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## REVISION CHART AND HISTORY LOG

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Executive Summary

The TeleFOT project investigates the impacts of functions brought to the driver by nomadic and aftermarket devices and the methodology chosen is Field Operational Tests (FOTs). The FESTA Handbook was used as the first approach for the implementation, execution and evaluation of the FOTs. The functions tested were Traffic information, Speed Limit Information, Speed Alert, Navigation Support (static), Navigation Support (dynamic), Green Driving Support, and eCall. The characteristics of these functions imply that they must be studied in a wider transportation context than just traffic and cover also transport and travel. Furthermore, the user must be studied in different roles as driver, passenger and traveller and the trip time line must be considered (i.e. trip planning and use during and after the trip). A consequence of that the platform used for the functions was not a vehicle but a nomadic device (to be used in a vehicle but also elsewhere) made it necessary to complement the FOT activities with controlled experiments. This resulted in a proposal for modification of the FESTA Handbook where also the well-known "FESTA V" was expanded to include a block "CONTEXT" to capture the wider use of the functions addressed (i.e. also outside the vehicle). Finally, a new and innovative top-down approach was added to improve the identification of research questions and hypotheses and in order to minimise the work at hand a prioritisation of the hypotheses using a cost-benefit approach was proposed and applied. These four proposed modifications have been accepted and are now found in the latest version 4 of the FESTA Handbook.

The following report has been accepted for the TRA 2012 Conference in Athens on 23-26 April, 2012. It was presented under the following title: Widening the use of the FOT methodology, Development based on experiences from the TeleFOT project.

Keywords: Type your keywords here, separated by semicolons ; Field Operational Test; FOT; Impact Assessment; Nomadic Devices; TeleFOT; FESTA Handbook
1. Introduction

The TeleFOT project investigates the impacts of functions brought to the driver and traveller by nomadic and aftermarket devices and the methodology chosen is Field Operational Tests (FOTs). A FOT is characterised by a large number of users using the systems and services in their daily life in real conditions for a long period of time. The FESTA Handbook was used as the first approach for the implementation, execution and evaluation of the FOTs.

The use of Nomadic Devices for traffic, transport and travel related applications have become increasingly commonplace in the last few years. Links to mobile networks, nomadic devices are now available with Bluetooth, WiFi networking, assisted GPS, speech recognition and high-end operating systems. They have also the capability to provide dynamic geo-referenced applications to assist the driver, the passenger and the traveller.

Nomadic devices need to be evaluated from the perspectives of user behaviour and acceptance, safety (particularly in regard to HMI issues), travel and traffic impacts and environmental implications. It also needs to be recognised that such devices can have broad mobility implications, both in terms of the strategic level of driving (route choice) and in terms of trip generation and mode choice (Michon, 1985; Rumar, 1993). Any evaluation of usage needs to consider the potential for both in-vehicle and out-of-vehicle usage of these devices.

The general ease of use of a device will have a major influence on acceptance and willingness to pay. Here ease of use refers not just to the usability while driving but to the user experience in all aspects of usage, i.e. pre-trip, in-trip and post-trip. Post-trip functionality is very relevant to usage in the fleet market and to support for and feedback on eco-driving.

Due to the above-mentioned fast innovation cycle, FOTs studying nomadic devices may require state of the art planning in order to keep up with the introduction of new features and functions. They will also need to consider the surrounding infrastructure since (rather like many cooperative systems) many functions rely on information and support from the outside. Weather forecasts, traffic information, updates on road conditions, dynamic speed limit information and speed advice are all dependent on service providers.

2. A wider approach needed for the TeleFOT FOTs

The functions tested in TeleFOT were Traffic information, Speed Limit Information, Speed Alert, Navigation Support (static), Navigation Support (dynamic), Green Driving Support, and eCall (Franzén et al, 2010). As the characteristics of these functions imply and as indicated above; they must be studied in a wider transportation context and cover, apart from traffic, also transport and travel; the individual must be studied in different roles: as driver, passenger and traveller; and the trip time line must be considered: trip planning and use during and after the trip.
The so-called “FESTA V” discloses in a condensed way the first approach to a FOT methodology (FESTA, 2008). In figure 1 the first proposal from the TeleFOT project is introduced. The “FESTA V” is expanded to start with the “CONTEXT” visualised as a horizontal bar across the opening of the “V”. In order to capture the wider approach needed for the study of impacts of functions provided by nomadic devices questions like “What are the Problems?, What are the Policy objectives?, What Impacts are desired?” has to be posed at the beginning of the FOT activities. This will make it possible to answer questions like “Are the Problems solved?, Are the Policy objectives met? Are the impacts valuable?” at the end of the FOT.

Figure 1   The FESTA V revised – A wider scope applied (FOT-NeT, 2011)

The main reason was that the choice of a function to be tested implies that there is either a problem that will be addressed and that the chosen function is defined to solve the problem or that a policy objective is stated and that the function tested can be used to reach the objective. An FOT can always be related to a wider view on the exercise than is defined by just a description of the function to be tested.

This is especially important as the functions provided by nomadic devices (as well as the nomadic devices themselves) might be used also outside the vehicle. This implies that the functions to be tested for their impacts are to be defined as based on the platform “nomadic device” and not on the platform “vehicle” as was a more or less a hidden assumption made in the first version of the FESTA Handbook (FESTA, 2008).
3. **A combined top-down and bottom-up approach for hypotheses generation**

One of the early stages in preparing an FOT is to formulate research questions and hypotheses. This should precede the definition of the study design and of the performance indicators. The definition of a research questions is “a general question to be answered by compiling and testing related specific hypotheses”. An example would be: “Does having a Forward Collision Warning system improve safety in driving?”

A hypothesis is defined as:

“a specific statement linking a cause to an effect and based on a mechanism linking the two. It is applied to one or more functions and can be tested with statistical means by analysing specific performance indicators in specific scenarios. A hypothesis is expected to predict the direction of the expected change.”

Two complementary approaches were recommended in the first version of the FESTA Handbook (FESTA, 2008):

- A top-down approach that considers six broad areas of system influence (Draskóczy et al, 1998)
- A bottom-up approach, applying use cases and situations to develop scenarios

### 3.1 Impact area (top-down) approach

From the TeleFOT project another useful top-down approach has been proposed – *The Impact area approach* (Karlsson et al, 2009). It starts from the most relevant impacts areas which are Efficiency, Environment, Mobility, Safety and User Uptake, and the basic principle behind the generation of hypotheses using this top-down approach lies in a theoretical understanding of the factors that influence the different impact areas.

It should be noted that there is likely to be overlaps of these factors among the impact areas under consideration and hence the same research questions and resulting hypotheses will be applicable across more than one impact area. The approach will result in *generic* research questions that are independent of any system functionality. The procedure for generating hypotheses in this top-down approach is as follows:

- The impact area should be considered in its entire context and primary measures affecting that area identified.
- Secondary factors of these measures are then identified that can be used to explain the variations in the primary measures.
- Finally the variables affecting the secondary measures are identified.
- The variables identified form the basis of the generic research questions] “Is there a change in the variable?” and the hypothesis based upon an anticipated effect of the variable “The variable will increase/decrease.”

This procedure should be undertaken for each of the impact areas. Two examples are presented in the following sections; Safety Impact and Mobility Impact.
3.1.1 Example – Safety Impact

Using the Safety Impact Area as a first example the primary measures affecting safety would be the “Number of events (accidents, near misses) that occur” and the “Severity of the event”. If we focus on the first of these primary measures the secondary factors would, for example be ‘Exposure of the vehicle on the road’, ‘The driving style of the driver’, ‘The distraction of the driver from the driving task’ and ‘Any interaction with the fitted device’. As the final step considering the factor ‘Exposure’, this can be measured with the variables ‘Length and duration of journey’, ‘Number of journeys undertaken’ and ‘Road type used’.

These variable then lead to the following examples of research questions (and related hypotheses)

- Does the system affect the length (miles) of journeys?
- Does the system affect the duration (hours) of journeys?
- Does the system affect the number of journeys undertaken?
- Does the system affect the road type used?

3.1.2 Example – Mobility Impact

Using the Mobility Impact Area as a second example the primary measures affecting mobility would be the “Amount of travel”, the “Travel patterns”, the “Mobility choice” and the “Journey quality”. With a focus on the first of these primary measures the secondary factors would for example be the ‘Number of journeys’ and the ‘Length of journeys’. As a final step considering the factor ‘Number of journeys’ this can be measured with the variables ‘Number of journeys in total’, ‘Number of commuting journeys’, ‘Number of other work related journeys’, ‘Number of other home related journeys’ and ‘Number of other journeys’.

These variable then lead to the following examples of research questions (and related hypotheses).

- Does the system affect the length (miles) of journeys?
- Does the system affect the duration (hours) of journeys?
- Does the system affect the number of journeys undertaken?
- Does the system affect the road type used?

4. Prioritising research questions and related hypotheses

The impact areas efficiency, environment, mobility, safety and user up-take were all addressed in TeleFOT. The well-known FESTA approach of a combined top-down and bottom-up approach was expanded to also include the alternative top-down approach, i.e. the impact area approach. This led to generic hypotheses that can be tested in a statistical manner. The direction each hypothesis should take (e.g. increase or decrease)
is based upon the anticipated effect once the top-down approach is integrated with the bottom-up (system defined) approach.

A complete list of the hypotheses have been developed and recorded. If it was considered that some were too trivial or too expensive to address in the subsequent study design and data collection, the reasons for not covering them was listed. It was also be noted that there are standardised techniques for observing driving behaviour with manual observers which may be less resource intensive than using dedicated data recording. Observations using such techniques can be carried out at various times during the study, preferably along a fixed route.

A huge number of research questions and associated hypotheses from the top-down and the bottom-up approaches have been developed. A key task was to integrate both sets of hypotheses in the context of each FOT. It was envisaged that the bottom-up approach formed the basis of the hypotheses list for an FOT and that the top-down approach was used to check that nothing significant for a particular impact area had been omitted.

![Figure 2](image-url) A combined top-down (impact area) and bottom-up approach for the generation of research questions and related hypotheses (Karlsson et al, 2009).

After the integration took place, the list of research questions/hypotheses was still very large. In order to derive a final, manageable set of research questions and hypotheses that could be applied throughout the various test sites, a cost–benefit approach was proposed and used to identify the likely "costs" of collecting the data.
Costs can be represented in terms of effort required to derive a performance indicator expressed predominantly in terms of resources. This should be offset against the likely “benefit” that proving/disproving the hypotheses will have. This is measured by way of the likely contribution towards providing a significant answer the research question and thus the level of contribution to the impact assessment. To some degree, this will depend upon the stakeholder needs and requirements, and therefore a prioritisation of their needs should also be considered.

This process has been performed and resulted in a list of between 7 and 13 Research Questions (RQs) per each impact area (in total 55) starting from over 150 RQs from the beginning. It should be noted that some of the RQs are found in more than one impact area. A list of the resulting Research Questions (and Hypotheses) are found in the Appendix and the process of identifying them is reported in five Deliverables from TeleFOT project (Welsh et al, 2010; Kulmala et al, 2010; Gaitanidou et al, 2010; Schröder, 2010; Karlsson et al, 2010).

5. Naturalistic studies vs. Controlled experiments

When the platform used for the functions is a nomadic device, the access to the internal data communication bus in a vehicle is very seldom available. The main reason being that the motor industry is cautious about the data distributed on this bus (also called the CAN-bus) as that data stream often is crucial for the specific brand characteristics. The CAN-bus can contain data about vehicle speed, acceleration/deceleration, and data related to foremost the driving of the vehicle. If a function is and integrated part of the vehicle system also data about the use of this function can be detected and measured via the CAN-bus.

In TeleFOT we have therefore been forced to apply a complimentary approach to the basic FOT (so called Large Scale FOTs or L-FOTs) , i.e. controlled experiments with instrumented vehicles to capture data which are important as a complement to the data collected otherwise. They are called Detailed FOT (or D-FOTs) but should in reality be looked upon as a controlled experimental set-up. The relation between the two types of test being performed in TeleFOT can be exemplified as in the figure below.

Figure 3  L-FOTs vs. D-FOTs (Karlsson et al, 2009)
The basic data can be captured by the function/system to be tested, e.g. GPS-coordinates and time stamps, or by an additional data logger. Furthermore, subjective data are of great importance in the analyses to be made. Questionnaires have been developed and distributed to all test persons (in the order of 100 persons was the target number) before, during and after the FOT activities (in most cases the total period is at least six months). Also travel diaries are used; one week at the beginning and the end of the test period and at least one week in between.

The instrumented vehicles used have different measurement systems installed; one example is from Loughborough University where an eye-tracker equipment was used. The equipment was fitted to the vehicles used for the Detailed FOTs (D-FOTs) to record head and eye movements. This device operates by processing the images recorded by two cameras mounted on the dashboard in front of the driver in conjunction with the reflection from an infra-red emitter. The influence of the function on the pattern of eye movements will be used as a measure of distraction in later analyses.

6. Concluding remarks

There are four elements that have emerged from the experiences gained in the TeleFOT project and that has had a distinctive influence on the FOT Methodology as it is now presented in the new and revised version of the FESTA Handbook (FOT-NeT, 2011).

The first emanates from the functions made available via nomadic devices (Franzén et al, 2010), that are not specifically related to the vehicle (or driving) but have a much wider applicability also for people travelling with other modes of transport and in other phases of a trip than that of driving a vehicle. This resulted in a modification of the “FESTA V” where a horizontal bar (named the context) was added to mark the importance of the context in which the function is supposed to be active.

Another experience is how the research questions and hypotheses were developed. A combined top-down and bottom-up approach was applied but where the top-down approach was new; the so called impact area approach was added (Karlsson et al, 2009). In the paper the different impact areas addressed in TeleFOT are addressed and the resulting Research Questions (RQs) after a prioritisation process (also developed in TeleFOT) to reduce the number of hypotheses (by use of a cost-benefit analysis) drastically without losing track of the core elements in the forthcoming analysis work.

Finally, the limited access to vehicle data (the CAN-bus is not available “from the outside”) made it necessary to combine the ordinary FOT (in TeleFOT called Large Scale FOTs or LFOTs) with complementary controlled experiments (in TeleFOT called Detailed FOTs or DFOTs). In the LFOTs data collection is made via the nomadic devices themselves (and additional data loggers) or via subjective measures (questionnaires, travel diaries, etc.) and in the DFOTs instrumented vehicles are used for the data collection (e.g. glance duration, level of distraction, etc.)
As a final conclusion the experiences from TeleFOT has widened the use FOT Methodology into areas where the platform for the function is not necessarily a vehicle but, in principle, can be any type of nomadic device.

7. References


FESTA (2008); FESTA Handbook (FESTA - Field operational test support action)

FOT-NeT (2011); FESTA Handbook, version 3, FOT-NeT Deliverable, Brussels


GAITANIDOU, E., BEKIARIS, E. SCHRODER, U. (2010); TeleFOT Deliverable D4.5.1 Efficiency Data Analysis Plan, Brussels.


KULMALA, R., RÄMÄ, P. (2010); TeleFOT Deliverable D4.4.1 Mobility Data Analysis Plan, Brussels.


Appendix.

Selected Research Questions related to the impact areas.
All impact areas were modelled with a focus on what elements define relevant research questions (and hypotheses) in the different areas.

**Efficiency** (Gaitanidou et al, 2010)

In the Efficiency area the following list of Research Questions (RQs) has been developed related to the secondary measures identified and relevant prioritisation made:

*Primary measure: TRAFFIC FLOW*

Secondary measures: Travel time, Delays, Speed, Density, Time headway

- RQ1 Is the travel time from origin to destination affected?
- RQ2 Are there any delays avoided?
- RQ3 Are the vehicles speeds in the network affected?
- RQ5 Are there any traffic jams avoided?
- RQ6 Is the time headway between the vehicles affected?
- RQ8 Is the distance from the preceding vehicle affected?

*Primary measure: TRAFFIC VOLUME*

Secondary measures: Density, Headways, Traffic composition

- RQ10 Is the traffic composition different?

*Primary measure: OTHER MODES THAN AUTOMOBILES*

Secondary measures: Public transport, Public transport terminals, Bicycle travel, Motorcycle travel, Pedestrian travel

**Environment** (Schröder, 2010)

In the Environment area the following list of Research Questions (RQs) has been developed related to the secondary measures identified and relevant prioritisation made:

*Primary measure: NOISE*

Secondary measures: Driver behaviour, Traffic density

- RQ1 Is average speed affected?
- RQ2 Is speed homogeneity affected?
- RQ3 Is speed distribution affected?
- RQ4 Is the number of journeys affected?
- RQ5 Is the distance travelled affected?
- RQ6 Is road type and choice of routes affected?
RQ7 Is transport mode affected?

*Primary measure: EMISSIONS*

Secondary measures: Amount of fuel, Type of fuels, Amount of emissions

RQ8 Is total fuel consumption affected?
RQ9 Is average fuel consumption affected?
RQ10 Is amount of CO emissions affected?
RQ11 Is amount of CO2 emissions affected?

*Primary measure: IMPACT ON SURROUNDINGS*

Secondary measures: Other vehicles, Communities

RQ12 Is the use of the systems influencing other traffic participants?
RQ13 Is the use of the system influencing traffic surroundings?

*Mobility* (Kulmala, Rämä, 2010)

In the Mobility area the following list of Research Questions (RQs) has been developed related to the secondary measures identified and relevant prioritisation made:

*Primary measure: AMOUNT OF TRAVEL*

Secondary measures: Number of journeys, Length of journeys

RQ1 Is the number of journeys undertaken affected in total?
RQ2 Is the number of other home related journeys affected?
RQ3 Is the number of other journeys affected?
RQ4 Is the length of journeys in distance affected?

*Primary measure: TRAVEL PATTERNS*

Secondary measures: Travel mode, Route, Time budget, Timing, Destination

RQ5 Is the duration of journeys affected?
RQ6 Is there a change in commuting mode of travel?
RQ7 Is there a change in route choice in commuting?
RQ8 Is there a change in departure time of a commuting journey?

*Primary measure: MOBILITY CHOICE*

Secondary measures: Enablers/Constraints

RQ9 Is there a change in travelling in adverse conditions (dark, fog, slippery road, etc.)?

*Primary measure: JOURNEY QUALITY;*

Secondary measures: Stress, Subjective safety, Comfort, Other journey qualities
RQ10 Is there a change in user stress?
RQ11 Is there a change in user uncertainty?
RQ12 Is there a change in feeling of subjective safety?
RQ13 Is there a change in feeling of comfort?

**Safety** (Welsh et al, 2010)

In the Safety area the following list of Research Questions (RQs) has been developed related to the secondary measures identified and relevant prioritisation made:

*Primary measure: NUMBER OF EVENTS*

Secondary measures: Exposure, Focus of attention, Driver behaviour, Fixation of the physical device

- RQ1 Is the route affected (where travel takes place)?
- RQ2 Is the amount of time on the road affected (how long travel takes place for)?
- RQ3 Does the device cause distraction?
- RQ4 Is speed affected?
- RQ5 Is vehicle positioning affected (proximity and lane positioning)?

*Primary measure: SEVERITY OF EVENTS*

Secondary measures: Exposure, Driver behaviour, Focus of attention, The physical device

- RQ 6 Is braking affected?
- RQ7 Is non-driving manual activity affected?

**User Uptake** (Karlsson et al, 2010)

In the User Uptake area the following list of Research Questions (RQs) has been developed related to the secondary measures identified and relevant prioritisation made:

The elements of the User uptake area (or rather User adoption area) can also be related to a simplified model where the different aspects (and their relations) are shown (see figure below)

*Primary measure: KNOWLEDGE/AWARENESS LEVEL*

Secondary measures: Knowledge of function, Problem perception

*Primary measure: AIMS/COMPLIANCE*

Secondary measures: Social aims, Personal aims

- RQ1 To what extent have the functions and devices been used (before, during, after journeys)?
- RQ2 Were the functions/devices used more or less over time?
RQ3 Is travel behaviour affected?
RQ4 Is driving behaviour affected?
RQ5 Will problem awareness/problem perception change?

*Primary measure: ACCEPTANCE*

Secondary measures: (Usage), Usability, Acceptance, Trust

*Primary measure: TRUST*

Secondary measures: Intended impact, Technical Reliability

RQ6 Is user acceptance influenced by perceived usefulness of device/function?
RQ7 Is user acceptance influenced by perceived ease-of-use?
RQ8 Is user acceptance influenced by perceived trust in device/function?
RQ9 Is user acceptance influenced by perceived trust in device/function?

*Primary measure: WILLINGNESS TO PAY*

Secondary measures: Perceived affordability, Desirability

RQ10 Is user acceptance influenced by the design of the user interface of the device?
RQ11 Is there a change in users’ acceptance over time?
RQ12 Is there a change in perceived affordability over time?

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**Figure.** Simplified User uptake model/User adoption model (Karlsson et al, 2010).