

Networked Clean Vehicles, How the Environment Information will Improve Fuel Efficiency and CO2 Emissions

I. Iglesias, L. Isasi, M. Larburu, A. Martin and A. Peña

Tecnalia Automocion

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ABSTRACT

International goals of reducing CO2 emissions in vehicles require sophisticated solutions in areas not strictly related to an improvement in the efficiency of the powertrain systems, but to an enhanced management of these systems, taking into account parameters of the environment provided by the infrastructure and/or other vehicles. The addition of infrastructure parameters into the control of the vehicle, obtained by means of innovative solutions such as vehicle to vehicle, infrastructure to vehicle (V2V - I2V) cooperative communications, has a significant potential to reduce the CO2 emissions.

Notable benefits in the fuel consumption are shown in this paper founded on the implementation of three different advanced driver assistance systems (ADAS), enhanced by using cooperative communications, in a virtual vehicle.

INTRODUCTION

In the last few years the ADAS systems have increased their penetration rate in the market due to the reduction of manufacturing costs, but mostly because of their safety payback. ADAS systems are nowadays based on complex and expensive sensors, in order to interact with the environment with the reliability required in safety applications. Nevertheless, these safety oriented systems can provide a useful tool to improve fuel consumption and reduce CO2 emissions, which frequently require environmental parameters difficult to acquire with the sensors of the current ADAS systems.

Nowadays lots are being done on vehicle to vehicle communications, i.e. networked vehicles with the infrastructure and other vehicles. The work carried out in this direction will help to increase safety, reduce CO2 emissions, and simplify the actual ADAS systems, reducing the number of specific and expensive sensors required.

In Europe, under the *Intelligent Car Initiative*¹ [1] from the European Commission, there are several running projects looking into cooperative communications focused on safety aspects, such as CVIS (Cooperative Vehicle-Infrastructure Systems), SAFESPOT, COOPERS (Co-operative Systems for Intelligent Road Safety), and the incipient PRE-DRIVE C2X (Preparation for driving implementation and evaluation of C2X communication technology).

V2V and I2V communications will enhance ADAS systems performance, by putting in additional parameters to perform ADAS control algorithms together with emission reduction goals.

In this paper, relevant benefits in emission are obtained by virtually testing three ADAS systems, based on cooperative communications, under two scenarios (urban area and open road) bringing into play several human drivers, always upholding the safety levels of the ADAS systems.

¹ The Intelligent Car Initiative aims to improve coordination between all road transport stakeholders in Europe, principally car manufacturers, road operators, telecom companies and transport service providers, in order to achieve an implementation of activities leading to smarter, safer and greener road traffic.

EXPERIMENTAL VIRTUAL SETTINGS

EXPERIMENTAL DESIGN

All drivers involved in the experimental virtual analysis drove one time each driving task, in order to avoid the learning influence in the driving behaviour. It should be noted that all drivers had a previous 30 minutes driving experience in the simulator, as detailed in the next section.

PARTICIPANT DRIVERS

A total of twenty drivers (standard driving skills) were selected to participate in the experimental tests. None of them had previous experience on immersive driving simulators. The group was formed by young subjects (ages 20-40 years, mean=29, SD=3.1), holding either 3 year driving experience or 75.000km. Initially all drivers had a 15 minutes driving practice in the simulator. Next, they received an ecodriving² introduction followed by a 15 minutes ecodriving session back in the simulator. [2]

EQUIPMENT AND TEST

Driving Simulator. The simulator used had a forward field of view of 120 degrees (three 42" LCD screens), and a vehicle mockup based on a saloon vehicle dashboard with an LCD screening the instrument cluster (speedometer, tachometer). Two speakers sound system in order to provide simulated engine and environmental noise. Concluding with the steering system which was based on a Logitech G25 game steering wheel system with force feedback and manual/automatic gear stick, customized to have a larger and more conventional steering wheel.

The simulator software was based on SCANeR II (V2.20) under a multi PC architecture configuration (3 PC in this case). Different modules of the simulator were executed on each PC, and connected via Ethernet in a local area network (LAN).



Figure 1. Driving simulator cockpit.

Simulated Scenarios. The experimental virtual analysis was based on two simulated scenarios: urban area with traffic lights, light-medium traffic and pedestrians crossing the lane, and open road with higher speeds, and light-medium traffic. The scenarios lengths were defined according to the New European Driving Cycle (NEDC).

- Urban area scenario. Straight urban road of 5 km with 5 equidistant traffic lights with random switching strategy [3], i.e. the lights changed independently from red to green. Furthermore, 25 equidistant crosswalks with random pedestrian crossing intention, i.e. only one active pedestrian per km, light-medium traffic with density randomly variable from 15 to 30 vehicles/km driving at 50 km/h (urban speed limit).
- Open road scenario. In this case, this scenario was 10 km long, with light-medium traffic with density randomly variable from 5 to 30 vehicles/km [4] and higher speed limits (70 km/h - 120 km/h). There were no traffic lights, and no pedestrians in this scenario.

The simulated autonomous vehicles in the traffic flow were managed by an Intelligent Driver Model (IDM) [5], with no additional ADAS.

The combination of these two scenarios is considered representative of normal driving conditions for the typical commuter use of passenger vehicles.

Simulated Host Vehicle. The host vehicle was a Renault Laguna with the following specifications: petrol engine, 2.000 cc displacement, 170 Nm torque, 92 kW power, 1380 kg weight and 6 gear robotized gearbox in automatic mode, used to mitigate dispersion of the results. Two versions of host vehicles defined with the previous specifications but with different ADAS systems implementation were tested:

² Ecodriving is a driving style based on smooth and safe driving at lower engine revolutions, easy to learn, and with a substantial impact on fuel consumption without increasing travel time.