Assessing the impacts of ITS on CO2 Emissions

The EU FP7 '*ICT-Emissions*' Project

Zissis Samaras, Professor
Leonidas Ntziachristos, Assistant Professor
Aristotle University of Thessaloniki

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

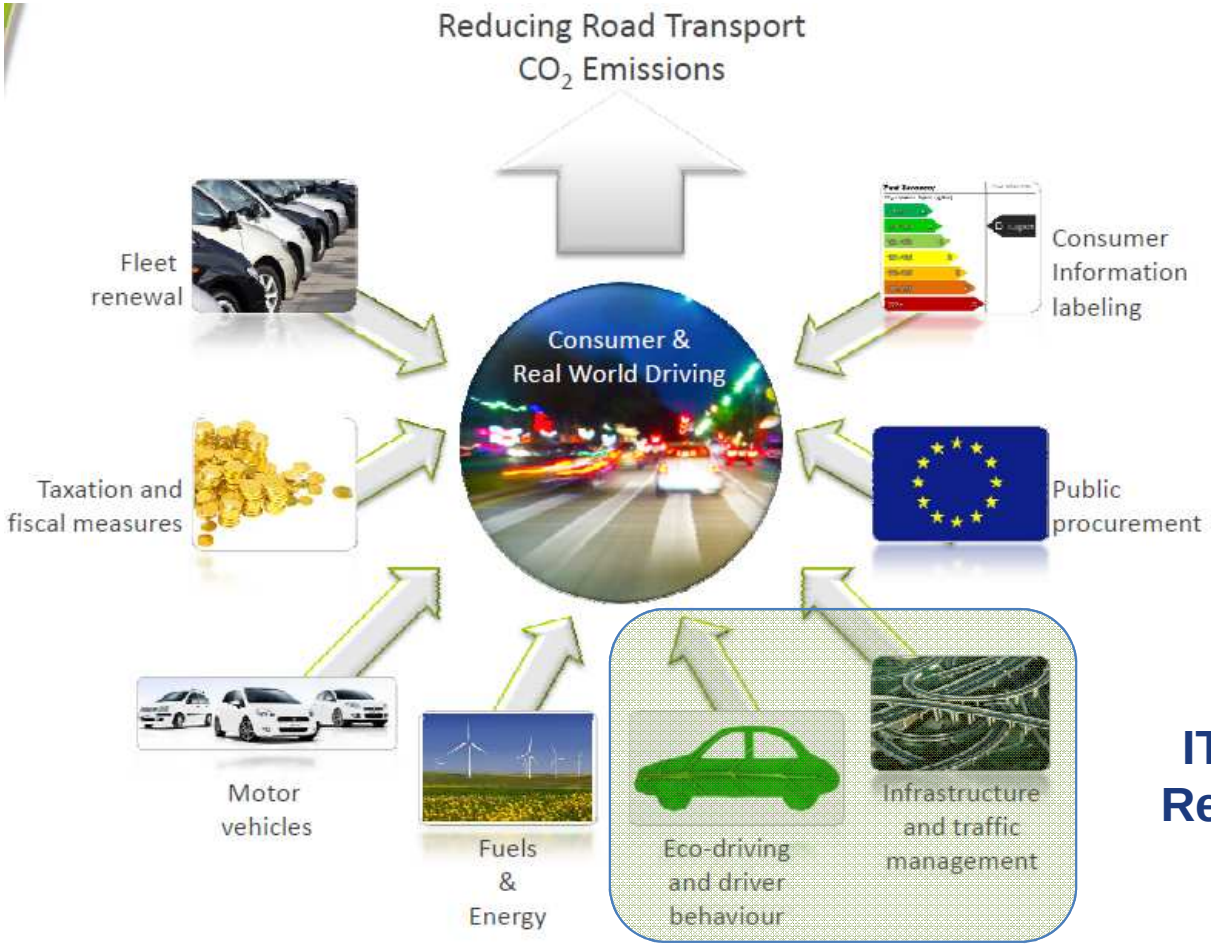
Background

- 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-Relevant Research Area

ITS: A subset of **I**nformation and **C**ommunication **T**echnologies (**ICT**)

Application

ICT Category

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

ICT-Emissions

SEVENTH FRAMEWORK PROGRAMME

ITS: A subset of **I**nformation and **C**ommunication **T**echnologies (**ICT**)

Application

ICT Category

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

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

Mean speed

Micro

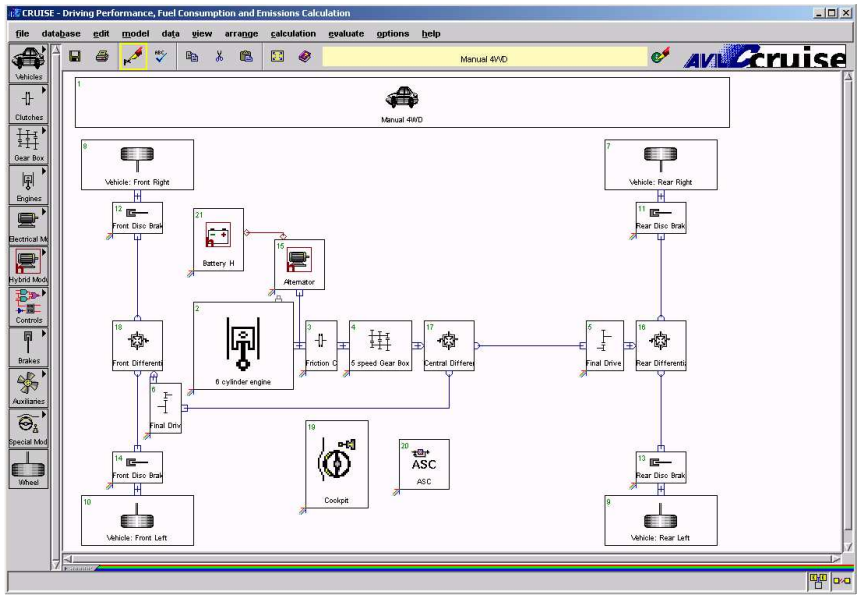
Meso

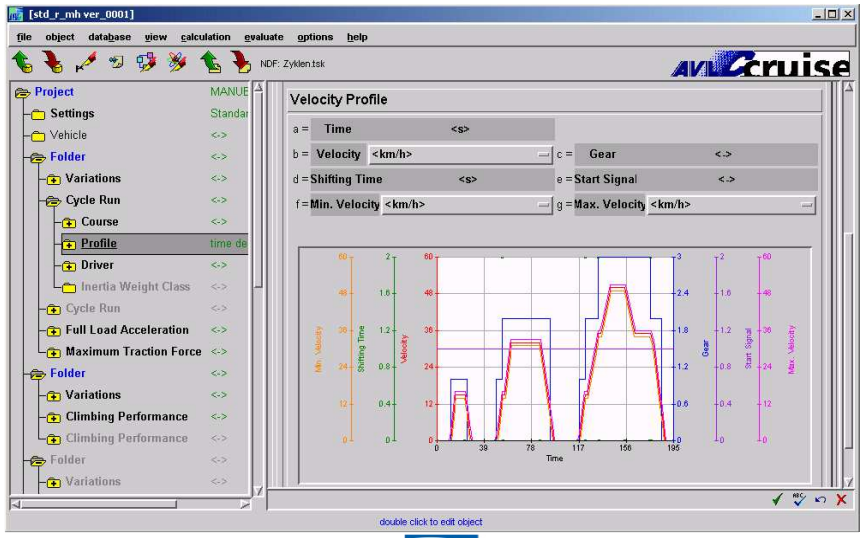
Macro

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





AVL CRUISE

- 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

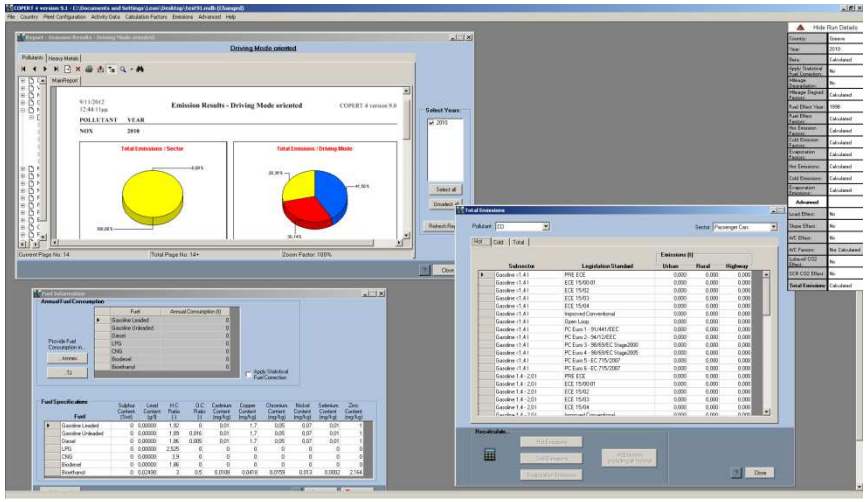
ICT-Emissions

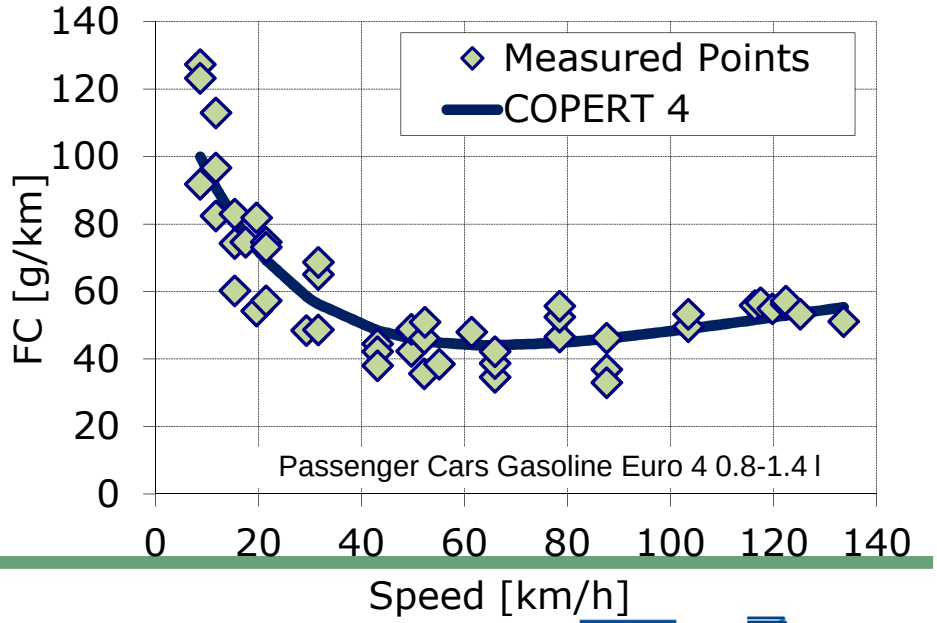
SEVENTH FRAMEWORK PROGRAMME

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





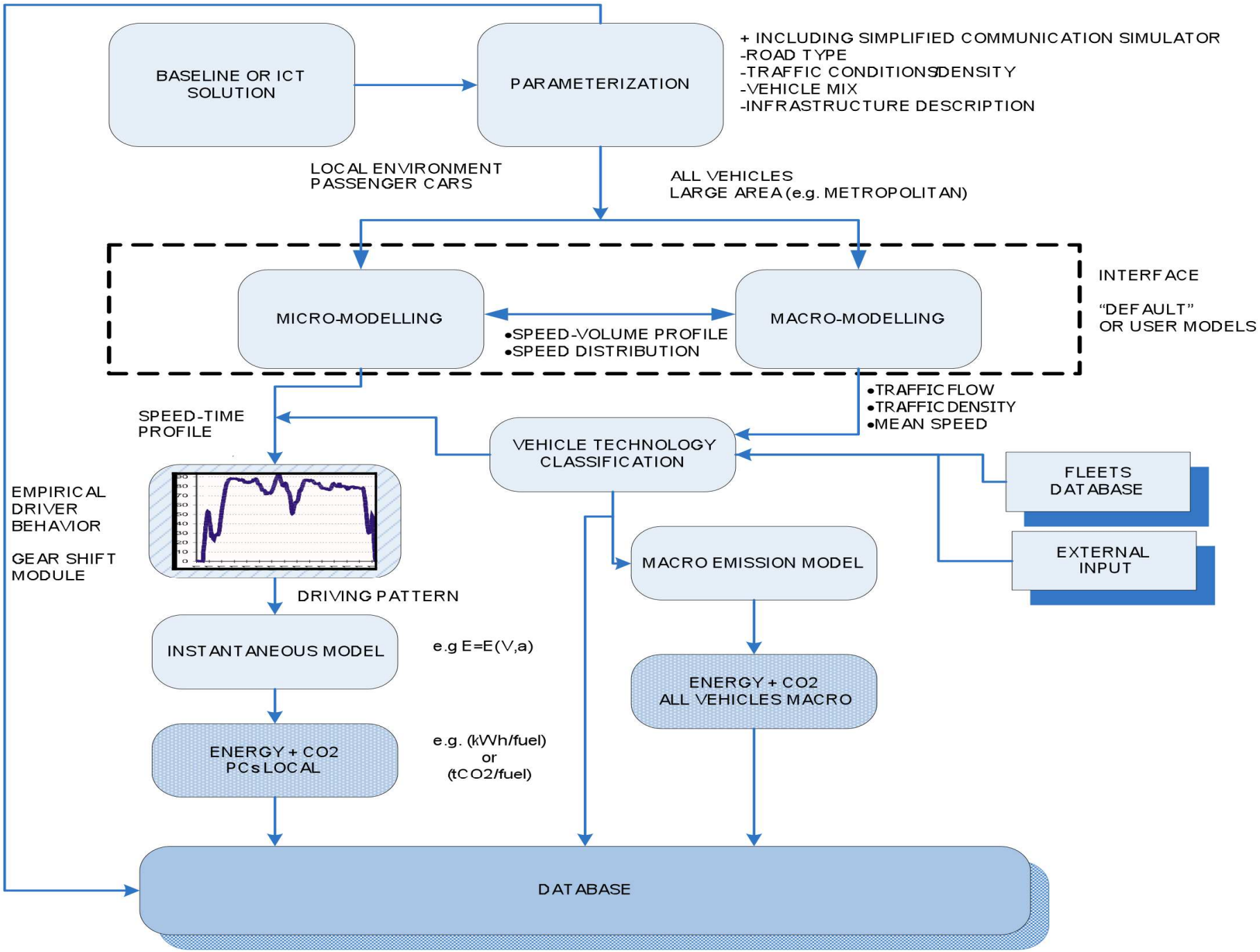
ICT-Emissions

SEVENTH FRAMEWORK PROGRAMME

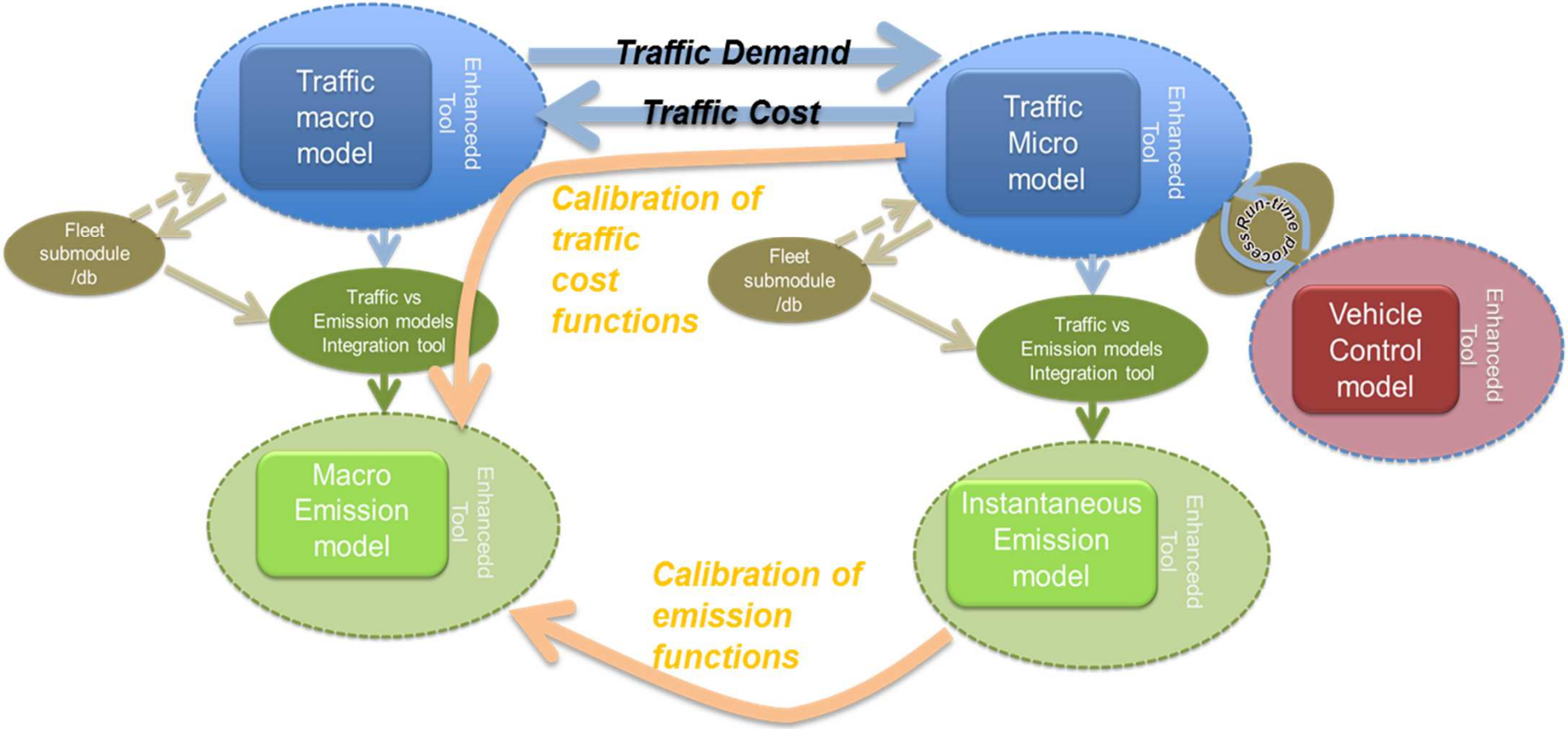
Beyond the State-of-the-art

- 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


BASELINE OR ICT SOLUTION
PARAMETERIZATION
+ INCLUDING SIMPLIFIED COMMUNICATION SIMULATOR
-ROAD TYPE
-TRAFFIC CONDITIONS/DENSITY
-VEHICLE MIX
-INFRASTRUCTURE DESCRIPTION
LOCAL ENVIRONMENT
PASSENGER CARS
ALL VEHICLES
LARGE AREA (e.g. METROPOLITAN)
MICRO-MODELLING
MACRO-MODELLING
•SPEED-VOLUME PROFILE
•SPEED DISTRIBUTION
INTERFACE
"DEFAULT"
OR USER MODELS
•TRAFFIC FLOW
•TRAFFIC DENSITY
•MEAN SPEED
SPEED-TIME PROFILE
VEHICLE TECHNOLOGY CLASSIFICATION
FLEETS DATABASE
EXTERNAL INPUT
EMPIRICAL DRIVER BEHAVIOR
GEAR SHIFT MODULE
MACRO EMISSION MODEL
DRIVING PATTERN
INSTANTANEOUS MODEL
e.g E=E(V,a)
ENERGY + CO2 ALL VEHICLES MACRO
ENERGY + CO2 PCs LOCAL
e.g. (kWh/fuel) or (tCO2/fuel)
DATABASE

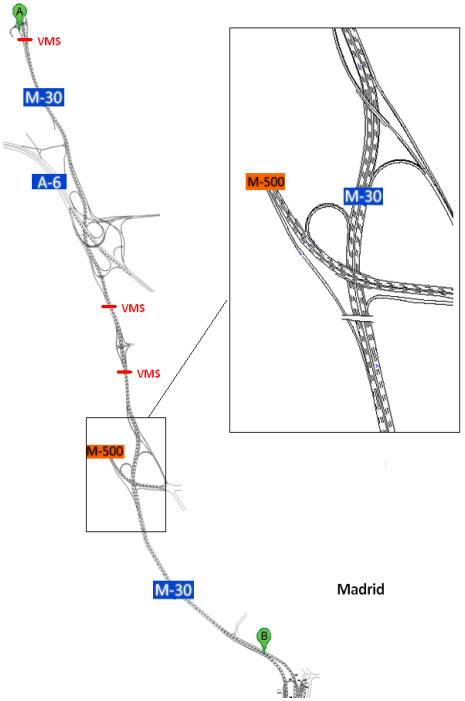
The overall architecture



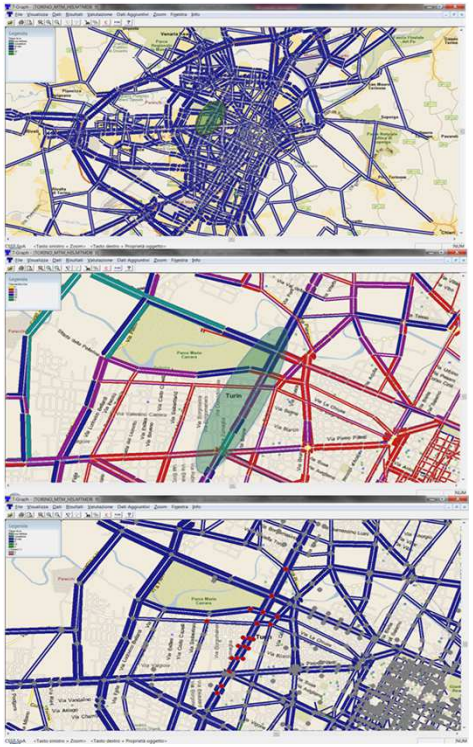
ICT-Emissions

SEVENTH FRAMEWORK PROGRAMME

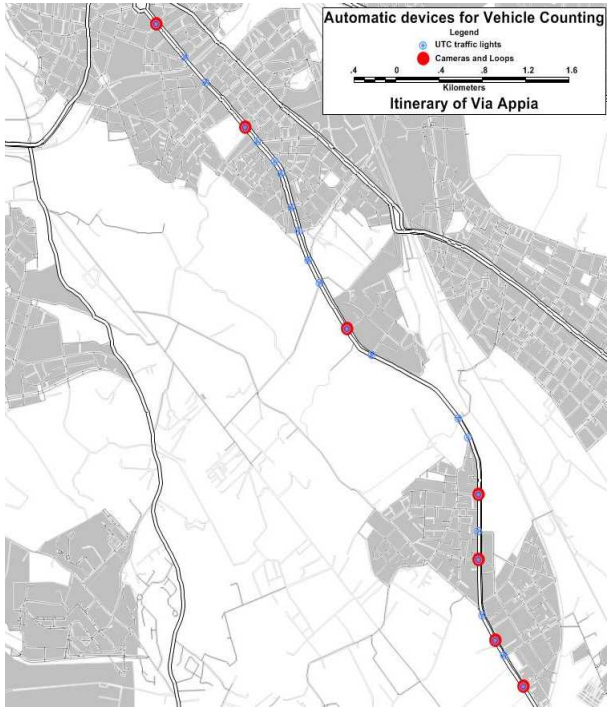
Demonstration Sites



- Urban motorway in Madrid



- Turin City Centre



- Rome Urban Corridor

ICT-Emissions

SEVENTH FRAMEWORK PROGRAMME

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

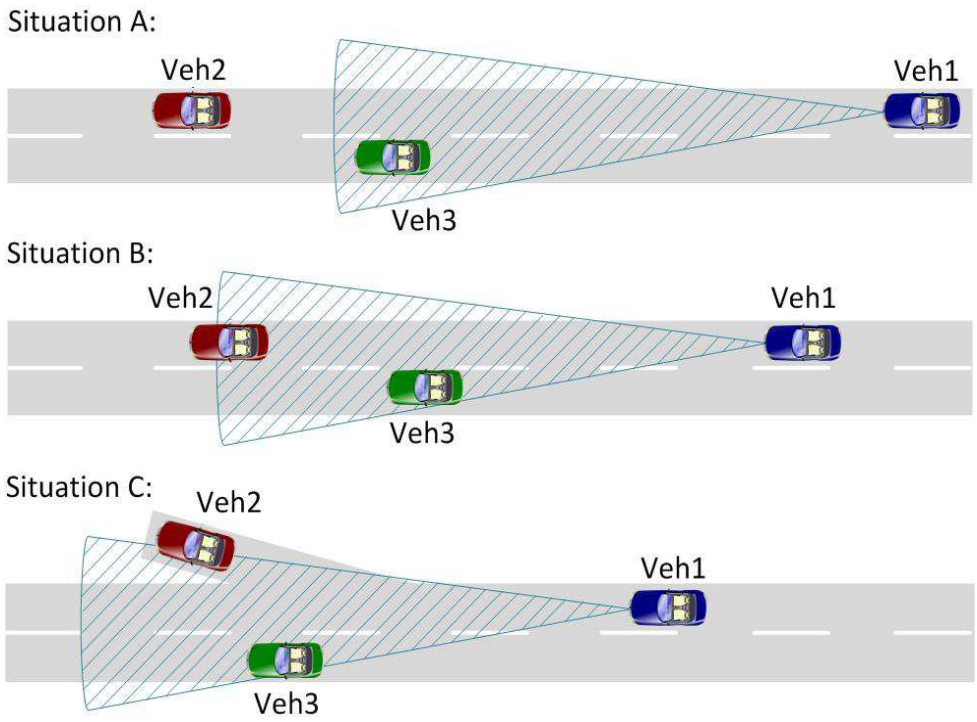
Examples of Case Studies

Classification	NAME	MICRO			MACRO	
		Traffic	Vehicle	Emission	Traffic	Emission
Traffic Management and Control	Traffic adaptive Urban Traffic Control - UTC	✓		✓	✓	✓
	Speed Control (point-to-point)	✓		✓	✓	✓
	Dynamic Speed Limits	✓		✓	✓	✓
Driver behaviour change and eco driving	Promotion of an energy-efficient style of driving	✓		✓	✓	✓
	Start&Stop			✓		
ADAS	*Cruise Control*	✓	✓	✓		
	Navigation based Cruise Control	✓	✓	✓		
	Adaptive cruise Control	✓	✓	✓		
	ACC+STOP&GO	✓	✓	✓		
	Cooperative Cruise Control - Lane merging Assistance	✓	✓	✓		

ICT-Emissions

SEVENTH FRAMEWORK PROGRAMME

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.

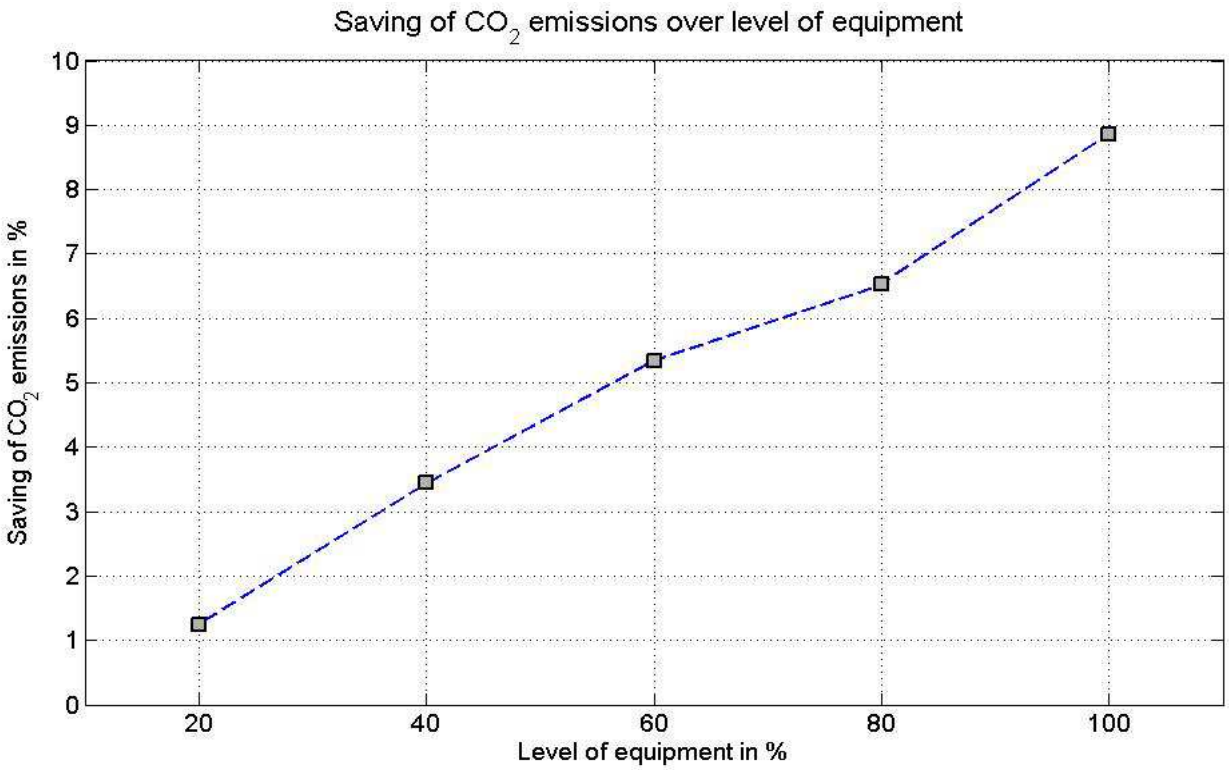
Situation C: If the target vehicle in Situation C exits the road, the ego vehicle switches from ACC to CC and accelerates to the target speed desired by the driver.

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

ICT-Emissions

SEVENTH FRAMEWORK PROGRAMME

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 CO_2 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/

ICT-Emissions

SEVENTH FRAMEWORK PROGRAMME

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