UNIVERSITY OF LEEDS

Mobility & Energy Futures Series

CAN TECHNOLOGY SUPPORT ECO-DRIVING?

Energy Leeds

The challenge

Road transport is responsible for almost a quarter of European carbon emissions. The European Commission have set a target of reducing greenhouse gas emissions by 20% (from 1990 levels) by 2020.

How best to achieve these targets? It's unrealistic to simply wait for 100% of all road vehicles to be highly automated and, potentially, super-efficient. Besides, travel demand may increase and off-set any benefits, as indicated in a previous briefing in this series (Self-driving Cars: Will they reduce energy use?).

New forms of vehicle powertrains such as hybrid and electric spell a positive way forward. Their market share is small however (1.4% of the total new car market in the UK) mainly due to high costs and concerns over battery range. Electric cars in particular suffer from an image problem as the "second run around" in a household. There is intense debate about whether and when new powertrain types can contribute substantially to emissions reduction. For example, Collantes (2007) predicted that fuel-cell vehicles will capture 5% of the new-vehicle market sometime between 2020 and 2060; however they are not yet commercially available in Europe. Therefore placing responsibility on the concept of full automation or relying on changes in car buying strategies is a passive and risky approach.

Going beyond the State of the Art

Eco-driving is the generic name for a driving style or set of behaviours which minimise fuel use. Accelerating more gently and shifting through the gears in an efficient way are examples of eco-driving. Additionally, before setting out on a trip a driver can improve the fuel efficiency of their vehicle via proper vehicle maintenance and tyre inflation, appropriate trip planning and consideration of low-carbon alternatives. The resulting fuel savings, as measured relative to 'normal' driving, vary widely – with figures between 3-20%. These data are highly dependent on the type of intervention tested, the vehicles and participants involved in the studies, as well as the typology of the roads on which the driving was undertaken.

Thus fuel efficient driving is a complex matter and in itself, driving is a complex behaviour, involving hundreds of separate tasks. Drivers are required to simultaneously control the vehicle, adjust their speed and heading according to the external conditions, deal with hazards and make navigational decisions. Eco-driving behaviour is often summarised by some simple instructions which are meant to be easily understood by drivers; but even they can sometimes be misunderstood or found to be misleading. Previous research undertaken at the University of Leeds (Pampel et al. 2014) suggests that drivers do have "mental models" of eco-driving – i.e. they know what they should do to save fuel, however in experimental trials these mental models were not activated and did not translate into fuel efficient behaviour. In this study, we observed that when drivers were prompted to drive in an eco-friendly way, they could do so - but it was easily disrupted; when they had to switch to a safety focus, drivers did not revert to their eco-driving automatically. This suggests that drivers need continual reminders and support for eco-driving.

There is already a substantial market in eco-driving devices, applications and vehicle manufacturers' integrated systems. What is lacking is a robust comparison between these technologies and exploration of varying modalities by which drivers wish to receive eco-driving support. Presenting drivers with information solely via the visual channel may not only be detrimental to safety,but also not very intuitive. After all, the "golden rules" of eco-driving refer to smoother acceleration and braking; thus there could be disconnect between what the eye sees on a visual display and how the foot should behave. Perhaps "green feet" need to be nurtured and encouraged via the vehicle pedals, not the dashboard?

The ecoDriver project (www.ecodriver-project.eu), led by the University of Leeds, challenged the state of the art by developing and testing a coherent set of eco-driving concepts and technologies. These ranged from low cost apps to high-end integrated systems. What underpinned them however, was the accuracy of the eco-driving guidance; it was real-time and situation relevant. When is the optimal time to receive guidance on the best way to ascend a hill? Directly before it. When should a driver receive feedback on their performance? As soon as possible afterwards. The advice was also constant, via the presentation of a "green speed." Using these concepts the systems were created and tested in both simulators and on real roads across seven European countries.

Real roads, real drivers

The resulting trials, the largest yet in Europe, produced 340,000 km of data. The technologies included haptic (communication which recreates the sense of touch by applying forces, vibrations, or motions to the user, in this case via the accelerator) and visual elements, supplemented with auditory prompts at key points. Both controlled (set routes) and naturalistic (participants could travel anywhere) trials were carried out. These were supported by a structured, experimental design with periods of driving with and without the eco-driving technology. Questionnaire data supplemented the objective data regarding speed and acceleration – both vital to evaluating compliance with eco-driving advice and energy savings.

Across all systems and all road types, average fuel savings were approximately 4%, when the eco-driving advice was active. Similar reductions in NOx values were also found. Digging deeper into the data, embedded systems (which use detailed on-board vehicle data) performed better than the smartphone app; the addition of a haptic element further decreased fuel consumption by up to 3%. This reduction may seem relatively small, but such marginal gains may combine with other initiatives (e.g. cleaner engines) to help reach the EU target.

These energy savings are captured as a direct result of changes in driver behaviour as encouraged by the in-vehicle technologies. Such behaviours include reductions in average speed and acceleration as well as earlier shifting up through the gears. The effects were particularly strong on rural roads, where drivers were less constrained by the behaviour of other traffic. Applying the golden rules on urban roads is difficult because there are many constraints related to safety that are a priority for the driver. On the other hand, there are very few constraints on motorways, and driving there is generally smoother. Of course these changes in behaviour as well as leading to energy savings, are also safety-beneficial. Decreases in speed around safety-critical locations such as pedestrian crossings and junctions carry benefits, particularly for vulnerable road users.

The future of eco-driving

Driving should always retain safety at its core. It is fortunate that improvements in safety, whether through road design, enforcement or in-vehicle safety systems, can also result in less energy being used. We still don't know whether drivers are more inclined to behave in the way they do because they believe it's safer or because they're saving energy. Our results also suggest that the energy savings vary widely between different drivers – with some achieving 20% reductions. Personalisation is key here – the type of information and advice which motivates drivers may differ. One driver may be more inclined to save fuel if the monetary benefits are presented; another may be motivated by environmental concerns (their carbon footprint). Yet another driver might not be concerned about either financial or environmental savings and simply – drive. Maybe this is the most challenging aspect of eco-driving – to be able to embed eco-driving practices into the norm much as the putting on of a seat-belt is (for the majority of drivers) part of their mental model for commencing a car trip. For now though, it is becoming increasingly clear that a one-off reminder at the beginning of a trip is not sufficient to encourage and maintain eco-driving behaviours. Humans, it seems, can benefit from technology to help them cultivate their green feet.

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References

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Mobility & Energy Futures Series

Transport consumes a fifth of global energy and has a near-exclusive reliance on petroleum. As such it has an important role to play in the Energy Trilemma of reducing energy consumption and associated greenhouse gas emission, creating an energy system built on secure supplies and developing the system in ways which are affordable.

Addressing the Energy Trilemma in the transport and mobility sector is especially challenging due to the continued growth in demand for the movement of goods and people, the technical, regulatory and social challenges of moving away from an oil based system of mobility and a complex and fragmented set of stakeholders required to work together to deliver change.

Drawing on the expertise and opinions of the University of Leeds academics from different disciplines, this series will highlight the drivers, gaps and opportunities in reducing the energy consumption and carbon emissions from the transport sector in future. This is the fourth briefing in the series.

Other issues in the series are available online at www.its.leeds.ac.uk/research/mobility-energy-futures-series

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