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SEVENTH FRAMEWORK PROGRAMME

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Executive Summary

This document corresponds to the deliverable D4.3.1 which is the draft description of the library of driving situations of the FP7 ICT-Emissions project. This deliverable describes the structure of the 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 simulate 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 delivers some preliminary options for 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. The current report is still in a draft version. It is expected that when actual results of the simulations are produced, then some of the fields proposed may have to be modified or additional fields will need to be created. In addition to this introductory chapter, Chapter 2 presents the structure of the Library and Chapter 3 presents the boundary conditions for its software implementation.

2 Description of the Database

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.

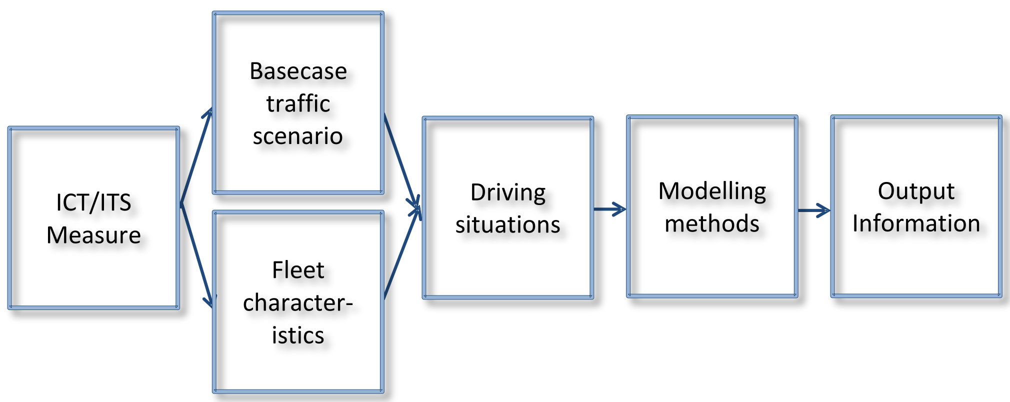

Figure 1: General structure of the library considered.

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. See also field **Fehler! Verweisquelle konnte nicht gefunden werden.**.

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.

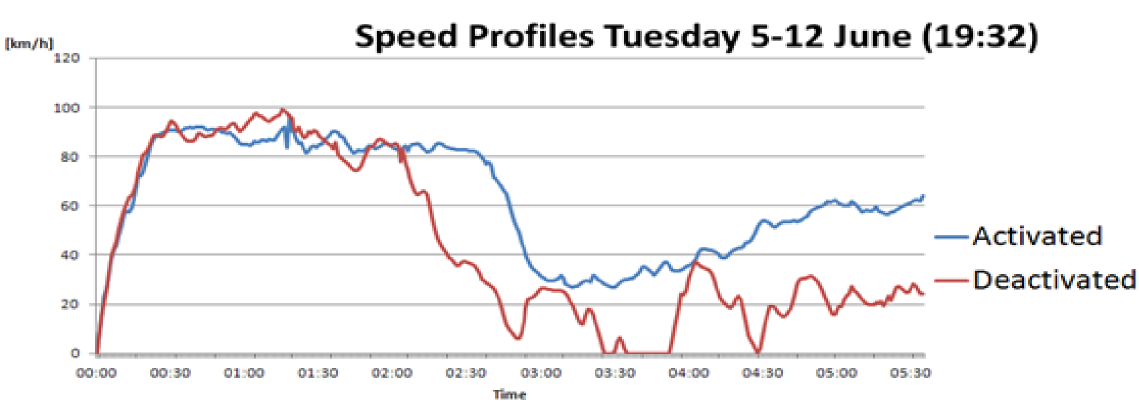

Figure 3: Example of second by second average microscopic driving profile.

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 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. The consortium will explore the different options – seeking also advice from IT experts on what would be a cost-effective option to develop – and will come up with an updated proposal in the final version of this deliverable (D4.3.2).

3.2. Visualisation Of the Information

Depending on the option decided for the software implementation, the consortium will take all steps necessary to make sure that all information produced will be made available to third parties in a transparent way. A user interface will allow locating and identifying the data desired in a straightforward way.

It should be made clear that it is to the interest of the consortium to make an as wide as possible dissemination and usage of the dataset produced. Allowing easy access to this information is a prerequisite to achieve such a wide dissemination.

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