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NOMADIC DEVICES IN THE VEHICLE ENVIRONMENT: PLANNING OF FIELD OPERATION TESTS IN EUROPE

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ABSTRACT

The market for the Nomadic Devices, such as on-board navigation devices and smart phones, integrated to road vehicles is increasing rapidly today. While providing useful services for travellers, at the same time, these devices may introduce significant usability and distraction problems, jeopardizing their safety as the devices are not usually specially designed for the vehicle context. Consequently, there is a need to study the impacts of such devices by Field Operational Tests (FOT). TeleFOT (Field Operational Tests of Aftermarket and Nomadic Devices in Vehicles), is a European Commission co-funded integrated project aiming to assess the impacts of aftermarket and nomadic devices used in vehicles for driver support and to raise wide awareness of the functions and potential these devices offer, by implementing Field Operational Tests. To do so it will build, mobilise and integrate European test communities for long term testing and assessment of driver support functions through aftermarket and nomadic devices. It will also work on the related methodological framework.

Keywords: *Nomadic Devices, Field Operational Tests, Traffic safety, Driver behaviour*

INTRODUCTION

The number of aftermarket personal navigation devices (PND) and smart phones (3G phones) is *increasing exponentially today*, and consequently, we are witnessing a breakthrough of these devices in assisting drivers. The GPS market is continuing to evolve from in-dash to PND to cell phones. In 2011, the total population of GPS-enabled location-based services subscribers reached 315 million, up from 12 million in 2006 [1].

The technology is mature and penetrating the market, but the big question is what are the most useful functions these systems can provide for travellers. At the same time the pros and cons of the best possible applications for safety functions are not investigated until today in a

satisfactory way. Furthermore, we know nothing about the impacts – let alone *long-term* impacts of these devices on traffic safety without regarding some sporadic and anecdotal evidence about the accidents that the use of e.g. navigators are associated with.

Compared to the OEMs' (original equipment manufacturers) in-vehicle navigators purchased as options that are relatively costly and little used today, aftermarket navigators with greater flexibility and far more affordable prices are making the revolution also in terms of functions they can provide. Smart phones have in principle the same potential as – or even more than navigators but the assortment of functions available is today more modest because the creation of business models is more complex than that of navigators.

The above mentioned systems (collectively called Nomadic Devices- abbreviated as NDs) are designed for general use, not specifically for in-vehicle use. That is why they may introduce usability and distraction problems decreasing safety as the devices are not specially designed for the vehicle context.

This is why there is a strong need to study the impacts and come up with recommendations, updating related standards and in the utmost case directives for designing and using these devices in traffic. To do so, long term operational tests are needed involving drivers in real conditions using NDs during their daily driving for long periods of time. This need is served through the conduction of the so called Field Operational Tests (abbreviated as FOT).

The origin of FOT's stems from the needs to assess the impacts of various road traffic safety measures on driver behaviour and safety – as actually is the case with the TeleFOT approach too. The first large scale FOTs were carried out in USA and Nordic countries in the late 1980's and the early 1990's. The topics of these tests ranged from assessing the impacts of new type of road markings, different types of tyres and ISA (Intelligent Speed Adaptation) and in-vehicle terminals on driver behaviour and risk taking.

Field Operational Tests are now recognized as the most powerful method to provide reliable data on the effects of systems in travel and traffic behaviour, on the related transport system effects on safety, flow, efficiency and environment, and on the overall social and business impacts of the services and systems in a large-scale deployment. In addition, all stakeholders wish to know with sufficient reliability the long-term acceptance and willingness-to-pay of ordinary users for the systems. The main reason for the wide acceptance of FOTs is that in them a large number of users use the systems and services in their daily life in real driving conditions. In addition to the facts on effects, benefits and costs, FOTs are naturally very useful in verifying the technical performance of the systems in large-scale deployments and in guiding the development of driver assistance functions.

Although FOTs have been used for some time now in US, large-scale testing of *intelligent vehicle systems* with ordinary drivers in ordinary traffic has been quite rare in Europe so far. Especially FOTs targeted on automotive infotainment, mobile or aftermarket products and their functions have not been realized yet.

This is why in 2007 a consortium of the most well known Research Institutes in the area together with related Industries has been gathered to realise the TeleFOT initiative.

The TeleFOT main objective is to assess the impacts of aftermarket and nomadic devices used in vehicles for driver support and to raise wide awareness of the functions and potential these

devices offer. To do so it will build, mobilise and integrate European test communities for long term testing and assessment of driver support functions through aftermarket and nomadic devices. It will also work on the related methodological framework. Its application area covers all information coming from beyond the driver's visual field, i.e. typical cooperation driving application areas. In addition to that, the project focus is also in navigation type of tasks and providing personalised speed management and "Green driving" support, where the benefits can be seen in the manoeuvring level, and in the appropriate choice of speed such as speed limit information or speed alert. It is also related to cooperative driving (I2V – V2I) closely, since aftermarket & nomadic devices used in vehicles receive the information contents from background systems through traffic information databases, GPS, tele-operators and service providers. For this reason, the project provides an excellent opportunity to test functions and services foreseen in cooperative driving systems after 2010.

PLANNING FOTs ON NOMADIC DEVICES

FOTs need to have clear and well identified objectives. In the case of TELEFOT and taking into account the special characteristics of NDs, it was identified that such tests should examine at least:

- Systems' usability, impacts on and benefits to ordinary users, the society and stakeholders,
- Long-term user acceptance and willingness to pay for such systems and different functions,
- Long-term impacts of assistance functions on driver behaviour and often so called behaviour compensation e.g. over-reliance on assistance functions and the possibly following decreased vigilance,
- Technical performance of the systems and services in real-life long enduring large-scale use,
- Real-life performance of different business models for operation and provision of intelligent vehicle safety systems and services.

Whenever tests to explore new areas are planned, researchers define hypotheses ('research questions') to be tested. Sometimes the hypotheses are implicit in the plan and not very clearly stated, however, especially in studies with experimental design they need to be explicitly stated. 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.

Based on the above, the TeleFOT initiative sets a number of general hypotheses to be tested. These are grouped in relation with the different parameters that the tests are investigating.

Concerning usability of the devices issues like the location of the device, the mounting systems, the personal characteristics of the driver (e.g. age, driving experience), the I/O used, size and lighting of the device display are to be examined.

In relation with traffic behaviour the effect of the different applications (navigation, speed limits info, hazards info etc.) provided from NDs to the driver workload, to his/her alertness, to speeding, to safe driving will be examined taking always into account the driver's characteristics.

Safety related tests will examine hypothesis like for example the decrease of dangerous situations because of driving assistance functions (e.g. Speed Alert function) and the decrease of line change incidents because of navigation assistance.

Concerning efficiency TeleFOT will examine hypothesis like the reduced travel times due to enhanced and advance information on travel conditions, hazards, accidents and the optimisation of travel planning due to navigation assistance.

Green driving will also be examined based on the hypothesis that measures to influence speed behaviour lower mean travel speeds and decrease fuel consumption. Also that Navigation assistance helps to optimise driving in terms time by avoiding congested routes and accident sites and that dedicated information and feedback on economic driving reduces fuel consumption. Finally business models and driver acceptance issue will also be examined.

METHODOLOGY

Methodologically, FOTs can be realised in a number of ways. A number of research activities have been realised recently focusing on testing methodological issues. The most recent one is the European 7th FW co-funded project *FESTA* that puts a lot of effort on the methodological issues of later large-scale FOTs such as the work proposed here. One can also mention initiatives like the EC 6th FW co funded projects PReVENT (PREVAL Sub-Project), eIMPACT, TRACE etc.

Without going into details here, the TeleFOT initiative envisions two major approaches that are needed in any given serious FOT approach:

1. Tests in daily traffic with sophisticated measurement methods but *with less controlled* conditions e.g. non-experimental driving to accumulate data and have an insight of long-term impacts.
2. Tests in closed-circuits or on roads with little traffic in *well controlled* conditions to get deeper in the behavioural dynamics of drivers and to establish causal relationships.

These approaches are interrelated so that data from less controlled daily driving may raise issues that need closer examination.

Overall, current technologies give ample possibilities to design the tests in an innovative and economic way. A typical and sound methodology for a comprehensive approach is depicted in Figure 1. Usually, the procedure is started by studies on usability aspects. Actually, these issues should be settled already in the applications development phase. However, often this is not the case, and a number of shortcomings in the applications have been identified.

After usability and ergonomics issues, actual behavioural studies have their turn. They usually deal with driver workload issues (too) and the assumed behavioural adaptation (that by the way has been shown to be a controversial concept and not fully recognized by the academia). During extensive testing and depending on the method used, also incidents, hazardous or exceptional situations (level 2) can be recorded.

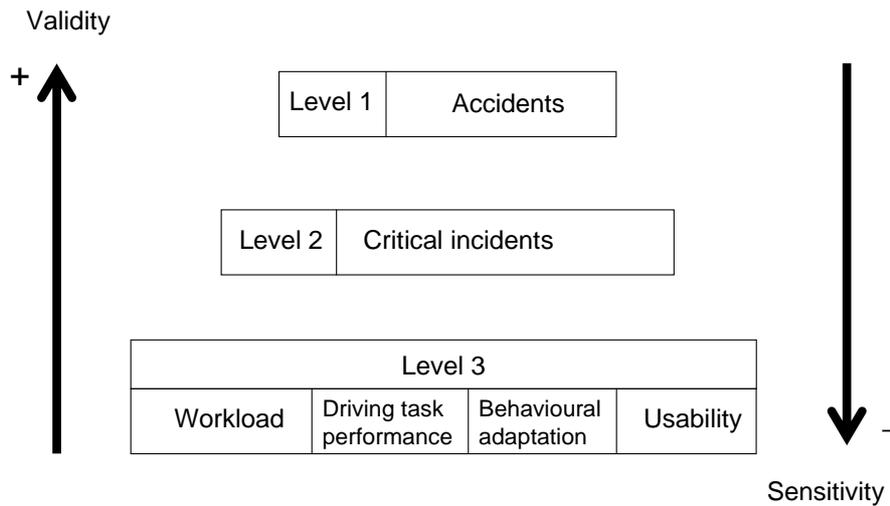


Figure 1. General methodology to assess the impacts of various measures on driver behaviour and safety.

The Traffic Conflict Technique (TCT) is perhaps the most developed indirect measure of traffic safety [2]. The technique itself is grounded in the ability to register the occurrence of near-accidents directly in real-time traffic and therefore offers a faster and, in many respects, more representative way of estimating expected accident frequency and accident outcomes. The conflict technique emanates from research originally at the Detroit General Motors laboratory in the late 1960's for identifying safety problems related to vehicle construction [3]. The use of this technique soon spread to different parts of the world. TRL in England soon recognized the need to add a subjective scale for observed conflicts as a measure of severity [4]. This technique was based on observer judgments using time-lapse filming, thereby proving costly and time-consuming. The Swedish Traffic Conflict Technique (STCT) was developed at LTH in different projects during the 1970's and 1980's before finally reaching its present day level of development in 1987. The Swedish technique focuses on situations where two road-users would have collided had neither of them made any kind of aversive manoeuvre. The point at which the aversive action is taken is recorded through observation as the "Time-to-Accident"(TA). The TA value together with the conflicting speed is used to determine whether or not a conflict is "serious".

The association of conflicts and accidents is depicted as a pyramid showing the relationship between conflicts and accidents.

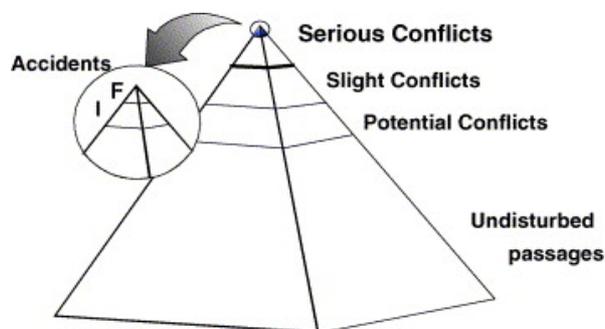


Figure 2. Relationship of critical incidents i.e. conflicts and accidents [2].

There have been validity concerns associated with the relationship between serious conflicts and the number of accidents. An American study by Migletz *et al.* showed that normal conflict studies could produce estimates of average accident frequency that were at least as accurate as those based on historical accident data, and Svensson [5] concluded from Swedish data that serious conflicts provide a better estimate of the number of expected accidents involving personal injury. The results of studies in many different countries have also been compared to show that the relative statistics for conflicts and accidents are in agreement despite environmental differences. Depending on the design of the experiment, conflict technique – or a derivative of it - is one method under consideration in TeleFOT too. The real benefit of conflict technique is its relation to accidents allowing the prediction of actual accidents based on the number of conflicts recorded.

Potential methods used in TeleFOT-type of long-term studies are listed in Table 1 below. Often different methods complement each other and are not used alone. The following table gives a crude overview of possible methods that can be used in FOTs. Table 1 is only referential, since other combination of the methods/designs/significance testing than listed in the table can be created. Furthermore, intelligent vehicle technologies give totally new possibilities to use “old” methods in a novel way. For example, conflicts can be recorded automatically by means of vehicle systems and driver behaviour can be studied through driver monitoring systems developed for vehicles such as the CAA-module (Cockpit Activity Assessment Module) developed together by Volvo Technology and VTT in the EC co-funded AIDE project. This method will be used also in TeleFOT.

Table 1. *Methods, design and significance testing generally used in FOTs to study driver behaviour.*

Method	Design	Significance testing
In-vehicle instrumentation obtrusive (recording process visible)	Before-after with or without a control group	t-tests, non-parametric
In-vehicle instrumentation unobtrusive (no visible instrumentation or recording)	Before-after with or without a control group	Multivariate tests, t-test, overall parametric tests
Driving-log	Usually not related to a design; could be a part of experimental design	Mainly descriptive, non- parametric
Observation (in-vehicle)	Usually not related to a design; could be a part of experimental design	Descriptive, Non- parametric usually
Interviews / surveys	Could be a part of before- after design	Descriptive, Non- parametric, parametric (with reservation)
Observation (outside vehicle) -usually focus on traffic flow or single behaviour features. Used less in actual FOTs - Traffic Conflict Technique (TCT)	Before-after with or without a control group	Multivariate tests, t-test, overall parametric tests

CONCLUSIONS

Nomadic Devices are being used already massively by travellers including drivers. Today there is a lack of studies and related tests on the impact of this to traffic safety, driver's workload and possibly to other aspects like usability, travel efficiency, green driving etc. Also business related issues like user acceptance and willingness to pay need to be investigated.

The TeleFOT initiative investigates the impacts of aftermarket and nomadic devices in sustainable road transport – safety and efficiency & environment. The main impacts are expected from traffic safety owing to better situation awareness of drivers. Environmental impacts are:

1. By-products of enhanced safety through less turbulent traffic flow and travel based on traffic regulations such as observing posted speed limits and proactive driving.
2. Through dedicated functions encouraging for “Green driving”. More efficient driving is promoted through better information on traffic conditions and improved navigation assistance.

The FOTs described in this paper, will be executed in three European user communities, namely the Northern, the Central and the Southern European test communities (Finland, Sweden; France, Germany, United Kingdom; Greece, Italy and Spain), within the course of the TeleFOT integrated project. These road tests are based on a large number of drivers using their mobile devices in their own vehicles where they interact with the functions and services provided to them. Their reactions and behaviour will be recorded with data loggers mounted on their vehicles. From these drivers, data on general reactions and behaviour will be recorded through loggers and transferred to a central databank for analysis. Following these tests, a series of detailed tests will be conducted. These tests will be carried out by means of instrumented vehicles capable of the precise recording of driver behaviour – especially in terms of investigating cockpit activities while driving, aiming at deeper explanations for phenomena revealed in large test groups.

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