is challenging. There is no such thing as a 'typical'

(Above) Accidents in LMICs are particularly challenging to data collectors (Right) iMAAP is TRL's latest tool to enhance crash data collection

It can be done...

In recent years, TRL has seen an increase in the quality of data collected by a number of its clients – notably in Mauritius, Sri Lanka, Jamaica and Botswana, among others. The greater availability of GIS digital mapping means more countries are collecting accurate map co-ordinates for crash locations, which is important to enable evaluation of engineering measures.

This is a major step forward because although it is frequently said that 'we know what works to improve road safety', the evidence comes exclusively from high-income country experience (see *Cause and affect* in the June 2010 issue of *Vision Zero*). There is an almost total lack of credible evaluation of measures from LMICs, where vehicles and behaviours can be very different. Thus reliable evaluation of engineering and other measures directly in LMICs is desperately required. We are moving to a situation where this may be easier, although under-reporting and a lack of expertise or capability of local staff remain serious issues. Technological advances are great, but we need to tackle the basics first.

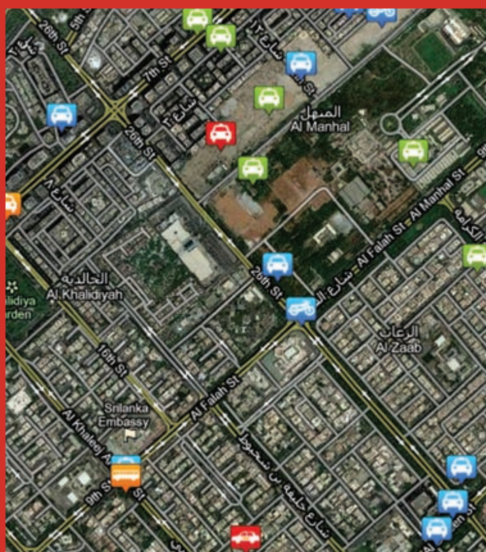


Image courtesy of Google Maps

Digital mapping is a vital tool for generating accurate map co-ordinates

project, but they generally require a broad range of IT and GIS skills, significant training of staff, as well as institutional strengthening, road safety knowledge and planning proficiency.

One of the main challenges is that clients frequently underestimate the required commitment and difficulty of collecting the basic data, which means there can be far too little planning or too few resources to develop this aspect. Often, transport/roads ministry engineers wish to access crash data to tackle dangerous locations on their networks, so it is frequently these bodies that initiate the projects. They sometimes commission projects without fully discussing with the police likely impacts on their current data collection practices, or getting agreement that additional resources will be in place to cover new or expanded associated tasks. This emphasises the need for good co-ordination between stakeholders.

Often there is a failure to take into account the additional resources required for supporting the personnel to perform data entry, or for obtaining and maintaining computers to run the system on. The logistics of training large numbers of staff in data collection and entry can also be underestimated.

The most critical undertaking remains the basic data collection task. Although the software can be set up to identify data quality problems, it is essential that accurate data is collected at the scene of the accident. MAAP has been most successful where TRL has worked closely with agencies that collect the data. Motivated local staff with a long-term commitment to ensuring the quality of data collection and entry processes also improves sustainability. There can be flexibility around the practicalities of how data is collected. For instance, in Ghana, staff from the Buildings and Roads Research Institute extract the information from written reports in police stations around the country and in Malaysia, the main toll road franchise, PLUS, collects the data directly itself.

As well as technical and logistical challenges, under-reporting of incidents is a huge problem in LMICs

Looking ahead

Recent advances in technology have presented strong opportunities for improving crash databases. The wider use of computerised databases means that linking data sources may improve the effectiveness of crash data systems. But this requires a high degree of cooperation between organisations and for the underlying data to be sound.

Web-based systems are frequently requested by clients but, although it's improving, internet access in many LMICs can still be slow and unreliable. Data can also be collected on mobile devices such as PDAs, and GPS units are a promising way to collect accurate crash co-ordinates. Yet we need to be realistic about available budgets and how effective these high-tech developments will be in the long term.

The MAAP software has undergone a complete review, specifically to take advantage of new technological developments and changing client requirements. This latest development, iMAAP, is designed to be as user-friendly as previous versions, but is web-enabled and can operate with different database platforms and GIS formats. It has more sophisticated functions for monitoring and evaluating safety measures. iMAAP can also be linked more readily to medical and other data sources in line with current best practice, and is designed to integrate directly with mobile data collection devices.

New developments in technology can clearly benefit crash database systems, but the fundamental issues of co-ordination and basic planning – particularly in LMICs – need to be addressed comprehensively to ensure these systems are successful and effective in the long term. New technologies must be implemented in practical, sustainable ways. Any moves to specifically tackle under-reporting (an issue that warrants an article of its own) are extremely important. We must get the basics right to truly benefit road safety in the long term.

"NEW DEVELOPMENTS IN TECHNOLOGY CAN CLEARLY BENEFIT CRASH DATABASE SYSTEMS… BUT CO-ORDINATION AND BASIC PLANNING NEED TO BE ADDRESSED COMPREHENSIVELY"

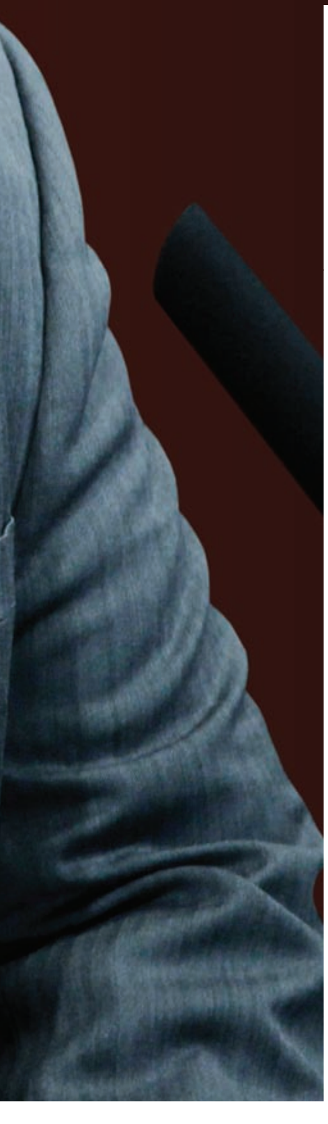
“WE WILL CONTINUE PRESSING FORWARD ON ALL OF OUR SAFETY INITIATIVES TO MAKE SURE OUR ROADS ARE AS SAFE AS THEY CAN POSSIBLY BE”

Before his appointment, Strickland was well regarded as a proponent for increased funding for many driving safety programmes such as drunk driving prevention and seatbelt use campaigns

Reasons to be cheerful

With safety recalls dominating 2010, it's been a baptism of fire for David Strickland. But having reduced traffic deaths by 25% in just five years, NHTSA hopes tackling distraction and impaired driving head-on will help the USA towards its own Vision Zero

AUTHOR LEANNE KEEBLE **MAIN PHOTOGRAPH** COURTESY OF CHARLES DHARAPAK/AP/PRESS ASSOCIATION IMAGES



The honeymoon period didn't last long for David Strickland following his appointment as NHTSA's administrator in January 2010. He barely had time to hang some pictures in his office before a number of safety recalls, most infamously Toyota, put him in front of the media's cameras for months, culminating with an intense grilling before Congress.

His background as a watchdog in consumer safety may have served him in good stead throughout this period, although perhaps a crash course in fire-fighting would have been more useful, as at times the safety woes of 2010 threatened to engulf NHTSA as well. The critics were vehement, calling into question the role of the administration and debating whether it had the resources and capability to conduct the necessary investigations into new and complex vehicle systems, as well as evaluate OEMs' claims about the operations of their vehicles.

The year of the recall

Lessons will undoubtedly be learned by all concerned – potentially a US$5.5 billion lesson in the case of Toyota, after recalling 14 million vehicles worldwide in 18 months. NHTSA will, however, feel vindicated by the results of a Congress-requested investigation into the unintended acceleration cases. NASA engineers with expertise in electronic and software systems looked into consumer claims that electronic systems may have played a role. But the results, published in February 2011, concurred with NHTSA's findings that mechanical safety defects were to blame – 'sticking' accelerator pedals and a design flaw that enabled them to become trapped by floormats.

The 10-month-long study involved the testing of mechanical components at NASA's Goddard Space Flight Center in Maryland, electromagnetic radiation testing at a Chrysler facility in Michigan, and research at NHTSA's Vehicle Research and Test Center in Ohio. According to Strickland, "NASA's findings, observations and recommendations – coupled with NHTSA's own work – point to several actions we can take now to lessen the risk of unintended acceleration," he says. "It also suggests areas where we can strengthen the agency's ability to address the safety of electronic control systems in the longer term."

In the short term, though, the Atlanta-born Strickland will consider three rulemakings: to require brake override systems; to standardise operation of keyless ignition systems; and to require the installation of event data recorders (EDRs) in all passenger vehicles. "Brake override systems will help prevent or lessen unintended acceleration incidents by assigning priority to the braking system over the throttle," Strickland suggests. "The NASA report notes that they can provide a broad overarching defence against unintended engine power from a wide range of causes, not just unintended acceleration."

Keyless ignition systems can exacerbate unintended acceleration incidents if, for example, the driver cannot quickly shut off the engine, while crash investigators could potentially mine EDRs for information relevant to unintended acceleration incidents that result in crashes.

NHTSA will also begin broad research on the reliability of electronic control systems to further ensure future generations of vehicles are safe. With the increasing reliance on electronics, such knowledge is in Strickland's opinion considered "critical". At the same time, the agency will look into the placement and design of accelerator and brake pedals, as well as human factors research such as how drivers use them. "Pedal misapplication occurs in vehicles across the industry and we want to know whether these types of incidents can be reduced through better pedal placement and design," he says.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As side collisions account for 20% of child car crash fatalities*, we have enhanced our award winning KID range by adding Side Impact Cushion Technology (SICT).
The air-filled, energy management cushions absorb the forces of a side collision before they reach your child, making our already safe KID, KID plus and KIDFIX seats 25% safer.**
* 2005 BRITAX study ** Internal BRITAX testing 2010
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David Strickland
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22 and going strong
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Test pilot
What was it like behind the wheel of the SARTRE roadtrain? Volvo's Dr Erik Coelingh has the inside story

The Toyota debacle is unlikely to disappear from the headlines soon though. NHTSA received around 3,000 reports of sudden acceleration incidents involving Toyotas over the course of the past 10 years, including allegations of 93 deaths (NHTSA has confirmed just five of them). Hundreds of plaintiffs and their lawyers are currently busy gathering evidence to strengthen their cases against Toyota, with trials expected to start in 2013. And in March 2011, another 2.1 million Toyota vehicles were recalled for the exact same problem, so yet more damaging publicity could be on the horizon for the beleaguered car maker.

Risky business

"It's clear that we cannot regulate or legislate risk away," says NHTSA's administrator. "It's already illegal to engage in dangerous behaviours such as being impaired while behind the wheel, yet people continue to break the law."

To combat the scourge, in early 2008 NHTSA and the Automotive Coalition for Traffic Safety entered into a cooperative research agreement to look at in-vehicle technology to prevent alcohol-impaired driving. "Through this effort, we are exploring the feasibility, understanding the potential benefits and identifying the public-policy challenges associated with a more widespread use of in-vehicle technology to prevent alcohol-impaired driving," Strickland reveals. "We are seeking to develop technologies that can accurately and reliably detect alcohol impairment and prevent impaired drivers from starting or operating their vehicles. Rather than focusing on police detecting and arresting impaired drivers on the road, this effort seeks to prevent impaired drivers from operating their vehicles."

Strickland admits this will be a long-term effort, but he is hopeful that it will produce a technology that is completely invisible to the driver and could be widely installed on a voluntary, market-driven basis. "We are now moving this technology out of the lab and into test vehicles."

The human factor

The safety recalls of 2010 put the topic of automotive safety under the spotlight, and threatened to undermine the many success stories of the past decade. Top of that list would be the fact that US traffic fatalities in 2010 dropped to their lowest level in recorded history – proof that a multi-faceted and determined approach to traffic safety can make a difference.

Early NHTSA projections for 2010 suggest a 3% drop from 2009 levels to 32,788, representing a 25% decrease since 2005 – and the lowest level since 1949, despite a significant increase in the number of vehicle miles travelled. Strickland insists neither he nor any of his colleagues at NHTSA and the USDOT are patting themselves on the back, acknowledging that there is still plenty of work to be done. "The decrease in traffic fatalities is a good sign," he says, "but we are always working to save lives. We will continue pressing forward on all of our safety initiatives to make sure our roads are as safe as they can possibly be."

Photograph courtesy of Cliff Owen/AP/Press Association Images

Toyota's troubles were taken all the way to Capitol Hill in Washington

"WE ARE VERY CONCERNED ABOUT THE IMPACT NEW TECHNOLOGIES HAVE IN INCREASING DRIVER DISTRACTION"

Throughout the safety recall furore of 2010, a little reported fact was that vehicle malfunctions are responsible for just 2% of all crashes, while 95% are caused by driver error, hence the pertinence of one of NHTSA's current high-profile campaigns. "We are very concerned about the issue of distracted driving and particularly the impact that new technologies have in increasing driver distraction," Strickland reveals. "In 2009, we estimate 5,474 people were killed in distraction-related crashes and of these 995 were mobile phone related." This is in fact nothing new to NHTSA. Distraction research has long been a core part of its mission, with particular focus on the extent and nature of the distraction safety problem, and applying measurement techniques to quantify the harmful effects of technology distractions on driving performance, as well as identifying potential countermeasures. "We are a data-driven organisation and we believe in sound science," Strickland continues. "We use the data and science to make informed decisions about what programmes to support or what actions to take to reduce the high toll that traffic crashes have on the public."

Programmes that have supplied NHTSA with useful distraction data include the National Occupant and Use Survey, which provides estimates on the number of drivers using electronic devices, crash causation studies (such as the NMVCC Survey), and naturalistic studies (the 100-Car Naturalistic Driving Study). "We launched our Distraction Research Plan in 2010 and outlined a comprehensive set of activities that will govern our approach. First and most importantly, we will continue to improve our understanding of the problem – that's where data comes in."

Strickland says that voluntary guidelines will also help to reduce the driver workload from in-vehicle systems. "We'll examine technology to keep drivers safe – for example, crash-avoidance systems or distraction-monitoring systems. And we will continue to work on increasing public awareness to recognise the risks and consequences of distracted driving."

Although recognising that there is a proliferation of infotainment-type technologies that may contribute to distraction, Strickland points to other technologies that offer great hope for enhancing driver awareness and increasing safety in the future. "I'm referring to vehicle-based systems such as forward collision warning, lane-change assist, advanced object-detection systems and so on. Some of these technologies are even capable of detecting vulnerable road users such as pedestrians and cyclists. We hope to encourage the demand for – and use of – these technologies.

Connected vehicles

"We are also working to determine the future safety benefits of vehicle-to-vehicle communications and NHTSA has already entered into a cooperative agreement with an industry partnership including Ford, GM, Honda, Hyundai-Kia, Mercedes-Benz, Nissan, Toyota and VW that will develop and evaluate the effectiveness of such safety systems, and we're currently in the second year of a three-year effort with this group."

The Crash Avoidance Metrics Partnership (CAMP) will ensure that vehicle communications are interoperable across all vehicles, regardless of make or model. It will also help NHTSA to determine the minimum performance levels and safety impact of applications enabled by V2V. "We believe V2V has the potential to save thousands of lives each year while offering the opportunity to reduce congestion and provide other services to vehicle owners. We are extremely encouraged by the research, analysis of the safety data, and the ongoing human factors work that all point to V2V as the next major safety breakthrough. V2V applications could address 80% of vehicle crash scenarios involving non-impaired drivers."

Despite the promise of V2V, Strickland feels crash-avoidance technologies can only go so far. "Drivers and other road users must take an active role in safety – their own and that of those sharing the road. Vehicle occupants need to buckle up and keep focused on the task of driving."

This is why the onslaught of infotainment gadgets is particularly alarming for Strickland. "My intention is for NHTSA to develop an evaluative framework to position the agency so that it's not reacting to every technology as it pops up and becomes a distraction," he says. "We need a framework that clearly defines the danger zone for the driver, and allows us to keep apace with the industry, rather than play catch-up. We won't take a back seat while new telematics and infotainment systems are introduced. These have too great a potential to create more and more distraction for drivers, so we'll take a hard look at the guidelines or requirements for these systems. We're challenging the auto and mobile phone industries to work with us to keep drivers focused on the task of driving."

A key part of this effort is NHTSA's work to develop a set of distraction guidelines. "Our initial focus is on developing them for visual-manual interfaces for in-vehicle technologies and we aim to publish these guidelines this autumn. From there, we will tackle guidelines for portable devices by 2013,

Photographs courtesy of Ford

Ford has introduced the 'smart intersection' to advance research into V2X technology that could help reduce accidents

and guidelines for voice interfaces by 2014. Vehicle-based distractions are concerning, but we are facing a new world with portable devices, and the risks they pose for driver distraction. In many cases, the interfaces on these devices are not optimised to be used by a driver, even though they have functions and applications that are intended to be used in a vehicle. And the fact that you have to hold them and manipulate them means the driver has to take his hands off the wheel."

Safety in mind

But with so much hype surrounding vehicle connectivity, how would NHTSA's top man go about reconciling consumer demands to be connected on the move with that of distraction? "Manufacturers should consider a 'car mode' for portable devices such as smartphones similar to 'airplane mode'," he suggests. "When these devices are brought into a vehicle and the vehicle is moved out of 'park' or above a couple of miles per hour, certain functions could be locked out – functions that are not safe to use while driving. Some devices already have this function. This mode could potentially simplify other tasks so that they are less risky. Research will help us establish what should and should not be part of the 'car mode'.

"Ultimately, it is up to the driver to make safe choices when getting behind the wheel. But technology manufacturers can help by designing products with safety in mind." ‹

The restrained approach

NHTSA's recently revised child restraint guidelines are to be categorised by age rather than type of childseat to keep apace with the latest scientific and medical research and the development of new child restraint technologies. "That decision is the most recent in a decades-long effort to keep our children safe on the road," says David Strickland. "When I was a kid, I remember riding in my mom's 1977 Lincoln Continental Mark V, lying across the rear panel behind the back seat. Parents today wouldn't dream of letting their kids ride in their cars in anything but their child safety seat or booster or strapped in with a seatbelt. National observational surveys confirm that, particularly for infants, child safety seat use is just about universal.

"How did we get from the free-wheeling days of kids riding unrestrained in cars – draped across rear seat backs looking out the windows, playing in the cargo areas of station wagons, in parents' laps in the front seat – to a comprehensive national programme for child occupant safety? It took leadership and constant interaction between the public, the safety advocates and government. It took listening and learning about what risks our society was not willing to take."

The first mandatory child restraint use law was implemented in Tennessee in 1978. Since 1985, all 50 states as well as DC have had child restraint use laws in effect. "So it took seven years for all the states to get a law on the books to protect children in passenger vehicles."

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Team players

By combining their technological solutions, software tools and engineering and testing services, the companies involved in the Beyond Safe partnership hope to offer the automotive market something completely different

AUTHOR NATHALY SCHOENMAKER, TASS, THE NETHERLANDS
IMAGES COURTESY OF TASS & TNO

Integration is a common word in automotive circles, particularly in the sphere of active and passive safety technologies. Such innovations are increasingly being linked to optimise the life-saving potential of vehicles, which in the future could even be integrated as part of a wider network of cars talking to cars and the infrastructure.

Increasing integration at all levels presents developmental challenges and added complexity for auto engineers. Beyond Safe, a new partnership between research organisation TNO, software specialist TASS and TTAI, a test house for vehicle safety engineering and passive safety testing, aims to relieve some of those pressures. Its *raison d'être* is to offer the automotive sector a range of software and solutions for vehicle safety, dynamics and sustainability – a one-stop shop, if you like, that will result in the design and production of safer, cleaner and more efficient vehicles.

Quick thinking

Leo Kusters, the director of TNO's Innovation Mobility division, is also the chairman of the Beyond Safe partnership and suggests it will benefit customers by helping them bring new technologies to market more quickly, efficiently and cost-effectively. "We can help them manage the increasing complexity and potentially exploding effort that you find in automotive development through the creation of simulation tools, test facilities and an accompanying methodology that – when combined – provide an efficient and comprehensive environment for designing and evaluating integrated safety systems," he says.

> Extensive development and testing processes are necessary to ensure assistance systems are safe and reliable

Vehicle engineers are often under pressure from time and budget constraints, and quality standards. They tend to create physical prototypes early on in the development process, so must spend a great deal of time on test track driving and road testing. "The use of simulation tools, in particular in the early stages, would help them save time and costs throughout the development process," Kusters says.

"Beyond Safe therefore offers for instance two complementary simulation software packages, PreScan and MADYMO, that cover all aspects of integrated safety design in simulation." Kusters describes the former as a dedicated vehicle and control sensor simulation tool specifically for designing active safety

Changing dynamic of safety

Leo Kusters' home country, the Netherlands, is right up there with the best when it comes to traffic safety. "I think we're currently second only to the UK," he says. "We have something like 700 fatalities on a fleet of around eight million vehicles and the government wants to reduce that by 200 over the next few years. If the trend follows the same pattern over the next 15 years as it has done over the past couple of decades, we would statistically cross the zero fatalities line in around 2025."

Kusters does, however, appreciate that it's not as simple as that, believing there will always be unavoidable traffic incidents that prevent the vision becoming a reality. "In the Netherlands, we're not far off the stage where we will have more casualties among vulnerable road users than in cars, so pedestrian and bicyclist safety will be one of the big focus areas in the future. At TNO, we have been working with the Dutch government and Autoliv to develop an exterior-mounted airbag to mitigate the effects of car-to-cyclist accidents. It's a challenging problem that many metropolitan areas are going to have to tackle."

A MADYMO simulation

systems and ADAS, enabling manufacturers to evaluate their intelligent safety system designs. "PreScan is a software tool that we launched a couple of years ago, which enables you to model the complete traffic situation including not only all of the vehicles and their behaviour but also all of the sensors, such as video and radar, to detect objects in the environment," he says. For over 30 years, MADYMO has been pretty much the established software for analysing and optimising occupant safety designs. Similar to PreScan, researchers and engineers can model, thoroughly analyse and optimise safety designs early on, which reduces the expense and time involved in building and testing prototypes. It also minimises the risk of making design changes late in development. These two products combined offer a unique tool to analyse the lengthy scenarios needed for the analysis of integrated safety systems.

The Beyond Safe hardware counterparts (VeHIL and crash lab) can be used for validation of the simulation results as well as for a more extensive evaluation of the integrated safety systems. VeHIL is essentially a missing link between simulations and road tests. "It allows developers to test and evaluate the functionality of a complete vehicle, as well as its subsystems and sensors, in controlled yet realistic circumstances," he says.

VeHIL is ideal to test all kinds of intelligent assistance systems from ACC/stop-and-go systems, pre-crash sensing, obstacle detection to V2V and V2I communications, platooning, and even autonomous controls.

"Through Beyond Safe, we can offer the entire product portfolio of the three parties worldwide," Kusters reveals. "By bundling R&D solutions, we are able to act as a strategic partner to OEMs and their suppliers, enabling them to gain a competitive edge in a rapidly changing environment."

One way in which Kusters feels the auto scene may alter in the future is in developing safety systems for a new era of cleaner vehicles. "The trend towards closer integration of active and passive safety technologies is clear, but there is also a need to consider safety and sustainability as a whole, such as powertrain development, reducing vehicle emissions, CO_2 and so on. A big challenge for the industry over the coming decades will be to maximise safety while minimising vehicle weight for emissions purposes. The trend towards greener powertrains also creates other safety challenges and one of our aims with Beyond Safe is to help bridge the gap between either discipline.

Time for a rethink

"In the future, we will have to rethink safety in regard to these new powertrains. Apart from the fact that electric and hybrid vehicles have completely different sound profiles – and there are moves to address this intelligently with directional sound generated only when active safety sensors detect a pedestrian within range – they also pose a completely different scenario in the event of a crash, with upwards of 400V of electricity presenting a hazard to both vehicle occupants and emergency services. Not only that, these types of powertrain present different challenges for braking and also stability control systems, as well as crash dynamics and mass distribution in the event of a collision. You can't just take traditional active and passive safety systems and place them into an electric or hybrid vehicle, so one of our goals going forward will be to look at technologies and systems to optimise the safety of this greener fleet." ‹

WiFi, not sci-fi

To many people, the idea of vehicles constantly talking to each other and the infrastructure sounds like a Spielberg-inspired blockbuster. But this isn't fantasy – it's fact based on simple technology and it's coming soon...

AUTHOR NICK BRADLEY
IMAGES COURTESY OF BMW, FORD & USDOT

Ford is building the first-ever prototype intelligent vehicles that will tour the USA in driver clinics over the next few months

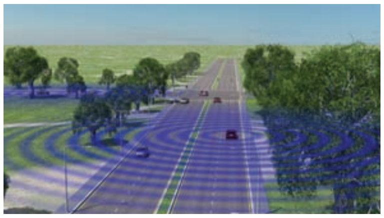
Depicting the traffic intersection of the future, an ad campaign from IBM a few years back showed cars hurtling across at high speed from all directions – seamlessly, safely, perfectly orchestrated. It was nothing more than a clever mix of editing and special effects, of course, although experts in the world of automotive safety and intelligent transportation systems feel at least a part of that vision will become a reality – and perhaps sooner rather than later.

Vehicle-to-vehicle and vehicle-to-infrastructure communications, or V2X, is a well-oiled topic and has been researched, demonstrated and trialled for several years already. The ingredients to make it happen, dedicated short-range communications (DSRC) with a sprinkling of GPS, are proven and commercially available. What's different now, though, is that there seems to be a genuine impetus among legislators to take the research to the next level – potentially all the way to full-scale deployment.

Peter Appel, from the USDOT's Research and Innovation Technology Administration (RITA), echoes the sentiment. "The potential for this technology to save tens of thousands of American lives demands that we move forward quickly," he says. "Roadway safety isn't just a transportation issue – it's a matter of public health. Nothing hammers this home more than the grim reality that crashes are still the leading killer of those aged between four and 34. Beyond the deadly toll on the youngest Americans, almost 2.5 million people were injured in crashes in 2008 – the status quo simply isn't acceptable."

The panacea?

The potential of DSRC and GPS as the enabler of V2X has long been regarded by car makers as the panacea to traffic fatalities. Mike Shulman, Ford's technical leader in its Active Safety Research and Advanced Engineering Department, has been working on the technology behind such intelligent vehicles for almost a decade. Shulman is also the progamme manager of CAMP, the Crash Avoidance Metrics Partnership, established in 1995 through a Ford-GM partnership that aims to research concepts that could consign traffic accidents to a thing of the past. "Similar to a lot of the work that has been conducted in the passive safety arena on anthropomorphic dummies and barrier-test procedures – where OEMs collaborate pre-competitively to a stage where they can take ideas in-house and work with suppliers to develop bags



The system allows cars to talk wirelessly with one another using DSRC on a secure FCC-approved channel

Ford is doubling investment in intelligent vehicles in 2011 and plans a new 20-member task force of scientists and engineers to explore further possibilities

"YOU HAVE TO REASSURE THE PUBLIC ABOUT THE PRIVACY ASPECTS – IT'S NOT ABOUT TRACKING OR ISSUING SPEEDING TICKETS, IT'S A TECHNOLOGY THAT CAN SAVE YOUR LIFE" and belts, etc – we wanted a similar organisation for active safety," says Shulman. "We recognised early on that V2X is a cooperative system – a Ford has to send messages to vehicles from other OEMs, so we tried to get as broad a participation as we could." With Ford and GM leading the pack, Honda, Toyota and Mercedes were next to sign up. "Engineers from the companies come together at our office to plan activities, conduct joint tests, etc. There are now eight of us in total, after Volkswagen-Audi, Nissan and Hyundai-Kia also came on board."

A great deal of Shulman's work with CAMP has been focusing on a common architecture and standards, potentially bigger challenges than actually getting cars to talk to one another. "We're finalising the standards right now," he says. "Exactly what the messages will be; how accurate the data elements need to be; how much latency there needs to be in each of the fields, and so on. In the USA, the lowest level is 802.11p but there's an intermediate IEE 1609 standard for security and at the upper level we have SAE J2735, which defines the message sets. We're also trying to finish up the J2945 for minimum performance standards."

Although the teamwork has been important, naturally each of the car makers has been pursuing their own applications. "There have been three phases for us at Ford. The first began in 2002 to look at the technology and convince ourselves that DSRC could be ready for mass-deployment. The second phase from 2005 was to build real applications and focused on what message sets you would need to enable these applications, as well as aspects such as security and positioning."

Smart thinking

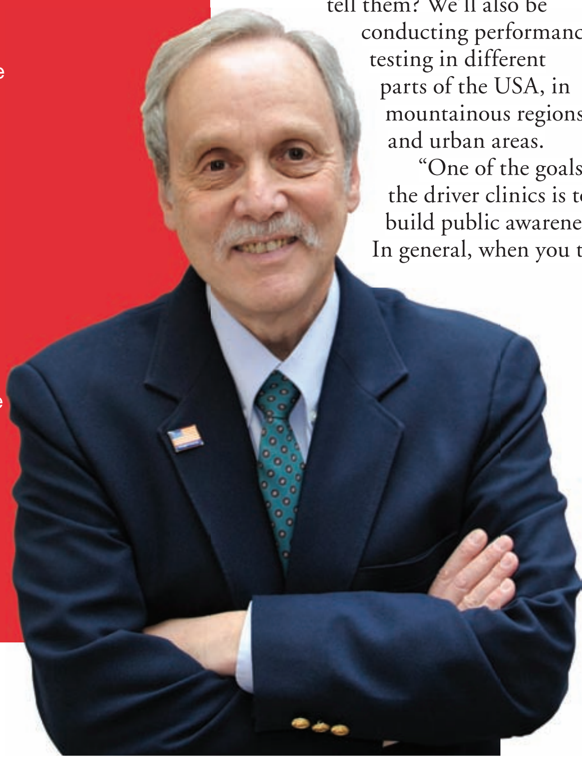
One of those applications was the Smart Intersection. "This transmits several data elements to the test vehicle, including a digital map of the intersection, six extra maps of the surrounding stop-sign intersections and crosswalks, lane-specific GPS location, as well as traffic light status and timing information," Shulman says. Once the information is received, the vehicle's collision avoidance system will deem whether the car can safely cross the intersection or if it needs to stop before reaching it. If it determines the need to stop and senses that the driver is not decelerating quickly enough, visual and audio warnings are issued.

"We finished on the Smart Intersection project in 2008 as well as various other V2V initiatives and in 2010 we entered our third phase. Everyone in the USA got really excited about the results coming out of the various projects so last year NHTSA published its strategic roadmap, stating that it wanted all of the project research completed as quickly as possible so that it could initiate a rulemaking process in 2013. This is the milestone that everyone's working towards.

"We're taking all of the applications that we've been building, integrating a real driver interface and we're going to run six driver clinics around the country, bringing in around 100 naive test subjects selected by age and gender. We'll put them into various different scenarios on a closed track and obtain specific feedback. What did they think of the system? Did the warning come on at the right time? Did they understand the warning? Did they comprehend what it was trying to tell them? We'll also be conducting performance testing in different parts of the USA, in mountainous regions and urban areas.

"One of the goals of the driver clinics is to build public awareness. In general, when you talk

The sub-projects within Europe's AKTIV project use V2V, V2I and in-vehicle systems to help inform drivers about what's transpiring around the vehicle and, in some cases, the vehicle will respond autonomously



Mike Shulman is leading Ford's intelligent communications efforts in the USA

Private investigations

Just as researchers in the USA are keen to ensure the privacy and security of their own V2X initiatives, so, too, are their European counterparts. Frank Kargl is the associate professor at the Distributed and Embedded Security Group of the University of Twente. He is also the coordinator of the PRESERVE project – or 'Preparing Secure Vehicle-to-X Communication Systems' – which aims to address the challenges of secure and privacy-friendly communication between vehicles. Kargl explains the challenges that he and his team will face. "The main one is to conduct frontline academic research to solve a number of important but still open research questions, while at the same time designing and building a security subsystem that is robust and scalable enough to be deployed and tested in field operational tests with hundreds of vehicles.

"The EC and auto industry operates on a very ambitious time schedule, with first standards being ready by 2013 and actual products being available in the second half of this decade. If we fail to come up with a convincing and well-tested solution to V2X security and privacy within this timeframe, this could mean that deployed systems will fall victim to attacks.

"If this happens, customers might even refuse adoption of those life-saving systems. Having an excellent set of partners, I am sure that PRESERVE will come up with a solution that will allow a secure and privacy-preserving deployment of V2X."

USDOT's RITA administrator Peter Appel (above right) is all smiles after surviving a Ford V2V safety demonstration

Safe and secure

USDOT can hardly contain its excitement about the life-saving potential of a V2X network. On his official blog recently, Ray LaHood, US Secretary of Transportation, noted comments from Deputy Assistant Secretary Brodi Fontenot, who was treated to a demonstration in the Ford system. "I wasn't comfortable knowing that we were being driven deliberately into the most common situations where crashes occur," Fontenot said. "But each time, the vehicle alerted the driver – way in advance of his ability to see the danger on his own."

"One of the most attractive aspects of this technology is its low cost," LaHood says. "When these vehicles go into production, we expect the safety enhancements to add no more to the cost of your car than the seatbelts we take for granted today."

Administrator Appel added: "Each extra vehicle on the road equipped with this makes everybody on the road safer."

to people about these concepts, they say 'You're gonna put what in my car!?' But once they understand that it's all built around existing technologies you already have in your laptop or phone and that it's just another pair of eyes to give you 360° support, they come around. You have to reassure them about the privacy aspects – it's not about tracking, it's a technology that can save your life."

Other OEMs will be conducting their own similar investigations and all of the data extrapolated will then be used by NHTSA for its own cost-benefit analysis from which it can support its regulatory procedures.

> "NHTSA SAYS IT THINKS A V2X NETWORK CAN ADDRESS 81% OF ALL VEHICLE-TO-VEHICLE CRASHES INVOLVING UNIMPAIRED DRIVERS"

A safety milestone

The big event on the horizon – the litmus test for the smart car generation – will be the Cooperative Safety Pilot Model Deployment. "NHTSA's going to pick one region in the USA and all of the OEMs are going to bring in the vehicles they've been working on. We'll instrument the infrastructure and bring in other vehicles such as trucks, buses and so on. There's going to be around 2,500-3,000 vehicles in total running around for about a year and we'll test it all out and establish if the standards are truly ready for a regulation."

So after years of papers, POCs and public demonstrations, a truly co-operative system finally appears to be so close you can almost touch it. Shulman, however, is keeping his feet on the ground. "One of the problems is that even if NHTSA was to require this on all new vehicles starting in a certain model year, it's going to take a long time to penetrate the fleet," he warns. "People appreciate this so one of the ideas is to develop an aftermarket device that can be retrofitted."

The business case for a device solely for a safety application is contestable, so the technology could potentially incorporate other mobility applications including tolling. It could also act as a traffic probe to provide information to traffic management centres, and be disseminated and redistributed to vehicles as congestion information.

But what does this V2X network mean for existing crash-avoidance technologies such as radar, cameras, etc? "We don't see it taking over any time soon from these types of technologies," Shulman says. "We'd like to move from an era of warning to eventually an era of control. If I give a driver a warning and he doesn't react, can I take some control and mitigate the crash to try to avoid it? The more information we have the better, and if a radar is 'seeing' something and the V2V message is consistent with that, you're more likely to have confidence in what you're being alerted to."

Shulman does, however, believe there are important differences between the two technologies. "You can put a radar on a car but the field-of-view isn't really wide enough to establish if another car has run a red light or a stop sign. V2X gives you 360° coverage over about 300m – radar gives you some information about range, relative velocity and angle to target, but with DSRC the target is literally talking to you: here's who I am; here's my mass, my bumper height, my position, speed, brake status, where I'm going, where I've been. It's a wealth of information that you can do so much with."

So what exactly is the life-saving potential of a network of connected, intelligent vehicles? "NHTSA says it thinks it can address 81% of all vehicle-to-vehicle crashes involving unimpaired drivers. People regard vehicles talking to each other like it's something out of science fiction, but this isn't *The Jetsons*." A Hollywood remake of that particular 1960s cartoon has apparently been in the offing for a while. V2X, though, could be hitting the streets much sooner.

To pop or not to pop?

New legislation is putting pedestrian protection technologies under the spotlight, in doing so intensifying the need for appropriate test procedures to develop the requisite sensors

AUTHOR THIERRY MOUSEL, IEE, LUXEMBOURG **IMAGES** COURTESY OF IEE

Starting in 2013, the Global Technical Regulation (GTR) on Pedestrian Protection will bring pedestrian safety to a new level, defining requirements beyond those currently existing in Europe and Japan as well as covering further countries. An increasing number of NCAP programmes are also including pedestrian safety tests in their vehicle assessments, with Euro NCAP having defined the most stringent conditions.

In order to comply with the various demands, some vehicle manufacturers already revert to pop-up bonnet systems for their sporty or premium models, and many more are likely to follow suit once the GTR becomes effective. The future may see A-pillar or windscreen airbags to even further enhance the protection of pedestrians. Research on this additional safety measure is already quite advanced.

Hard-to-detect targets

All of these measures require a sensing system that is able to trigger them reliably in the event of a pedestrian-vehicle collision, while making sure that no actuation is taken in collisions with other objects such as stray footballs, branches or roadsigns. Furthermore, the sensor must be robust enough against lighter impacts (e.g. parking dents) likely to occur over a vehicle's lifetime. Such performance requirements lead to a number of questions. For instance, how can you make sure that the sensing system reacts appropriately? What does my sensor have to 'see'? How can you make sure that even the hardest-to-detect pedestrian – the one transferring the least amount of momentum into the bumper at low impact speeds – will reliably trigger the protection system? And last but not least, how can such a sensing system be tested appropriately?

Up until now, the grade of sensor testing was left to the sensor manufacturer and OEM, as pedestrian protection legislation has not yet defined a test procedure for the impact sensors of pop-up bonnet systems. This legislative loophole will need to be closed in the future. Euro NCAP realised this deficit and made a first necessary step by coming forward with a basic assessment procedure in early 2011 that will be applied to vehicles with pop-up bonnets. The protocol includes simulations of vehicle-to-pedestrian collisions as well as physical tests with specific leg impactors.

Reliable impact classification

From the sensing point of view, specific information about certain impacts has proved to be a prerequisite for reliable impact classification. This includes effective mass and width of the impacting object, its material characteristics (rigid or soft), and the impact location (as bumpers have inhomogeneous structures). IEE's Protecto sensor – a pressure-based sensing system integrated into the bumper foam along the crossbeam – is able to deliver on these parameters.

(Main picture) The Protecto sensor can be integrated in the absorber (as in the picture) or on the crossbeam

But although this information helps to characterise a pedestrian impact, it's still unclear which sensing thresholds have to be defined in order to protect all pedestrian statures, and especially the 'worst-case' pedestrians. A major challenge is that the stature of the pedestrians who are hardest to detect varies with bumper height and a vehicle's front-end geometry.

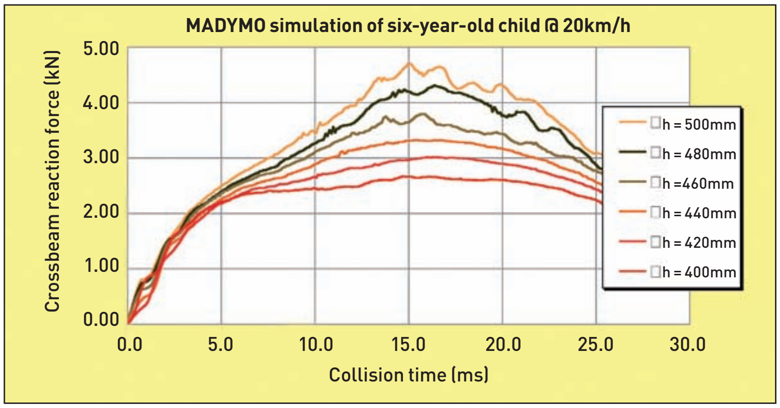
The graph below indicates that bumper height variations have a considerable influence on the impact characteristics of a specific pedestrian stature – an effect that is especially significant for a six-year-old pedestrian. At an impact height of 400mm, the model is hit well below its centre of gravity and impact severity is comparably low. But with increasing bumper height, the contact point quickly moves closer to the six-year-old's centre of gravity, hence the impact severity (peak force) increases.

To identify the pedestrian stature generating the least momentum transfer into the bumper, extensive simulations need to be run with appropriate pedestrian models and various vehicle front-end geometries. As sensing systems have about 20-25ms before a trigger decision has to be taken, the momentum transfer is calculated over a 20ms period, and a sensor trigger level of 1kN is taken into consideration. For a representative vehicle, the worst-case pedestrians were identified as indicated in the table.

IEE-WPI hybrid model representing a 50% male pedestrian

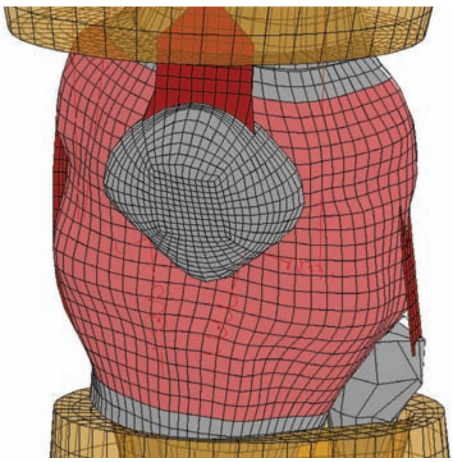
Table below shows the pedestrians who are hardest-to-detect based on momentum transfer assessment for car-to-pedestrian impacts at 20km/h

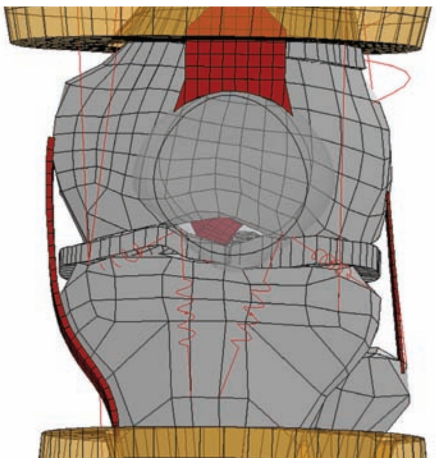
Bumper height	Hardest-to-detect pedestrian
400mm	Six-year-old child
420mm	5% female
440mm	5% female
460mm	5% female
480mm	50% male
500mm	50% male



Impact force versus collision time for a walking MADYMO model representing a six-year-old child; influence of bumper height variation

A bumper height variation of only 10cm leads to a shift of the hardest-t o-detect pedestrian from the six-year-old child to the 5% female and up to the 50% male. Trigger thresholds of a sensor must therefore be defined on the basis of the hardest-to-detect pedestrian for the corresponding vehicle bumper height. If a wrong pedestrian reference is selected for the sensor threshold calibration, then failure of the pedestrian protection measure is likely in a real-life impact against a hardest-to-detect pedestrian stature.





Pedestrian models

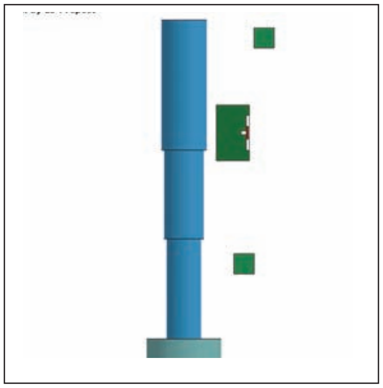
IEE generated these results by using two different pedestrian models: modified MADYMO models (the rigid knee was replaced by a more human-like knee); and an in-house model, the IEE-WPI pedestrian (Worcester Polytechnic Institute). The final IEE-WPI model has a lower body based on finite elements and a simplified upper body described by multi-body elements. The finite elements of the legs guarantee appropriate interaction with the bumper material in the early collision phase.

The detailed modelling of the knee allows for knee bending and ligament rupture, while the muscle and tissue material characteristics guarantee a human-like transition of the forces into the bumper upon impact. The simulation can therefore generate a realistic reproduction of a real pedestrian-vehicle impact, including sensor signals that can be used for algorithm calibration.

It was important to ensure that there was only a single-leg interaction with the vehicle front, and therefore the MADYMO model had to be set into a walking posture. Recently, a new MADYMO pedestrian human model has been proposed, providing more detailed contact surfaces for a realistic contact with finite element car models. This also has a defined walking posture and is likely to be appropriate to generate consolidated findings on pedestrian-vehicle collisions once the complete model family is available.

Next-generation IEE leg impactor

The simulation results were used as a basis to design a new impactor able to represent the hardest-to-detect pedestrian in physical tests with vehicles. Early on, in 2006, IEE had developed a first-generation lower-limit leg impactor, which is currently one of three impactors listed in Euro NCAP's deployable bonnet system assessment protocol. As this impactor was based on a more simplified approach, it had some weaknesses – e.g. restrictions related to impact test conditions. The new IEE G2 impactor eliminates these weaknesses. The finite element model of the IEE G2 impactor will become a key element in IEE's future Protecto system developments, as a major part of sensor design and algorithm calibration is realised via simulation (up to 80%). The IEE G2 impactor weighs 6.6kg, and is made up of a carbon-fibre tube with two concentrated lead masses surrounded by a PU material for muscle and tissue representation. IEE will publish a paper on its new impactor generation at the upcoming ESV Conference in Washington, to take place from 13-16 June 2011.



The IEE G2 impactor positioned in front of a simplified front-end structure representing bonnet leading edge, crossbeam with foam absorber and lower stiffener

When comparing the momentum transfer of the IEE G2 impactor with that of the first-generation IEE leg and various pedestrian statures (see graph below), it can be seen that the IEE G2 impactor is an appropriate test tool with regards to testing 'worst-case' scenarios.

Sensor development based on this impactor can therefore make sure that pedestrian safety is guaranteed due to appropriate actuation of the deployable bonnet.

Early crash-sensing

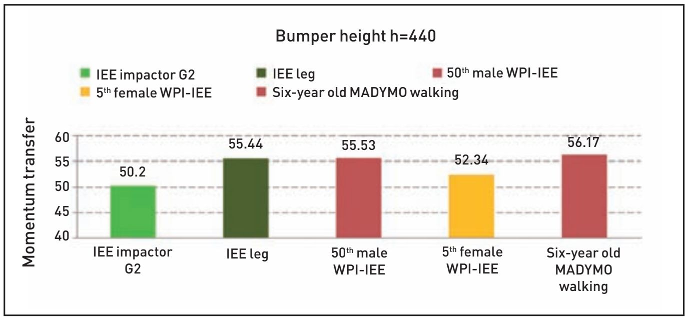
Apart from detecting pedestrian impacts, the Protecto sensor can also be used for the detection of crash events. When used as an early crash-detection system, it detects the impact location as well as the geometry of the collision object. Current crash-sensing systems tend to have problems detecting frontal impact against tree-like structures in a timely manner, and therefore restraint systems may be triggered too late for optimal protection. The IEE sensor, however, can provide information about whether the collision is against a small object (tree) or rather against a wide object (car). In addition, the crash overlap can also be determined, so the Protecto sensor could potentially replace current upfront crash sensors and provide enhanced information to the ECU that triggers the airbags, as well as to other restraint system components dedicated to optimised passenger safety.

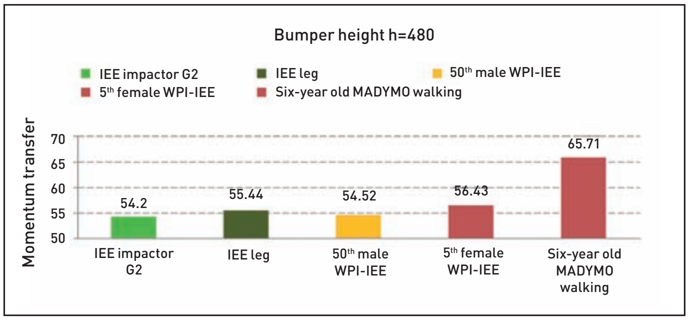
What the future holds

Although reliable pedestrian-sensing is already a great challenge with regards to pop-up bonnet systems, an even greater challenge is likely to lie ahead. As the future may bring A-pillar or windscreen airbags, the reliable discrimination between pedestrians and other objects will become even more important. Airbags, contrary to some pop-up bonnet actuators, are not reversible, so false deployments have to be reduced to an absolute minimum. The Protecto sensor has proven in various OEM benchmark tests to be highly reliable in the classification of collision objects.

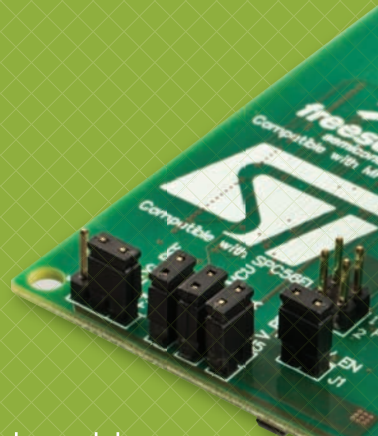
A number of research activities are currently taking place focusing on appropriate pedestrian-protection measures, test procedures, pedestrian models, pedestrian-sensing systems and 'lower-limit' impactors. The need for an application-specific test procedure has in the meantime been widely recognised, and the protection of a wide range of pedestrians has to be considered, as each pedestrian stature has an equal right to protection. These research results should be taken into consideration to amend and improve existing pedestrian protection legislation. The engineering focus must aim at finding a reliable sensor that can fulfil appropriate test requirements, and consequently save pedestrians' lives. ‹

(Below) Comparison of impact strength simulated for typical bumper heights and different collision scenarios with human models and impactors





Safe and secure with silicon

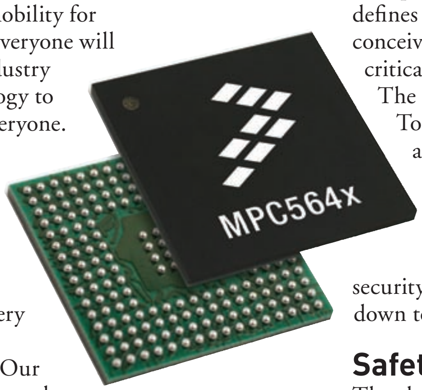


An increasingly connected world means that security features are of the highest priority: to create safe systems, security must be integrated at the design level

AUTHOR MARC OSAJDA
IMAGES COURTESY OF FREESCALE SEMICONDUCTOR

Four megatrends are currently shaping the future of the automotive market: mobility for everyone; safety for everyone; a clean world for everyone; and everyone being connected. There are 2.5 billion people in China and India who want access to some sort of mobility. By 2020, worldwide vehicle product should reach 100 million units[1], so we need to be prepared to provide mobility for all. However, mobility for everyone will not be sustainable if the industry can't provide green technology to make a cleaner world for everyone. Mobility for everyone will also be unsustainable if road fatalities in the emerging markets (where the bulk of fatalities occur) can't be reduced to achieve safety for everyone. And every day our world is becoming a little bit more connected. Our future vehicles will be connected as well, through car-to-car or car-to-infrastructure connectivity, or connected to the cloud to access mega databases of information. We are in the era of everyone being connected.

These four megatrends have a significant effect on how the electrical/electronic architecture of the vehicle is evolving. Computing power and software complexity is exploding, memory size is growing exponentially, and electronic control units (ECUs) are becoming interconnected within the car and to the external world, creating two new fundamental challenges for the automotive electronics industry.



The MPC564xL reduces design complexity and component count by putting key functional safety features on a single chip with a dual-core, dual-issue architecture

The first is to help ensure that complex ECUs are safe and will not create unexpected dangerous results (such as inadvertent airbag deployment, electric power steering not responding, etc). This requirement is addressed by the upcoming ISO26262 standard that defines new, state-of-the-art rules for conceiving and developing safety-critical automotive electronic systems.

The second aspect relates to security. To guarantee that ECUs are as safe as possible, it's critical to ensure that non-authorised people can't manipulate mission-critical data in any of the ECUs. To have this level of security, protection has to be realised down to the silicon level.

Safety at the silicon level

The challenge for system engineers is to design control units in a way that dangerous failures are prevented – or at least sufficiently controlled when they do occur. Dangerous failures may arise from random hardware failure mechanisms, systematic hardware failure mechanisms, software errors or common cause failures.

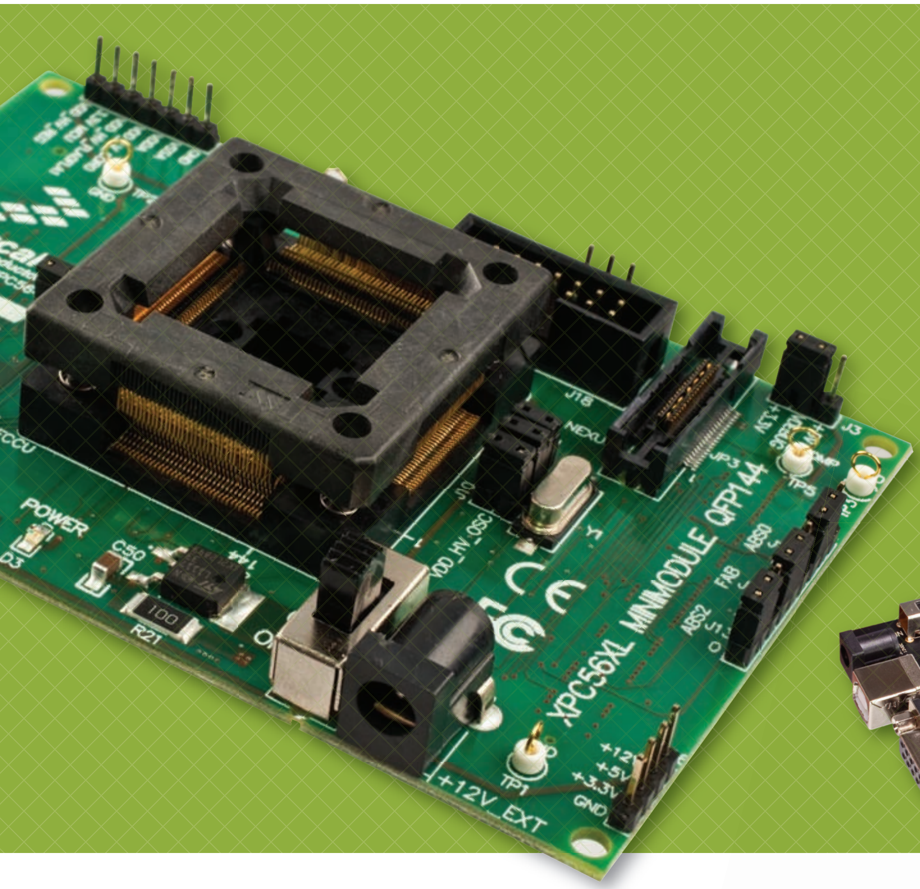
Freescale can look back on more than a decade of design experience in dual-core controller technology for safety-critical applications. For instance, the Qorivva 32-bit, dual-core microcontroller MCP5643L is specifically targeting ISO26262-compliant automotive applications.

Single-point faults: Single-point faults can be immediately critical for system safety functions and they require fast detection. Typical examples of such faults are bit flips in cores or memories induced by external influences such as radiation or electromagnetic interference. As a key measure against single-point faults, the MPC564xL family introduces a 'sphere of replication', allowing users to run key elements of the microcontroller in dual-core lockstep mode.

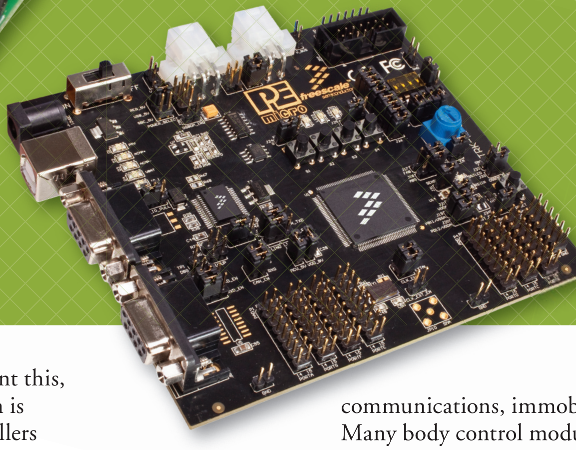
Latent faults: Latent faults are typically hidden. Once occurred, these faults do not compromise system safety functions. An example is a fault in the ECC logic for memory error detection/correction. It would only become critical when a memory bit flip (e.g. in a Flash module) occurs and, consequently, cannot be detected/corrected anymore.

The MPC564xL controller architecture offers hardware self-test (BIST) mechanisms for detection of this fault category. These tests exercise the microcontrollers' logic elements with a coverage of 90% and higher.

Common cause faults: Common cause faults (CCF) may result from the fact that redundant elements share a common die. Typical examples are system clock or power supply issues,



“THE CHALLENGE FOR SYSTEM ENGINEERS IS TO DESIGN CONTROL UNITS IN A WAY THAT DANGEROUS FAILURES ARE PREVENTED”



which can influence chip-internal blocks in a similar way and potentially cause identical failures. The MPC564xL family provides hardware blocks for detection of clock deviations as well as hardware monitors for main voltages – e.g. internal core voltage, Flash supply voltage, etc.

Security at the silicon level

In mid-2010, a group of university students used the CAN-based onboard diagnostic (OBD-II) interface to insert malicious code into some main ECUs, meaning they were able to interfere with safety-critical systems such as braking.[2] Although somewhat extreme, this particular case is proof that vehicle electronics are susceptible to hacking and consequences could be severe, not only for OEM reputations, car resale value and warranty charges, but also for society. To prevent this, robust component protection is required for the microcontrollers that power the most critical ECUs.

The MPC5646C is the first microcontroller on the auto market that implements the new specification for component protection, as defined by German car manufacturers in the HIS initiative. The secure hardware extension (SHE) is intended to move the control over cryptographic keys from the software domain to the hardware domain and thereby protect those keys from software attacks.

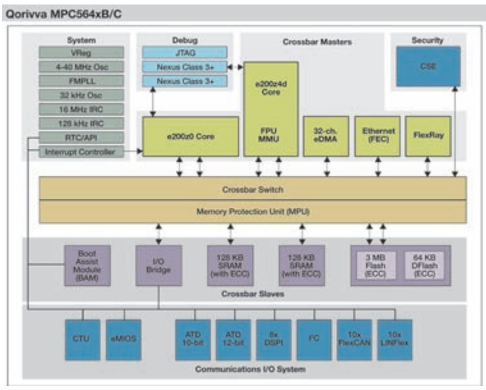
The MPC5646C addresses the above concerns by having data security capabilities. There are many use cases where having security capabilities is critical – secure boot-up modes, secure mileage, component protection, management of programming, digital rights management, car-to-car communications, immobilisers, etc. Many body control modules already support security through encryption capabilities in software. This is susceptible to software attacks and is a riskier security method compared with a hardware solution. The MPC5646C offers a unique cryptographic services engine (CSE) that moves the control over cryptographic keys from the software domain to the hardware domain to significantly reduce security risks. The CSE module helps protect the security keys from software attack, provides an authentic software environment and allows for distributed key ownership.

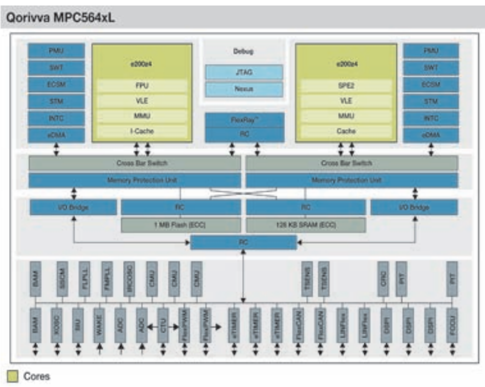
Increasing complexity and functionality in a market environment that is confronted with shorter development cycles and increasing cost pressure is part of daily life for automotive electronics industry players.

Microcontroller features that help the designer focus on the actual application and simplify challenges, such as the safety concept of the MPC5643L or the MPC5646C’s CSE, are clear added value for ECU architects. As such, the semiconductor industry is enabling the deployment of safer and more secure electronic control units for cleaner and safer mobility. ‹

[1] *Source, IHS*
[2] *Source, 2010 IEEE Symposium on Security and Privacy*

(Above) **The MPC5643L targets electric power steering and applications requiring a high Safety Integrity Level (SIL)**





(Below left) **MPC5646C block diagram and key features** (Below right) **MPC5643L block diagram and key features**

Forward statement

TRW offers a behind-the-scenes look at how it's worked alongside an OEM to develop a new camera-based safety system for rollout in 2013

AUTHOR JOHN PRAINITO, TRW AUTOMOTIVE, GERMANY
IMAGES COURTESY OF TRW AUTOMOTIVE

With EU targets to reduce road fatalities by half by the year 2020, the need to develop and introduce advanced safety technologies is immediate. Legislators, consumer groups and the automotive industry itself are placing greater focus on intelligent safety technologies that offer enhanced protection to occupants and pedestrians. With the forthcoming mandate for ESC in Europe and North America, greater opportunities are presented to integrate sophisticated driver assist systems and further enhance the safety of road users.

However, it can take several years to develop an advanced integrated safety system and most users will have little understanding of the breadth and depth of development and sophisticated off- and on-road testing involved.

TRW's new video camera system will first be installed by a large OEM within the next few years

Contract talk

As a provider of active and passive safety products and services to the automotive industry, TRW has recently won a new contract for its video camera sensor, due to start production in 2013. The camera, mounted behind the rear-view mirror, monitors lane markings and environmental objects to enable features such as lane-departure warning, forward-crash and forward-distance warning, automatic headlight control, traffic-sign recognition, pedestrian detection and more.

The process of bringing such a product into production usually starts with TRW showcasing it to the customer – either through marketing or through a well-established relationship among engineers. The main goal is to make sure that the vehicle manufacturer understands TRW's capabilities and how all parties can work together – and appreciates that the company has the experience and knowhow to apply the system. Collaboration is required at a number of levels, and sometimes between several companies, depending on the complexity of the system and how new the technology is.

With TRW's latest video camera award, however, similar technology had already been developed by the company and is in production on the Lancia Delta, so new customers can draw upon this valuable experience to ascertain how they would want to apply additional technology to their new vehicle platforms. For a first technology launch, however, the process of development, testing, data evaluation and application can take much longer to prove the product.

This can also be the case if TRW was implementing an integrated system – such as its camera working with radar, electronic power steering, or electronic stability control.

The video camera sensor in question is a scalable technology offering a host of functions that can be programmed into the software. Collaboration between TRW and its customers would often start with a development contract to assess the features of the video camera system.

Understanding the spec

Early development work with customers usually takes place to establish the precise requirements. In the case of this recent camera award, the customer needed to evaluate the technology at prototype level to ensure its performance would meet their specifications and the expectations of the consumer.

During the one-year development contract, TRW used a Six Sigma approach to set up tests and assess the boundaries for the system – evaluating the technology in worst-case scenarios, both on a test track and public roads. This process enabled data to be analysed and reports to be generated for the vehicle manufacturer in order for the algorithms to be modified to improve the performance. With a safety system such as this, the testing progress is extremely rigorous.

TRW worked very closely with the vehicle manufacturer's engineering teams over the course of the development contract, as well as a third party which provides the chipset for the camera. Four TRW engineers were working full-time on the project, and met with the vehicle manufacturer on a weekly basis to discuss open issues and exchange information. This was sometimes challenging to co-ordinate as it was dealing with different engineering sites, and people in different countries and time zones.

By using the three dimensions of spatial location and analysing the pixels' three directions of motion, the stereo camera identifies any kind of object, with a special focus on vulnerable 'objects' such as pedestrians

By the end of the contract, a set of requirements was generated that customers could present to their management teams and use to define a request for quotation. At the same time, TRW needed to present its own business case internally and work with in-house purchasing and finance teams and manufacturing plants to ensure the project would be viable.

The contract for this video camera sensor was won in January this year and TRW will now continue to work on developing the technology for the specific vehicle platform until the start of production in two years' time.

Production design has started in earnest, which involves looking at the exact specification including the CAN communication protocol, special requirements for power and EMC, updating of the printed circuit board, the connector and more.

The product also needs to be tested environmentally and thermally and integrated into the vehicle. Additionally, more data is collected as there will always be subtle changes such as the windscreen angle, the placement of the camera and the exact height from the ground.

Working to a schedule

The main challenge in such a contract is to complete all of the work to a fixed schedule, working not only with TRW's customers' engineering teams and manufacturing plants, but also meeting its own internal requirements in terms of quality, purchasing and manufacturing to ensure everything is ready for the start of production.

Bringing an advanced safety system into production requires a close partnership between the vehicle manufacturers and suppliers – both of whom need to be focused on understanding the requirements of the driver.

To date, the introduction of advanced driver assistance systems has been relatively slow, but regulation will see the pace speed up. In Europe, for instance, legislation will see Automatic Emergency Braking introduced for heavy trucks, which gives the industry the opportunity to apply the wealth of experience gained from truck sector to the passenger car market.

Not on my watch

Advanced camera solutions from TRW provide safety systems such as forward collision warning (FCW), following distance indication (FDI) and lane departure warning (LDW). These functions are realised with a forward-looking monocular camera mounted at the windscreen in the region of the rearview mirror.

TRW's LDW system uses video cameras and can be integrated with electrically powered steering to enable haptic feedback for active lane-keeping assist. It detects when the vehicle is drifting towards the lane markings, while electric steering provides gentle guidance through the steering wheel for the driver to stay in lane.

The camera-based FCW identifies the closest object in the vehicle's path and determines its scale change. Whenever the size and optical growth of this object indicate a potential collision, a warning is given to the driver. An FDI warning will be given when driving too close to the impeding vehicle.

On top of these safety functions, the camera also provides comfort features such as automatic high-beam control and speed-limit sign recognition. It can also be used to support the additional option of pedestrian detection.

When fused with radar, the camera enables Automatic Emergency Braking due to its complete detection and situation analysis.

In case of error...

For the first time, a standard is being introduced to help answer what happens when a sophisticated electronic safety system malfunctions? One expert is on hand to offer advice on test tools to help meet this standard

AUTHOR RAIMUND TRUMMER, DEWETRON, AUSTRIA
IMAGES COURTESY OF DEWETRON

The ever-growing complexity of electronic components used in vehicles increases the risk of malfunctions. Many electronic support systems are designed to make driving safer, but they also raise the question of what happens if, for instance, an ESC system malfunctions and causes an automatic course correction on a busy motorway?

The answer is found in the 10 volumes of ISO 26262 – *Functional Safety for Road Vehicles* – which is due to be released by mid-2011, setting a development standard for safety-relevant electric/electronic systems in vehicles up to 3.5 tonnes gross weight.

Volume three describes the process of a functional safety concept. At the first step, the system and vehicle functions are described by items and each item is matched with its potential malfunctions. The simulation of such malfunctions in specific driving situations enables a classification corresponding to the Automotive Safety Integrity Level (ASIL), from A (low hazard) to D (high hazard) up to QM (not safety-relevant). The classification according to ASIL – volume nine is established by the severity (S) of the effect, the frequency of the driving situation (exposure (E)) and the controllability (C) for the driver. With a rising ASIL, safety requirements for the corresponding system will increase too. Volumes four, five and six deal with implementation of the functional safety concept at the system, hardware and software level.

In summary, it can be said that with the introduction of ISO 26262, the automotive industry has available – for the first time – an applicable standard for functional safety.

To determine the ASIL, a well-defined method for risk and hazard analysis is specified, but the three parameters (exposure, controllability and severity) offer quite a large interpretation range, meaning that knowhow and experience is essential for practical application.

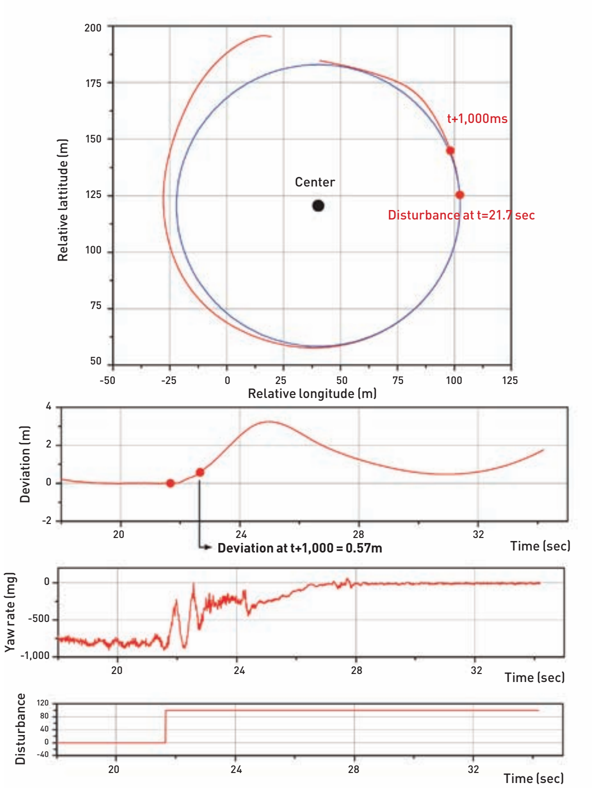
Measuring controllability

As with many other safety-related standards, compliance is crucial and documented evidence must be provided. Put simply, all mechatronically controlled systems where sensor information is the basis for actions must be tested, evaluated and fine-tuned before the systems can be released for mass-production. Adequate test tools are needed to achieve objective results on vehicle behaviour when a sensor failure during a certain driving manoeuvre is simulated. Besides the basic requirement to precisely measure position and yaw rate, the biggest challenge is to synchronously record ECU internal parameters. Time-to-market is always critical and such mixed signal recordings enable time-saving improvement and fine-tuning of the complete system. Precisely defined test procedures are also necessary to guarantee reproducibility of testing.

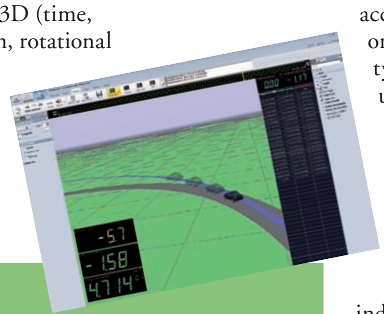
The DEWE-FS (Functional Safety) is an evaluation tool ideally suited for analysing the controllability (C) of a vehicle when a sensor malfunction is simulated. It comprises a mixed signal data acquisition system and an inertial navigation system (INS)/GPS sensor. It evaluates the OEM-defined rules that have to be fulfilled by stability control systems. The measure of interest is the delta yaw rate and what's derived from it, for example, lane deviation. Lane deviation must be determined online with a variation of ±2cm.

Position, velocity and angular rate sensing

An INS/GPS system is used to meet the specific sensing requirements for this application. The INS comprises three gyroscope channels to measure the rotational speed and three accelerometer channels to measure the linear acceleration. Based on these measured signals, the velocity and the relative position are analytically deduced. For drift correction – which is caused by limited sensor accuracies – impressed disturbances and integration steps, the inertial data is combined with real-time kinematic DGPS (differential GPS) data. Data fusion is achieved through the use of a Kalman filter within the navigation computer of the GPS/INS system. The Kalman filter ensures the optimal fusion of inertial measurements and GPS data, while the online calibration of sensor errors leads to a stable system performance. The strategy also allows for compensation for GPS outages and suppression of jumps in GPS position, while overall system accuracy is significantly better than individual accuracies. Position data can be obtained with high dynamic and high output rate, alongside highly accurate vehicle motion states and short installation times (strap-down). Finally, all measurement parameters are available in 3D (time, acceleration, speed, position, rotational speed, angle, etc) on the CAN protocol, while all parameters are available in body-fixed, horizontal and in geographic – north, east, down (NED) – co-ordinates.



An example of a potential test scenario



For testing the controllability of a vehicle during a (simulated) sensor malfunction, accurate lane deviation and yaw rate are needed, complemented by ABS/VDC internal data via XCP. The test vehicle is equipped with a DEWE-FS instrument and the INS/GPS system. The Dewetron data-acquisition unit synchronously records the data from the INS/GPS system, vehicle CAN or FlexRay data and ECU parameters over XCP, together with data from optional digital and analogue sensors and video images.

Dewetron's sync-clock technology is used to exactly time-tag all data sources. Within the data acquisition unit, a precise 80MHz system clock is generated and synchronised to the atomic clock reference signal of the GPS satellite. Dividing the system clock into multiple-phase synchronous slower clocks for analogue inputs, CAN data or video pictures ensures that all recorded data is in perfect sync.

Test scenarios

No test standards or test scenarios have been established for the evaluation of the controllability of a vehicle according to ISO 26262.

Driving a straight line with constant speed, driving a steady circle with about 0.5*g* lateral acceleration at constant speed, or driving a predefined curve are typical tests that are currently used for these evaluations. The procedure is always the same: the vehicle is run in a steady condition, then a sensor failure is simulated and the vehicle's reaction is benchmarked for typically one second after the impact of the failure induction – when the brakes intervene, for instance.

It is important that time is not taken from error induction because there might be 'sleeping errors' that only appear at the next movement of the steering wheel. The failure simulation is usually done through a gateway in the communication path from sensor to ECU, which distorts the sensor information. It can also be done directly in the ECU via XCP messages.

There is a great deal of potential to improve the functional safety aspects by following the guidelines of the upcoming ISO 26262. Performing reproducible test manoeuvres to achieve robust results is crucial to comply to the standard and to increase safety.

Detailed analysis

The following is one example of a scenario that could be tested. A test driver drives the car on a steady circle with a constant yaw rate of approximately 10°/sec, and then a malfunction of the yaw rate sensor is simulated by inducing a step function onto the CAN signal. The behaviour of the vehicle is measured and it leaves its track by 3.5m.

The DEWE-FS systems support quick test setup, driver guidance, recording of manoeuvres and even provide what's called a 'playstation mode' for following a virtual test track on a 3D display.

Definition of the test track can be achieved by charting cones or marked lanes on a proving ground, by defining track co-ordinates in the software setup or by recording a master ride. Each method is very easy to do.

Manoeuvres can be driven either following the markings on the proving ground or following the track on a 3D display on the screen.

The chance to freely drive a manoeuvre results in huge time-savings when testing in situations such as driving over an iced lake. The vehicle just needs to be in a steady condition for three seconds to enable solid prediction of the travelling path and for performing all the calculations after inducing the sensor malfunction.

Based on the high-quality data gathered, an immediate report can be generated or further analyses can be performed.

Global warning

Offering high levels of safety at an affordable price, this new 77GHz Mid Range Radar has the potential to enhance safety for all vehicle segments – and all over the world

AUTHOR PRAVEEN TAMANG, BOSCH, GERMANY
IMAGES COURTESY OF BOSCH

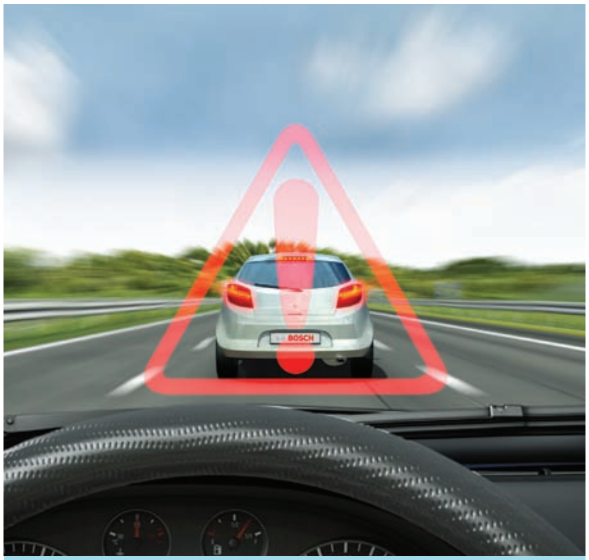
The new-generation 77GHz Mid Range Radar (MRR) from Bosch brings together three generations of radar development and manufacturing experience. A low-cost, scalable radar platform, MRR is specifically designed to provide affordable safety- and comfort-oriented features for all vehicle platforms.

Features

A wide range of comfort and safety features will result from using a single mid-range radar sensor. Adaptive Cruise Control (ACC) and a Heading Distance Indicator (HDI) enhance driving comfort by taking over routine driving tasks and/or by informing the driver about the headway distance to the preceding vehicle. Within a speed range of 0-150km/h, the MRR-based ACC automatically regulates the pre-selected distance or time gap to the preceding vehicle by accelerating or decelerating as the situation demands, or by gently applying the brakes.

The upper speed limit of 150km/h is sufficient to cover normal driving speeds within most countries' motorway speed limits. However, even with speed limits of up to 120km/h, dynamic approach situations with major differences in relative velocity can arise all of the time. Take, for example, a situation where an ACC vehicle driving at 120km/h approaches a vehicle that is slowing down due to congestion and driving at about 60km/h. The detection range of 160m enables the MRR to detect vehicles in its lane early so that a smooth ACC-regulated approach is possible. The smoothness of the ACC regulation and the avoidance

MRR-based Adaptive Cruise Control from 0-150km/h

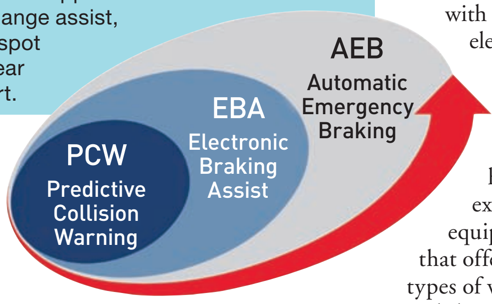


Key features of the 77GHz MRR

- 77GHz frequency band with global frequency release for automotive applications;
- Integrated Silicon-Germanium MMICs (Monolithic Microwave Integrated Circuits);
- Detection range: 0-160m;
- Field-of-view: 45°;
- Angular accuracy: up to 0.3°;
- Cycle time: ~50ms;
- Dimensions: 70 x 60 x 30mm (l x b x h);
- Auto-alignment capability;
- No moving parts, rugged vibration-proof design;
- Optional: sensor data fusion possible – e.g. with a video sensor.

MRR variants

- 24V variant for heavy trucks;
- MRR rear variant for applications such as lane-change assist, including blind-spot detection and rear cross traffic alert.



(Top) MRR enables safety features such as Predictive Emergency Braking System that help in avoiding/ mitigating rear-end collisions (Above) Predictive Emergency Braking System

of harsh braking manoeuvres are important in enhancing user confidence as well as acceptance of the system.

The high detection range is crucial for ACC performance, but other features such as field-of-view and angular accuracy are also important for mastering typical ACC scenarios such as vehicles cutting-in while changing lanes within a short distance to the ACC vehicle in front. A wide 45° field-of-view combined with an angular measurement accuracy of up to 0.3° enables the MRR to detect such situations early and avoid harsh braking reactions. The high angular accuracy is also essential to identify a vehicle to be 'followed' from a cluster of vehicles ahead, such as on a multi-lane motorway.

The 77GHz MRR's performance is not only key to good ACC performance; it is also vital when it comes to detecting imminent rear-end collisions. The safety features that are part of the Bosch Predictive Emergency Braking System – Predictive Collision Warning (PCW), Emergency Braking Assist (EBA) and Automatic Emergency Braking (AEB) – rely on the efficient and accurate measurement of relative velocity and distance to the preceding vehicle. In a critical situation, such as when the vehicle in front starts decelerating rapidly or braking hard, timing is essential. A collision warning to the driver can make all the difference.

German accident statistics show that prior to a rear-end crash, approximately half of all drivers do not apply the brake pedal hard enough, while 30% don't apply the brakes at all. Bosch has developed the Predictive Emergency Braking System to assist the driver in these situations. A separate Bosch study suggests that up to 72% of all rear-end collisions involving personal injury and fatalities could be avoided by using Predictive Emergency Braking Systems. Bosch already offers such systems based on long-range radar technology, and LRR3, the third generation of its Long-Range Radar Sensor, went into series production at the start of 2009.

The 77GHz MRR sensor is at the core of the Bosch Predictive Emergency Braking System, which assists the driver in critical situations with a whole array of collision-avoidance and -mitigation measures used in conjunction with Bosch's ESP. The MRR sensor continuously monitors the traffic situation ahead to assess the potential of an impending rear-end collision. If this is imminent, the PCW sends out an audible/visual warning to the driver and prepares the brake system to ensure that full braking power is available as soon as the driver reacts to the warning and steps on the brake pedal. The driver is therefore made aware of the danger and can react earlier to avoid the collision by braking or taking evasive action.

If the brake pressure applied by the driver is insufficient to avoid a collision, the EBA steps in and automatically increases the brake force to provide effective braking support. However, if the driver doesn't react to the collision warning at all, AEB is activated to give the driver more time to react or, if the collision is unavoidable, to reduce the impact speed and minimise the consequences of the accident.

The AEB system also includes a setting for low speeds, designed to avoid or reduce the impact of low-speed collisions, especially in urban areas. The low-speed variant works below 30km/h and reacts to both moving and stationary obstacles.

Why choose 77GHz?

Based on 77GHz technology, Bosch's Mid Range Radar is three to five times more accurate at velocity measurement and distance separation capability than 24GHz, the result of improved Doppler resolution with three times higher carrier frequency and bandwidth. The 76-77GHz frequency range with 500-1,000MHz bandwidth has worldwide coverage with radar output power levels, assuring good, uniform MRR sensor performance globally. As well as higher accuracy in velocity measurement, the extra bandwidth means that objects at a distance can be singled out better with the 77GHz MRR, minimising unnecessary or false system reactions. In comparison, the 24GHz narrowband (200MHz bandwidth) applications are also released worldwide, but they face radar output power limitations, for example in the USA and China. The higher integration level offered by the 77GHz MRR and its smaller size enables sensor integration in the vehicle with minimum impact on design elements.

The 77GHz MRR combines the performance advantages of 77GHz technology, which until now has been limited to more expensive long-range radar equipment, with a low-cost concept that offers radar technology for all types of vehicles. The worldwide release and the 77GHz frequency band makes the MRR a perfect global solution, with identical sensor performance assured in all regions. The 77GHz frequency band is almost exclusively reserved for automotive applications, so reduces the chances of interference from other frequency users. This makes the MRR ideal for fulfilling the requirements of existing and legislation-driven safety features such as AEB (applicable onwards for heavy trucks from 2013) in the near future.

Its competitive cost, small size and ability to incorporate a wide range of features with a single sensor make Bosch's new 77GHz MRR an attractive all-round proposition for road users. ‹

"ROAD LAYOUTS CHANGE AND BENDS ARE REALIGNED SO THE MAPPING COMPANIES HAVE TO KEEP THEIR INFORMATION UP TO DATE"

Around the corner

Digital map content is no longer just the domain of routing and navigation systems, but is increasingly becoming key for advanced driver assistance systems, spanning headlight control and preventative safety and accident mitigation applications

AUTHOR SAUL WORDSWORTH
IMAGES COURTESY OF BMW, CITROËN & NAVTEQ

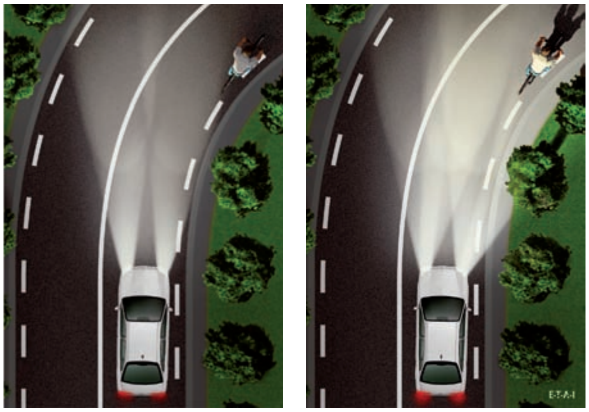
The integrated Intelligent Learning Navigation system from BMW can share information it has learned with other vehicles and therefore also benefit from their knowledge

Over the course of the past 15 years, advanced driver assistance systems (ADAS) have revolutionised vehicle safety. The likes of adaptive cruise control (ACC), lane departure warning (LDW) and electronic stability control (ESC) have all incontrovertibly enhanced road safety and many are now standard in new vehicles. Another automotive revolution from this period has been the mass-introduction of in-vehicle navigation systems, providing drivers with support in the difficult task of wayfinding through unfamiliar road networks. These systems work well independently – but what of their integration?

The ADAS Interface Specification (ADASIS) Forum was first established in 2002 as an industry platform for

ADAS suppliers, vehicle manufacturers, navigation system suppliers and map data providers to work together on developing what has been termed the ADAS Horizon Concept or 'Electronic Horizon'. Vincent Blervaque is director of Development and Deployment for ERTICO, and coordinator of the Forum that forms part of the EC-funded PReVENT project. "Sensors deployed in ADAS technology enhance safety by improving relevant contextual information to the vehicle," he says. "However, their range is generally confined to the vehicle's immediate proximity. With the use of enhanced mapping data, the vehicle can know in advance the sharpness of an upcoming corner, the gradient of the next hill or a change in the speed limit. Electronic Horizons inform the driver about the next stretch of road before he reaches it. All of this added information can further assist auto manufacturers in their quest for safety."

Chicago-based firm NAVTEQ develops the most widely accessed GPS navigation maps in Europe and North America. Bob Denaro is vice-president of ADAS for NAVTEQ. "Electronic Horizons bring an extra layer of predictability to driving," he says. "You've got sensors on the vehicle operating the likes of ABS and ESC, and another class of sensor such as radar and video looking down the road. With an Electronic Horizon your 'view' is extended further. Your car can see beyond the line of sight – around a bend for example, or over the brow of a hill – based on enhanced mapping data which is streamed seamlessly to the in-vehicle display."



3D maps could allow vehicle headlights to be swivelled or tilted in order to illuminate as much of the oncoming road as possible and in anticipation of the vehicle path

Practical application

"The loss of control on a sharp bend is not an insubstantial part of the accident picture," explains Oliver Carsten, Professor of Transport Safety at the University of Leeds. "Many of these kinds of accidents take place on rural roads at night, possibly in foggy conditions. With the benefit of Electronic Horizons, the advanced mapping information can not only inform the driver of the sharpness of an upcoming bend but compare the speed of the vehicle with the maximum recommended speed for that particular bend and if necessary automatically slow the vehicle."

In an LDW scenario, Denaro cites the fact that this particular ADAS uses video cameras to detect the sides of the road. "Unfortunately sensors can be fooled by obscured lines at the side of road or the sun shining into the camera," he says. "Enhanced mapping data can extend the capability of those sensors and warn the driver if necessary."

> "ENHANCED MAPPING DATA CAN EXTEND THE CAPABILITY OF THOSE SENSORS AND WARN THE DRIVER IF NECESSARY"

Progress report

The consortium partners on the Forum, including the likes of Tele Atlas, NAVTEQ, Volvo, Ford, BMW and ERTICO, are working together to drive the broad adoption of a standardised interface between in-vehicle ADAS applications and map data sources. This is achieved by aligning OEM requirements, delivering specifications and supporting implementation.

"As a result of the delivery of a standardised interface, we will be able to have different applications accessing the same data, as well as systems from different suppliers," says Blervaque. The advantages of this members-only forum include an acceleration in time-to-market, a reduction of development costs, and broader options for OEM and supplier cooperation and uniformity. "We are hopeful that we can create the interface within two years – that is our motivation," Blervaque says.

This is not to say that solutions do not already exist. The current BMW 5 Series and previous series have both featured the technology. The new Audi A8, meanwhile, features a limited version of Electronic Horizons, including a map-based headlamp control, while a number of Toyotas and Nissans in Japan also include these features. It is also fair to say that nearly all automotive manufacturers have such solutions in development. But for now, at least, nothing is standard and the Electronic Horizon concept is yet to spread beyond a small number of luxury vehicles.

"It's a patchy market," agrees John Craig, automotive product manager for Intermap Technologies, a leading mapping and data company. "The future of the Electronic Horizon market could be big but for now it is far from clear."

"The creation of a perfect Electronic Horizon solution will not be easy," adds Professor Carsten. "The more information that is required, the more responsibility there is to make sure it is accurate and precise. Such road data can be hard to collect and must be verified by teams of highly trained individuals. Road layouts change and bends are realigned so the mapping companies have to keep their information up to date. No one wants to provide duff data. Such companies will only collect data if they see a market for it. Mapping for

Fringe benefits

"If we can solve the problem of aggregating data and allow companies to look at the data, we are going to come to understand that there are stretches of road that for whatever reasons seem to experience a disproportionate number of accidents," says Bob Denaro of NAVTEQ. "When we start seeing clusters of crashes at particular intersections or on certain roads, we may not know why these areas are dangerous but the data is still valuable as it can be used to warn vehicles of accident black spots. The application of this kind of information could, for instance, also be useful for insurance companies and the law enforcement."

Ahead of the curve

In 2006, a large-scale trial was undertaken by the University of Michigan Transportation Research Institute to measure a number of vehicle safety features, including the effectiveness of curve speed warning systems. This system alerted volunteer drivers to their speed and recommended they slow down if they were approaching a curve too quickly.

When asked at the end of the trial whether the curve speed warning system would prevent them from driving into curves too fast, only a small number of participants agreed this was the case. Many voiced concerns about the system's reliability and felt that such a system would only be useful when approaching an unfamiliar curve. In addition, some stated that as a result of false alarms or situations when the system did not warn when one was expected, some drivers might begin to ignore the system. Overall, the data could not confirm a change in a driver's curve-taking behaviour.

Although this is not a like-for-like experiment, it does underline the value of Electronic Horizons operating in unknown surroundings and the importance of ensuring any system on the market is as accurate and reliable as possible.

ordinary navigation is not too demanding. But it's far more demanding for applications such as Electronic Horizons."

NAVTEQ is one company that does see a market. It has already created its own solution, simply known as 'Electronic Horizon'. "Unlike most other companies, we have always systematically collected much of the information required to enhance ADAS systems, including road geometry, speed limits and exit lanes. More recently we have gone back out and mapped with great precision curvature values and included the additional parameters of height and slope. Beyond that, the super-elevation of the bank of the road would be useful. This information will be gathered in due course." Denaro's desire is to make Electronic Horizon an affordable, standard feature in all vehicles. As such NAVTEQ has developed a scaled-down solution with limited road attributes – only those essential to ADAS.

The MAPS&ADAS subproject of PReVENT is driven by needs identified by the ADASIS Forum with regard to the use of digital maps as primary and/ or secondary sensors for ADAS

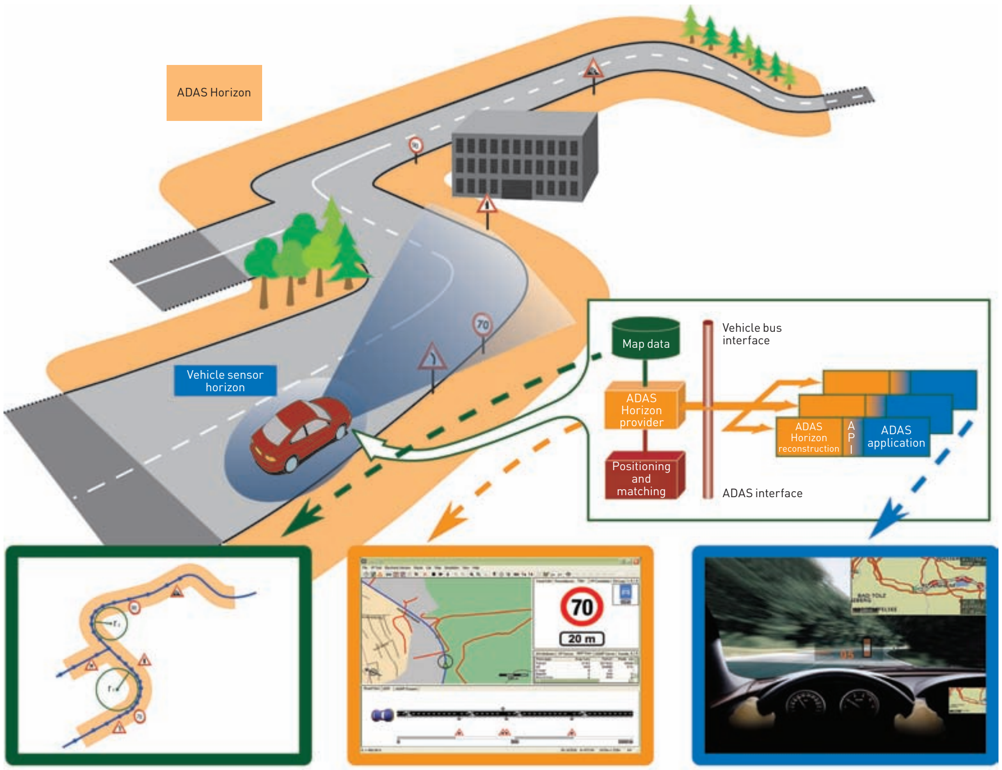
"It's a printed circuit board the size of a business card," he says. "That's the entire hardware, software and data in there. Hopefully this simple, cost-effective solution can go some way to introducing ADAS to the masses."

Unlocking the potential

Regardless of NAVTEQ's own solutions, Denaro believes that hidden within Electronic Horizons lies the key that could unlock this potentially life-saving advancement to a wider audience. "An excellent use of ADAS will be improved fuel economy," he says. "If the vehicle knows about an upcoming slope it can adjust the powertrain via its ACC to drive more optimally. This could prove very popular – but may also be the way Electronic Horizons become standard. Once any solution is in situ it can be used in conjunction with all ADAS safety systems."

It is likely to be smaller vehicles rather than the luxury end of the market that will generate greatest interest in improved fuel economy. A genuinely marked improvement is an attribute that would add sufficient consumer value.

"Fuel economy will typically go up by between 10-15%," Denaro concludes. "That could well be incentive enough for such a system to become standard. It is my belief that through improved fuel economy, the Electronic Horizon concept will catch on. I only wish it would happen more quickly but I am sure that within five years, there will be many cars enjoying the safety benefits of Electronic Horizons."



ADAS map ADAS interface ADAS applications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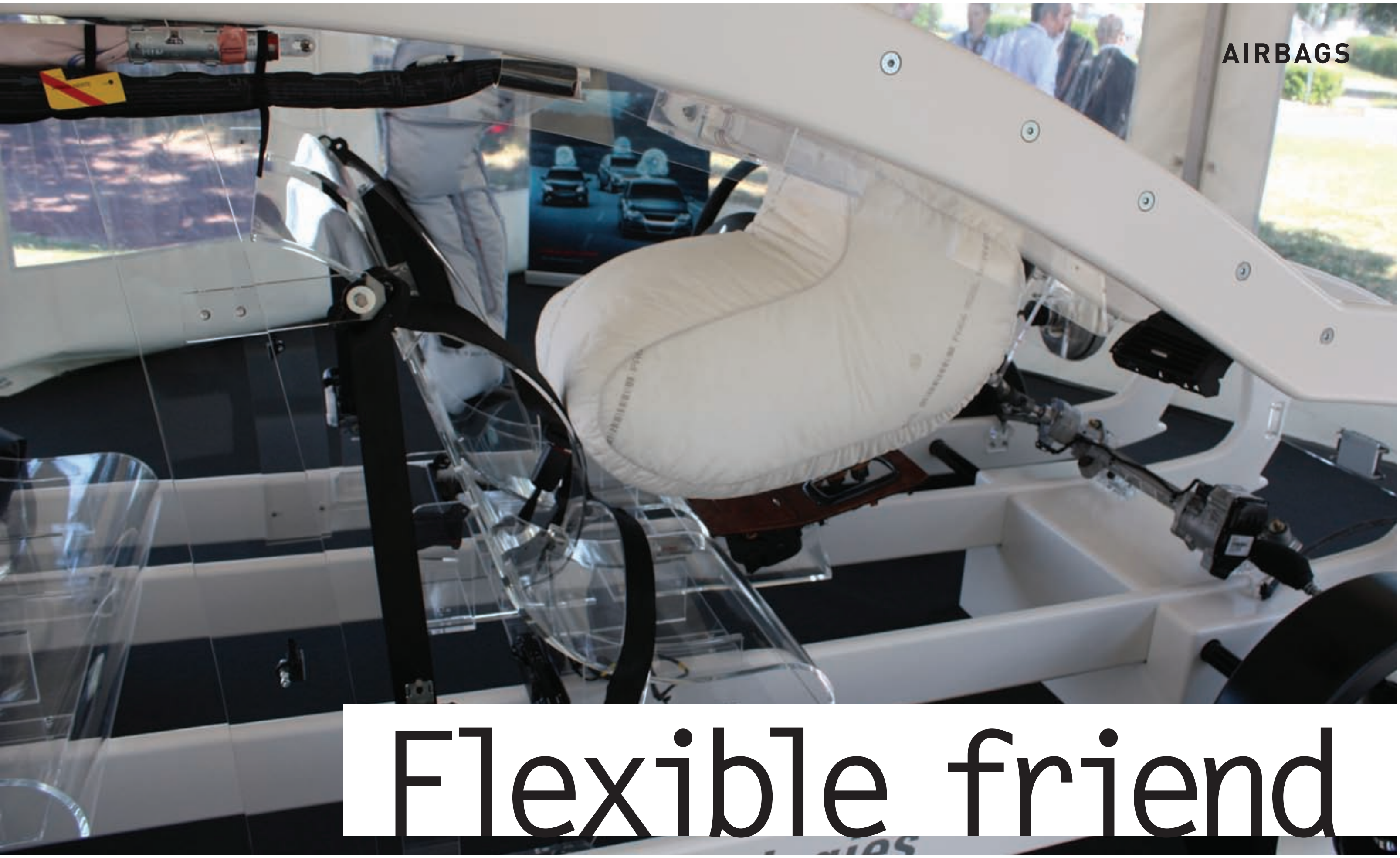


Flexible friend

A smart airbag system integrated into the vehicle roof not only offers enhanced protection for occupants, but also provides OEMs with cost and design flexibility advantages

AUTHOR ALFONSO BUSTOS, TRW AUTOMOTIVE, GERMANY **IMAGES** COURTESY OF TRW AUTOMOTIVE

Airbags are central to vehicle occupant safety and in recent years the life-saving potential of the technology has become increasingly clear. Widely accepted to have saved more than 25,000 lives around the world, the airbag has also helped prevent serious injuries to many times that number of people.

As a result, legislators, consumer groups and the automotive industry itself are focusing on the continuing development of such passive systems. Vehicle manufacturers, particularly those selling into Europe, North America and some regions in the Asia-Pacific market are looking to achieve four- or five-star ratings for new vehicles through the installation of various airbag technologies.

Safety systems are becoming increasingly versatile – both active and passive variants. With the increasing focus on reducing road fatalities, vehicle manufacturers and suppliers are developing new and innovative ways to protect occupants, one area of focus being the design and configuration of airbags.

TRW has developed what we consider to be a unique 'bag-in-roof' technology that helps reduce potential passenger injuries and replaces airbags typically mounted elsewhere in-vehicle.

The system gives designers more freedom and eliminates the risk of injury to passengers resting their feet on the dashboard

As a result, this gives designers more freedom and allows for improved appearance, function and ergonomics.

The new roof airbag offers several advantages – an important one being that it eliminates the need to package a relatively large passenger airbag in the instrument panel, which can significantly reduce the development costs of the dashboard as there is no need to engineer a specific 'door' that opens with the airbag deployment. It is also functionally compatible with a wide range of constructive vehicle architectures.

The airbag unit comprises a cushion and a gas generator, which supplies the gas to the cushion in the event of an impact. The product also offers easy assembly with opportunities to standardise as some of the components are common to all applications.

Various studies have shown this kind of airbag technology has the potential to enhance the protection of vehicle occupants if they're out of position – for instance leaning forward or resting their feet on the dashboard. We have undertaken development work for the new bag-in-roof technology over the past two years with a major vehicle OEM in Europe, which has resulted in the award of a significant production contract.

Quick thinking

A six-dimensional stereo camera to detect objects faster could be used to initiate full emergency braking should a driver fail to react to a pedestrian in the road

AUTHOR WILFRIED MEHR, CONTINENTAL, GERMANY **IMAGES** COURTESY OF CONTINENTAL

Of the 35,050 people that were killed in traffic in Europe in 2009,[1] 6,853 – or 20% – were pedestrians, while 70% of these died in a city or town. The biggest single problem in city traffic is distraction; at times there is just too much going on to notice the pedestrian who emerges between parked cars, or to see the other car approaching the junction. A moment of distraction can be enough to cause an accident.

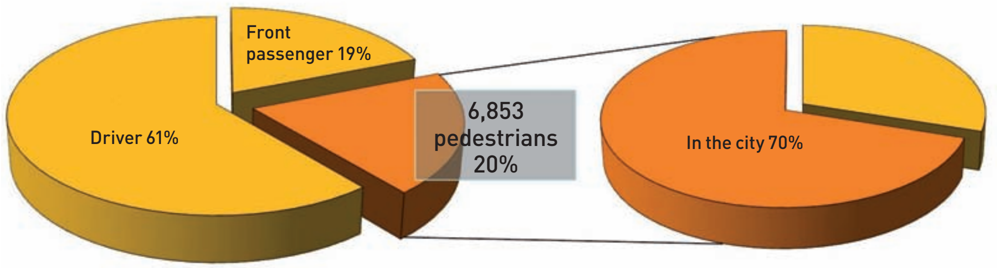
Pedestrians and cyclists are in particular danger and the European Union has reacted to this by demanding better pedestrian safety.[2] The ideal way to achieve this would be to avoid hitting a pedestrian or cyclist, but if that's not possible, the second most important measure is to mitigate the impact. Emergency brake assist functions aim to help drivers in situations when they step on the brake, but do not do it wholeheartedly. Typically, the first generation of a collision mitigation system will only intervene when the driver begins to react. However, in 37% of all fatal pedestrian accidents, the driver doesn't even touch the brake pedal.[3] Further improvement will therefore depend on forward-looking brake assistance and a number of vehicle models are already equipped with forward-looking collision mitigation braking systems. Two of these – the Volvo S60 and the Lexus LX – explicitly brake for pedestrians and both systems are based on a combination of long-range radar and camera technology. As there are still quite a few accident scenarios that cannot be addressed by today's technology, Continental is developing a forward-looking emergency brake-assist function as a new part of the ContiGuard safety system. The system uses a high-resolution stereo camera to identify any kind of obstacle in a shorter time and with high accuracy – in particular pedestrians and other vulnerable road users.

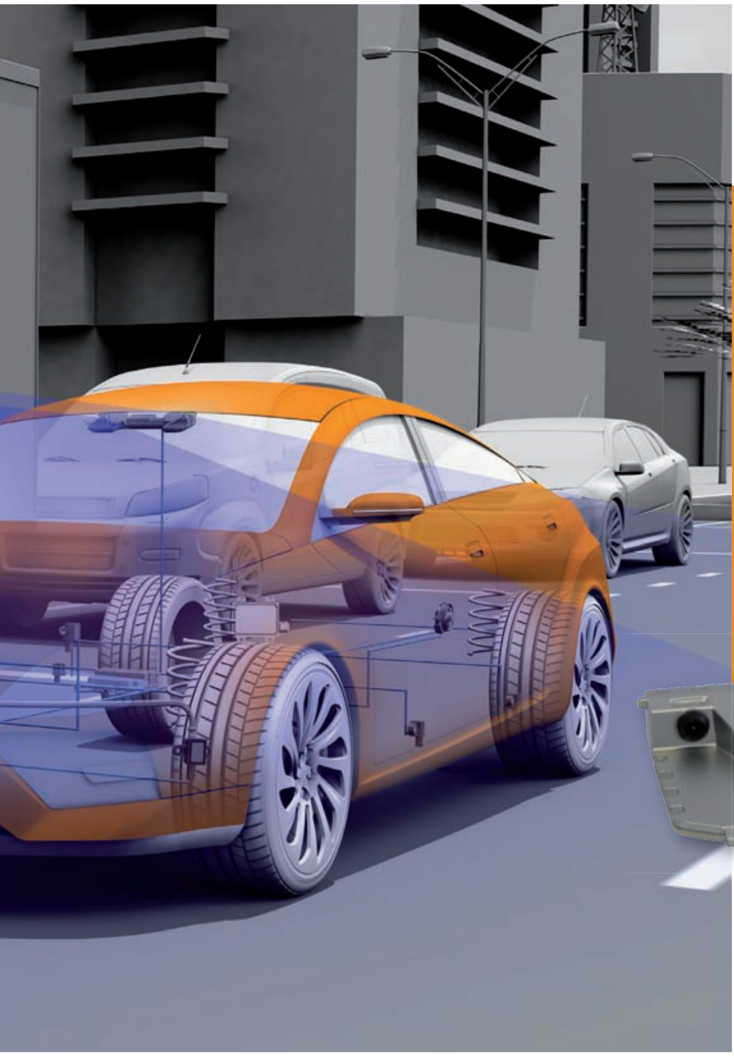
The stereoscopic view

Two CMOS mono cameras are installed roughly 20cm apart and a megapixel chip in each camera provides the greyscale and colour information that is interpreted inside the camera housing. The images from the left and right optical paths are then matched to check for correlation and if an area with similar characteristics is identified by both cameras, this is a first-level confirmation of a potential object.

However, the 'binocular vision' of the stereo camera has more to offer. Based on the parallax provided by the two optical paths, the signal interpretation algorithm immediately calculates the distance to the potential object and thus adds the third dimension. This is achieved with a high

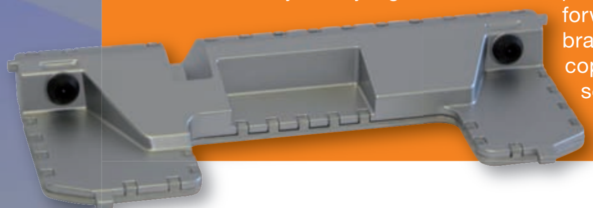
Chart shows fatalities in the EU for 2009





Stereo vision explained

Using stereoscopic vision has a number of advantages for driver assistance. Firstly the distance to an identified object is known precisely, which makes it possible to use the remaining time before a potential collision in the most efficient way. Also, using two cameras increases the certainty of object classification. Once an object has been identified and verified against the six-dimensional (6D) list of criteria, the level of certainty is very high. 6D object identification is particularly helpful when there is little contrast between an object and its background, or when the object is partially obscured. The stereo camera can also identify unusually shaped objects, in particular pedestrians (including children and wheelchair users), with greater precision. Last but not least, the stereoscopic vision can be used to identify possible trajectories to avoid a collision. Overall, stereo vision will improve the performance of the forward-looking emergency braking system so that it can cope with more accident scenarios than existing technologies are able to do.



level of precision; within 20 to 30m, the distance calculation will be correct to within 20 to 30cm. In contrast to radar, this superior resolution is available in situations where several objects are located close to one another. Radar has difficulty differentiating adjacent objects due to signal backscatter and mono cameras are unable to achieve the precision of the stereo camera either. Before estimating the distance, a mono camera needs to know what type of object it is looking at. Objects that it has not been 'trained' to recognise can therefore not be identified. Although this technology works well for vehicle recognition and the classification of clearly visible pedestrians, non-standard obstacles, partially obscured vehicles or pedestrians will go unnoticed.

Continental is leading development efforts in pedestrian protection

6D instead of 3D

Another key advantage of the stereo camera technology is its analysis of each single pixel. As well as the three-dimensional object information, each relevant pixel of the extracted objects is observed for its direction of motion. The optical flow and the change of the object's size over time will reveal pixel movement on the horizontal, vertical and longitudinal axis. Relevant objects in front of the vehicle are therefore identified by having common features on a six-dimensional scale. This offers unique reliability and enhanced performance for ADAS.

Suddenly it is possible to envisage a forward-looking emergency brake system that reacts to all kinds of obstacles and that can cope with many more accident scenarios than today's technology. By combining the detailed 6D information with pedestrians' appearance characteristics, the certainty of the equipment recognising an object reaches the required level of reliability to initiate full emergency braking if the driver doesn't react.

The Vienna Convention[4] dictates that a driver must always be in control of his vehicle. As a result, autonomous emergency braking may only be initiated if the driver can no longer physically avoid an impact. Only then will the forward-looking collision mitigation system intervene and take over. This reduces the remaining time before a collision for full braking (up to 1*g*) to less than 0.6 seconds on average.

Considering this short time span, it becomes obvious why object recognition must be highly reliable. Continental's solution also works on pedestrians such as wheelchair users or small children, as well as partially obscured pedestrians stepping out between parked cars.

The stereo camera method offers a further benefit. Due to its accurate measurement of the road surface and any 3D objects on the road, it can be used to analyse the road and check if there is a possible trajectory that would avoid a collision. If there is not, the warning and braking can then be triggered earlier, which will gain valuable hundreds of milliseconds for deceleration – and may save a life.

One study[5] found that current brake-assist solutions can realistically prevent around 6% of serious accidents, but adding the forward-looking capability doubles this to 12%. If the forward-looking emergency braking assist avoids a collision between a pedestrian and an oncoming object, this would boost the potential to roughly 41%. Continental's technology will help to exploit this potential. Clearly it will be a high-end system initially, but it is an all-in-one solution that can also support technology for lane departure warning, intelligent lighting and traffic sign recognition. ❮

[1] *EU: CARE 2009 report*

[2] *EU: Regulation (EC) No 78/2009*

[3] *GIDAS 07-2009;* Equal Effectiveness Study *Hannawald & Kauer*

[4] *Economic Commission for Europe. Convention on Road Traffic. Article 8. Vienna 1968*

[5] *Bende, Hummel, Kuehn:* Benefit estimation of ADAS for cars derived from real-life accidents. *German Insurers Accident Research, No. 09-0317*

Children first

A new development from a world-leading authority on child safety has helped to reduce the severity of injuries resulting from side-impact crashes

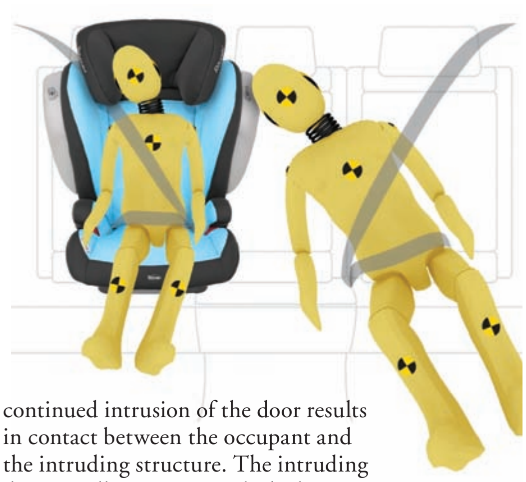
AUTHOR FARID BENDJELLAL, BRITAX CHILDCARE GROUP, GERMANY
IMAGES COURTESY OF BRITAX

Side impacts are the leading cause of severe injuries to children involved in lateral collisions. According to a NHTSA study from 2008, they represent 60% of AIS3+ injuries to those aged between three and 10 years. AIS (Abbreviated Injury Scale), the injury scaling system, provides a reasonably accurate way of ranking the severity of injury – on a scale of 1 to 6, with 1 being minor, 5 severe and 6 being an unsurvivable injury. The study additionally showed that the head is the most frequently injured body region – for nearside occupants the corresponding frequency of injury is twice that of the torso. A 2006 US investigation of 62 crashes, meanwhile, looked into AIS2+ injuries to different body areas for nearside, centre and far-side occupants, which showed that 70% concern the head and face areas, with just 7% related to the thorax. It's a similar scenario in Europe, with the 2006 CHILD Programme showing 75% of the injuries were to the head.

It's clear from all of these studies that the head is the key part of the child's body to protect in side impacts.

Physics of side impacts

So why are side impacts so severe? When a nearside door is impacted by another vehicle it intrudes laterally into the passenger compartment. Once it engages with the door-sill, the whole impacted vehicle will be subjected to a lateral movement. During this phase, occupants tend to move against the intruding structure. The combination of the movement of the occupant towards the intruding structure and the continued intrusion of the door results in contact between the occupant and the intruding structure. The intruding door usually interacts with the lower part of the occupant's body, forcing the head to rotate towards the struck side.



SICT has been designed to absorb as much impact energy as possible to protect children in side impacts

The SICT (Side Impact Cushion Technology) solution for child restraint systems (a convertible seat for the USA and a booster version for Europe) was developed by Britax to help limit the effects of side impacts involving children. It consists of an air-filled cushion attached to both wings of the CRS. It acts as an interface between the door and the CRS and it absorbs impact energy as it simultaneously compresses and releases air.

Regulatory requirements relating to side impacts for CRS vary between countries. When development of SICT started, a test method and performance criteria using an anthropomorphic dummy had been established in Australia since 2004. In Europe, though, no mandatory test existed, just consumer testing (Stiftung Warentest/ADAC). In the USA, there was neither consumer nor mandatory tests.

Side-impact test of the SICT-equipped CRS

Testing of SICT

Britax therefore developed an internal side-impact test procedure, using a mixture of sled tests (corresponding to the most stringent ADAC tests), as well as simulations and pendulum tests. The relative effectiveness of the new system was established via comparative sled tests using the same CRS with and without SICT. Peak-to-peak comparisons showed a reduction of approximately 17% of maximum head acceleration and 30% of maximum chest acceleration in the US fixed-door tests. In the EU fixed-door tests, performance indicators similar to those used by Stiftung Warentest/ADAC were considered – HIC, head, chest and pelvic accelerations, head lateral displacement and neck loads. On average, the SICT offered a substantial reduction across all of these parameters. Of particular note, though, head and chest acceleration in the EU tests were reduced respectively by 21% and 40%, while film analysis showed that the head remains contained within the seat throughout the whole motion. The tests using the new draft EU intruding door method showed also the same positive outcomes despite the fact that the method is more severe.

SICT is not the panacea for injuries to children resulting from side impacts. It's an accompaniment to continued enhancements to the vehicle structure to reduce intrusion, and/or energy absorption elements in the passenger compartment, as well as more general improvements in passive technologies such as side-curtain airbags, with sizes adapted to child anthropometry. ‹

Check points

The development of an intelligent, automated tyre tread depth measurement system is a win-win situation for everyone, benefiting truck drivers, other road users, enforcement agencies and the environment

AUTHOR DIETMAR SCHWALM, PROCONTOUR, GERMANY
IMAGES COURTESY OF PROCONTOUR

We all know that the condition of a vehicle's tyres is essential to remain in full control out on the road. But can you actually remember the last time you checked the profile tread depth or air pressure on your own tyres? We mostly forget – or leave it for a more suitable time. Removing the small valve cap and bending down to operate the tyre inflator is an inconvenience. It's just as inconvenient to use a coin or a tyre tread depth gauge to check the profile depth. Both checks are of utmost importance to increase the safety on our roads, yet they're being carelessly neglected.

Wouldn't it be nice to measure all important facts about tyres just by travelling over a sensor in the road? Such a system is already a reality. High-speed digital cameras combined with laser technology and intelligent software algorithms have the ability to measure the tyre tread depth and the tyre pressure of each single tyre, while tyre wear patterns can also be detected to obtain information about possible incorrect toe and camber settings. Axle load can even be calculated with the captured tyre data.

By employing such a system for routine checks, police forces can preselect vehicles with tyre conditions that might be a concern. Of course, deficient tyres are just one part of the potential technical defects that might be detected on a vehicle, so by making tyre checks easier, such an asset significantly increases an enforcement agency's efficiency. This subsequently leads to fewer undetected dangerous vehicles on our roads. For the driver concerned, the mere hint that the profile depth could be near to the legal (and thus safe) limit would lead to some exchanging their worn-out tyres promptly, instead of waiting until a dangerous aquaplaning scenario.

ProContour H3-D now offers a multifunctional and automated measuring system for detecting tyre tread depth, air pressure, tyre type and also wear patterns in flowing traffic

The automated measurement of tyre conditions is also recommended at border controls to ascertain the technical condition of HGV traffic. Foreign trucks with serious technical defects are currently detected by chance, yet most travel undetected for thousands of kilometres across Europe – or they appear in tragic news stories with horrific footage involving fatalities. This has to be avoided – and can be avoided. In the case that each HGV passes a tyre tread depth sensor when crossing the border, tyre conditions can be detected easily and officers could refuse entry to that vehicle. Automated tyre checks may halt urgent deliveries, which could potentially force owners/operators to apply some due care and attention in relation to the care of their fleets.

In this context, it's worth noting that automated tyre tread depth measurement systems are also able to detect axle load so by calculating the total vehicle weight, overloaded vehicles can be effectively targeted. Such vehicles are an all-too common and dangerous sight on roads worldwide, and are disproportionately involved in serious accidents, particularly in developing nations such as India, China, Africa and South America, where they are responsible for a huge number of accidents, resulting in death and serious injury. These could be reduced by checking trucks at parking areas using automated tyre tread depth measurement systems, as successfully demonstrated in the ASSET Road project.

Persuading people to care more about their tyres, 'supported' through regular routine checks by the police will reduce the number of accidents and casualties. Furthermore, correct tyre pressure and/or correct toe and camber settings will reduce fuel consumption, helping to reduce CO_2 emissions while extending the lifetime of the tyres themselves. The automated measurement of tyre tread depth is a huge benefit in all these respects. ❮

Visual aid

Reflecting the seemingly conflicting needs of bringing more information in-vehicle and reducing the time a driver needs to divert his eyes from the road, BMW unveils a new concept

"THE DRIVER CAN ASSIMILATE IMPORTANT INFORMATION FASTER AND TAKE APPROPRIATE ACTION"

Head-up display (HUD) technology is an area where much effort is being invested in developing safe and efficient solutions. BMW has assumed a pioneering role with its Vision ConnectedDrive concept. Part of this new range is an enhanced HUD that provides a three-dimensional display of information and icons. In essence, this offers an optical fusion of the actual view of the road ahead with virtual content. It can be used for tasks such as projecting route information on upcoming junctions in relation to the driver's actual field-of-view.

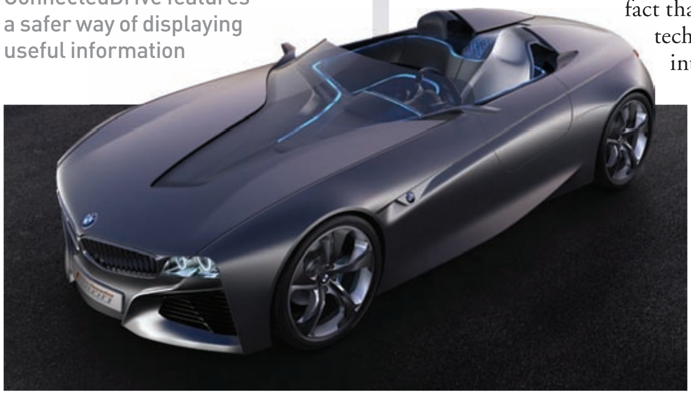
This new HUD has been installed in BMW's concept vehicle alongside a freely programmable instrument cluster, whose display complements the projections generated by the HUD. Information can be displayed in the foreground or the background, depending upon its relevance and current traffic conditions. This enables individual pieces of information to be optically emphasised to a greater or lesser degree depending upon the driving situation, to gain the appropriate amount of attention. Tailoring the system in this way means that drivers are less at risk of being bombarded with a continuous flow of extraneous information. The fact that the display is in the driver's line of vision also has obvious safety merits and BMW is respecting the fact that any new in-vehicle technologies being introduced today must not take a driver's eyes off the road. Providing timely guidance without distraction is the aim.

In the Vision ConnectedDrive, a large section of the windscreen acts as an HUD and BMW has designed this to become the main display interface for the driver, rendering a conventional instrument cluster obsolete. All real-time journey information (such as speed, navigational details or warnings) is projected onto the windscreen. This information is directly in the driver's field-of-view; it appears as if it is hovering above the bonnet.

The display technology's ability to superimpose different pieces of content on the HUD means that the driver only focuses on the information he needs at that moment. For instance, the speed of the vehicle will remain visible in the background while current information on routing or warnings is being displayed in the foreground.

An additional feature of the HUD is something that BMW describes as "augmented reality": this means that the actual driving situation can be overlaid with virtual information to enrich it. What this boils down to is simply that the driver sees more. The HUD places the additional virtual information precisely over the actual driving situation. To take one example, this enables the superimposition of navigational information on the street itself or the highlighting of hazards such as vehicles or pedestrians. As a result of this, the driver can assimilate important information faster and take appropriate action. ‹

BMW's Vision ConnectedDrive features a safer way of displaying useful information



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