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uCARe consortium

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Note: Prior versions of the model requirements were discussed using an Excel file.

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Executive summary

The basic requirements for the simulation tool core and the vehicle models, to be produced in WP2, are listed. The process followed to obtain these requirements is also described.

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Definitions & Abbreviations

Accel.	Acceleration
A/C-system	Air-conditioning-system
Cd	Drag coefficient
DoW	Description of Work
e.g.	Example given
etc.	Et cetera
FC	Fuel Consumption
GVM	Gross Vehicle Mass
HBEFA	Handbook Emission Factors for Road Transport
HVAC	Heating, Ventilation and Air Conditioning
i.e.	Id est
ICE	Internal Combustion Engine
LCV	Light Commercial vehicle
LDV	Light Duty Vehicle
max.	Maximum
min.	Minimum
Pe	Effective engine power
PC	Passenger Car
rpm	Rounds per minute (engine speed)
RRC	Rolling Resistance Coefficient
SCR	Selective Catalytic Reduction
V	Velocity
V_avg	Average velocity
WP	Work Package

1 Introduction

1.1 Background uCARe

With four million people dying annually due to outdoor pollution, improvement of air quality has become one of society's main challenges. In Europe, traffic and transport have a large effect on air quality, specifically passenger cars and commercial vehicles and to a lesser extent non-road mobile machinery. While technical improvements and more stringent legislation have had a significant impact, traffic and transport emissions are still too high and air quality is still poor. Although the use of electric and other zero-emission propulsion technologies may drastically reduce the pollutant exhaust emissions from traffic, the slow introduction of such vehicles as well as the trend of increasing vehicle lifetimes means that vehicles with internal combustion engines are expected to dominate the fleet beyond 2030. This project is the first opportunity to improve emissions of vehicles, not by improving vehicle technology, but by actively involving vehicle users and enabling their contribution to clean driving.

So far, expertise on pollutant emissions has mainly been used to advise European policy makers on limited effectiveness of emission legislation (through real-world emission factors such as HBEFA and COPERT) and how to reduce traffic and transport pollutant emissions. The numerous mitigation methods are rarely extended to include the perspectives of users uCARe enables a next essential step: providing user targeted emission reduction measures. These measures will be implemented and evaluated in real-life pilot projects.

The overall aim of uCARe is *to reduce the overall pollutant emissions of the existing combustion engine vehicle fleet by providing vehicle users with simple and effective tools to decrease their individual emissions and to support stakeholders with an interest in local air quality in selecting feasible intervention strategies that lead to the desired user behaviour*. The overall aim is accompanied by the following objectives:

1. To identify **user-influenced vehicle emission aspects** (such as driving behaviour and vehicle component choice).
2. To determine the **emission reduction potential** of each vehicle emission aspect with help of the uCARe model developed within a toolbox.
3. To develop a **toolbox**, containing models and emission reduction measures, that enables stakeholders to identify the most appropriate intervention strategies that reflect the specific users and their motivation.
4. **Support policy makers** and other **stakeholders with an interest in air quality,** such as municipalities and branch organizations, **in identifying intervention strategies** that translate the measures into desired behaviour of the user.
5. **To test and evaluate** intervention strategies in a set of pilot projects conducted with various target user groups in at least four European countries. The pilot projects illustrate effectiveness and feasibility of the toolbox and intervention strategies developed on its basis.
6. Perform an **impact assessment** of the intervention strategies effectiveness, in terms of cost, penetration, achieved emission reduction and lasting effects.
7. **Actively feed** European cities and international parties with uCARe learning and results, via awareness raising campaigns, communication tools, interactive web application and other dissemination activities. Open access to the broad public to the toolbox, data and developed tools.
8. Summarise the findings **in blueprints for rolling out** different user-oriented emission reduction programmes, based on successful pilots.

This document is part of WP2 and lists the core requirements for the tool WP2 will build based on the Augmented Emission Maps of WP1. These requirements refer to the simulation core; other requirements, e.g. regarding the user interface, will be included later.

1.2 Purpose of the document

The document provides the basic requirements for the simulation tool and the vehicle models to be produced in WP2. All partners were involved in the decision making process and the demand list was commonly agreed.

1.3 Document Structure

Chapters 1 to 4 provide background information on uCARe and the document.
Chapters 7 and 8 describe the process and the resulting target specifications for the simulation tool.

1.4 Deviations from original DoW

1.4.1 Description of work related to deliverable as given in DoW

"Catalogue of requirements for the simulation method" [DoW].

Task 2.2 will, in cooperation with WP3, analyse the list of possible behaviour changes to set up a catalogue of requirements for the simulation method.

Thus the deliverable is the guiding document for the development of simulation methods and vehicle models in WP2 with the catalogue of requirements for the simulation method.

1.4.2 Time deviations from original DoW

None.

1.4.3 Content deviations from original DoW

None.

2 Process to define the model requirements

For vehicle emission and energy consumption simulation, we use following wording in this deliverable:

- Simulation method: describes which physical, empirical or other relations are applied to calculate emissions (e.g. using equations of longitudinal dynamics to calculate the engine power demand).
- Simulation tool: is the software which calculates the emissions, using the simulation method developed and the vehicle models as input.
- Vehicle model: is the input data set for a vehicle or for a vehicle group, necessary to apply the simulation method and to run the simulation tool.

There are several basic rules in software and model development which shall be followed in WP2:

1. The simulation tool has to satisfy to the user demands.
2. The method has to fit to the model structure and to the user demands.
3. The model has to fit to the available data.
4. As simple as possible, as complex as necessary.

As a first step in the development of the simulation tool, a system specification, i.e. the software requirements have been compiled.

The work flow to come up with the system specifications was for each area:

- Start with a common discussion in a meeting (Audioweb or face-to-face)
- Circulate a list within the partners to add demands not considered in the discussion.
- Discuss the resulting list once more in the group to eliminate possibly unnecessary functionality demands.

The results are described in the next chapter.

3 Resulting model requirements and boundaries

Following fields of application for the software were identified:

Main users are WP3 and WP4.

Demands for WP3:

The software shall provide feedback to the drivers of vehicles on the emission and energy consumption of a complete trip and possibly also online during the trip.

The software shall evaluate the driver behaviour and shall show a ranking between ECO and High-Emitter for the driving style of a trip.

The software shall provide suggestions to the driver how to act more energy and emission efficient.

The software shall be able to read the necessary information on the vehicle trip from the OBD connection of the car via a dongle. Data shall be transmitted from the dongle to a laptop, tablet or mobile phone.

The software and dongle shall be easy to be installed and adjusted for all vehicles, to encourage a frequent usage, e.g. in eco-drive workshops and driving schools.

The software should not distract the driver and feedback shall be motivating to adjust the behaviour for more environmental friendly vehicle use.

Demands for WP4:

The software shall be able to calculate emission changes due to variations of driving style (defined by speed and gear trajectories), vehicle status (e.g. tire pressure, roof boxes, loading,…) and ambient conditions (cold start extra emissions, air density) for all passenger car and LCV classes at least from EURO 3 on.

Following sources for the vehicle model data were identified:

a) Existing emission test data (main source) and new measurements to be performed in uCARe (to fill gaps), converted into emission maps as input from WP1.

b) Literature.

c) Existing models.

b) and c) can be used to fill gaps and/or to develop data sets from physical or empirical relations.

Based on the software demands listed above, a list of possible changes of the vehicle user behaviour was set up. The list contains only those changes, where the model is expected to calculate effects on emissions and energy consumption (Table 1).

Since the method shall make use of emission maps provided by WP1, all behavioural changes of the vehicle user have to be related by the calculation methods to the axis of the emission maps, which provide emissions as function of CO_2 mass flow and vehicle speed and also as function of CO_2 mass flow and engine speed (the latter option is needed to characterise effects of gear shift behaviours).

The discussion of possible options to relate amendments in driving behaviour and vehicle setting to CO_2 mass flow and vehicle and engine speed, lead to the selection of the methods of longitudinal dynamic simulation to compute the engine power (Pe). Engine speed (rpm) shall be simulated based on the transmission ratios if no measured rpm signal is available. From the instantaneously computed Pe and rpm the CO_2 mass flow can be calculated using generic engine efficiency maps. With CO_2 and rpm the emission maps from WP1 can directly be applied to calculate the emission mass flow at each time step of a trip for all

use cases listed in Table 1. Cold start effects on pollutant emissions shall be simulated based on a catalyst model. For CO_2 and energy consumption a simpler friction model may be applied.

For non-exhaust emissions WP2 intends to develop a method to calculate tire and brake wear as function of vehicle velocity, wheel power and tire specifications. Since the available measurement data is yet limited, the details of the methods for non-exhaust are still under discussion.

Based on the draft method designs described above, Table 1 also lists the parameters, which are affected by the behavioural changes in the calculation method. The completed list shows, that all driver actions can be simulated. To reach a satisfying accuracy of the simulation, is task of the ongoing work in WP1 and WP2.

Table 1: Demand list for the software development in WP2

	Influences on	
Driver action	**Directly**	**Indirectly**
Improved gear shift behaviour	rpm, power	max torque @ rpm, accel., v_avg
Anticipatory driving	acceleration, deceleration levels	Pe, rpm, P_brake, v_avg, tire wear, brake wear
Maintenance of best tire pressure	RRC, tire wear	Pe
Tire selection (type, RRC-class, others?)	RRC, tire wear	Pe
Avoiding dead freight	mass (loading), tire wear	Pe
Dismount unused roof boxes	Air drag, mass	Pe
Setting of HVAC	P_aux	Pe, (rpm)
Use of additional trailers , bike racks, etc	mass, air drag	Pe, (rpm)
Extended idling	idling emissions	Cool down and heat up effects on exhaust after treatment (EAT)
Correct wheel alignment	RRC, tire wear	Pe
Maintenance (air filter, engine oil…)	system losses,	Pe
Less dynamic driving	velocity trajectory	v_avg, v_stdev, Pe, tire wear
Short trips/Cold start	number of trips, stop time	Coolant temperature, cool down and heat up effects on exhaust after treatment
Tire maintenance (storage)	rubber hardness	Tire wear
Adapt target speed	tire wear, Pe, rpm	
Choice of brake clutches	brake wear	