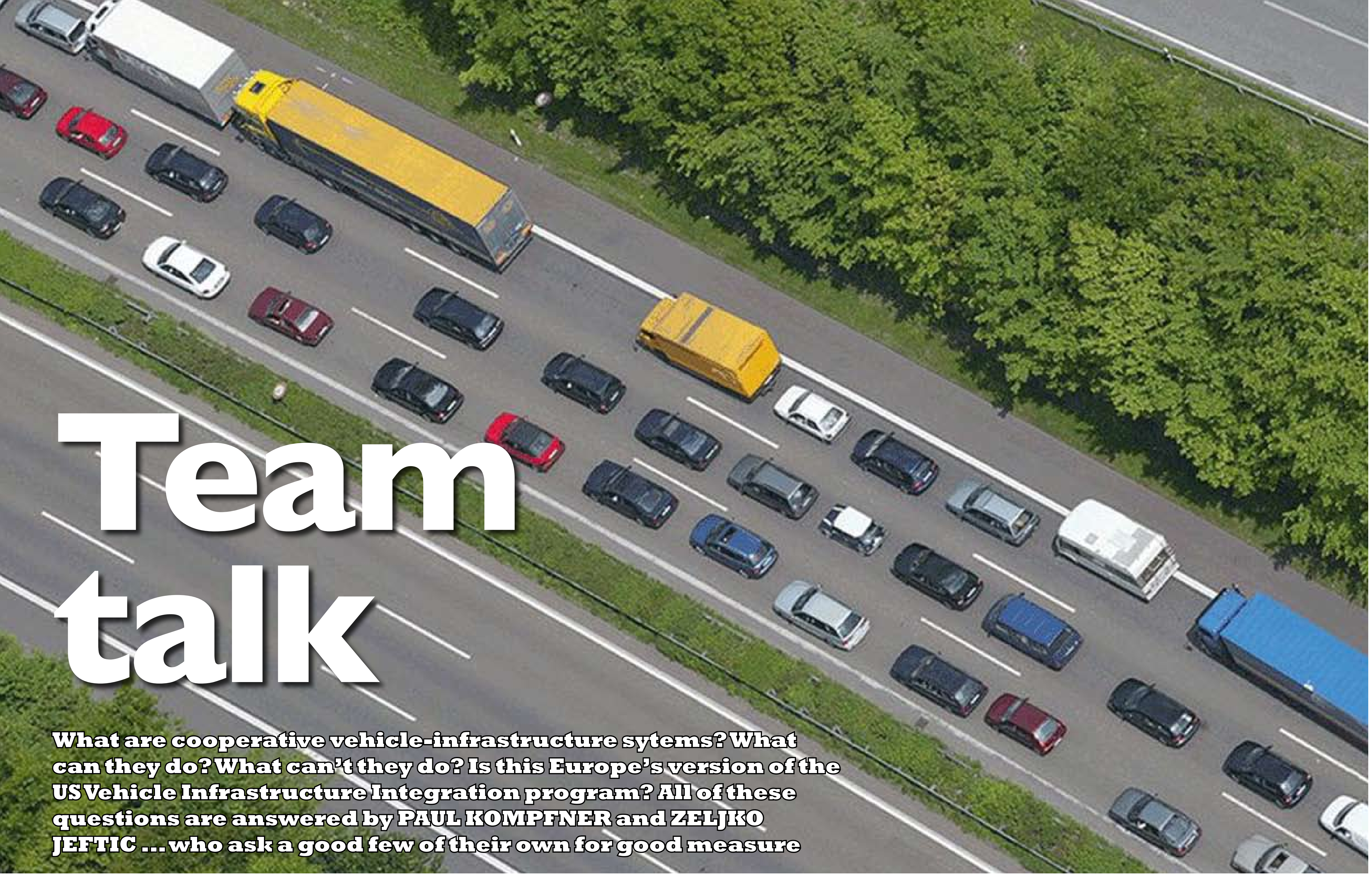

Team talk

What are cooperative vehicle-infrastructure sytems? What can they do? What can't they do? Is this Europe's version of the US Vehicle Infrastructure Integration program? All of these questions are answered by PAUL KOMPFNER and ZELJKO JEFTIC ... who ask a good few of their own for good measure

This year it appears to be the fashion to talk about "cooperative systems," "the always connected car" or vehicle-to-infrastructure communications.

There seems to be universal agreement that the future of telematics will be the car that communicates. Indeed, the European Union is putting over €50m of R&D money into a group of large-scale projects that are intended to establish Europe as the global technology leader in this domain. Of course the proof of the pudding is in the eating – in this case in what proportion of the roadside infrastructure will be equipped to communicate with cars, and likewise how many new cars and other vehicles will roll off the production line with a series-fit embedded communication system.

This article, by the management team of the EU "CVIS" (Cooperative Vehicle-Infrastructure Systems) project, takes a sideways glance at cooperative systems, and asks some probing questions about what they are, how they might work in practice, who needs to play a part in their operation and what "deployment" means for cooperative systems. Let's begin with a visit to the future…

A day in the life of cooperative systems…

What will tomorrow's world look like once drivers, pedestrians, vehicles, portable devices, roadside infrastructure and centres can talk to each other? Let's follow Stephanie on her trip to work and see how the paradigm of driving has changed for her now she can benefit from a wide range of cooperative mobility services.

It's 7.35am on 17 March 2014, and Stephanie is woken by the alarm on her cooperative mobile phone. The phone knows her agenda for today, and has just been alerted that there's been an accident on her preferred route to work, with an expected delay of 10 minutes. The alarm wakes her up earlier than usual and tells her she'll need to take a detour. After a shower and breakfast she gets into her cooperative vehicle and leaves for the office.

Throughout her journey the vehicle screen displays a speed recommendation transmitted from the cooperative traffic system, as well as the status of the approaching traffic signals. She knows from experience that if she keeps to the suggested 65 km/h speed she can pass through the next few intersections without being stopped by a red light. At the same time, she might earn extra "green points" as a cooperative driver, credits that she could cash in later for access to environmental controlled zones, or to the right to use city-centre bus lanes whenever there is spare capacity.

Further along her trip she stops before a traffic light that's blinking red, which is accompanied by an alarm and a message on the display saying an emergency vehicle is approaching. A few seconds later a fire engine races across the intersection from her left, riding a "blue wave" of synchronised green lights all along its route to the scene of the fire. The cooperative emergency management system even sends new route advice messages to the other traffic, diverting drivers away from the incident area. Stephanie follows the updated advice and turns off her usual route for a few blocks, until she's passed the fire scene and can rejoin the main road.

Nearing the end of her journey, Stephanie gets a message from the vehicle behind her. It happens to be her neighbour Julie, saying hello and asking if she has time for a coffee – she accepts, as her trip was turning out to be quicker than expected. After a short break, when her car dispatches a few quick mails she dictated earlier for her office colleagues and clients, Stephanie is guided to the parking space reserved for her today, and arrives at the office.

All along the journey, Stephanie's car has been connected to the roadside data monitoring service and has downloaded data on its position, speed and heading, and extra information about the trip coming from the car's sensors. The cooperative monitoring centre has processed this data with that from the thousands of other vehicles on the road, and has used the real-time traffic data to provide routeing recommendations to its service customers. Stephanie's entire journey was safer, faster, cheaper and "greener" thanks to the new cooperative systems.

So what are "Cooperative Systems"?

Before they can cooperate, systems must first of all give, take and share information with each other. While systems individually may hold vast amounts of information, stored in the vehicle, in roadside equipment, in control and management centres and in mobile devices, these are usually organised vertically, with one organisation running the entire chain from data collection and processing to data delivery. If this information can be shared with other, cooperative services and applications, then all members of the cooperative mobility community - driver, passenger, traffic operator, emergency agency, fleet manager, pedestrian, etc - can benefit from it, and real synergy can occur.

Beyond information sharing, systems can cooperate in the sense of modifying their behaviour in the light of knowledge of others' actions and intentions, even negotiating amongst each other. This already happens in a limited way at unsignalised or four-way stop junctions, when simple rules may apply, such as priority from the right or "first-come first-served". Such interaction can become much more sophisticated and bring widespread benefits if based on collective data collection and information sharing – provided that drivers obey the rules and follow the advice.

Key building blocks

The essential technology elements that need to be in place to support cooperative mobility include: wireless communication networks, wireless communication and positioning units in the vehicle, wireless and fixed communication units attached to roadside equipment, management, control and service centres running

cooperative applications, and the interface to users.

For its basic communication technology, the CVIS project has settled on CALM (Continuous Air-interface Long and Medium range communications) architecture and specifications, based on standards developed in ISO TC/204, working group 16, as its basic communication technology. In order to maintain a continuous network connection while a vehicle is moving at speed, CALM enables use of all suitable existing communication channels, e.g. UMTS, and facilitates the integration of new ones as they are rolled out, e.g. WiMAX.

The ability to use flexibly different communication channels should lead to a high quality of service and reduced communication costs. It also means that early services can be rolled out using existing networks.

However being able to talk is still not good enough, cooperative systems need to speak the same language in order to understand each other. The CVIS project is devising a common language comprising a set of protocols and data models for a set of core application modules around which real applications and services can be developed. These common software modules allow applications to interact with users in their own language, while the open application management environment provides both a set of basic core services as well as an open platform for any kind of new collaborative service. Accurate positioning is a key requirement for cooperative systems, and the CVIS core platform includes an advanced positioning and mapping module. This will use GPS and Galileo (when available), as well as techniques based on the radio communication systems themselves, such as triangulation from wireless network nodes and registering the location of nearby transmitters such as Bluetooth. To provide sufficient accuracy, high-precision local maps of key infrastructure need to be created, that can be linked with real-time data on the position of the vehicles that happen to be nearby at that moment. In this future architecture, probably the greatest uncertainty concerns just which organisations need to be present and what they need to do. We look into this question in more depth below.

Last but not least, the human being is the most important element in any cooperative system. The general approach in current cooperative system developments worldwide is based on providing drivers with information, guidance, advice and even commands (in the case of traffic control), but never actually taking over control of the vehicle. Although this would of course be quite possible even with today's technology.

The driver is the centre of attention

Although one could be forgiven for thinking that the vehicle is at the heart of cooperative systems, with all the talk of "vehicle-to-vehicle" and "vehicle-to-infrastructure" communications, in fact ultimately a human being will be the object of such communications. While the simplest of cooperative systems will simply redistribute to the driver as traffic information the data just collected (with his consent of course) from his "probe vehicle" as it circulated in the road network, it is likely that more complex systems will be developed that require or allow a driver to follow advice or take the initiative.

As an example, a system may send to each driver who happens to be within a cluster of vehicles approaching a traffic light an individualised recommended speed which, if he maintains that speed, will allow the cluster to pass on green and avoid stopping. To benefit, each driver must comply voluntarily with the speed recommendation. Success of this idea will depend on drivers learning quickly that they will get real benefits if they follow the advice.

The personal touch

If cooperative systems are a kind of club, we can ask how an individual would become a member. Will this be automatic once he buys a "communicating car"? Will his car "talk" freely (and free of charge) to any suitably equipped roadside equipment without further ado? Or will he need to sign up for specific cooperative services – even to pay for them? Will there be a mix of free and pay services?

Following this thread further, we can look at the person at the centre of the cooperative community. Since the collection of monitoring data from road users is such an important element in the cooperative cycle, users' willingness to provide these data will be critical. They will need to be processed anonymously and in complete security, to avoid fears of a mass-media hyped "Big Brother". Given their value, users who provide data could be offered credits towards their service subscription. This leads to the question of how users would "buy" cooperative services, whether singly or in bundles, and from whom. City residents might become subscribers to personal travel services provided by their local traffic authority, such as route assistance or parking services – these might be free of charge to locals but incur a fee for visitors.

Cooperative organisation

Probably the greatest uncertainty surrounds the question of which are the organisations that will need to be involved – or even to be set up – to make cooperative systems work. Clearly the vehicle manufacturers have a role, even if only to ensure that new vehicles will have the appropriate equipment installed. But once they can communicate directly with each vehicle they sell – and with each owner - why shouldn't they seek to become a service provider to their customers, adding "vehicle relationship management" to the more traditional "customer relationship management"?

Who will operate the backbone mobile communication networks? The cellular mobile network operators will have a role, at least for providing coverage outside built-up areas. But they too might see an interest to operate other types of wireless network such as WLAN or Wi-MAX™, that are better able to support the direct, short-range communication requirements of cooperative systems. Is there also a need for a separate organisation to operate a dedicated "cooperative systems network" to handle the rather special needs for secure collection, management and delivery of data and related services, from and to vehicles?

While CVIS is basing its technology around IPv6, this does not mean the "world wild web" – there is still a requirement for a protected network environment, and this may need to be managed.

The cooperative services model depends on the collection of data from vehicles, the road network and the environment. Once processed and integrated, these data become the source of the information to drivers that propels the cycle of cooperation. Monitoring data will need to be managed by some organisation, although in practice it could be the traffic network operator or an existing service provider, or else a separate entity, either public, private or public-private.

On the ground, there are all the infrastructure and fleet operators and other bodies that will want to install cooperative system communication links to their equipment in order to be able to interact with vehicles. This is crucial, since the cooperative system cycle will not be closed without such deployment. The problem is that there are so many different actors who could possibly be involved. This raises the question whether they need to be organised into some kind of business network in order that road users find a coherent offer of cooperative services rather than an indisciplined jungle?

This goes to the heart of the nature of cooperative systems in practice: will this be nothing more than a new technology that anyone can adopt and instantly become a cooperative service provider? In this case there might

be no need for any more than a label saying "complies with cooperative systems standards". Otherwise, there will be a need for a much more structured approach in which the various operators and service providers would ensure a planned and coordinated deployment and in which cooperative service operations were also harmonised and controlled cooperatively.

So what is deployment?

What does deployment mean for cooperative systems? Certainly it's not a simple matter of installing some loop detectors, traffic lights and a junction controller unit – as for a basic traffic control installation. The complexity of cooperative systems and the number of entities and decision-makers involved means that even cooperative system deployment needs to be cooperative!

The main elements to be deployed include the following:

• The vehicle: an onboard unit supporting wireless communication on the media chosen to deliver cooperative services, enabling a permanent Internet Protocol connection;

• The roadside: a box linked to roadside installations that provides wireless communication to nearby vehicles (on the same media as implemented in the vehicle unit), with interfaces to existing roadside systems and onward to back-office services;

• The communication system: while existing cellular (2G, 3G…) data services will be one medium used for cooperative systems in order to ensure virtually complete coverage, there is a growing consensus that some kind of wireless local area network (WLAN or "Wi-Fi") for vehicles is needed: a (mesh) network of local hotspots throughout cities and along main highways; in addition, communication units installed for tolling or access control (e.g. DSRC, infra-red) can be used to fill in the network. Also, Wi-MAX ("WMAN" or wireless metropolitan area networks) could be a future carrier if it should be deployed across urban areas and if the mobile version of the standard becomes the norm;

• Operating and management centres: these are the elements that will make up the operational services running in the background and foreground, and that constitute the cycle of cooperation. They include data management centres, traffic management and control centres, emergency service centres, public transport and commercial fleet management centres, etc.

As we've seen above, it is not so clear how and in what order deployment will take place in practice. Will vehicle makers begin installing communication units in their new cars, trucks and buses as soon as standards are fixed? Will city traffic authorities be first off the line to install communication units in equipment for traffic monitoring and control? Or will motorway operators take the lead? When will roadside equipment suppliers begin offering products adapted for cooperative systems?

Taking off

As the world of cooperative systems involves potentially so many different stakeholders it seems likely a special dedicated effort will be needed to make deployment happen in a suitably coordinated way. We would like to propose that Europe needs its own initiative to launch and then steer cooperative system deployment.

The United States has its VII initiative, driven by the US DOT, and a VII Consortium made up of federal and state highway departments and the automotive industry, established "to determine feasibility of widespread deployment and to establish an implementation strategy". Arguably the stakeholder community in Europe is more splintered than in America, hence the need is stronger for a European consortium – a "Cooperative System Alliance" or CSA – to drive implementation. Such a group could work to bring cooperative system implementation into the political arena at all levels from municipal to national to European Union. Coordination of public investment will be needed if the potential benefits for transport safety and efficiency and for the environment are to be realised.

The European CSA could support individual stakeholder groups such as traffic management suppliers, mobile network operators, vehicle manufacturers and suppliers, motorway operators, fleet owners and operators and urban traffic authorities each to adopt a common approach for deployment, and then to coordinate deployment strategy across all sectors of the community. Without this common approach it is hard to see who would be willing to take a first step towards cooperative systems when there is a risk that necessary complementary investments are not going to materialise.

Unfortunately, until now there is very little of cooperative systems visible to the average citizen and driver, so we should not expect deployment to be user-driven! All the more reason to deepen the experience gained through collaborative R&D projects and then to create public awareness through demonstrations and persuasive publicity for the results of cooperative system evaluations. Before then, let us have some good debate about what cooperative systems are, what benefits they can bring, and how to make them happen. TH

CVIS, which is IP coordinated by ERTICO in EU FP6, started on 1 February 2006 and will finish in January 2010. The CVIS project acknowledges the support provided by the European Union through a grant of up to €22m towards the total project budget of €41m.

The CVIS consortium has 60members, from sectors including automotive manufacturers and suppliers, traffic system suppliers, public and private road operators, mobile network operators, motoring associations and research institutions.

An open workshop on CVIS architectures will be held on 21 June in Aalborg, Denmark and ERTICO will jointly organise an international workshop on cooperative systems architectures the following day, also in Aalborg. For more information go to www.cvisproject.org or email Paul Kompfner, CVIS IP Manager or Zeljko Jeftic, Deputy CVIS IP Manager, at cvis@mail.ertico.com