Fuel's gold

Various initiatives are researching how we can save fuel and reduce emissions through the use of C2X technology. **Sonja Koesling** contemplates whether the PRE-DRIVE C2X project could be the jewel in the environment's crown

Images courtesy of Audi, BMW, Daimler, PTV & Volkswagen

The car a few years from now will be incredibly smart – a life-saving, lean, green talking machine. And while such a vision may conjure up scenes from *Knight Rider,* there are no dangerous criminals pursuing the lone crusader in this case, although the driver and his motorized companion are trying to make the world a better place. "Seven hundred meters left until you reach the traffic lights," advises Alter K.I.T.T.. "Please change down into second gear and reduce your speed to 30km/h." By following the instructions, the driver no longer has to stop at the intersection as the traffic light is green upon arrival, as a result conserving fuel and reducing CO_2 emissions – all of which helps the environment.

Focusing on green phase

Such a vision of the future is steeped more in fact than fiction, however, and describes the use case of GLOSA, or Green Light Optimized Speed Advisory, analyzed as part of the European PRE-DRIVE C2X research project by a team of traffic, communications and engine technology experts from PTV, Karlsruhe Institute of Technology (KIT) and the Graz University of Technology. If all drivers in the road network used C2X, the team believes fuel savings of up to 5% could be achieved.

The study is, of course, far more pessimistic than previous research-led investigations, including *Predictive Use of Traffic Signal State for Fuel Saving* by Behrang Asadi and Ardalan Vahidi, which partially predicted a 47% fuel saving. "Our results refer to all vehicles in a large network and not only to one vehicle passing through an intersection," explains Dr Thomas Benz, director of ITS Research at PTV and manager of the simulation work package at

The goal of PRE-DRIVE C2X was the realization of an integrated simulation toolset to assess safety, traffic and environmental impact of C2X communication technology and to upscale the results to the European level

PRE-DRIVE C2X. "We have used a more differentiated approach for PRE-DRIVE C2X and have thus been able to obtain more detailed results." To this end, Benz and his project team developed a comprehensive integrated simulation tool set, including dedicated models for traffic flow, C2X communications and environmental effects.

Modeling reality

Rather than focus on an isolated intersection, PRE-DRIVE C2X analyzed a part of Karlsruhe's road network in Germany, based on real-life measurements using PTV's VISSIM for traffic simulation. The software tool allows users to simulate traffic flows on a microscopic level while considering car-following behavior as well as signal control. Moreover, a communications module was linked to VISSIM that reproduces the communication between the traffic light and the vehicle.

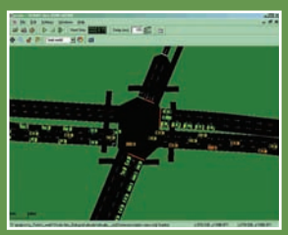
PRE-DRIVE C2X then investigated fuel consumption and emissions: "A majority of previous studies have been based on mathematical approaches calibrated for an average passenger car," Benz continues. "None of these studies addressed aspects such as gear shifting or different vehicle and emission types in detail, however." To model these factors in a highly realistic manner, PRE-DRIVE C2X used the emissions module PHEM (Passenger car and Heavy duty Emission Model). "PHEM is a dynamic model that calculates fuel consumption and emissions from vehicles' instantaneous speed and acceleration," Benz explains. Developed and applied by Graz University of Technology, the underlying database is derived from measurements of more than 1,000 vehicles. "The results clearly show that highly realistic traffic simulation models such as VISSIM and a highly realistic model such as PHEM form a natural combination," he says.

From single vehicles...

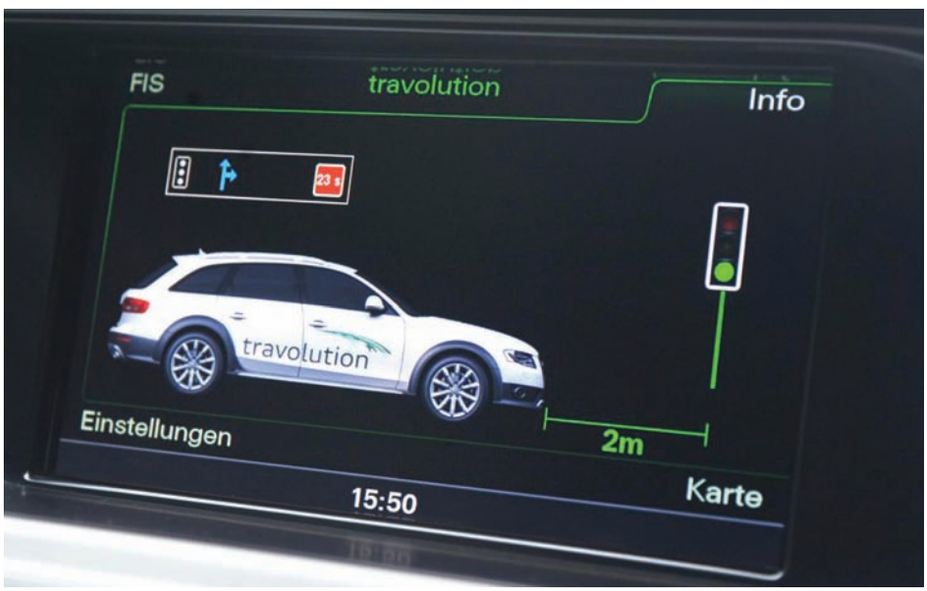
The transportation experts first looked at the vehicle's movements at a traffic light, and in this regard they were primarily focused on gear choice. "We were particularly interested in the driver's gear choice while approaching a traffic light without having any information about the signal state," Benz says. "And we wanted to find out how much fuel is used throughout this time." The experts then simulated a vehicle that received such information and the recommended gear choice over distance, with the results showing that the specific choice of gear has a significant impact on fuel consumption. A vehicle which approached the traffic light in the third gear used up to 24.5% more fuel than a vehicle without C2X communications technology.

VISSIM explained

VISSIM is a microscopic traffic simulation software tool and is part of the PTV Vision software suite. It simulates all modes of transport, including automobiles, buses, trains, cyclists and pedestrians, while taking the behavior of other road users into consideration. The basic concept is that drivers of a faster-moving



vehicle start to decelerate as they reach their individual perception threshold to a slower-moving vehicle. As they cannot exactly determine the speed of that vehicle, they will gradually adapt their speed to the preceding vehicle. Moreover, VISSIM allows simulation of different vehicle types. PTV's transportation experts have integrated C2X communication into each vehicle type, which can be used whenever needed.



Audi is part of the PRE-DRIVE C2X consortium. The car-maker's Travolution road traffic emissions reduction system involves wireless local area network connections between cars and traffic lights, which supply a flow of data from one to the other

This changed as soon as the second gear was recommended, with fuel consumption reduced by up to 43%.

...to the entire road network

In real life, no vehicle moves within a vacuum, especially in inner-city areas where numerous road users have to share the network. "For PRE-DRIVE C2X, we have simulated GLOSA on a busy part of the Karlsruhe system," Benz states, with around 850-950 vehicles on the 3km² area during rush-hour. "We assumed 40% of the vehicles had Otto engines and 60% were diesel from EURO 0 to EURO 4," he says. "Our scenario was also based on the assumption that the driving behavior would not always be perfect. Other road users might influence a driver's individual speed, for example."

Based on these parameters, the project team simulated GLOSA by evaluating five different penetration rates of radio-equipped vehicles – 0, 25, 50, 75 and 100%. "The first thing that grabs your

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attention when looking at the results is that the fuel savings were significantly lower than in single-vehicle analyses," Benz says (see the chart in *I2V and fuel consumption* sidebar).

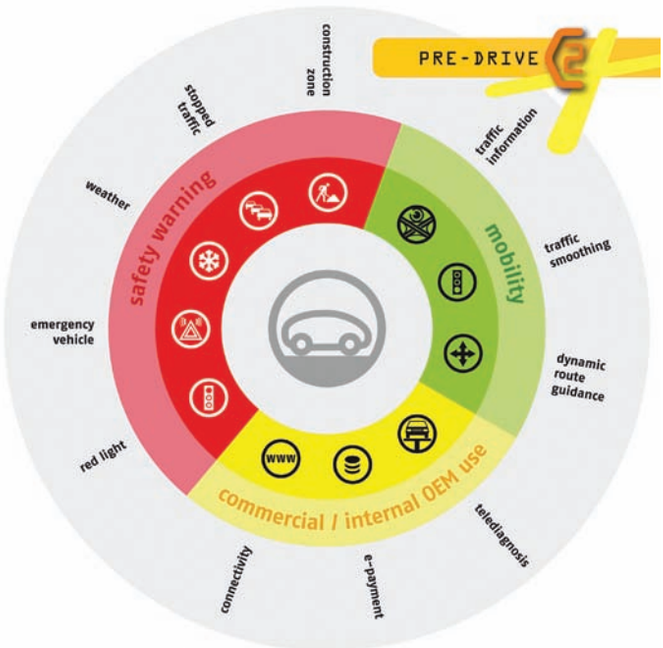
From the simulation to the field test

Nevertheless, 5% fuel economy means a 5% actual fuel saving that helps us conserve the environment and puts cash back into our wallets. It is therefore vital that PRE-DRIVE C2X is assessed via field trials and with this in mind the follow-up project, DRIVE C2X, started in January 2011. In cities including Frankfurt and Gothenburg, a fleet of test vehicles will collect data in real-life traffic, the results of which will be evaluated by the various members of the project team by the end of 2013. Should the PRE-DRIVE C2X results be confirmed in the field trials, the next step would be to provide all road users with access to traffic signal information. But will drivers embrace C2X and to what extent?

Psychological factors

Communication technologies are a part of information systems, but unlike systems such as emergency braking assistance (EBA) and electronic stability programs (ESP) – which intervene automatically in borderline situations – drivers themselves decide whether or not they want to follow the recommendations. "And little research has so far been conducted regarding the acceptance and degrees of success of these recommendations," confirms Professor Bernhard Schlag, Department of Traffic and Transportation Psychology at the Dresden University of Technology. It is clear, however, that trust in a system plays a major role in this field, meaning drivers need a positive learning experience as the new technology will have an impact on their everyday driving routines. "It is important that success is noticeable," Schlag adds.

But how can everyone become aware of the benefits to be gained from GLOSA? To this end, it is important to show not only the reduced amount of CO_2 emissions but also the improved fuel consumption and shorter waiting times at traffic signals. According to Schlag, the technology won't assert itself until drivers simply follow the instructions provided by the system instead of thinking about whether the recommendations are useful or not. It therefore remains to be seen whether every driver of a 'smart' car will turn into a brave *Knight Rider* whose primary purpose is to protect the environment.



PRE-DRIVE C2X develops an integrated simulation model for cooperative systems that enables an holistic approach for estimating the expected benefits in terms of safety, efficiency and environment

I2V and fuel consumption

How much fuel can be saved through C2X communications? How many vehicles would need to use wireless technology? What is the perfect information distance between the vehicle and the traffic signals? The chart opposite shows the results of the EU PRE-DRIVE C2X project. To translate these research findings into practice, cars have to be equipped with appropriate radio technology. Additionally, HMIs play an important role and will be brand-specific.

Car-makers such as Daimler, Audi, BMW, Volvo Technology, etc, were therefore also involved. Their first task was to formulate the criteria and coordinate everything with the electronics industry and software developers. In total, 24 organizations were involved in the EU project, which had a budget of €8.4 million – of which €5 million was funded by the EC as part of the Seventh Framework Programme. PRE-DRIVE C2X started on July 1, 2008 and was completed on June 30, 2010.