Assessing the impacts of ITS on CO2 Emissions

The EU FP7 ‘ICT-Emissions’ Project

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Project Partners

Aristotle University, Coordinators

Research Centre of the Fiat Group

Fiat Group trucks

Advanced Driver Assistance Systems (ADAS) developer

OEM software and testing solutions supplier

Madrid Univ. traffic engineering

Traffic controllers in Turin

Traffic controllers in Rome

Traffic controllers in Madrid

Network of cities interested in sustainable mobility

European Commission Joint Research Centre
Background

- Europe is committed in reducing manmade GHG emissions. The “20-20-20” targets set three objectives for 2020:
  - A 20% reduction in EU GHG emissions from 1990 levels;
  - Raising the share of EU energy consumption produced from renewable resources to 20%;
  - A 20% improvement in the EU's energy efficiency (mostly the buildings sector).
Improvements in the transport sector

- The *White Paper* on Transport: 60% cut of 2010 GHG emissions by 2050
  - No more conventionally-fuelled cars in cities.
  - 40% use of sustainable low carbon fuels in aviation; at least 40% cut in shipping emissions.
  - A 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport.
Integrated approach required to meet challenging targets
ITS: A subset of Information and Communication Technologies (ICT)

**Application**

- Eco-driving and Advanced Driver Assistance Systems (ADAS)
- Safety systems
- Traffic management and control
- Logistics and fleet management
- Navigation and travel information services
- Demand and access management
ITS: A subset of Information and Communication Technologies (ICT)

**Application**
- Eco-driving and Advanced Driver Assistance Systems (ADAS)
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**ICT Category**

Not addressed by ICT-Emissions Project
Target of ICT-Emissions

• To answer questions such as:
  – What is the environmental benefit of introducing “green navigation” on GPS navigators?
  – How much can adaptive cruise control, enabling V2V communication reduce real-world emissions?
  – How much would a city benefit for different UTC systems?
  – What is the impact of dynamic speed limits on a ring-road?
Main concept of ICT-Emissions

• Develop an *integrated* methodology that can be used to quantify the CO$_2$ emissions of ICT solutions for road transport with a view to the future
  – Integrated: Addressing traffic, vehicle and the driver
  – *Exactly same approach can be used for air pollutants as well (not addressed by ICT-Emissions)*
Scales

1 Hz Velocity Profile

- Mean speed/trip distance
- Mean speed/speed fluctuation
- Mean speed/quality indicator

Micro  Meso  Macro

Mean speed
Approach

1. Develop vehicle simulators to calculate CO$_2$ emissions of cars when operating in ICT regimes

2. Extend commercial traffic models to simulate the impact of ICT measures at the micro and macro scales
   - Develop links with the vehicle simulators
   - Develop links with average speed emission model - COPERT

3. Validate the methodology on measured real-world ICT application cases

4. Collect the impact of ICT measures on traffic, energy and emissions in a library

5. Issue recommendations and implementation guidelines for use of best-practice ICT measures
Micro-level: Vehicle Simulator

- Incorporates detailed specifications for all vehicle subsystems (powertrain, auxiliaries, chassis, aftertreatment, etc.)
- Contains fuel consumption and pollutants emission engine map
- Is fed with s-by-s driving profile and calculates fuel consumption and emissions
- Validated with real-world measurements
Macro-level: COPERT

- Consists of the methodology and the input interface on a single software package

- Adopts the average speed approach for EF estimation
  - Straightforward and easy to obtain at national level
  - Lacks sensitivity as temporal/spatial resolution increase
Beyond the State-of-the-art

- The ICT-EMISSIONS project attempts to establish the missing links between traffic and emission modelling at the micro and the macro scale

A flowchart of the methodology to realize this progress beyond the state of the art is given to the next slide
The overall architecture
Demonstration Sites

- Urban motorway in Madrid
- Turin City Centre
- Rome Urban Corridor
Demonstration / Validation

• Data for the demonstration sites include for both ICT on / ICT off condition
  – Simulated traffic conditions in micro / macro scale
  – Measured traffic profiles with probe vehicles
  – Measured fuel consumption with equipped vehicles
Examples of Case Studies

<table>
<thead>
<tr>
<th>Classification</th>
<th>NAME</th>
<th>MICRO Traffic</th>
<th>MICRO Vehicle</th>
<th>MICRO Emission</th>
<th>MACRO Traffic</th>
<th>MACRO Emission</th>
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<td></td>
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<tr>
<td>Driver behaviour change and eco driving</td>
<td>Promotion of an energy-efficient style of driving</td>
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<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td></td>
<td>Start&amp;Stop</td>
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<td>Cruise Control</td>
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<td>ACC+STOP&amp;GO</td>
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<tr>
<td></td>
<td>Cooperative Cruise Control - Lane merging Assistance</td>
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</table>
Example of application: Adaptive Cruise Control (ACC)

**Situation A:** potential target vehicle within the range of the distance sensor (veh3), however, the ACC system recognizes that it travels on a different lane, compared to the ego vehicle (veh1). Hence, Cruise Control is active.

**Situation B:** the ego vehicle has closed the gap to the vehicle in front (veh2) so much that the latter becomes a target vehicle. The control mechanism diminishes the distance until the desired time gap is reached.

**Situation C:** If the target vehicle in Situation C exits the road, the ego vehicle switches from ACC to CC and accelerates to the target speed desired by the driver.
ACC Simulation Approach

- Average recording driving profile provided as an input (baseline – ICT off case)
- The vehicle control model calculates driving profiles of ACC-equipped vehicles (ICT-on case)
- Driving profiles introduced in vehicle simulators which calculates new fuel consumption

Parameter: Fraction of ACC-equipped vehicles
ACC Simulation Result

- Level of equipment: ACC equipped vehicles
- Simulation for typical profile of urban ring road
Key Deliverables

• A methodology and a handbook to calculate CO$_2$ emissions in ICT/ITS regimes
  + Calibrated tools (proprietary)
• A library with results from already simulated cases
• A final deliverable with main conclusions and recommendations
Cooperation with Ecostand

On the development of a standard methodology for determining the impacts of ITS on energy efficiency and CO₂ emissions

http://www.ecostand-project.eu/

- A CSA for the joint EU – US – Japan Task Force
- Several meetings: November 2011 Brussels, Feb 2012 Amitran Stakeholders Berlin, October 2012 – ITS Congress Vienna, a few teleconferences
- Main inputs from Ecostand: ITS categorisation, modeling structure, contact with Japan, wider dissemination
- Expected outputs: our methodology, case studies, libraries
Thank you for your attention!

http://www.ict-emissions.eu/
### Application range & boundary conditions

1. Passenger cars are the primary target and will be dealt with at both micro and macro scale
2. Trucks will be addressed only at the macro level
3. Urban scale
4. All current and future technologies of passenger cars
5. Buses and PTWs in a simplified manner