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5.0	06.08.15	Werner Maier	Added a summary and conclusion chapter

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Executive Summary

This document corresponds to the deliverable D4.3.2 which is the description of the database library of driving situations of the FP7 ICT-Emissions project. This deliverable describes the structure of the database library that will be produced in the project to store the key input, modelling and output information produced by the different traffic and emission simulations conducted in the framework of the project. This can facilitate easy access to the data for future reference.

The general structure of the library follows the approach adopted when developing the methodology of the project, i.e. defining an ICT measure which we wish to simulate, determine the basecase traffic condition and the vehicle fleet affected, then setting up the models and calculating the results. Performing the complete calculation requires a large number of data regarding traffic network, vehicle characteristics, consumption factors, etc. The library will not store all of this information for each simulation run but will contain key information on how the runs have been executed.

The variables and parameters that are proposed to be stored in the library refer to the following six components of the simulation:

1. The ICT/ITS MEASURE component provides information on the details of the measure being simulated. This includes verbal description of the measure, its difference over the basecase, the number of vehicles being affected, extensiveness of the measure, etc.

2. The BASECASE TRAFFIC SCENARIO component where the parameters used to characterize the traffic situation are listed and described.

3. The FLEET CHARACTERISTICS component with the vehicles that have been included in the simulation and their characteristics.

4. The DRIVING SITUATIONS component with the characteristics of the driving situations generated by the basecase scenario, the fleet characteristics and the ICT/ITS measure applied.

5. The MODELLING METHODS component which describes the key characteristics of the methods (models) that have been used to produce the results.

6. The OUTPUT INFORMATION component which collects the results of the ICT/ITS measure in terms of traffic effects, energy and CO_2 effects, both in absolute and in relative terms over the basecase.

This report outlines the various fields per component which are considered important to include in the library. Finally, it describes the software implementation of the library itself.

1 Introduction

Detailed description of a traffic condition is a cumbersome process because it involves often thousands of vehicles, each operating on its own pattern, at an external frequently changing environment (e.g. traffic light patterns, accidents occurring, etc.). One could however identify some descriptive parameters that may characterise traffic to a certain extent. These parameters can be mainly classified as measurements of quantity, such as traffic flow density or mean speed, and measurements of quality, such as level of congestion. The traffic stream parameters can be macroscopic, which characterize traffic as a whole or microscopic which studies the behaviour of individual vehicles in the traffic stream with respect to each other. As far as the macroscopic characteristics are concerned, typical descriptive values are the ones outlined above, i.e. traffic flow, density, and speed. Microscopic traffic characteristics include either the exact vehicle speed profile or proxy magnitudes, such as headway with the vehicle in front, acceleration patterns, etc.

Further, the variance in driving may be influenced by several factors, either exogenous, such as urban area structure, street type, number of lanes, traffic conditions, and type of vehicle (Lyons et al., 1989; Ericsson, 2000; Brundell-Freij and Ericsson, 2005) or endogenous, such as the driver characteristics (Brundell-Freij and Ericsson, 2005; Hari *et al.*, 2012; Malikopoulos and Aguilar, 2012). The exact driving situation that a vehicle operates in is well known to affect exhaust emission and fuel consumption. ICT-Emissions aims at developing an integrated methodology that can be used to evaluate the impact of ICT-related measures on mobility, vehicle energy consumption and CO_2 emissions. Hence, in order to describe the regime of application of the ICT-Emissions methodology, one will have to characterise the environment this is being applied to, the traffic conditions, the vehicles being affected, and other exogenous and endogenous information. Only by providing these boundary conditions, the effect of the ICT measure considered can be understood – and replicated if necessary. It should be expected that the same ICT measure could have a much different effect if it was applied on a different environment.

In order to provide this information for all situations that will be simulated within ICT-Emissions in a transparent way, the consortium has proposed to develop an electronic library. The library should contain information that should describe the general environment of the condition simulated, the traffic conditions, the vehicle stock considered, the modelling tools and their key parameterization, and the results of the simulation. There are two intentions in creating such a library:

- To provide modelling details in an organised way for future reference from researchers that would like to reproduce / modify the given traffic situation in their own modelling environment and confirm or extend our findings.

- For general reference by third parties on the impacts of ICT measures in given situations. This is particularly useful in those applications where there is no wish or ability to perform a detailed simulation but rather a general understanding of the impact of a given ICT solution is required. Even in this case, it is important to be able to locate the relevant details of the application.

The intention of this report is to provide a description of this library, i.e. its structure, the fields where information should be stored and the general software requirements for the actual implementation of the library. In addition to this introductory chapter, Chapter 2 presents the structure of the database library and explains the data which is stored in it. Chapter 3 gives a detailed view on the software implementation and shows how the database library is realized in the ICT-Emissions project as a server-database application which can be accessed via a web front-end in a common web browser.

2 Description of the Database – An Abstract View on the Data

2.1. General Structure

The library structure follows the general concept of the project as such (Figure 1). It is constructed on the basis of the cause–effect scheme, where first the ICT measure is described, then the basecase associated with it is provided and finally the modelling methods and the output information are given.

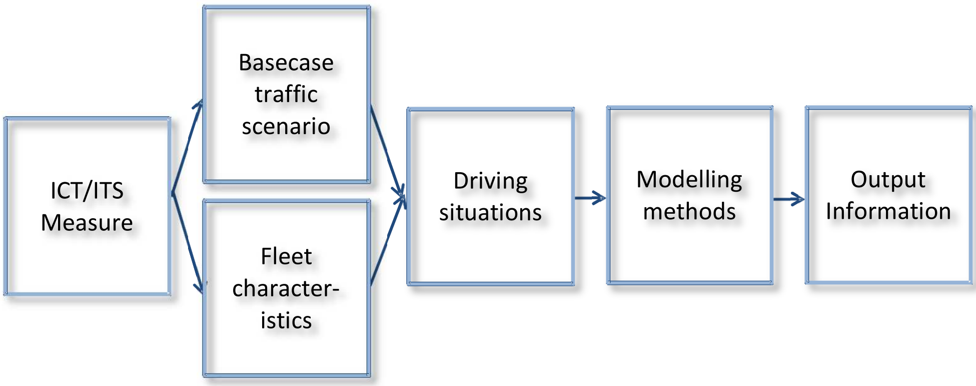

Figure 1: General structure of the library considered.

In more detail:

7. The ICT/ITS MEASURE component provides information on the details of the measure being simulated. This includes verbal description of the measure, its difference over the basecase, the number of vehicles being affected, extensiveness of the measure, etc.

8. The BASECASE TRAFFIC SCENARIO component where the parameters used to characterize the traffic situation are listed and described.

9. The FLEET CHARACTERISTICS component with the vehicles that have been included in the simulation and their characteristics.

10. The DRIVING SITUATIONS component with the characteristics of the driving situations generated by the basecase scenario, the fleet characteristics and the ICT/ITS measure applied.

11. The MODELLING METHODS component which describes the key characteristics of the methods (models) that have been used to produce the results.

12. The OUTPUT INFORMATION component which collects the results of the ICT/ITS measure in terms of traffic effects, energy and CO_2 effects, both in absolute and in relative terms over the basecase.

2.2. ICT/ITS Measure Component

Information on the simulated ICT measure should be included in this component of the database. In particular, the following fields are foreseen:

ICT 1. Title of the ICT measure implemented according to the classification outlined in Chapter 4 of ICT-Emissions Deliverable 2.1 (Toffolo et al., 2012). For example, “i-2.6 Dynamic speed limits.

ICT 2. Description of the ICT measure. Free text to provide the general framework of the application. For example: “This measure involves the simulation of dynamic speed limits on the urban ring-road in the area of Madrid, Spain. In particular the M30 Motorway, west section (5.8 km) with a normal speed limit of 90 km/h. The implementation of the measure is through variable message signs (VMS) deployed along the roadway and connected via a communication system to the traffic management centre. The simulation conducted refers to decreased speed limits to 80 km/h, 60 km/h or 40 km/h depending on the upstream flow conditions.”

ICT 3. Photograph or schematic of the area of implementation. For actual cases simulated, a photograph of the area can be very descriptive by showing how the measure is implemented, number of lanes, general flow conditions, etc. In case this is only a simulation of a generic traffic scenario, a schematic generated e.g. by the traffic models used can also be included to visualise the conditions.

ICT 4. Number of vehicles being affected. An ICT measure may affect a variable number of vehicles. For infrastructure related ICT measures (e.g. UTC on/off cases) this number corresponds to the number of vehicles on the streets of the area being affected when the ICT measure is enabled/disabled. For on-board ICT measure, such as adaptive cruise control, this field should contain the percentage of vehicles equipped with the particular system..

ICT 5. Duration of event/simulation. The ICT measure can be enabled for a few seconds, minutes or longer periods. This field should contain the duration of the event, which also should be less or equal the duration of the simulation. For example, for modelling the dynamic on-trip routing, the duration of the event is the duration of the trip itself.

ICT 6. Scale of implementation. Mostly for infrastructure enabled ICT measures, this field should contain characteristics of the scale of implementation. For example, for dynamic speed limits this could be “9 trips along the motorway stretch affected by 3 VMS” or for UTC implementation, this could be “50 traffic-light controlled junctions”.

Figure 2 shows a photo of the area being affected, which complements the description of the ICT measure in the relevant field.

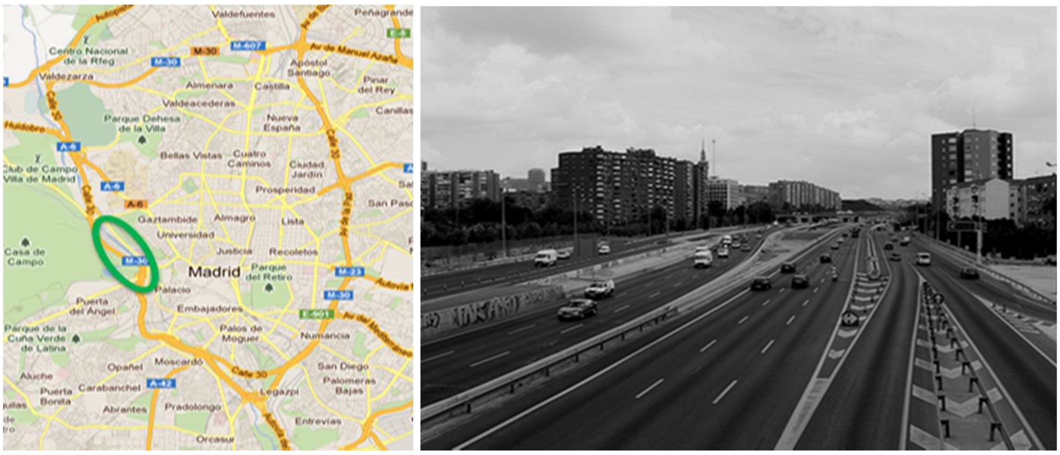

Figure 2: Example of area of implementation (Madrid – M-30 ring motorway section).

2.3. BASECASE TRAFFIC SCENARIO COMPONENT

This component stores key information of the basecase condition, on which the ICT measure refers to. The fields foreseen to describe the basecase condition include:

BC 1. Geo-location information. A map of the area or other characteristics of the basecase area may be shown, in particular if different from the simulated ICT-on condition. For example, for dynamic trip routing, the basecase trip will be different than the ICT-on trip. This could be provided with a separate map-based trip colouring.

BC 2. Short description of the area considered. This could be free-text to describe main functions of the street(s) or city network considered. For example this could be: "the area considered is the downtown Turin area, consisting of 450 traffic-controlled junctions and with a traffic load of 150 thousand vehicles per hour in the basecase condition. The total area stretches over 8 square kilometres and involves 65 km of total street coverage".

BC 3. Date and time and events. Description of typical day/time that the basecase condition would be encountered, or to describe if special events determine the basecase condition. For example, events that disrupt the normal flow of traffic, usually by physical impedance in the travel lanes (e.g. accidents), major events (e.g. football match), weather conditions, etc.

BC 4. Network description Information that was used in the simulations to describe the area considered. This could include number of links in macro-modelling, number of lanes for motorway micro-modelling, etc.

BC 5. Number of vehicles. This should include the number of vehicles in the basecase scenario. For macroscale modelling, this could be traffic density (veh/km) or traffic flow (veh/h) while for microscale modelling, this could be the exact number of vehicles considered in the simulation.

BC 6. Traffic level. Qualitative and, where possible, quantitative information to describe the basecase level of congestion. Qualitative characterisations could be descriptors such as “free flow”, “normal”, “congested” and quantitative information could be delay times, drop in average speed, a percentage saturation parameter, etc.

BC 7. Duration of event/simulation. This is similar to field ICT 5 and may receive identical information if the basecase and the simulation refer to the same event. However, it may be the case that the ICT-on simulation is a subset of the basecase or that the simulation durations differ. Hence, a separate field with the same usage as ICT 5 is foreseen also in the basecase scenario.

BC 8. General driving characteristics. This field is mostly applicable in micro-modelling where different on-board or infrastructure-related measures are affected by the driving behaviour. For example, adaptive cruise control would have a different impact for aggressive than timid driving. Qualitative information could be stored in this field, such as “timid”, “normal”, or “aggressive” driving. Quantitative information, such as mean positive acceleration or speed fluctuation indicators could also be stored to describe the driver’s behaviour.

2.4. Fleet Characteristics Component

One of the main features of the ICT-Emission project is that it covers a variety of vehicle types and technologies, ranging from conventional vehicles to advanced electricity based ones. Therefore, the impact of each ICT-measure will be different for different compositions of the fleet considered. In fact, several of the ICT-measures proposed may be simulated with a different composition of the stock in order to obtain a sensitivity of the output to the fleet composition considered.

FL 1. Share of commercial vehicles. ICT-Emissions mainly focuses on passenger cars and commercial vehicles are dealt with in a simplified manner. This field should contain the share of commercial vehicles in the total vehicle number considered.

FL 2. Conventional PC split. Conventional passenger cars are split into 30 classes, depending on their efficiency, size and fuel used. This field should contain the number or the share of the passenger cars considered per specific category.

FL 3. Advanced PC split. In addition, the project considers several advanced vehicle types, including hybrids, plug-in hybrids, electric, etc. Implementation of ICT measures is considered to have a considerably different effect on advanced vehicles than conventional ones. This is why this field provides separately the split of passenger cars to the advanced vehicle types.

FL 4. ADAS equipped vehicles. This field may contain similar information to field ICT 4, however it further specifies it, since a different number of advanced or conventional vehicles may be equipped and have enabled the ADAS solution considered. Therefore, this field will contain the actual implementation of ADAS per vehicle type.

2.5. DRIVING SITUATIONS

The main input in traffic modelling and calculation of the impact of ICT measures is the driving situation(s) affected by the measure considered. As stated in the introductory chapter, the driving situation is the most difficult parameter to describe because of its variability (different for each moment and for each vehicle). Also, the driving situation(s) can be described in different terms for the microscopic and macroscopic modelling cases.

2.5.1. MICROSCOPIC APPLICATIONS

DSMi 1. Driving profile. In microscopic modelling, the models operate on a second-by-second speed profile. This is actually different for each vehicle considered by the model. However, an average profile can be produced out of the many vehicles being considered. It is proposed that this profile should be stored in this field as a reference for the condition simulated. Figure 3 shows an example of average driving profiles in the case of Madrid with and without the dynamic speed limits activated.

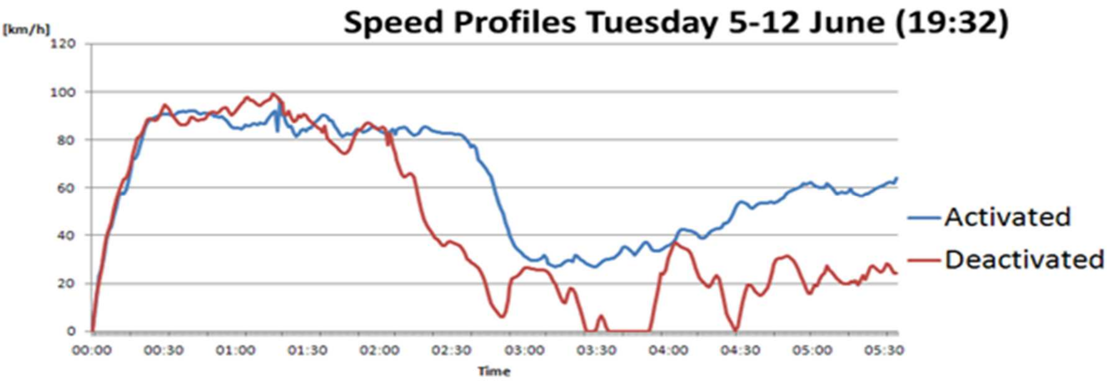

Figure 3: Example of second by second average microscopic driving profile.

DSMi 2. Statistics of driving. In the absence of an exact driving profile, or in order to complement it, statistical information to describe the driving pattern may be provided. This can include a variety of variables, describing speed, acceleration, and stop time for the driving sequence.

Table 1: Examples of statistical information used to describe a driving condition.

Length (m)		6697
Total time (s)		736
Speed (km/h)	Average	33
	Max	81
	Average (no stops)	46
	99 %tile	70
	% of constant speed (|acc|<0.1m/s^2)	16
Stop	% of time v<3 km/h	3
	No/km	1.05
	Mean time (s)	30.7
Acceleration (m/s^2)	Positive	0.510
	Negative	-0.595
	Positive (no stop time)	0.517
	Negative (no stop time)	-0.614

2.5.2. Macroscopic Applications

In the case of macroscopic applications, a driving pattern is not available, hence alternative methods to characterise the driving situations are necessary. The following two descriptors are proposed:

DSMa 1. Average speed frequency distribution. For the links considered in the macroscopic modelling one may provide the frequency distribution of the average speed, e.g. 10% <10 km/h, 20%, 10-20 km/h, etc. With this information one may understand the modelling environment under which the macroscopic simulations have been performed.

DSMa 2. Congestion factor frequency distribution. Similar to the average speed, a congestion level for each link may be calculated by comparing the spent travel time over the minimum travel time. According to this parameter, links may be classified. Hence, this field could store information such as 20% of links with congestion<1.2, 30% of links with congestion 1.2-1.5, etc.

The information stored in both the microscopic and the macroscopic relevant field is generally different when the ICT measure is enabled, than in the basecase. Hence, it is foreseen that two sets of information will be included per field, once for the ICT-on and one for the ICT-off case.

2.6. MODELLING METHODS COMPONENT

The consortium has decided to implement different microscopic and macroscopic traffic models in the simulations mostly in order to demonstrate that the methodology developed is not model specific. Description of the model specificities will be required in the library to provide enough details on how the simulation has been conducted. Naturally, it is not possible to store all model parameters. Hence, only the main specifications of the models and the key information will be stored in the database. Two generic fields, which are model independent will contain the number and version of the models used:

MM 1. Name/version of the traffic model used. This will contain the name of the traffic model used (e.g. Aimsun, Visum, etc.) and its version, e.g. "Aimsun 7.1". Specific remarks or comments on possible extensions on the models developed within this project may also be clarified in this field, e.g. "Aimsun 7.1 with specific interface for ADAS applications".

MM 2. Name/version of the emission model used. This will contain the name of the emission model used (e.g. COPERT, CRUISE, etc.) and its version, e.g. "COPERT 4 v10.0".

MM 3. Name/version of the ADAS specific model used. We only use the B&M Messina framework for our modelling hence this field will only contain information when an ADAS specific measure is being implemented. Nevertheless, the field is open for other models too, should they become available in the future.

2.6.1. AIMSUN &VISSIM

AIMSUN and VISSIM are microscopic traffic models. The main modelling parameters that will have to be included in the library contain the following (TSS, 2006)

MM 4. Car following and lane changing model used. Information on whether the default parameters or user-specified parameters have been used for the two sub-models in the software. Detailed information may not be given (some of it may be proprietary) but indications on the changes carried out should be included for the transparency of the modelling.

MM 5. Geometry and turning movement. Basic information on whether the default approach or a modified approach has been used to develop the geometry of the network and boundary conditions on the turning movement of vehicle will be stored in this field. Not all details of modelling can be included, but just some free text guidance for future reference.

MM 6. Vehicle type parameters. ICT-Emissions develops exact specifications for the vehicles to be simulated with microscopic models. This field will describe whether the vehicles simulated follow the default ICT-Emissions specifications or if modifications have been introduced for the particular run.

MM 7. Demand module. The field will indicate whether and how the demand module has been calibrated, i.e. whether this is linked to a macroscopic model or whether demand has been explicitly defined through given OD matrices.

2.6.2. VISUM and MT.Model

VISUM is a macroscopic traffic model with application in transportation planning, travel demand modelling and network data management (PTV, 2001). It provides a variety of assignment procedures and 4-stage modelling components which include trip-end based as well as activity based approaches. It may further integrate demand modelling with microscopic traffic simulation (VISSIM). The MT.MODEL is also a macroscopic model which offers the capability to simulate the variations to the actual mobility and transport planning. MT.MODEL architecture is based on the general structure of a Decision Support System (DSS). It comprises models for vehicle assignment, multi-user assignment, traffic supply, traffic demand, and Origin-Destination (OD) matrix estimation.

Providing exact details for the macro-models used is very cumbersome as they are mathematically complex and in need of many data to simulate a street network. Hence, only one free text field is considered here which will provide comments on the model used and specific information on the use of the model which is required for the transparency of the simulation.

MM 8. Macroscopic model. Name of the model used and necessary details on its application.

2.6.3. Microscopic (or instantaneous) model – AVL CRUISE

The AVL CRUISE vehicle and powertrain level simulation tool is used to simulate emissions and fuel consumption of each vehicle considered in the ICT-Emissions project. Detailed specifications of the vehicles included in the AVL CRUISE environment are given in Deliverable 3.1 and Deliverable 3.2 of the project and need not be repeated in the library. Specifications on the use of the vehicles for some of the ICT measures considered may have to be given:

MM 9. ICT measure activation. Details on the implementation for some of the on-board ICT measures, such as start-and-stop or gear-shift indicator, will be provided in this field.

MM 10. Road geometry. The slope of the road considered will be provided in this field. Slope has a paramount effect on CO2 emissions.

2.6.4. Macroscopic Emission Model – COPERT 4

COPERT 4 will be used to calculate emissions at a macroscopic level. COPERT 4 estimates emissions on the basis of average travelling speed and contains detailed emission and consumption factors for over 250 individual vehicle types. Only some basic parameters on the use of COPERT 4 will be provided in the library:

MM 11. Fuel specifications. CO2 emissions depend on the fuel used and in particular the H:C and the O:C ratio, that will be provided in this field. Also, possible scenarios will require to specify in this field the biofuel used.

MM 12. Environmental conditions. Temperature conditions and the inclusion of cold-start in the calculations may increase emissions. Details on the approach to take into account environmental factors will be given.

MM 13. Ageing and other corrections. Vehicle ageing effects as well as some vehicle characteristics may have an impact on CO_2 and other pollutant emissions. Description of the advanced features specifications will be provided in this field.

2.6.5. Vehicle ADAS model

In ICT-Emissions an important topic is the analysis of the effect of advanced driver assistance systems (ADAS) on the fuel consumption of the vehicles. The model used for this application is a specific model developed in the MESSINA software platform by Berner & Mattner (Wegener and Kruse, 2009). MESSINA is a software platform for model-based ECU testing from specification to Hardware-in-the-Loop (HiL) testing. The following parameters will be stored in the library in reference to the ADAS simulation:

MM 14. ADAS submodule implemented. Depending on the ADAS system considered, a different simulation approach may have been followed, as outlined in Deliverables 4.1 and 4.2 of the project. The method used will be included in this field.

MM 15. Driver model. The driver model used when an ADAS system is implemented will be provided in this field. Details on the driver model are given in Deliverable 4.2

2.7. OUTPUT INFORMATION COMPONENT

The output information includes the results of implementation of each/combined ICT/ITS measure in absolute terms and in relative terms over the basecase. The following field are considered to be included in the library

OUT 1. Total CO_2 benefit. The total CO_2 benefit obtained for the particular ICT enabled condition over the basecase will be reported in absolute (kg) and relative (%) units.

OUT 2. CO_2 benefit per vehicle category. Benefits obtained by the different vehicle segments/types will be described in absolute (kg) and relative (%) units over the basecase.

OUT 3. Total Energy benefit. The total energy benefit over the basecase per energy source used will be reported in absolute (kWh) and relative (%).terms

OUT 4. Energy benefit per vehicle category. Energy benefits obtained for the different vehicle categories over the basecase will be reported in absolute (kWh) and relative (%) terms.

OUT 5. Travel time benefit. Average benefits of travelling time (resp. average speed) over the baseline will be reported in actual (s) and relative (%) terms.

OUT 6. Stop time benefit. Average benefits in reducing the stop time over the basecase will be reported in actual (s) and relative (%) terms.

3 Implementation of the Library

3.1. Software Implementation

There are different software options to implement this library.

The original option considered was to develop specifically designed Excel files to store all information. Excel is advantageous over more specialised software such as Microsoft Access or a different database software due to its versatility and because it is accessible and available by a variety of users, including non-experts. In addition, Excel files are relatively easy to develop and do not require significant resources or experienced personnel to produce. Excel templates could be populated using the information presented in the previous chapters in this report, for each simulation executed. The Excel files that will contain the information would be appropriately named so that their content is obvious and the file names would be stored in a catalogue with a short description for easy access to the information.

However, during the second annual review meeting, concerns were expressed from the reviewers that storing the information in Excel files would not allow wide dissemination of the dataset and that it would not enable easy access and sorting of the information produced. Therefore, it was requested that the consortium explores the possibility to build a specialised database software with the appropriate interface that would allow more user friendly access and storage of all the information produced.

Hence, the consortium presents in this final version D.4.3.2 of the deliverable a software solution which realizes the ICT-Emissions Database Library as a server-database application. This application is deployed on a central server which has access to a database to persist and retrieve data. The server will be hosted and maintained at the Aristotle University of Thessaloniki. The web front-end of the server application can be accessed by opening the URL

http://ictemissions.meng.auth.gr

in a web browser.

This centralized approach avoids synchronization issues which might arise if a local database (or Excel file) is exchanged between the partners of the consortium to persist the data of their simulation runs. In the following, the architecture of the server-database application and the database schema is described. Furthermore, this deliverable describes the interface which was elaborated by the consortium to upload data to the database. Since the form of the interface heavily depends on which data can be extracted from the integrated ICT-Emissions simulation platform (WP5 of the ICT-Emissions project), the design of the interface could not be finished after the integration of the different components of the simulation platform (micro/macro traffic models and micro/macro emission tools) was sufficiently advanced. This caused some delay to the implementation of the new version of the ICT-Emissions Database Library and to the finalization of this deliverable D.4.3.2.

Regarding the data which is specified in Section 2, less information is stored in the new version of the database since it resulted that not all the data in Section 2 can be automatically extracted from the modelling tools used in the ICT-Emissions project. Hence, we had to adapt the interface and the content of the database to the data which in fact can be provided in the simulations.

3.1.1. ARCHITECTURE OF THE SERVER-DATABASE APPLICATION

The architecture of the server-database application is depicted in Figure 4. The server application provides two web interfaces, one for data import/removal and one for the retrieval of database reports. The two interfaces can be accessed via the HTTP protocol. In case of an import or deletion process, data is sent to the server via HTTP POST, whereas reports are obtained from the server/database by a client by sending an HTTP GET request to the server. For the operating phase of the server-database application appropriate security mechanisms are implemented to grant access to certain domains of the application only to selected users. These security mechanisms are described in Section 3.3. Hence, a secure connection over HTTPS is used when a client accesses the web services.

The import web service parses the data received by a client. A mapping logic translates the data into the format of the database and splits data to different tables (see 3.1.2). A database access layer implements methods with database-specific SQL queries.

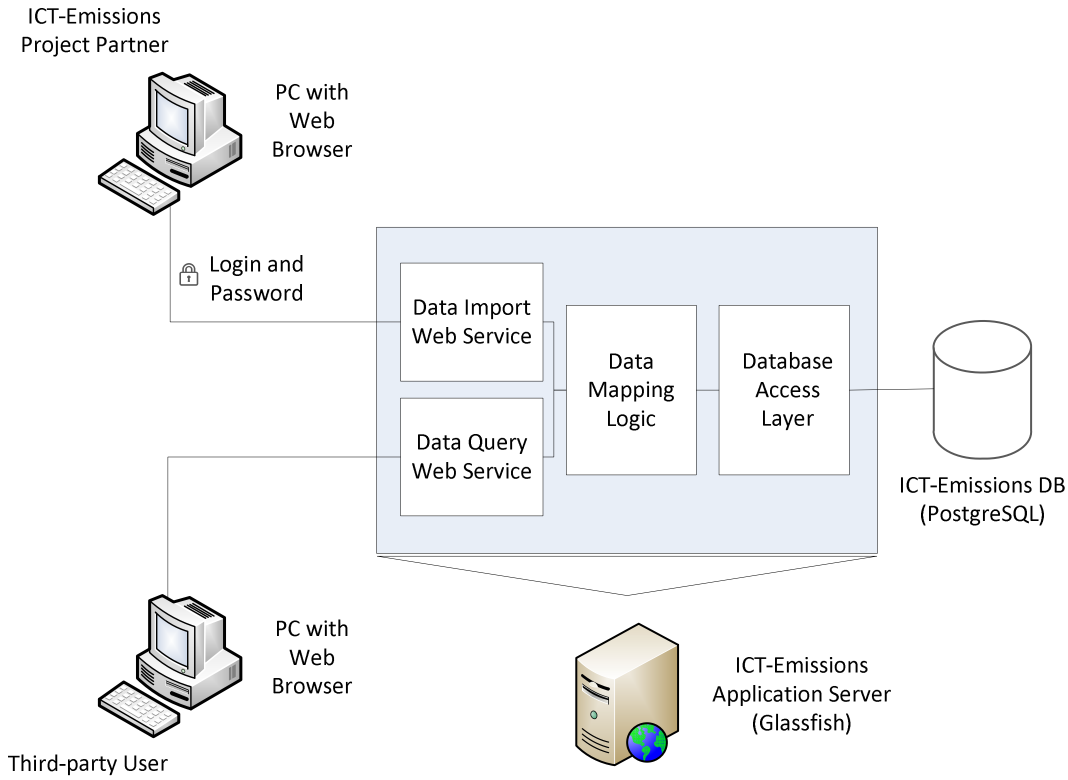

Figure 4: The architecture of the server-database application.

The Application Server is a Glassfish server which implements the Java EE 6 standard. The database is a PostgreSQL database. The decision in favour of these two software components is because they are open-source tools. Hence, there are no license fees during the operating phase of the server-database application.

The software architecture is designed in a way that single components can be exchanged easily. The database access layer e.g. has a Java interface, which can be implemented for specific databases.

3.1.2. Entity-Relationship Model

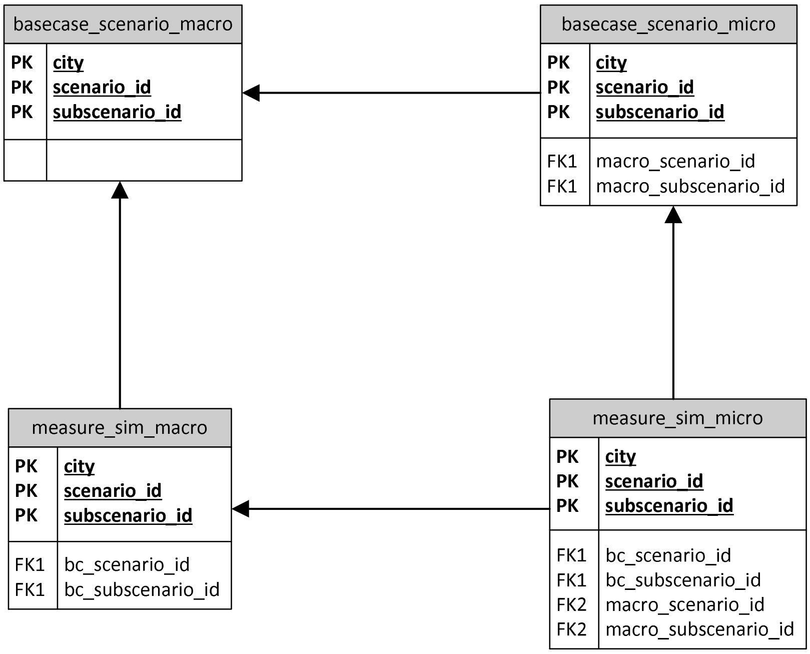

Figure 5: Entity-relationship model of the ICT-Emissions Database Library

The entity-relationship model, which reflects the schema of the database, is shown in Figure 5. The schema consists of four tables. Two of them store data from simulations where ICT measures are applied to traffic scenarios. The table *measure_sim_macro* stores data from ICT simulations on a macroscopic level. The table *measure_sim_micro* contains data from simulations where ICT measures are applied to microscopic traffic simulations. In addition, data from simulations of basecase scenarios are stored in separate tables, both for the microscopic and for the macroscopic scale.

Each entry in the four tables can be uniquely identified by specifying the city where the simulation is performed as well as a scenario identifier and a subscenario identifier. The scenario identifier indicates a given ICT measure and the subscenario identifier can indicate a given parameterization of the scenario (e.g. a certain penetration rate of ICT vehicles). Hence, the primary key of each database entry is a compound key which consists of the attributes *city*, *scenario_id* and *subscenario_id*. Since there is a finite set of cities (Madrid, Rome and Turin), the attribute *city* is in fact an enumeration. The *scenario_id* and the *subscenario_id* are numbers.

The reason for storing microscopic and macroscopic data or information from basecase or ICT measure simulations in different tables is to establish relationships between them. Each ICT-measure simulation can be linked with the corresponding basecase scenario by specifying the attributes *bc_scenario_id* and *bc_subscenario_id* in the tables *measure_sim_micro* and *measure_sim_macro*, which together serve as a foreign key. The relationship is a one-to-many relationship. This means that several

ICT-measure simulations can be related to the same basecase scenario. Further relationships are established between the tables for the microscopic and the macroscopic data. Several microscopic scenarios in a city can be related to the same macroscopic scenario in the same city. Hence, there is also a one-to-many relationship between the macro and the micro tables. The relationships between the tables are used for joining information in different tables. In a database query, e.g., data such as the amount of CO_2 emissions of a basecase scenario can be efficiently retrieved as a reference for the corresponding data of the ICT scenario.

The tables in Figure 5 only contain the primary and the foreign keys. Of course, they also contain payload data. Selected attributes from the database table *measure_sim_micro* are shown in Figure 6.

measure_sim_micro	
PK	**city**
PK	**scenario_id**
PK	**subscenario_id**
	bc_scenario_id
	bc_subscenario_id
	macro_scenario_id
	macro_subscenario_id
	scenario_ict_measure_description
	traffic_level
	km_roads
	car_perc
	freight_perc
	bus_perc
	co2_total_kg
	co2_avg_g_km
	stop_time
	perc_stop_time
	number_stops
	speed_const_perc
	speed_max
	pos_acc
	neg_acc
	speed_avg
	veh_x_h
	veh_x_km

Figure 6: Selected attributes from the database table *measure_sim_micro*

Apart from the primary key and the foreign keys descriptive information is stored about the traffic scenario (*scenario_ict_measure_description*, *traffic level*, *km_roads*). Besides the shares of different vehicle types (*car_perc*, *freight_perc* and *bus_perc*) describing the fleet composition of the traffic scenario are stored. The results of the simulation (output of the emission model) are the total amount of CO_2 emissions (in kg) and the relative amount of CO_2 emissions per length (in g/km). Furthermore, driving statistics are saved in the database. For the microscopic level these are, e.g., the number of stops (*number_stops*), the average positive and negative acceleration (*pos_acc* and *neg_acc*). Macroscopic data is represented by the last three attributes *speed_avg* (average travel speed), *veh_x_h* and *veh_x_km* (which are measures for traffic flow and traffic density).

In addition, optional information from the traffic simulations can be stored in the four tables, which allows for a deeper analysis of the simulation. This is, e.g. the number of links/nodes in a traffic scenario or specific data for different road categories (e.g. the total length of all roads from the categories urban, urban highway, extra-urban and extra-urban highway, respectively). Optional data can also be data related to the different vehicle categories in a simulation (e.g. the CO_2 emissions for cars, freight or busses, respectively).

A detailed overview of all attributes which can be stored in the database for a simulation is given in the Annex of this deliverable.

3.1.3. Interface for Data Import

The consortium agreed to choose an interface for data upload which consists of a set of three CSV file templates. The format CSV (Comma Separated Values) is found to be convenient, since the databases which are used by the partners to store the output of their modelling tools provide a straight-forward way to extract data in CSV files.

One CSV file contains the payload data obtained from the simulations. This is the data described in Section 3.1.2. A subset of the attributes in the CSV file is shown in Figure 7. The extract shows that the CSV file can contain data from each type of simulation. The rows can contain data from either macroscopic or microscopic simulations (see column *scale_sim*) and data from basecase or ICT measure simulations (see column *scenario_ict_measure_descrip*). The rows are separated by the data mapping logic of the server application using the information in these two columns and assigned to the different tables in the database in Section 3.1.2.

	A	B	C	D	E	F	G
1	scenario_id	subscenario_id	scale_sim	city	scenario_ict_measure_descrip	sub_scenario_ict_measure_descrip	CO2_total_kg
2	22	1	microscopic	Turin	utc	first utc micro scenario imported	1305
3	22	2	microscopic	Turin	utc	another utc micro scenario	1234
4	22	3	microscopic	Turin	eco_drive	this is a ecodrive micro scenario	1342
5	22	4	microscopic	Turin	utc	this description is for a utc micro scena	1251
6	12	1	macroscopic	Turin	eco_drive	another description	1624
7	12	2	macroscopic	Turin	utc	this is a macro scenario	1705
8	212	1	macroscopic	Madrid	eco_drive	short desc	1623
9	222	1	microscopic	Madrid	eco_drive	normal length description	1324
10	11	1	macroscopic	Turin	basecase		1800
11	21	1	microscopic	Turin	basecase		1400

Figure 7: Subset of attributes transmitted in a CSV file to the import interface of the server.

The relationships between ICT measure simulations and basecase simulations are specified in another CSV file. As shown in Figure 8 the CSV file contains a table which maps the basecase simulations to the corresponding ICT measure simulations using the scenario identifier and subscenario identifier. The scenario identifier and the subscenario identifier of an ICT measure simulation are given in the columns *ict_scenario_id* and *ict_subscenario_id*, respectively. The scenario identifier and the subscenario identifier of the corresponding basecase scenario are given in the columns *bc_scenario_id* and *bc_subscenario_id*, respectively In addition, the city and the simulation scale are given in the CSV file to uniquely specifiy a simulation. Since the city and the scale are the same for an ICT measure simulation and its corresponding basecase simulation, it is sufficient to have this information only once per row in this CSV file.

	A	B	C	D	E	F
1	city	scale	bc_scenario_id	bc_subscenario_id	ict_scenario_id	ict_subscenario_id
2	turin	microscopic	21	1	22	1
3	turin	microscopic	21	1	22	2
4	turin	microscopic	21	1	22	3
5	turin	microscopic	21	1	22	4
6	turin	macroscopic	11	1	12	1
7	turin	macroscopic	11	1	12	2

Figure 8: CSV file which maps ICT measure simulations to their corresponding basecase simulations.

In another CSV file the relationships between microscopic and macroscopic simulations are specified. Figure 9 shows a similar mapping as it is used for the ICT-measure/basecase-correspondences. The mapping is done using the scenario identifiers and the subscenario identifiers of the microscopic and macroscopic simulations. The scenario identifier and the subscenario identifier of a microscopic traffic simulation are given in the columns *scenario_id_micro* and *subscenario_id_micro*, respectively. The scenario identifier and the subscenario identifier of a microscopic traffic simulation are given in the columns *scenario_id_micro* and *subscenario_id_micro*, respectively. The scenario identifier and the subscenario identifier of the corresponding macroscopic traffic simulation are given in the columns *scenario_id_macro* and *subscenario_id_macro*, respectively. For uniqueness, the city, which is the same for corresponding microscopic and macroscopic simulations, is also included.

	A	B	C	D	E
1	city	scenario_id_macro	subscenario_id_macro	scenario_id_micro	subscenario_id_micro
2	turin	11	1	21	1
3	turin	12	1	22	3
4	turin	12	2	22	1
5	turin	12	2	22	2
6	turin	12	2	22	4
7	madrid	212	1	222	1

Figure 9: CSV file which maps microscopic simulations to corresponding macroscopic simulations.

The information in the CSV files in Figure 8 and Figure 9 is used by the data mapping logic of the server application to set the foreign keys in the database tables.

For a user-friendly upload of the CSV files, the server application offers an XHTML-webpage where the CSV files can be selected from the file system of the computer. By pressing the button *Import* below, the import process is started and the data in the CSV files is written into the database. The webpage can be opened by a common web browser, such as Microsoft Internet Explorer, Mozilla Firefox or Google Chrome. A screenshot of this user interface is shown in Figure 10.

Figure 10: Web interface for data upload.

After the upload has finished, the user gets feedback on which data sets of the CSV files have been imported successfully to the database and which failed due to a violation of the interface specification (see Annex). An example is shown in Figure 11.

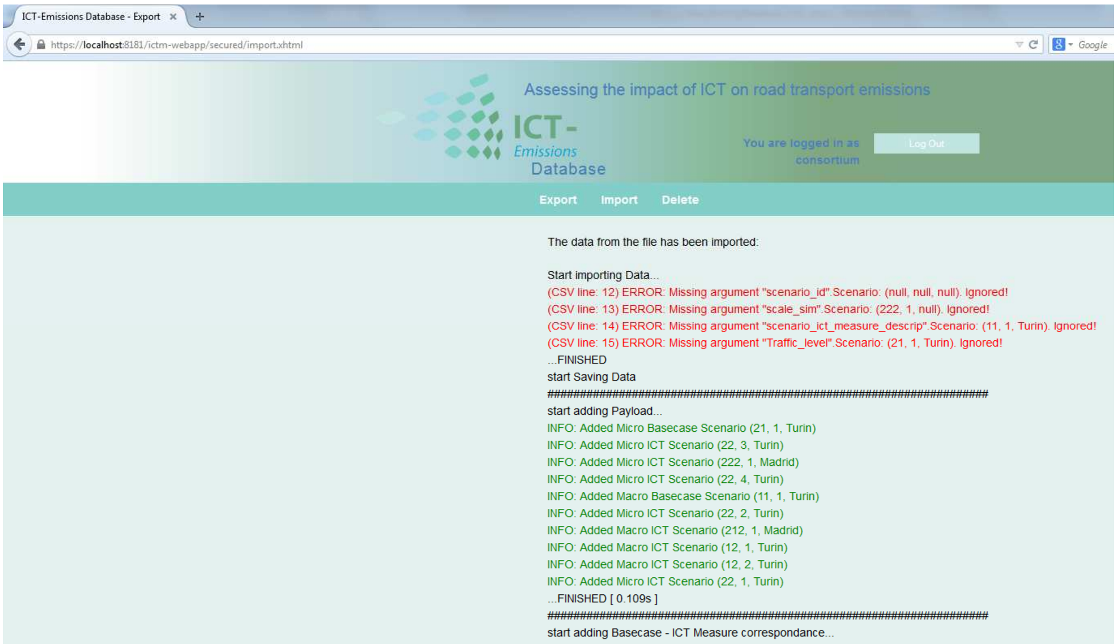

Figure 11: Feedback on the import process

3.1.4. DELETING SIMULATION DATA FROM THE DATABASE

The web interface of the ICT Emissions Database also provides a page where members of the consortium can delete data sets from the database in case they are obsolete or not valid anymore. To this end, the user uploads a CSV file which contains information about the simulation scale (microscopic or macroscopic) and about the values of the primary key (*scenario_id*, *subscenario_id* and *city*) of the data sets which should be removed. The deletion process is started when the button *Delete* is pressed. Figure 12 shows a screenshot of this web page.

Figure 12: Web interface for deleting data sets from the database

3.2. GENERATING REPORTS FROM THE DATABASE

A third-party user (city authorities, researchers or other stakeholders of the ICT-Emissions project) can access the information in the database via another web interface, which is shown in Figure 13. This web interface is also an XHTML page which can be opened in a common web browser.The user can make selections for the criteria which are used to query the database and to generate reports. These criteria are the ICT measure, the city and the simulation scale. The ICT measure can be chosen from the finite set of ICT measures for which simulations are performed in the ICT-Emissions project. This set is defined in WP 6 of the project and comprises currently the measures *Green Navigation*, *Urban Traffic Control (UTC)*, *Variable Speed Limits (VSL)*, *Eco Drive*, *Start & Stop*, *Cruise Control* and *Adaptive Cruise Control (ACC)*. Among the cities the user can choose between the cities *Madrid*, *Rome* and *Turin*. For the scale the user has the two options *macroscopic* and *microscopic*. For the ICT measure, the city and the scale multiple selections are possible. This means that a user can simultaneously retrieve data for multiple ICT measures, from multiple cities or for both macroscopic and microscopic simulations in the database reports.

After the user has made the selection in the three list boxes, he can trigger the generation of a brief summary report by pressing the button *Generate summary* which is located below the list boxes. This report appears as a table right of the list boxes. It contains for each data set a consecutive number, the ICT measure, the subscenario description, the city, the scale and the relative benefit of an ICT measure over the basecase. The benefit is computed as

$$benefit = -\frac{em_{ICT} - em_{BC}}{em_{BC}}$$

where em_{ICT} is the total amount of CO_2 emissions in kg from the ICT measure simulation and em_{BC} is the total amount of CO_2 emissions in kg from the basecase simulation.

The intention of this brief summary is to give the user a coarse overview of the effectiveness of an ICT measure over the basecase.

If the user would like to have more detailed information on a simulation, e.g., on the microscopic driving statistics or on the emissions per vehicle type or per road class, the user can generate a CSV report which contains all the attributes which are stored for the simulation in the database (see Annex). This CSV report is generated by pressing the button *Export details to CSV …* on the bottom left of the web page. In this context the user can also select the symbol which should be used as a CSV separator in the generated CSV file.

By choosing the option *add Basecase* directly below the three list boxes on the left of the web page the user can include all the information on the basecase simulation in the CSV report. The option *add Macro/Micro* includes both in the brief summary on the web page and in the CSV report information on corresponding macroscopic data sets or microscopic data sets from the database.

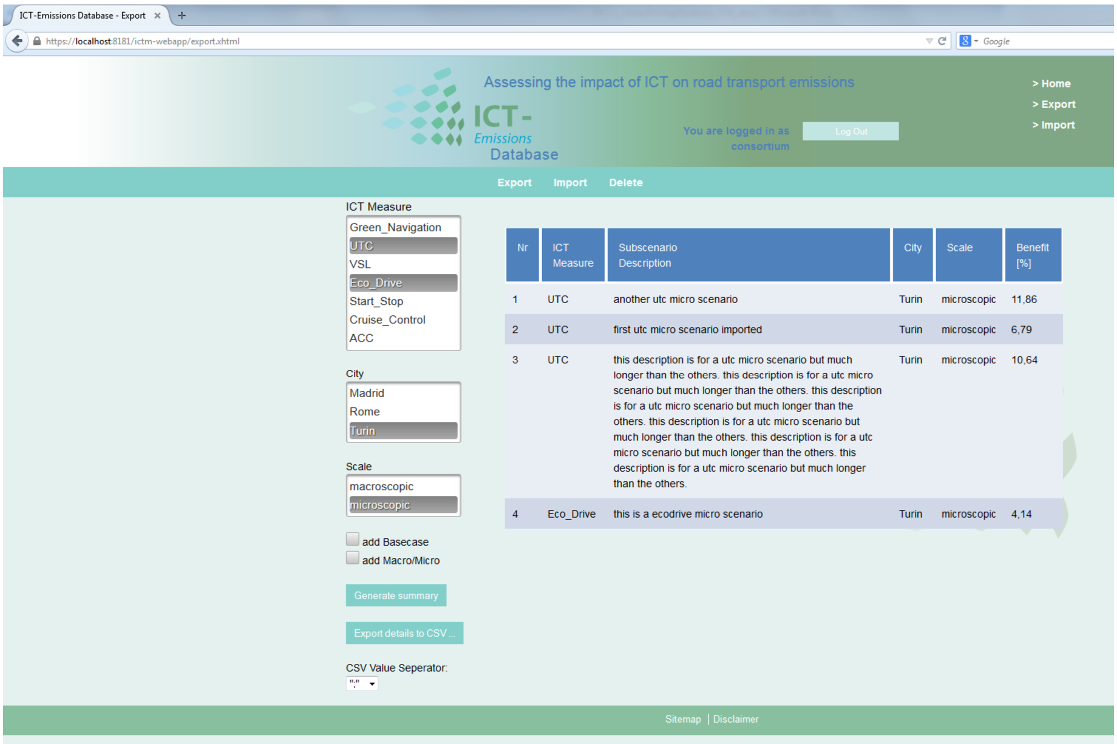

Figure 13: Web interface for a third-party user to retrieve information from the ICT-Emissions Database Library

3.3. User Authentication

Some functionalities such as the import of new data sets and the removal of existing information from the database should only be used by the consortium members. To this end, security mechanisms are implemented in the web application which make these functions inaccessible to third-party users.

When a user loads the home page of the ICT-Emissions Database, only the export functionality is available by default. That means that a user can only generate reports from the database, but neither import nor delete data from the database.

When an authorized user enters his username and his password (see highlighted region in Figure 14 (top)), the additional menu items *Import* and *Delete* appear after the login (see left highlighted region in Figure 14 (bottom)).

As the right highlighted region in Figure 14 (bottom) shows, the user gets information that he is logged in, as long as the session is active. The user is automatically logged out after a certain period of inactivity. Furthermore, the user can also press the *Log Out* button to stop the session.

Figure 14: Additional functionality after the authentication of an authorized user.

4 Summary and Conclusions

This report describes the ICT-Emissions Database Library which stores the simulation results generated for the analysis of the impact of the ICT measures considered in the ICT-Emissions project on CO_2 emissions. The database can be consulted by city authorities who intend to implement a given measure in their city to reduce CO_2 emissions and would like to learn about the impact of the measure. Furthermore, researchers might be interested in the details of the performed simulations and use the results as a reference for their own approaches.

The first part of this report provides a description of the database and collects the requirements. The information stored in the database is structured in several components, two of them separating the information from ICT measure simulations from basecase simulations. Besides, there are components which store information about fleet characteristics, driving situations, modelling methods and output information. On a microscopic level statistical data is stored for the driving situations, such as the average positive and negative acceleration, the number of stops etc. On a macroscopic level traffic flow and density data is stored. The modelling methods comprise characteristics and specific parameterizations of the simulations. The output information block stores the actual outcome of the simulations, such as CO_2 data.

The second part of this report describes the implementation of this database as a web application. It provides a web interface which allows a user to set several parameters to retrieve simulation data from the ICT measures in the cities considered in the ICT-Emissions project. The user gets a list of all ICT simulations returned by the database together with a short description of the simulation and the benefit with respect to the corresponding basecase scenario. The entries in the list can be sorted by the benefit values. This allows a user to put the measures which perform best on the top of the list. The web application also provides a function for the partners of the ICT-Emissions consortium to import the data of their simulations from CSV files. This function is only visible after the partner has provided the username and the password. For the partners there is also a delete function to remove simulation results from the database.

The database is publically accessible, following the link http://ictemissions.meng.auth.gr

5 Sources

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ANNEX

1 Interface Specification of the Payload Information for Data Upload

In the following the set of attributes which can be contained in a payload CSV file is specified. Since the import process on the server checks the available columns in a payload CSV which is uploaded to the database by their names, it is not necessary to insert empty columns for optional data which is not available in the CSV. In the following table the names of the attributes are given together with their measure unit, a description and the information if they are optional.

No.	Attribute name	Measure unit / data type	Description	Optional (yes/no)
1	scenario_id		Scenario identifier (Part of the key of a data set)	no
2	subscenario_id		Subscenario identifier (Part of the key of a data set)	no
3	scale_sim		Simulation scale (Part of the key of a data set) <u>Permitted values:</u> macroscopic, microscopic	no
4	city		Name of the city where the simulation is performed (Part of the key of a data set) <u>Permitted values:</u> Madrid, Rome, Turin	no
5	scenario_ict_measure_decrip		Name (keyword) of a simulated ICT measure <u>Permitted values:</u>	no

			Basecase, Green_Navigation, UTC, VSL, Eco_Drive, Start_Stop, Cruise_Control, ACC	
6	sub_scenario_ict_measure_descrip		Description of the simulated sub scenario (characteristics, parameterization)	yes
7	CO2_total_kg	kg	Absolute amount of CO_2 emissions in a simulation	no
8	CO2_avg_g_km	g/km	Relative amount of CO_2 emissions per length in a simulation	no
9	vehXkm	veh*km	Traffic flow	no
10	vehXh	veh*h	Traffic volume per hour	no
11	speed_avg	km/h	Average speed	no
12	t_time	minutes	Travel time	yes
13	stop_time		Time that the vehicle is in standstill (<= 3 km/h) Only microscopic	yes
14	perc_stop_time		Percentage of the time that the a vehicle is in standstill related to the total time Only microscopic	yes
15	number_stops		Number of stops of a vehicle Only microscopic	yes
16	speed_avg_NOstop		Average speed excluding time periods of a standstill Only microscopic	yes

17	speed_const_perc		Percentage of constant speed periods Only microscopic	yes
18	speed_max		Maximum speed Only microscopic	yes
19	pos_acc		Positive acceleration Only microscopic	yes
20	neg_acc		Negative acceleration Only microscopic	yes
21	pos_acc_NOstop		Positive acceleration excluding time periods of a standstill Only microscopic	yes
22	neg_acc_NOstop		Negative acceleration excluding time periods of a standstill Only microscopic	yes
23	Traffic_level		Traffic level Permitted values: free, normal, congested	no
24	Simulation_minutes	minutes	Simulation time	yes
25	num_links		Number of map links	yes
26	num_nodes		Number of map nodes	yes
27	num_zones		Number of zones	yes
28	num_veh_types		Number of vehicle types	yes
29	vehicle_type_list	string	List of the vehicle types	yes
30	num_user_class		Number of user classes	yes

31	user_class_list	string	List of user classes	yes
32	km_roads	km	Length of all roads	no
33	OD_tot_dem	vehicle/h	OD total demand	yes
34	CAR_perc	%	Fleet composition: Percentage of cars	no
35	Freight_perc	%	Fleet composition: Percentage of commercial vehicles	no
36	Bus_perc	%	Fleet composition: Percentage of buses	no
37	km_roads_urban	km	Length of all urban roads	yes
38	km_roads_urban_highway	km	Length of all urban highways	yes
39	km_roads_extraurban	km	Length of all extra-urban roads	yes
40	km_roads_extraurban_highway	km	Length of all extra-urban highways	yes
41	free_speed_urban	km/h	Free speed on urban roads	yes
42	free_speed_urban_highway	km/h	Free speed on urban highways	yes
43	free_speed_extraurban	km/h	Free speed on extra-urban roads	yes
44	free_speed_extraurban_highway	km/h	Free speed on extra-urban highways	yes
45	OD_tot_dem_CAR		OD total demand related to cars	yes
46	OD_tot_dem_Freight_Veh		OD total demand related to commercial vehicles	yes
47	OD_tot_dem_BUS		OD total demand related to buses	yes

48	det1_tot_km	km	Detail information 1 on road length	yes
49	det1_num_veh		Detail information 1 on number of vehicles	yes
50	det1_descr		Detail information 1 - description	yes
51	det2_tot_km	km	Detail information 2 on road length	yes
52	det2_num_veh		Detail information 2 on number of vehicles	yes
53	det2_descr		Detail information 2 – description	yes
54	det3_tot_km	km	Detail information 3 on road length	yes
55	det3_num_veh		Detail information 3 on number of vehicles	yes
56	det3_descr		Detail information 3 – description	yes
57	det4_tot_km	km	Detail information 4 on road length	yes
58	det4_num_veh		Detail information 4 on number of vehicles	yes
59	det4_descr		Detail information 4 – description	yes
60	Fuel_abs	l	Absolute fuel consumption	yes
61	Fuel_rel	l/100km	Relative fuel consumption per length	yes
62	Energy_abs	kWh	Absolute electric consumption (for electric vehicles)	yes
63	Energy_rel	kWh/	Relative electric	yes

		100km	consumption per length (for electric vehicles)	
64	CAR_CO2_abs	kg	Absolute amount of CO_2 emissions related to cars	yes
65	CAR_CO2_rel	kg	Relative amount of CO_2 emissions per length related to cars	yes
66	Freight_CO2_abs	kg	Absolute amount of CO_2 emissions related to commercial vehicles	yes
67	Freight_CO2_rel	kg	Relative amount of CO_2 emissions per length related to commercial vehicles	yes
68	BUS_CO2_abs	kg	Absolute amount of CO_2 emissions related to buses	yes
69	BUS_CO2_rel	kg	Relative amount of CO_2 emissions per length related to buses	yes
70	perc_driver_type_calm	%	Percentage of calm drivers	yes
71	perc_driver_type_normal	%	Percentage of normal drivers	yes
72	perc_driver_type_aggressive	%	Percentage of aggressive drivers	yes
73	perc_adas	%	Percentage of ADAS vehicles	Yes
74	speed_avg_std	km/h	Standard deviation of speed related to average speed	Yes
75	det1_vehXkm	veh*km	Detail information 1 Traffic flow	yes
76	det1_vehXh	veh*h	Detail information 1	yes

			Traffic volume per hour	
77	det1_speed_avg	km/h	Detail information 1 Average speed	yes
78	det1_t_time	minutes	Detail information 1 Travel time	yes
79	det1_stop_time		Detail information 1 Time that the vehicle is in standstill (<= 3 km/h) Only microscopic	yes
80	det1_perc_stop_time		Detail information 1 Percentage of the time that a vehicle is in standstill related to the total time Only microscopic	yes
81	det1_number_stops		Detail information 1 Number of stops of a vehicle Only microscopic	yes
82	det1_speed_avg_NOstop		Detail information 1 Average speed excluding time periods of a standstill Only microscopic	yes
83	det1_speed_const_perc		Detail information 1 Percentage of constant speed periods Only microscopic	yes

84	det1_speed_max		Detail information 1 Maximum speed Only microscopic	yes
85	det1_pos_acc		Detail information 1 Positive acceleration Only microscopic	yes
86	det1_neg_acc		Detail information 1 Negative acceleration Only microscopic	yes
87	det1_pos_acc_NOstop		Detail information 1 Positive acceleration excluding time periods of a standstill Only microscopic	yes
88	det1_neg_acc_NOstop		Detail information 1 Negative acceleration excluding time periods of a standstill Only microscopic	yes
89	det1_speed_avg_std	km/h	Detail information 1 Standard deviation of speed related to average speed	yes
90	det2_vehXkm	veh*km	Detail information 2 Traffic flow	yes
91	det2_vehXh	veh*h	Detail information 2 Traffic volume per hour	yes

92	det2_speed_avg	km/h	Detail information 2 Average speed	yes
93	det2_t_time	minutes	Detail information 2 Travel time	yes
94	det2_stop_time		Detail information 2 Time that the vehicle is in standstill (<= 3 km/h) Only microscopic	yes
95	det2_perc_stop_time		Detail information 2 Percentage of the time that a vehicle is in standstill related to the total time Only microscopic	yes
96	det2_number_stops		Detail information 2 Number of stops of a vehicle Only microscopic	yes
97	det2_speed_avg_NOstop		Detail information 2 Average speed excluding time periods of a standstill Only microscopic	yes
98	det2_speed_const_perc		Detail information 2 Percentage of constant speed periods Only microscopic	yes
99	det2_speed_max		Detail information 2	yes

			Maximum speed Only microscopic	
100	det2_pos_acc		Detail information 2 Positive acceleration Only microscopic	yes
101	det2_neg_acc		Detail information 2 Negative acceleration Only microscopic	yes
102	det2_pos_acc_NOstop		Detail information 2 Positive acceleration excluding time periods of a standstill Only microscopic	yes
103	det2_neg_acc_NOstop		Detail information 2 Negative acceleration excluding time periods of a standstill Only microscopic	yes
104	det2_speed_avg_std	km/h	Detail information 2 Standard deviation of speed related to average speed	yes
105	CAR_vehXkm	veh*km	Traffic flow related to cars	yes
106	CAR_vehXh	veh*h	Traffic volume per hour related to cars	yes
107	CAR_speed_avg	km/h	Average speed related to cars	yes
108	CAR_t_time	minutes	Travel time related to	yes

			cars	
109	CAR_stop_time		Time that the vehicle is in standstill (<= 3 km/h) related to cars Only microscopic	yes
110	CAR_perc_stop_time		Percentage of the time that a vehicle is in standstill related to the total time (cars) Only microscopic	yes
111	CAR_number_stops		Number of stops of a vehicle related to cars Only microscopic	yes
112	CAR_speed_avg_NOstop		Average speed related to cars excluding time periods of a standstill Only microscopic	yes
113	CAR_speed_const_perc		Percentage of constant speed periods related to cars Only microscopic	yes
114	CAR_speed_max		Maximum speed related to cars Only microscopic	yes
115	CAR_pos_acc		Positive acceleration related to cars Only microscopic	yes
116	CAR_neg_acc		Negative acceleration related to cars Only microscopic	yes
117	CAR_pos_acc_NOstop		Positive acceleration	yes

			related to cars excluding time periods of a standstill Only microscopic	
118	CAR_neg_acc_NOstop		Negative acceleration related to cars excluding time periods of a standstill Only microscopic	yes
119	CAR_speed_avg_std	km/h	Standard deviation of speed related to average speed (cars)	yes
120	Freight_vehXkm	veh*km	Traffic flow related to commercial vehicles	yes
121	Freight_vehXh	veh*h	Traffic volume per hour related to commercial vehicles	yes
122	Freight_speed_avg	km/h	Average speed related to commercial vehicles	yes
123	Freight_t_time	minutes	Travel time related to commercial vehicles	yes
124	Freight_stop_time		Time that the vehicle is in standstill (<= 3 km/h) related to commercial vehicles Only microscopic	yes
125	Freight_perc_stop_time		Percentage of the time that a vehicle is in standstill related to the total time (commercial vehicles) Only microscopic	yes
126	Freight_number_stops		Number of stops of a vehicle related to commercial vehicles	yes

			Only microscopic	
127	Freight_speed_avg_NOstop		Average speed related to commercial vehicles excluding time periods of a standstill Only microscopic	yes
128	Freight_speed_const_perc		Percentage of constant speed periods related to commercial vehicles Only microscopic	yes
129	Freight_speed_max		Maximum speed related to commercial vehicles Only microscopic	yes
130	Freight_pos_acc		Positive acceleration related to commercial vehicles Only microscopic	yes
131	Freight_neg_acc		Negative acceleration related to commercial vehicles Only microscopic	yes
132	Freight_pos_acc_NOstop		Positive acceleration related to commercial vehicles excluding time periods of a standstill Only microscopic	yes
133	Freight_neg_acc_NOstop		Negative acceleration related to commercial vehicles excluding time periods of a standstill Only microscopic	yes
134	Freight_speed_avg_std	km/h	Standard deviation of	yes

			speed related to average speed (commercial vehicles)	
135	BUS_vehXkm	veh*km	Traffic flow related to buses	yes
136	BUS_vehXh	veh*h	Traffic volume per hour related to buses	yes
137	BUS_speed_avg	km/h	Average speed related to buses	yes
138	BUS_t_time	minutes	Travel time related to buses	yes
139	BUS_stop_time		Time that the vehicle is in standstill (<= 3 km/h) related to buses Only microscopic	yes
140	BUS_perc_stop_time		Percentage of the time that a vehicle is in standstill related to the total time (buses) Only microscopic	yes
141	BUS_number_stops		Number of stops of a vehicle related to buses Only microscopic	yes
142	BUS_speed_avg_NOstop		Average speed related to buses excluding time periods of a standstill Only microscopic	yes
143	BUS_speed_const_perc		Percentage of constant speed periods related to buses Only microscopic	yes
144	BUS_speed_max		Maximum speed related to buses	yes

			Only microscopic	
145	BUS_pos_acc		Positive acceleration related to buses Only microscopic	yes
146	BUS_neg_acc		Negative acceleration related to buses Only microscopic	yes
147	BUS_pos_acc_NOstop		Positive acceleration related to buses excluding time periods of a standstill Only microscopic	yes
148	BUS_neg_acc_NOstop		Negative acceleration related to buses excluding time periods of a standstill Only microscopic	yes
149	BUS_speed_avg_std	km/h	Standard deviation of speed related to average speed (buses)	yes