

Large Scale Collaborative Project
7th Framework Programme
INFSO-ICT 224067

Impacts on Efficiency – Preliminary Results

Report	Impacts on Efficiency – Preliminary Results		
Summary	Report on preliminary results of the impacts on Efficiency		
Sub Project	SP 4	Evaluation and assessment	
Workpackage	WP 4.5	Efficiency impact assessment	
Task	T 4.5.1	Data analysis	
Authors	Touliou, K. (CERTH/HIT); Innamaa, S. (VTT); Pagle, K. (ICCS); Will, D. (IKA); Brignolo, R. (CRF)	File name	TeleFOT_D 4 5 2_Impacts on Efficiency – Preliminary results.doc
Status	Final		
Distribution	Public (PU)		
Issue date	2011-04-28	Creation date	2013-03-12
Project start and duration	1 st of June, 2008 – 54 months		
	Project co-funded by the European Commission DG-Information Society and Media in the 7th Framework Programme		

TABLE OF CONTENTS

EXECUTIVE SUMMARY	10
1. INTRODUCTION.....	12
2. EFFICIENCY	20
2.1. Efficiency typology.....	20
2.2. Efficiency research focus	22
3. METHOD.....	24
3.1. LFOTs contribution	24
3.2. DFOTs contribution	25
3.3. Data sources used so far.....	25
3.3.1. Travel diary	25
3.3.2. Questionnaires	26
3.3.3. Simulation	26
3.3.4. Logged data	28
3.3.5. Statistical analysis.....	33
4. PRELIMINARY ANALYSES OF EFFICIENCY RESEARCH QUESTIONS.....	36
4.1. EFRQ1 Is the travel time from origin to destination affected?(VTT)	36
4.1.1. Data	36
4.1.2. Results.....	36
4.1.3. Initial conclusions and further steps.....	39
4.2. EFRQ2: Are there any delays avoided? (Centro Ricerche FIAT, CRF).....	40
4.2.1. Data	42
4.2.2. Analysis	42
4.2.3. Initial conclusions and further steps.....	45
4.3. EFRQ3 Are the vehicles speeds in the network reduced/increased? (IKA)	45
4.3.1. Data	46
4.3.2. Analysis	47
4.3.3. Initial conclusions and further steps.....	48
4.4. EFF-RQ4: Is the time headway between the vehicles increased/decreased?(CERTH/HIT)	49
4.4.1. Data	50
4.4.2. Analysis	51
4.4.3. Initial conclusions and further steps.....	61
4.5. EFF-RQ5 Are there any traffic jams avoided?(ICCS)	62
4.5.1. Data	63
4.5.2. Analysis	64
4.5.3. Initial Conclusions and further steps	66
4.6. EFF-RQ6 Is the distance from the preceding vehicle smaller/larger?(CERTH/HIT).....	67
4.6.1. Data	68
4.6.2. Analysis	68
4.6.3. Initial conclusions and further steps.....	71
5. DISCUSSION.....	72
5.1. Implications for Efficiency so far	73
5.2. Considerations for final analyses.....	73
6. CONCLUSIONS	75

REFERENCES 79

ANNEX. PARTNERS' POTENTIAL FOR CONTRIBUTION TO THE EFFICIENCY RQS
FOR LFOTS AND DFOTS 80

LFOTS..... 80

DFOTS 83

LIST OF FIGURES

Figure 1. Efficiency impact area rationale.....	15
Figure 2. Efficiency related hypothesis pillars.....	18
Figure 3. Pelops Interaction Scheme	27
Figure 4. Pelops Vehicle Model	27
Figure 5. Average duration of commuting journeys made during one travel diary data collection period per person for commuting journeys when speed information/alert was in use and when no function was in use	38
Figure 6. Average duration of commuting journeys made during one travel diary data collection period per person for commuting journeys when speed navigation was in use and when no function was in use	38
Figure 7. Average duration of commuting journeys made during one travel diary data collection period per person for commuting journeys when green driving application was in use and when no function was in use	39
Figure 8. Average duration of commuting journeys made during one travel diary data collection period per person for commuting journeys when traffic information was in use and when no function was in use	39
Figure 9. Participants' age distribution in Spanish LFOT1	42
Figure 10. Participants' perceived changes on traffic delays avoidance... ..	43
Figure 11. Participants' perceived change in delays as a function of Km driven per year (a) and driving experience (b).....	44
Figure 12. Perceived change in delays as a function of frequency (%) of road types driven.....	45
Figure 13. Speeding behaviour with three different configurations at 100 km/h speed limit.....	48
Figure 14. Percentages (%) of km driven per year.....	52
Figure 15. Perceived driving style (%).....	53
Figure 16. Perceived driving experience (%).....	53
Figure 17. Mean THWY values per tested function	56
Figure 18. Mean percentage (%) of driving time spent with headway values: a) >5 seconds, b) between 1.5 and 5 seconds, and c) <1.5 seconds.....	57
Figure 19. Mean Δ THWY values (sec) between Baseline 2 and DFOTs ...	59
Figure 20. Mean Δ THWY values (sec) between DFOT1 and the rest of DFOTs and the control group	60
Figure 21. Mean Δ THWY values (sec) between DFOT2 and the rest of DFOTs and the control group	60
Figure 22. Mean Δ THWY values (sec) between DFOT3, UKDFOT2 and the control group	61
Figure 23. Perception of change in traffic jams avoidance (Sweden; LFOT1).....	64
Figure 24. Perception of change in traffic jams avoidance (Sweden; LFOT4).....	65

Figure 25. Perception of change in traffic jams avoidance (Finland; LFOT)
..... 65

Figure 26. Perception of change in traffic jams avoidance (Greece; LFOT3)
..... 66

Figure 27. Mean min distance (m) from preceding vehicle across DFOTs 69

Figure 28. Mean min distance (m) values per DFOT 70

LIST OF TABLES

Table 1. Efficiency research questions per responsible partner.....	16
Table 2. Selected research questions.....	20
Table 3. Research Questions analysis' allocation per main responsible partner.....	21
Table 4. Initial scripting of data collection for Efficiency RQs	30
Table 5. Scripting of data allocation to Efficiency related RQs	34
Table 6. Average duration(s) of commuting journeys made by car.	37
Table 7. Basic demographics.....	51
Table 8. Mean, SD, min, % of time spent with THWY<5 seconds per function.....	55
Table 9. Basic demographics.....	68
Table 10. Data used in preliminary and final analysis per RQ.....	76
Table 11. LFOTs potential contribution to answering Efficiency RQs	80
Table 12. DFOTs potential contribution to answering Efficiency RQs.....	83

LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
ACC	Adaptive Cruise Control
ADAS	Advanced Driver Assistance System
ANOVA	Analysis of Variance
CAN	Controller-Area Network
CAS	Collision Avoidance System
DFOT	Detailed Field Operational Test
D-GPS	Differential Global Positioning System
DTC	Distance-to-Collision
EFF	Efficiency
ETA	Effective Time of Arrival
GPS	Global Positioning System
IVIS	In-Vehicle Information System
HD	High Definition
LFOT	Large Scale Field Operational Test
NAV	Navigation
OBDII	On Board Diagnostic System
PELOPS	Program for the dEvelopment of Longitudinal micrOscopic traffic Processes in a Systemrelevant environment
PND	Portable Navigation Device

ABBREVIATION	DESCRIPTION
RDS	Radio Data system
RQ	Research Question
SA	Speed Alert
SI	Speed Information
THWY	Time Headway
TI	Traffic Information
TTC	Time To Collision
2G/3G	2 nd Generation/3 rd Generation

REVISION CHART AND HISTORY LOG

REV	DATE	REASON
0.1	2011/06/06	First skeleton sent to involved partners
0.2	2011/08/05	Feedback by partners incorporated
0.3	2011/08/08	First draft sent for peer review
0.4	2011/09/09	Peer reviewed version received
Final	2011/09/16	Feedback and comments were incorporated in the final version to submitted to EC
Re-submitted draft	2012/05/08	Feedback received by all responsible partners and incorporated to the existing draft with updated Research Questions' data analysis input for internal peer review and Checkpoint review
0.5	2012/06/04	Peer review comments received from UNIMORE and required changes were made
0.6	2012/06/15	Checkpoint review comments were received and required changes were made
0.7	2012/07/11	Peer review comments received from VTT and required changes were made
0.8	2012/07/17	Peer review comments received from ICCS and required changes were made
Final	2012/07/23	Final version ready to be submitted to EC

EXECUTIVE SUMMARY

This deliverable aims at providing preliminary findings on the impacts of nomadic devices on driving Efficiency based on the selected hypotheses and respective research questions according to *"Efficiency Data Analysis Plan"* (D 4.5.1). In Chapter 1 the main Research Questions analysed by responsible partners are presented with regards to the adapted methodological framework and prospective analyses as a next step. This deliverable is very useful for final analysis and presents the type of data that are collected and analysed for the final analysis. The main variables are identified for each Research Question related to Efficiency and the nature of final analysis is determined.

In Chapter 2 the Efficiency typology for each Research Question (i.e. numbering and respective hypotheses) and research focus are discussed. The main methodology and types of collected data are presented in Chapter 3. The first analysed data are derived from the Finnish, Swedish, Spanish, and Greek LFOTs. Interim results from DFOTs (Greek, UK, and German) are discussed in Chapter 4.

Analysis so far for each Efficiency Research Question undertaken is presented and discussed in sections 4.1-6. The results to date showed no impact in how users perceive duration of journeys (section 4.2) and avoidance of traffic jams (section 4.5) due to using green driving application, navigation, speed information and alert or traffic information. However, a small but significant reduction in travel delays and avoidance of traffic jams was found (section 4.2). Further steps would include further stratification for background characteristics. On the whole, FOT participants were relatively positive about the impact that after-market devices had on their perceptions of traffic jams avoidance. No consistent trend of speeding behaviour dependent on the usage of the systems was found for simulation to be performed (section 4.3).

Lower headways were found with all combination of functions by analysing DFOT data so far but no effect of distance was revealed (sections 4.4 and 4.6, respectively) meaning that the addition of the aftermarket devices with tested functions either increases Efficiency or it does not affect it. Data from the German DFOT will be added in the final analysis.

This deliverable provides preliminary results for the Efficiency related research questions and will provide valuable feedback to both involved partners and data

analysts in order to conduct further analysis. Moreover, the partner responsible for the Efficiency impact area (CERTH/HIT) will distribute to responsible partners relevant information and advice resulting by work performed to date in order to be used as an additional process towards the final analysis deliverable "*TELEFOT Applications Efficiency Impact*" (4.5.3.).

Final analysis will be based on whole datasets from more LFOTs and DFOTs as shown in table 10.

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.

This deliverable aims to provide preliminary results of first available data sets of data from both LFOTs and DFOTs analysed in order to answer the Efficiency Research Questions, as described in "*Efficiency Data Analysis Plan*" (Deliverable 4.5.1). The structure and layout is based on the common framework provided for all relevant deliverables. The analysis of available data will provide both a foundation and a preview for the final analysis, and most importantly, will serve as the basis for probable interpretations that will follow in the overall analysis. In other words, this deliverable is very useful for final analysis and presents the type of data that are collected and analysed for the final analysis. The main variables are identified for each Research Question related to Efficiency and the nature of final analysis is determined.

It is essential to note that this deliverable has been renamed to "*Impact on Efficiency-Preliminary Results*" in order to reflect all efforts relevant to Research Questions undertaken (including simulation) and follows the rationale of relevant deliverables. The content of the deliverable was initially planned to be based on simulation, therefore mainly on answering question on speed variations. Efficiency impact assessment is directed not only towards micro-simulation but also towards analysis of actual testing data and, therefore, it was decided to include preliminary findings from all relevant Efficiency Research Questions. DFOTs were scheduled to start after LFOTs, in most occasions, in order to gather enriched and indepth data.

Change of content aimed to create a document that mostly provides very first data analysis and interpretations from the large and small scale efforts and paves the way for the final analysis with emphasis, of course, on Efficiency. This document is a transitional document from initial to final analysis offering first results that will be enriched later with all completed datasets' analysis- whenever they are available in the respective test-sites-and their analysis will be presented and discussed in the final deliverable "*TELEFOT Applications Efficiency Impact*" (D 4.5.3). Data collection for many DFOTs was still on-going while preparing this document; therefore not all data analysis is presented. Hence, statistical significance testing was performed whenever plausible (i.e. where complete datasets were available).

In addition, although not initially scheduled for DFOT vehicle data, data from Greek DFOTs are currently being map-matched and therefore additional analysis will be performed for aggregated Greek data in the final analysis.

It is important to clarify that Efficiency is viewed from the perspective of the driver as defined in Deliverable 4.5.1. Deployment of assistive technologies inside and outside the vehicle inevitably will affect the efficiency of both driver and traffic, as these systems will be increasingly used. Heavier and denser traffic flows will impose a heavier burden on both traffic and the driver. In conjunction with increased traffic volume and congestion their interaction is of vital importance for future traffic management and driving behaviour training schemes. Technology changes the way for vehicle interaction (e.g. vehicle to X communication) and, consequently, the parameters of accidents increase and potentially change. Taking into consideration existing important variables (e.g.

alcohol, fatigue, and human error in general), the inter-combinations for potential accident risks and issues (e.g. prominent accident and near-crashes events) substantially increase.

Penetration rates for these systems continuously increase. If ADAS and IVIS affect the way the driver behaves on the road, then they probably affect traffic dynamics. In addition, shorter headways and distances kept from the preceding vehicles (within safe limits) could enhance traffic efficiency. The complexity of a traffic system and the complexity of the arising driver-systems' interactions within the vehicle evidently create cumulative complexity for the understanding of how efficient these systems/devices are for both driver and traffic system. Maximising the utility of functions installed/used would potentially maximise the efficiency for each individual driver within the network. Taking into consideration driver's own perception of effect and efficiency allows for accommodating their notions, suggestions and attitudes (i.e. individual perspective and differences) to how much efficient driving could be with utilising certain Portable Nomadic Devices (PNDs) functions and, therefore, harmonising traffic networks.

The following diagram (Figure 1) provides the rationale of the undertaken approach in order to be utilised for better understanding the findings (both preliminary and final). In addition, a detailed framework will be presented in Deliverable 4.5.3 aiming at harmonising the final outcomes for global impact assessment and also for estimation of probabilities for penetration rates for both existing (i.e. aftermarket systems) and the next generations of these systems.

It works as a parallelism for a notial intersection for different sources of data; an intersection of respective research questions' data analysis leading to better understanding of the impact the nomadic devices' functions might have on Efficiency. Needless to say, the relationship between these sources and outcome is not simple nor linear in nature but rather complex and confounding.

In short, Efficiency is a complex impact area and should be taken into consideration from different driving perspectives and research angles. This consideration leads also to the possibility of the calculation of a qualitative and aggregated impact index. This comparable index might lead to the identification of the importance of certain functions for certain impact areas. The significance of each impact assessment area could prove to be valuable for future research not

only for aftermarket devices but in addition for devices (informative, assistive or both) under development.

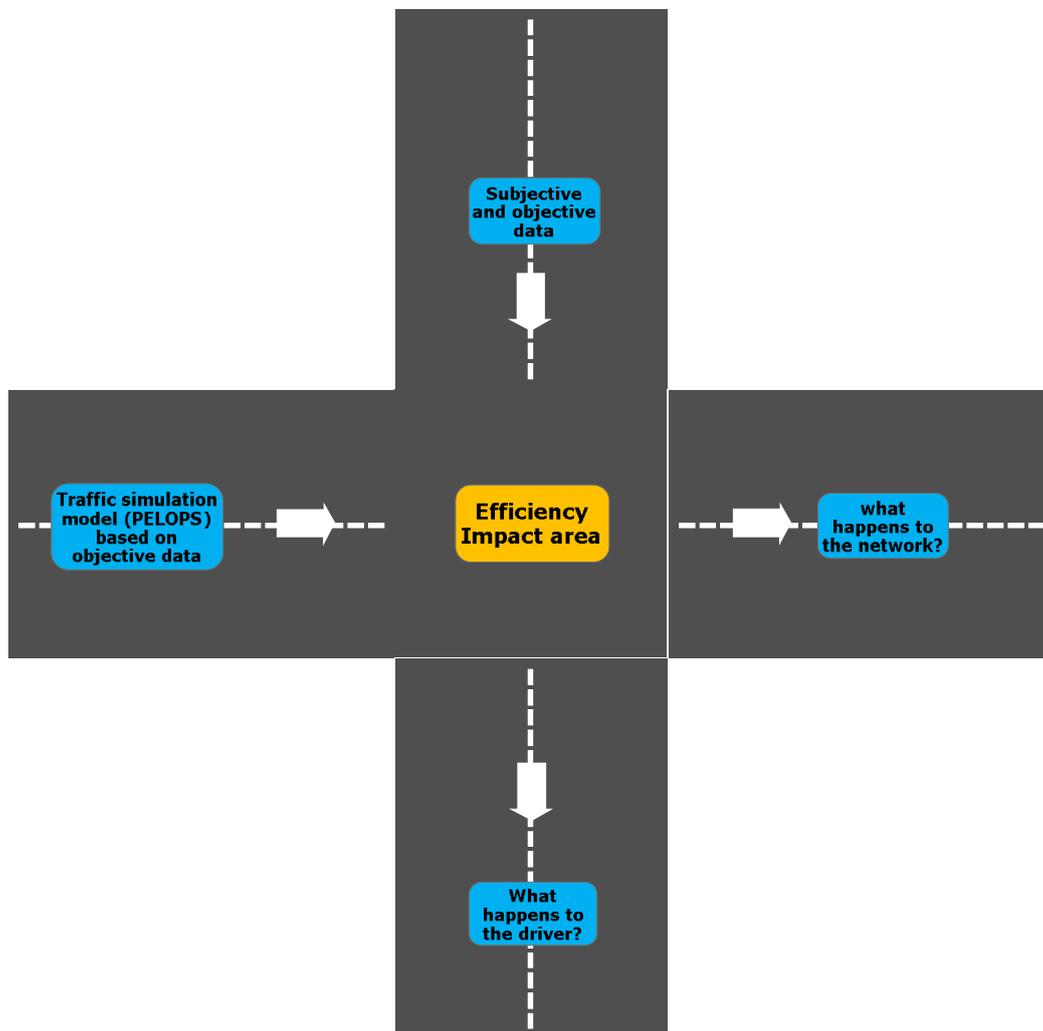


Figure 1. Efficiency impact area rationale

Specifically, in TeleFOT methodological framework the impact approach- instead of system-based approach-ensures channeling of indicators under the prism of certain evaluation criteria set within each impact area (D4.5.1).

The following table (Table 1) is added to have an overview of the next potential dates for final analysis. The final results will be presented in detail and discussed in Deliverable 4.5.3, comprising all available data analysis from both LFOTs and DFOTs. An estimation of probable dates for final results would give involved

partners good indications for when the final deliverable is estimated to be accomplished. With this in mind, the final column has been added.

Table 1. Efficiency research questions per responsible partner

Efficiency Research question	Main Partner responsible	Data collection end	Final data sets available for 4.5.3 analysis
RQ1 Is the travel time from origin to destination affected?	VTT	December 2010	March 2012
RQ2 Are there any delays avoided?	CRF	December 2011	March 2012
RQ3 Are the vehicles speeds in the network reduced/increased?	IKA	December 2011	March 2012
RQ4 Is the time headway between the vehicles increased/decreased?	CERTH	March 2012	March 2012
RQ5 Are there any traffic jams avoided?	ICCS	December 2011	March 2012
RQ6 Is the distance from the preceding vehicle smaller/larger?	CERTH	March 2012	March 2012

Certain considerations and assumptions should be taken into account. Specifically, most data are derived from different sources (i.e. scale variation and different field trial sites) and different populations are represented in the overall sample. In addition, not all elements of traffic efficiency are possible to be investigated within TeleFOT project in this impact area but are depicted as a tree-to-branch diagram (Figure 2) to emphasise the diversity in range and assortments in Efficiency impact area. Traffic volume, traffic flow and the presence of other automobiles are important to get an overall assessment of traffic efficiency. Behaviour of other traffic users was not plausible to be measured and it is probably best to be evaluated on a traffic management level.

Intermediate analysis of research questions under investigation is an important "opportunity" to solve arising problems. The objectives of this work, in general, for the overall final analysis will attempt to offer answers based on the inferences derived by the final analysis of respective Research Questions:

- To evaluate the impact of TeleFOT systems in terms of traffic Efficiency;
- To analyse the effect of the use of such systems on driver's efficiency-related parameters in different scenarios of use;
- To allow identification of the optimum penetration rates of equipped vehicles that should be adopted according to each context of use based on inferences made from all data analysed within the framework of this impact area;
- Similarly, to estimate a route to achieve the optimal market adoption and deployment.

The Research Questions under investigation have been developed based on these objectives

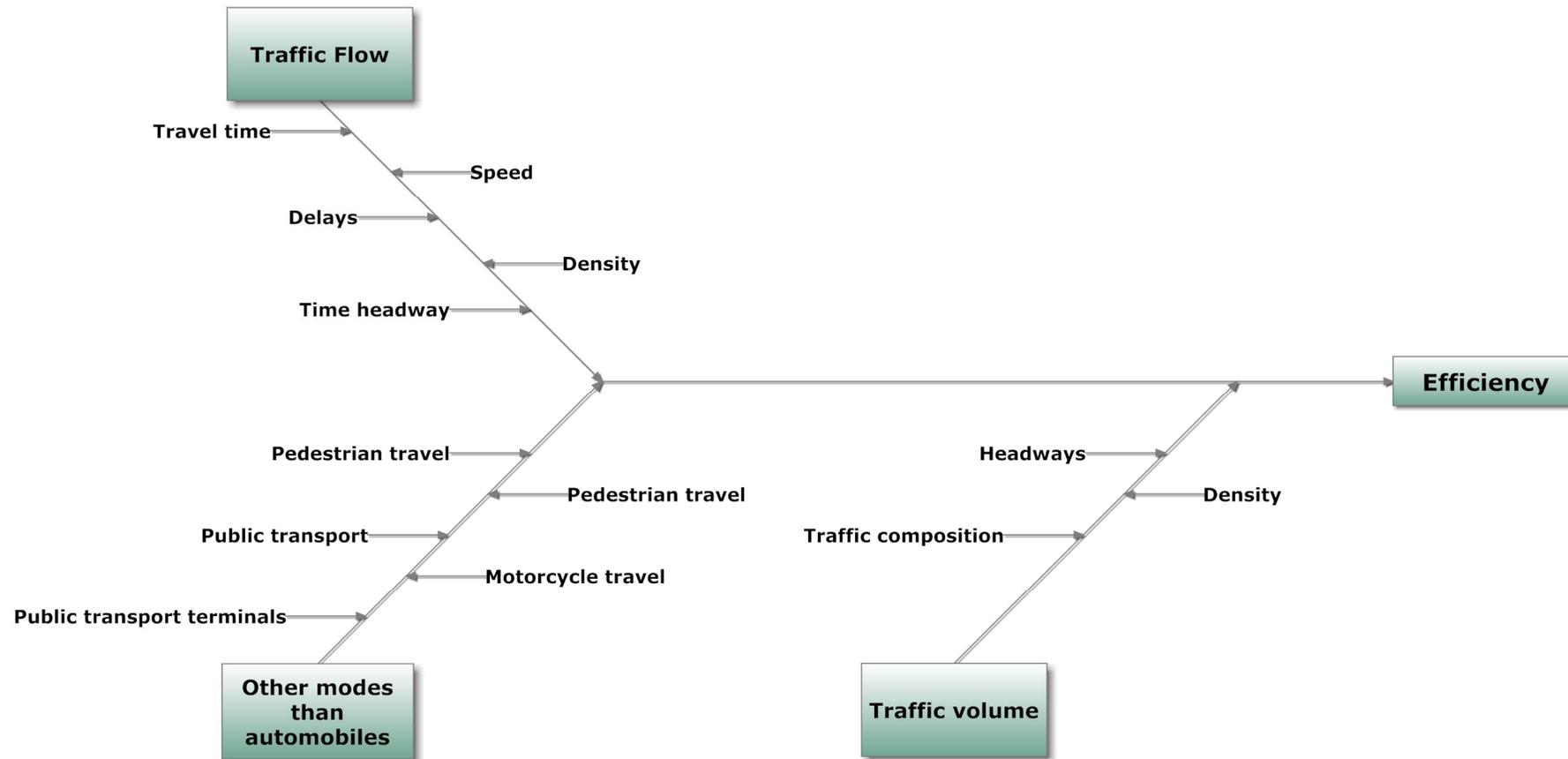


Figure 2. Efficiency related hypothesis pillars

The pillar corresponding to the “Other modes than automobiles” will not be investigated also because it does not provide the driver’s perspective and therefore it is outside the scope of this impact area’s analysis framework. Speed, travel time, time headway are important elements of traffic flow that will be evaluated within TeleFOT Efficiency impact assessment. With regards to vehicle, headways –both distance and time- are estimated. Composition and density were not evaluated in the real data analysis. This tree-to-branch diagram (Figure 2) will facilitate in discussing the analysis inferences in D4.5.3. Hence, figures 1 and 2 will be revisited during the final steps of analysis for Efficiency Research Questions.

It was indicated early in the project that due to the nature and content of research questions, results could be derived by both LFOTs and DFOTs.

Hence, this deliverable provides preliminary data analysis permissible at this point of the project.

2. EFFICIENCY

2.1. Efficiency typology

Efficiency in TeleFOT field trials is investigated from the perspective of the road user, as set and clearly defined in D 4.5.1. Elements of Efficiency that are important to the road user, in TeleFOT's case the driver, have been specified and are depicted in Figure 2. The following table (Table 2) presents the research questions selected to be investigated and are related to Efficiency.

Table 2. Selected research questions

Efficiency Research questions	
RQ-EF1 Is the travel time from origin to destination affected?	
RQ-EF2 Are there any delays avoided?	
<i>RQ-EF3 Are the vehicles speeds in the network reduced?</i>	Merged and renamed: RQ-EF3
<i>RQ-EF4 Are the vehicles speeds in the network increased?</i>	
RQ-EF5 Are there any traffic jams avoided?	
<i>RQ-EF6 Is the time headway between the vehicles increased?</i>	Merged and renamed: RQ-EF4
<i>RQ-EF7 Is the time headway between the vehicles decreased?</i>	
<i>RQ-EF8 Is the distance from the preceding vehicle larger?</i>	Merged and renamed: RQ-EF6
<i>RQ-EF9 Is the distance from the preceding vehicle smaller?</i>	

Hence, the allocation of RQ responsibilities is summarised in the following table (Table 3) with changes indicated in Table 2 taken into consideration.

Table 3. Research Questions analysis' allocation per main responsible partner

Research question	Hypotheses	Main Partner responsible
RQ1 Is the travel time from origin to destination affected?	H1.1 Travel times are likely to increase/decrease (when device is used compared to when device is not used)	VTT
RQ2 Are there any delays avoided?	H2.1 Delays are likely to be avoided	CRF
RQ3 Are the vehicles speeds in the network reduced/increased?	H3.1 The vehicle speeds in the network are likely to be reduced. H3.2. The vehicle speeds in the network are likely to be increased	IKA
RQ4 Is the time headway between the vehicles increased/decreased?	H4.1 It is likely that the time headway between vehicles is increased H4.2 It is likely that the time headway between vehicles is decreased	CERTH
RQ5 Are there any traffic jams avoided?	H5.1 It is likely that traffic jams are avoided.	ICCS

Research question	Hypotheses	Main Partner responsible
RQ6 Is the distance from the preceding vehicle smaller/larger?	H6.1. It is likely that the distance from the preceding vehicle is larger. H6.2. It is likely that the distance from the preceding vehicle is smaller.	CERTH

It was suggested that some research questions (3 and 4) should be merged into one. As shown in Table 2, these two questions were merged in to one two-sided rather than having two one-sided. Similarly, RQs 6 and 7 were merged into RQ4 and RQ8 and 9 to 6. Regarding RQ-EF2 and RQ-EF5, the investigation and evaluation of relevant data does not rely heavily on the notion of pre-existing delays and traffic jams, respectively but on their own subjective evaluation. Hence, driver's own feeling of avoidance of jams and delays is of significant importance for driver to perceive the system and functions as effective and their driving experience as efficient. As different nomadic devices are used per test site, it was decided to rely on perceived avoidance of delays and traffic jams to facilitate data consolidation and analysis.

2.2. Efficiency research focus

The different types of support to driver and vehicle have been categorised to Advanced Driving Assistance System (ADAS) and In-Vehicle Information System (IVIS) for better understanding about the information type, purpose and support orientation for both vehicle and driver. It will not be too far in the future when highly sophisticated and complex systems will provide personalised support to drivers by providing both assistance and information and the distinction used to-date between informative and driving assistive systems will not apply.

Current findings should be viewed from the perspective of Efficiency impact assessment and analysis in order to gain insight about research status quo and related findings. Often impact assessment areas share research questions and overlapping between Research Questions and analysis is observed. Some research questions are mutually dependent as they could be viewed and, consequently, answered under the prism of more than one impact areas. Specifically, longitudinal and lateral distances are important vehicle parameters for both safety and efficiency. Data analysis of speed and headway adjustments is oriented more towards traffic efficiency impact assessment.

There are findings advocating that increased safety could lead to lower efficiency and vice versa. However, not all research is directed towards this positive/negative relation between these two impact areas. According to traffic engineering theory (Pline, 1992), speed increase could lead to higher network efficiency and decrease of vehicle headway could lead to more efficient traffic conditions with optimised distances between vehicles. If speeds in the network and headways are adjusted, then road capacity could increase and delays and jams could be decreased (Golias et al., 2010). Speed variations in traffic are investigated with the application of micro-simulation model (PELOPS) and could provide useful inferences about harmonisation and optimisation of the road capacity. The PELOPS model is presented in section 3.3.3.

Therefore, there are two inferential directions for our data analysis. The first direction is the direct extrapolation of findings to the traffic network. In this case we get results from creating fleets for the traffic network. This is feasible with the application of micro-simulation for calculating speeds in the network. Results from other research questions, though, are based on data collected from one or two research vehicles. Hence, the second indirect effect to traffic flow is the estimation of efficiency with focus on data analysis from actual testing with instrumented vehicles.

In a nutshell, the potential effect to the traffic network will be achieved by both micro-simulation and consolidated data analyses from both LFOTs (mostly qualitative) and DFOTs (mostly quantitative).

3. METHOD

This section presents the type of data that were used for pre-liminary analysis. Preliminary analysis focused on analysis of a subset of data, although more data are available on the database. However, analysis was not feasible to be carried out for all data at this point.

3.1. LFOTs contribution

The LFOTs will contribute data from completed travel diaries, questionnaires and logged data; preliminary results are included in this deliverable for answering the research hypotheses relevant to travel time changes (duration), delays and traffic jams avoided. In addition, travel durations from qualitative data sources will be compared will logged data for the final results analysis. The Finnish and Spanish LFOTs contributed data to the Efficiency impact assessment by providing travel diary data so far. The responsible partner for this analysis was VTT.

The analysis of perceived avoidance of traffic jams is based on post-questionnaires from the Finnish FOT (TI, SI/SA, GD¹) and Greek LFOT3 (NAV, TI²) and are included in the analysis of EFF-RQ5. Further analysis is included with results from the Swedish FOT2 (NAV, GD, TI) and FOT4 (TI) and the analysis so far was performed by ICCS.

The analysis of subjective feeling of avoidance of delays included data derived by the Spanish LFOT (Navigation Support) and is presented in section 4.2. Further analysis will be performed for the Italian LFOT1 and Swedish LFOT4 (Traffic Information).

LFOT data are utilised mainly to answer EFF-RQ 1(H1.1), EFF-RQ 2(H2.1-2), and EFF-RQ 5 (H5.1-2).

¹ TI: Traffic Information
SI/SA: Speed Information/Speed Alert
GD: Green Driving
NAV: Navigation Support and Route Guidance

² NAV: Navigation Support and Route Guidance
TI: Traffic Information

3.2. DFOTs contribution

Some of the research questions within the Efficiency framework will be answered by using DFOT data since these more enriched data are necessary for performing in-depth analyses. In this context, DFOTs will provide logged data to answer the RQs that were aimed to mostly utilise objective measurements such as vehicle parameters (e.g. distance and time headway). The DFOTs that provided data in this regard are as follows:

The Greek DFOTs (1-3) provided in depth analysis of most vehicle parameters required in order to answer Efficiency related RQs. In particular, the parameters under investigation are time and distance headway.

The German DFOT supports this impact assessment area also with high-resolution data from their tests. Besides vehicle dynamics data such as velocity, acceleration and steering wheel angle, the German DFOT delivers high quality GPS-positions of a D-GPS, lane information and information of the vehicles in front output by a radar sensor.

In addition, aggregated data from the UKDFOT2 investigating the effect of FCW and Green Driving Support are included in this analysis.

Mainly DFOT data are used in order to answer EFF-RQ 3 (H3.1-2), EFF-RQ 4(H4.1-2), and EFF-RQ 6(H6.1-2).

3.3. Data sources used so far

Description of data sources and types are beyond the scopes of this deliverable. Detailed description of qualitative and quantitative data and both test conduction procedures can be found in respective deliverables in SP3 deliverables. Brief overview of data sources used up to this point is presented below. These sub-sections present data used so far for the purposes of preliminary analysis and by no means is exhaustive of data types and sources that will be used for final analysis.

3.3.1. Travel diary

Research question EFRQ1 "Is the travel time from origin to destination affected?" included one hypothesis EF-H1.1 "Travel times are likely to increase/decrease (when device is used compared to when device is not used)". Analysis of this

hypothesis was made based on travel diary data from LFOTs in Finland and Valladolid/Spain. Both sites had collected travel diaries four times during one week. In Finland the number of participants who had filled the travel diary per period varied between 38 and 93 and in Valladolid between 90 and 117. Descending trend in response rate could be seen. These commuting journeys were included in the analysis of EFRQ1.

3.3.2. Questionnaires

Solely questionnaires data were used to evaluate two EFF-RQs (2 and 5), mainly data that result from LFOTs and have to do with RQs (i.e. delays and traffic jams perceived avoidance) that were not possible to be answered by the micro-simulation and/or objective data (i.e. distance, headway, speed variations).

3.3.3. Simulation

For simulations of traffic Efficiency the simulation tool PELOPS is used. PELOPS is a microscopic traffic simulator. It is used for the evaluation of traffic- and infrastructure-supported traffic influence measures and driver assistance systems. The evaluation takes place in form of macroscopic (throughput), microscopic (time gaps, velocities, accelerations) and submicroscopic (fuel consumption, emissions) parameters. The models included in the simulation model and their inter-relations with respective variables are presented in Figure 3. Data collected from DFOTs are used in order to perform the simulations.

If required, the comprehensive stretch model allows a detailed description of the influences of a stationary traffic environment such as incline, windings and traffic signs. This environment can be extended by the setting of stretch-dependent traffic environment parameters such as wetness, slippery surface etc. for different road resistances (Figure 3). The depiction of the traffic element "driver" is divided into a decision-handling and a vehicle model.

In the vehicle model the controls are converted into dynamic vehicle quantities. The modelling of vehicles is characterised by a high specification degree. The single elements of the drive train such as engine, transmission (manual or automatic), retarder etc. can be specified with very high accuracy.

PELOPS is provided with a MATLAB® interface which allows the implementation of vehicle models and control algorithms for driver assistance systems. As the vehicle can be reproduced after the "cause-effect" principle, also the influences of control technical devices (e. g. distance control, electronic acceleration pedal and brake etc) can be investigated. The aim of the investigation includes vehicle related effects (fuel consumption or emissions) as well as effects on the traffic environment via macroscopic characteristics such as stretch throughput, average velocity and dynamic effects of a convoy of vehicles.

3.3.4. Logged data

The main data derived by DFOTs will be for the analysis of headway and distance. The possibility of logged data will be finally analysed in relation to the qualitative data derived by the completed questionnaires distributed to the participants.

The following scripting (Table 4) was originally created in order to depict the relations among data types (sources), the functions to be tested (e.g. Navigation (NAV), Collision Avoidance Warning (CAS) etc.) and the characteristics of participating drivers. In addition, the variables selected based on the study design were included. Scripting is a process to logically connect the Research Questions developed with data sources, functions tested, type of participants and main variables within the methodological framework adopted. This scripting was applied in order to provide the basis for the data collection procedure and link the types of data selected with all related aspects of the nomadic devices.

The questionmark (?) reflects the inherent difficulty to find the appropriate data types in order to answer specific Research Questions as Efficiency is a very challenging impact area with not so concrete definitions and even scarcer findings in relevant current research. This was an important phase before data analysis started for the first sets of data. Scripting was a valuable step for both preliminary but also for the subsequent analysis steps. It should be noted though that the initial scripting was made before any changes to Research Questions, therefore they are presented in the table as they were discussed in the initial plan

made for the structure of hypotheses in Deliverable 4.5.1. A second table (Table 5) presents the final Efficiency scripting based on data availability, Research Questions and respective hypotheses tested by each partner with the additional changes in Research Questions. These differences also led to changes in analysis' preparation steps taken and those that are still to be carried out.

Table 4. Initial scripting of data collection for Efficiency RQs

Research questions	Scripting elements					
	Sources	Functions	Fleets	Design	Main variable(s)	Supporting variable(s)
RQ-EF1 Is the travel time from origin to destination affected?	Logfiles Questionnaires Travel diaries	Primary: NAV+TI Secondary: SA or SI	Non-professional drivers	Pre-post	Travel time	Speed Congestions Traffic volume Individual performance
RQ-EF2 Are there any delays avoided?	Microsimulation (?) Questionnaires	Indirectly: NAV+TI	Non-professional drivers	Pre-post	Number of delays avoided/Perceived avoidance of delays	Travel time(s)
RQ-EF3 Are the vehicles speeds in the network reduced?	Microsimulation , travel diaries	SA, SI, GD	Non-professional drivers	Data taken from actual testing	Average speeds and deviations	Speed limits data

RQ-EF4 Are the vehicles speeds in the network increased?	Microsimulation , travel diaries	SA, SI, GD	Non-professional drivers	Data taken from actual testing	Average speeds and deviations	Speed limits data
RQ-EF5 Are there any traffic jams avoided?	Travel diaries, User Uptake questions	NAV, TI	Non-professional drivers	post	Questionnaire answer	Driving background questionnaire
RQ-EF6 Is the time headway between the vehicles increased?	Logfiles	CAS	Non-professional drivers	With- without	Time headway	
RQ-EF7 Is the time headway between the vehicles decreased?	Logfiles	CAS	Non-professional drivers	With- without	Time headway	

RQ-EF8 Is the distance from the preceding vehicle larger?	Logfiles	CAS	Non-professional drivers	With-without	Distance	
RQ-EF9 Is the distance from the preceding vehicle smaller?	Logfiles	CAS	Non-professional drivers	With-without	Distance	

3.3.5. Statistical analysis

Statistical testing was not the same for all research questions because different types of data were used for answering them. Data analysed so far for answering EFFRQ1 were based on travel diary data and statistical comparisons of mean were performed with paired-sample T-tests. Duration of journeys with a certain function was compared pairwise to those made without using any of the functions during the same travel diary data collection period to get the result per function. For answering EFFRQ2 a statistical analysis was performed with the application of Fisher and Chi square in an attempt to correlate participants' age and driving experience. And ANOVA analysis was performed to evaluate if the drivers that declared a slight decrease in the delay have a different distribution of total driving time on different types of roads. While for EFFRQ5 no statistical tests were performed (only distributions are provided in the respective section). Preliminary statistical analysis was performed (such as the Chi-square) and comparisons (such as ANOVA) to evaluate if there is a correlation between the results and the drivers' characteristics or the exposure to the functions.

In order to answer the third Efficiency research question micro-simulation was performed and statistical testing was not relevant.

Finally, no statistical testing was performed for Efficiency research questions 4 and 6 because data analysis is still ongoing. Mean differences and simple effect sizes are presented and discussed. However, non-parametric tests will be performed mainly because of different sample sizes in different pilot sites.

For different countries data comparisons, Kruskal-Wallis -nonparametric equivalent to ANOVA- will be applied as between participants' design applies. Multiple comparisons can be performed by using pairwise comparisons (for example, using Wilcoxon sum rank tests) and using a correction to determine if the post-hoc tests are significant (for example a Bonferroni correction).

For within participants' comparisons (same country) Friedman comparisons will be performed. These follow-up tests most frequently involve comparisons between pairs of group medians. For the Friedman test, we could use the Wilcoxon test to examine unique pairs (e.g. Bonferroni adjustment).

The α level was set at .05 for all comparisons.

Table 5. Scripting of data allocation to Efficiency related RQs

Research questions	Scripting elements						
	Sources	Functions	Fleets	Design	Main variable(s)	Supporting variable(s)	Other
RQ-EF1 Is the travel time from origin to destination affected?	Logged data User Uptake Questionnaires Travel diaries	Primary: NAV+TI Secondary: SA or SI	Non-professional drivers	Pre-post	Travel time (duration)	Logged time	Driving Background variables' stratification
RQ-EF2 Are there any delays avoided?	User Uptake Questionnaires	Indirectly: NAV+TI	Non-professional drivers	Pre-post	Perceived avoidance of delays	Logged time (if available)	Driving Background variables' stratification
RQ-EF3 Are the vehicles speeds in the network	Micro simulation (PELOPS)	SA, SI, GD	Non-professional drivers	Data taken from actual	Speeding behaviour	Longitudinal acceleration	Potential to investigate LFOTs contribution to

reduced/increased?					testing			analysis
RQ-EF5 Are there any traffic jams avoided?	Travel diaries, User Uptake questions	NAV, TI	Non-professional drivers		post	User Uptake (scale selection)	Driving background questionnaire	
RQ-EF6 Is the distance from the preceding vehicle larger/smaller ?	DFOTs, Logged data	CAS with NAV, SI, SA, Green Driving support	Non-professional drivers		With-without	Distance headway (DHWY in m) Mean, min, max, variations	Distribution per road type categories	Relation to User Uptake questionnaires and locally used Qs (i.e. usability Questionnaires in DFOTs)

4. PRELIMINARY ANALYSES OF EFFICIENCY RESEARCH QUESTIONS

4.1. EFRQ1 Is the travel time from origin to destination affected?(VTT)

Efficiency research question EFF-RQ1 "Is the travel time from origin to destination affected" and hypothesis EFF-H1.1 "Travel times are likely to increase/decrease (when device is used compared to when device is not used)" were answered for the preliminary results by analysing travel diary data from LFOTs of Finland and Valladolid/Spain.

4.1.1. Data

Both sites (Finish and Spanish) collected travel diaries four times during one week. In Finland the number of participants who had completed the travel diary per period varied between 38 and 93 and in Valladolid between 90 and 117. Descending trend in response rate could be seen.

In Finnish LFOT, participants had traffic information, green driving as well as speed information and alert in their use. In the LFOT of Valladolid, the participants had navigation as well as speed information and alert in their use. The results were analysed per function.

In travel diary data only commuting journeys made by car were included as duration of journey was studied for comparable origins and destinations. Average duration of commuting journeys made by car was calculated separately for journeys when certain function was in use and for journeys when no function was used. Those drivers were selected for the analysis who had reported commuting journeys both with a certain function and without any functions.

Statistical comparison of mean was performed with paired-sample T-test. Duration of journeys with a certain function was compared pairwise to those made without using any of the functions during the same travel diary data collection period to get the result per function.

4.1.2. Results

Average duration of commuting journeys was calculated for each participant for each travel diary data collection period separately for commuting journeys when a certain function was in use and when no functions were in use. There were no

statistically significant differences (Table 6) in duration for any of the function either in Finland or Valladolid, Spain. Individual observations were plotted in Figures 5-8. Single long journey in Valladolid data may have dominated the regression curve fitting in Fig 5. Nevertheless, Figures confirm the statistical result as most observations are very close to curve $y = x$.

Table 6. Average duration(s) of commuting journeys made by car.

FUNCTION	LFOT	DURATION, WITH FUNCTION	DURATION, NO FUNCTION	N	<i>p</i>
Speed info/alert	Spain/Valladolid	1403.16	1361.44	43	0.288
	Finland	2007.82	1428.21	24	0.276
Navigation	Spain/Valladolid	1217.75	1157.39	15	0.185
Green driving	Finland	1867.84	1305.26	19	0.342
Traffic info	Finland	2524.25	1665.95	18	0.232

Duration of journeys with a certain function was compared pairwise with paired-sample T-test to those made without using any of the functions during the same travel diary data collection period.

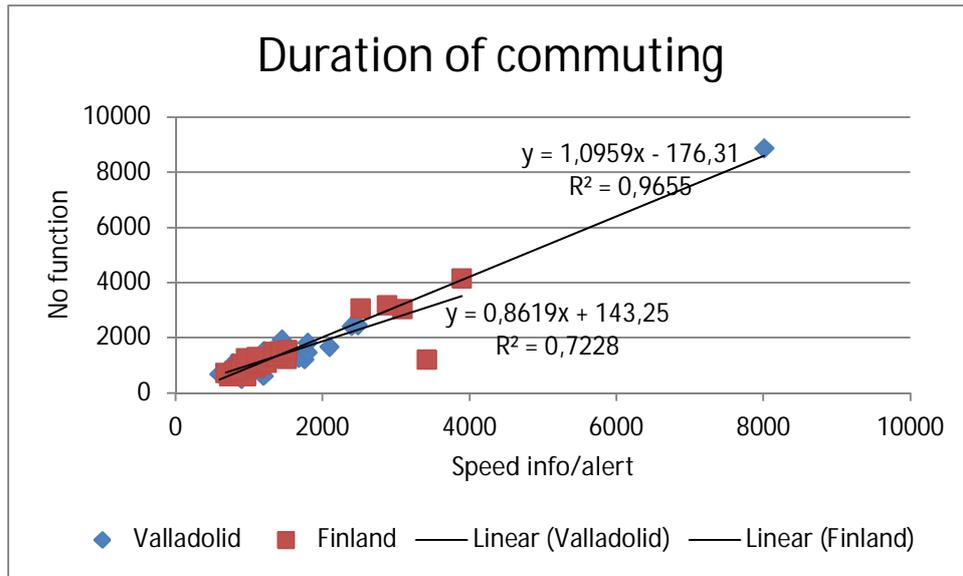


Figure 5. Average duration of commuting journeys made during one travel diary data collection period per person for commuting journeys when speed information/alert was in use and when no function was in use

However, it must be noted that in Valladolid data the single long journey has dominated the linear reference curve.

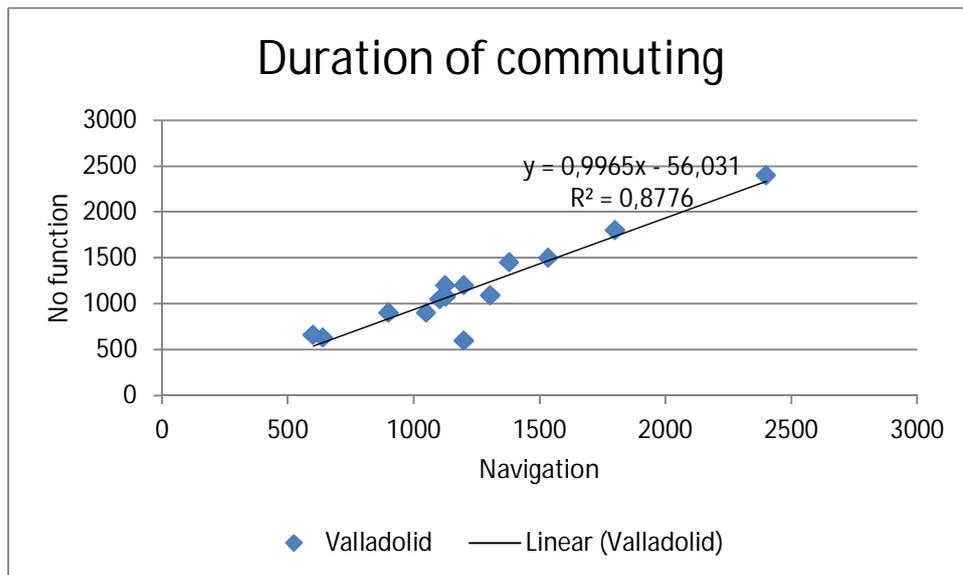


Figure 6. Average duration of commuting journeys made during one travel diary data collection period per person for commuting journeys when speed navigation was in use and when no function was in use

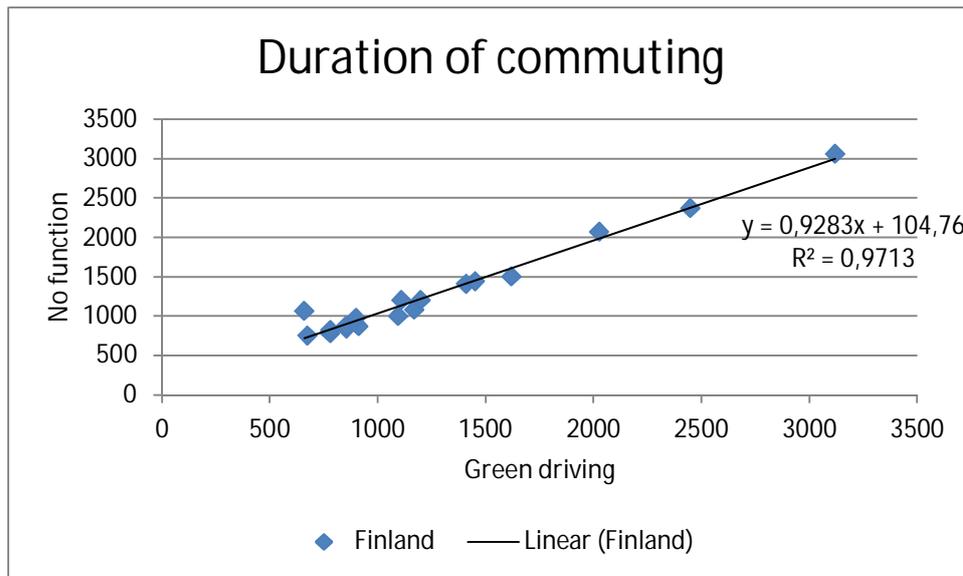


Figure 7. Average duration of commuting journeys made during one travel diary data collection period per person for commuting journeys when green driving application was in use and when no function was in use

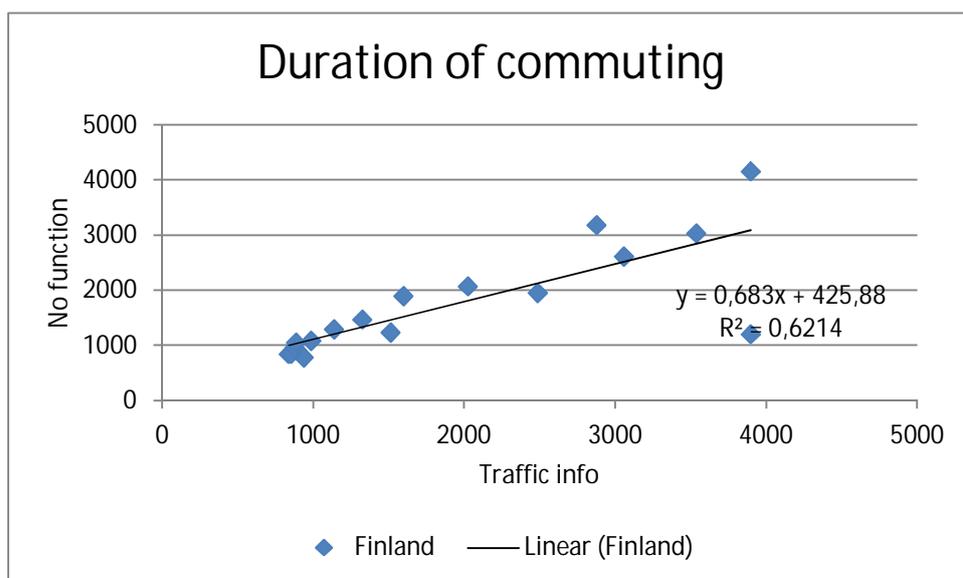


Figure 8. Average duration of commuting journeys made during one travel diary data collection period per person for commuting journeys when traffic information was in use and when no function was in use

4.1.3. Initial conclusions and further steps

Efficiency research question EF-RQ1 "Is the travel time from origin to destination affected" and hypothesis EF-H1.1 "Travel times are likely to increase/decrease (when device is used compared to when device is not used)" were answered for

the preliminary results by analysing travel diary data from LFOTs of Finland and Valladolid/Spain.

The results showed no impact in duration of journeys due to using green driving application, navigation, speed information and alert or traffic information. However, the only uniquely identified origin destination pair in travel diary data is commuting journeys. For many people commuting journeys are made during peak hour and route has been optimised even before the trial. Consequently, no great impacts of device use were expected.

Final analysis will include also logger data. From logger data all origins and destinations used several times can be identified. Consequently, the potential impact in duration of journeys can be studied for more origin destination pairs than just for those made between the home and the place of work. However, as (at least most) test sites did not log the use of function, the impact can be studied for the possibility to use a function rather than for the actual use of it. The results obtained by analysing the travel diary data will be complemented by data from Swedish LFOT2, UK LFOT and Italian LFOT.

4.2. EFRQ2: Are there any delays avoided? (Centro Ricerche FIAT, CRF)

This section presents preliminary findings from subjective data about avoidance of delays (H2.1).

This section describes the line of thought and the steps that are and will be taken in order to answer this Efficiency related Research Question. Navigation systems integrated with Traffic Information can provide the best route choice in order to avoid traffic jams and delays. Integration of Traffic information brought via RDS or 2G/3G are more and more diffused and have a potential for really improving the traffic efficiency (e.g. currently TomTom HD Traffic claims a saving of 15% time in congested areas, see http://www.tomtom.com/en_gb/services/live/hd-traffic/).

This section defines the strategy based on two scenarios and identifying the appropriate data collection process.

Objective of analysis

The main objective of this question is to determine whether the Traffic Info (TI) and Navigation (dynamic/ static) Functions of a nomadic device allow drivers to avoid congestions and to save potentially important time while driving on a daily basis.

Strategy for analysis

After a first attempt to make an analysis based on objective data collected from data loggers it was decided to use as indicator a specific question in the “post” questionnaire. The choice was due to the fact that logged data, although supported by travel diary data were not meaningful enough –and decision was not easy to reach-for finding out if delays were avoided. The lack of a real traffic situation provided uncertain results. Measuring travel time duration and comparing it with theoretical data would consequently have meant an overlapping with the previous Research Question (i.e. EFF-RQ1) which focuses on the influence of functions on travel time. Hence, it was decided to base the analysis on subjective data using the same approach adopted for the analysis of EFF-RQ5.

Test definition

A key and common input for FOTs is the collection of subjective data through questionnaires. The Lime Survey tool was used for the collection. Two types of questionnaires were used:

- Background questionnaire, provided to the participant prior testing
- User Uptake questionnaires (one for each function tested in TeleFOT) were submitted before starting using the nomadic device and then verified “during” and “after” the completion of testing period.

In particular, for the evaluation of EFF-RQ2, the question number 7.16 (shown below) from the post – questionnaire (labelled “After”) was selected.

- *Do you find that your delays when travelling has changed due to your access to the navigation support function?*

In this way the direct feeling of the driver has been registered via a pentary (i.e. five point) rating ordinal scale corresponding to the following options:

- Delays have radically decreased
- Delays have slightly decreased

- Delays have not changed
- Delays have slightly increased
- Delays have radically increased

4.2.1. Data

The preliminary analysis was based on the questionnaire data collected during the Spanish LFOT1 where participants used the navigation and support function. The sample included 117 initial participants which completed the “Background driving Information” questionnaire. For the whole testing period, participants in the Spanish LFOT1 travelled approximately total 833000 Km. The distance was measured as the sum of the lengths of all the legs of the FOT. The distance travelled in each leg was calculated from the odometer data by the acquisition system. The post-questionnaires were completed by 95 participants (37% of female and 63% of male participants completed the Background questionnaire). A similar distribution was noted for the post-questionnaire (Female/Male ratio: 33/67 %).

4.2.2. Analysis

Age distribution is depicted in Figure 9. Most drivers were between 28 to 62 years which is representative of the majority of active drivers. Therefore, the active sample included in the Spanish LFOT1 is representative of active drivers’ population.

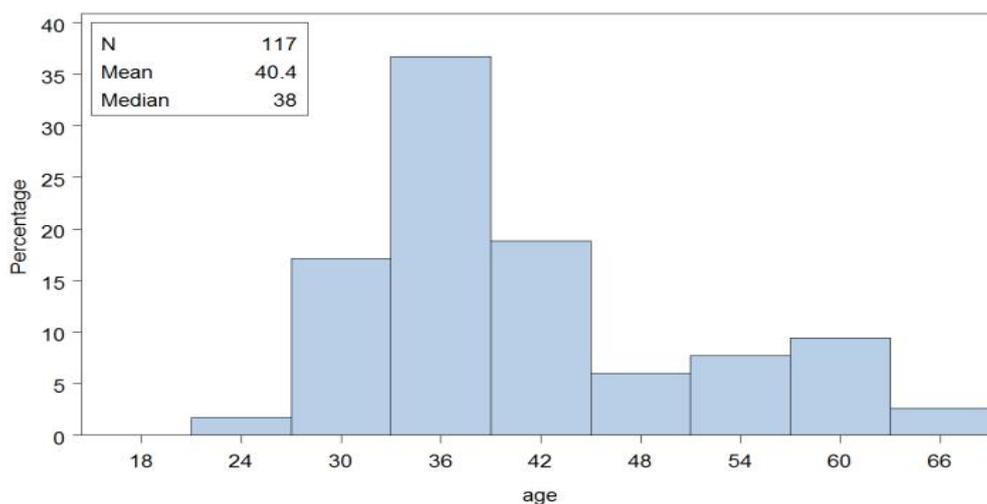


Figure 9. Participants’ age distribution in Spanish LFOT1

In addition, it is expected that most participants were experienced drivers as not many young participants were included in the study.

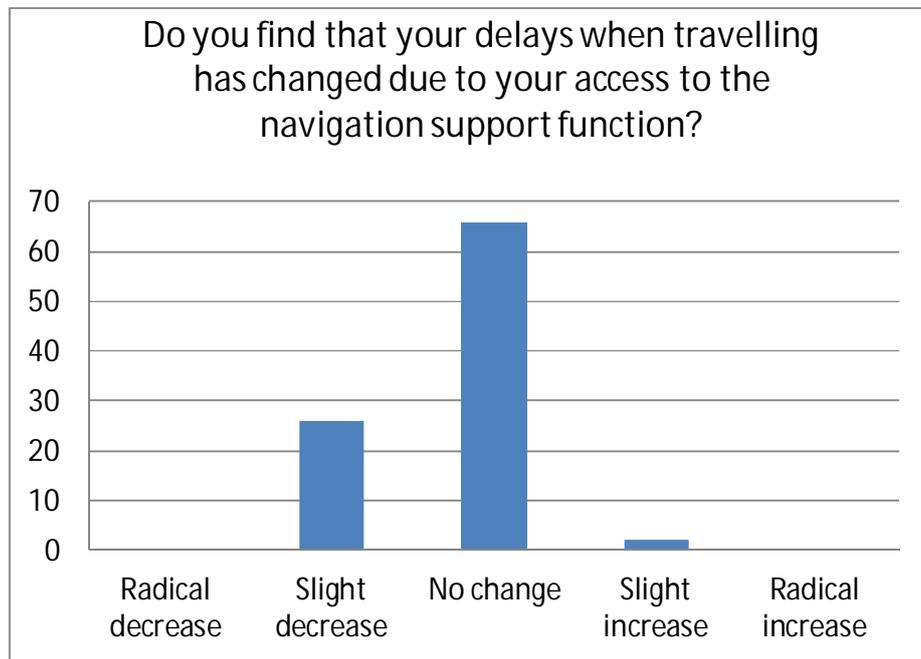


Figure 10. Participants' perceived changes on traffic delays avoidance

Proportion of different rating scale choices (i.e. Radical Decrease, Slight Decrease, No Change, Slight Increase, and Radical Increase) were calculated for the navigation function.

According to Figure 10, the majority of participants reported that the navigation support system did not affect travel delays (66 out of 96 participants, equivalent to 70%). On the contrary, 26 drivers (~ 28%) stated that they perceived a slight decrease in their delays; therefore they got to their chosen destination in less time with no significant delays. Hence, almost one third of participants stated that they had fewer delays because of using the navigation and support function. Only 2 participants (~ 2%) reported slight increase in their delays.

Based on these results, a small but significant reduction in travel delays was found; assessing, of course, that the function can provide benefits in this respect.

In an attempt to correlate participants' age and driving experience, with their feeling of change in delays because of using the navigation and support guidance system, no statistical influence of age was found. In order to investigate if there are other influencing factors, a statistical analysis was performed with the application of Fisher and Chi square tests on:

- Km driver on average per year
- Driving experience

Analysis-to-date is presented in the following graphs (Figure 11) when the potential effects of some of the background variables are taken into account.

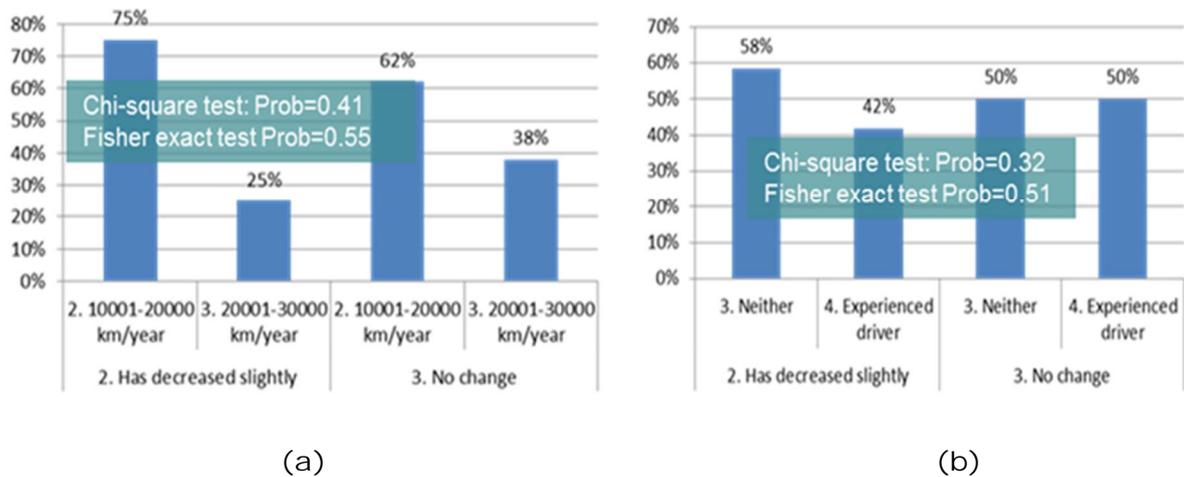


Figure 11. Participants' perceived change in delays as a function of Km driven per year (a) and driving experience (b)

(b)

Figure 11 reports the distribution and the test results. Only "Slight decrease" and "No change" have been considered because "Slight increase" included only two representatives. No statistically significant difference was found ($p > .05$).

A further test (ANOVA analysis) was performed to evaluate if the drivers that declared a slight decrease in the delay have a different distribution of total driving time on different types of roads (city, rural roads, highways, other). The results were of no statistical significance ($p > .05$).

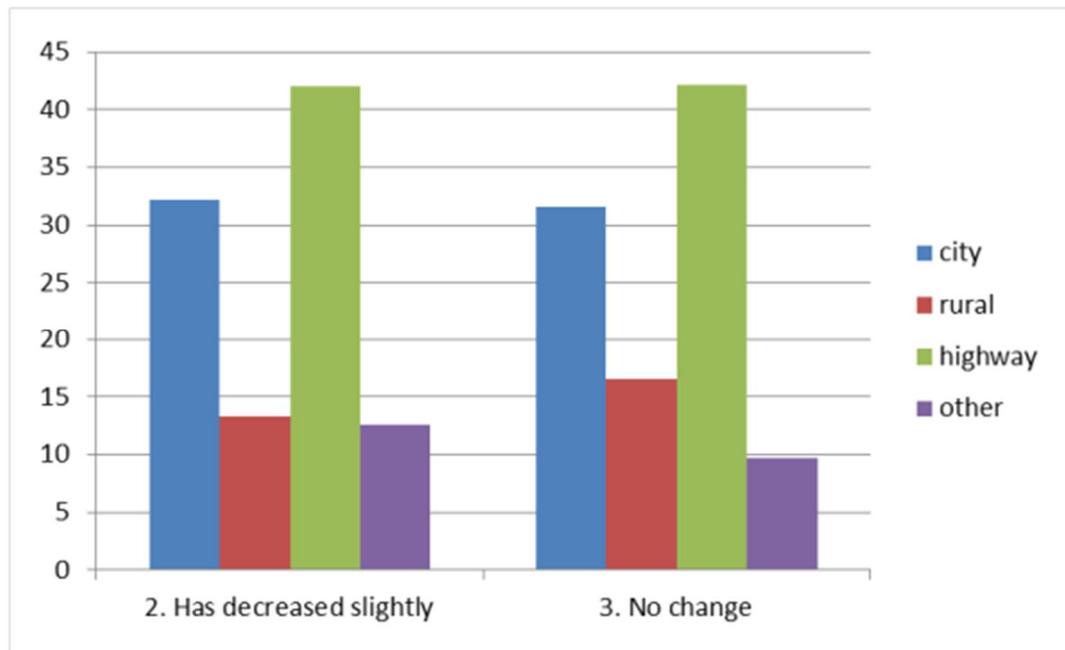


Figure 12. Perceived change in delays as a function of frequency (%) of road types driven

4.2.3. Initial conclusions and further steps

These findings constitute the preliminary analysis for the Spanish LFOT1 and will be repeated for other LFOTs where Navigation and Traffic information functions were used in order to investigate if findings are similar across pilot sites with similar functions.

Further steps would, also, include further stratification for background characteristics in order to reveal other variables that might be important in perceived delays overall. Comparisons among sites will be conducted as an essential part of final analysis.

4.3. EFFRQ3 Are the vehicles speeds in the network reduced/increased? (IKA)

The hypotheses which have to be accepted or rejected in the context of the EFFRQ3 are "H3.1. The vehicle speeds in the network are likely to be reduced or "H3.2. The vehicle speeds in the network are likely to be increased".

The analysis to answer this EFF-RQ is based on traffic flow simulations. The measurement data of the journeys made whilst using the nomadic device must be contrasted to the data of journeys made whilst driving without the nomadic

device as a first step. The driver behaviour must be adapted in the traffic flow simulation according to the measurement data and a second driver model will be implemented using a different set of driver parameters derived from the measurement data of journeys with the nomadic device used. The driver model includes the acceleration behaviour, the safety distance, the compliance to speed limits, etc. This information can only be gained from some of the DFOTs, and specifically from those that collect information from the vehicle CAN bus (such as the Greek, the Spanish and the German DFOTs). The reason for using the data from these DFOTs to answer this EFF-RQ is because vehicle data from the CAN bus with a high resolution is necessary to get sufficient information about the aforementioned driving style parameters. CAN bus measurements are not available in all DFOTs.

For every timestep in the simulation, position in x- and y-direction, yaw angle, driving lane, velocity and acceleration for every vehicle is displayed.

If a change is found in driver behaviour (based on logged data) because of using the functions, then a network of vehicles can be build up in the traffic flow simulation and different penetration rates of drivers with an influenced behaviour are applied. After the simulations with different penetration rates the velocities of the vehicles in the network will be compared and the hypotheses can be answered.

4.3.1. Data

The first DFOT data analysed in order to derive data for the simulation were from the German DFOT. There are three configurations and four routes which have to be driven in the German DFOT:

- Configuration A: only nomadic device with SI/SA,
- Configuration B: only ACC, LKA and FCW³,
- Configuration C: combination of A and B

Since test participants get the current speed limit always displayed (on the nomadic device), they might be encouraged to drive within a certain ranges of speed close to the speed limit and avoid speeding. Therefore, a speeding ratio is

³ ACC: Adaptive Cruise Control
LKA: Lane Keep Assist
FCW: Forward Collision Warning

calculated which describes the ratio between driven speed and current speed limit.

The speeding ratio (e.g. for a speed limit of 100 km/h) is calculated by the following equation:

$$\text{speeding ratio} = \frac{v \text{ (speedlimit=100 \& freeFlow \& } v > 95 \frac{\text{km}}{\text{h}})}{\text{Speedlimit}(\text{speedlimit=100 \& freeFlow \& } v > 95 \frac{\text{km}}{\text{h}})}$$

The following criteria were applied:

- Firstly, only those sections in which the driver has no preceding vehicle (free flow) during a journey are taken into account.⁴
- Secondly, the speed limit at the current position is 100 km/h (resulting from map matching)
- Finally, the velocity should be above 95 km/h. For the calculation of speeding ratios the driver needs not to be influenced by the behaviour of preceding vehicles and speeding behaviour relies heavily on his/her decision and overall attitude towards speeding and speed limit compliance.

Logged data (i.e. vehicle parameters' related data) from seven drivers have been analysed so far. Each driver made twelve trips which are approximately 1260 km per driver and 8820 km in total. As mentioned before, only specific sections are taken into account to define the speeding ratio. Only 220 km of 8750 km belong to this section, i. e. only 2.5 % of the whole distance can contribute to evaluate the speeding ratio for a speed limit of 100 km/h.

4.3.2. Analysis

The analysis shows no consistent trend of speeding behaviour dependent on the usage of the systems. There are test participants that speed less when not using the SI/SA function (configuration B compared to configuration A) as well as test participants who speed more. The same can be noticed when comparing A and C.

According to measurement data analysis, the SI/SA functionality seems not to have an influence on speed limit compliance in the German DFOT. There are

⁴ For the calculation of speeding ratios the driver needs not to be influenced by the behaviour of preceding vehicles and speeding behaviour relies heavily on his/her decision and overall attitude towards speeding and speed limit compliance.

drivers who speed less when driving without the system (configuration B cp. to A) and even more when driving with the combination of both functions (configuration C cp. to A). Although they have SI/SA support available at both conditions, they behave diversely regarding speed limit compliance (cp. Figure 13). However, the differences between the configurations are quite small (A→B: $-0.0297 \triangleq -2.48 \%$, A→C: $0.0649 \triangleq 5.4 \%$).

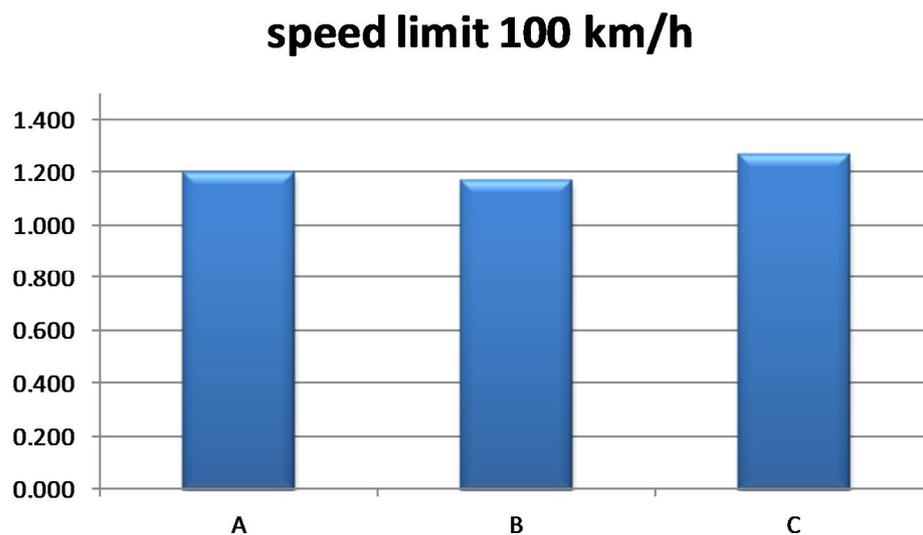


Figure 13. Speeding behaviour with three different configurations at 100 km/h speed limit

4.3.3. Initial conclusions and further steps

To underline the findings of the German DFOT, other DFOTs have to be analysed regarding speed limit compliance and other driver related parameters which can be adapted in the traffic flow simulation. The necessary data of other relevant DFOTs might help to either prove the findings of the German DFOT or show a changed behaviour of drivers regarding speed limit compliance. Other DFOT data to be analysed are from the Spanish and Greek DFOTs.

The results so far show that a significant effect cannot be determined in the speeding behaviour of the test participants. Therewith a traffic flow simulation cannot be set up and the hypotheses cannot be answered with the recorded data by means of a simulation.

Other analysis routes are investigated in order to facilitate the analysis for this Efficiency Research Question. Two steps are possible to be followed. First, to

investigate the presence of speeding effect in data derived by other DFOTs, as mentioned above, and in case these data are not accommodating to use LFOT data. The latter is still under exploration as it was not initially planned to use LFOT data for this type of analysis due to inherent restrictions. Inherent restrictions are differences in frequency, quality, depth and availability of vehicle parameters. If certain restrictions could be accepted, then an analysis could be performed just for LFOTs and then in combination with data from DFOTs in case overall data could highlight differences not present in isolated LFOTs and/or DFOTs.

4.4. EFF-RQ4: Is the time headway between the vehicles increased/decreased?(CERTH/HIT)

Time to headway (THWY) is (h_t) = difference between the time when the front of a vehicle arrives at a point on the highway and the time the front of the next vehicle arrives at the same point (in seconds).

Average Time Headway ($\overline{h_t}$) = Average Travel Time per Unit Distance * Average Space Headway

$$\overline{h_t} = \overline{t} * \overline{h_s}$$

It is widely known that drivers are advised to follow the “two-second” rule behind the vehicle in the traffic. The two seconds are supposed to be adequate in case of abrupt breaking in order to avoid rear-end collisions. Highest risk for rear-end accidents exists on main arteries and motorways. Dangerous tailgating, i.e. loose following of the leading vehicle (i.e.vehicle in front), is very common in Greece and especially in large urban areas such as Athens and Thessaloniki. Athens is the base for LFOTs and Thessaloniki for the DFOTs.

The “two second” rule may be affected by various factors ranging from physical condition to alertness and fatigue. Therefore, it is hypothesised that if the application of the nomadic devices is assistive, usable, with high learnability then headway will significantly decrease (always within safe limits or will not significantly change). Therefore, the involved workload and distraction will not be distracting in excess, if THWY measures are within safe intervals. The latter is a whole debate by itself about what is excessive and how personalised the

definition of excessive workload is. More specifically, a topic of significant debate in the literature is what levels of task demands (especially visual, cognitive, and psychomotor) are excessive.

Voger and colleagues (2003) compared and discussed the use of the two safety indicators "headway" and "time to collision (TTC)" with respect to their usefulness in determining the safety of different traffic situations, like different locations in a junction. Over a 6-day-period traffic flow measures were taken in a four-way junction with stop signs on the minor road. It was found that for vehicles in a car following situation headway and TTC are independent of each other. The percentage of small headways is relatively constant across different locations in the junction, while the percentage of small TTC values varies between different locations. It is recommended to use headway for enforcement purposes, because small headways generate potentially dangerous situations. TTC, on the other hand, should be used when a certain traffic environment is to be evaluated in terms of safety, because it indicates the actual occurrences of dangerous situations (Voger, 2003). Thus, it was decided to use the headway as a more appropriate measure within TeleFOT project.

If headway measures are not increased or kept at safe levels, then driving is more efficient for both the driver and the traffic network. The analysis presented in this Deliverable follows the rationale of the final analysis to the point, of course, is feasible at this stage and is based on the evaluation plan discussed in "*Efficiency Data Analysis Plan*" (D4.5.1). The preliminary analysis was also necessary in order to identify any pitfalls and reveal if other analysis would be needed. The significance of focusing on preliminary analysis aims to uncover not only hypothesis directions (i.e. accept or reject them) and data analysis issues but also any other statistical analysis, variables' interactions, and correlations not initially included in the data analysis methodology and design.

4.4.1. Data

For answering EEFRO 4 data from the Greek DFOTs (CERTH/HIT: DFOT1-3) and the UK DFOT2 (MIRA) are included. The same 4 DFOTs will provide data for the final analysis.

The UKDFOT2 utilised the Foot-LITE system which is a 'Smart' driving system and incorporated Green Driving Support (GDS) with safety features of Lane Departure Warning (LDW) and Forward Collision Warning (FCW). Foot-LITE provides the

driver with feedback and information on Smart driving behaviours in the vehicle, in real time via an integrated visual interface presented on a Smartphone. The Smart driving advice offered is based on numerous internal parameters, with data being collected via an adapted lane departure warning camera and OBDII ports, as well as accelerometer and GPS. A within subjects design was used, with all 40 participants completing an experimental condition (Foot-LITE) and a control. Participants selected were MIRA staff and were not paid for their participation; however time could be 'booked' to the project.

In the Greek DFOTs (1-3), a highly instrumented vehicle was used (Lancia Thesis Emblema) with both Lane Departure and Collision Avoidance (LDW and CAS) advanced driver assistance systems (ADAS). Participants received auditory warning when they departed the lane (rumble strips sound) and both auditory (sharp beep) and haptic (vibrating safety belt) warnings when the distance kept from leading vehicle was becoming increasingly dangerous. An aftermarket nomadic device (Samsung Omnia II) was used with the TeleFOT application installed. In addition, vehicle data were available in CANbus. Three DFOTs (Navigation Support, Navigation Support and Speed Information, and Navigation Support with Speed Alert) and two baseline conditions (with and without ADAS) were conducted. Detailed accounts of Greek DFOTs can be found in "*Detailed FOT Execution*" (Deliverable 3.6.1).

4.4.2. Analysis

Basic overall descriptives for the participants are presented below. 48 participants (40.65±11.031⁵ years old) were recruited in both country sites.

Table 7. Basic demographics

Gender	Age (mean±SD)	Driving years
Male (N=35)	41.2±11.427	21.17±1.93
Female (N=13)	39.15±10.164	17.46±12.333

The following graph (Figure 14) shows mileage per year driven by all participants stratified in four categories according to the TeleFOT Background Questionnaire

⁵ Mean±Standard Deviation

draft found in deliverable "Testing and Evaluation Strategy" (D.2.2.1). The translated versions are annexed in Deliverable "Test tools" (D3.2.2b). More than 70% (73%) travel between 10000 and 30000 km per year and merely 6% of participants drive above 50000 km per year. In addition, the vast majority of participants (90%) stated that they are experienced or very experienced drivers (figure 16). Most drivers (73%) reported to have a balanced driving style which is neither aggressive nor defensive.

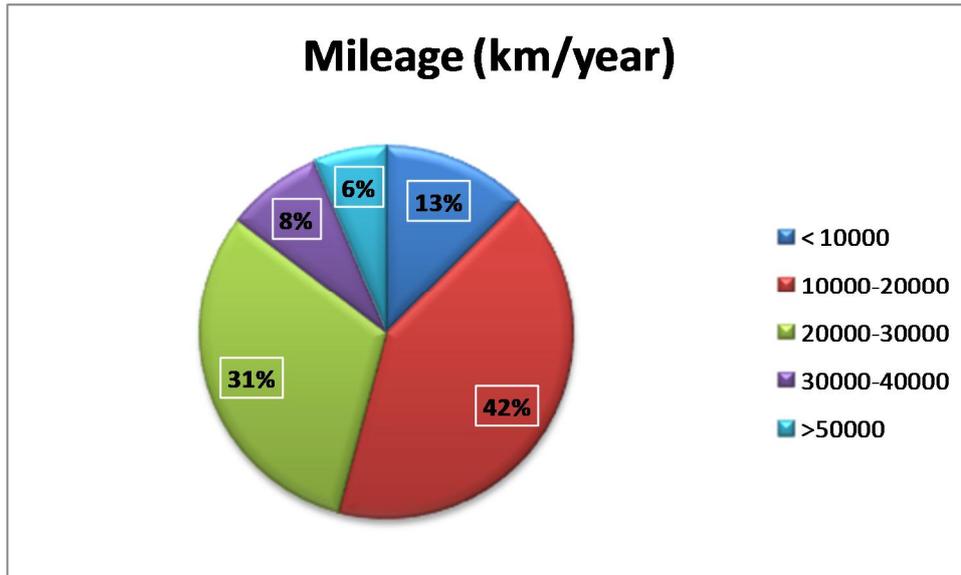


Figure 14. Percentages (%) of km driven per year

No statistical difference was found (χ^2 test; $p > .05$) between male and female participants for perceived driving experience and style and overall percentages (%) are presented below. Perceived driving style and experience are the subjective assessments of drivers themselves.

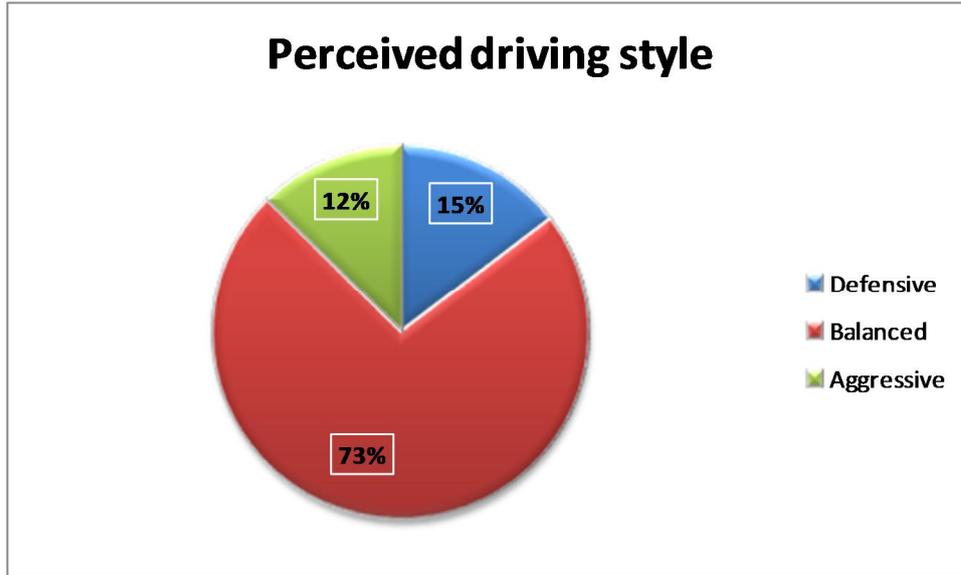


Figure 15. Perceived driving style (%)

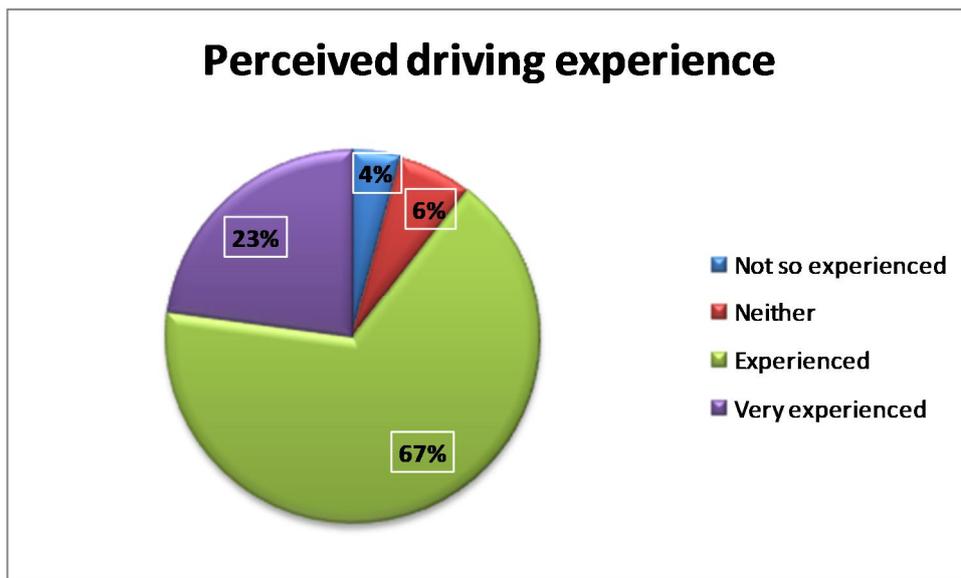


Figure 16. Perceived driving experience (%)

The analysis presented is based on UK DFOT (all mean aggregated data) and 30% of data analysis from the three Greek DFOTs. Therefore, statistical analysis presented mostly depicts the statistical analysis to be carried out for the final data sets and to explore the relations between variables (mean±SD,min, % of time spent with THWY<1.5 seconds). Almost, 70% more of data analysis will be presented in Deliverable 4.5.3 and results from Baseline 1 will be added (Greek DFOT pilots). Baseline 1 is driving with no ADAS support (though recorded in

CANbus) and without the aftermarket device with the TeleFOT application. Similarly, participants in Baseline 2 drove with no nomadic device support but they received ADAS warnings.

At this stage, there are two major levels of analysis:

- The first level of analysis reflects the effect of the nomadic device per system tested (across the baselines and the four DFOTs conducted). It will be interesting to analyse per DFOT THDWY variations (including min/max) and then overall. The latter holds true when taking into consideration the assumption that their effect might be additive and cumulative in nature. However, in reality the situation about how these functions interact is far more complex.

The following table (Table 7) presents the THWY mean, SD, min values (sec), % of time spent with THWY < 1.5 sec per function tested for both DFOT sites.

According to the following table, the lowest THWY values were observed in the control condition for the UK DFOT2 and in the Greek DFOT3 where participants received all the combinations of warnings and functions. Hence, it seems that no warnings, information and driving assistance had the same effect with all possible combinations of assistance. It is important to note, though, that measures from the UKDFOT2 result from all sample and for the Greek sample it is only a few participants that data have been analysed to date. However, mean THWY values show that participants in all DFOTs kept the “two seconds” rule and their overall driving performance was efficient for themselves and, subsequently, for the traffic network. Furthermore, if we take into consideration that lower mean THWY values could be translated to increased Efficiency for the traffic network, then all combinations of functions (i.e. navigation and support with speed information and speed alert) would be the most efficient solution for the driver.

Great discrepancies are evident in time spent with potentially dangerous time headway values between DFOTs (i.e. less than 1.5 seconds). This is probably because of different geographical regions (road segments) in the two different countries. In addition, UK DFOTs analysis is based on certain only road segments and for the Greek DFOTs is based on all routes. In addition, there is a possibility these differences (size of difference: 8-9%) to reflect differences in personality driving profiles and temperamental attributes more than the functions and ADAS

themselves. The latter could be investigated –up to a point- by the final analysis and comparison of more question items from the background questionnaires.

Time spent with very low THWY values in the Greek DFOTs is fourfold greater than the time participants spent driving with potentially dangerous headway values in the UKDFOT2. It is assumed these discrepancies to be the result of differences in design and the aforementioned probable explanations.

Table 8. Mean, SD, min, % of time spent with THWY<5 seconds per function

Function	Mean±SD	Min	% time spent with THWY<1.5 sec
Green Driving Support+ADAS (UK DFOT2)	2.33±0.15	0.74	2.32%
Navigation Support +ADAS (Greek DFOT 1)	2.97±0.50	0.52	11.5%
Navigation Support+Speed Information + ADAS (Greek DFOT 2)	2.37±0.65	0.37	10.5%
Navigation Support+Speed Alert + ADAS (Greek DFOT 3)	2.24±0.56	0.47	11.4%
Baseline ADAS (Greek Baseline 2)	2.52±0.65	0.81	13.7%
Control (UKDFOT2)	2.05±0.14	0.66	6.61%

Additionally, to the table above, the graph below presents both the mean values and the respective variations. The variations (i.e. standard deviations) are greater in the Greek DFOTs as sample size is both smaller and all data are not yet included.

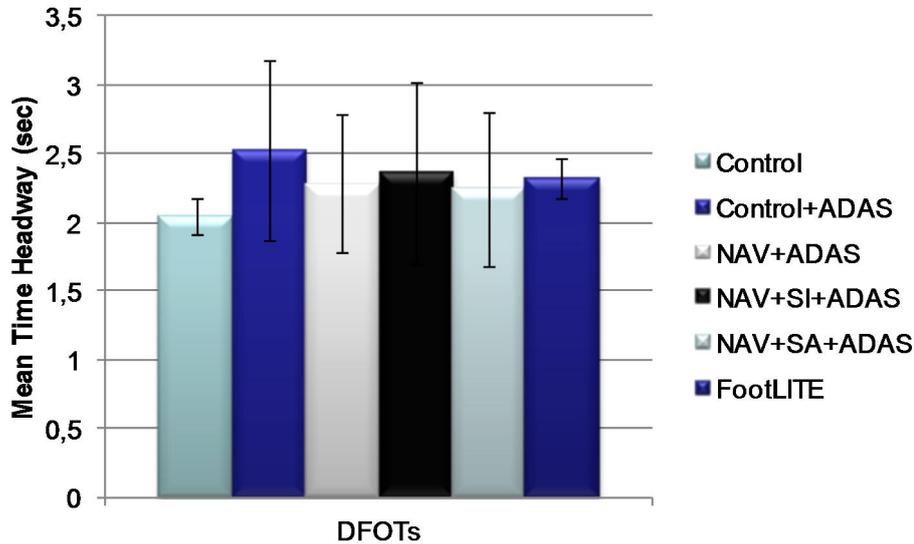


Figure 17. Mean THWY values per tested function

The following graph (Figure 18) depicts the overall headway behaviour for the whole duration of the journey. Lowest HWY is observed in the control group (2.05 ± 0.14). Highest mean HWY is observed in the Control with ADAS group (2.52 ± 0.65). All other functions (Speed information, alert, and green driving information) appear to have similar effect to mean HWY values (i.e. slight increase of SI (DFOT2)).

The data presented below are from the Greek FOTs as raw data from the UKDFOT will be analysed as a next step when all relevant data will be consolidated. It is evident that distribution of the three categories of headway values is not of great difference among the Greek DFOTs.

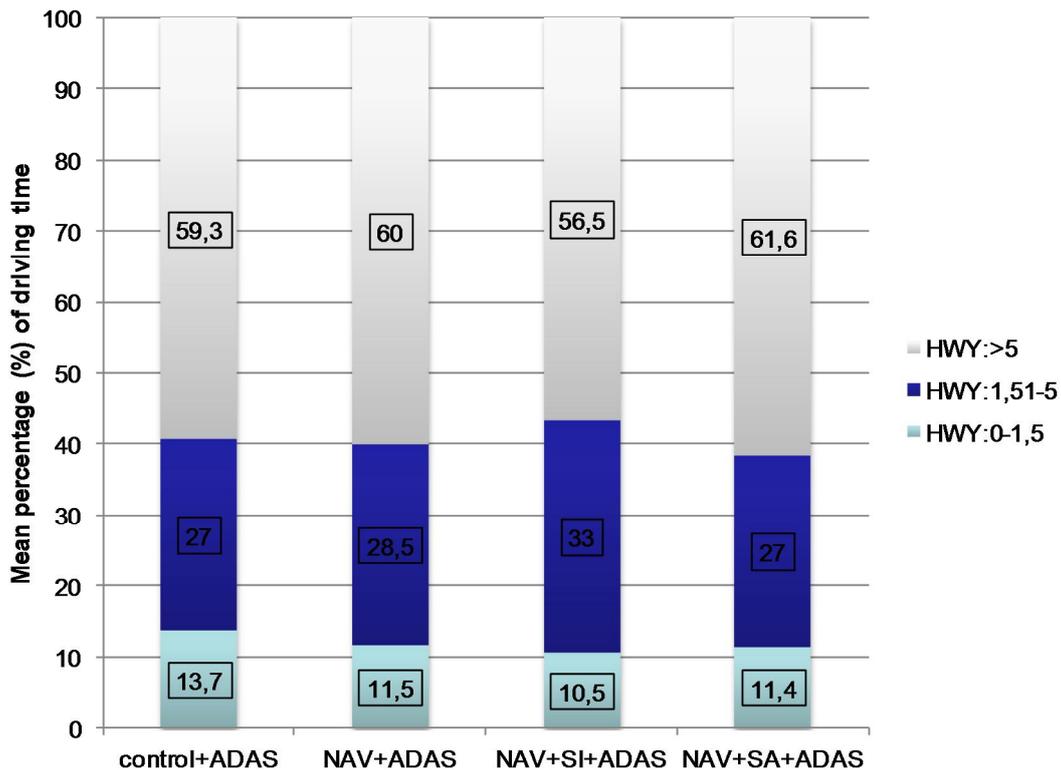


Figure 18. Mean percentage (%) of driving time spent with headway values: a) >5 seconds, b) between 1.5 and 5 seconds, and c) <1.5 seconds

More driving time ($\approx 14\%$) was spent with low HWY values for the control group with ADAS. Less time ($\approx 11\%$) was spent with low HWY values for the Navigation and Speed Information group. For the Navigation support and Navigation support and Speed Alert DFOTs similarly lower headway values were recorded. Overall, it seems that the “safety keeping” pattern of drivers does not change and probably the impact to Efficiency will be similar to just having Navigation support. These results are also important for defining the safety type of behaviour with regards to assistive devices while driving and its relation to Efficiency.

By applying individual analysis the effect in headway will be determined per service tested (i.e. different for baseline, navigator, speed alert, speed information) followed by an overall effect which will show the effect of the whole device. Hence, this could, also, be translated into how cumbersome/assistive the functions were.

Overall, participants with just ADAS show higher minimum HWY than participants with Navigation support, Speed Alert, and ADAS. If lower headways are perceived as increase in Efficiency for traffic network, then the addition of the aftermarket

devices with tested functions increases Efficiency. But as these values are low for safety keeping, then their effect on the driver are negative and then indirectly -as mentioned in the introduction section about analysis perspective- not efficient for the driver and the network (if accidents have higher probability to happen). The combination might be cumbersome or participants are risk compensating because of the presence of so many assistive technologies.

Less than 40% of data are included and, hence, no inferences are possible yet. Statistical tests were not carried out as not all data are included. For different countries data comparisons, Kruskal-Wallis -nonparametric equivalent to ANOVA- will be applied as between participants' design applies. Multiple comparisons can be performed by using pairwise comparisons (for example, using Wilcoxon sum rank tests) and using a correction to determine if the post-hoc tests are significant (for example a Bonferroni correction). For within participants' comparisons (same country) Friedman comparisons will be performed. These follow-up tests most frequently involve comparisons between pairs of group medians. For the Friedman test, we could use the Wilcoxon test to examine unique pairs (e.g. Bonferroni adjustment)

- The second level of analysis focuses on the interaction between the application of the nomadic device (including its functions) and both lane Departure Warning and Collision Avoidance Warning Systems. As both systems will be used simultaneously, it is not possible to isolate the interaction and/or effect of its system. Both systems are "a system" for this analysis. Their interaction with the nomadic devices as a whole and the separate services will be investigated. Baseline assessments for both nomadic devices and ADAS will provide the weights for analysing the data of Greek DFOTs 1, 2, and 3.

A straightforward approach is to calculate simple effect sizes (i.e. mean differences) and check if there is equivalence or not among THWY values (falling within 95% Confidence Intervals values). Failing to find equivalence will not necessarily mean that there are definitely differences and these differences lead to a more efficient driving style.

The following graphs show the mean difference between the baseline 2 group and DFOT1 compared to baseline 2 mean difference and navigation support with speed information (DFOT2). In the same pattern, the possible comparisons (14 comparisons) were made. In this attempt, no confidence intervals will be

calculated as not all data have been analysed but respective graphs are presented. The mathematical symbol \bar{x} is used to depict mean and the difference is expressed with the Greek letter Δ (delta) in the following graphs and within text.

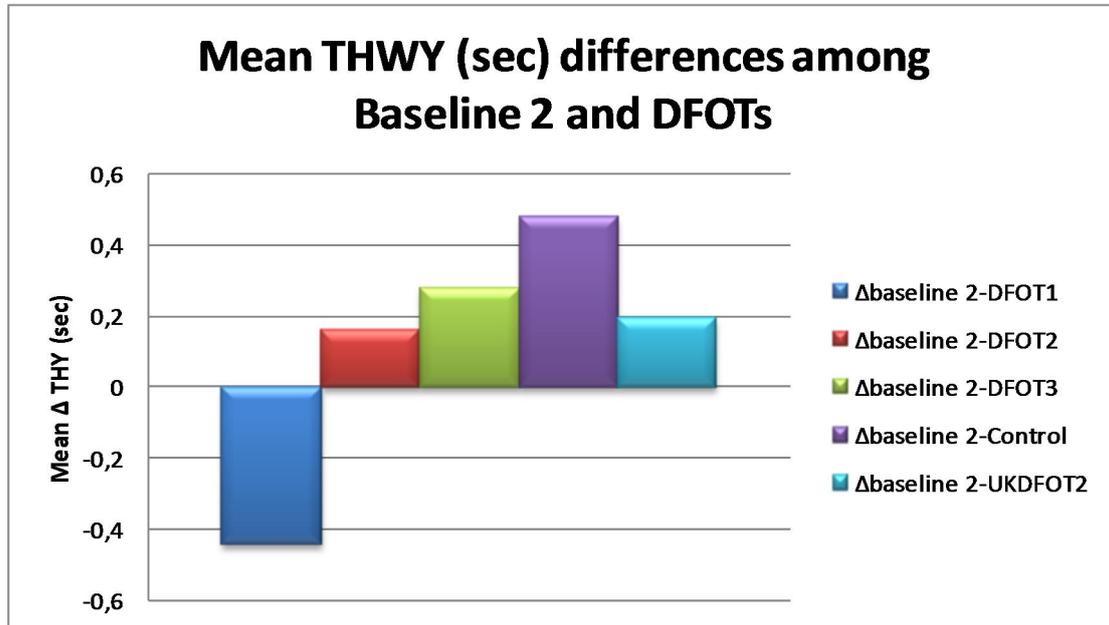


Figure 19. Mean Δ THWY values (sec) between Baseline 2 and DFOTs

The greatest differences were found between Baseline 2 and DFOT1 ($\Delta\bar{x} = -0.44$ sec). Therefore, participants when using the Navigation support and ADAS increased their headway by 0.44 seconds compared to receiving only ADAS warnings. This finding shows that navigation supported participants in order to drive more efficiently on an individual level. In other words, following instructions about route selection could potentially improve their headway keeping. This would be discussed also in the section where preliminary results for distance keeping (m) are presented and would be interesting to see if they support this finding, as well.

Similarly, participants with no ADAS feedback showed decreased ($\Delta\bar{x} = -0.48$ sec) mean headway value compared to participants with ADAS feedback. Hence, ADAS showed to enhance safety keeping behaviour. Further analysis will provide sufficient strength in order to be able to either accept or reject the hypothesis. In addition, the analysis of complete datasets would allow for confidence intervals calculations for these mean differences and determination of effect sizes. Smaller

differences were found for the remaining Δ comparisons, meaning that their effect for Efficiency was possibly comparable among these pairs.

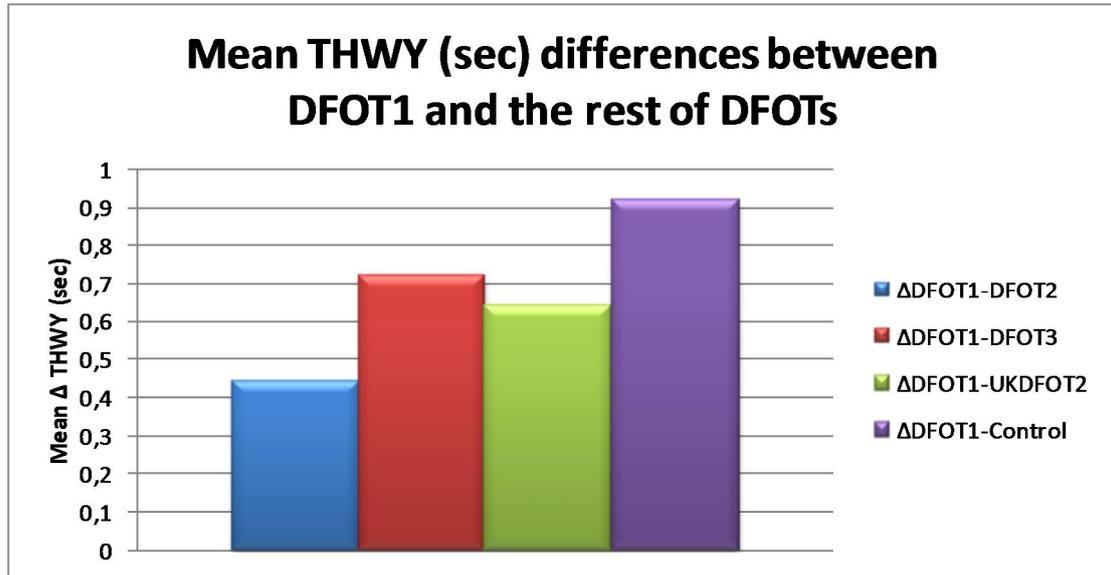


Figure 20. Mean Δ THWY values (sec) between DFOT1 and the rest of DFOTs and the control group

THWY values were decreased in both Baseline 2 (Figure 20) and in control compared to DFOT1 ($\Delta\bar{x} = -0.92$ sec) (Figure 21). Greater values were recorded in DFOT1 compared to the other DFOTs (i.e. $\Delta\bar{x}_{DFOT1-2} = 0.44$; $\Delta\bar{x}_{DFOT1-3} = 0.72$; $\Delta\bar{x}_{DFOT1-UKDFOT2} = 0.64$).

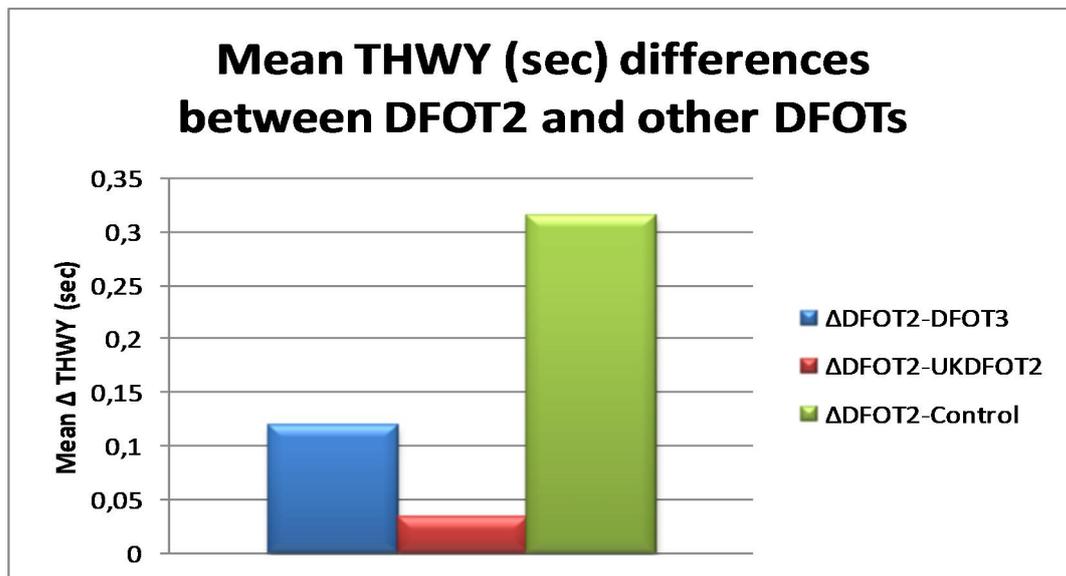


Figure 21. Mean Δ THWY values (sec) between DFOT2 and the rest of DFOTs and the control group

In the same way, increased headway was found for DFOT2 compared to the control group ($\Delta \bar{x} = -0.32$ sec). Therefore, the addition of speed information in the functions tested with the aftermarket nomadic device was assistive for the driver but it is not evident if it was more efficient for the driver. It remains, though, to be compared to the control group (i.e. Baseline 1) from the same pilot site.

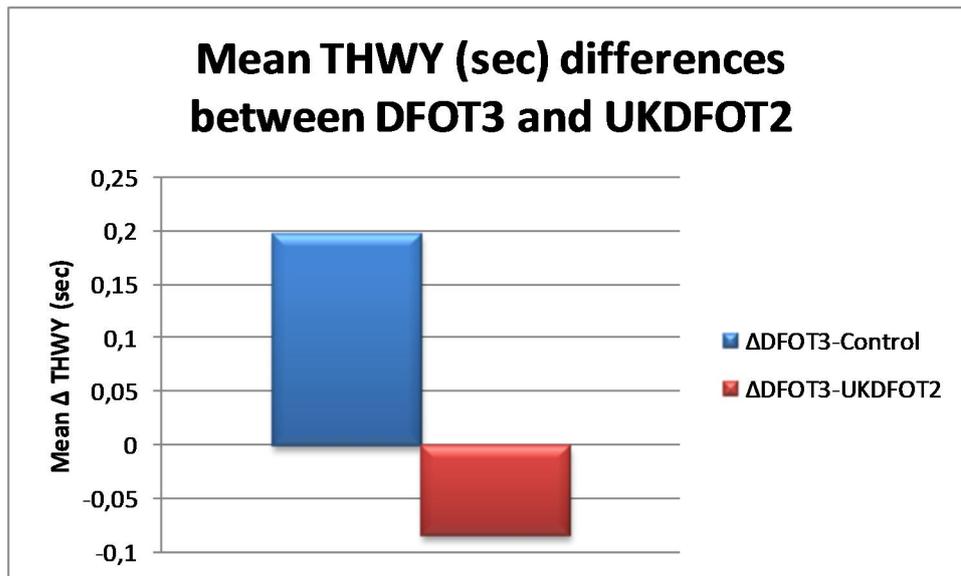


Figure 22. Mean Δ THWY values (sec) between DFOT3, UKDFOT2 and the control group

4.4.3. Initial conclusions and further steps

Qualitative data from the questionnaires (both User Uptake and within DFOTs separate usability questionnaires used) and a focus group will enhance and provide further topics of discussion and recommendations for improvement.

The focus group is an addition to existing questionnaires as it has proved to be valuable support to device development, in general. It will provide topics of discussion not covered by the questionnaire. As the testing period is short compared to the LFOTs, the duration is plausible to extract considerable suggestions, recommendations and account of experience (i.e. participants can easily retrieve information but are not able to base it on their every day impressions).

Finally, data from the German DFOT, raw data analysis of UK DFOT2 and remaining analysis for the Greek DFOTs (1-3) with both baselines (1-2) will be included in the final analysis. In addition, these data will be correlated and potentially stratified with factors arising from User Uptake questionnaires, focus groups, and other locally used usability questionnaires.

4.5. EFF-RQ5 Are there any traffic jams avoided?(ICCS)

The following Hypothesis has been addressed in this analysis:

EFF-H5.1 It is likely that traffic jams are avoided.

Traffic congestion significantly affects both the quality of life and the national economies and is considerably onerous as people cannot plan it. It affects choice of habitation, time it takes to get to work and it leads to wasted fuel (Cambridge Systematics, 2002). The problem has been tackled by traffic operational improvements the last decades from the infrastructure viewpoint. At this analysis, the interest is shifted towards exploring the potential effect of already used devices for either alleviating or burdening the driver. As routes followed in different countries (i.e. different networks) it would be more valuable for analysis and comparisons reasons to focus on what participants believe is the effect of a system.

As data are based on questionnaires derived by LFOTs, participants have used the device for a long period of time for their own daily driving needs and, therefore, perceived effect is based on repeated occasions and not just several and/or isolated occasions.

The analysis of the hypothesis EFF-H5.1 "It is likely that traffic jams are avoided (when device is used compared to when device is not used)" was made based on the collected User Uptake post (static) traffic information questionnaires filled in by the relevant LFOT participants (for which the traffic information support function was provided to them).

Participants were asked whether they thought their 'getting stuck in traffic jams' during driving changed due to their access to the navigation support system. The participants were asked to rank likely changes in perception of getting stuck in traffic jams on a 5-point scale where '1' represents radical decrease in perceived getting stuck in traffic jams (equivalent to traffic jams avoidance was perceived

as increased due to access to the specific function) and '5' represents radical increase (equivalent to traffic jams avoidance was perceived as decreased due to access to the specific function).

The research question is applicable to the dynamic navigation support and the traffic information functions. Moreover, for all test-sites, participants were only included in the analysis if they completed the after questionnaires within the LFOTs. This led to the exclusion of a number of participants.

It was expected that the introduction of the devices would increase participants' perception of traffic jams avoidance as the devices would provide the participants the relevant information.

4.5.1. Data

For this hypothesis, the traffic information functions provided by the system in the Finish LFOT, Swedish LFOT2 and LFOT4 and the Greek LFOT3 can be treated independently. Navigation support, Green Driving support and Speed info/alert are expected to have no effect and hence any effect observed could potentially be attributed to Traffic Info only.

Analysis of changes in the perception of traffic jams avoidance following use of a Traffic Information system could be analysed at three test-sites (Finland, Greece and Sweden). These are as shown in the following figures (Figures 23-26).

Participants were asked after the completion of the LFOT whether they thought their 'getting stuck in traffic jams' during driving changed due to their access to the traffic information system. As mentioned above, participants were asked to rank the likely changes in perception of getting stuck in traffic jams on a 5-point scale where '1' represents radical decrease in perceived getting stuck in traffic jams (equivalent to traffic jams avoidance was perceived as increased due to access to the specific function) and '5' represents radical increase (equivalent to traffic jams avoidance was perceived as decreased due to access to the specific function). Data were available from relevant LFOTs performed at Finland, Sweden, and Greece.

4.5.2. Analysis

First analyses' results are presented in the following graphs (Figures 23-26).

Swedish LFOT2

The vast majority of participants in Swedish LFOT2 reported that they thought that the traffic info service made no changes to their getting stuck in traffic jams (44 out of 68 participants, equivalent to 64.71%) or that it slightly decreased their perceived getting stuck in traffic jams (23 out of 77 participants equivalent to 33.82%), while one participant reported that the access to the function resulted to a radical decrease of getting stuck to traffic jams (1.47%).

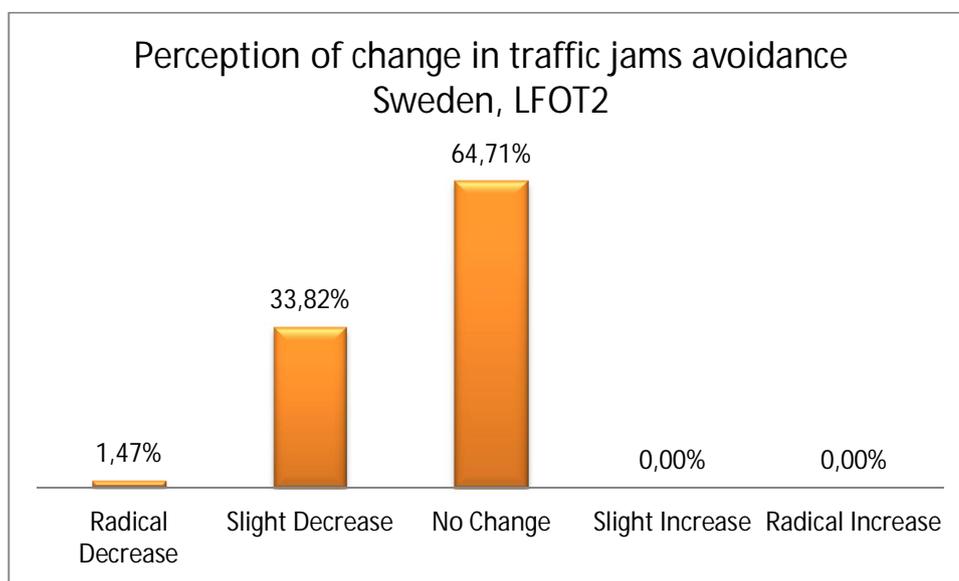


Figure 23. Perception of change in traffic jams avoidance (Sweden; LFOT1)

Swedish LFOT4

The majority of participants in Swedish LFOT4 reported that the use of traffic information service made no changes to their getting stuck in traffic jams (24 out of 43 participants, equivalent to 55.8%) or that it slightly decreased their perceived getting stuck in traffic jams (16 out of 43 participants equivalent to 27.12%), while one participant reported that the access to the function resulted to a radical decrease of getting stuck to traffic jams (1.69%) and two participants reported that the access to the function resulted to a slight increase on getting stuck to traffic jams (3.39%).

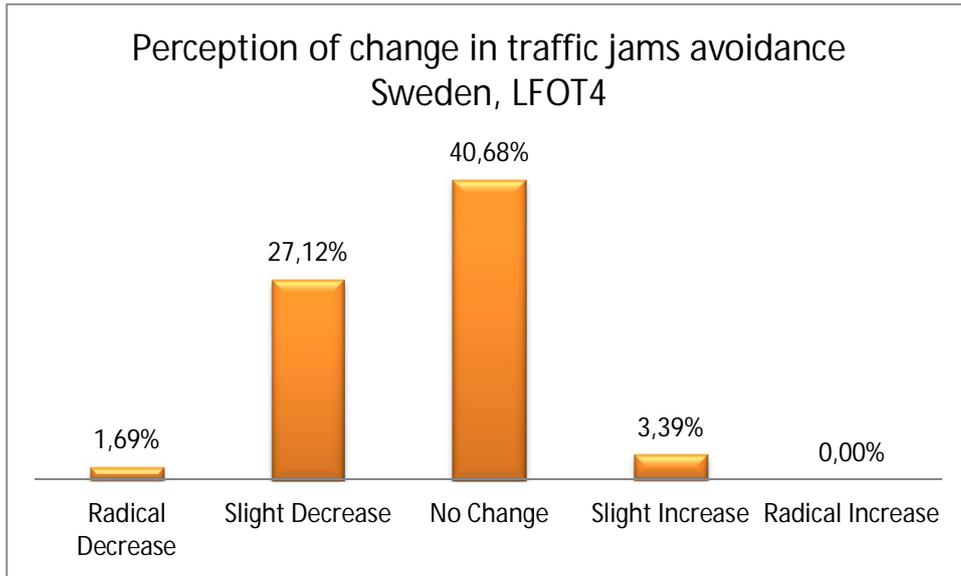


Figure 24. Perception of change in traffic jams avoidance (Sweden; LFOT4)

Finnish LFOT

The vast majority of participants in the Finnish LFOT reported that the traffic information service made no changes to their getting stuck in traffic jams (31 out of 77 participants, equivalent to 40.26%) or that it slightly decreased their perceived getting stuck in traffic jams (8 out of 77 participants equivalent to 10.39%), while the rest of participants did not answer this question.

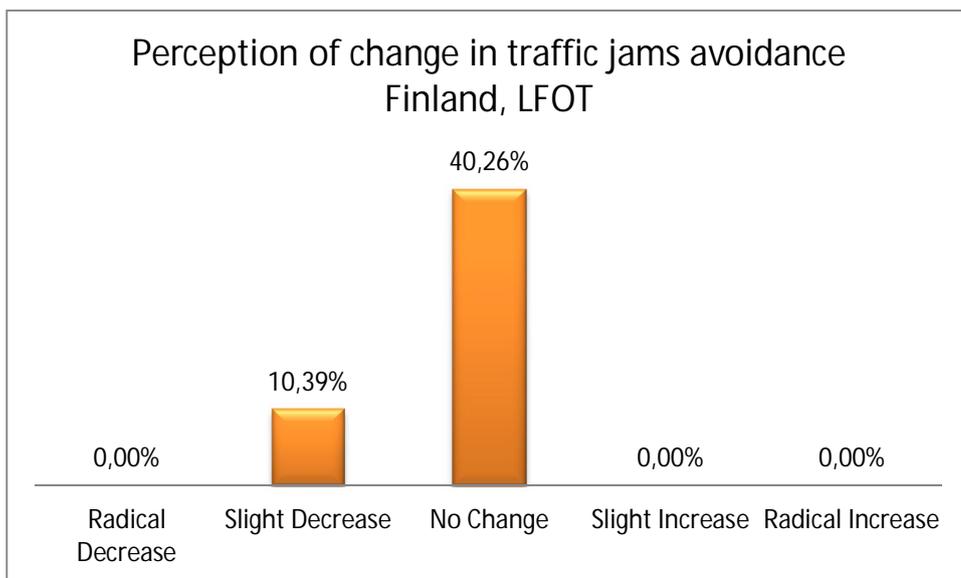


Figure 25. Perception of change in traffic jams avoidance (Finland; LFOT)

Greek LFOT3

More than half of participants in the Greek LFOT3 thought that the traffic info service slightly decreased their perceived getting stuck in traffic jams (41 out of 77 participants equivalent to 53.25%) or that it made no changes to their getting stuck in traffic jams (32 out of 77 participants, equivalent to 41.56%), while three participants reported that the access to the function resulted to a radical decrease of their getting stuck to traffic jams (3.9%) and one participant reported that the access to the function resulted to a slight increase on getting stuck to traffic jams (1.3%).

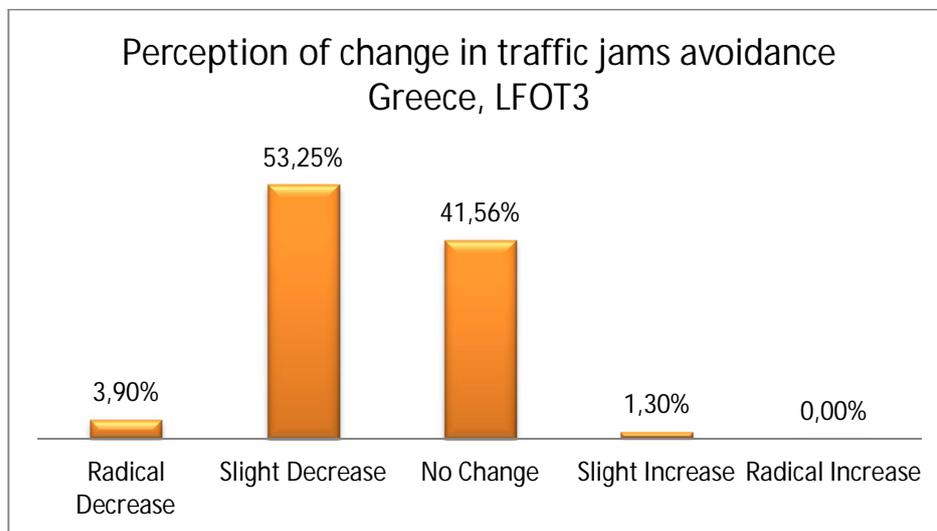


Figure 26. Perception of change in traffic jams avoidance (Greece; LFOT3)

4.5.3. Initial Conclusions and further steps

On the whole, FOT participants were relatively positive about the impact that the nomadic devices' functionalities had on their perceptions of traffic jams avoidance.

Respondents -after experiencing the functionalities offered by the devices- thought that the function either made no change or slightly decreased their getting stuck in traffic jams. Some participants did indicate that due to access to the traffic information service, their feeling of getting stuck in traffic jams was decreased radically.

Overall, hardly any of the participants responded that they believed the device would have a radical increase on their feeling of getting stuck in traffic jams, although some participants did indicate that the devices would slightly increase their perceived getting stuck in traffic jams.

Further analysis will include stratification based on background variables to reveal any influencing factors on how users' feeling of traffic jams avoidance is affected by other variables (e.g. driving frequency, type of roads, leaving in a city or rural area).

4.6. EFF-RQ6 Is the distance from the preceding vehicle smaller/larger?(CERTH/HIT)

The adapted rationale is the same with the design described in section 4.3 (i.e. two levels of analysis are carried out). It is anticipated that smaller distances mean that the driver engages in more dangerous and riskier behaviour but they are more efficient for traffic network. If the usage of the nomadic device leads to safer driving behaviour, then its application will be regarded as successful for safety but how it is regarded for Efficiency? An efficient driver is someone who does not create large gaps in distances and has a harmonious distance keeping behaviour which should be within safe limits in order not to cause accidents or near-crashes. The latter also disrupts the harmony of traffic flow.

In addition, the collision avoidance warning should enhance and rectify driver's safety distance keeping behaviour. The analysis is based on distances of the ego vehicle (i.e. instrumented vehicle driven by participants) to the leading vehicle < 50 m. Distances, of course, are influenced by the synchronisation (i.e. speed adaptation effect) to the leading vehicle. In other words, the distance kept is related to the speed of both vehicles. If the ego vehicle accelerates, even if the preceding vehicle does not change speed, then the synchronization fails and the ego vehicle has to either overtake or engage into dangerous following behaviour. In addition, Time to Collision indicator might be calculated in the final analysis as a surrogate variable of distance to preceding vehicle as it holds advantages for crashes related inferences. Both time and distance headway results' sections - 4.3 and this section- provide complementary results for measuring the effect of these two variables on driving efficiency.

4.6.1. Data

Vehicle data from the Greek DFOTs are used in order to answer this research question. Data from Greek DFOTs are used for preliminary results and for final analysis as well. Distance is sensitive measure and high resolution CANbus data are required. Not all DFOTs gather this measurement and potential for using other data is limited.

One key overall parameter of interest is to investigate how in-vehicle functions could affect car following behaviour. It is anticipated that car following behaviour is affected by individual characteristics and differences but as analysis is based on same participants across DFOTs, it is assumed that this effect is minimised. Additionally, participants' inclusion/exclusion criteria allowed for controlling for potentially confounding variables (e.g. extreme sensation seeking behaviour might have affected distance keeping distribution regardless traffic and road environments).

4.6.2. Analysis

The following table presents the overall demographic characteristics of drivers in all three Greek DFOTs. Overall, 8 (34.38 ± 2.774 years old; 8x5 conditions) drivers participated in three DFOTs and two baseline conditions (1: ADAS off; 2: ADAS on).

Table 9. Basic demographics

Gender	Age (mean \pm SD)	Driving years
Male (N=5)	34.4 \pm 2.88	12.8 \pm 4.6
Female (N=3)	34.3 \pm 3.21	7.67 \pm 5.03

Drivers reported that they do not drive more than 30000 km per year (most stated around 10-20000 km/year) and they are experienced drivers. Moreover, most participants stated that they are either defensive or balanced drivers. Only, two drivers perceive themselves as aggressive drivers. These two were male participants.

The levels and interactions explained in section 4.3 apply, also, in this section; however, distance measurements are derived by the analysis of results from three Greek DFOTs.

Distance from the preceding vehicle is the actual distance headway and is evaluated in the data logger with the analysis of the vehicle parameter Distance to Headway (DTHWY) as measured by the CAN.

Overall, kept distance seems to be smaller in the navigation support with ADAS condition (17.29 ± 4.89). On the contrary, greater mean distance was recorded in the navigation support with speed alert warning and ADAS (i.e. DFOT3 with all possible functions) (24.08 ± 7.9). Findings are different for distance keeping when compared to time headway. For example, distance keeping behaviour is "improved" with the addition of speed information and speed alert functions from one DFOT to the other –as depicted in Figure 27- compared to ADAS and static navigation support with ADAS. Therefore, the provision of speed information could improve traffic efficiency and flow with regards to distance adjustment from the driver's viewpoint.

The next step would be to investigate distance keeping for different speeds (e.g. speed intervals <20, 20-35, 35-50, 50-80, >80 km/h) and across different road contexts (information resulting by map matched data). Analysis so far triggered the necessity for further analysis focusing on speed intervals in order to increase sensitivity and specificity of obtained findings and, subsequently, of the inferences made. It is essential to note that inferences at this stage are more 'food for thought' for the final analysis rather than conclusive statements. These are objectives set for the final data analysis.

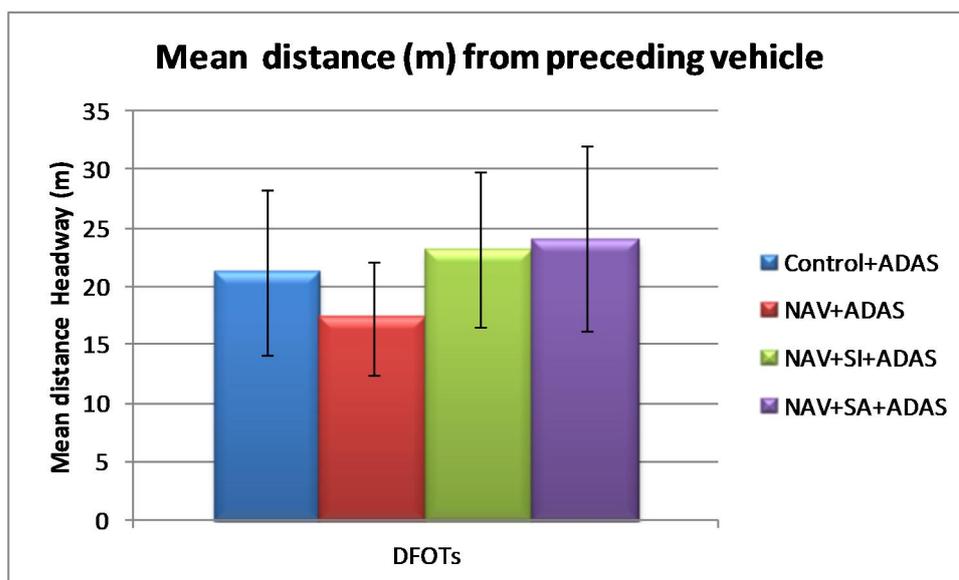


Figure 27. Mean min distance (m) from preceding vehicle across DFOTs

A similar picture is drawn from the investigation of the mean min distance values across the three DFOTs and baseline 2 analyses so far (Figure 28). Lowest minimum distance was found in Navigation and Support with ADAS DFOT1 (1.87 m) and highest minimum distance kept was found for Baseline 2 (2.78 m). However, the improvement of distance with the addition of speed information and speed alert is not evident in the analysis of minimum distances across DFOTs. Therefore, the addition of speed information and alert did not affect the Efficiency for the driver with respect to minimum distances kept. If no effect on Efficiency is revealed, the effect of these functions might not be restrictive or negative for Efficiency. Nevertheless, these are remarks for the next step of analysis to be taken into consideration.

This is not a negative finding for Efficiency, though, and it could lead to more flexible systems to be able to penetrate the market without compromising the Efficiency of traffic flow in the network. However, the final analysis remains to be performed in order to investigate if these inferences hold true. Slightly higher minimum distance was found for speed information (2.3 m) (DFOT2) when compared to speed alert (2.2 m) (DFOT3). The mean difference is very small (10 cm) in order to be reported as a difference after all.

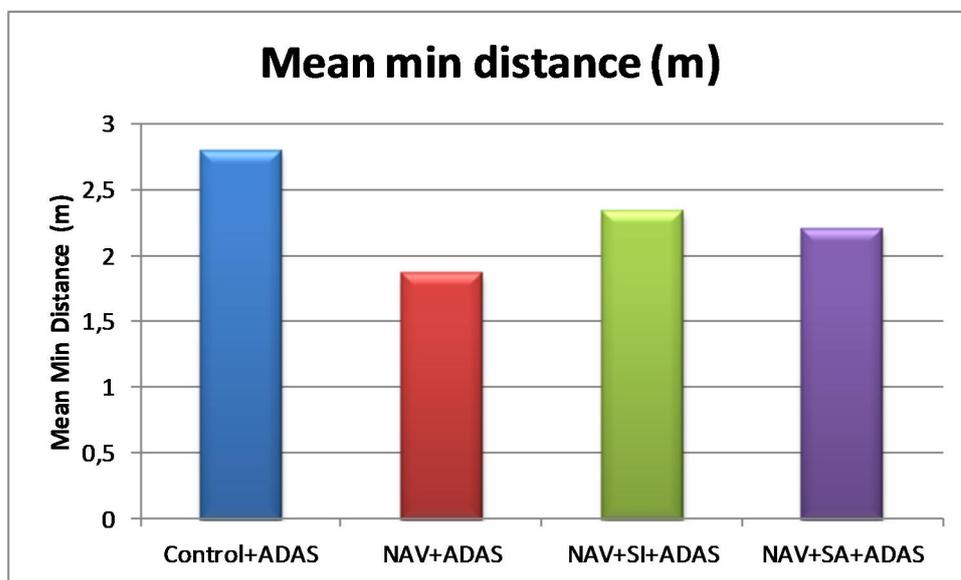


Figure 28. Mean min distance (m) values per DFOT

4.6.3. Initial conclusions and further steps

Qualitative data gathered and the focus group will also provide supportive analysis for this research question, as well with the addition of locally used usability questionnaires.

The parameters discussed in section 4.3 and 4.4 are the primary variables for analysis. Therefore, they are the variables that are definitely included in both 4.3 and 4.4 secondary variables as video data might support -and in some cases will assist - clarifying instances such as usability and usage.

Performed pre-pilots have indicated a 15% increase in headway keeping when the ADAS systems are on and are in line with experience from previous research studies performed with the instrumented vehicle (e.g. PROLOGUE small scale field trials). (Touliou and Margaritis, 2010). However, the impact of the nomadic device has not been apparent in the small pilot and verification tests and now in the preliminary findings.

5. DISCUSSION

The first analysed data are derived from Finnish, Swedish, Spanish, Greek LFOTs and German, UK, Greek DFOTs.

The Finnish study provided results that aim to investigate the effect of the device on travel time. Results did not show an effect on travel time because of functions used; hence the use of functions did not have an effect on Efficiency. These data will be enriched by findings from Swedish LFOT and from logged data to investigate if there are discrepancies between reported community travel duration based on travel diaries and questionnaires and real logged durations. In addition, other types of journey types (e.g. for leisure and entertainment) could be taken into consideration for further stratification and more in-depth investigations.

Data analysis from Finnish, Swedish, and Greek LFOTs provided results with regards to how the traffic information system included in the nomadic device helped them to avoid traffic jams. Participants completed post-questionnaires regarding traffic jams avoidance when the navigation support advisory system were used. Participants were relative positive about traffic information function and more than half of them believed that it did not change encountered traffic jams. On the other hand, almost a third of participants stated that they believed it helped them avoid traffic jams. In addition, extremely low percentage of users believed that using the system increased occurrences of getting stuck in traffic jams.

Moreover, the analysis of perceived delays, based on questionnaire data by the Spanish LFOT, showed that a third of participants reported they thought delays were decreased because of traffic information function used with navigation support and guidance. Analysis of more LFOT data will provide a clearer picture about perceived changes for other sites with traffic information available.

Both time and distance headway measurements have shown increase with regards to functions added to navigation route guidance when compared to baseline and ADAS measurements. Analysis so far has shown increase of these vehicle parameters with the addition of functions. The interpretation on a driver level could be that participants complied in general with the warnings received. On another level, though, the inferences extrapolated to network are not so easy and clear to be made. To start with, decrease in headways can be translated in increase in traffic efficiency and this was not recorded for these two vehicle

parameters in all DFOTs studied till now. However, it is not necessary to have increase on traffic efficiency by simply extrapolating findings from individual driving experience.

The application of micro-simulation for estimations on traffic flow did not show any change, therefore a specific driving model for change in efficiency due to the application of these functions belonging to the TeleFOT used aftermarket devices was not plausible at this stage. However, still data analysis is performed and more data are to be analysed for other vehicle parameters from other sources.

5.1. Implications for Efficiency so far

Implications for Efficiency cannot be estimated at this point as final results are not available. Implications, though, will be mainly directed towards the driver's Efficiency. It seems that inferences will not be made easy to accommodate for this findings and the initial "intersection" rationale will be guiding the analysis to be performed.

An important finding from the analysis of Efficiency research questions till now is that differences were not shown for most of research questions. Therefore, the differentiation between driver and traffic efficiency was a good starting point and might prove valuable for furthering the analysis skeleton of final analysis.

Further stratification with background characteristics it will prove useful and might ease understanding of both qualitative and quantitative analysis. The empowering effect of using different data sources is on one hand showing a harmonising effect (i.e. no differences till now) and forces analysts to move one step further to peripheral driving elements in order to yield meaningful findings.

In case functions of aftermarket devices do not play a crucial role on Efficiency impact assessment this will not necessarily be translated into a disadvantage but probably it might exclude problems and difficulties for traffic flow assessment and traffic network management, design and flow scheduling.

5.2. Considerations for final analyses

In the final analysis, the long term impacts of having access to the functions will be studied. Then the results will be analysed separately for each function as well as the significance of the timing of the use wherever possible.

Previous research experience gained by the conduction of small scale trials within the framework of PROLOGUE project has shown a relation between driver distraction and ADAS but of no statistical significance. Although, statistical analyses did not reveal any significant associations of secondary tasks presence and warnings' activation and events, lane deviation warnings were associated most with inattentive behaviour with external stimuli (e.g. looking at the scenery) and forward collision warning with internal tasks (e.g. searching for a radio station). The latter may be the result of increased annoyance by the forward collision warnings, as reported by the participants. Inconclusive findings are in line with current research (Sayer et al., 2005); however, the limited number of secondary tasks retrieved may be the result of the quasi-experimental characteristics of the study.

These issues have been taken into considerable account during the design and data mining/reduction process and were defined. In other words, secondary tasks were not included as a potential measurement due to the time constraints of some trials (i.e. DFOTs) but vehicle surrogates were included as more stable associators to driving distraction. Moreover, the constrictions of using an instrumented vehicle were of increased importance and value when designing the routes and the timeplan for some of the DFOTs (e.g. for Greek DFOTs).

Whenever plausible individual characteristics will be taken into consideration and will be investigated as co-factors for revealing interactions in subsequent analysis (e.g. driving style, personal opinions).

Large scale studies produce large datasets and accommodate for real life scenarios' variability in test sites.

The final analysis will include data gathered from more sites, hence the diversity of performed tests will provide both breadth and depth into the findings and the interpretations aim to be generalisable. In addition, Efficiency analysis will gain knowledge from large scale and detailed scale data analysis. The analysis will be further enhanced to consider scaling up of main findings on a European level.

The effects of these findings for inferences for global assessment will be investigated under the prism of final analysis.

6. CONCLUSIONS

Final conclusions will not be drawn at this stage as analysis is still ongoing in most sites. Data collection has finalised for LFOTs in December 2011 and for most DFOTs in March 2012. At this stage, data have become available in the internal database and responsible partners have contacted TeleFOT partners in order to gather related data. At the time this deliverable is being compiled responsible partners have already finished preliminary analysis and are moving on at more indepth and final analysis.

No differences were revealed and simulation was not performed. Such complexities are inherent in Efficiency analysis.

However, important feedback was received from the already analysed data within LFOTs as it is apparently difficult to reveal differences in both perceived and objective measurements. Subjective estimations are of great importance in TeleFOT (i.e. User Uptake questionnaires).

Real traffic information about delays and congestions (i.e. traffic jams) was not plausible to be satisfactorily and reliably derived and it was decided to base the analysis of the respective research questions to subjective data. The methodological framework adapted early in the project relies heavily on subjective assessment which is a crucial pillar of assessment not only as a distinct assessment area within the project but also as a data collection medium. The evaluated functions are integrated in nomadic devices and subjective evaluations derived by LFOTs provide a longitudinal data source.

In addition, individual and personality differences have been proven important elements in research with advanced driving assistance systems and still not taken into very serious consideration in relevant research. Therefore, a consideration of diverse data types could prove very useful for furthering these topics in assistive systems' research.

Moreover, some patterns were revealed during preliminary analysis. For example, there seems to be a relation between the time a journey takes to reach a destination (i.e. Finnish study; approx. 24 minutes) and the usefulness of the nomadic device for the driver, .

A valuable lesson learnt amidst data analysis is the fact that the Efficiency impact area derives analysed data from different sources (i.e. LFOTs, simulation, detailed

tests) and the combination and, probably, time management requires extra care, effort and coordination for the diverse data to be incorporated into the same impact area and to be co-related with the rest of the impact factors. Therefore, these results would lead to overlapping inferences (i.e. same data sets used for more than one RQ and impact area) and that could reveal correlations of greater importance for the final analysis processes.

Last but not least, final analysis will be based on complete datasets from more LFOT and DFOT sites. Specifically, the following table (Table 10) presents the sites that provided data for the preliminary analysis and the sites that will be included in the final analysis. It is important to keep in mind that even for the sites that were included in this Deliverable only parts of the available data were analysed.

Table 10. Data used in preliminary and final analysis per RQ

Research Question	Preliminary analysis (D 4.5.2)	Final analysis (D4.5.3)
RQ-EF1: Travel duration	Partial analysis of travel diaries from 2 LFOTs: <ul style="list-style-type: none"> • Finnish LFOT • Spanish LFOT (Valladolid) 	Whole datasets analysis of travel diaries and GPS logged data from 8 LFOTs: <ul style="list-style-type: none"> • Finnish LFOT • Italian LFOT • 2 Spanish LFOTs (Valladolid & Madrid) • 2 Swedish LFOTs (2 & 4) • UK LFOT • Greek LFOTs (1-3)
RQ-EF2: Avoidance of delays	Analysis of User Uptake questionnaires from Spanish LFOT1	Analysis of User Uptake questionnaires from: <ul style="list-style-type: none"> • 2 Greek LFOTs (1 and 3) • Italian LFOT

Research Question	Preliminary analysis (D 4.5.2)	Final analysis (D4.5.3)
		<ul style="list-style-type: none"> • Spanish LFOT1 • 3 Swedish LFOTs (1, 2, and 4) • UK LFOT • Finnish LFOT
RQ-EF3: Speed variations	Partial analysis of vehicle logged data from German DFOT	Analysis of vehicle logged data from: German DFOT UK DFOT
RQ-EF4 Change in time headway	Partial analysis of vehicle logged data: <ul style="list-style-type: none"> • 3 Greek DFOTs • UKDFOT 	Complete dataset analysis of vehicle logged data: <ul style="list-style-type: none"> • 3 Greek DFOTs • UK DFOT2 • German DFOT
RQ-EF5 Avoidance of traffic jams	Partial analysis of User Uptake Questionnaires: <ul style="list-style-type: none"> • Swedish LFOTs (2 and 4) • Finnish LFOT • Greek LFOT3 	Complete analysis of User Uptake Questionnaires: <ul style="list-style-type: none"> • Swedish LFOTs (2 and 4) • Finnish LFOT • Greek LFOTs (1-3) • Finnish LFOT • Spanish LFOT2
RQ-EF6 Change in distance	Partial analysis of: <ul style="list-style-type: none"> • 3 Greek DFOTS • UKDFOT 	Complete dataset analysis from: <ul style="list-style-type: none"> • 3 Greek DFOTs

Research Question	Preliminary analysis (D 4.5.2)	Final analysis (D4.5.3)
headway		<ul style="list-style-type: none"> • UK DFOT2 • German DFOT

This deliverable is the stepping stone towards Deliverable 4.5.3. Many ideas for further analysis came up during analysing first phase results. Moreover, involved partners responsible for certain Efficiency research questions communicated their ideas and potentials for inferences. Collaboration among partners for producing preliminary result is fruitful in order to fill in the gap between this deliverable and the final stage of data analysis with regards to data selection, reduction, data coherence and other not anticipated issues.

REFERENCES

Cambridge Systematics, Inc. (2002). *The Benefits of Reducing Congestion. NCHRP Project 8-36, Task 22 Demonstrating Positive Benefits of Transportation Investment*. National Cooperative Highway Research Program Transportation Research Board. National Research Council, USA.

Gaitanidou, E., Bekiaris, E., Schröder, U. (2010). *Deliverable 4.5.1: Efficiency Data Analysis Plan*. TeleFOT Large Scale Collaborative Project, 7th Framework Programme.

Golias, J., Yannis, G., Antoniou, C. (2010). Classification of driver-assistance systems according to their impact on road safety and traffic efficiency. *Transport Reviews: Transnational Transdisciplinary Journal*, 22, 2, 179-96.

Karlsson, I.C.M., Rämä, P., Alonso, M., Engelbrektsson, P., Franzén, S., Henar Vega, M., Kulmala, R., May, A., Morris, A., Mascolo, Juliene E., Schröder, U., Welsh, R. (2009). *Deliverable 2.2.1: Testing and Evaluation Strategy*. TeleFOT Large Scale Collaborative Project, 7th Framework Programme.

Koskinen, S., Tarkiainen, M. Peltola, H., Kulju, M., Innamaa, S., Scholliers, J. Touliou, K., Will, D., Birell, S. (2012). *Deliverable 3.6.1.: Detailed FOT Execution*. TeleFOT Large Scale Collaborative Project, 7th Framework Programme.

Pagle, K., Amditis, A., Kotsiourou, K., Tsogas, M., Koskinen, S., Scholliers, J., Schröder, U., Alonso, M., Vega, H., Parra, N., Mieza, J., Solar, A., Fruttaldo, S., Tesauri, F., Engelbrektsson, P., Karlsson, M., Mascolo, J. E., Kalogirou, K., Gaitanidou, L., Morris, A., Fowkes, M., Dar, K. (2010). *Deliverable 3.3.2b.: Test Tools*. TeleFOT Large Scale Collaborative Project, 7th Framework Programme.

Pline, J. (1992). *Traffic Engineering Handbook*. (4th Edition). Englewood Cliffs: Prentice Hall for the Institute of Transportation Engineers.

Sayer, J. R., Mefford, M. L., Shirkey, K., Lantz, J. (2005). Driver distraction: A naturalistic observations of secondary behaviours with the use of driver assistance systems. In: *Third International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design*.

Touliou, K., Margaritis, D. (2010). *Small Scale Field Trial in Greece: focus on assessment of FCW and LDW. PROLOGUE Deliverable D3.6*. CERTH/HIT, Thessaloniki, Greece.

Vogel, K. (2003). A comparison of headway and Time to Collision as safety indicators. *Accident, Analysis & Prevention*, 35, 3, 427-33.

ANNEX. PARTNERS' POTENTIAL FOR CONTRIBUTION TO THE EFFICIENCY RQS FOR LFOTS AND DFOTS

The following tables present the potential for contribution of different partners within TeleFOT from LFOTs and DFOTs for the Efficiency Research Questions. In addition, the tables present the type of systems used in each pilot site and the functions tested. The TeleFOT sites that have collected data used for answering Efficiency Research Questions are highlighted with yellow colour.

LFOTs

Table 11. LFOTs potential contribution to answering Efficiency RQs

Partner	Member State	FOT	Device name (if relevant)	Function to be tested	EF1 - Is the travel time from origin to destination affected?	EF2 - Are there any delays avoided?	EF3 - Are the vehicles speeds in the network changed?	EF4 - Is the time headway between the vehicles different?	EF5 - Are there any traffic jams avoided?	EF6 - Is the distance from the preceding vehicle different?
Loughborough/MIRA	UK	LFOT1	Blom	Blom navigation			x			
Loughborough/MIRA	UK	LFOT2	Footlite	FOOTLITE green driving advisor			x			
CIDAUT	Spain Valladolid	LFOT1	Blom	speed limit info, speed alert, navigation support (static), speed camera alert	x					
ETRA	Spain Madrid	LFOT1	ecoNAV	Traffic info, speed limit info, green driving support						

Partner	Member State	FOT	Device name (if relevant)	Function to be tested	EF1 - Is the travel time from origin to destination affected?	EF2 - Are there any delays avoided?	EF3 - Are the vehicles speeds in the network changed?	EF4 - Is the time headway between the vehicles different?	EF5 - Are there any traffic jams avoided?	EF6 - Is the distance from the preceding vehicle different?
UniMORE	Italy	LFOT1	Blom	Speed limit info, speed alert, nav support (static)	x	x				
Chalmers	Sweden	LFOT1		Speed limit info, speed alert, green driving support						
Chalmers	Sweden	LFOT2		Navigation support (static), green driving, traffic info	x	x	x		x	
Chalmers	Sweden	LFOT3		Traffic info, speed alert, speed limit, navigation support (static)	x	x	x		x	
Chalmers	Sweden	LFOT4		Traffic info	x	x	x		x	
VTT	Finland	LFOT1		Green driving, speed alert, traffic info	x				x	
UTBM	France	LFOT1	eCall alerts system	eCall						
ICCS	Greece	LFOT1	Samsung OMNIA II, Telenavis Hellas	Nav support (static)						
ICCS	Greece	LFOT2	Telenavis Hellas	Nav support (static), speed limit info						

Partner	Member State	FOT	Device name (if relevant)	Function to be tested	EF1 - Is the travel time from origin to destination affected?	EF2 - Are there any delays avoided?	EF3 - Are the vehicles speeds in the network changed?	EF4 - Is the time headway between the vehicles different?	EF5 - Are there any traffic jams avoided?	EF6 - Is the distance from the preceding vehicle different?
ICCS	Greece	LFOT3	Samsung OMNIA II, Telenavis Hellas	Nav support (static), traffic info					x	
ICCS	Greece	LFOT4	Samsung OMNIA II, Telenavis Hellas	Nav support (static), speed alert						
Partner responsible for leading the research question					VTT	CRF	IKA	CERTH	ICCS	CERTH

DFOTs

Table 12. DFOTs potential contribution to answering Efficiency RQs

Partner	Member State	FOT	Device name (if relevant)	Function to be tested	EF1 - Is the travel time from origin to destination affected?	EF2 - Are there any delays avoided?	EF3 - Are the vehicles speeds in the network changed?	EF4 - Is the time headway between the vehicles different?	EF5 - Are there any traffic jams avoided?	EF6 - Is the distance from the preceding vehicle different?
VTT	Finland	DFOT1	CAA	Visual behaviour assesment/ADAS						
VTT	Finland	DFOT2	eCall	eCall receiving and handling in PSAP						
VTT	Finland	DFOT3	Several	Navigation (benchmarking tests)						
VTT	Finland	DFOT4	TeleISA	Speed alert and speed limit information						
Loughborough	UK	DFOT1	Blom	Navigation/Speed Alert			x			
Loughborough	UK	DFOT2	FOOTLITE	Green Driving Advisor			x			
Loughborough	UK	DFOT3	MobilEye	Forward Collisoin Warning/Lane Keeping Assist			x	x		
IKA	Germany	DFOT all	Several	Navigation support/speed limit info/speed alert/LKA/FCW/ACC			x	x		x

Partner	Member State	FOT	Device name (if relevant)	Function to be tested	EF1 - Is the travel time from origin to destination affected?	EF2 - Are there any delays avoided?	EF3 - Are the vehicles speeds in the network changed?	EF4 - Is the time headway between the vehicles different?	EF5 - Are there any traffic jams avoided?	EF6 - Is the distance from the preceding vehicle different?
Cidaut	Spain	DFOT	Blom	Navigation						
CRF/MM	Italy	DFOT		Navigation	x					
CERTH	Greece	DFOT1	Samsung OMNIA II, Telenavis Hellas	Navigation support (static), ADAS (CAS, LDW)	x		x	x		x
CERTH	Greece	DFOT2	Samsung OMNIA II, Telenavis Hellas	Speed limit info, navigation support, ADAS (CAS, LDW)	x		x	x		x
CERTH	Greece	DFOT3	Samsung OMNIA II, Telenavis Hellas	Speed alert, navigation support, ADAS (CAS, LDW)	x		x	x		x
Partner responsible for leading the research question					VTT	CRF	IKA	CERTH	ICCS	CERTH

