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7th Framework Programme

INFSO-ICT 224067

Efficiency Data Analysis Plan

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LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
CAS	Collision Avoidance System
DTC	Distance To Collision
GD	Green Driving, one of the TeleFOT functions to be assessed
GPS	Global Positioning System
ICT	Information Communication Technology
NAV	Navigation, one of the TeleFOT functions to be assessed
SA	Speed Alert, one of the TeleFOT functions to be assessed
SI	Speed Information, one of the TeleFOT functions to be assessed
TI	Traffic Information, one of the TeleFOT functions to be assessed
TTC	Time To Collision

REVISION CHART AND HISTORY LOG

REV	DATE	REASON
0.1	08/10/2009	First skeleton
0.2	18/12/2009	First draft based on common SP4 outlines
0.3	16/04/2010	Peer review comments
04	17/06/2010	Revised draft incorporating the peer review comments

EXECUTIVE SUMMARY

The aim of this deliverable is to provide an analysis plan for the assessment of impact in the area of efficiency. This is one of the four areas, whose impact is subject of assessment within TeleFOT. In order to come up with a common (to the possible extent) assessment planning for all four areas, a uniform layout and structure has been decided for all four respective deliverables (i.e. D4.3.1, D4.4.1, D4.5.1 and D4.6.1).

Following the commonly defined structure, after defining the target of the deliverable and traffic efficiency, an outline of the data sets to be subject of analysis is provided, in terms of the research questions, hypothesis and relevant variables to be selected, collected and analysed.

Then the general approach for the impact assessment is presented, in terms of the work allocation between the partners participating in the specific WP, the study design and analysis planned for each of the previously mentioned hypothesis and the common strategies and consolidation aspects across the four impact areas. Risk assessment is also carefully taken into account, through risk identification and contingency measures suggestion.

Through the work performed in this deliverable, an original guidance is provided to the data collection and data analysis to be performed throughout the tests. Of course, the actual conditions and differentiations across tests sites and throughout the duration of the FOTs, may impose consecutive changes to the original analysis plans, which will carefully be incorporated in the preliminary planning.

Thus, the work performed in this deliverable along with the rest impact areas deliverable (i.e. D4.3.1, D4.4.1, D4.6.1 and D4.7.1) will be used as guidance for the test sites plans (WP3.4) in order for the sites to identify which research questions from each impact area they will be able to answer through the results of their tests and, consecutively, which indicators should be measured. Moreover, this will be also affecting (and vice versa) the work of WP3.3 (Test sites set-up) for the sensors and test tools to be used to be decided per site. Of course, the work to be further elaborated within WP4.5 (and the respective WPs for the rest of the impact areas) will be strongly linked to the Analysis Plans, adapted of course to any additional needs that may come up in the course of work.

1. INTRODUCTION

TeleFOT is a Large Scale Collaborative Project under the Seventh Framework Programme, co-funded by the European Commission DG Information Society and Media within the strategic objective "ICT for Cooperative Systems".

Officially started on June 1st 2008, TeleFOT aims to test the impacts of driver support functions on the driving task with large fleets of test drivers in real-life driving conditions.

In particular, TeleFOT assesses via Field operational Tests the impacts of functions provided by aftermarket and nomadic devices, including future interactive traffic services that will become part of driving environment systems within the next five years.

Field Operational Tests developed in TeleFOT aim at a comprehensive assessment of the efficiency, quality, robustness and user acceptance of in-vehicle systems, such as ICT, for smarter, safer and cleaner driving.

The analysis undertaken within the TeleFOT project aims to assess the impact of after market nomadic devices in five distinct assessment areas; Safety, Mobility, Efficiency, Environment and User Uptake. In order to measure the impacts SP2, in collaboration with SP4, has developed core research questions and hypotheses for each assessment area that also take into account the functionality of the devices specifically under consideration in TeleFOT. The next stage is to provide details regarding the analysis techniques that will be used to answer each hypothesis. Thus, each analysis plan deliverable details the proposed approach to be followed but does not give analysis outputs.

The primary objective of each analysis plan therefore is to take each hypothesis and identify the most appropriate analysis approach for testing the hypothesis and to identify the type of data that will be used including whether from an LFOT, a DFOT or a combination of both. This builds further upon the tables in D2.2.1 (Appendix III.i – III.v) and delivers important information to SP3 regarding the finer detail of the FOT experimental design and sample size requirements. There will, as indicated in WP4.2 – co-ordination and review, be a co-ordinated approach in developing the analysis plans across the impact areas so that the analysis methods are harmonised where there is hypothesis overlap between the impact areas.

It is anticipated that the analysis plans will provide the final link, along with information from SP2 and the capabilities of the data loggers, that will allow the data specification to

be completed within the Data Working Group (WP2.3 task 2.3.1) and the data base structure to be finalised (WP2.3, WP3.7, WP4.1).

The objective of this deliverable is to provide an analysis plan for efficiency assessment in TeleFOT. This deliverable (together with deliverables 4.3.1, 4.4.1, 4.6.1 and 4.7.1) will be used as a guidance in the data collection and analysis during and after the execution of the TeleFOT tests in all test sites of both types (LFOT and DFOT). What consists the final target is the extraction of conclusions, out of the analysis results, regarding the impact of the use of the TeleFOT functions on the four areas of impact defined in SP4.

A common definition of traffic efficiency can be met as the extent to which a certain transportation input can meet the travel demand of people in a transportation system. In order to assess the traffic efficiency of a certain network, measurements should be performed, not only involving private vehicles, but also other users of the network, such as the public transport users, pedestrians etc. In terms of the tests to be performed in TeleFOT this is not possible to a whole extend. What is within the scopes of TeleFOT FOTs regarding traffic efficiency is the measurement of a set of indicators that are characterising the traffic efficiency, such as the speed, the travel times, the traffic composition, etc., and thus make an estimation of the level of traffic efficiency on the network. Traffic simulation is a valuable tool in this process, since it allows simuation of single vehicle's parameters (micro-simulation) as well as generalisation at network level and monitoring of efficiency (macro-simulation).

The choice of study design and data to be collected have been done in cooperation with the other assessment work packages in TeleFOT SP4 in cooperation with SP2 and SP3.

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2. DATA

2.1. Research questions

The efficiency research questions developed in cooperation with SP2 are presented in Table 1. The selection of efficiency research questions is identical to what was presented in the D2.2.1. The distinction between primary, second level and third level research question lies in the level of detail that each category deals with and illustrates the procedure that was followed in order to come up with the final set of research questions for which relevant hypotheses have been drawn (third level).

Table 1. Efficiency research questions of the first, second and third levels.

Primary Research Question	Second Level Research Question	Third Level Research Question
TRAFFIC FLOW (Is there a change in traffic flow?)	TRAVEL TIME (Is there a change in travel times in the network?)	Is the travel time from origin to destination affected?
	DELAYS (Is there a change in the delays of the vehicles in the network?)	Are there any delays caused?
		Are there any delays avoided?
	SPEED (Is there a change in the vehicle speeds?)	Are the vehicles speeds in the network reduced?
		Are the vehicles speeds in the network increased?
	DENSITY (Is there a change in the density of vehicles in the network?)	Are there more vehicles on specific road?
		Are there any traffic jams avoided?
		Are there any traffic jams?
	TIME HEADWAY	Is the time headway

Primary Research Question	Second Level Research Question	Third Level Research Question
	from the preceding vehicle)	between the vehicles increased?
		Is the time headway between the vehicles decreased?
TRAFFIC VOLUME (Is there a change in traffic volume?)	DENSITY (Is there a change in the density of vehicles in the network?)	Is the density different in specific areas?
	HEADWAYS (Is there a change in the distance from the preceding vehicle?)	Is the distance from the preceding vehicle larger?
		Is the distance from the preceding vehicle smaller?
	TRAFFIC COMPOSITION (Is there a change in the traffic composition in the network?)	Is the traffic composition different?
OTHER MODES THAN AUTOMOBILES	PUBLIC TRANSPORT	Is travel time in public transport affected?
	PUBLIC TRANSPORT TERMINALS	Are delays at terminals reduced?
	BICYCLE TRAVEL	Is travel time for bicyclists affected?
	MOTORCYCLE TRAVEL	Is travel time for motorcyclists affected?
	PEDESTRIAN TRAVEL	Is travel time for pedestrians affected?

All possible research questions can not be answered in TeleFOT for the functions in question, i.e. navigation (NAV), traffic information (TI), speed alert (SA), speed information (SI), and green driving (GD). An analysis of the importance of each research question with regard to the TeleFOT function as well as the feasibility of data collection was carried out to identify the key research questions for mobility assessment in TeleFOT. The results of this analysis are shown in **Error! Reference source not found.**.

Table 2. The importance and feasibility of efficiency related research questions in TeleFOT *(High importance and good feasibility are indicated by green, adequate importance and feasibility by amber, and poor importance and feasibility by red)*.

Third Level Research Question	Important in relation to the function assessed in the project/impact measurability of RQ/other rationale	Feasibility of collecting data to answer hypotheses
Is the travel time from origin to destination affected?	NAV, TI likely to affect the travel time, as different routes may be suggested by occasion. The effect of SA or SI is considered secondary.	Through travel diaries or GPS data
Are there any delays caused?	TI and NAV may influence this but rather in case of malfunction.	N/A
Are there any delays avoided?	Delays may be avoided by means of NAV&TI provision, which would result in avoiding unexpected events on route (i.e. demonstration, road closure, etc.)	Through travel diaries &GPS data
Are the vehicles speeds in the network reduced?	This may be affected by SA and SI, as well as GD	Travel diaries, GPS
Are the vehicles speeds in the network increased?	This may be affected by SA and SI, as well as GD	Travel diaries, GPS

Third Level Research Question	Important in relation to the function assessed in the project/impact measurability of RQ/other rationale	Feasibility of collecting data to answer hypotheses
Are there more vehicles on specific road?	This may be infuenced by NAV and TI, in case the vehicles are routed through specific roads.	Travel diaries, however requires having a fleet of vehicles in the same road at the same time, thus it would not be possible to be measured through the FOTs
Are there any traffic jams avoided?	Through NAV and TI, in terms of avoiding unexpected events on route (i.e. demonstration, road closure, etc.)	Travel diaries, GPS
Are there any traffic jams?	The impact of the specific functions to the creation of traffic jams is rather indirect.	N/A
Is the time headway between the vehicles increased?	This may be influenced by the indications of CAS (in DFOT)	CAS
Is the time headway between the vehicles decreased?	This may be influenced by the indications of CAS (in DFOT)	CAS
Is the density different in specific areas?	The traffic density may be differentiated by area depending on the NAV, TI but also SA, GD and SI	Could be feasible to be measured through travel diaries and/or simulation
Is the distance from the preceding vehicle larger?	This may be influenced by the indications of CAS (in DFOT)	CAS
Is the distance from the preceding vehicle smaller?	This may be influenced by the indications of CAS (in DFOT)	CAS

Third Level Research Question	Important in relation to the function assessed in the project/impact measurability of RQ/other rationale	Feasibility of collecting data to answer hypotheses
Is the traffic composition different?	Could be the result of change of transportation mode, emerging from TI.	The travel diaries could contribute to this, even though they would be based on subjective estimations of the participants. Traffic microsimulation might be more appropriate for this.
Is travel time in public transport affected?	This could be affected by NAV and TI, with the use of which private cars may be routed such as to avoid the route of public transport vehicles and thus the travel time of PT could be enhanced.	GPS, simulation
Are traffic jams in terminals avoided?	Difficult to determine how this could be influenced by the functions of TeleFOT. Might be the outcome of mode shift, but rather an indirect one.	N/A
Is travel time for bicyclists affected?	NAV and TI may indirectly affect it	Simulation
Is travel time for motorcyclists affected?	NAV and TI may indirectly affect it	Simulation
Is travel time for pedestrians affected?	NAV and TI may indirectly affect it	Simulation

2.2. Hypotheses to be tested

The hypotheses related to the selected third level research questions are listed in Table 3.

Table 3. Possible hypotheses related to the selected efficiency research questions.

Third Level Research Question	Possible Hypotheses
Is the travel time from origin to destination affected?	Travel times are likely to increase/decrease (when device is used compared to when device is not used)**
Are there any delays caused?	Delays are likely to be caused.
Are there any delays avoided?	Delays are likely to be avoided.
Are the vehicles speeds in the network reduced?	The vehicle speeds in the network are likely to be reduced.
Are the vehicles speeds in the network increased?	The vehicle speeds in the network are likely to be increased.
Are there more vehicles on specific road?	It is likely that there are more/less vehicles on specific road.
Are there any traffic jams avoided?	It is likely that traffic jams are avoided.
Are there any traffic jams?	It is likely that traffic jams are caused.
Is the time headway between the vehicles increased?	It is likely that the time headway between vehicles is increased.
Is the time headway between the vehicles decreased?	It is likely that the time headway between vehicles is decreased.
Is the density different in specific areas?	It is likely that the density in specific areas is increased/decreased.
Is the distance from the preceding vehicle larger?	It is likely that the distance from the preceding vehicle is larger.
Is the distance from the preceding	It is likely that the distance from the

Third Level Research Question	Possible Hypotheses
vehicle smaller?	preceding vehicle is shorter.
Is the traffic composition different?	It is likely that the traffic composition is different.
Is travel time in public transport affected?	Travel times are likely to increase/decrease.
Are delays at terminals reduced?	It is likely that delays at terminals are reduced.
Is travel time for bicyclists affected?	It is likely that bicycle travel times are decreased.
Is travel time for motorcyclists affected?	It is likely that motorcycle travel times are decreased.
Is travel time for pedestrians affected?	It is likely that pedestrian travel times are decreased.

2.3. Variables required

The detailed linking of the variables to the hypotheses is shown in Annex 1. The summary of all variables required for the mobility assessment and the testing of the hypotheses is listed in Table 4.

Table 4. Variables required by efficiency assessment.

Variables to SELECT on[1]		**Variables to ANALYSE[2]**		**Variables to INTERPRET results[3]**	
Measure	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**
Specific driver	Data logger (if only one possible driver per vehicle)/CAN + travel diary (if multiple drivers per vehicle) L, D	Duration of journey	Travel diary OR Data logger/CAN L,D	Reason for change in travel time	Travel diary OR Interview L,D
	Data logger (if only one possible driver per vehicle) + travel diary (if multiple drivers per vehicle) L	Time of journey	Travel diary OR Data logger L	Reason for using ND on this journey/leg/link	Travel diary OR Interview L

[1] variables that the FOT must record/measure so that you can SELECT the appropriate data files for analysis
[2] variables that the FOT must record/measure so that you can ANALYSE the impact of the nomadic device, i.e. the dependent variables
[3] variables that the FOT must record/measure so that you can INTERPRET the results and come to conclusions about why the effects have occurred

Variables to SELECT on[1]		Variables to ANALYSE[2]		Variables to INTERPRET results[3]	
Measure	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**
	Data logger/ CAN L,D	Speed	Data logger/CAN L,D	Reason for increasing/decreasing speed	Travel diary OR Interview L,D
	CAN D	TTC	CAN D	Reason for altering time headway	Background questionnaire Interview D
	CAN D	DTC	CAN D	Reason for altering distance	Background questionnaire Interview D
	travel diary	Mode of transport selected	Travel diary L	Reason for using changing transportation mode	Travel diary OR Interview L
Traffic environment	Travel diary Test planning L,D	Type of driving environment (highway, rural, urban, etc.)	Travel diary OR Data logger/CAN L,D	Attitudes and reasons to: - change type of driving environment	Background questionnaire Travel diary L,D
Time of journey	Travel diary OR Data logger L	Date of journey	Travel diary OR Data logger L	Perceived changes and reasons in: - selected time of journey	Background questionnaire Travel diary L

3. GENERAL APPROACH FOR THE IMPACT ASSESSMENT

3.1. Contribution from Partners

The partners expected to make a contribution to WP4.5 and in particular to task 4.5.1 data analysis, are shown in Table 5.

Table 5. Contribution from Partners to efficiency assessment according to DoW.

Partner	Contribution	Person Months
VTT	Responsibility for FOT data from Finland Link between data analysis and Task 2.2.2 Research questions & indicators	2
CRF	Contribution to the data analysis in the Italian test site	3
CERTH/HIT	Lead this Task Responsibility for FOT data from Greece D4.5.1 methodological framework for efficiency analysis D4.5.2 First simulation results	6
ICCS	Contribution to data analysis for Greek FOT	1
IKA	Analysis of data from FOTs by means of traffic flow simulation in order to determine the impact of the regarded systems on traffic efficiency	3
MIRA	Responsibility for FOT data from UK Contribute to formulation of detailed analysis techniques for efficiency assessments from UK FOT experience	1

Each TeleFOT FOT site will collect the travel diary data ensuring that sufficient high percentage of diaries (>80%) delivered at each site are returned filled in during each phase of data collection. Moreover, data will also be collected through the data loggers and the test vehicle sensors, to measure the relevant indicators. This is the responsibility

of the test site leaders. For the needs of this Task, the following partners should ensure the communication of data (travel diaries and logged data) from the sites:

Finland	VTT
Greece	CERTH/HIT
UK	MIRA
Germany	IKA
Italy	CRF

Since there is no effort assigned in this WP to either a Spanish or a Swedish partner, the following partners will be in charge get in contact with these test sites for the communication of their data to WP4.5:

Spain	CERTH/HIT
Sweden	ICCS

All sites will use identical travel diaries translated into the national languages by the site responsible partners. All WP4.5 site responsible partners will be responsible for the data collection for their test sites, including the coding of the travel diaries into the TeleFOT evaluation data base.

Analysis that requires LFOT data should be undertaken by the WP4.5 leader and other partners specified in the DoW with recourse for the activity. This is co-ordinated by the WP4.5 leader and appropriate guidance given to each partner involved in helping with the analysis. Again, templates to be completed with results should be provided in line with the analysis plans by the WP4.5 leader.

The WP4.5 leader has responsibility for bringing all of the results together and, in discussion with other partners who have resources (DoW), interpreting the results and forming conclusions.

Test sites and their responsible partners listed above are obliged to provide the data to answer the core TeleFOT hypotheses as a priority. Other issues can only be explored if there are resources remaining within WP4.5 once the core TeleFOT analysis has been undertaken.

3.2. Analysis strategy for each hypothesis

- In this section, the strategy for analysing each hypothesis is presented in turn.

RQ-EF1 Is the travel time from origin to destination affected?

H-EF1.1 Travel times are likely to increase/decrease (when device is used compared to when device is not used)

The data is collected via travel diaries and feedback questionnaires, as well as via the data loggers (registering time and GPS data) in the case of LFOTs and via CAN in the case of DFOTs. The point is to investigate whether the use of the TeleFOT function(s) affects the duration of similar or repeated journeys. The null hypothesis would be that there is no influence. An additional hypothesis is that the effect is changing after getting experience with the function(s). The analysis will be performed at before/after and intermediate stages, investigating the reasons for the change (in any) in travel time, relating changes of type of driving environment as well as selection of time of journey and whether they are linked to the TeleFOT functions.

RQ-EF2 Are there any delays avoided?

H-EF2.1 Delays are likely to be avoided

The data in this case is also collected through travel diaries and feedback questionnaires, in combination with data logger input relating to timing of provided feedback from the system. The aim is to identify whether the use of the TeleFOT function(s) results in avoidance of delays in travelling (e.g. avoidance of a known as congested route segment and rerouting). The null hypothesis will in this case as well be that there is no influence. During the analysis it will be investigated the reasons for using the Nomadic Device on the specific journey (before or during it) and whether it affected the decisions of the driver.

RQ-EF3 . Are the vehicles speeds in the network reduced?

H-EF3.1 The vehicle speeds in the network are likely to be reduced.

The data collection will be performed through the data logger and travel diary (for LFOTs) and the CAN (for DFOT) as well as feedback questionnaires. The target is to conclude whether the use of the TeleFOT function(s) affected the vehicle speed (by increasing in this Hypothesis and, accordingly, decreasing in H4.1). The vehicle speed at all times as well as the mean speed will be registered and comparisons will be made between the

situation with and without the system, as well as between different route choices. The analysis will be performed in the basis of investigating the reasons for increasing/decreasing speed, the relation of this behaviour in terms of the type of driving environment chosen (urban, highway, rural, etc.) and the reasons/influence of TeleFOT functions to this behaviour.

RQ-EF4 Are the vehicles speeds in the network increased?

H-EF4.1. The vehicle speeds in the network are likely to be increased.

See H3.1

RQ-EF5. Are there any traffic jams avoided?

H-EF5.1 It is likely that traffic jams are avoided.

See H2.1

RQ-EF6. Is the time headway between the vehicles increased?

H-EF6.1 It is likely that the time headway between vehicles is increased

This hypothesis (as well as H7.1, H8.1 and H9.1) is possible to be measured only in the case of DFOTs. Through the CAN of the equipped vehicles to be used in DFOTs, the TTC (Time to Collision) will be measured (mean and min/max values) with and without the use of the device. An initial calculation will define the baseline for the participants. Trials will be performed in different traffic environments and levels of learnability (measurements at different intervals along the duration of the tests). The comparison with the baseline will aim to investigate whether there is a significant modification in time headway (increase in this case, decrease in the case of H7.1) and its link with the TeleFOT functions. Background questionnaires will also be used for data collection, in terms for the participants to indicate the perceived reasons for the differentiation of their TTC.

RQ-EF7. Is the time headway between the vehicles decreased?

H-EF7.1 It is likely that the time headway between vehicles is decreased

See H6.1

RQ-EF8. Is the distance from the preceding vehicle larger?

H-EF8.1. It is likely that the distance from the preceding vehicle is larger.

In this hypothesis, the data collection and analysis procedures will be similar to the ones of H6.1, only in this case instead of the TTC, it is the DTC (Distance to Collision) that is being measured by the CAN.

RQ-EF9. Is the distance from the preceding vehicle smaller?

H-EF9.1. It is likely that the distance from the preceding vehicle is smaller.

See H8.1

RQ-EF10. Is the traffic composition different?

H-EF10.1 It is likely that the traffic composition is different.

The data collection for this hypothesis will be performed through travel diary, feedback questionnaires and/or data logger (only LFOTs). The participants will be asked whether they consulted and if yes which of the TeleFOT function(s) pre trip (or on trip) and whether this has altered their decision in choice of transport mode (also in connection with the time of the journey). The function feedback throughout the duration of the tests will be registered and comparisons will be made between the with and without the system groups and in different intervals within the duration of the tests.

3.3. Traffic simulation in support of efficiency impact analysis

The impacts on traffic efficiency cannot be analysed directly using the data from the FOT because of relatively low number of equipped vehicles. For this reason simulation tools will used in order extrapolate effects measured in the FOT and to derive from that the potential impacts on traffic flow and efficiency. In the simulation different equipment rates can be considered which allow making the impacts of the considered systems and functions visible.

The relevant effects which need to be measured in the FOTs in order to be modelled in simulation tools are related mainly to changes in driver behaviour caused by the use of

the nomadic systems and functions. These are related for example to speed, time gap and distance towards preceding vehicles.

The evaluation process will be carried out in two different types of micro-simulation scenarios. The first one is a traffic-flow simulation in which the traffic in a given road section is simulated without any traffic relevant disturbances.

The second simulation type is an In-depth simulation of special scenarios, like lane constrictions and bottle necks. This simulation assesses the reaction of different drivers in varying vehicles on predefined traffic situations. With this approach, situations which e.g. lead to obstruction of traffic, can be evaluated more in detail and different strategies for the avoidance or solving of these situations can be tested.

The influence between the base line (non equipped vehicles) and the changes due to the use of NDs is implemented by changing driver parameters, like his willingness to change his lane, acceleration and deceleration behaviour or the width of gaps he will cuts in during a lane change based on the measured impacts on driver behaviour derived from the FOT data.

The micro simulation calculates the movement and behaviour of every driver-vehicle unit step by step in given time increments. With this data it is possible to track the movements of every vehicle inside the considered road section in time response and therefore to determine its speed and acceleration at every way point or point in time. With its position the distance towards other vehicles inside the traffic environment can be assessed. During the traffic flow simulation virtual inductive measuring loops along the road section can be implemented in predefined distances. With these data fundamental diagrams describing the distribution of average velocity, traffic density and traffic flow can be generated as indicators for the impacts of the systems on traffic efficiency.

With speed, time and position other efficiency surrogate measure like the Time Headway (THW) and travel time can be computed.

3.4. Consolidation across impact areas

The consolidation of analysis results will be overseen by WP4.2 – co-ordination. This will ensure that each impact area takes a broad view of all of the results coming from each of the test sites and from all of the hypotheses. In order to keep each impact area manageable, the prioritisation of Hypotheses has taken place as described above. However, it is still important to review all of the results in order to establish whether

further impacts are seen that need to be considered beyond the Hypotheses considered in this draft analysis plan.

3.5. Strategy for Global Assessment

As with all FOT data, in TeleFOT there will be a requirement to generalise the results to the general driving population – otherwise there is little overall value in conducting the FOT in the first place. However, this is not straightforward and the main problem is determining how close the TeleFOT subjects represent the target population.

A straightforward method in statistical analysis is to simply pool the data from different sites to form a single data set and perform statistical analysis as if they were measured in a single site. Due to the different driving rules and regulations, and potentially different driving characteristics of drivers in the different countries, this approach is not efficient because the country-to-country variation is not taken into consideration in the analysis. Instead we shall incorporate more complicated linear mixed-effect models which include both fixed effects and random effects in the analysis. Specifically, the hypotheses formulated in the previous sections are tested using linear mixed-effect models, where a factor termed 'country' is included and is treated as a random effect in the models so that the country-to-country variation is taken into account when we test the effect of device in use on the primary variables of interest.

Naturally, the extent to which data from different countries can be combined will vary according to the hypothesis under test and the data on which it depends

3.6. Strategy for dissemination of results – short and long term

The following will be considered and employed as and when appropriate in order to ensure timely dissemination of the results;

- Individual test site feedback to local stakeholders
- Stakeholder forums organised through SP5
- Presentation of key results at relevant conferences and other forums in the international arena
- Utilisation of the FOTNET forums
- Publications in recognised international journals

- Press releases (organised through SP5)
- TeleFOT website

4. RISK ASSESSMENT

No matter how well the data collection, collation and storage processes have been performed, it is likely that there will be problems and constraints with the data analysis. Contingencies may be required in the event that problems occur with missing, lost, erroneous and inconsistent data.

Table 6 summarises the risks that are inherent in TeleFOT data collection, how the risk can be managed and proposed solutions in the event that the identified risk becomes a reality. This table has been prepared previously as part of Deliverable 2.3.1 and is a manifestation of the work that was undertaken within FESTA within the data quality task. The basic principles that are generically outlined in the Contingency Plan apply to all Assessment activities (Safety, Mobility, Environment, Efficiency, User Uptake).

Table 6. TeleFOT Generic Data Contingency Plan

Risk including risk severity (e.g. low, medium, high)	Reduction (how the risk can be managed)	Solution (if the risk happens)
Missing data at point of collection (medium risk, medium severity)	Arrange check-list of required data-fields to ensure that collection is fully specified. Covered in Task 2.2.2 re data spec and WP2.3 re data acquisition and quality.	Missing data will be denoted as such in analyses and caveats will be applied to results.
Loss of data post-collection (low risk, high severity)	Ensure that data back-ups are provided (main server and DVD)	Back-up will be utilized. If data cannot be recovered, same caveats as above will be applied
Inconsistent data across test communities meaning comparisons cannot be made (low risk, medium severity)	Data quality ensured in Task 2.3.2, Pilot data analysis conducted in WP4.1. Data consistency will be ensured through the review process of WP4.2	In this unlikely event, data analyses will not be conducted where data inconsistencies are found
Insufficient data to ensure scientific rigour/statistically valid outcomes (medium risk, high severity)	This will be established and addressed in a pilot study (WP4.1) – any indications that the data will not give statistically robust results will result in revision of methods,	In this unlikely event, the data analyses will be modified accordingly and the validity of the outcomes described.

Risk including risk severity (e.g. low, medium, high)	Reduction (how the risk can be managed)	Solution (if the risk happens)
	tools and data specification (WP2.2&2.3)	
Late identification of needed analysis and analysis procedures cannot accommodate it (medium risk, medium severity)	WP2.2 takes input from FESTA and identifies research questions & indicators which should avoid late identification of required analyses. Task 2.3.3 will identify database structure and incorporate flexibility to respond to unpredicted analysis requirements. Pilot study in WP4.1 will test analysis procedures.	All efforts will be made to include the required analyses. Where this is not possible, the risk management strategies should have ensured that this analysis is not core to the needs of the impact assessment.
Privacy of participant data compromised (low risk, high severity)	Covered by WP3.7 all reasonable measures will be taken to ensure privacy. Protocols will be developed based on expert advice. Data stored in lockable filing systems – no personal data stored on database. Participant identification shredded shortly after use.	Participants will be informed of privacy compromise and appropriate remedial actions will be taken in consultation with participants.
Commercially confidential data compromised (low risk, high severity)	Covered by WP3.7. Protocols will be developed. Stakeholders will be informed before participation that all reasonable measures will be taken to ensure commercially sensitive information will be kept confidential. Covered by consortium agreement plus other appropriate documentation as advised by experts.	Stakeholders will be informed of compromise and appropriate remedial actions will be taken in consultation with stakeholders.
Non-agreement on aspects of data analysis	Multiple partners in WPs on analysis and implications (WPs	Conflict resolution procedures defined in

Risk including risk severity (e.g. low, medium, high)	Reduction (how the risk can be managed)	Solution (if the risk happens)
between SP4 partners (medium risk, medium severity)	4.3-4.7). All analysis WP partners have significant expertise in the relevant areas and have common research motivations. All analysis work packages lead by independent research organizations rather than commercial partners.	consortium agreement and managed in WP1.1
Conflicts of needs between SP4 and SP2 (low risk, medium severity)	Common partners in SP2 & SP4	Conflict resolution procedures defined in consortium agreement and managed in WP1.1
Conflicts of needs between SP4 and SP3 (low risk, medium severity)	Common partners in SP3 & SP4	Conflict resolution procedures defined in consortium agreement and managed in WP1.1
Benchmarking/crash-tests identify planned devices/applications as intrinsically unsafe and/or unusable in FOTs (low risk, high severity)	FOTs are using mature technologies hence the risk of unsafe/unusable systems should be low.	Stakeholders and partners responsible for national FOTs will be informed of results of crash-tests and recommended remedial actions will be proposed (e.g. restricted use of devices/functions or alternative devices/functions used)

Other Potential Problems and Solutions

1. Combination of Functions

There is general recognition that when statistical tests are undertaken in the context of a system or function, robust conclusions about the results cannot be drawn if the system or function does not operate in isolation. For example, if a driver is using a navigation device on a smart-phone, it cannot be concluded that the navigation device alone is

responsible for possible distraction if, for example a speed alert system is incorporated into the same device.

Some solutions to the combination of functions have been proposed (for example, via the FOT-seminars; FOT-NET; http://www.fot-net.eu/en/library/_/), but many of the solutions involve developing hypotheses that take the combination of functions into account at the outset. Therefore where possible, conclusions reached by data analysis should be supported by qualitative data obtained by focus groups and questionnaires. Supporting qualitative information from the questionnaires and focus groups should be sufficient to identify whether a particular "driver behaviour" has been observed as a result of a single function or not. However, where this is not the case, appropriate caveats should be applied to the data.

2. Subjective Data

A number of factors contribute to the quality of the subjective data collected by means of interviews and/or questionnaires. Issues to consider when collecting subjective data are now discussed;

The Questions

Questions (in either a questionnaire or interview situation) can be open-ended or close-ended. Open-ended questions do not supply any answer categories while close-ended questions do.

If close-ended, the answer categories should be as few as possible in relation to the questions; be relevant in relation to the type of question; be mutually exclusive; be reasonable and make sense. They should allow the respondent or interviewee to be able to answer the question.

The answers to open-ended questions will take longer to analyse than close-ended. Missing data is more common for open questions than closed. Furthermore, most often these answers must be coded which in itself may result in errors. This can be avoided by the support of a clear and consistent code key. Furthermore, in an interview situation, the interviewer can summarise the answer or group of answers, and allow the interviewee to agree or disagree and/or to comment on the interpretation. Consistency in coding can be checked by comparing several independent analysts' coding of the whole or a subset of the collected data. Questions can also be direct or indirect. An indirect question directs the interviewee's attention to another person (or to other persons) other

than the interviewer and can be a way to address more sensitive questions or areas where a "true" answer may not be anticipated.

Missing data is a threat to the quality of the data at all levels of operation, whether an entire interview or questionnaire is missing or the answers to individual questions are missing (or indeed, answers are not readable). In addition, data can be missing due to the respondent providing an answer, or providing a rating which is outside allowed categories. In the case of a missing questionnaire or interview, efforts must be made to ensure that data collection is as complete as possible and reminders must be administered. Furthermore, overall the number of questions should be considered carefully. Where possible, it is preferable to limit the number of questions. In addition, the number of open questions should be as few as possible in order to reduce the effort of the respondents.

5. SUMMARY

This deliverable contains the outline efficiency assessment plan.

In the introduction, the objectives of the deliverable and the aim of efficiency impact assessment are described.

Next, the efficiency assessment related, 1st, 2nd and 3rd level research questions are listed together with the hypotheses linked to the research questions. After this, the key research questions were identified. This was done as all possible research questions are not feasible to be studied in TeleFOT with regard to the ITS functions in question, i.e. navigation (NAV), traffic information (TI), speed alert (SA), speed infomation (SI), and green driving (GD). Hence, the key research questions for TeleFOT efficiency assessment were identified with an analysis of the importance of each research question with regard to the TeleFOT function as well as the feasibility of data collection.

The data collection analysis for each research question and consecutive hypothesis are provided in the third chapter of the deliverable. Links between different hypothesis are also identified.

Also the responsibilities of the different partners participating in WP 4.5 are defined, in order to efficiently cover the needs of the work to be performed, in terms of data collection, organisation and analysis. Common strategy and consolidation aspects across the four different impact areas are also stated.

Risk assessment is another aspect that is considered of major importance and has been seriously dealt with, by identifying most probable risks and suggesting contingency plans for each of them.

This deliverable will be used, together with D4.3.1, D4.4.1 and D4.6.1, as an original guide for the test data collection and analysis. Moreover, the work performed in these deliverables will be used as guidance for the test sites plans (WP3.4) in order for the sites to identify which research questions from each impact area they will be able to answer through the results of their tests and, consecutively, which indicators should be measured. Moreover, this will be also affecting (and vice versa) the work of WP3.3 (Test sites set-up) for the sensors and test tools to be used to be decided per site. However, it should be noted that the contents of these deliverables are subject to change throughout the duration of the FOTs, depending on alterations in the originally planned procedures/FOT contents, as well as at the primary stages of analysis, according to the preliminary outcomes.

ANNEX 1: VARIABLES REQUIRED BY THE CORE EFFICIENCY RESEARCH QUESTIONS AND HYPOTHESES.

EFFICIENCY: ALL FUNCTIONS (Navigation, Traffic information, Speed alert, Speed information, Green driving)								
			Variables to SELECT on[4]		Variables to ANALYSE[5]		Variables to INTERPRET results[6]	
Third Level Research Question	**Hypothesis**	**Impact / Implication**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**
1. Is the travel time from origin to destination affected?	1.1 Travel times are likely to increase/decrease (when device is used compared to when device is not used)	An increased travel time from origin to destination indicates a decrease in traffic efficiency	Specific driver	Data logger (if only one possible driver per vehicle)/CAN + travel diary (if multiple drivers per vehicle) L, D	Duration of journey	Travel diary OR Data logger/CAN L,D	Reason for change in travel time	Travel diary OR Interview L,D
			Traffic environment	CAN Travel diary	Type of driving	Travel diary OR	Attitudes and reasons to:	Background questionnaire

[4] variables that the FOT must record/measure so that you can SELECT the appropriate data files for analysis
[5] variables that the FOT must record/measure so that you can ANALYSE the impact of the nomadic device, i.e. the dependent variables
[6] variables that the FOT must record/measure so that you can INTERPRET the results and come to conclusions about why the effects have occurred

EFFICIENCY: ALL FUNCTIONS (Navigation, Traffic information, Speed alert, Speed information, Green driving)								
			Variables to SELECT on[4]		Variables to ANALYSE[5]		Variables to INTERPRET results[6]	
Third Level Research Question	**Hypothesis**	**Impact / Implication**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**
				L,D	environment (highway, rural, urban, etc.)	Data logger L,D	- change type of driving environment	Travel diary L, D
	IMPORTANT NOTES FOR THIS HYPOTHESIS It is essential to control for the effects of all confounding factors on this hypothesis as we know that day of week, time of year etc will affect this		Time of journey	Travel diary OR Data logger L	Date of journey	Travel diary OR Data logger/CAN L	Perceived changes and reasons in: - selected time of journey	Background questionnaire Travel diary L
2. Are there any delays avoided?	2.1 Delays are likely to be avoided.	An increased number of avoided delays indicates an increase in traffic efficiency	Specific driver	Data logger (if only one possible driver per vehicle) + travel diary (if multiple drivers per vehicle) L	Time of journey	Travel diary OR Data logger L	Reason for using ND on this journey/leg/link	Travel diary OR Interview L
	IMPORTANT NOTES FOR THIS HYPOTHESIS		Traffic	Travel diary	Type of driving	Travel diary	Attitudes and reasons to:	Background

EFFICIENCY: ALL FUNCTIONS (Navigation, Traffic information, Speed alert, Speed information, Green driving)								
			Variables to SELECT on[4]		Variables to ANALYSE[5]		Variables to INTERPRET results[6]	
Third Level Research Question	**Hypothesis**	**Impact / Implication**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**
	It is essential to control for the effects of all confounding factors on this hypothesis as we know that day of week, time of year etc will affect this		environment	L	environment (highway, rural, urban, etc.)	OR Data logger L,D	- change type of driving environment	questionnaire Travel diary L,D
3. Are the vehicles speeds in the network reduced?	3.1 The vehicle speeds in the network are likely to be reduced.	An increase in vehicles speeds indicates an decrease in traffic efficiency	Specific driver	Data logger/ CAN L,D	Speed	Data logger/CAN L,D	Reason for increasing/decreasing speed	Travel diary OR Interview L,D
4. Are the vehicles speeds in the network increased?	4.1. The vehicle speeds in the network are likely to be increased.	An increase in vehicles speeds indicates an increase in traffic efficiency						
	IMPORTANT NOTES FOR THESE HYPOTHESES It is essential to control for the effects of all confounding factors on this hypothesis as we know that day of week, time of year etc will affect this		Traffic environment	Travel diary L	Type of driving environment (highway, rural, urban, etc.)	Travel diary OR Data logger L,D	Attitudes and reasons to: - change type of driving environment	Background questionnaire Travel diary L,D

EFFICIENCY: ALL FUNCTIONS (Navigation, Traffic information, Speed alert, Speed information, Green driving)								
			Variables to SELECT on[4]		Variables to ANALYSE[5]		Variables to INTERPRET results[6]	
Third Level Research Question	**Hypothesis**	**Impact / Implication**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**
5. Are there any traffic jams avoided?	5.1 It is likely that traffic jams are avoided.	An increased number of avoided traffic jams indicates an in increase in traffic efficiency	Specific driver	Data logger (if only one possible driver per vehicle) + travel diary (if multiple drivers per vehicle) L	Time of journey	Travel diary OR Data logger L	Reason for using ND on this journey/leg/link	Travel diary OR Interview L
	IMPORTANT NOTES FOR THIS HYPOTHESIS It is essential to control for the effects of all confounding factors on this hypothesis as we know that day of week, time of year etc will affect this		Traffic environment	Travel diary L	Type of driving environment (highway, rural, urban, etc.)	Travel diary OR Data logger L,D	Attitudes and reasons to: - change type of driving environment	Background questionnaire Travel diary L,D

EFFICIENCY: ALL FUNCTIONS (Navigation, Traffic information, Speed alert, Speed information, Green driving)								
			Variables to SELECT on[4]		Variables to ANALYSE[5]		Variables to INTERPRET results[6]	
Third Level Research Question	**Hypothesis**	**Impact / Implication**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**
6. Is the time headway between the vehicles increased?	6.1 It is likely that the time headway between vehicles is increased	An increase in the time headway indicates an increase in traffic efficiency (up to the limit where it does not evoke an increase of overtaking)	Specific driver	CAN D	TTC	CAN D	Reason for altering time headway	Background questionnaire Interview D
7. Is the time headway between the vehicles decreased?	7.1 It is likely that the time headway between vehicles is decreased	A decrease in the time headway indicates a increase of traffic efficiency, up to the limit that dictates safety						

EFFICIENCY: ALL FUNCTIONS (Navigation, Traffic information, Speed alert, Speed information, Green driving)								
			Variables to SELECT on[4]		Variables to ANALYSE[5]		Variables to INTERPRET results[6]	
Third Level Research Question	**Hypothesis**	**Impact / Implication**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**
	IMPORTANT NOTES FOR THESE HYPOTHESES It is essential to control for the effects of all confounding factors on this hypothesis as we know that day of week, time of year etc will affect this							
8. Is the distance from the preceding vehicle larger?	8.1. It is likely that the distance from the preceding vehicle is larger.	An increase in the distance from the proceeding vehicle indicates an decrease in traffic efficiency	Specific driver	CAN D	DTC	CAN D	Reason for altering distance	Background questionnaire Interview D
9. Is the distance from the preceding vehicle smaller?	9.1. It is likely that the distance from the preceding vehicle is smaller.	A decrease in the distance from the proceeding vehicle indicates a increase of traffic efficiency, up to the limit that dictates safety						

EFFICIENCY: ALL FUNCTIONS (Navigation, Traffic information, Speed alert, Speed information, Green driving)								
			Variables to SELECT on[4]		Variables to ANALYSE[5]		Variables to INTERPRET results[6]	
Third Level Research Question	**Hypothesis**	**Impact / Implication**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**
	IMPORTANT NOTES FOR THESE HYPOTHESES It is essential to control for the effects of all confounding factors on this hypothesis as we know that day of week, time of year etc will affect this							
10. Is the traffic composition different?	10.1 It is likely that the traffic composition is different.	A change in traffic composition indicates a change in traffic efficiency.	Specific driver	travel diary L	Mode of transport selected	Travel diary L	Reason for using changing transportation mode	Travel diary OR Interview L
	IMPORTANT NOTES FOR THIS HYPOTHESIS It is essential to control for the effects of all confounding factors on this hypothesis as we know that day of week, time of year etc will affect this		Time of journey	Travel diary OR Data logger L	Date of journey	Travel diary OR Data logger/CAN L	Perceived changes and reasons in: - selected time of journey	Background questionnaire Travel diary L

ANNEX 2 LITERATURE TO SUPPORT EFFICIENCY RQ AND INDICATOR SELECTION

Traffic efficiency is usually defined as the extent to which a certain transportation input can meet the travel demand of people in a transportation system.
It is the main factor that determines the scale of transportation supply and the relationship between supply and demand in a transportation system. In a macroscopic point of view, if we take transportation infrastructure as the input element and take transportation mobility (or transportation capacity) as the output element in transportation systems, then transportation efficiency is the macro parameter influencing the input/output proportion of the system. (Yuan, Lu, 2004)

Brilon (2000) has proposed to use the parameter

$$E = q\ V\ T$$

Where E= traffic efficiency (veh*km/h)
q= volume (veh/h)
v=travel velocity over an extended section of the freeway (km/h)
T=duration of the time period for analysis of flow (h)
as a measure to characterize the efficiency of traffic flow on a freeway. This parameter describes the "production per time unit" of a freeway. The more veh*km a freeway produces per hour, the greater the efficiency with which the potential of the existing infrastructure is exploited.

Also, according to Sohn (2008), traffic efficiency is mainly affected by the following factors:

- Average travel speed of road segment (km/h)
- Average travel speed of intersection (km/h)
- The relationship between the average speed of a road segment and that of the entire arterial.

The important role of ITS in traffic efficiency has been recognized ever since International Intermodal Surface Transportation Efficiency Act was formed in1991 (ISTEA). Several studies (Antoniou et al, 2002; van Arem et al, 2005) have also indicated the positive influence of the use of classic ADAS, controlling the longitudinal (and secondarily the lateral) behaviour of the vehicle, as well as cooperative ones, based on car-to-x communication (Schumacher et al. 2009) to traffic efficiency, thus implying that the limiting parameters of these ADAS (speed, time and space headway, lane change behavior, etc.). Moreover, also the use of car navigation and route information have been found to contribute to traffic efficiency

The assessment of traffic efficiency is highly based on traffic simulation modeling. In most of the commonly used micro and macro simulation models (e.g. VISSIM, VISUM, AIMSUN, etc.) the main parameters that are used for traffic efficiency are:

- the traffic flow and flow rate (as the equivalent hourly rate at which a number of vehicles passes a fixed point in a given time interval),
- the traffic density (defined as the number of vehicles per unit of length occupying a given length of a lane or section at a certain point in time, time in the network),
- the mean speed (in terms of time - as the average speed of all vehicles passing a fixed point in a given time interval, and space – as the harmonic mean of vehicle speeds observed on a given section),
- delays in the network, etc.

In the case of TeleFOT, the effect of the use of different ITS, whose information is provided with the use of nomadic devices, is examined in terms of several areas, among which also traffic efficiency. For the needs of the project a series of research questions have been proposed, bearing in mind all the above. The final selection of the research questions to be finally examined is depended also on the interaction between the different areas (safety, mobility, efficiency, environment) as well as the actual measuring potential of the implied parameters/indicators by the devices to be used in the FOTs.

Efficiency is perceived differently from the road authority's and the road user's perspective. Road authorities consider efficiency from a system level and road users from an individual level. The meaning of efficiency also varies between various road user groups due to their different properties and individual preferences. Here efficiency is discussed from the point of view of the road users.

According to Luoma (1998) the best efficiency indicator for car drivers seems to be the difference between individual, condition dependent desired speed (target speed) and driving speed. The target speed is a very subjective concept and difficult to measure. For many drivers, target speed is relatively close to the speed limit of the road. However, as traffic conditions may vary very rapidly within a long road section and, therefore, even for high average travel speed levels the efficiency may be regarded as insufficient if, on a small part of the section, driving speed was considerably lower than the individual target speed. It is very unreliable to make assumptions of driving conditions for a longer section of road on the basis of the average speed of vehicles in one spot of the road.

The effect of road type is essential for efficiency and for the perception of it. Different road types have different speed limits, capacities and geometrics. It is obvious that although there would be no other traffic on a road section, most of the drivers would consider driving more efficient on a motorway section than on a narrow two-lane highway. This is affected strongly by individual factors. Salovaara (1990) presented a coarse classification of road types to be used with efficiency. The classification was made according to the number of lanes, the width of the road, curves, the speed limit, the capacity and the intersection type. Essential for efficiency is the number of lanes (all together and per direction) and the possibilities to overtake. Also intersections (type and number) and the arrangements for light traffic are important.

The structural bottlenecks of the road network may cause problems for the efficiency of road users. Intersections are essential because between them the road may have enough capacity and the capacity of the intersections is the limiting factor. Traffic control affects efficiency via the control logic of traffic lights, speed limits and variable message signs.

The capacity of the road section can be considered dynamic, because it is a function of prevailing traffic conditions and control. The capacity affects the efficiency mostly via the relation of traffic volume and the capacity. In the vicinity of the capacity driving speeds decrease and travel times increase. Consequently drivers are forced to drive the low speed set by the traffic flow and consequently driving comfort gets worse. Traffic volume affects the efficiency and its perception because drivers rather drive freely and alone than in congested traffic. Traffic volume as well as traffic density and headway distribution have an effect on efficiency also by the number of overtakings and possibilities for overtaking. Non-recurrent events (predictable ones like roadwork and non-predictable ones like accidents) affect the efficiency.

Other traffic related factors affecting the efficiency are the vehicle speed distribution, proportion of heavy traffic and the seasonal changes of traffic (season, week day, hour). However, the main attributes are weather and traffic volume. The seasonal changes

affect mostly the time budget because in bad weather conditions or in congested traffic more time is reserved for travelling than normally. Non-traffic related factors that affect the efficiency are weather and road conditions and traffic information systems.

REFERENCES

Hong YUAN, Huapu LU; *Evaluation and Analysis of Urban Transportation Efficiency in China*, 2004

Brilon, W. (2000), *Traffic Flow Analysis beyond Traditional Methods*, Proceedings of the 4th International Symposium on Highway Capacity, pp. 26-41, TB Circular E-C018, Transportation Research Board, Washington D.C.

Keemin Sohn, *A systematic decision criterion for the elimination of useless overpasses*, Transportation Research Part A, 42 (2008) 1043–1055

C.Antoniou, G.Yannis, J.Golias, *Road network efficiency and environmental impact assessment of Driver Assistance Systems*, Proceedings of the 9th World Congress on intelligent transport systems, ITS America, ERTICO, Chicago, October 2002

Bart van Arem, *The impact of Co-operative Adaptive Cruise Control on traffic flow characteristics*, T-ITS-05-10-0110

Henrik Schumacher, Christian Priemer, Eric N. Slottke, *A Simulation Study of Traffic Efficiency Improvement Based on Car-to-X Communication*, VANET'09, September 25, 2009, Beijing, China.

Tomohisa Yamashita, Kiyoshi Izumi, Koichi Kurumatani, *Car Navigation with Route Information Sharing for Improvement of Traffic Efficiency*, 2004 IEEE lntelllgent Transportation Systems Conference, Washington, D.C.. USA. October 36, 2004.

Luoma, S (1998). Tieliikenteen sujuvuus ja sen mittaaminen [Transport system efficiency and its estimation]. Tielaitoksen selvityksiä 21/1998, Finnish Road Administration, Helsinki. 101 + 27 p.

Salovaara, V (1990). Tien liikenteellinen palvelutaso. Tie ja liikenne 12/90, Helsinki. p. 10-14