Measure for measure

Leonidas Ntziachristos, **Silvana Toffolo**, **Daria Tommasi** and **Hermann Heich** explain how cities can assess and reduce the carbon footprint of their road traffic activities

Combating global warming and climate change is one of the most important environmental challenges of recent years. As a result of its heavy dependence on fossil fuels, the transport sector is a significant consumer of energy and a major source of greenhouse gas (GHG) emissions. More specifically, it accounted for around 32 per cent of total final energy consumption in the 27 Member States of the European Union by 2012 (European Commission, 2014) and was responsible for around 25 per cent of GHG emissions, if shipping and aviation are included (European Environment Agency EEA, 2013). Road transport is the largest contributor, emitting 72 per cent of all transport-related GHG emissions.

Efforts to reduce GHG emissions from road transport in Europe are varied. First, fleet average efficiency improvements have been agreed upon for passenger cars (Regulation (EU) No 443/2009) and light commercial vehicles (Regulation (EU) No 510/2011), while monitoring and labelling of heavy duty vehicles CO_2 is underway (European Commission Communication COM (2014) 285 final). Secondly, greening fuel has been promoted by reducing the carbon footprint and increasing the penetration of sustainable fuels (Directives 2009/28/EC and 2009/30/EC), while more aspirational targets are set for the 2030 horizon (COM (2014) 15 final). In addition to these two elements, a new approach is actively being promoted: it has to do with improving transport conditions and fostering more efficient use of the vehicle as such.

The ICT-EMISSIONS project, co-funded by the European Commission's Directorate General Connect (DG Connect), addresses energy efficiency of Intelligent Transport Systems (ITS) that stems from Information and Communication Technologies (ICT). The project has developed and validated a comprehensive methodology to evaluate the impact of traffic measures on mobility, vehicle energy consumption and CO_2 emissions of fleets in urban areas. The methodology combines commercial traffic and emission models on micro and macro scales to quantify energy consumption and CO_2 emissions of various ITS measures. The innovative aspect comes from modifications within the models as well as in the development of interfaces that combine the tools to enable a seamless impact assessment.

Three cities have been used as real world laboratories for validating the methodology. Madrid, Spain, is used to test

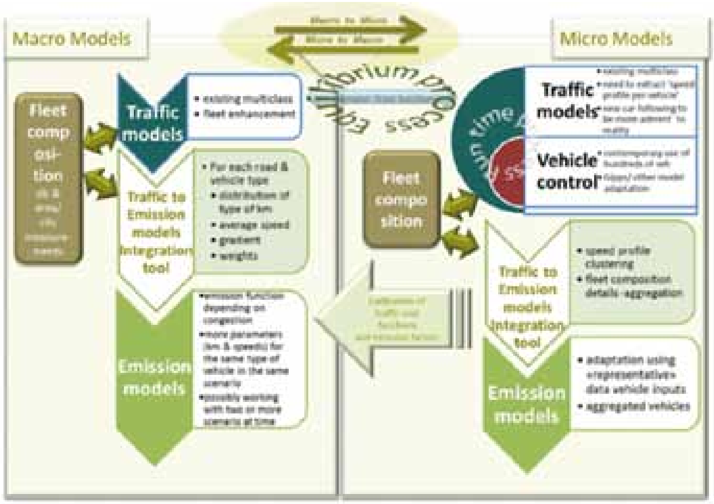

Figure 1: Schematic of the methodology implemented in ICT-EMISSIONS

ICT interventions on the extended ring-road of the city, Rome, Italy, for testing urban traffic management in a single corridor, and Turin, Italy, because urban traffic management can be adjusted to large sections of the city. This article presents some preliminary results on the implementation of the methodology in a real-world experiment in the city of Turin.

PRESENTATION OF OVERALL METHODOLOGICAL SCHEME

ICT-EMISSIONS has developed an integrated modelling platform enabling the simulation of the impact of ICT measures on fuel consumption and CO_2 emissions. The approach focuses on both the macro scale, ie the complete link-level urban network, and on the micro scale, ie second-by-second driving profile impacts. The ICT applications that can be modelled cover all basic categories of measures for passenger transport, including navigation and travel information, traffic management and control, demand and access management, driver behavior change and advanced driver assistance systems (ADAS). The methodology developed does not cover logistics and freight management measures.

The methodology developed is generic and can be used with any model that operates either on the macro or the micro scale. As an outline, when an ICT measure is adopted this will have a local trip-level effect which, depending on

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Figure 2: Traffic light junctions controlled by Turin Urban Traffic Control (UTC)

the penetration of the measure, will also manifest itself in the macro level. For example, implementing traffic-adaptive traffic lights over an urban corridor will affect the driving patterns of vehicles on that particular corridor but also the entire traffic pattern in the section of the urban network linked to this corridor. In order to simulate the impact of this intervention, traffic models need to predict the change in the driving pattern at the micro level and then the impact on the activity at the macro level. Therefore, traffic and emission models at the micro and macro level need to be linked and provide consistent results. This is the critical part in such simulations.

There is only one proprietary model developed in the project that is required to simulate the impacts of adaptive cruise control (ACC) – a measure that falls under the ADAS category – to the vehicle driving pattern. Figure 1 schematically shows the overall structure of the methodology.

In order to demonstrate implementation of the methodology in real world experiments, specific interfaces and modules have been developed to link off-the-shelf traffic models with the ACC module and with the emission models used and make them operate in an automatic or, when unfeasible, a semi-automatic mode. The traffic models that have been used for the demonstrations include the Aimsun model from TSS and the Vissim and Visum models from PTV AG. For emission and fuel consumption modelling, AVL Cruise has been used at the micro level and COPERT+ (COPERT with congestion correction functions) has been used at the macro level.

A REAL-WORLD EXPERIMENT TO TEST THE METHODOLOGY

In the metropolitan area of Turin an adaptive Urban Traffic Control (UTC) system for the management of urban traffic has been in operation for many years. This system is designed to improve traffic conditions in Turin and is able to respond quickly to critical traffic situations. The central element in this system are adaptive algorithms that define the best policy for traffic light management, with the aim to improve the overall conditions of urban traffic by minimizing total travel time. Figure 2 depicts the deployment of the UTC system in Turin.

During the real-life experiment, field surveys were carried out to detect travel times and related fuel consumption on some of the main axes of the city and thus to verify the effectiveness of the UTC. This was carried out using four floating cars equipped with GPS devices to track the car's position. The data delivered by the floating cars allowed for deriving the speed profile with a resolution of one second. One of the floating cars delivered fuel consumption in addition to the speed profiles. The trials were conducted on nine midweek days (Tuesday, Wednesday and Thursday), six days with UTC system active "on" and three days with UTC not active "off" and were conducted during three time slots: from 0500-0600 hrs (free traffic), from 0700-0900 hrs (saturated traffic) and from 1200-1400 hrs (normal traffic). The analysis focused on a particular route: Corso Potenza, from Via Foligno to Via Boston (about 6.9 km, see Figure 3).

UTC system "on" implies the duration of each traffic light phase is re-calculated every three seconds in order to optimize traffic according to real time traffic flow measurements; UTC system "off" implies traffic light phases are fixed and the system collects only traffic flow measurements for statistical purpose.

The floating cars carried out a total of 220 runs, 151 in UTC-on condition and 69 in UTC-off condition. The

Figure 3: Field trials' corridor

measurements allow for the evaluation of interesting information on the route that characterize the traffic flows such as average travel time, speed, stops, acceleration, etc.

The first results of the analysis concern the average travel times in both directions: in saturated traffic, the travel time in UTC-off condition is 22.30 minutes (18.3 km/h), instead in UTC-on condition it is 20.00 minutes (20.5 km/h). In normal traffic, the travel time in UTC-off condition is 16.30 minutes (25 km/h), instead in UTC-on condition it is about 15.00 minutes (26.9 km/h). The maximum UTC benefit in terms of travel time reduction, occurs during peak hours (about 12 per cent): in normal conditions (about 8 per cent) traffic is quite fluid.

IMPACT OF UTC ON/OFF

Figure 4 shows the impact of previous interventions on the fuel consumption of different types of passenger cars operating in the corridor in normal driving conditions. In total four different types have been considered, operating on gasoline or diesel. Because UTC has an impact on the duration of stops, we have also examined the impact on the same vehicles when equipped with a start-and-stop system (SS) that switches off the engine when the vehicle decelerates to a standstill. These impacts were calculated by feeding typical driving profiles encountered in the corridor into specially designed vehicle models setup in AVL Cruise model.

In all cases examined, the operation of the UTC has a positive impact on fuel consumption which ranges from 2.8 to 5.7 per cent. Fuel consumption and the relative impact is larger in the case of the gasoline vehicle. Interestingly, the differences are bigger in both the diesel and the gasoline case when the vehicles are equipped with a start-and-stop system. This demonstrates that combining different measures/systems could provide the maximum benefits.

This preliminary comparison shows that ITS measures do have the potential to offer significant fuel consumption and GHG savings in real-world conditions. A combination of technological measures and further optimization of available systems can significantly enhance the efforts to diminish the contribution of road transport to climate change.

OUTLOOK

The preliminary results of the experiments are encouraging and show that ITS measures can have a positive influence on the situation of traffic. Furthermore, the results show a significant reduction of fuel consumption and reduced CO_2 emissions. Having demonstrated these positive effects on the example of UTC in Turin, the ICT-EMISSIONS project will be in the position to deliver more of these results in the

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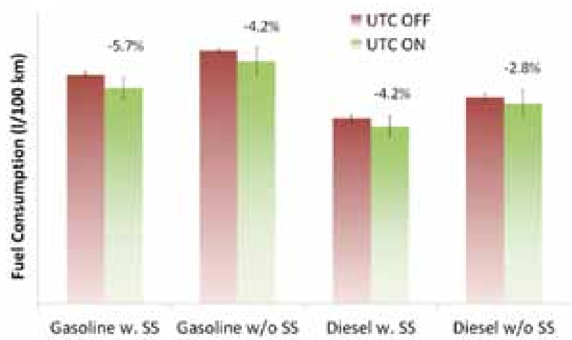

Figure 4: Impact of UTC on emissions of different passenger cars in the city of Turin. SS: stands for start-and-stop system

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near future. These results will be derived from other real-life experiments but also from extensive scenario runs. The integrated modelling platform will be used to simulate the impact of several ITS applications such as driver assistance systems, eco-driving solutions, green navigation, cruise control and variable speed limits. ICT-EMISSIONS will also look into the future by delivering results on the impact of future vehicle fleets comprising advanced vehicles such as hybrids that are penetrating the market.

The innovation of the ICT-EMISSIONS methodology stems from modifications to the commercial models and their intelligent combination through specifically designed interfaces. As in all European Projects, modifications to the models as well as the interfaces will be documented enabling interested parties to replicate these innovations. This will put cities and traffic planners in a position to investigate the impact of ITS measures in a consistent way.

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