Fact sheets: TeleFOT [Field Operational Tests of Aftermarket and Nomadic Devices in Vehicles]

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Additional Information:

- This is a compilation of fact sheets about TeleFOT. 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”: http://www.telefot.eu/

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Today there is an increasing need to move and stay always connected: with other people, for business or leisure, as well as with the environment, to exchange relevant information for our mobility. The number of devices supporting transportation is increasing, in particular aftermarket nomadic devices as personal navigation devices or smart phones. Their use is carefully studied in laboratories before getting to the market and many research projects have been focusing on a wide number of transport applications. But the TeleFOT project aimed to find out the answer to the following question:

“What are the impacts when services provided via such devices are used in real world conditions?”

This was achieved through Large Scale Trials of normal everyday use of nomadic devices to study how drivers receive, use and react to functions and services. These were characterised by: many months of driving, large numbers of participants, unobtrusive instrumentation of vehicles and naturalistic driving. These were complemented by Detailed Trials with fewer vehicles & participants but highly instrumented vehicles, a high level of experimental control and very detailed data collection such as eye tracking.

The data collected aimed to answer questions about the impacts of use of the functions provided by nomadic devices on Safety, Mobility, Efficiency, Environment. Also User Uptake (acceptance and adoption of functions) was addressed. More details available on the website.
Key findings for Navigation Support
Impacts: Safety, Mobility, Efficiency, Environment

- Participants perceived a slight increase in the use of rural roads but the logged data showed an increase in city/urban roads, particularly city roads with low speed limits (e.g. residential).
- Journey distances and journey durations (for comparable journeys) were shorter and this was noticed by drivers.
- The introduction of the navigation function resulted in increase in percentage ‘eyes off road time’.
- There was a significant decrease in headway variation and less time spent with very low headway values (the latter when advanced driver assistance systems were present).
- Perceived increases in safety were reported by 17-37% of drivers and in comfort by 18-59% of drivers.
- Perceived decreases in stress were reported by 24-50% of drivers and in uncertainty by 41-66% of drivers.
- According to the travel diaries, usage varied across the test sites: between 25 and 75% of drivers never used the system, those who did use it did so for more than 25% of their journeys. However, the percentage of non-users was lower according to the de-briefs.
- Where the system was used it was for unfamiliar roads.
- In most countries, initial attitudes to the system were positive but this decreased over time (apart from in Sweden where it increased).
- At the end of the trial, willingness to keep was 48-93%, willingness to pay was 7-44%.
- The correlation between the following factors and “willingness to keep” were as follows (all $p<0.001$): “benefit” was moderate ($r=0.589$); “design of device” was weak ($r=0.281$); “trust in information provided” was moderate ($r=0.483$); “design of user interface” was moderate ($r=0.372$).
- The correlation between the following factors and “willingness to pay” were as follows: “benefit” was moderate ($r=0.496$); “design of device” was weak ($r=0.217$); “trust in information provided” was moderate ($r=0.419$); “design of user interface” was moderate ($r=0.353$).
- There were no detected changes in the following: number of journeys, journey start times, perceived delays, avoidance of traffic, transport mode, fuel consumption, CO2 emissions, average speed, speed variation, speed distribution, actual or perceived speed violations, lane positioning, braking behaviour, manual (hands-busy) activity.

IMPORTANT:
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Key findings for Traffic Information
Impacts: Safety, Mobility, Efficiency, Environment

- There was a **perceived** and **actual increase** in the use of *rural roads* and an **actual decrease** in the use of *city roads*.
- **Journey durations** (for comparable journeys) were **shorter** and this was noticed by drivers.
- **Average speed increased** on urban roads.
- There was a significant **decrease in headway variation** and **less time spent with very low headway values** (the latter when advanced driver assistance systems were present).
- **Perceived increases in safety** were reported by 15-23% of drivers and in **comfort** by 24-46% of drivers.
- **Perceived decreases in stress** were reported by 18-40% of drivers and in **uncertainty** by 14-43% of drivers.
- **Usage varied** across the test sites: in Finland, more than 75% of drivers never used the system, those who did use it did so for more than 25% of their journeys.
- In Greece **initial attitudes** to the system were **positive**, in Finland **negative**. In both they became **more negative over time**.
- The **correlation** between the following factors and “**willingness to keep**” were as follows (all p<0.001): “benefit” was moderate (r=0.589); “design of device” was weak (r=0.281); “trust in information provided” was moderate (r=0.483); “design of user interface” was moderate (r=0.372).
- The **correlation** between the following factors and “**willingness to pay**” were as follows: “benefit” was moderate (r=0.496); “design of device” was weak (r=0.217); “trust in information provided” was moderate (r=0.419); “design of user interface” was moderate (r=0.353).
- **There were no detected changes** in the following: perception or actual journey distance, number of journeys, road types, journey start times, perceived delays or avoidance of traffic, transport mode, speed variation, speed distribution, speed violations, lane positioning, braking behaviour, manual (hands-busy) activity. There was insufficient information to measure changes in fuel consumption or CO2 emissions.

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Key findings for Speed Info/Alert
Impacts: Safety, Mobility, Efficiency, Environment

- There was a significant decrease in headway variation and less time spent with very low headway values (the latter when advanced driver assistance systems were present).
- Perceived increases in safety were reported by 22-62% of drivers and in comfort by 6-48% of drivers.
- Perceived decreases in stress were reported by 13-38% of drivers and in uncertainty by 23-39% of drivers.
- Usage varied across the test sites. In Italy and the UK 75% of drivers never used the system, those who did use it did so for more than 25% of their journeys, some for more than 75%.
- Where the system was used it was for unfamiliar roads and/or roads with higher speed limits.
- Of those that used the system, most reported an increase in perceived compliance with speed regulations (the Finnish and UK test site findings contradicted this).
- The most negative attitudes were found in the Italian, Finnish and UK test sites.
- At the end of the trial, willingness to keep was 12-88%, willingness to pay was 2-29%.
- The correlation between the following factors and “willingness to keep” were as follows (all p<0.001): “benefit” was moderate (r=0.589); “design of device” was weak (r=0.281); “trust in information provided” was moderate (r=0.483); “design of user interface” was moderate (r=0.372).
- The correlation between the following factors and “willingness to pay” were as follows: “benefit” was moderate (r=0.496); “design of device” was weak (r=0.217); “trust in information provided” was moderate (r=0.419); “design of user interface” was moderate (r=0.353).
- There were no detected changes in the following: route choice/road type, journey distance or duration, number of journeys, journey start times, perceived delays or avoidance of traffic, visual distraction, average speed, speed variation, speed distribution, actual speed violations, lane positioning, braking behaviour, manual (hands-busy) activity, transport mode, fuel consumption, CO2 emissions.

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Key findings for Green Driving Support
Impacts: Safety, Mobility, Efficiency, Environment

- Participants perceived a slight increase in the use of rural roads and a slight decrease in highway use.
- There was no perceived change in journey distances or durations, however the data revealed an actual increase in the duration of journeys (with comparable origin/destination).
- There was a smaller variation in speed distributions.
- Most Finnish participants perceived a change in speed limit compliance but Swedish participants noted no change.
- There was a significant decrease in headway variation and less time spent with very low headway values (the latter when advanced driver assistance systems were present).
- Perceived increases in safety were reported by 10-28% of drivers and in comfort by 10-21% of drivers.
- Perceived decreases in stress were reported by 10-18% of drivers and in uncertainty by 4-19% of drivers.
- There was a significant decrease in fuel consumption and CO2 emissions.
- Large numbers of participants claimed (according to travel diaries) never to have used the system. Those who did use it did so for at least 25% of their journeys, some for more than 75%. However, the numbers reporting that they never used the system was lower according to the de-briefs.
- Where the system was used it was for longer journeys.
- In most countries, attitudes to the system became less positive over time.
- At the end of the trial, willingness to keep was 41-65%, willingness to pay was 4-17%.
- The correlation between the following factors and “willingness to keep” were as follows (all p<0.001): “benefit” was moderate (r=0.589); “design of device” was weak (r=0.281); “trust in information provided” was moderate (r=0.483); “design of user interface” was moderate (r=0.372).
- The correlation between the following factors and “willingness to pay” were as follows: “benefit” was moderate (r=0.496); “design of device” was weak (r=0.217); “trust in information provided” was moderate (r=0.419); “design of user interface” was moderate (r=0.353).
- There were no detected changes in the following: route choice/road type, number of journeys, journey start times, perceived delays or avoidance of traffic, visual distraction, average speed, speed variation, actual speed violations, lane positioning, braking behaviour, manual (hands-busy) activity, transport mode.

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Summary and Implications of Findings for Safety

- Throughout TeleFOT, there were no measurable events (e.g. accidents or injuries) during the baseline and experimental conditions. Therefore it is impossible to fully quantify impacts on safety since we cannot say whether injuries went up or accidents fell in relation to any function use.
- We are left to infer the impact on safety associated with the use of the functions supported by the TeleFOT devices through answers to other specific safety research questions.
- For ‘perception of safety’, the function that was perceived to have the greatest benefit for safety was speed alert.
- It was found that traffic information slightly increased the use of rural roads in the Swedish FOT which could represent a switch to road types with a higher accident risk but also resulted in shorter journey times, which reduces exposure to accidents. These two effects have opposing impacts on safety.
- Use of Green Driving systems could result in a potential increase in exposure and accident risk due to a shift in road type and longer journeys.
- The result on distraction is perhaps the most measurable in relation to safety since “eyes off road time” increased due to the function and the length of gazes also increased. However, this was the case for Navigation but not Green Driving.
- The HMI for Green Driving and Navigation are quite different – the green driving device tested to answer questions relating to distraction was an image associated with a simple response required whereas navigation device tested required more cognitive processing to interpret the information.
- Although there were a few glances over 2 seconds, these occurred both to the navigation and equally to other areas of the visual scene. The “National Highway Traffic Safety Administration (NHTSA) “2 second guide” is a rough rule of double risk which needs to be contextualised further with vehicle speed and complexity of road environment which influence crash risk.
- The 3 devices used to provide the functions were limited; alternative devices with a diversity of HMI’s may provide wider ranging and perhaps different results.
- The market is evolving quickly and has even moved on during the life of the project. There is now more use of smart-phone applications to provide functions which is a clear example of a change in HMI. We have to ask the question ‘Is the HMI comparable to TeleFOT devices in relation to distraction?’ Hence there is a need to keep evaluating how the changing HMI effects in particular driver distraction.
- Overall, the main limitation of the Safety Impact Assessment was that the usual metrics for studying ‘road safety’ (i.e. changes in injuries and accidents) did not apply. Due to the relatively small numbers of drivers and devices and the study time-limitations

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Summary and Implications of Findings for Mobility

• Aftermarket or nomadic devices providing driver support functions have a positive impact on mobility at a personal level. Specifically, the quality of travel improved for all functions tested, as the stress and uncertainty related to travel decreased and the feeling of safety and comfort increased.
• Furthermore, the amount of travel increased with navigation support and traffic information. However, it deteriorated for green driving support, resulting in the use of longer routes and longer travel times. The travel patterns improved with new routes with navigation, traffic information and green driving support.
• Sometimes longer routes with slower speeds can be a better choice from the standpoint of total fuel consumption.
• The findings suggest that participants had high expectations of positive impacts for all driver support functions before using them. However, when the functions were activated, a clear deterioration was seen in attitudes. Nevertheless, the FOTs lasted a relatively long time and at the end of the field-tests attitudes were much more positive and participants agreed on the benefits of the functions.
• The fact that TeleFOT functions did not affect many aspects of travel patterns (timing, driving conditions and transport mode) is understandable, as the devices were located in the car and the functions were used after starting the journey by the participant’s own car. Thus the functions were not targeting the original decision to make the journey, the timing or the mode. In addition, information on adverse conditions was provided during the journey, not before it.
• Impacts were assessed based on commuting and other frequently made journeys, as their number was high and the same leg could be identified during both the baseline and treatment phases. However, the elasticity of commuting is the least with fixed timing and destination. Therefore, the impact potential of other journeys might have been higher although difficult to assess with FOTs.
• Although the absolute impacts of driver support functions provided by aftermarket and nomadic devices are not high, they are positive for various dimensions of personal mobility. It should be noted that these small impacts may be an indicator of longer term impact potential. As travel patterns are hard to impact, it takes time – probably longer than a 17-month period, which was the longest duration of FOTs in TeleFOT.

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Summary and Implications of Findings for Efficiency

- Increasing traffic efficiency is a goal which involves harmonised traffic flow, optimal traffic volume, increased road capacity, less accidents, and greater accessibility for all road users.
- Efficiency has been considered purely for passenger cars in TeleFOT and not for other road users or other factors that may affect traffic elements (e.g. modal choice or change).
- Efficiency is therefore considered to be the traffic efficiency determined from the driver's perspective.
- Apparently not all functions affect traffic efficiency and not all functions play the same role (either primary, secondary, or neutral) in different impact areas.
- As was anticipated, navigation and traffic information seem to be the most important functions for improving efficiency. Speed limit information and speed alert have a secondary role. The effect of green driving support is not clear; it seems conflicting. It appears that green driving support increases travel duration (negative effect) but decreases variation (almost as much as the rest of functions) in headways.
- The effect of core TeleFOT functions and ADAS appeared to be complementary and not conflicting wherever it was possible to investigate separate impacts. The combined effect of Advanced Driver Assistance Systems (ADAS) and core TeleFOT functions is however, more complicated so conclusions could not be drawn.
- A set of sustainable structural indicators could be set for monitoring the effect of functions to traffic and driver efficiency that could infiltrate the development of the next generation of driver assist and information systems and would prove useful for strategies within policy making for nomadic device deployment.
- These indicators would be time (e.g. journey) duration and headways as they are both easily and universally measurable.
- Objective assessment for delays and avoidance of traffic jams should be based on more complex algorithms than certain sets of assumptions and restrictions.
- Subjective evaluation is actually correlated to exposure but these would hold true also for objective assessments for different test-sites.

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Summary and Implications of Findings for Environment

• **Green driving support** which is designed to help the driver to drive in a more economic and fuel efficient way, has a significant impact on fuel efficiency.
  - The average **fuel saving** was about 4% compared to the baseline condition. With regard to the society, an **application** on the navigation device or a **smart phone** could **contribute** to more fuel efficient driving (if the advice is not ignored or disregarded by the driver) and along with this, **lower CO2 emissions**.
  - The traffic information function could be **beneficial to the environment** when guiding the driver from low class roads onto higher class roads which have higher speed limits and a more fluid traffic flow. The **optimal range of driving speeds** and for lower fuel consumption is 60 km/h – 80 km/h. So, the benefits of changing from low speed roads to high speed roads is obvious.
  - Whether **shorter journeys** are beneficial for the environment or not, needs a closer review. Shorter journeys are beneficial if the absolute fuel consumption of the journey is less compared to the original, longer journey. The opposite is true if the journey is shorter, but due to slow moving traffic for instance, the absolute fuel consumption is higher. This must be considered when drawing a conclusion about the impact of the navigation function on the environment. With the available information, a final statement cannot be given for this function.
  - When talking about the benefit not only for the driver himself, but for the **whole society**, every function which saves fuel and therefore emissions, contributes to one big objective: to **reduce emissions** as much as possible. This societal value is clearly identified for the above mentioned functions and therefore a **valuable outcome** of this project.

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Summary and Implications of Findings for User Uptake

- **User uptake** is when a new technology, a new *device* or *function*, is adopted and integrated into everyday life, i.e. invested, used and made use of – in the case of the functions tested in TeleFOT - in relation to planning and undertaking journeys by car and/or by other means of transport.

- Participants’ **expectations** were high before the trials. When the functions were first introduced **attitudes** became less positive, the **benefits** were rated lower, and there were some **negative changes** in the participants’ trust in the information. Post-trial, the **attitudes** became slightly more positive, the **benefits larger**, and the **trust** in the information **higher**. The evaluation curve describes a “U”- or a “TeleFOT V”-shape. Field tests which last for longer periods of time are hence crucial for providing a greater understanding of the process that is **user uptake**.

- The devices and functions were unused by a proportion of the participants which could indicate a **low level** of acceptance. However, **green driving function** and the **speed information/alert function** were used more frequently than, for instance the **navigation function**. Usage can be explained by the former functions being beneficial for a large number of trips while the latter beneficial to only a portion of journeys made. Use frequency is thus not necessarily the best indicator of user uptake.

- **User acceptance**, measured as **willingness to keep** the device for usage, seems to be influenced by several factors and **perceived benefit** is the key. The benefits differ for different functions but include comfort, economic, environmental, efficiency, and safety benefits.

- **Context matters.** Some participants used the **functions** across all types of journeys whereas others experienced the **functions** as beneficial only for some journeys. For instance, the **traffic situation** in the area where the individual undertakes his or her journey may not be perceived as **problematic** and information on e.g. **road-works** or **queues** are hence not considered to provide any additional value.

- **Trust** in information provided and **design of the user interface** (perceived ease-of-use) are two **important factors** whereas the **physical design** of the device itself does not seem to play such a significant role for willingness to keep.

- **Willingness to pay** for access to the functions appears to exist among a group of participants. The sum that a majority of these is willing to pay **each month** for access to a function is within the range of **1–10 EURO**. A small part of the participants has indicated a higher monthly fee (predominantly **11–25 EURO**). However several information services, such as for instance **navigation support** and **traffic information**, are now offered as ‘apps’ and for free. Willingness to pay may therefore no longer be a relevant factor to consider in order to understand **user uptake** of the type of functions tested in TeleFOT.

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TeleFOT Impact Assessments – General Conclusions

- Participants expectations for all of the different functions tested within TeleFOT were high but they became more negative as the FOTs progressed. By the end of the FOTs, the participants were positive again about the functions.
- Participants assessments of the designs of the devices were positive but there were some negative view.
- Acceptance of the devices changed over time – acceptance results in usage rather than vice-versa.
- Many of the TeleFOT functions reduced driver stress and uncertainty and improved perceptions of safety and comfort.
- There is no evidence to suggest that the TeleFOT functions affected Mode of Transport and Timing of Commuting journeys.
- Average speed was found to decrease with use of the Green-driving function.
- Eyes off road time (EORT) was found to change when the navigation function was introduced although the Green-driving function did not change visual behaviour.
- The Green-driving function was found to decrease fuel consumption but increase journey duration. Average speed and speed variance were both smaller with this function.
- Navigation support has positive implications in all areas of Mobility and many aspects of Efficiency but the function effects are small for Environment. Some effects for Safety are evident in terms of distance travelled (reduces) and distraction (increases).
- Traffic Information is positive for Mobility in terms of reduced journey duration and reductions in stress and uncertainty. It was also positive for Efficiency in terms of reduced travel durations, reduced headway variations and perception of avoidance of congestion. The impact of this function on Environment was inconclusive.
- Speed Information/Alert has a small but mainly positive effect for Mobility, Efficiency and Safety.
- The Green-driving function had a positive effect on Efficiency and Environment. This function had a mixed effect on Mobility and a negative effect on Safety (by changing exposure).
- Overall the TeleFOT project was not without limitations but most of these were recognised at the beginning of the project and specific measures were introduced to overcome these. However, some of the limitations are still important to highlight as follows.
- TeleFOT was reliant on third-parties for execution of the FOTs in some cases. This was highly beneficial on the one-hand as it provided extra input to the project at minimal cost. However, one implication was that the project had little control over this input.
- Smaller sample sizes were necessary in the Detailed FOTs compared to the Large-scale FOTs although this was largely offset by enhanced data acquisition in the detailed FOTs.
- The majority of the FOTs were performed using a within-subject (or before-and-after) design. In the some cases, a matched control-group throughout the whole test-period might have been beneficial but practical reasons (e.g. resources in time and money) made this impossible.
- The fast-moving pace of technology could limit the results to some degree - the TeleFOT project began in 2008 just as technology proliferated. By the end of TeleFOT, technology had evolved substantially so that the results, whilst possibly generalizable to the first or second generation of after-market devices could not easily be applied to the state-of-the-art. Many of the functions tested have already migrated from smart-phones to apps built on APIs and a new world that is dominated by platforms and technology-enabled services.

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