Large Scale Collaborative Project

7th Framework Programme

INFSO-ICT 224067

Safety Data Analysis Plan

Deliverable n.	4.3.1	Safety Data Analysis Plan	
Sub Project	SP 4	Evaluation and Assessment	
Workpackage	WP 4.3	Safety Impact Assessment	
Task n.	T 4.3.1	Data Analysis	
Author(s)	Ruth Welsh; Andrew Morris; Baibing Li; Andrew May; Tracy Ross; Steven Reed	File name	TeleFOT_D4.3.1_Safety Impact Assessment Analysis Plan_v4.0
Status	Final Document		
Distribution	PU (Public)		
Issue date	2010-03-16	Creation date	2009-12-10
Project start and duration	1st of June, 2008 – 48 months		

European Commission
Information Society and Media

Project co-funded by the European Commission

DG-Information Society and Media

in the 7th Framework Programme

SEVENTH FRAMEWORK PROGRAMME

TABLE OF CONTENTS

TABLE OF CONTENTS 2
LIST OF FIGURES 3
LIST OF TABLES 3
LIST OF ABBREVIATIONS 4
REVISION CHART AND HISTORY LOG 5
EXECUTIVE SUMMARY 6
1 INTRODUCTION 8
2 DATA 10
3 GENERAL APPROACH AND STRATEGIES FOR THE IMPACT ASSESSMENT 21
4 RISK ASSESSMENT 38
CONCLUSIONS 44
ANNEX 1 CORE RESEARCH QUESTIONS AND HYPOTHESES SELECTION PROCESS 46
ANNEX 2 LITERATURE TO SUPPORT RQ SELECTION 72
REFERENCES 77

LIST OF FIGURES

Figure 1: Process for the identification of the 'ideal' generic FOT research questions & hypotheses. 48

LIST OF TABLES

Table 1: Minimum data requirements for safety impact hypotheses. 13

Table 2: Contribution from Partners 21

Table 3: Video Analysis Signature 34

Table 4: TeleFOT Generic Data Contingency Plan. 38

Table 5: Types of Variables 50

Table 6: Safety Hypothesis Feasibilty 52

LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
ADAS	Advanced Driver Assistance System
CAA	Cockpit Assessment Activity
DLC	Distance to Line Crossing
DoW	Description of Work
DWG	Data Working Group
DFOT	Detailed Field Operational Trial
FOT	Field Operational Trial
GPS	Global Positioning System
ICT	Information Communication Technology
LFOT	Large-scale Field Operational Trial
ND	Nomadic Device
RQ	Research Question
TLC	Time to Line Crossing
TTC	Time to Collision
SP	Sub Project

REVISION CHART AND HISTORY LOG

REV	DATE	AUTHOR	REASON
1.0	2009-12-10	Ruth Welsh	First Draft circulated to partners for comments
2.0	2009-12-18	Ruth Welsh	Second draft sent to for internal review process
3.0	2010-03-11	Ruth Welsh	Third draft based upon internal review comments
4.0	2010-3-16	Ruth Welsh	Final document sent to project co-ordinator

EXECUTIVE SUMMARY

Sub-Project 4 (abbreviated as SP4) of TeleFOT deals with the evaluation and assessment of data collected during the various Field Operational Tests (FOTs) throughout the test-sites in the project. The prime aim is to ensure that appropriate and rigorous analyses are conducted in order to identify the impacts of aftermarket and nomadic device/function use with confidence & validity.

Work-Package 4.3 (abbreviated as WP4.3) relates specifically to the analysis of data in the context of safety and driver behaviour. It is expected that the FOTs will generate a significant amount of data relating to the impact of nomadic and aftermarket systems on the driving task in a safety context. For example, traffic conflicts, visual distractions and speed control issues may all become evident within the trials. Analysis/Assessment of Safety-related data is therefore expected to be a significant undertaking involving extensive use of the TeleFOT database and other supporting information.

In order to structure the analysis and assessment activities within TeleFOT, it was identified at an early stage that an Analysis Plan would be required for each Impact Area (Safety, Efficiency, Environment, Mobility and User-uptake) which encapsulates the basic aims and objectives of the analytical work relating to the area. In the main, these relate to the hypotheses and research questions that were developed within SP2 and are reported on in D2.2.1. Setting explicitly formulated hypotheses helps the researcher to define the tasks at hand, the methodology and to carry out statistical testing that either verifies or falsifies the hypothesis set. However, it was expected that each plan would expand the description of the hypotheses so that the specific statistical tests that will be applied to the data can be described. Therefore, this report outlines the approaches that have been used in formulating the Analysis Plan together with an overview of how each hypothesis will be addressed by statistical analysis. Data analysis will involve both quantitative and qualitative data which will be collected by means of (1) data loggers; (2) video recorders and (3) travel diaries, questionnaire, interview and focus groups. Appropriate statistical tests will be used to analyse the data and these are described in the analysis plan.

Whilst in the main, it is expected that the data analyses will be conducted in the context of the research questions that will be generated in SP2, the final analysis activities will

also respond to other research issues that may arise within the trials. Furthermore, as the FOTs within TeleFOT involve “samples” rather than “populations” of drivers, it is the intention of SP4 to evaluate the “representivity” of the data both at a national level and pan-European level in order to make predictions about applicability to the wider driving population and the transport system in general. The approach that will be used to achieve this is also briefly described.

Much of the background work that has been carried out in order to reach the final list of Hypotheses that form the basis for the analysis plan is presented in Annex 1. Additionally, a literature, justifying the scientific and research background for each research question is presented in Annex 2.

This document has been developed as an integral part of WP4.3, task 1. This same task will also handle subsequent revisions to the plan that may be required once the detail of the travel diaries and questionnaires are know (WP2.2) the experimental design for each FOT is finalised (SP3 with reference to WP2.1) and pilot analyses are undertaken (WP4.1).

It is anticipated that the analysis plans will provide the final link, along with information from SP2 and the capabilities of the data loggers, that will allow the data specification to be completed within the Data Working Group (WP2.3 task 2.3.1) and the data base structure to be finalised (WP2.3, WP3.7, WP4.1). WP2.3 will assess the feasibility of collecting the variables required in this document and revisions will need to be made based upon the outcome of this feasibility assessment.

Upon completion of all of the analysis plans (D4.3-4.7) WP4.2 (co-ordination) will review all of the combined analytical requirements to ensure a cost effective analysis strategy across all the impact areas.

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 friendliness 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 (WP4.3 leader LOUGH), Mobility (WP4.4 leader VTT), Efficiency (WP4.5 leader CERTH/HIT), Environment (WP4.6 leader IKA) and Business Models User Uptake (WP4.7 leader CHALMERS). In order to measure the impacts SP2, in collaboration with SP4, has developed core research questions and hypotheses for each assessment area that also take into account the functionality of the devices specifically under consideration in TeleFOT. The next stage is to provide details regarding the analysis techniques that will be used to answer each hypothesis. Thus, each analysis plan deliverable details the proposed approach to be followed and ***does not*** give analysis outputs.

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

It is anticipated that some data required for the analyses will need to be derived from logged / collected data. In such instances, the analysis plans will provide details of the variables that require scripting. These scripts will be applied to the data during post processing. The scripting rules will be determined within the data working group.

In addition the analysis plans will;

- Establish which analysis will be undertaken at a local level (test site FOT data) and which will be carried out at the SP level (combined FOT data)
- Determine the partner responsibilities for undertaking analyses

The analysis plans also aim to provide strategies to;

- Avoid excessive duplication of effort across the impact areas
- Deal with the inevitable variability within the data collection
- Accommodate the assessment of devices with multiple functionalities
- Plan for detailed long term and more immediate short term output to stakeholders
- Provide a global assessment

It is anticipated that the analysis plans will provide the final link, along with information from SP2 and the capabilities of the data loggers, that will allow the data specification to be completed within the Data Working Group (WP2.3 task 2.3.1) and the data base structure to be finalised (WP2.3, WP3.7, WP4.1).

It is however important to realise that these are initial analysis plans and that there is a need to be adaptable based upon the outcomes from the pilot analysis, the difference between theory and practice.

It should be noted that at the time of producing this document, the function eCall has not yet been considered. This is being addressed directly by the French partners and a contribution is expected and the plans will be modified accordingly to accommodate the new RQs and Hypotheses that will be required for eCall.

2 DATA

2.1 Hypothesis Selection

Based upon the previous work undertaken developing the research questions (RQs) and hypotheses (H) a core set of RQs and associated hypotheses to be considered within the Safety Impact Assessment has been established (compare with table III.i d/ D2.2.1). AT this time, this does not include eCall but RQs and Hypothesis will be availebl for this function at a later date.

These core hypotheses were selected from the more generic safety RQs and Hypotheses using selection criteria based upon:

- The relevance of each question to TeleFOT (e.g. has a relationship with the functionalities to be assessed),
- The importance of each question (justified by current literature, public perception and the strength of contribution to the impact assessment)
- The feasibility of answering the associated hypotheses, limited by a knowledge of the data to be collected.

The ‘core' hypotheses are those that will be addressed by all the test sites that have data (LFOT / DFOT and required function) to support the analysis methods proposed. They should be addressed across as many of the sites as possible in order to provide the European perspective required by the project.

The process by which the core hypotheses have been reached is further explained in Annex 1.

For the safety impact assessment, the focus of the analysis will be upon the following research questions and associated hypotheses (compare with table A2 Annex 1) although a review will be made of the results for all of the impact areas in case anything additional contributes to the safety impact assessment. Justification for each RQ from current literature is provided in Annex 2.

RQ-S1Is the route affected (where travel takes place)?

H-S1.1 There is a change in the proportion of road types driven on when the device is used compared to when it is not.

H-S1.2 People choose different routes (based on road type) when the device is used compared to when it is not.

H-S1.3 There is a change in the proportion of urban/rural driving when the device is used compared to when it is not.

RQ-S2 Is the amount of time on the road affected (how long travel takes place for)?

H-S2.1 Subjects report a change in the number of trips undertaken because they have the device.

H-S2.2 There is a change in the distance travelled between comparable origins and destinations.

H-S2.3 Subjects report a change in the distance travelled between comparable origins and destinations.

H-S2.4 There is a change in the duration of journeys travelled between comparable origins and destinations.

H-S2.5 Subjects reports a change in the duration of journeys travelled between comparable origins and destinations.

H-S2.6 There is a change in the length of time driven without a break.

RQ-S3 Does the device cause distraction?

H-S3.1 The duration and/or frequency of glances to defined target areas of the visual scene changes.

RQ-S4 Is speed affected?

H-S4.1 The number of speed violations / proportion of time spent in excess of the speed limit changes with the device.

H-S4.2 There is a change in average speed.

RQ-S5 Is vehicle positioning affected (proximity and lane positioning)?

H-S.1 The longitudinal positioning of the vehicle will change as a result of having the nomadic device.

H-S5.2 The lateral positioning of the vehicle will change as a result of having the nomadic device.

RQ-S6 Is braking affected?

H-S6.1 The device changes braking behaviour.

RQ7 Is non driving manual activity affected?

H-S7.1 There is a change in the duration of hands off wheel time.

2.2 Data Requirements for Hypothesis Testing

Referring to table A1 and A2, Appendix 1, the following list (table 2.1) summarises the minimum data requirements to enable all of the hypotheses above to be tested and explored. Each data field (or variable) is categorised as being required for case selection (variables to **select** on), for statistical testing (variable to **analyse**), or for data mining to try and explain the results (variables to **interpret** results).

Whilst some indication is given in the table, the detail relating to exactly how the required variables will be collected is still to be determined within SP2, WP2. This should be available by 01 June 2010.

Table 1: Minimum data requirements for safety impact hypotheses.

Variables to SELECT on **(variables that the FOT must record / measure so that you can SELECT the appropriate data files for analysis)**		**Variables to ANALYSE** **(variables that the FOT must record / measure so that you can ANALYSE the impact of the nomadic device, i.e. the dependent variables)**		**Variables to INTERPRET results** **(variables that the FOT must record / measure so that you can INTERPRET the results and come to conclusions about why the effects have occurred)**	
Measure	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**	**Measure**	**Data source & whether in L + / or D-FOT**
Function status - on/off **in use / not in use**	ND Task logger Travel Diary **Controlled condition in D-FOT**	Perceived influence of function on - choosing to make a trip - road choice - trip duration (hour/min/sec) **trip distance (km)**	Travel diary Interview **(Questionnaire)**	**Driver experience**	Participant selection **Background Questionnaire**
Specific driver	Data logger (if only one	Information received from	ND task logger and video	Driving style	From control condition

Variables to SELECT on **(variables that the FOT must record/measure so that you can SELECT the appropriate data files for analysis)**		**Variables to ANALYSE** **(variables that the FOT must record/measure so that you can ANALYSE the impact of the nomadic device, i.e. the dependent variables)**		**Variables to INTERPRET results** **(variables that the FOT must record/measure so that you can INTERPRET the results and come to conclusions about why the effects have occurred)**	
	driver per vehicle) Travel diary (if 2+ drivers per vehicle)	device - what (content) - when (time) - how (mode)	in DFOT	- speed - headway - lane keeping **braking**	GPS Accelerometer Video Specialist equipment in D-FOT
Driver characteristics - visual ability - driving experience	Participant selection Background questionnaire	Length (km) of - journey - leg - link	GPS/Data logger + Map matching Controlled in D-FOT	Driver violation history - speed	Participant selection Background questionnaire
Start/finish position of - journey - leg link	GPS/Data logger + Map matching	Duration (hour/min/sec) of - journey - leg link	GPS/Data logger + Map matching Directly measured in D-FOT	Reason for journey	Travel diary (Interview)

Variables to SELECT on **(variables that the FOT must record/measure so that you can SELECT the appropriate data files for analysis)**		**Variables to ANALYSE** **(variables that the FOT must record/measure so that you can ANALYSE the impact of the nomadic device, i.e. the dependent variables)**		**Variables to INTERPRET results** **(variables that the FOT must record/measure so that you can INTERPRET the results and come to conclusions about why the effects have occurred)**	
Length (km) of - journey - leg (link)	GPS/Data logger + Map matching	Road type - speed limit - number of carriageways - urban/rural (Navteq categories)	GPS/Data logger + Map matching Controlled in D-FOT	Reason for break in journey	Travel diary (Interview)
Duration (hour/min/sec) of - journey - leg (link)	GPS/Data logger + Map matching	Length (km) driven per road type	GPS/Data logger + Map matching Controlled in D-FOT	Reason for using ND on - journey - leg link	Travel diary (Interview)
Portion of journey where - system presents new/ visual information OR	ND Task manager OR Video of system AND	Speed KM/H	GPS OR Data logger	Perception of ND effect on - route choice road types	Interview OR Questionnaire

Variables to SELECT on (variables that the FOT must record / measure so that you can SELECT the appropriate data files for analysis)		**Variables to ANALYSE** (variables that the FOT must record / measure so that you can ANALYSE the impact of the nomadic device, i.e. the dependent variables)		**Variables to INTERPRET results** (variables that the FOT must record / measure so that you can INTERPRET the results and come to conclusions about why the effects have occurred)	
- driver requests new /visual information OR - driving situation means driver is likely to need information / visual information from the system (supply and/or demand driven) Selected according to: - Time (related to location or event) OR - - Distance (related to	GPS & map-matching		OR CAN		

Variables to SELECT on **(variables that the FOT must record / measure so that you can SELECT the appropriate data files for analysis)**		**Variables to ANALYSE** **(variables that the FOT must record / measure so that you can ANALYSE the impact of the nomadic device, i.e. the dependent variables)**		**Variables to INTERPRET results** **(variables that the FOT must record / measure so that you can INTERPRET the results and come to conclusions about why the effects have occurred)**	
location or event) OR - Task start/end					
		Average speed	GPS/Data logger/CAN	Factors other than ND that affected - route choice - headway lane keeping	Travel diary Interview
		Speed (km/h) per road type	GPS/Data logger + Map matching Controlled in D-FOT	Factors other than ND that affected - route choice - headway lane keeping	Travel diary Interview

Variables to SELECT on **(variables that the FOT must record / measure so that you can SELECT the appropriate data files for analysis)**		**Variables to ANALYSE** **(variables that the FOT must record / measure so that you can ANALYSE the impact of the nomadic device, i.e. the dependent variables)**		**Variables to INTERPRET results** **(variables that the FOT must record / measure so that you can INTERPRET the results and come to conclusions about why the effects have occurred)**	
		Vehicle stationary for - break - Other purpose	GPS/Data logger + Map matching (for Point of Interest to infer) Travel diary	Factors other than ND that affect the distribution, duration, frequency of glances to defined areas of the visual scene	Visual tracking Video Interview
		Target of glance (e.g.) - Forward view - Side view - Mirrors - Device Other internal objects	Visual tracking equipment (e.g. Seeing machines, CAA) Video	Factors other than ND functionality for looking at the ND (e.g. sending/ receiving a text / phone call)	Visual tracking Video Interview
		Distance to lead vehicle	Specialised equipment for D-FOT	Factors other than ND that affect the distribution, duration, frequency of	Video Interview

Variables to SELECT on (variables that the FOT must record / measure so that you can SELECT the appropriate data files for analysis)		Variables to ANALYSE (variables that the FOT must record / measure so that you can ANALYSE the impact of the nomadic device, i.e. the dependent variables)		Variables to INTERPRET results (variables that the FOT must record / measure so that you can INTERPRET the results and come to conclusions about why the effects have occurred)	
				taking hands off wheel	
		Harsh braking events	GPS (derived acceleration) Accelerometer	Other reasons for changes to hands off wheel time (e.g. operating devices other than the ND)	Video Interview

2.3 Scripting requirements for derived data

The variables listed above will either be directly logged (data logger / travel diary / questionnaire) or will need to be derived. The following variables will require additional definition and scripting.

- Journey
- Section of a journey (e.g. leg / link)
- Road type and proportion of road types driven on
- Proportion of urban and rural driving
- Length of time driven without a break
- Duration of glances to defined target areas of the visual scene
- Number of glances to defined target areas of the visual scene
- Speed violations
- Average speed
- Braking and harsh braking events
- Hands off wheel time

The detail of these definitions and scripting requirements are being currently considered in WP4.3 and expect to be available by 01 June 2010. This does not affect the data to be collected, but has implications for the post processing of the data in preparation for analysis.

3 GENERAL APPROACH AND STRATEGIES FOR THE IMPACT ASSESSMENT

This chapter outlines the general approach that will be taken to undertake the impact assessment for safety. It includes details of the responsibilities for the data collection and analyses, the proposed analytical procedures to be undertaken as well as strategies for global assessment and dissemination of results.

3.1 Contribution from Partners

The following partners are expected to make a contribution to WP4.3 and in particular to task 4.3.1 data analysis.

Table 2: Contribution from Partners

Partner	Contribution	Person Months
LOUGH	Lead this Task Responsibility for FOT data from UK Link between data analysis and Task 2.3.2 Quality of data D4.3.1 Impacts on safety – data analysis plan D4.3.2 Impacts on safety – preliminary results	9
VTT	Responsibility for FOT data from Finland Link between data analysis and Task 2.2.2 Research questions & indicators Calibration of conflict (near accident) thresholds in the overall data to produce surrogate safety indices	3
BROADBIT	Provision of data filtering and driver behaviour profiling via accelerometer log	1
ETRA	Contribution to the data analysis for the evaluation of the safety impact assessment	1.5
CRF	Contribution to the data analysis for the evaluation of the safety impact assessment	3

Partner	**Contribution**	**Person Months**
CERTH/HIT	Responsibility for FOT data from Greece	1
CHALMERS	Responsibility for FOT data from Sweden Link between data analysis and Task 2.2.3 Experimental design	3
CIDAUT	Responsibility for FOT data from Spain Combined analysis from data obtained in field operational tests and detailed FOT focusing on safety related aspects. Link with Task 5.1.2 Communication and liaison to other SPs	5
ICCS	Contribution to data analysis for Greek FOT	2
IKA	Analysis of data from FOTs in order to determine the impact on safety, partly by means of traffic flow simulation.	5
MIRA	Joint responsibility for FOT data from UK Liaison with other UK actors in UK FOTs in relation to data analysis issues, in particular review of the “representivity” of the UK driver sample	1
NAV	Support in the identification of critical driving environments causing driver distraction derived from road network map database information.	1
UNIMORE	Contribute to identify safety implications of results for different situations and categories of devices concerned. Links will be provided to the SP5 Dissemination activities, such that different stakeholder groups will be addressed through the most relevant implications.	3
UTBM	Contribute to data analysis in the context of eCall	1

The following general approach for generating analysis results will be employed

- Analysis that requires use of the DFOT data should be carried out locally by partners responsible for the test site. In the DoW, each partner has time to contribute towards the data analysis. This should concentrate on the DFOT data that is collected in the member state that the partner represents. These are

- Finland: VTT
- Spain: CIDAUT, RUCKER, ETRA and BLOM
- Greece: CERTH and ICCS
- UK: MIRA and LOUGH
- Germany: IKA
- Italy: CRF

This in particular involves analysis relating to video data and other specialist equipment, and also additional subjective data such as focus groups. However, a template to be completed for the required analysis for each hypothesis should be provided as guidance by the WP leader for each impact area based upon the analysis plans.

- Analysis that requires LFOT data should be undertaken by the WP leader and other partners specified in the DoW with recourse for the activity. This should be co-ordinated by the WP leader and appropriate guidance given to each partner involved in helping with the analysis. Again, templates to be completed with results should be provided in line with the analysis plans by the WP leaders.
- The WP leaders have responsibility for bringing all of the results together and, in discussion with other partners who have resources (DoW), interpreting the results and forming conclusions.
- Test sites must be made aware that there is an obligation to provide the data required to answer the core TeleFOT hypotheses as a priority. This applies where the function under consideration in the hypothesis is being considered by the site and the appropriate type of FOT (LFOT or DFOT) is being carried out. The analysts are then required to answer the core hypotheses. Other issues can only be explored if there are resources remaining once the core TeleFOT analysis has been undertaken.

3.2 Analysis Strategy for Each Hypothesis

In this section, the strategy for analysing each hypothesis is presented in turn. Initially, details of participants' demographics and social factors will be summarised and reported e.g.

- Gender
- Age
- Marital status
- Education
- Driving experience
- Driving history (prior offences)

NOTE At the time of developing these plans, is has been assumed that a within subject experimental design is being carried out for the LFOTs at each test site in order to make some decisions on appropriate techniques. It is also assumed that a minimum of 50 subjects will participate in each LFOT and that the LFOTs will run for at least 3 weeks in the control phase and 9 weeks in the trial phase. This is in accordance with the recommended design reported in D2.2.1. Should this in reality not be the case, the plans will need to be reconsidered to ensure that the robustness of the analysis is sufficient under other experimental designs.

RQ-S1 Is the route affected (where travel takes place)?

H-S1.1 There is a change in the proportion of road types driven on when the device is used compared to when it is not / H1.2 People choose different routes (based on road type) when the device is used compared to when it is not

Analysis using the questionnaire data --- (after 6 month use of device or suitable time period)

The participants will be asked to answer the question whether they perceive any changes in the proportion of road types driven on when they use the device comparing not use.

Data will be collected by User Uptake Questionnaire. Only data collected <u>post test</u> will be considered.

The proportion of participants indicating a change in routes chosen (more/less highway, more/less rural road) because of access to the ND will be compared with the proportion of participants indicating no change a change with access to the ND.

The assumption is that the proportion of participants indicating a change will be higher than the number of participants indicating no change.

A further analysis will be made as to whether the change refers to more/less highway, more/less rural roads etc. and the specific reasons. Also, a further analysis will investigate relationships between change/no change and background factors, e.g. age, gender, driving experience, driving patterns etc. (retrieved from Background Questionnaire).

Let p denote the population proportion of all drivers who perceive a change after 6 months use of the device. The following hypothesis will be tested:

H_0: $p = 0$

H_1: $p \neq 0$.

A z-test (Triola 2009) will be performed (if the sample is large) or the Fisher's exact test (Everitt 2nd Edit) will be performed (if the sample is small).

Furthermore, logistic regression analysis (Dobson 2002) will be performed to investigate the relationships between the perceived change and the demographic and social factors (e.g. age, gender, previous driving experience, etc.).

Analysis using the questionnaire data --- (prior to the use of the nomadic device)

A similar analysis can be made using an entry questionnaire carried out at the beginning of the investigation. It will be of interest to investigate the difference between before and after the use of the nomadic device.

Analysis using the DFOT data (and controlled use cases in the LFOT data)

A group comparison will also be applied to compare if there is any difference with and without the device based on the data collected from a controlled experiment. A t-test or a nonparametric test (Triola 2009) will be performed to test

H_0: the difference in proportions of road types with and without the device = 0

H_1: the difference in proportions of road types with and without the device $\neq 0$.

For the DFOT, ideally a pilot study is needed to assist to set up potential suitable routes and start time (peak or off-peak time), ensuring substantial variation on the participants route choices.

Analysis using the diary data

The data collected from the dairies will be used to analyse the *revealed* behaviour of the participants. The data should be carefully selected by clearly defining the journeys and purposes of travels.

Regression analysis will be performed and adjusted for the journey distance and other variables. If more than one journey is included for a participant, a mixed-effect linear model will be used to analyse the repeated measurements.

Ideally, matched origin-destinations from both the before and after the use of the device cases are selected and the proportions of road types recorded in these matched pairs are investigated. Regression analysis will be performed, regressing the difference of the paired data in proportions of road types on the journey distance and the other variables. If more than one journey is included for a participant, a mixed-effect linear model will be used to analyse the repeated measurements.

The analysis will be supported by objective data collected in the LFOT where this is possible through appropriate data / journey selection.

H-S1.3 There is a change in the proportion of urban/rural driving when the device is used compared to when it is not

The variables of interest are proportions of urban/rural areas. The methods described in H1.1 / H1.2 will be used.

RQ-S2 Is the amount of time on the road affected (how long travel takes place for)?

H-S2.1 Subjects report a change in the number of trips undertaken because they have the device

Data will be collected by User Uptake Questionnaires. Only data collected post test will be considered.

The proportion of participants indicating a change (more or less) in the number of trips because of access to the ND will be compared with the proportion of participants indicating no change a change in the number of trips with access to the ND.

The assumption is that the proportion of participants indicating a change will be higher than the proportion of participants indicating no change.

A further analysis will be made as to whether the change refers to more or less trips. Also, a further analysis will investigate relationships between change/no change and background factors, e.g. age, gender, driving experience, driving patterns etc. (retrieved from Background Questionnaire).

H-S2.2 There is a change in the distance travelled between comparable origins and destinations

The data is also collected via travel diaries. The null hypothesis would be that the TeleFOT function(s) has(have) no influence on the travel duration – more / less would be tested against this null hypothesis (before/ after and test/control). An additional hypothesis is that the effect is changing after getting more experience with the function(s). Therefore the hypothesis will be tested at discrete intervals during the course of the use of the function.

The analysis will be supported by objective data collected in the LFOT where this is possible through appropriate data / journey selection.

H-S2.3 Subjects report a change in the distance travelled between comparable origins and destinations

Data will be collected by User Uptake Questionnaires. Only data collected post test will be considered.

The proportion of participants indicating a change in the distance travelled because of access to the ND will be compared with the proportion of participants indicating no change a change (longer/shorter) in the number of trips with access to the ND.

The assumption is that the proportion of participants indicating a change will be higher than the proportion of participants indicating no change.

A further analysis will be made as to whether the change refers to longer or shorter trips in terms of distances travelled and the specific reasons. Also, a further analysis will investigate relationships between change/no change and background factors, e.g. age, gender, driving experience, driving patterns etc. (retrieved from Background Questionnaire).

H-S2.4 There is a change in the duration of journeys travelled between comparable origins and destinations

The data is also collected via travel diaries. The null hypothesis would be that the TeleFOT function(s) has(have) no influence on the travel duration – more / less would be tested against this null hypothesis (before/ after and test/control). An additional hypothesis is that the effect is changing after getting more experience with the function(s). Therefore the hypothesis will be tested at discrete intervals during the course of the use of the function.

The analysis will be supported by objective data collected in the LFOT where this is possible through appropriate data / journey selection.

H S-2.5 Subjects reports a change in the duration of journeys travelled between comparable origins and destinations

Data will be collected by User Uptake Questionnaires. Only data collected post test will be considered.

The proportion of participants indicating a change (longer/shorter) in the duration of journeys travelled because of access to the ND will be compared with the proportion of participants indicating no change a change in the number of trips with access to the ND.

The assumption is that the proportion of participants indicating a change will be higher than the number of participants indicating no change.

A further analysis will be made as to whether the change refers to longer or shorter in duration time and the specific reasons. Also, a further analysis will investigate relationships between change/no change and background factors, e.g. age, gender, driving experience, driving patterns etc. (retrieved from Background Questionnaire).

H- S2.6 There is a change in the length of time driven without a break

Analysis using the questionnaire data

The variable of interest is the length of time driven without a break. The methods described in H-S1.1 will be used.

Analysis using the diary data

The variable of interest is the length of time driven without a break. The methods described in H-S1.1 will be used.

RQ-S3Does the device cause distraction?

H-S3.1 The duration and/or frequency of glances to defined target areas of the visual scene changes

Analysis for the frequency using the DFOT data

Poisson regression analysis (Dobson 2002) will be performed, regressing the number of off-road glances on device in use (or not in use), level of driving experience, and the other variables.

Note - Treat the total journey distance as the exposure in Poisson regression.

Analysis for the duration using the DFOT data

Group comparison will be used to assess if there is any difference in the duration of off-road glances per mile with and without the device based on the data collected from a controlled experiment. Use, for example, a t-test to test:

H_0: the difference in duration of off-road glances per mile with and without the device = 0

H_1: the difference in duration of off-road glances per mile with and without the device $\neq$ 0.

Furthermore, regression analysis will be performed, regressing the duration of off-road glances per mile on device in use (or not in use), total journey distance, level of driving experience, driving history, and the other variables.

RQ-S4 Is speed affected?

H4.1 The number of speed violations / proportion of time spent in excess of the speed limit changes with the device

Analysis for the number of speed violations using the DFOT data (or selected use case journeys from the LFOT data)

Poisson regression analysis will be performed, regressing the number of speed violations on device in use (or not in use), level of driving experience, driving history, and other variables.

Note - Treat the total journey distance as the exposure in Poisson regression.

Analysis for the proportion of time spent in excess of the speed limit using the DFOT data (or selected use case journeys from the LFOT data)

Group comparison will be applied to compare if there is any difference in the proportion of time of speed violations with and without the device based on the data collected from a controlled experiment (use case journeys from LFOT) test

H_0: the difference in the proportion of time of speed violations with and without the device = 0

H_1: the difference in the proportion of time of speed violations with and without the device $\neq 0$.

Further, regression analysis will be performed, regressing the proportion of time of speed violations on device in use (or not in use), total journey distance, level of driving experience, driving history, and the other variables.

H-S4.2 There is a change in average speed

For the evaluation of special road segments, these road segments have to be defined first. The road segments can consist e.g. of the way from home to work (as a whole or just parts of it). For this evaluation road segments should be chosen which are frequently used during a “normal” working week. With the logged GPS-position and map matching the compliance with the chosen route can be determined and with the recorded speed the average speed for this section can be calculated.

For the correct evaluation the status of the ADAS function (in use / not in use) has to be known. In the large scale FOT this can only be done with the help of travel diaries, in which the driver notes down which system he has used during his journey.

RQ-S5 Is vehicle positioning affected (proximity and lane positioning)?

H-S5.1 The longitudinal positioning of the vehicle will change as a result of having the nomadic device

This can only be measured in the DFOTs. The mean and minimum TTC (Time To Collision) and Time Headway will be stored together with a parameter showing if the device is in use or not. There will be an initial calculation with the reference group (same drivers) before getting the device to define their baseline (driving style). Successive trials should then be undertaken for different types of roads (urban, rural, highway, peri-urban) and for different levels of learnability (1 week, 4 weeks, 8 weeks after system use). These will be compared to the base line in order to test this hypothesis.

H-S5.2 The lateral positioning of the vehicle will change as a result of having the nomadic device

This can only be measured in the DFOTs. The mean and minimum TLC (Time to Line Crossing) and DLC (Distance to Line Crossing) will be stored together with a parameter showing if the device is in use or not. There will be an initial calculation with the reference group (same drivers) before getting the device to define their baseline (driving style). Successive trials should then be undertaken for different types of roads (urban, rural, highway, peri-urban) and for different levels of learnability (1 week, 4 weeks, 8 weeks after system use). These will be compared to the base line in order to test this hypothesis.

RQ-S6 Is braking affected?

H-S6.1 The device changes braking behaviour

Analysis for the number of harsh braking using the DFOT data

Poisson regression analysis will be performed, regressing the number of harsh braking on device in use (or not in use), level of driving experience, driving history, and other variables.

Note - Treat the total journey distance as the exposure in Poisson regression.

Analysis using the questionnaire data

On the basis of the data from the questionnaire, the participants' perceived change in harsh braking when the device is on use compared to when it is not will be compared using the same method as outlined in H-S1.1

RQ-S7 Is non driving manual activity affected?

H-S7.1 There is a change in the duration of hands off wheel time

Similar to H-S3.1

3.3 Special requirements for analysis of video data from the DFOTS in a safety context

It is expected that unlike other Impact Assessments, a large component of analysis in the safety context will involve the study, categorisation and analysis of video footage taken during the Detailed FOTs.

Analysis of video data is not a straightforward task since much of the footage taken is of no relevance or consequence to the device under evaluation. However, within TeleFOT, the Safety consequences of driver behaviour will be evaluated by studying specific “signatures” from the data-loggers which will be synchronised (probably by time-stamp) to the video footage. Such “signatures” will include harsh braking, swerving, rapid acceleration/deceleration and where appropriate self-reported critical events (although the usage of self-reports will be explored further in the pilot studies).

It will be necessary for the analysts to study each “signature” individually in order to evaluate the driver behaviour at the time that the “signature” occurred. An assessment will be made as to whether the “signature” was in response to the driver interaction with the system controls, or in response to a verbal or audio instruction from the system or not related to the system at all. Signatures that are deemed not to be associated with system interaction will not be studied further. This will allow the development of a mini-database of critical events that are related solely to driver and system interaction. Driver eyes off road time will measure where signatures are deemed to be related to system interaction.

Depending on the numbers of relevant critical events, statistical analysis will be performed accordingly. If sufficient numbers of events are available, appropriate statistical tests will be applied. Alternatively, descriptive statistics will be used.

The relevant signatures will be as follows;

Table 3: Video Analysis Signature.

Signature	Threshold	Denotes
Deceleration	~ -0.5g	Harsh Braking
Acceleration	~ 0.5g	Sudden avoidance manoeuvre
Lateral acceleration	~ 0.3g	Swerve
Yaw	rad/s	Swerve
Swerve	2 rad/s and >30km/h	Sudden avoidance manoeuvre
Over-speed	Vehicle travelling at 50% over speed limit	Driver choosing to ignore speed alert
Time To Collision	3 seconds	Stopping time (in relation to speed)
Self-report	none	All relevant events

3.4 Traffic simulation in support of safety impact assessment

For the evaluation of safety different parameters can be considered. These parameters are related to speed, acceleration and deceleration or distance towards preceding vehicles. The evaluation process can be carried out in two different types of simulation. The first one is a traffic-flow simulation in which the traffic in a given road section is calculated in time steps one by one. Herein the movement of every car is computed separately. The second simulation type is an In-depth simulation of special scenarios, like lane change manoeuvres. This simulation assesses the reaction of different drivers in varying vehicles on predefined traffic situations. With this approach dangerous situations, which e.g. have lead to an accident in real life, can be evaluated more in detail and different strategies for the avoidance of accidents can be tested.

The influence between the base line (non equipped vehicles) and the changes due to the use of NDs is implemented by changing driver parameters, like the willingness to change the lane, acceleration and deceleration behaviour and the proximity of vehicles in the other lane.

Inside the micro simulation the movements of the vehicle are calculated step by step in given time increments. With this data it is possible to track the movements of every vehicle inside the considered road section in time response and therefore to determine its speed and acceleration at every way point or point in time. With its position the distance towards other vehicles inside the traffic environment can be assessed.

With speed acceleration and position other safety surrogate measure like the Time Headway (THW), distance towards predecessor divided by vehicle speed, or Time to Collision (TTC), distance towards predecessor divided by relative velocity towards predecessor, can be computed.

For the estimation of safety impacts minimum and maximum values as well as cumulative frequency and frequency distribution can be determined for predefined parameters in the simulation. Inside the simulation defined incidents like harsh braking can also be estimated.

3.5 Sampling requirements from the travel diaries, questionnaires and focus groups

In general, the approach taken in TeleFOT will be to use the objective, logged data to test the hypotheses, either from the LFOT or (where this is not feasible) from the DFOT. For example, video analysis of safety-related events will focus on the DFOTs for the reasons given in section 3.3 above.

If objective data cannot be used for hypotheses testing (either impossible or infeasible to collect or analyse this data), then the next best option is data collected from the travel diaries, since this data will be collected in real time and contexts – relating to specific journeys. However, the travel diary must be concise in order to encourage participants to complete it, and this means that the scope of data that can be collected is limited. For example it will not be possible to determine the reasons for travel mode choice for each journey (even though these are of interest from a safety perspective).

If the limitations of the travel diary mean that insufficient data can be collected to test hypotheses using the diaries, then the periodic questionnaires can be used, to provide categorical or rating scale response data which can be analysed using Chi-square or non-parametric statistical techniques.

In addition, qualitative responses from interviews and/or focus groups will be used to explore hypotheses in more detail, and provide a greater level of understanding of both what driver behaviour is occurring, and why this is so. The project will specifically aim to triangulate data, either in terms of data source (e.g. logged and diary-based data), and/or data type (e.g. quantitative and qualitative data).

3.6 Consolidation across impact areas

The consolidation of analysis results will be overseen by WP4.2 coordination. This will ensure that each impact area takes a broad view of all of the results coming from each of the test sites and from all of the hypotheses. In order to keep each impact area manageable, the prioritisation of hypotheses has taken place as described in section 2. However, it is still important to review all of the results in order to establish whether further impacts need to be considered beyond the hypotheses considered in this analysis plan.

3.7 Strategy for Global Assessment

As with all FOT data, in TeleFOT there will be a requirement to generalise the results to the general driving population; otherwise there is little overall value in conducting the

FOT in the first place. However, this is not straightforward and the main problem is determining how close the TeleFOT subjects represent the target population.

A straightforward method in statistical analysis is to simply pool the data from different sites to form a single data set and perform statistical analysis as if they were measured in a single site. Due to the different driving rules and regulations, and potentially different driving characteristics of drivers in the different countries, this approach is not efficient because the country-to-country variation is not taken into consideration in the analysis.

Instead we shall incorporate more complicated linear mixed-effect models which include both fixed effects and random effects in the analysis. Specifically, the hypotheses formulated in the previous sections are tested using linear mixed-effect models, where a factor termed ‘country’ is included and is treated as a random effect in the models so that the country-to-country variation is taken into account when we test the effect of device in use on the primary variables of interest.

3.8 Strategy for dissemination of results – short and long term

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

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

4 RISK ASSESSMENT

No matter how well the data collection, collation and storage processes have been performed, it is likely that there will be problems and constraints with the data analysis. Contingencies may be required in the event that problems occur with missing, lost, erroneous and inconsistent data. Table 4 summarises the risks that are inherent in TeleFOT data collection, how the risk can be managed and proposed solutions in the event that the identified risk becomes a reality. This table has been prepared previously as part of Deliverable 2.3.1 and is a manifestation of the work that was undertaken within FESTA within the data quality task.

The basic principles that are generically outlined in the Contingency Plan should apply to all Assessment activities (Safety, Mobility, Environment, Efficiency, User Uptake).

Table 4: TeleFOT Generic Data Contingency Plan.

Risk including risk severity (e.g. low, medium, high)	Reduction (how the risk can be managed)	Solution (if the risk happens)
Missing data at point of collection (medium risk, medium severity)	Arrange check-list of required data-fields to ensure that collection is fully specified. Covered in Task 2.2.2 re data spec and WP2.3 re data acquisition and quality.	Missing data will be denoted as such in analyses and caveats will be applied to results.
Loss of data post-collection (low risk, high severity)	Ensure that data back-ups are provided (main server and DVD)	Back-up will be utilized. If data cannot be recovered, same caveats as above will be applied
Inconsistent data across test communities meaning	Data quality ensured in Task 2.3.2, Pilot data analysis	In this unlikely event, data analyses will not be

Risk including risk severity (e.g. low, medium, high)	Reduction (how the risk can be managed)	Solution (if the risk happens)
comparisons cannot be made (low risk, medium severity)	conducted in WP4.1. Data consistency will be ensured through the review process of WP4.2	conducted where data inconsistencies are found
Insufficient data to ensure scientific rigour/statistically valid outcomes (medium risk, high severity)	This will be established and addressed in a pilot study (WP4.1) – any indications that the data will not give statistically robust results will result in revision of methods, tools and data specification (WP2.2&2.3)	In this unlikely event, the data analyses will be modified accordingly and the validity of the outcomes described.
Late identification of needed analysis and analysis procedures cannot accommodate it (medium risk, medium severity)	WP2.2 takes input from FESTA and identifies research questions & indicators which should avoid late identification of required analyses. Task 2.3.3 will identify database structure and incorporate flexibility to respond to unpredicted analysis requirements. Pilot study in WP4.1 will test analysis procedures.	All efforts will be made to include the required analyses. Where this is not possible, the risk management strategies should have ensured that this analysis is not core to the needs of the impact assessment.
Privacy of participant data compromised (low risk,	Covered by WP3.7 all reasonable measures will be taken to ensure privacy.	Participants will be informed of privacy compromise and

Risk including risk severity (e.g. low, medium, high)	**Reduction (how the risk can be managed)**	**Solution (if the risk happens)**
high severity)	Protocols will be developed based on expert advice. Data stored in lockable filing systems – no personal data stored on database. Participant identification shredded shortly after use.	appropriate remedial actions will be taken in consultation with participants.
Commercially confidential data compromised (low risk, high severity)	Covered by WP3.7. Protocols will be developed. Stakeholders will be informed before participation that all reasonable measures will be taken to ensure commercially sensitive information will be kept confidential. Covered by consortium agreement plus other appropriate documentation as advised by experts.	Stakeholders will be informed of compromise and appropriate remedial actions will be taken in consultation with stakeholders.
Non-agreement on aspects of data analysis between SP4 partners (medium risk, medium severity)	Multiple partners in WPs on analysis and implications (WPs 4.3-4.7). All analysis WP partners have significant expertise in the relevant areas and have common research	Conflict resolution procedures defined in consortium agreement and managed in WP1.1

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

Other Potential Problems and Solutions

(1) Combination of Functions

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

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

(2) Subjective Data

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

The Questions

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

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

The answers to open-ended questions will take longer to analyse than close-ended. Missing data is more common for open questions than closed. Furthermore, most often these answers must be coded which in itself may result in errors. This can be avoided by the support of a clear and consistent code key. Furthermore, in an interview situation, the interviewer can summarise the answer or group of answers, and allow the interviewee to agree or disagree and/or to comment on the interpretation. Consistency in coding can be checked by comparing several independent analysts' coding of the whole or a subset of the collected data. Questions can also be direct or indirect. An indirect question directs the interviewee's attention to another person (or to other persons) other than the interviewer and can be a way to address more sensitive questions or areas where a "true" answer may not be anticipated.

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

CONCLUSIONS

This document has produced the following information for use by the test sites, the Data Working Group and the data analysts

- A full list of the **Core** safety hypotheses to be addressed by the safety impact (in conjunction with activities in SP2)
- A comprehensive list of the variables required in order to test the hypotheses
- Details of how the data are to be collected for each variable
- A list of variables that require additional scripting
- An analysis strategy for each hypothesis

The information should be used initially by the test sites to finalize their experimental designs and data collection requirements. It should also be used by the Data Working Group to assist the data specification, task 2.3.1 WP2.3. In particular the definition, scripting and calculation of these for all impact areas is critical for the successful analysis of the data since the analysis will not be done on the raw data streams. In particular the following have yet to be undertaken and needs to be co-ordinated through the DWG

- Coding of scripts to generate the values
- Data base design to accommodate this
- Storage of data centrally to enable this post-processing scripting
- Agreement of responsibilities

It is important to realize that this draft analysis plan has been developed ahead of data being collected. It is essential that pilot FOTs are undertaken so that the feasibility of collecting the required data can be assessed. Once the data starts to flow pilot analyses should be undertaken to test the feasibility of answering each hypothesis and allow for contingencies to be set in place where necessary.

It is clear that whilst strategies are suggested that use logged quantitative data, there is a heavy reliance upon data from qualitative sources and in particular the travel diaries. It is therefore essential that sufficient data is collected from the diaries in order to ensure robust conclusions can be made. At the time of writing this deliverable, these decisions are in discussion within SP2 and SP4.

ANNEX 1 CORE RESEARCH QUESTIONS AND HYPOTHESES SELECTION PROCESS

This annex sets out a process for choosing and recording the Research Questions and Hypotheses within TeleFOT, at a level of detail that enables:

- SP2 to develop D2.2.1 'Testing & Evaluation Strategy and IR2.2.3./2.2.4.
- SP3 to identify what core data the different test sites need to collect
- SP4 (WPs 4.3-4.7) to complete the Deliverables on analysis plans

IMPORTANT: this process does not mean starting again, it builds on D2.2.1.

Overview

TeleFOT needs to identify, for each impact area, Research Questions and Hypothesis that are relevant not only to the functions under current assessment but that can also be applied to any generic system that would be assessed in future FOTs. Thus the initial identification process should be system independent as far as possible, and should form an 'ideal' set of research questions. Subsequently a pragmatic subset (taken from the ideal set) should be chosen. These form the CORE SET to be addressed specifically by the FOTs undertaken in TeleFOT.

It is intended that this CORE SET of Research Questions and Hypotheses will be tackled by ALL test sites. There may also be additional ones, which individual test sites will address, based on particular interests and data capture capability.

Target Partners

The responsibility for choosing the Research Questions and developing the appropriate Hypotheses should rest with the individual impact area leaders:

WP4.3 Safety – **LOUGH**

WP4.4 Mobility – **VTT**

WP4.5 Efficiency – **CERTH / HIT**

WP4.6 Environment – **IKA**

WP4.7 User Uptake – **CHALMERS**

The impact area leaders should consult with others within their WP as necessary.

RELEVANT PARTS OF DELIVERBALE D2.2.1

The process detailed in this annex should:

Use and build on the following parts of D2.2.1:

Section 3.2 Generating hypotheses top-down and bottom-up

Section 4.1 From hypotheses to measurement

Appendix III Research Questions, Hypotheses, Performance Indicators and Measures

Enable the following parts of D2.2.1 to be developed:

Section 3.3 Tentative list of common research questions & hypotheses

Section 8.2 Data to be collected

Section 8.3 Data collection methods & tools

Stage 1 – identify the 'ideal' generic FOT research questions & hypotheses

The first stage is to ensure that each Impact WP leader has finalised the 'ideal' set of Research Questions (those generic to any evaluation in any FOT), starting with the over-arching first level questions, and arriving at a set of third level questions that are sufficiently specific that Hypothesis can be generated for them. This process does not mean starting again; it must make use of the previous work undertaken in D2.2.1 'Testing and Evaluation Strategy'.

This stage should finalise the red area highlighted below in Tables III.i to III.v in Appendix III of D2.2.1. Particularly, it must identify a full set of hypotheses (the current tables give example hypotheses, others may be applicable). Note that a Third Level Research Question can have more than one Hypothesis associated with it.

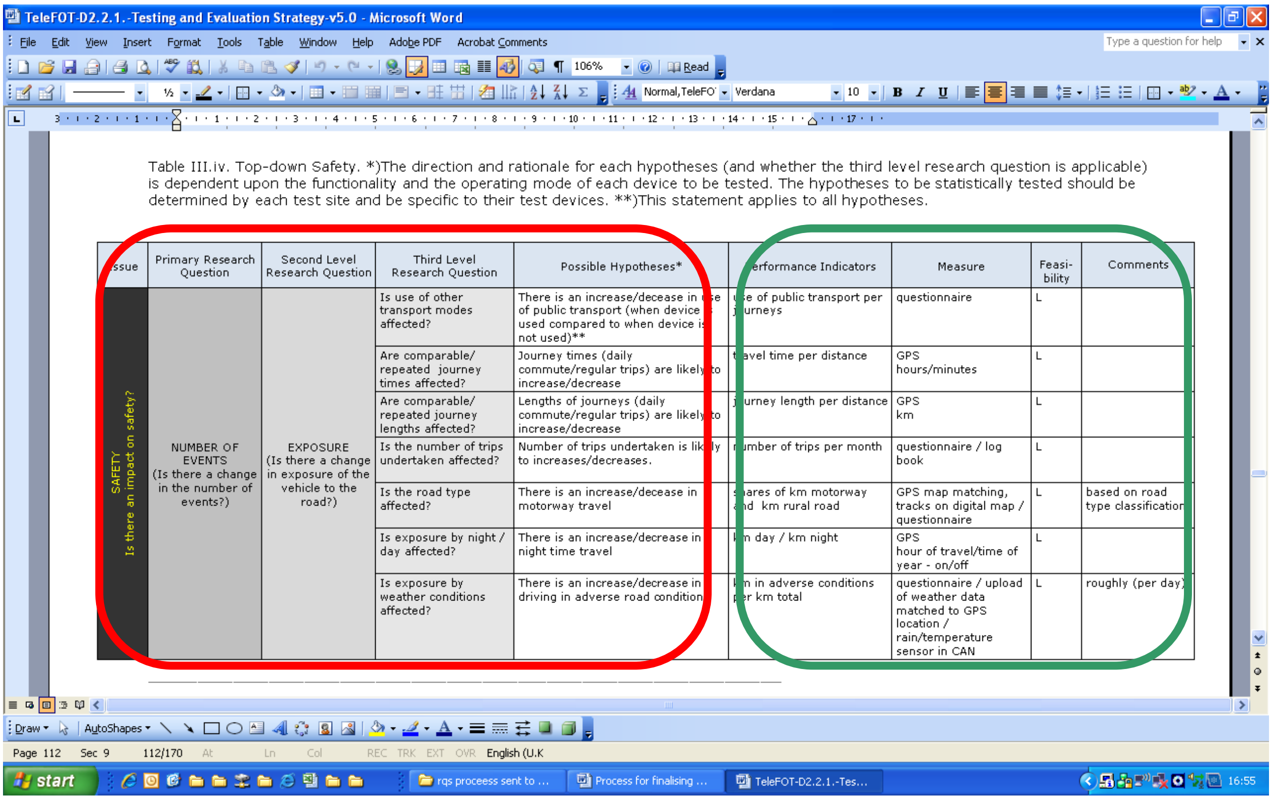

Table III.iv. Top-down Safety. *)The direction and rationale for each hypotheses (and whether the third level research question is applicable) is dependent upon the functionality and the operating mode of each device to be tested. The hypotheses to be statistically tested should be determined by each test site and be specific to their test devices. **)This statement applies to all hypotheses.

Issue	Primary Research Question	Second Level Research Question	Third Level Research Question	Possible Hypotheses*	Performance Indicators	Measure	Feasi-bility	Comments
SAFETY Is there an impact on safety?	NUMBER OF EVENTS (Is there a change in the number of events?)	EXPOSURE (Is there a change in exposure of the vehicle to the road?)	Is use of other transport modes affected?	There is an increase/decease in use of public transport (when device is used compared to when device is not used)**	use of public transport per journeys	questionnaire	L	
			Are comparable/ repeated journey times affected?	Journey times (daily commute/regular trips) are likely to increase/decrease	travel time per distance	GPS hours/minutes	L	
			Are comparable/ repeated journey lengths affected?	Lengths of journeys (daily commute/regular trips) are likely to increase/decrease	journey length per distance	GPS km	L	
			Is the number of trips undertaken affected?	Number of trips undertaken is likely to increases/decreases.	number of trips per month	questionnaire / log book	L	
			Is the road type affected?	There is an increase/decease in motorway travel	shares of km motorway and km rural road	GPS map matching, tracks on digital map / questionnaire	L	based on road type classification
			Is exposure by night / day affected?	There is an increase/decrease in night time travel	km day / km night	GPS hour of travel/time of year - on/off	L	
			Is exposure by weather conditions affected?	There is an increase/decrease in driving in adverse road condition	km in adverse conditions per km total	questionnaire / upload of weather data matched to GPS location / rain/temperature sensor in CAN	L	roughly (per day)

Figure 1: Process for the identification of the 'ideal' generic FOT research questions & hypotheses.

These 'ideal' research questions should be research-driven, and not take into account any aspects of data collection or analysis – they should identify the most important questions that should be addressed from the point of view of each impact area. The research questions should also be system-independent, since one aim of TeleFOT is to consider all forms of nomadic/aftermarket devices.

This 'ideal set' must be kept as a future reference tool for other FOTs.

Stage 2 – identify the 'CORE SET' of TeleFOT Research questions

The second stage is to identify which Research Questions and Hypothesis will be tackled specifically within TeleFOT, taking into account those which are most important within TeleFOT, and the feasibility of tackling them. Decisions made when choosing this CORE SET should be documented i.e. why certain Research Questions or Hypotheses from the 'ideal set' were included in/excluded from the 'core set'.

It is the responsibility of each impact leader to ensure that they are confident that results will be achieved from each hypothesis and that the number of hypotheses is kept manageable and meaningful for all partners involved in the data collection.

The feasibility of each hypothesis can only be determined via an iterative process of Stage 2a and Stage 2b below. It should result in a sub-set of the Hypotheses in the red area above and an expansion of the green area. All of this should be reported in the same structure as the table provided alongside this document.

STAGE 2a – *Important* Research Questions for TeleFOT

Based on the 'ideal' set, each impact area leader should identify the third level Research Questions and associated hypotheses that are most important to TeleFOT, based on the following criteria:

- Most important from a research perspective (your expert knowledge and research literature)
- The expectations of the Commission (including feedback from the annual review)
- Expectations of partners
- Expectations of other stakeholders and funding bodies (e.g. public, industrial organisations, national governments)

STAGE 2b – *Feasible* Research Questions for TeleFOT

Having identified which third level Research Questions and Hypotheses are most important for TeleFOT, it is necessary to assess their feasibility within the project, to include data collection and data analysis. This can only be done by identifying, in detail, how the data necessary to test a hypothesis needs to be collected. Note that this can include objective data collected via an in-car data logger, and data collected from drivers, via questionnaires, interviews, focus groups etc.

In order to determine the feasibility of specific Hypotheses, it is necessary to detail the variables that must be recorded, how these are measured, and where this data comes from.

This stage expands the green area above.

There are three sets of variables associated with each hypothesis:

Table 5: Types of Variables

Type of variable	**Role**	**Example**
Variable(s) to SELECT ON	Variable(s) recorded in the database so appropriate data files can be selected for analysis	Speed advisor system present and operating
Variable to ANALYSE (dependent variable)	Used to measure the impact of the nomadic device	Number of speed violations per road section
Variable(s) used to INTERPRET results	Used to interpret any impact that has been determined, and come to conclusions regarding why effects have occurred	Driver attitudes to speeding Time pressures Lead traffic situation

For each variable, the specific measure must be described, together with the source of the data.

Table 6 below shows the resulting table for the safety impact assessment

Stage 3 –TeleFOT consensus on Research questions

There must be project consensus on the final set of Research Questions – to ensure that the overall project needs are met, and that the data collection methods (that will be used by the whole project) are feasible. It is anticipated that, once the WP4.3-4.7 leaders have separately identified their CORE SET, the TeleFOT Core Group will agree on a final CORE SET of Research Questions to be addressed, and data collection methods to be used across all the test sites.

Table 6: Safety Hypothesis Feasibilty

SAFETY: ALL FUNCTIONS (Navigation, Traffic, Speed alert, Speed information, Green driving) eCall to be added								
			Variables to SELECT on (variables that the FOT must record/measure so that you can SELECT the appropriate data files for analysis)		**Variables to ANALYSE** (variables that the FOT must record/measure so that you can ANALYSE the impact of the nomadic device, i.e. the dependent variables)		**Variables to INTERPRET results** (variables that the FOT must record/measure so that you can INTERPRET the results and come to conclusions about why the effects have occurred)	
Third Level Research Question	**Hypothesis**	**Impact/Implication**	**Measure**	**Data source & whether in L +/or D-FOT**	**Measure**	**Data source & whether in L +/or D-FOT**	**Measure**	**Data source & whether in L +/or D-FOT**
1. Is the route affected (where the travel takes	**1.1 There is a change in the proportion of road types**	Some roads types are, according the accident statistics, more dangerous than	Device in use or not for the 'with' part of the LFOT	ND Task Manager – LFOT Travel Diary – LFOT	Road type • Speed limit • Number of	Map matching in LFOT Experimentally controlled DFOT	Did the device influence the route choice or was there another reason	Travel diary OR Interview

place)	**driven on when the device is used compared to when it is not.**	others (e.g. motorways versus high speed single carriageway)		Always used DFOT	carriageways • Depends on what NavTeq can provide			LFOT Always take ND advice in DFOT
	IMPORTANT NOTES FOR THIS HYPOTHESIS • If assessed in an LFOT, would have to make assumptions that over the assessment period comparable journey patterns occurred or you need to pick out matched start and destination from both the before and after and look at the road type used in these matched pairs • Need to understand what NavTeq map matching variables look like • LFOT and DFOT		Specific driver	Data logger (if only one possible driver per vehicle) + travel diary (if multiple drivers per vehicle) L	Length (km) driven on each road type. Event log each time road type changes according to the definitions in 'road type' variable – then GPS gives distance between each	Map matching in LFOT GPS in LFOT Experimentally controlled in DFOT	Reason for using ND on this journey/leg/link	Travel diary OR Interview L

				event marker			
		Journey/leg start and finish position	GPS or other data logger LFOT Experimentally controlled in DFOT				
1.2 People choose different routes (based on road type) when the device is used compared to when it is not	Some roads types are, according the accident statistics, more dangerous than others (e.g. motorways versus high speed single carriageway)	Applicable to all subjects	N/A	Ranking of influence of device on route choice	Questionnaire	Additional probing questions relating perceived change in road type e.g. did you find you were travelling more often on motorways because of the device's influence?	Questionnaire
IMPORTANT NOTES FOR THIS							

	HYPOTHESIS • This hypothesis is to be answered subjectively. It is anticipated that at the exit questionnaire or interview the subject will be asked how influential the ND was on their rout choices. This will perhaps be a ranked answer and appropriate statistics applied. (e.g. 60% very, 20 % a little, 20% not at all) • LFOT only							
	1.3 There is a change in the proportion of urban/rural driving when the device is used compared to when it is not	Some roads types are, according the accident statistics, more dangerous than others (e.g. motorways versus high speed single carriageway)	Device in use or not for the 'with' part of the LFOT	ND Task Manager – LFOT Travel Diary – LFOT Always used DFOT	Road type • Urban / rural	Map matching in LFOT Experimentally controlled DFOT	Did the device influence the route choice or was there another reason	Travel diary OR Interview LFOT Always take ND advice in DFOT
	IMPORTANT NOTES FOR THIS		Specific driver	Data logger (if only one	Length (km)	Map matching in LFOT	Reason for using ND on	Travel diary

	HYPOTHESIS • If assessed in an LFOT, would have to make assumptions that over the assessment period comparable journey patterns occurred or you need to pick out matched start and destination from both the before and after and look at the road type used in these matched pairs • Need to understand what NavTeq map matching variables look like – can urban/rural be defined • LFOT and DFOT		possible driver per vehicle) + travel diary (if multiple drivers per vehicle) L	driven on each road type. Event log each time road type changes according to the definitions in 'road type' variable – then GPS gives distance between each event marker	GPS in LFOT Experimentally controlled in DFOT	this journey/leg/link	OR Interview LFOT N/A DFOT
		Journey/leg start and finish position	GPS or other data logger LFOT Experimentally controlled in DFOT				

2. Is the amount of time on the road affected (how long travel takes place for)?	2.1 Subjects report a change in the number of trips undertaken because they have the device	An increase in journeys implies an increased exposure and as exposure increases the likelihood of accident involvement increases	Applicable to all subjects	N/A	Ranking of influence of device on making a trip or a single yes/no question	Questionnaire	N/A	N/A
	IMPORTANT NOTES FOR THIS HYPOTHESIS • This hypothesis is to be answered subjectively. It is anticipated that at the exit questionnaire or interview the subject will be asked how whether they made trips because they had the device that they would not otherwise have made. This could be ranked or a simple yes/no • LFOT only							
	2.2 There is a change in the distance	An increase in journey length implies an increased	Device in use or not for the 'with' part of the FOT	ND Task manager – LFOT Travel Diary – LFOT	Length (km) of journey / leg /link	GPS co-ordinates Map matching How is length of	Need to know that route selection was due to the	Travel diary

	travelled between comparable origins and destinations	exposure and as exposure increases the likelihood of accident involvement increases		Always used DFFOT		each link derived?? Experimentally controlled in DFOT – can be logged from the odometer	device	
	IMPORTANT NOTES FOR THIS HYPOTHESIS • The challenge here is making the situation in the before and after comparable. As many of the confounding factors as possible need to be controlled by carefully matching journeys in the before part of the study with those after. This may need to be analysed at the leg or link level in order to make sense. • Need to understand how the 'Length' of the link etc reaches the database.		Specific driver	Data logger (if only one possible driver per vehicle) LFOT + travel diary (if multiple drivers per vehicle) LFOT Always known in DFOT				
			Journey start / finish Leg start / finish Link start / finish	GPS or other logging device LFOT Experimentally controlled and Logged in DFOT				

	2.3 Subjects report a change in the distance travelled between comparable origins and destinations	An increase in journey length implies an increased exposure and as exposure increases the likelihood of accident involvement increases	Applicable to all subjects	N/A	Yes/No answer to structures question	Questionnaire	N/A	N/A
	IMPORTANT NOTES FOR THIS HYPOTHESIS • Purely subjective perhaps part way through and then at the end of the trial where subjects are asked whether they thought that journeys were shorter / longer. There needs to be clarification that we mean in distance and for instances form the same origin to the same destination.							

	2.4 There is a change in the duration of journeys travelled between comparable origins and destinations	Increase in journey time implies increase in exposure and increase in accident risk	Device in use or not for the 'with' part of the FOT	ND Task manager – LFOT Travel Diary – LFOT Always used DFFOT	Time (mins) of journey / leg /link	GPS co-ordinates Map matching How is duration of each link derived?? Easy to log in DFOT	Need to know that route selection was due to the device	Travel diary
	IMPORTANT NOTES FOR THIS HYPOTHESIS • The challenge here is making the situation in the before and after comparable. As many of the confounding factors as possible need to be controlled by carefully matching journeys in the before part of the study with those after. This may need to be analysed at the leg or link level in order to make sense.		Specific driver	Data logger (if only one possible driver per vehicle) LFOT + travel diary (if multiple drivers per vehicle) LFOT Always known in DFOT				

	Need to understand how the 'duration' of the link etc reaches the database.		Journey start / finish Leg start / finish Link start / finish	GPS or other logging device LFOT Experimentally controlled and Logged in DFOT				
	2.5 Subjects reports a change in the duration of journeys travelled between comparable origins and destinations	An increase in journey length implies an increased exposure and as exposure increases the likelihood of accident involvement increases	Applicable to all subjects	N/A	Yes/No answer to structures question	Questionnaire	N/A	N/A
	IMPORTANT NOTES FOR THIS HYPOTHESIS • Purely subjective perhaps part way through and then at the end of the trial where subjects are asked whether they thought that journeys took longer / less time. There needs to be							

	clarification that we mean in distance and for instances form the same origin to the same destination.							
	2.6 There is a change in the length of time driven without a break	Long periods are driving without a break can cause fatigue and an increased risk if an accident	Journey length in time when car is in motion	GPS or other data logger	Vehicle in motion during journey	Key on / off Movement from GPS / logger	Reason for each break or an overall observed shift in behaviour	Travel diary Interview
	IMPORTANT NOTES FOR THIS HYPOTHESES This is only applicable to longer journeys over X amount of time		Device in use or not for the 'with' part of the FOT	ND Task manager – LFOT Travel Diary – LFOT Always used DFFOT	Vehicle stationary for the purpose of a break (based on location)	Points of interest from map matching No movement from GPS / Logger Travel diary reporting duration of breaks		

	LFOT only							
3. Does the device cause distraction	3.1 The duration and/or frequency of glances to defined target areas of the visual scene changes	Visual distraction from the primary driving tasks will increase risk of accidents	Device in use or not for the 'with' part of the FOT	Always used DFOT	Number of glances AND/OR Duration of glances	Video Seeing machine CAA	Level of driving experience (due to impact on visual scanning behaviour)	Participant selection process Background questionnaire
	IMPORTANT NOTES FOR THIS HYPOTHESES DFOT only Portion of journey for analysis must be consistent across 'conditions' i.e. by time or distance or task Balance of set up (time consuming for		Portion of journey where - system presents new visual information OR - driver requests new visual information OR - driving	ND Task manager OR Video of system OR GPS & map-matching	Target of glance (e.g.) • Forward view • Side view • Mirrors • Device • Other	Visual tracking equipment (e.g. Seeing machines, CAA) Video	Other 'non function' related reason for looking at device e.g. receiving texts on smart phone, boredom.	Visual tracking equipment (e.g. Seeing machines, CAA) Video of system Interview

	seeing machine) and time spent analysing video footage Ideally, this should be done by the subjects who taking part in the LFOT and should be undertaken prior the LFOT and at strategic points during the LFOT to assess change over time Need to base driving experience selection criteria on any research evidence relating this to impact on visual behaviours	situation means driver is likely to need visual information from the system (supply and/or demand driven) Selected according to: - Time (related to location or event) OR - Distance (related to location or event) OR - Task start/end		internal objects			
		Driver	Defined by D-FOT			Other reasons for changes to visual scanning behaviour (e.g. glare on screen, distraction from external sources)	Visual tracking equipment (e.g. Seeing machines, CAA) Video of system Interview

			Drivers visual ability and corrections (spectacle use etc)	Participant selection process Background questionnaire				
			Drivers' experience with device	Participant selection process Background questionnaire				
4 Is speed affected	4.1 The number of speed violations / proportion of time spent in excess of speed limit changes with the device	Excessive speed beyond that recommended for he road is bad for safety	Device in use or not for the 'with' part of the LFOT	System always used in DFOT	Road type • Speed limit • Number of carriageways • Depends on what NavTeq can provide	Map matching in FOT Experimentally controlled DFOT	Did the device influence the route choice or was there another reason	Travel diary OR Interview LFOT Always take ND advice in DFOT

	IMPORTANT NOTES FOR THE HYPOTHESIS Some devices may result in drivers driving more slowly because that is the functionality of the system (e.g. speed alert) In other cases, the driver may drive more quickly as they have more confidence in where they are going (e.g. navigation system) and they know that they are unlikely to encounter congestion (e.g. traffic information)		Specific driver	Data logger (if only one possible driver per vehicle) + travel diary (if multiple drivers per vehicle)	Speed of vehicle on each road type.	Map matching in LFOT GPS in LFOT Experimentally controlled in DFOT	Reason for using ND on specific journeys – especially relating to speed alert	Travel diary OR Interview
							Driving history in terms of prevalence to violations – prior offences	Questionnaire – screening – need to ensure confidentiality

	4.2 There is a change in the average speed		Speed [m/s]	GPS/ CAN messages → L, D	Average speed [m/s]	GPS/ CAN messages → L, D		
			Driver ID	PND/ Data logger/ Travel Diary →L				
5. Is vehicle positioning affected (proximity and lane positioning)?	5.1 the longitudinal positioning of the vehicle will change as a result of having the nomadic device	There will be a change in headway clearance distance as the driver is informed that he/she is too close to the vehicle in front.	Device in use	Device always used in DFOT	Distance to preceding vehicle (how would we measure this - laser?) with device on/off	Experimentally controlled	Underlying reason for close proximity to preceding vehicle in the first place – related to personality type	Questionnaire

	IMPORTANT NOTES FOR THE HYPOTHESIS DFOT only – the headway distance cannot be measured in a LFOT May be difficult to do because of ethical considerations (i.e. enhanced risk of crash?)		Specific Driver	Always known in the DFOT			Does the device influence the headway distance or is it ignored after a while	Allow subject to decide whether to heed advice in trials Interview post-trial
	5.2 The lateral positioning of the vehicle will change as a result of having the nomadic device	The vehicle is more likely to stay within its own lane of travel	Device in use	Device always used in DFOT	Lane position (how would we measure this - laser?) with device on/off	Experimentally controlled	Does the device influence the lane-keeping behaviour or is it ignored after a while	Allow subject to decide whether to heed advice in trials Interview post-trial
	DFOT only – the lateral movement cannot be measured in a LFOT May be difficult to do because of ethical considerations (i.e. enhanced risk of crash?)		Specific Driver	Always known in the DFOT				

6. Is braking affected?	6.1 the device changes braking behaviour	The device provides information to the driver indicating that the vehicle is too close to the preceding vehicle. As a result, there is less of a requirement for harsh braking (LDW) or because of distraction harsh braking occurs	Device in use	Data logger Always used in DFOT	Harsh braking – needs to be defined	GPS / accelerometer	Need to be certain that specific braking behaviours are observed as a result of the information provided by the system / or as a result of added distraction and are NOT normal driving behaviour by subjects – this may not be easy	Select subjects of specific characteristic s?
	IMPORTANT NOTES FOR THE HYPOTHESIS Mainly DFOT Might be possible within LFOT if data		Specific driver	Always known in DFOT	Eye glance info see distraction above	Video		

	logger can sample acceleration/deceleration at a relevant frequency but unlikely. The idea of friction of the road surface has been postulated. For harsh braking relating to added distraction, need to know about the distraction and therefore DFOT only				When and what info received from device	Device management centre		
7.Is non driving manual activity affected	7.1 There is a change in the duration of hands off wheel time	Removing hands from wheel results in loss of control of vehicle	DFOT Device on / off	Always used DFOT	Number of times hands removed from wheel / duration of time hands removed from wheel	Video CAA	Level of driving experience	Participant selection process Background questionnaire
	IMPORTANT NOTES FOR THE HYPOTHESIS Will not be evaluated as part of the FOT itself – photographs of subjects' vehicles will be taken at the outset of the study to look at mounting positions.		Portion of journey where system presents new information or driver requests new information or driving situation means that driver is likely to need information from the	ND task Manager Video system GPS and map matching			Other non function related reason for taking hands off wheels e.g receiving texts on smart phone	Video Interview

		system. Selected according to time (related to the location or event) or distance (related to the location or event) or task start/end					
		Driver	ID or defined in DFOT			Other reasons for changes to manual behaviour (e.g. operating devices other than ND)	Video Interview
		Drivers' experience with device	Participant selection process Background questionnaire				

ANNEX 2 LITERATURE TO SUPPORT RQ SELECTION

Is the route affected where travel takes place?

Different types of roads can pose more of a risk of accidents occurring than others. If the satellite navigation devices take people on different types of roads to those which they would normally choose this could have an effect on their safety. Road Safety Foundation (2009) takes account of 45,000km of the country's motorways and A-roads and found that 62% of fatal or serious collisions happen on single carriageways, 13% on dual carriageways and 10% on motorways. They also found single carriageways are twice the risk of dual carriageways and 6 times riskier than motorways. Risk is 30 percent higher on non-primary A roads compared to primary A roads.

Is the amount of time on the road affected (how long travel takes place for)?

Chipman, MacGregor et al. (1993) showed among other factors such as time of day and road choice the amount of exposure (distance travelled and time it took) has an effect on the drivers crash risk. They also conclude that time spent driving may be a better estimate of risk than distance as people take more time to drive through more hazardous situations so can give an estimate of the high and low risk road segments. Janke (1991) states that '*if two groups of drivers are equally competent and prudent, but differ in miles driven, the higher mileage group will have more accidents on average because of their greater exposure to risk*'. This shows how the car navigation devices could possibly affect driver's safety if the device encourages drivers to use their car more and so have a greater exposure to risk.

Is when travel takes place affected?

The navigation device could lead to travelling at different times on the road and may drive in more varied conditions such as in the dark and in wet or icy weather which could have an impact on their safety. The Department for Transport (2009) shows that on all types of road and in all weather conditions there were 124,541 accidents in daylight and 170,591 accidents in the dark. Lin, Fearn (2003) found that night time driving restrictions effectively reduced the likelihood of a fatal injury in young drivers. This shows that driving in the dark can be dangerous for some user groups and if navigation systems lead to an increase in willingness to expose themselves to night time driving then this could have an effect on their safety. Ranney, Simmons et al. (1999) found using a simulator study that it takes longer to detect targets and also found impaired critical tracking performance during night time conditions. Anderson, Holliday (1995) also found effects of the dark on driver's performance in relation to contrast sensitivity. Simulated lens opacities that have no effect on day time measures of visual acuity had a significant effect on night time measures of contrast sensitivity for moving targets, meaning anyone with impaired vision could perform significantly worse when driving at night compared to in the day. The weather can also have an effect on driving performance. Keay, Simmonds (2006) found that rainfall consistently represents a driving hazard. Similarly Brodsky, Hakkert (1988) found that added risk of an injury accident can be two to three times greater in the wet than in the dry. A more recent study by Brijs, Karlis et al. (2008) found similar results. This shows if people drive in different conditions due to using a satellite navigation device then this could have safety implications.

Is fatigue affected?

Driver fatigue is known to occur when driving requires sustained attention over long periods (Lal, Craig 2001). Häkkänen, Summala (2001) found driver fatigue, when taking into consideration those who had fallen asleep and those who had felt tired preceding the accident, was estimated to occur in 4% of trailer truck drivers involved in accidents. Connor, Norton et al. (2002) found decreased levels of self reported alertness were associated with increased risk while driving. There was also an eightfold increased risk if drivers reported sleepiness. Lardelli-Claret, Luna-Del-Castillo et al. (2003) found that drowsiness was strongly associated with collisions, surprisingly even more so than for alcohol usage. Ting, Hwang et al. (2008) found that in the last 10 minutes of a 90 minute simulated driving task median reaction times were 0.31 seconds longer than in the first period of the session, this equates to an additional 8 meters in stopping distance if the driver was travelling at 100km/h. The results clearly demonstrate that the effect of time-on-task is a significant cause of fatigue and risk of accidents.

Is workload affected?

The secondary task of interacting with the in vehicle information system (IVIS) may have an effect on the drivers workload which could lead to reduced safety if carrying out the primary task of driving and the secondary task of interacting with the IVIS exceeds the drivers threshold. Törnros, Bolling (2005) looked at the effects of mobile phone use on driver workload and the effects this had on performance. They found that both hand held and hands free phone use while dialling had an effect on the lateral control of the vehicle and this was '*interpreted as an indication of reduced safety'.* Santos, Merat et al. (2005) found that when comparing driving with and without an IVIS system in use, in both a simulated environment and on the road, participants self-report data indicated that they clearly felt a performance decrement in the simulator and instrumented vehicle when IVIS was in use. Hamish Jamson, Merat (2005) looked at IVIS systems and both the visual and cognitive demands these can place on the driver. They found that drivers '*seemed incapable of fully prioritising the primary driving task over either the visual or cognitive secondary tasks as an increase in IVIS demand was associated with a reduction in driving performance: drivers showed reduced anticipation of braking requirements and shorter time-to-collision*'. This shows how IVIS systems could possibly have an effect on driver safety if they lead to increased workload and so change their behaviour such as leaving less braking time. Hancock, Verwey (1997) also suggests that high workload tasks may lead to fatigue which is also believed to affect safety, see '*is fatigue affected'* section above. Blanco, Biever et al. (2006) looked at the effect of IVIS systems on driving performance and found that multiple decision making elements in a task had a negative impact on driving performance of both car drivers and truck drivers when compared to tasks with only one decision-making element. They also said in reference to cognitive demands that '*this single factor may influence the safety of the automotive tasks to a greater degree than any other factor'.*

Does the device cause visual distraction?

The nomadic device could possibly affect the visual behaviour of the driver which could intern lead to an increased likelihood of collisions. Information collected from police reported crashes found that up to 12.9% of crashes were identified as being due to the driver being distracted. Of the 12.9% up to 64% of these distracters could be classed as being in vehicle visual distractions e.g. adjusting radio, adjusting climate control or dialling a mobile phone (Stutts, Reinfurt et al. 2001). Horberry, Anderson et al. (2006) found that in vehicle tasks such as interacting with the entertainment system can affect driving performance, such as the driver's ability to maintain speed and their preparedness to react to unexpected events. Reed-Jones, Trick et al. (2008) found that devices with a higher static time on task (time spent interacting with the device) produced significantly more lane deviations than devices which required less interaction. They also found some in vehicle distracters had significant impacts on collision and hazard response time. Maciej, Vollrath (2009) found a strong distraction effect caused by in vehicle information systems with reduced lane discipline and increased reaction time needed to change lane. This was shown to be mainly due to visual distraction shown by the 30 to 40% off windscreen glance time. Memarovic (2009) showed similar results, finding that drivers using a navigation device with a graphical display spent less time looking at the road in comparison to a device that gave audible directions only. Memarovic also found a correlation between glancing at the display and a higher variance in driving performance measures. In a recent simulator study by Chisholm, Caird et al. (2008) it was found that when drivers interacted with an iPod there was an increase in collisions and perception response time. They also found that difficult iPod tasks significantly increased the amount of attention directed in the vehicle. Chisholm, Caird et al. (2008) conclude that '*future research should identify related device functions (e.g., on other MP3 players, Blackberries, iPhones and so fourth) that produce prolonged glance behaviour*'.

Is speed affected?

Aarts, van Schagen (2006) conducted a review of the link between driving speeds and the risk of road crashes. They said '*at high speeds the time to react to changes in the environment is shorter, the stopping distance is larger, and manoeuvrability is reduced*'. Maycock et al (1998) (as cited in Aarts, van Schagen (2006)) found that a 1% increase in speed is related to a 13.1% increase in crash liability. Kloeden, McLean et al. (1997) found cars involved in casualty crashes were generally travelling faster than cars that were not involved in a crash and more importantly 14 per cent of casualty crash involved cars were travelling faster than 80 km/h in a 60 km/h speed zone, compared to less than 1 per cent of those not involved in a crash. This shows the effect that exceeding the speed limit can have on driver's safety.

Is vehicle positioning affected (proximity and lane positioning)?

Patel, Council et al. (2007) found approximately 40% of all 2004 fatal crashes were single-vehicle, run-off-the-road crashes, and also noted '*the problem was even more significant on two-lane rural roads, where shoulder rumble strips were an important treatment in the prevention of these*'. This shows how important maintaining appropriate lane positioning is, as deviations in lateral control accounts for a high percentage of automotive fatalities. Knipling (1993) found 'th*e most common contributing causal factor associated with rear-end crashes is driver inattention to the driving task. A second, and overlapping, major causal factor is following too closely. One or both of these factors are present in approximately 90 percent of rear-end crashes*'. Therefore if the navigation device affects proximity to the vehicle ahead then this can have a major effect on the vehicle occupant's safety.

Is braking affected?

Lamble, Kauranen et al. (1999) found drivers detection ability in a closing headway situation was impaired by about 0.5 s in terms of brake reaction time and almost 1s in terms of time to collision, when they were doing a non-visual cognitive task whilst driving. Al-Darrab, Khan et al. (2009) found similar results, they discovered mobile phone call duration had more of an effect on the driver's braking response times than both time of day or head way between the cars. These studies show how driver distraction can have an effect on braking behaviour which could possibly have an effect on the driver's safety as well as the safety of any other road users who are in close proximity.

REFERENCES

AARTS, L. and VAN SCHAGEN, I., 2006. Driving speed and the risk of road crashes: A review. *Accident Analysis & Prevention,* **38**(2), 215-224.

AL-DARRAB, I.A., KHAN, Z.A. and ISHRAT, S.I., 2009. An experimental study on the effect of mobile phone conversation on drivers' reaction time in braking response. *Journal of Safety Research,* **40**(3), 185-189.

ANDERSON, S.J. and HOLLIDAY, I.E., 1995. Night driving: effects of glare from vehicle headlights on motion perception. *Ophthalmic and Physiological Optics,* **15**(6), 545-551.

BLANCO, M., BIEVER, W.J., GALLAGHER, J.P. and DINGUS, T.A., 2006. The impact of secondary task cognitive processing demand on driving performance. *Accident Analysis & Prevention,* **38**(5), 895-906.

BRIJS, T., KARLIS, D. and WETS, G., 2008. Studying the effect of weather conditions on daily crash counts using a discrete time-series model. *Accident Analysis & Prevention,* **40**(3), 1180-1190.

BRODSKY, H. and HAKKERT, A.S., 1988. Risk of a road accident in rainy weather. *Accident Analysis & Prevention,* **20**(3), 161-176.

CHIPMAN, M.L., MACGREGOR, C.G., SMILEY, A.M. and LEE-GOSSELIN, M., 1993. The role of exposure in comparisons of crash risk among different drivers and driving environments*. *Accident Analysis & Prevention,* **25**(2), 207-211.

CHISHOLM, S.L., CAIRD, J.K. and LOCKHART, J., 2008. The effects of practice with MP3 players on driving performance. *Accident Analysis & Prevention,* **40**(2), 704-713.

CONNOR, J., NORTON, R., AMERATUNGA, S., ROBINSON, E., CIVIL, I., DUNN, R., BAILEY, J. and JACKSON, R., 2002. Driver sleepiness and risk of serious injury to car occupants: population based case control study. *British medical journal,* **324**(7346), 1125.

DEPARTMENT FOR TRANSPORT, 2009. Reported Road Casualties Great Britain: 2008 Annual Report. London: Crown.

DOBSON, A.J., 2002. An introduction to generalised linear models. Chapman & Hall, London.

EVERITT, B.S. The Analysis of Contingency Tables. 2nd Edition. Chapman & Hall, London.

HÄKKÄNEN, H. and SUMMALA, H., 2001. Fatal traffic accidents among trailer truck drivers and accident causes as viewed by other truck drivers. *Accident Analysis & Prevention,* **33**(2), 187-196.

HAMISH JAMSON, A. and MERAT, N., 2005. Surrogate in-vehicle information systems and driver behaviour: Effects of visual and cognitive load in simulated rural driving. *Transportation Research Part F: Traffic Psychology and Behaviour,* **8**(2), 79-96.

HANCOCK, P.A. and VERWEY, W.B., 1997. Fatigue, workload and adaptive driver systems. *Accident Analysis & Prevention,* **29**(4), 495-506.

HORBERRY, T., ANDERSON, J., REGAN, M.A., TRIGGS, T.J. and BROWN, J., 2006. Driver distraction: The effects of concurrent in-vehicle tasks, road environment complexity and age on driving performance. *Accident Analysis & Prevention,* **38**(1), 185-191.

JANKE, M.K., 1991. Accidents, mileage, and the exaggeration of risk. *Accident Analysis & Prevention,* **23**(2-3), 183-188.

KEAY, K. and SIMMONDS, I., 2006. Road accidents and rainfall in a large Australian city. *Accident Analysis & Prevention,* **38**(3), 445-454.

KLOEDEN, C.N., MCLEAN, A., MOORE, V. and PONTE, G., 1997. *Travelling speed and the risk of crash involvement.* Volume 1 (CR172). Federal Office of Road Safety, Transport and Communications, Canberra.

KNIPLING, R.R., 1993. IVHS technologies applied to collision avoidance: Perspectives on six target crash types and countermeasures, *Proceedings of the 1993 Annual Meeting of IVHS America: Surface Transportation: Mobility, Technology, and Society,* 1993, Citeseer pp249-259.

LAL, S.K.L. and CRAIG, A., 2001. A critical review of the psychophysiology of driver fatigue. *Biological psychology,* **55**(3), 173-194.

LAMBLE, D., KAURANEN, T., LAAKSO, M. and SUMMALA, H., 1999. Cognitive load and detection thresholds in car following situations: safety implications for using mobile (cellular) telephones while driving. *Accident Analysis and Prevention,* **31**, 617-623.

LARDELLI-CLARET, P., LUNA-DEL-CASTILLO, J.D.D., JIMÉNEZ-MOLEÓN, J.J., RUEDA-DOMÍNGUEZ, T., GARCÍA-MARTÍN, M., FEMIA-MARZO, P. and BUENO-CAVANILLAS, A., 2003. Association of main driver-dependent risk factors with the risk of causing a vehicle collision in Spain, 1990–1999. *Annals of Epidemiology,* **13**(7), 509-517.

LIN, M. and FEARN, K.T., 2003. The provisional license: night-time and passenger restrictions—a literature review. *Journal of Safety Research,* **34**(1), 51-61.

MACIEJ, J. and VOLLRATH, M., 2009. Comparison of manual vs. speech-based interaction with in-vehicle information systems. *Accident Analysis & Prevention,* **41**(5), 924-930.

MEMAROVIC, N., 2009. *The influence of personal navigation devices on the drivers' visual attention on the road ahead and driving performance*, University of New Hampshire.

PATEL, R.B., COUNCIL, F.M. and GRIFFITH, M.S., 2007. Estimating Safety Benefits of Shoulder Rumble Strips on Two-Lane Rural Highways in Minnesota: Empirical Bayes Observational Before-and-After Study. *Transportation Research Record: Journal of the Transportation Research Board,* **2019**(-1), 205-211.

RANNEY, T.A., SIMMONS, L.A. and MASALONIS, A.J., 1999. Prolonged exposure to glare and driving time: effects on performance in a driving simulator. *Accident Analysis & Prevention,* **31**(6), 601-610.

REED-JONES, J., TRICK, L.M. and MATTHEWS, M., 2008. Testing assumptions implicit in the use of the 15-second rule as an early predictor of whether an in-vehicle device produces unacceptable levels of distraction. *Accident Analysis & Prevention,* **40**(2), 628-634.

ROAD SAFETY FOUNDATION, 2009. *EuroRap 2009 Results.* Hampshire: Road Safety Foundation.

SANTOS, J., MERAT, N., MOUTA, S., BROOKHUIS, K. and DE WAARD, D., 2005. The interaction between driving and in-vehicle information systems: Comparison of results from laboratory, simulator and real-world studies. *Transportation Research Part F: Traffic Psychology and Behaviour,* **8**(2), 135-146.

STUTTS, J.C., REINFURT, D.W., STAPLIN, L. and RODGMAN, E.A., 2001. The role of driver distraction in traffic crashes*. University of North Carolina Highway Safety Research. Chapel Hill, NC. Prepared for AAA foundation for traffic Safety.* Retrieved November 22, 2009 from http://www.safedriver.gr/data/84/distraction_aaa.pdf.

TING, P., HWANG, J., DOONG, J. and JENG, M., 2008. Driver fatigue and highway driving: A simulator study. *Physiology & Behaviour,* **94**(3), 448-453.

TÖRNROS, J.E.B. and BOLLING, A.K., 2005. Mobile phone use—Effects of handheld and handsfree phones on driving performance. *Accident Analysis & Prevention,* **37**(5), 902-909.

TRIOLA, M.F., 2009. Elementary Statistics Using Excel. 4th Edition. Addison Wesley, New York.