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## Impacts on Mobility – Preliminary Results

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## LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
GD	Green driving
NA	Navigation
SA	Speed alert
SI	Speed limit information
TI	Traffic information
UU	User uptake

## REVISION CHART AND HISTORY LOG

REV	DATE	REASON
0.1	29/12/2010	First skeleton (SI)
0.2	21/1/2011	First piloting results added (SI)
0.3	11/2/2011	More piloting results added and modified for more uniform presentation; input on concept of mobility and method (SI)
0.4	3/3/2011	Final piloting results added, chapter on pilot results modified for more uniform presentation (SI)
0.5	14/3/2011	Validation of travel diary and logger data added (SI)
0.6	22/3/2011	Language reviewed versions of chapters 2, 3.1 and 4, new table to chapter 6.2 (SI)
0.7	31/3/2011	Finalisation of draft (SI)
0.8	1/4/2011	Missing references added (SI)
0.9	26/5/2011	Revision according to review comments (SI)
1.0	3/6/2011	Language revised version (SI)
1.1	3/6/2011	Format changes (PMononen)



## EXECUTIVE SUMMARY

The objective of this deliverable was to provide preliminary results from the analysis of mobility impacts from the TeleFOT project. Specifically, the objective was to discuss the concept of mobility, to validate the method proposed for mobility impact assessment and to pilot the mobility research questions.

Mobility is concluded to be the willingness to move along with potential and realized movement rather than just physical movement of vehicles, people and goods. Along with transport and infrastructure it encompasses people's and road users' attitudes, opinions and choices in their daily travelling and movement. The concept of mobility is versatile. However, it is often reduced to transport or confused with accessibility or efficiency.

In TeleFOT, a travel diary was developed to meet the information needs in order to address research questions and hypotheses related to mobility impact assessment. Diaries are collected once in the before-phase of the FOT and two or three times in the after-phase depending on the length of the FOT. A supplement to the travel diary is filled in during the after-phase travel diary data collection periods to collect essential information about major changes in the mobility needs and possibilities of the test users and their families due to factors other than TeleFOT functions.

Trips reported in the travel diary were compared to logged trips. Travel diaries were returned by 73% of test participants. In general the travel diaries were filled diligently by users, with 96% of travel diaries returned fully completed. However, only 67% of all trips either reported in the travel diary or logged were found in both data sets. Forty-one percent of trips reported in the travel diary were missing the corresponding logger data. Eight percent of logged trips were missing the corresponding travel diary entry. An alarmingly high (18%) proportion of the logged data was trips that were fragmented into several trips in the logger data.

The pilot analyses of the research questions indicated no problems for the final analysis. All research questions concern a change in something. The change itself could not be analysed based on the first data sets available for the pilots. However, it was confirmed that most of the variables needed could be obtained from the data. The analysis of route choice could not be piloted yet, as map matching was not complete. In addition, a question related to user uncertainty was added to the post-test questionnaires. The preliminary results show no high expectations among the test participants.

In conclusion, the mobility impacts of TeleFOT functions should be possible to analyse for the final results as planned. More specific instructions were given for the final analysis.

## 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 5 years.

Field Operational Tests developed in TeleFOT aim at a comprehensive assessment of the efficiency, quality, robustness and user acceptance of in-vehicle systems, such as ICT, for smarter, safer and cleaner driving.

The analysis undertaken within the TeleFOT project aims to assess the impact of aftermarket nomadic devices in five distinct assessment areas; Safety, Mobility, Efficiency, Environment and User Uptake. In order to measure the impacts, core research questions and hypotheses were developed for each assessment area that also take into account the functionality of the devices specifically under consideration in TeleFOT. Each analysis plan deliverable details the proposed approach to be followed but does not give analysis outputs. The next step is to pilot the analysis proposed in the analysis plans to ensure that the final analyses can be performed as planned.

The objective of this deliverable is to provide preliminary results of mobility impacts for mobility assessment in TeleFOT. Specifically, the objective is to discuss the concept of mobility, to validate the method proposed for mobility impact assessment and to pilot the mobility research questions.

## 2. MOBILITY

### 2.1. Concept of mobility

Traffic is a consequence of fulfilling people's needs to move. Moving in itself does not often benefit the person, but is a way to get to the place where the action that brings the benefit can be performed (Kalenaja et al. 2008). Mobility is the potential for movement. It consists of means of travel and networks one has access to and is willing to use (Kulmala and Rämä 2010; Spinney et al. 2009). The concept of mobility should be understood as being richer than just traffic and transport, as is often the case in existing "mobility" policies. Nor should it be reduced to mere accessibility or used as a synonym for efficiency. Mobility has a role in itself beyond, but not in opposition to, these two important concepts. (Gudmundsson 2005)

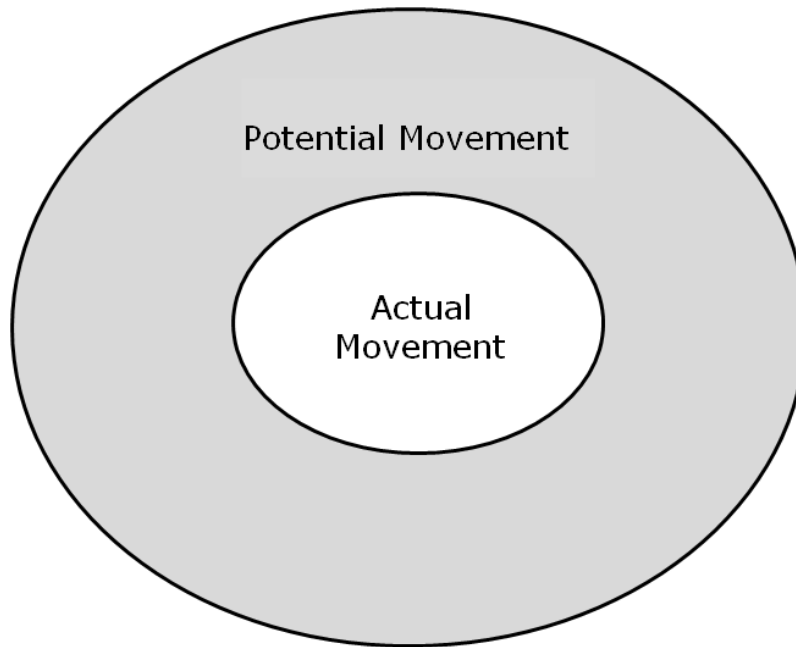
When the basic transportation infrastructure and services are functioning well and people have a choice in their means of travel, the quality of travel often becomes more important than the simple ability to get somewhere. Mobility in itself also includes people's preferences in travel and choices of time, mode and route, their feelings, and entails also the ease of travel itself. (Button et al. 2006; Gudmundsson 2005.) Mobility as a term is an umbrella containing traffic and transport with all the reasons and motivators, blending psychology and sociology into transport.

Mobility is a broad concept, and is largely used in many different contexts. According to Gudmundsson's (2005) "The Key Dimensions of Mobility", which he used to create a mobility policy that covered all aspects of mobility, mobility should be considered from four viewpoints:

- Mobility as potential and realized movement
- Mobility as dependent on potency and tendency
- Mobility as expressed in qualities and quantities
- Mobility as externally and internally sustainable

Mobility refers to the ease of movement rather than just movement itself, entailing also the potential to move. Actual movement is rather straightforward, easily conceivable in terms of distance and duration of the movement, whereas potential movement is the transport system's ability to enable a particular amount and type of movement to take place. Potential movement, which can also be understood as available systemic potential, varies in time and space and with the services used, as the peak rush hour blocks the

streets but disappears as day turns to night. Actual and potential movements are not entirely separate but rather a nested set, actual movement being able to happen in line with potential (Figure 1). (Gudmundsson 2005.)



**Figure 1 – Difference in actual and potential movement (Gudmundsson 2005)**

The difference in "size" between realized and potential movement in Figure 1 illustrates the difference between how much travel would be possible compared to how much is actually done. The potential to move does not always meet the need to move, sometimes resulting in excess capacity when at other times there is too little. The available potential both enables and constrains the actual movement. (Gudmundsson 2005.)

Potential movement can be further divided into a potency (or supply) side and a tendency (or demand) side. When the two overlap, actual movement may be produced. Potency reflects the transport system's potential capacity, and tendency the need or desire to move. This need is produced and conditioned by a range of socio-economic factors, the influence of which controls the physical separation of activity spaces, and the preferences, roles, lifestyles and activity patterns of individuals. Together these factors create the pressure (tendency) to release the potential into movement. (Gudmundsson 2005.) However, supply and demand do not always meet, proven by idle seats in some vehicles and people standing in the aisles or corridors in others. With the help of intelligent transport systems it may be possible to even out the capacity in time and space.

Once the quantity of travel needed is satisfied, quality becomes a critical factor. Safety, comfort, reliability, privacy, continuity, and even "greenness" may be important choice parameters in everyday mobility (Nilsson and Küller 2000). If, for example, buses are felt to be unsafe and appear dirty, they are not used as much as they could be even if the bus service runs fast and cheaply between the desired locations. Qualities are not separate from potential movement but should rather be seen as important attributes of it. (Gudmundsson 2005.)

The qualitative dimensions of travel are hard to capture fully. Some of these aspects are readily quantifiable like travel time, emissions and ITS services available, while others like insecurity of travellers and aesthetic qualities are not. (Gudmundsson 2005.) For some travellers, trade-offs are made on a daily basis, while for others choices of particular modes or routes are deeply entrenched (Jensen 1999). Moreover, finding the value for the qualitative factors that affect people's choices is very hard, as there are plenty of different opinions for the most important factors affecting travel amenity. In a study on social security in public transport in Helsinki, 24% of travellers said they could use more public transport provided it was safer (Forsblom and Happonen 2005).

Mobility sustains the wider economy and vice versa and thus enjoys plenty of investment. Internal mobility investments cover infrastructure, but mobility has external impacts affecting, for example, the environment in terms of air quality and pollution. To be internally and externally sustainable, investment should help increase mobility, but it can be difficult to define where the money for improvements should go. Insufficient system investments may in some cases slow down growth in wellbeing or even lead to breakdown. However, maintaining extensive system potential might not be economically sustainable. (Gudmundsson 2005.) Building new lanes on congested roads is expensive and may not help much, as for example at least half of all metropolitan area congestion has been assessed to be due to operational rather than infrastructural problems (Button et al. 2006).

Gudmundsson's analysis proposes a very rich conceptual description of mobility. It covers potential and actual movement at micro and macro levels. To realize this idea, extensive amounts of data would have to be collected, and importantly, many of the measures to be monitored would have to be estimated. (Gudmundsson 2005.)

In conclusion, mobility is the willingness to move along with potential and realized movement rather than just physical movement of vehicles, people and goods. Along with transport and infrastructure it encompasses people's and road users' attitudes, opinions

and choices in their daily travelling and movement. The concept of mobility is hard to fully define, and is often reduced to transport or confused with accessibility or efficiency.

## 2.2. Personal mobility

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Individuals' mobility patterns are based on a number of conscious and unconscious choices. It has frequently been noted that banal travel patterns tend to repeat themselves routinely, continuing the same pattern from day to day, week to week and year to year. (Pendyala et al. 2000.) Modern everyday life is no longer characterized by a connection to territorial anchored communities, but by a much higher degree of mobility between a number of different communities (Freudendal-Pedersen 2005). It is common nowadays to choose workplaces and activities based on personal interests, not on what is available nearby, thus creating a need to commute more. Gärling and Axhausen (2003) stated that the reason for repeating behaviour may simply be that the intention, like driving to work, is formed repeatedly.

An important reason for this interest in habitual travel choice is its bearing on travel demand management strategies. A choice that is non-deliberate may in fact be difficult to influence with rational arguments like increased costs or pollution, since the person making the choice tends to discount relevant information. (Gärling and Axhausen 2003.) If these habits are desired to be broken and people are encouraged to try other modes and ways of travel, it should be figured out how these choices can again become deliberate and rational.

One part of this reluctance to consider new modes of travel and new routes is that the person has already gathered lots of information about his/her normal route with the vehicle most used, and travelling thus seems "easy". The relationship between how strongly past behaviour or habit and intention determine behaviour is assumed to be reciprocal (Triandis 1977): the stronger the determinant habit is, the weaker the determinant intention is, and vice versa. The more frequently a choice is made, the more habitual or script based it becomes (Gärling and Axhausen 2003.) Thus, if the route or vehicle were to be changed, the person would need to seek information and construct new routes and evaluate alternatives, bringing psychological stress upon him or her. It may be assumed that the cost of searching for and constructing new alternatives is generally too high and expected gains with new alternatives too uncertain. (Gärling and Axhausen 2003.)

Once formed, personal travel patterns seem hard to alter, thus affecting the use of different travel modes. The reasons why people choose their mode of transport are difficult to find. They can be sought with the help of concepts of personal mobility and mobility culture. Transportation is built, used and developed by people. This human factor brings with it a need for clarifying the concept of personal mobility and how it could be made operational so as to assess and monitor the results of policies that try and aim to provide it. (Gudmundsson 2005.)

Firstly, in any given population some people are more susceptible, or ready, to change their travel behaviour than others. This relates partly to more subjective factors such as people's attitudes, perceptions and level of confidence towards their current travel mode choices, and towards alternative travel choices, as well as their wish to actually change their travel mode behaviour. In this context, if people currently have negative perceptions and attitudes towards alternative modes, little or no confidence in using other modes, or see no reason to change modes, they will be unlikely to do so. The role of mobility management interventions should be to attempt to change these attitudes and perceptions, and instil confidence in a positive way in order to motivate people to try out, and ultimately adopt, new travel mode behaviours. (Carreno et al. 2010)

Gärling and Axhausen (2003) also addressed the problem of why private car use cannot be easily suppressed. The car is an attractive alternative to many, and there are often obstacles that prevent switching to other modes. Thus, drivers may be unable to switch even though they are motivated to do so. Unavailability of alternatives is of course a main obstacle in many cases, or if they have a mobility impairment that prevents them from switching car trips to traditional bus services, cycling or walking. Yet, inertia or habit may also play an important role. It increases the transaction costs since switching to another mode makes it necessary to learn new routines. Furthermore, searching and processing information about alternatives are reduced. Hence, important changes may go unnoticed such as, for instance, attractive alternatives becoming available. In this instance mobility management interventions alone would be unlikely to change people's travel behaviour, and "harder" more infrastructural measures would have to be implemented first or simultaneously (such as the addition of new bus services, or demand for responsive services for mobility-impaired people). The role of mobility management would be more supplementary in ways such as increasing awareness of these new services (via travel awareness campaigns), or provision of free tickets to entice people to try new services. (Carreno et al. 2010; Gärling and Axhausen 2003.)

Accordingly, the implications are that any mobility management intervention is likely to affect people in different ways based on their susceptibility to change behaviour and stage position within the behavioural change process. Further, evaluations that focus on behavioural change as such would not detect any of the subtler attitudinal and perceptual changes that would also occur as people progress to later stages of readiness to change (Carreno and Welsch, 2009).



### 3. METHOD

#### 3.1. Travel diary data collection

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In TeleFOT, a travel diary (Annex I) was developed to fulfil the need for information and thus address research questions and hypotheses related to mobility impact assessment. The travel diaries are used in large scale FOTs only, as the experimental design of the detailed FOTs is not suitable for mobility impact assessment. Test fleets of professional drivers using TeleFOT functions only during work are excluded from the mobility impact assessment. The travel diary is filled in paper format, one paper a day. Diaries are collected once in the before-phase of the FOT (tested functions not yet available) and two or three times in the after-phase (tested functions available to participants) depending on the length of the FOT. The length of each travel diary data collection period is one week. More specifically, the travel diary data collection is timed as follows:

- First week: To be collected during the before-phase of the FOT. Participants do not have the tested functions available at this point.
- Second week: Approximately 2 months after the after-phase of the FOT has started. Participants have tested functions available.
- Third week: Approximately 6 months after the after-phase of the FOT has started.
- Fourth week: At the end of the after-phase for FOTs that last for 8 months or longer.

A supplement to the travel diary (Appendix I) is filled in during the after-phase travel diary data collection periods to collect essential information about major changes in the mobility needs and possibilities of the test users and their families due to factors other than TeleFOT functions (one questionnaire per week). This information is needed for interpretation of the results and to minimise extra variance.

#### 3.2. Data

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##### 3.2.1. Travel diary data

The preliminary results were based on 63 participants' trips reported in their travel diaries. These 63 travel diaries contained altogether 1,831 trips. This data was collected during the before-phase of the Finnish LFOT when test participants had a limited set of

services in use. These services included traffic information (TI), speed limit information (SI) and speed alert (SA). In addition, the driving diary feature of the green driving (GD) application was in use. The diaries were filled in daily during the first week of October 2010 (4-10.10.2010).

### 3.2.2. Logger data

Logger data used for the preliminary results was collected during the same time period as travel diaries were used in the validation study. In the Finnish LFOT, TeleFOT applications had an autostart feature. However, it was dependent on having Bluetooth active on the mobile phone, and the participant had to accept the application to actually start. Logger was included in the application and, consequently, recorded the trip only if the application was turned on.

Six participants did not have any logged data from the time of their travel diaries. In addition, three participants had logged trips where they were passengers, against the guidelines. These trips (corresponding to trips reported to have travel mode 3 in the travel diary) made up 100% of all logged trips of these three participants. These participants were included in the validation, because if only logger data was used it could not have been known who the driver was. However, when validating trips made by car or van as driver, the trips made as passenger were excluded, leaving the amount of logger data journeys at 1,045.

### 3.2.3. Matched data

Travel diary trips and logged trips were matched for the 54 participants (six participants not having any logger data and three who had only logged journeys as passenger were excluded) when times and length of trips could be reasonably matched. In the combination of two data sets, trip starting time in the logger data had to differ by a maximum of 10 minutes, or be included in the travel diary trip time frame. Likewise, trip ending time in the logger data had to be within the travel diary trip time frame or 10 minutes more at the most. Crucial in this matching were the trips represented in travel diaries; matching could be done only if there was no other trip within a 20-minute time frame that the logger data trip could be matched with. This was done because test participants' accuracy in reporting travel diary trips was expected to vary somewhat.

Logger data had fragmented trips, for example multiple logger data entries fitting between the starting and ending time of a single travel diary trip. For comparing data

and logger data calculations, every fragmented trip was handled as one trip although separately from trips with a single corresponding trip in the logger data. To neutralize the biasing effect these fragment clusters might have had in data analysis, clusters were added up to have only one length, starting time and ending time.

A combined data set was made where matching trips were inserted as single entries. Trips with no counterpart in both data sets were included in the combined data as incomplete entries. The combined data included 1,970 lines of data (travel diary trips, logged trips and logger trip fragments), totalling 1,831 trips. The difference was due to the fragmentation.

#### 3.2.4. Questionnaire data

Questionnaire data available for the preliminary results were pre-test user uptake questionnaires of GD and SI/SA completed by Finnish participants, totalling 82 respondents.

As the Finnish participants had the SI/SA service activated as part of the TI service at the time of filling in the questionnaire in the pre-phase of the LFOT, the opinions analyzed in the pilot corresponded to the very first feelings of using the system. The GD application was not active at that time. Therefore the opinions analysed here correspond to anticipatory expectations of the system.

The pilot analysis of research questions M-RQ10.1 and M-RQ10.2 was made based on pre-test questionnaires filled in by Italian Large Scale FOT participants, 30 respondents in all. In the pre-phase of the LFOT, Italian test users had no access to the Navigation (NA, Static) and SI/SA functions to be activated by TeleFOT. The Finnish questionnaire data of the GD application was used in the pilot of M-RQ10.1 and M-RQ10.2.

## 4. VALIDATION OF TRAVEL DIARY DATA

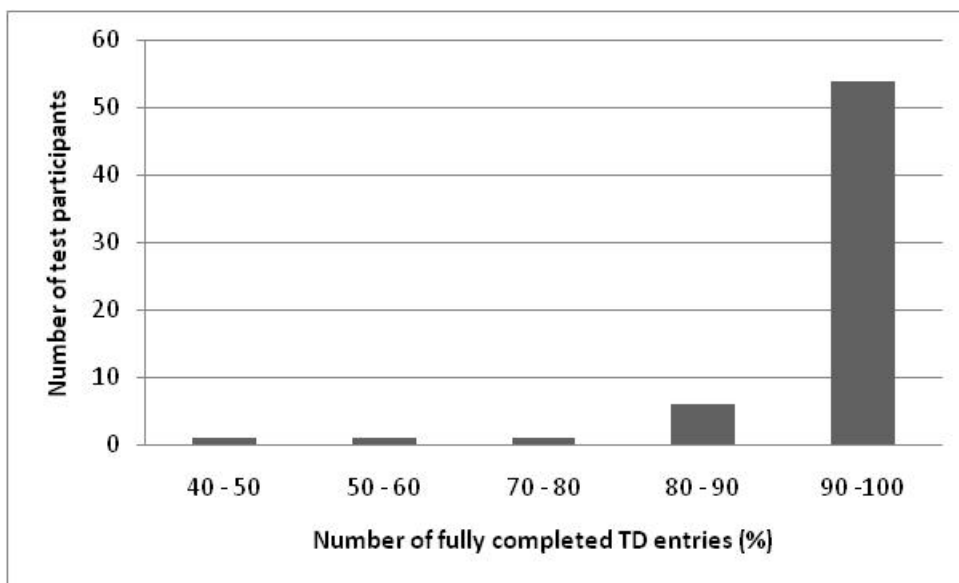
### 4.1. Trips reported in the travel diary

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#### 4.1.1. Accuracy of form filling

In the travel diary there were 12 factors to report about each trip. Seven factors, namely origin, destination, start time, end time, trip length, mode of travel and purpose, had to be answered in order for the travel diary to be fully filled for analysis if no functions were used and nothing unusual happened. Mode of travel was used in the assessment of accuracy of filling instead of primary mode of travel, as one participant had filled in only the mode, leaving the primary mode empty.

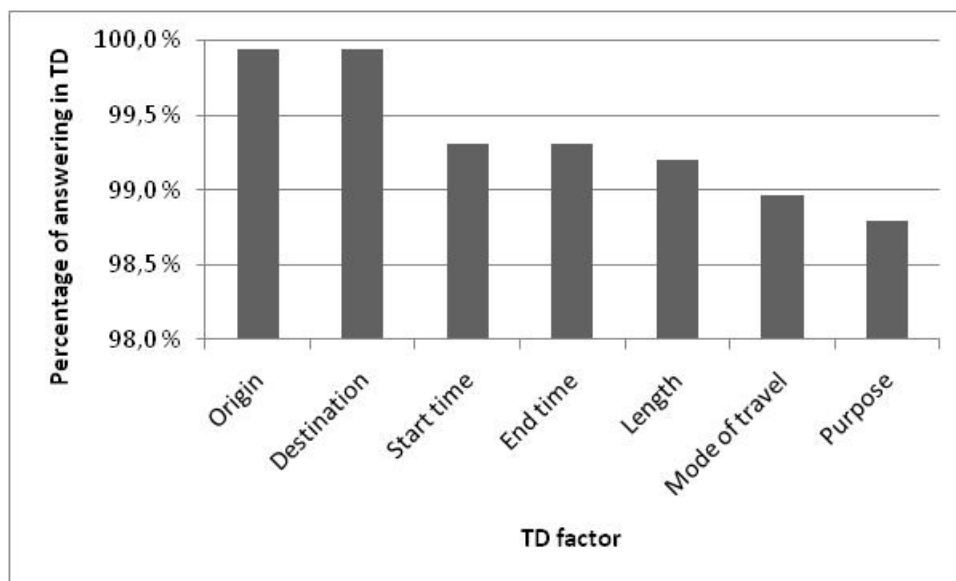
The percentage of fully filled entries in the travel diary was calculated from all the trips in each of the 63 participants' travel diaries (Figure 2). On average, the participants answered all seven factors in 96.3% of their travel diary entries. Diligent completion of the travel diary was common, with 85.7% of the test participants having answered specific factors in 90-100% of their travel diary entries and as many as 95.2% in over 80% of their travel diary trips. Only three out of 63 participants had less than 80% of their travel diaries fully filled in, the minimum being 47.6%. Based on these results, the collection of travel diary data was successful. The generally high level of completion portrays the travel diary as a well-accepted method among participants.



**Figure 2 – Number of participants according to percentage of completed travel diary entries. A travel diary entry was considered complete if the origin, destination, start time, end time, trip length, mode of travel and purpose were reported.**

The answer rate (i.e. returns per request) of the first travel diary collection was 73%. It remains to be seen whether this diligence will continue as the study progresses. As time progresses test participants may become forgetful and negligent during the travel diary answering week. Travel diary collections are spaced 3 to 4 months apart, so that even as the novelty of the study wears off, the task should not be considered too laborious. Boredom with the study may occur, and this may reduce the percentage of answers, but quite possibly the change will not be dramatic.

With two exceptions, factors were marked down with a minimum of 99% accuracy. The peak factors were "origin" and "destination", answered within 99.9% of travel diaries. The least marked were "purpose" and "mode of travel", answered in 98.6% and 98.7% of travel diary entries, respectively. Consequently, the overall accuracy of filling was excellent.

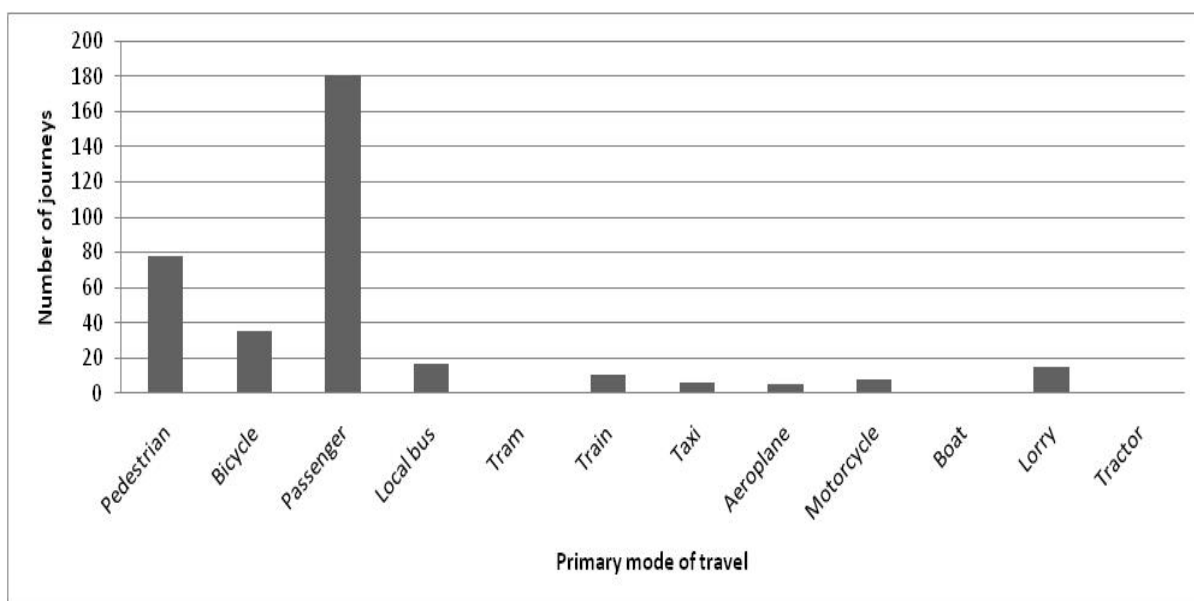


**Figure 3 – Diligence of filling in the seven factors in the travel diary required for the travel diary to be fully answered**

Origin and destination are the factors easiest to remember and fill out afterwards, as they most often are from a predefined list. It is hard to know why the purpose was not filled in more, as the participants would probably remember their trip's purpose at least from their trip destination. It could be that in some of the unanswered cases, the trip purpose was felt to be ambiguous and thus left out.

#### 4.1.2. Mode of travel

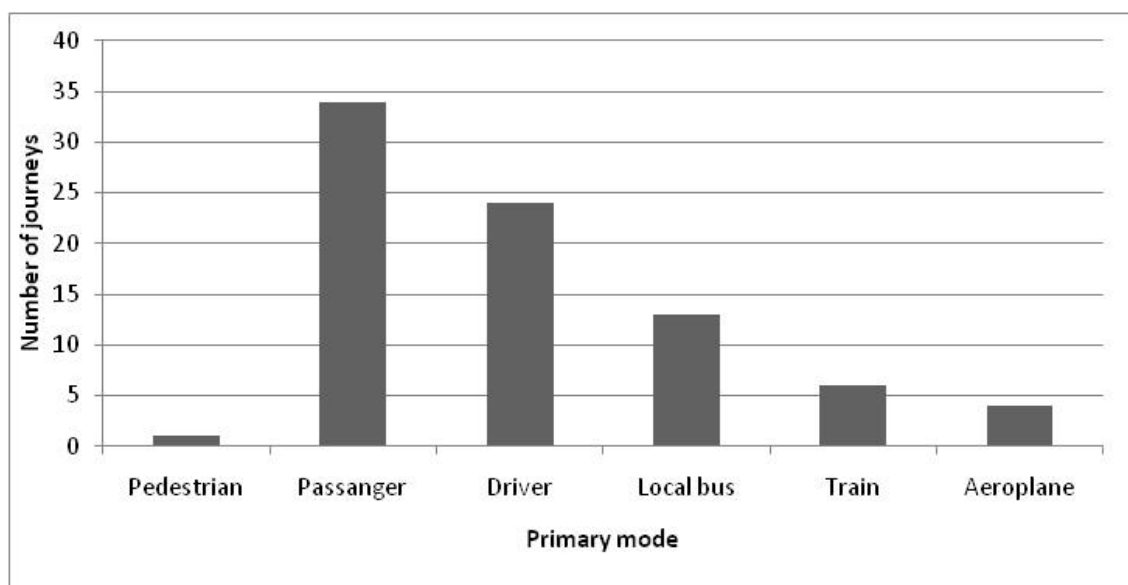
In the travel diary, 18 different modes of travel were specified (Annex I). The most popular mode of travel was driving a passenger car or van, resulting in 79.6% of trips reported in travel diaries. Of the test participants 68.4% had driven a car in over 80% of all their travel diary trips. The large amount of trips driven by car is also a sign, as it means that a large proportion of test participants' trips are potentially possible to log. Among the 20.4% of trips not made as driver of a car or van, three modes of travel were up in popularity: passenger in a car or van in 10.2% of all travel diary trips, pedestrian in 4.5% and bicycle in 2.0% of all travel diary trips (Figure 4). In nine categories, there were less than 1% of all travel diary trips in each (local bus, tram, train, taxi, airplane, motorcycle, boat, lorry, and tractor) whereas in five categories there was no recorded action (long distance coach, metro, moped, skidoo, and other mode of travel).



**Figure 4 – Trips according to primary mode of travel, excluding the mode driver of passenger car or van**

Test participants could report the use of multiple modes of travel during one trip, but were instructed to mark as the primary mode of travel that which was used for the longest distance. 99.0% of all travel diary entries had at least one mode of travel and primary mode of travel written down. Two modes used were reported on 1.9% of trips, whereas three were reported in 2.6% and four in 0.2% of trips.

Only 17.5% of test participants made multi-modal trips. Among the test participants the popularity of multiple modes varied a lot, from a maximum of 88.5% of participant's trips to a minimum of 2.4%. With trips that had more than one mode of travel, the most common primary mode of travel was as passenger in a passenger car or van (41.5%) followed by driver in a passenger car or van (29.3%) (Figure 5). The most common secondary mode used was pedestrian in 82.7% of journeys, implying longer walks to the car and back, or the test participant forgetting that he/she was not meant to mark down short walking trips to the car etc.



**Figure 5 – Primary mode of travel in multiple travel mode trips**

The small number of trips with more than one mode of travel may also be explained by geographical and infrastructural factors. Obviously only a few of the test participants live in an area with many modes of travel to choose from, as nine modes of travel had less than 1% of all travel diary trips in each and in five modes there were none. Some of the less popular modes can be explained by geographical factors because local bus networks are extensive only in the biggest cities, and tram and metro networks only exist in the capital, Helsinki. Avoiding motorcycle travel goes with the season, as October is not a favourable time of year for this activity.

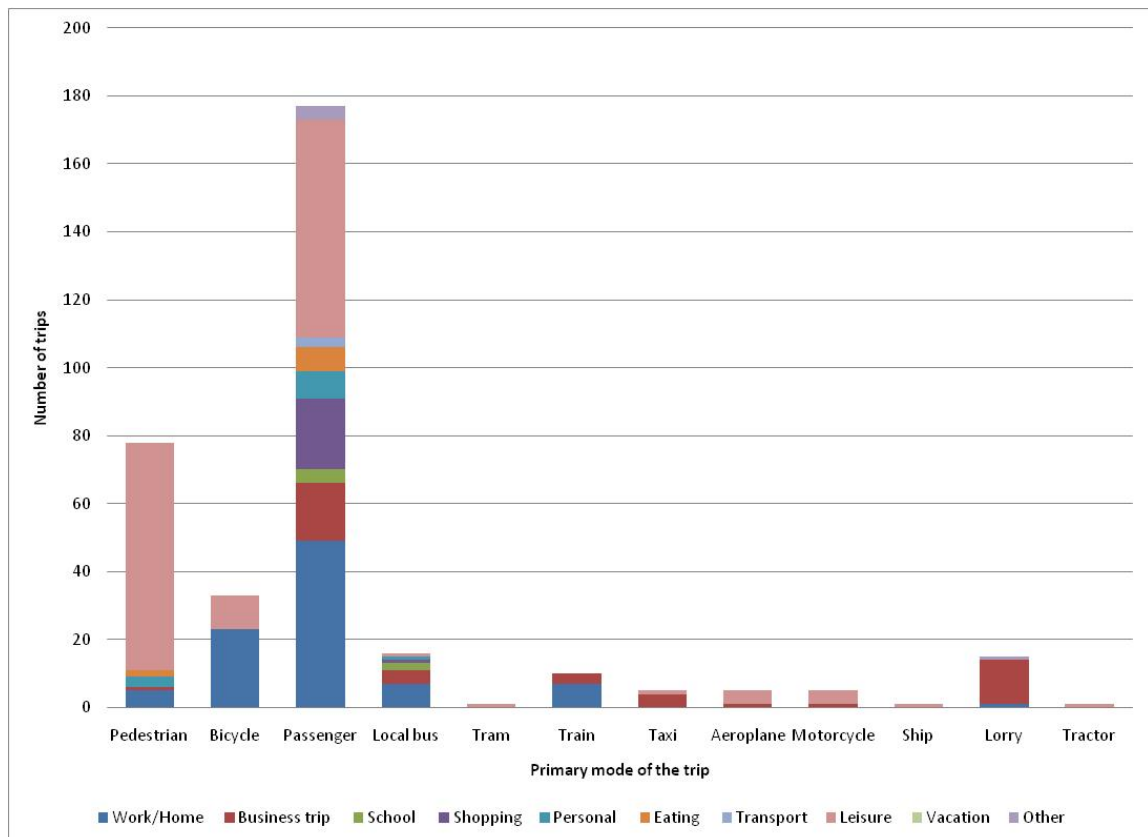
#### 4.1.3. Purpose of trip

In the travel diaries ten different purposes of travel were defined for the test participant to choose from (Annex I). The purpose was reported for 1,718 trips, with four cases where the purpose had been mistakenly marked as 11 (the maximum being 10). These four cases were excluded. As the primary mode also had to be included in the travel diary for analysis of the reported purposes, the number of trips in the analysis of purpose of trip decreased to 1,699. In view of the predominance of driving a passenger car or van as mode of travel, the results were separated into two parts: one excluding drivers, and one including only them. The calculations were based on 1,352 trips made as the driver of a passenger car or van and 347 trips in other modes.

Modes of travel excluding that of driver of a passenger car or van were divided into purposes as shown in Figure 6. Here the passenger of a car or van was the most popular



mode, with 51.0% of all trips excluding driving a car or van, and leisure (36.2%) and commuting (27.7%) being the most common purposes of trips made with this mode. The pedestrian mode comprised 22.5% of the trips, having leisure as the most common purpose of travel (85.9% of pedestrian trips). Together these two modes formed the clear majority of trips (73.5%). It is interesting that bicycle trips had only two purposes: 69.7% for commuting and the remaining 30.3% for leisure.

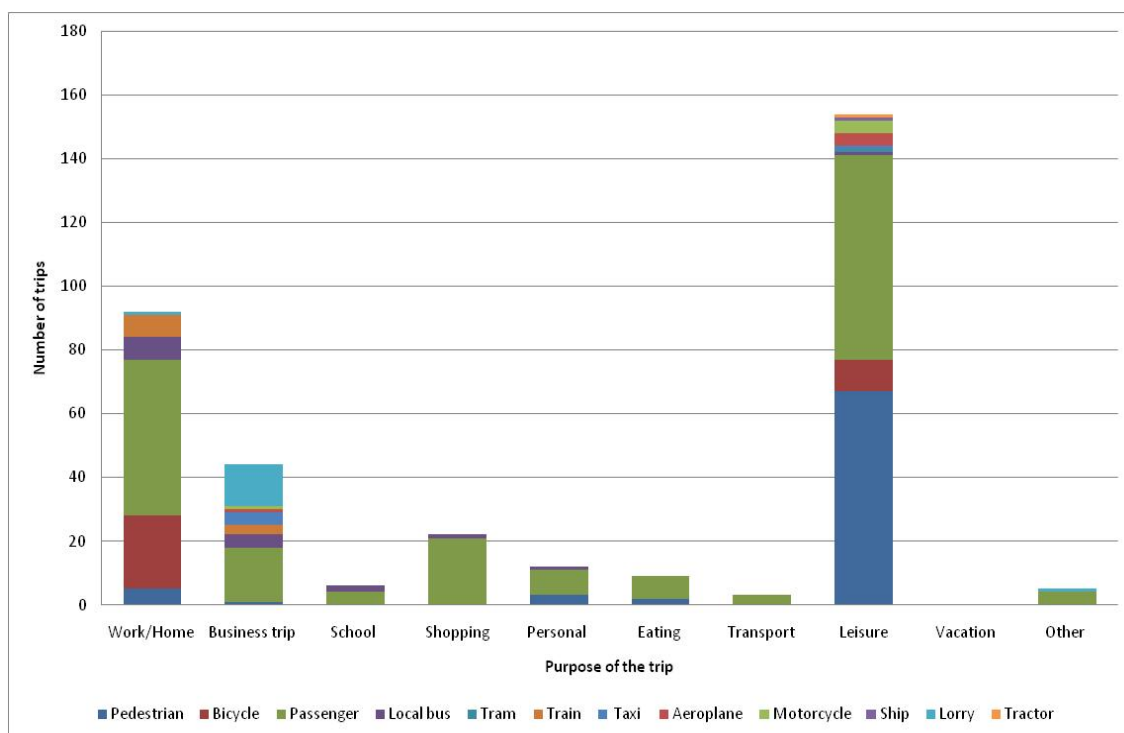


**Figure 6 – Primary modes of travel divided by purpose (excluding the mode of driver of a passenger car or van)**

Of the 10 trip purposes, leisure (41.2%) was the most common excluding those made as driver of a passenger car or van (Figure 7). The two most common modes used were pedestrian (43.5% of leisure trips with a mode other than driver of a passenger car or van) and passenger of a car or van (41.6%). Leisure activities compose a great share of test participants' reason to move. Not all destinations are far away, as many of the destinations were reached on foot.

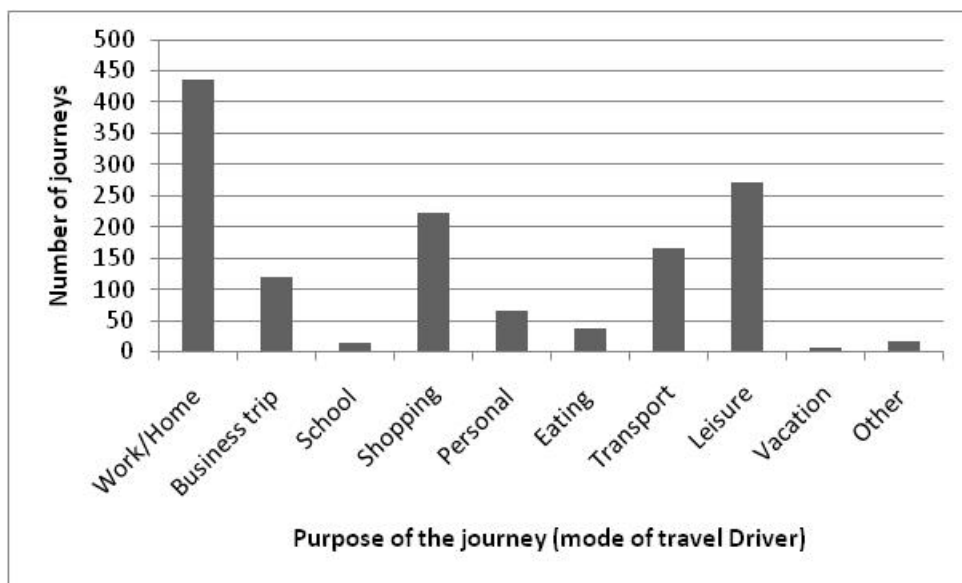
The second and third most common trip purposes were commuting (24.6%) and business trip (12.7%). For commuting, the two most commonly used modes were passenger of a car or van (53.2% of commuting trips made with a mode other than driver of a

passenger car or van) and bicycling (25.0%). For business trips, the two most commonly used modes were passenger of a car or van (38.6% of business trips made with a mode other than driver of a passenger car or van) and lorry (29.5%). The high share of business trips by lorry can be attributed to their being used to transport goods, causing a workday to contain many business trips. It is probable that at least one of the test participants drives a lorry as their profession.



**Figure 7 – Trip purposes divided by trip’s primary mode of travel, excluding primary mode of driver of passenger car or van**

When moving to the travel mode as driver of a passenger car or van, the three most popular purposes of trips were commuting (32.2% of trips made as driver), leisure (20.0%) and shopping (16.5%, Figure 8). Unlike the other modes of travel, driver of a passenger car or van was a mode used for every purpose of travel.

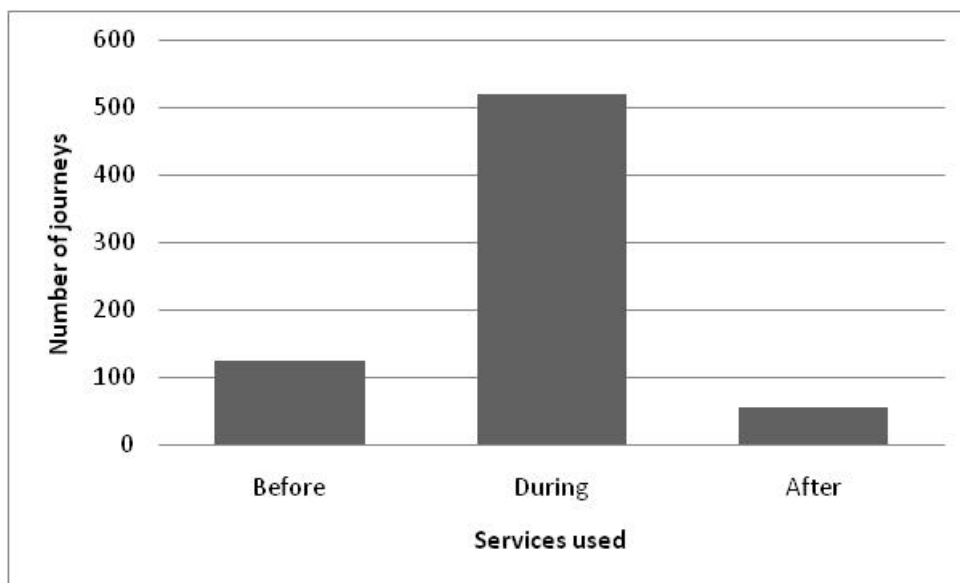


**Figure 8 – Trips made as driver of a passenger car or van according to purpose**

#### 4.1.4. Use of functions

The first week of filling in the travel diaries was made during the before-phase of the FOT when only TI and the driving diary feature of the GD application were activated. In addition, contrary to the original plan, a SA service was available to all test participants.

The use of offered services during the trip was reported in 30.0% of trips (Figure 9), and in 36.0% of trips driven by a passenger car or van. 24.7% of the reported trips had other than only a TI service in use. Before starting the trip, services were used in 7.2% of the reported trips, and afterwards only in 3.2% of the reported trips. Use of services was not confined to the use of a private car as the driver, as instructed, but also occurred during trips made with a tractor or bicycle in addition to trips made as a passenger.



**Figure 9 – Number of journeys when services were used before starting the trip, during the trip or after completing the trip**

Test participants were clearly interested in using the offered services. This is only natural, as they wanted to participate in a study where different services were being tested, some actually refusing to take part if placed in a control group with only the most basic services. They probably gave an overly positive picture of the average Finnish driver's willingness to use services.

During the actual FOT with all the services available, the use of services is likely to rise. After an adaptation period, the participants form their own opinion of the services, from which point their attitude may deviate in two directions, either towards negligence if several services feeding information are felt to be irritating, or getting used to the stimulus and developing a habit of reacting to the services, or a combination of both. It will be interesting to see how the test participants' attitudes develop, as this will give a strong indication of the level of acceptance and allowance for guidance and disturbance during trips.

#### 4.1.5. Use of options "other" and "unusual"

In filling out the travel diary, the test participant was offered a number of predefined locations, purposes and modes of travel (Annex I). If none of the options offered in the travel diary suited the trip, test participants had the possibility to describe the trip verbally. As the readily available option lists were fairly comprehensive, this option was

seldom used. Destination was described verbally for 4.0% of all travel diary trips, purpose for 2.4% of travel diary trips and origin for 1.9% of travel diary trips.

19.0% of test participants reported something unusual in their travel diaries, resulting in more information in 7.3% of all travel diary trips. Here the most common reason (43.8% of all unusual trips, which is a mere 2.4% of all travel diary trips driven by car) was participants' problems with the performance of the GD application (the application did not work or froze). Also mentioned were problems with incorrectly logged logger data (19.2% of unusual trips), where the logged journey had fractured, the journey length was incorrect or the point of origin or destination was wrong. In 17.8% of unusuals (1.0% of all the travel diary journeys), the participants reported that the travel diary trip was driven with other than their own car. In 6.8% of trips marked unusual, the reason was traffic conditions like slippery road, crash or traffic congestion. The remaining 12.3% of unusual trips consisted of several trips test participants do not make often, like taking the car to be washed or to an elk hunt.

## 4.2. Trips recorded in both the travel diary and logger data

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### 4.2.1. Number of trips

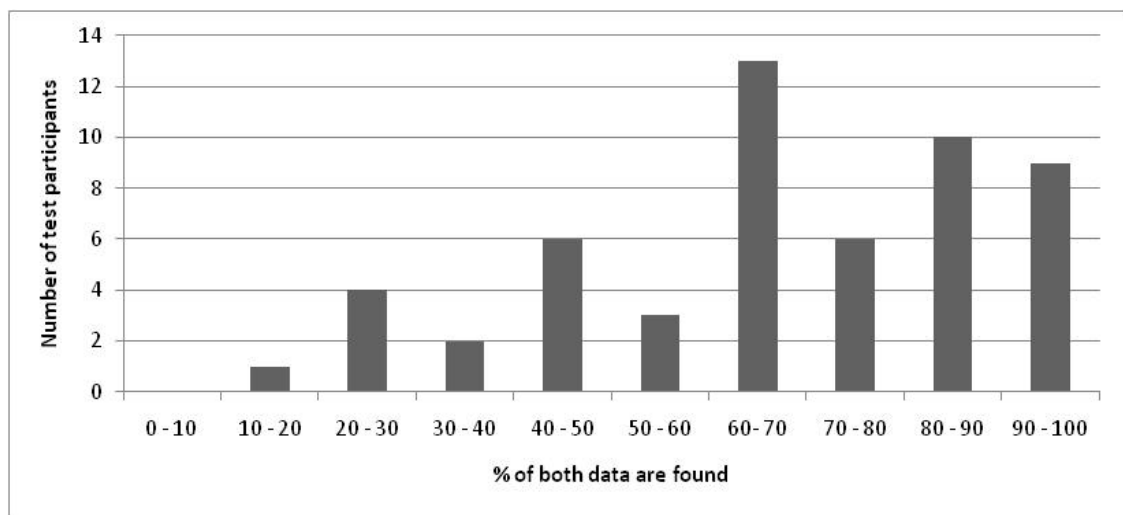
The test participants were advised to log the trip (in practice, activate functions) only if they were driving. However, out of 181 trips where the participant had marked in the travel diary that they had travelled as a car passenger, 50 trips also had corresponding logger data. This resulted in 4.6% of logger data representing the driving behaviour of other people than the selected test participants. Consequently, these trips logged as passenger were not counted in the total number of trips with both data. If these trips logged as passenger were included, 1,003 trips (57.5% of all travel diary trips) would have both data instead of 930 trips (55.9% of all travel diary data). Also six participants missed logger data completely.

The analysis in this chapter was conducted with 54 test participants having correctly logged data. Calculated from all travel diary data and logged trips, 55.9% of test participants' trips can be found from both travel diary and logger data. Fragmented trips were counted here as one trip per set of fragments.

38.5% of trips made by passenger car or van as the driver missed either travel diary data or logger data. More specifically, 40.7% of travel diary trips that should also have been logged were missing the corresponding logger data and 8.2% of logged trips were

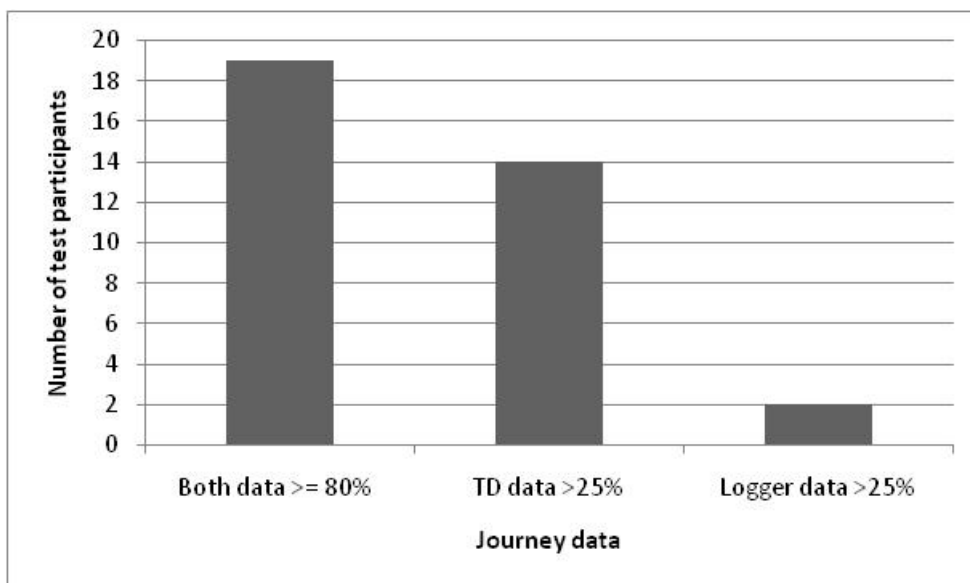
missing the corresponding travel diary entry. The reason for missing trips in the logger data is the lack of fully automatic logging and consequently participants not turning the application on. In addition, some trips reported to have been driven were made using another vehicle than the logged car. Therefore 100% correspondence cannot be expected. Missing travel diary trips are consequent to test participants forgetting to report them.

The amount of travel diary and logger data pairs was divided by the total amount of trips per person. Counted with all 54 test participants included in this validation, 75.9% of them had both travel diary and logger data in 50% or more of their trips (Figure 10). When setting the limit on at least 80% of trips the proportion of test participants was 35.2%, and 16.7% of participants had at least 90% of their trips in both sets of data.



**Figure 10 – Proportion of car trips for which both data were recorded, per test participant**

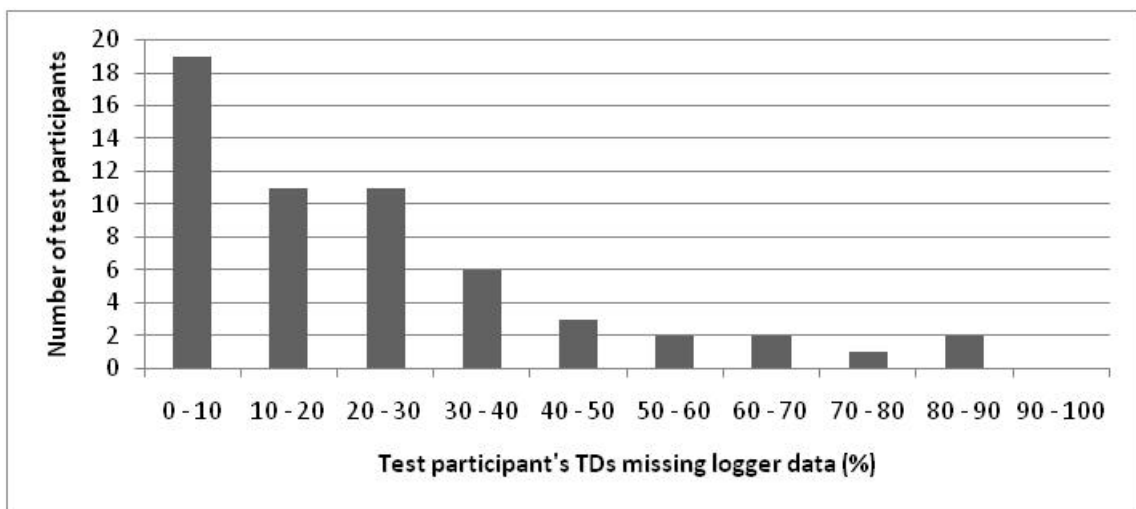
Since only 35.2% of test participants had both data in at least 80% of their trips, the result clearly indicated that other data was overrepresented in the participant's data set. From the 54 test participants, 29.6% had over 25% more of the other data: 25.9% had more travel diary data and 3.7% logger data (Figure 11).



**Figure 11 – Number of participants having at least 80% of trips in both data sets and number of participants whose data stressed on travel diary or logger data by over 25%**

When the limit of stress was lowered to 50% of other data, 11.1% of participants had more travel diary data but none had 50% more logger data. The total amount of data is very uneven for some of the participants. The number of participants having >25% of travel diary data clearly suggests that they had some kind of problem with data logging and would need help to log correctly. The participants having >25% of logger data are more peculiar, suggesting that they were forgetful or not that interested in completing their travel diaries. Either way, the importance of filling in a travel diary in a given week should probably be stressed a bit more to get a more accurate picture of these participants.

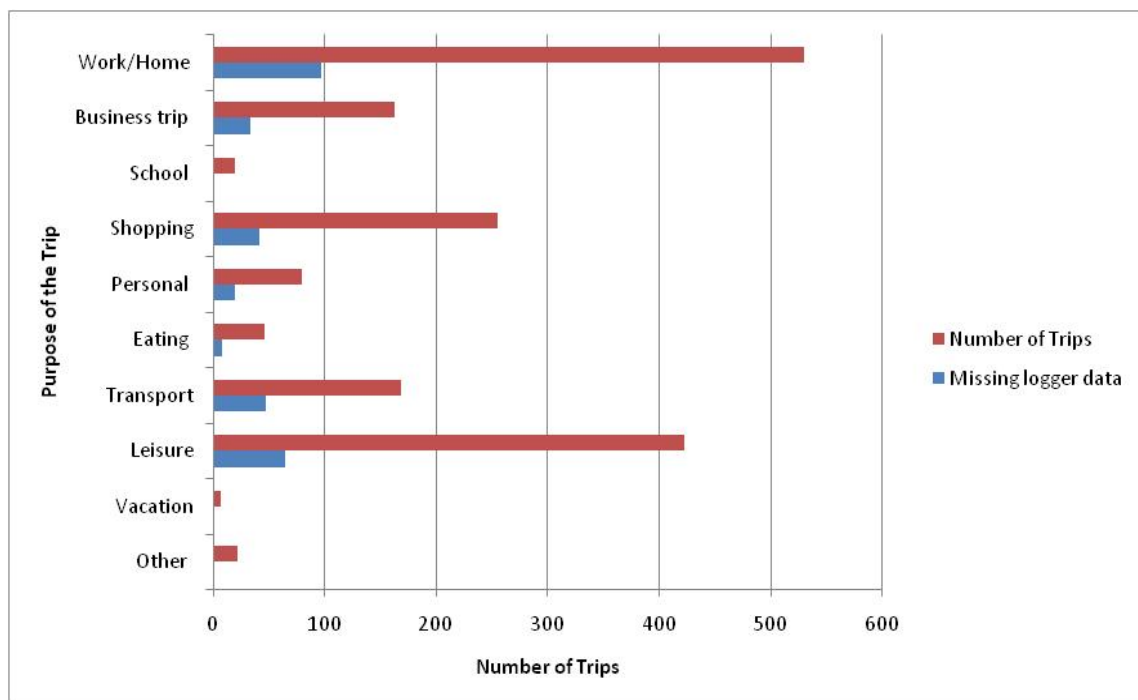
Only four of the 54 test participants (7.4%) had a corresponding logged trip for all of their travel diary trips, whereas one third (33.3%) had a corresponding travel diary entry for every logged trip. 29.6% of test participants missed only 0-10% of logger data and exactly half (50.0%) missed a maximum of 20% of corresponding logger data trips (Figure 12). The results prove that participants had the skill to use data loggers quite well, but it was either forgotten or chosen not to be used by many participants on many trips.



**Figure 12 – Travel diary missing corresponding logger data in percent from test participants' travel diary trips**

The most common purpose of trips missing logging data was commuting (31.7%, Figure 13). The reason for routinely logging what seemed like similar, repeated trips might have been lost on test participants, even though the effect of services can be most clearly seen in the changes in driving a repeated trip. The second purpose was leisure trips with 23.4% of all trips missing logging data. These results were in accordance with the popularity of purposes per all travel diary trips, where these two purposes comprise 52.2% of all purposes (Figure 8).



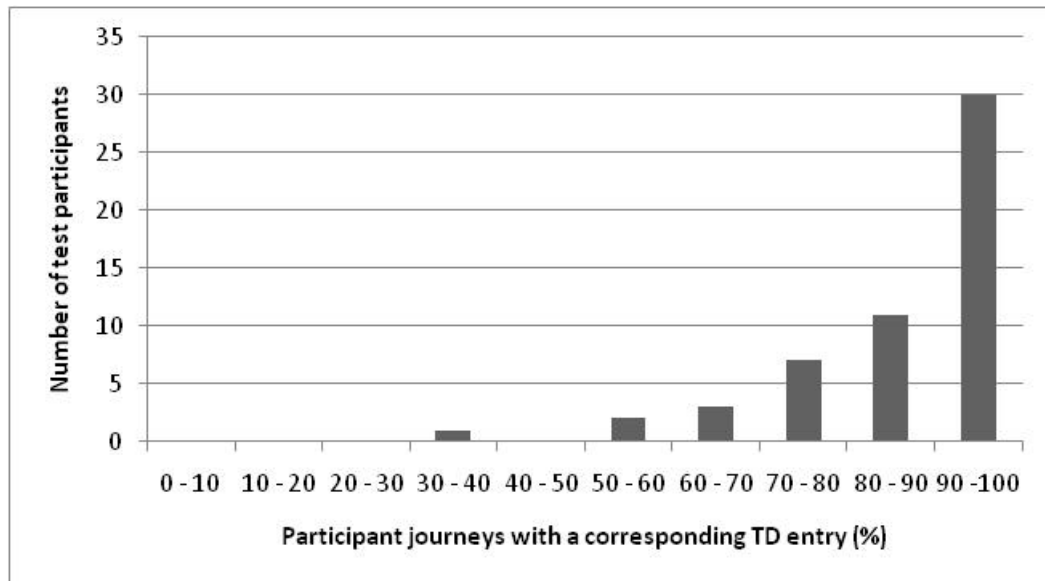


**Figure 13 – Number of travel diary trips missing logger data, according to trip purpose**

However, commuting and leisure purposes did have logger data, as corresponding logged trips and travel diary trips were found in 70.0% of commuting trips and 65.9% of leisure trips reported in the travel diary. When studied by proportion of missing logger data and not by mere amount, transport as a purpose missed the most logger data on most of its trips (28.0% of all transport trips, Figure 13), followed by personal business with 23.8% trips missing logger data, with leisure and commuting coming in fourth and sixth place respectively. Based on the results, participants driving transportation and personal business trips are more prone to leave the journey unlogged, but a higher travel diary - logger data ratio would be achieved if commuting and leisure trips were logged more dutefully as their sheer number exceeds the others. This could be achieved, for example, if participants felt that they benefit most from the systems available for those trips, for example in congested commuting conditions.

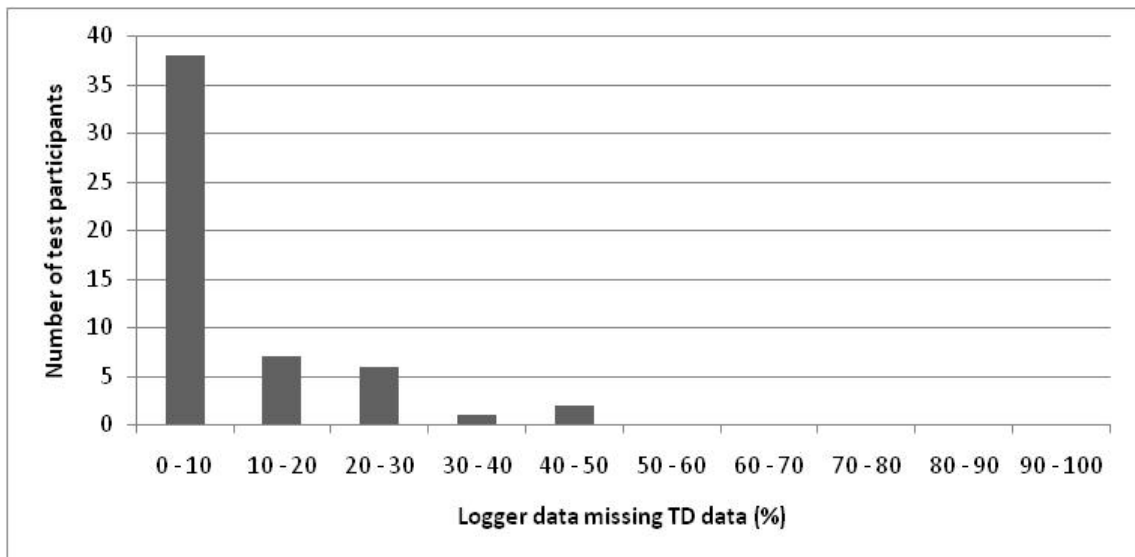
Observed from the logger data point of view, test participants reported their driven trips in the travel diary quite meticulously. Two thirds (66.6%) of test participants had a corresponding travel diary trip entry for their logged trips (Figure 14), and 55.6% of participants had a travel diary entry in 90-100% of their logged journeys. A corresponding travel diary entry was found for at least 30% of logged trips, showing that

every participant who returned the travel diary had at least tried to mark down most of their trips.



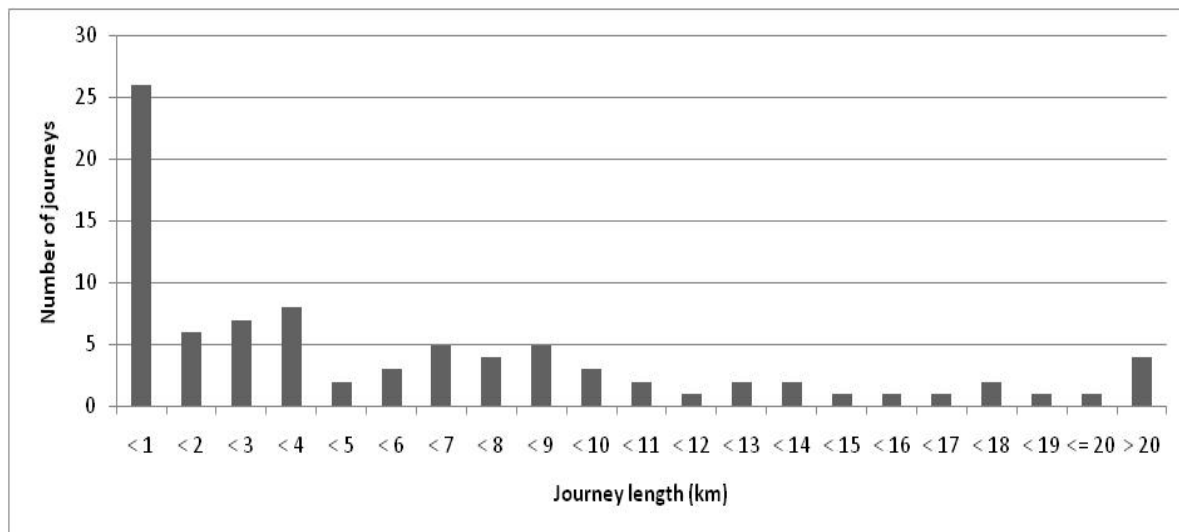
**Figure 14 – Participants’ logged trips with corresponding travel diary trips, percentage of the participant’s trips**

70.3% of participants missed a corresponding travel diary trip in less than 10% of their logged trips (Figure 15). None of the participants missed logger data for over 50% of the corresponding travel diary trips.



**Figure 15 – Test participants’ logged trip missing corresponding travel diary trip in percentages**

The length of the logged trip had no effect on whether the trip was reported in the travel diary or not. The shortest trip that was not marked down in the travel diary was 7 metres, and the longest 39.7 kilometres (Figure 16). However, it must be noted that according to the instructions very short vehicular trips (for example moving a car from one place to another very close by, not an actual trip) were not meant to be included in the travel diary. 14.9% of trips missing a corresponding travel diary entry were shorter than 200 m and 95.4% of logged trips missing a corresponding travel diary entry had length less than 20 km. The shortest trips should not be considered as trips outside the travel diary, but as cases where the trip should be filtered from the logger data. Here trips of less than 200 m might also be one reason for over-representation of logged trips with some test participants. They probably had data loggers activated also when moving their car, causing “ghost trips” that could be eliminated from the study, as the main point is to study the mobility of test participants, not how many times their car is moved.



**Figure 16 – Length of logged trips missing a corresponding travel diary entry**

Logger trips without travel diary data were heavily stressed on trips with length less than 1 km (29.9% of trips). These short trips can be “ghost trips” as explained above or short trips simply forgotten to be added to the travel diary after the trip.

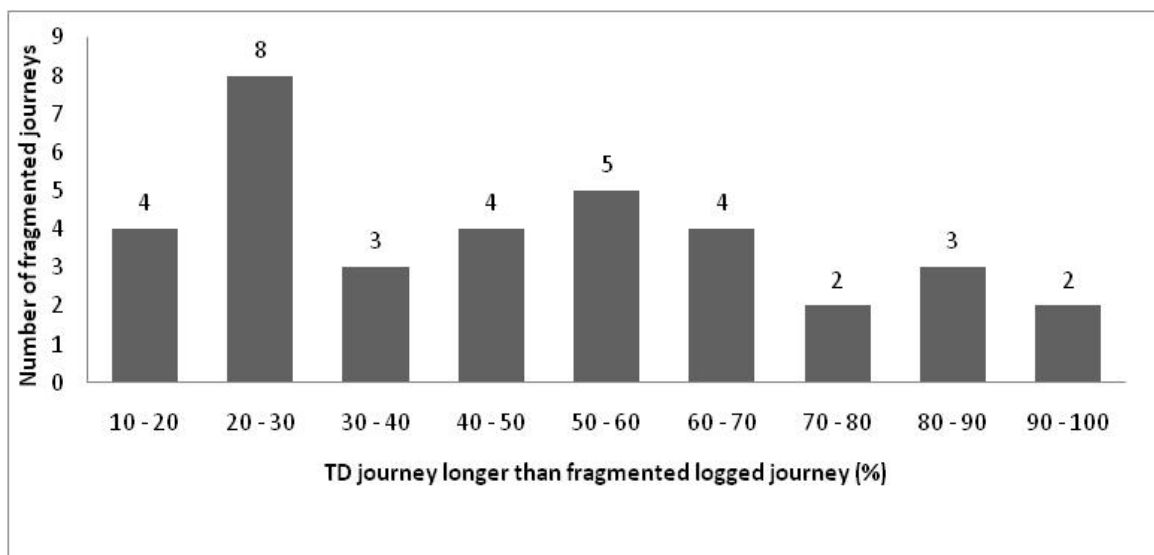
#### 4.2.2. Trip length correspondence

Trip length was recorded both in travel diary data and logger data: in the travel diary it was reported by test participants and in the logger data counted by data logger. Trip length correspondence was studied from the trips where the travel diary gave the

primary mode as driver of a passenger car or van, excluding five trips where the travel diary missed the length of the trip.

Trip lengths were considered equal if the logged trip length differed by at most 10% from the travel diary trip length. Consequently, 76.9% of trips had equal length in both data sets. Within this margin of error, only three journeys were exactly of equal length whereas 49.1% of equal length trip pairs had a longer travel diary trip and 50.9% a longer logged trip, showing that test participants marked their trip according to their own estimation or found it from a source that gave a different result from the data logger. Among the trips with both data, in 5.3% of travel diary trips having corresponding logger data this data was fragmented.

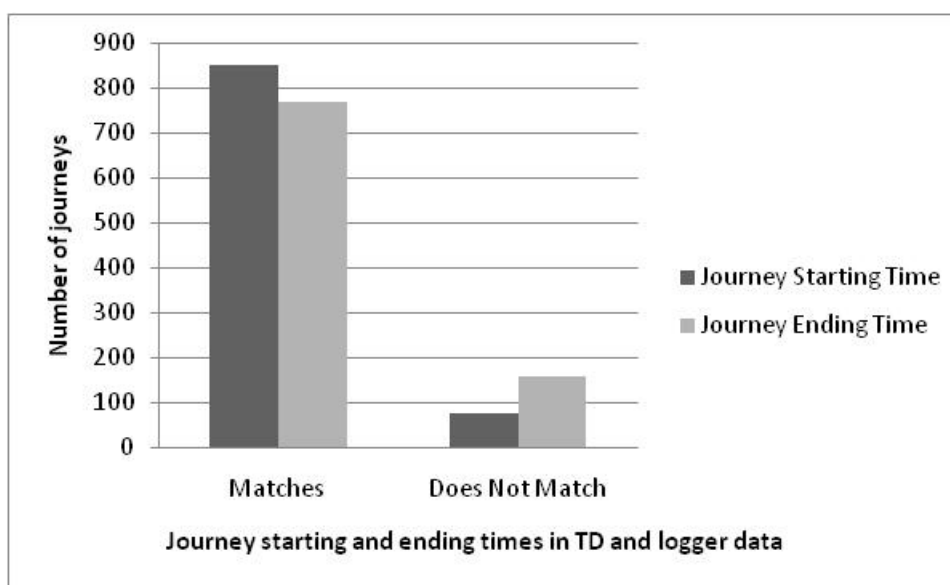
With pairs of trips (more than 10%) of different length, the travel diary trip was longer in 75.8% of cases (in other words in 17.5% of all trip pairs found from both data). The reasons could be that participants had made part of the trip with another vehicle, overestimated their trip length when marking it down in the travel diary, or the data logger logged only part of the trip. Logged trips were, for one, longer in 5.5% of all the trips found from both data. The reasons for longer logged trips are e.g. underestimated lengths of travel diary trips and a logger that connected two different travel diary trips as the same.



**Figure 17 – Travel diary trip longer than fragmented logged trip**

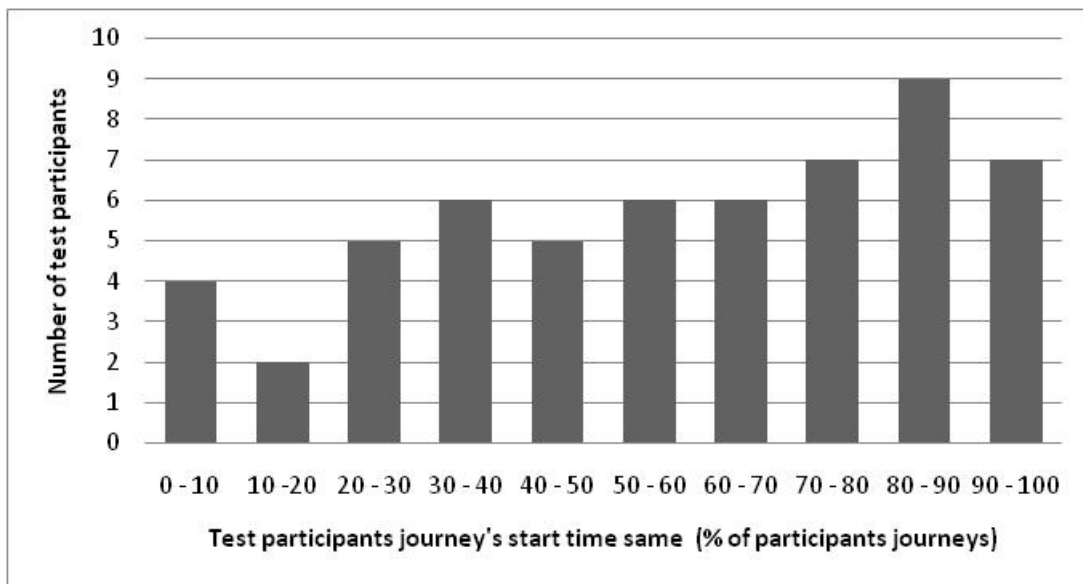
#### 4.2.3. Trip time correspondence

Trip starting time matched in 91.9% of trips found both in the travel diary and logger data (Figure 18). The time was considered to match if the difference was at most 5 minutes from the travel diary starting time. Trip ending times matched only in 83.0% of trips. Inside the margin of error, 33.5% of travel diary journeys had a longer duration whereas in 17.1% of trips the logged trip was longer. Trip starting time was earlier in the travel diary for 23.1% of trips and in logged trips for 25.4% of trips. Trip ending time was earlier in 19.0% of travel diary trips and in 25.5% of logged trips. In time correspondence analysis, four journeys that missed either trip starting time, ending time or duration in the travel diary were excluded.



**Figure 18 – Matching trip starting and ending times in travel diary and logger data. The accepted error margin was 5 minutes from the travel diary start and ending time**

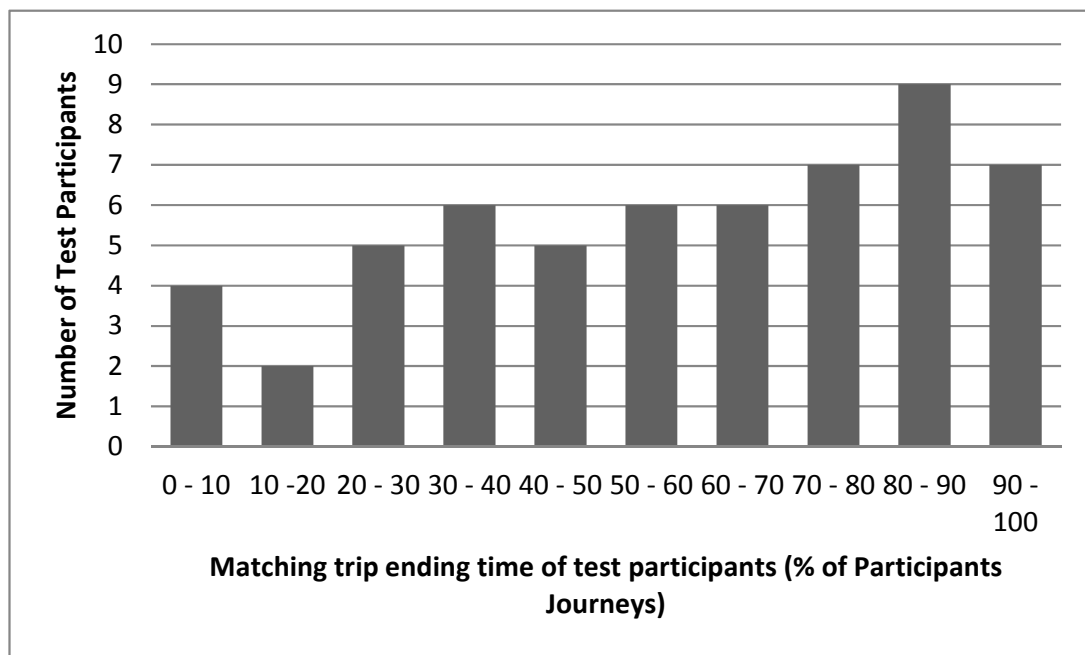
The test participants had a starting time correspondence of 90-100% in on average 12.3% of trips and of over 80% in 28.1% of trips (Figure 19). With starting times, data correspondence was stressed in over 50% of trips (61.4% of test participants). Only 7.0% of participants had 0-10% of starting time correspondence in the data.



**Figure 19 – Matching trip starting time in travel diary and logger data, per person. The accepted error margin was 5 minutes from the travel diary start time.**

The results indicate a large personal difference in test participants' diligence and accuracy in filling in the travel diary and using the logger device, as the results are spread through each of the 10% bands as shown in Figure 19.

With trip ending times, data collection methods did not work together as well as with starting times. Only 54.5% of test participants, compared to 61.4% for starting time, had trip ending times matching in over 50% of their trips (Figure 20). Only 7.0% of the participants had corresponding data in over 90% of trips, and only 17.5% in 80% of trips.

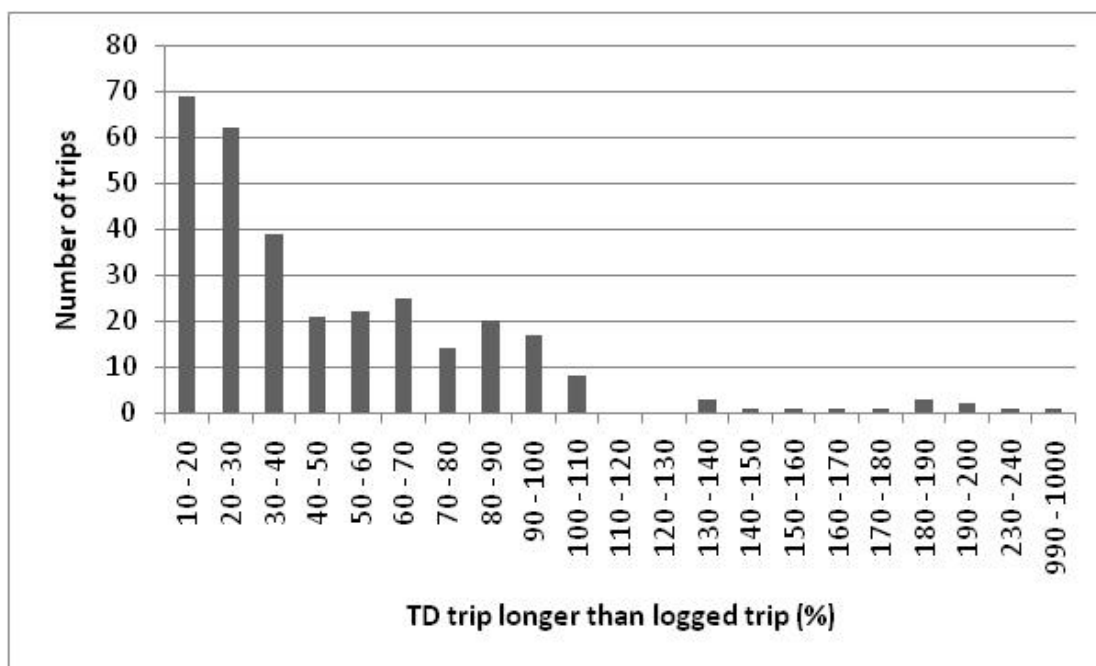


**Figure 20 – Matching trip ending time in travel diary and logger data, per participant. The accepted error margin was 5 minutes from the travel diary ending time.**

Matching results for trip ending time were also spread across the scale. Here the mode of the results was low at 30-40%, clearly lower than for starting times. This could be because ending time is estimated more often than starting time. The results for matching starting and ending time hint at the starting time being mostly marked down at the beginning of the journey, perhaps at the same time that the data logger is turned on, resulting in a fairly punctual starting time. The ending time may be forgotten when arriving at the destination, and is added later based on estimation. The length of the trip is easier to mark down correctly, as it is either known or can be checked, but the time is simply remembered.

Travel diary and logged trips had the same duration in 66.4% of trips. The duration of the trip was considered the same if the logged trip duration was within 10% of the travel diary trip duration. Within matching durations 65.9% of trips were of exactly the same duration, the travel diary trip time was longer in 19.2% of trips and the logged trip time in 15.0%. For the 33.6% of trips that did not match, the travel diary journey duration was usually longer (22.1% of trips for both data sets) than in the logger data (11.4%). For travel diary trip duration longer than the logger duration, the difference varied most commonly from 10% to 100% greater (92.9% of non-matching trips, Figure 20), most markedly in the 10-20% difference range (42.1% of non-matching trips). As the duration

of the trips conflict, it can be deduced that the data collection methods do not log the same times.

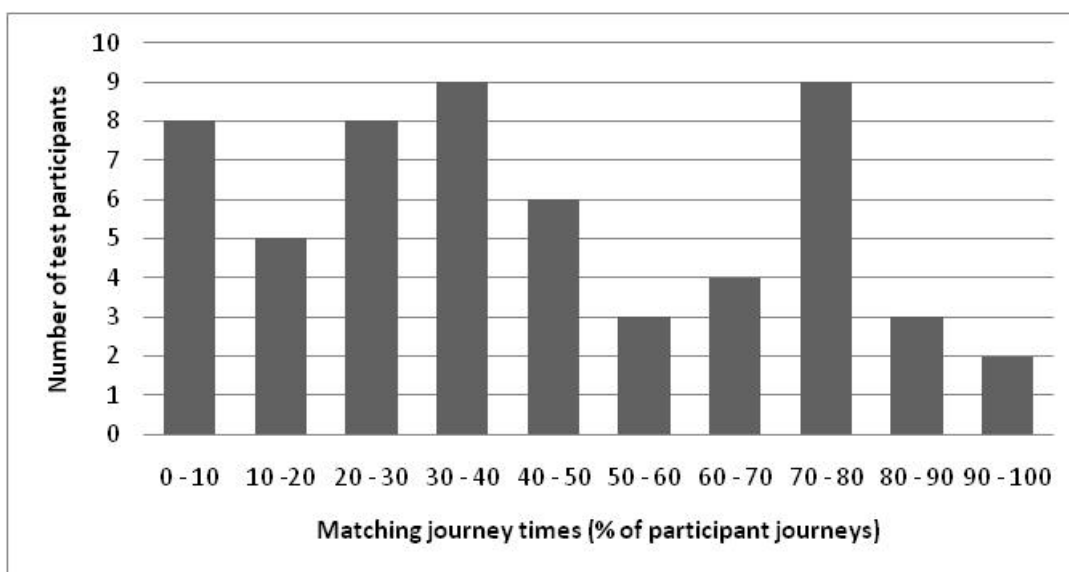


**Figure 21 – Amount of travel diary trips having longer duration than logger trips (%)**

The primary reason for mismatching could be the inaccuracy in reporting the starting and ending times of short trips in the travel diary. The duration of the travel diary trip was defined as the difference between these moments of time. Participants probably marked down an approximation of the starting and ending times, whereas the data logger logged actual duration based on its clock. For trips with duration under 20 minutes, a difference as small as 2 minutes causes trip times not to match. Also, if data logger software took some time to start logging, the logged time could end up being shorter than the actual trip.

The proportion of trips with corresponding duration in both data varied per test participant. Only 3.5% of participants had 90-100% of trips with corresponding duration in both data, and 8.8% of participants had 80-100% of trips with corresponding duration (Figure 22). Remarkably, quite a lot of participants (12.7%) had correspondence in duration for only 0-10% of trips. The proportion of trips with correspondence was less than 50% of trips for 63.2% of participants.

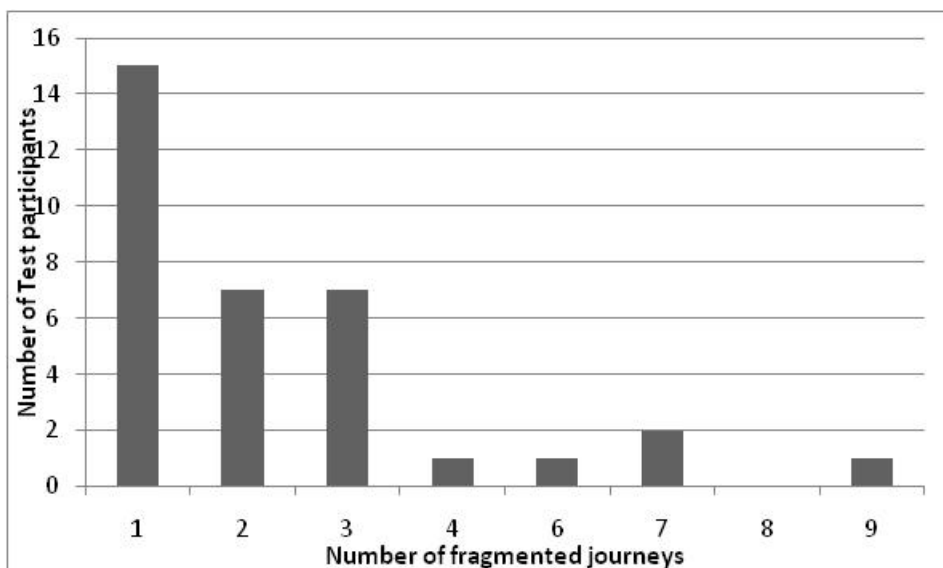




**Figure 22 – Trips with matching travel diary and logger data, per person**

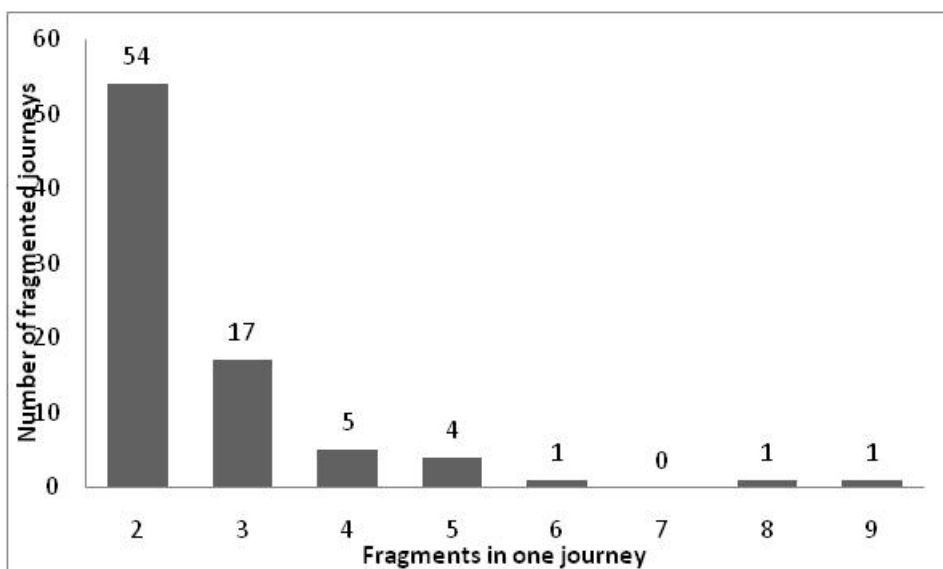
#### 4.2.4. Fragmented trips

With the data logger, 83 of travel diary trips (6.1% of all travel diary trips made as the driver of a passenger car or van) had fragmented logged trips within the timeframe of a single travel diary trip. Fragmented logged trips made up 8.9% of the trips having both travel diary and logger data sets. Of the 57 test participants having logger data, 59.6% had fragmented logged trips. However, 44.1% of participants who had fragmented logged trips had only one fragmented logged trip in their data set, and 20.6% had two or three fragmented trips (Figure 23). Consequently, 85.3% of test participants who had fragmented logged trips (50.8% of all participants with logger data) had only up to three fragmented trips in this one-week data set. Nevertheless, one participant had up to nine fragmented logged trips.



**Figure 23 – Fragmented logger data trips**

Fragmented trips made up 18.0% of all logged trips. Most of the trips were not fragmented much, as 65.1% of fragmented trips were in two parts and 20.5% in three parts (Figure 24). The number of fragmented trips is alarmingly high and the consequences severe, as it increases the number of test participants' logged trips by creating trips of false length and duration if only the logger data is considered in the analysis.



**Figure 24 – Number of fragments in one trip**

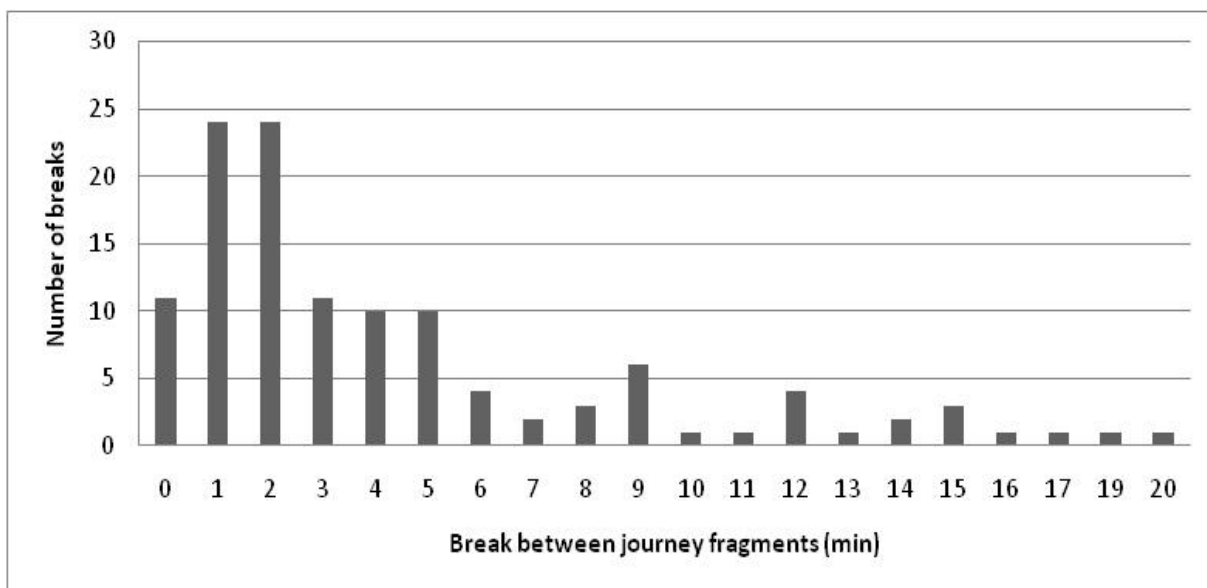
The reasons for the fragmentation can be either human or technical. For longer trips, the test participant may enter the trip in the travel diary as one single trip from point A to point B, leaving out coffee breaks during the trip that the logger correctly breaks into two

separate trips. However, loggers are not totally reliable either; logged trips sometimes missed a comparatively longer part of the trip at the beginning, in the middle or at the end of the trip. Data loggers sometimes ended and started a trip at the same time in the middle of a travel diary trip. Also in the “Unusual” column of the travel diary there were complaints about the TeleFOT application not working. All of these factors caused a cluster of logger recordings matching a single travel diary entry.

There were 11 cases in which more than one travel diary entry corresponded to the same logger trip. In all of them the destination of the trip had been changed in the travel diary, so entering it as a new trip in the travel diary was in accordance with the guidelines given to the participants. If the participant did not remember to change the destination and the gap between trips in the travel diary was from 0 to 2 minutes, the data logger could not distinguish the change of trip. This is one clear error source that cannot at present be overcome; because the logger should not be able to record a short stop at for example traffic lights as two separate trips.

For fragmented trips the duration was determined as the difference between the first starting time and the last ending time. Logger data fragmentation caused an error in the duration of logged trips, as fragmented trips seem to have lost part of the trip from the beginning or end of the trip in addition to some time in between data fragments. Consequently, trip duration matched only in 48.2% of the trips, compared to 66.4% correspondence in all trips having both data. Not surprisingly, travel diary trip duration was over 10% longer in 41.0% of the fragmented trips.

With trip fragmentation some part of the trip was not logged. However, in 7.9% of fragmented trips the time difference between trip fragments was 0 minutes without change of destination, suggesting user error or data logger malfunction (Figure 25). The logger started a new journey automatically only if a car's engine has been turned down for 2 minutes or the user has changed the trip purpose (business or personal). The most common break durations are 1 to 2 minutes, resulting in 34.2% of trip breaks (Figure 25). There are multiple reasons for the error, starting with loss of the Bluetooth connection to the user shutting down the equipment.



**Figure 25 – Time between two fragments of a trip**

Breaks that lasted over 20 minutes made up 12.9% of all breaks, having a maximum length of 2 hours 35 minutes (Table 1). Breaks this long between two trip fragments have to be either because of user error or software or device malfunctions. Because of logger trip fragmentation, up to 265 minutes of a logged trip were lost (Table 2). The time missed between logged fragments was up to 10 minutes in 66.3% of fragmented trips. Interestingly, in four trips fragmentation had not lost any of the logged trip duration.

**Table 1 – Break between trip fragments that lasted over 20 minutes**

Minutes	Number of Breaks
20 - 30	4
30 - 40	2
40 - 50	2
50 - 60	3
60 - 200	7

**Table 2 – Missed trip time in fragmented trips**

Minutes	Logged Journeys
0 - 10	55
10 - 20	8
20 - 30	8
30 - 60	5
60 - 300	7

Regarding trip length 50.6% of fragmented trips had a trip length within 10% of the corresponding travel diary trip length. In 42.2% of fragmented trip data, the travel diary trip was longer than the fragmented logged trip. In 2.5% of the trips, travel diary trip length was up to 90-100% longer than the summed length of the fragmented logged trip (Figure 22), suggesting logger use error.

#### 4.2.5. User diligence

Test participants are likely to differ in their diligence in completing the travel diary and using the data logger. The 54 test participants who had both data were divided into three groups based on the amount of trips having both data per total amount of trips. Groups were classified as Good (80-100% of travel diary trip had a logged counterpart) with 19 test participants, Mediocre (50-80%) with 22 test participants, and Poor (0-50%) with 13 test participants. These groups' results in terms of correspondence of start and end times, trip duration and trip lengths were studied. The studied factors were also divided into three parts along the same percentages.

With this division two extremes were identified (Table 3). Only in the "Good" group were the participants with matches in the 80-100% category ("good-good" match) more prevalent than others (except in trip duration matching). Having well-corresponding data sets does not make them perform as well in other areas, as in the group there were still participants with poor matching of data.

**Table 3 – Having both data vs. matching of both data. The cell with most participants in each row is shaded. "Good" between 80-100%, "Mediocre" between 50-80% and "Poor" between "0-50%".**

	Matching	Good (19 test participants)	Mediocre (22 test participants)	Poor (13 test participants)
Start time	Good	16	0	0
	Mediocre	3	16	0
	Poor	0	6	13
End time	Good	10	0	0
	Mediocre	8	13	0
	Poor	1	9	13
Journey time	Good	5	0	0
	Mediocre	10	6	0
	Poor	4	16	13
Journey length	Good	9	0	0
	Mediocre	8	12	0
	Poor	2	10	13

The “Poor” group with the least amount of trips found in both data sets had problematic matching performance in all the studied areas (13 participants in Table 3). The test participants in this group clearly had trouble with their motivation or data logging, needing extra concentration to perform better. With more motivation, help and training some of them could move to the upper groups.

When studying the “Poor” group more closely in terms of demographics, it was anything but uniform. Only two of the 13 participants were female, the date of birth had a 37-year range from 1943 to 1980, they owned seven different brands of car, and they had had a driver’s license for 11 to 50 years.

The “Good” group was not as uniform in the results; in none of the factors studied did all the participants achieve the highest percentile match. Still, the number of participants having a “Good” or “Mediocre” result always beat the number in the “Poor” group. In terms of demographics they were just as mixed as the “Poor” group: three out of 19 participants were female, the date of birth had a 30-year range from 1954 to 1984, and the test participants owned 11 different brands of car. The number of participants in this study was so low that no clear definition of “Good” and “Poor” participants could be created. The definition would be interesting to create with a greater data set.

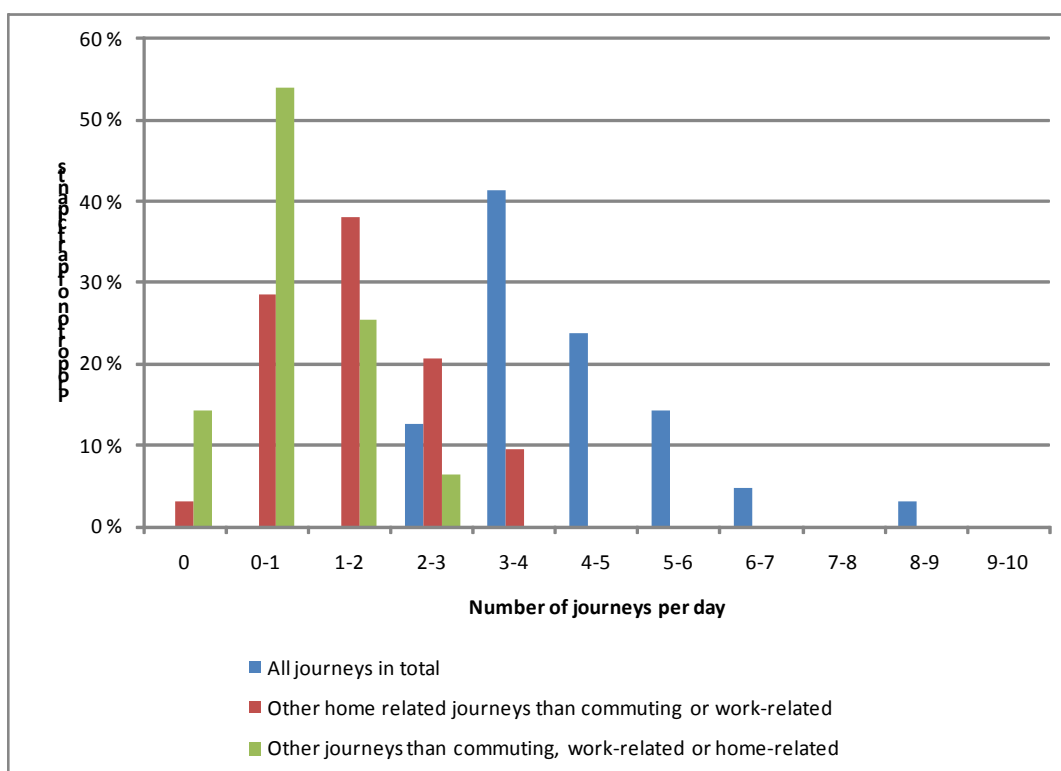
## 5. PILOT ANALYSES OF MOBILITY RESEARCH QUESTIONS

5.1. M-RQ1.1 Is the number of journeys undertaken affected in total?

M-RQ1.4 Is the number of other home related journeys affected?

M-RQ1.5 Is the number of other journeys (than home or work related) affected?

The average number of journeys in total was 4.3 per day per participant based on journeys reported in the travel diary. The most common average number of journeys in total per day was 3–4 covering 41% of participants (Figure 26). 65% of participants made on average 3–5 journeys per day and 92% of participants made on average 2–6 journeys per day.



**Figure 26 – Distributions in the number of journeys**

The average number of other home-related journeys than commuting or work-related was 1.7 per day per participant (Figure 26). The most common average number of other home-related journeys per day was 1–2 covering 38% of participants. 70% of participants made on average at most two other home-related journeys per day and 90% of participants made on average at most three other home-related journeys per day.

The average number of journeys other than commuting, work-related or home-related was 0.8 per day per participant (Figure 26). The most common average number of other journeys per day was at most one, covering 68% of participants. 94% of participants made on average at most two other journeys per day.

The changes in the numbers of different journeys could not be analysed with the single travel diary dataset available for piloting. However, it was confirmed by the pilot analyses that it is possible to analyse the numbers of different journeys. In the final analyses of M-RQ1.1, M-RQ1.4 and M-RQ1.5, the difference in number of journeys between the pre-phase and later phases of the LFOT will be calculated in addition to the statistical significance of the results. Consequently, the absolute numbers presented here are not significant from the point of view of the final analysis, but only as regards changes in the numbers.

In the final analysis, the (more) objective results based on travel diary data will be complemented by participants' subjective assessment of the change in number of car and public transport journeys, because they have access to the device (i.e. according to the results of S-H2.1 "Participants report a change in the number of journeys undertaken because they have the device").

## 5.2. M-RQ2.1 Is the length of journeys in terms of distance affected? M-RQ2.2 Is the duration of journeys affected?

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### 5.2.1. Length of journeys

The variable length of journeys (in distance) could be directly considered from the data registered by the participants in the travel diary. Considering only journeys as driver of a car or van as primary mode, a total number of 226 journeys with the TI function active (regardless of the timing of use) were reported by participants. Considering this overall figure, the following facts were calculated:

- Minimum length: 0.10 km
- Maximum length: 269.1 km
- Mean length: 21.18 km
- Standard deviation of the length: 35.11 km

On the other hand, participants reported in the travel diary 1,107 journeys without the TI function. The main figures obtained are shown below:



- Minimum length: 0.10 km
- Maximum length: 393 km
- Mean length: 19.93 km
- Standard deviation of the length: 39.52 km

Considering the comparison between journeys with and without the TI functions, a mean comparison was done (ANOVA). No statistical differences were found ( $p=0.594$ ) between the situations.

Participants reported a total amount of 1,208 journeys without activating the GD function and therefore, based on these journeys, the following figures could be obtained:

- Minimum length: 0.10 km
- Maximum length: 393 km
- Mean length: 20.95 km
- Standard deviation: 39.92 km

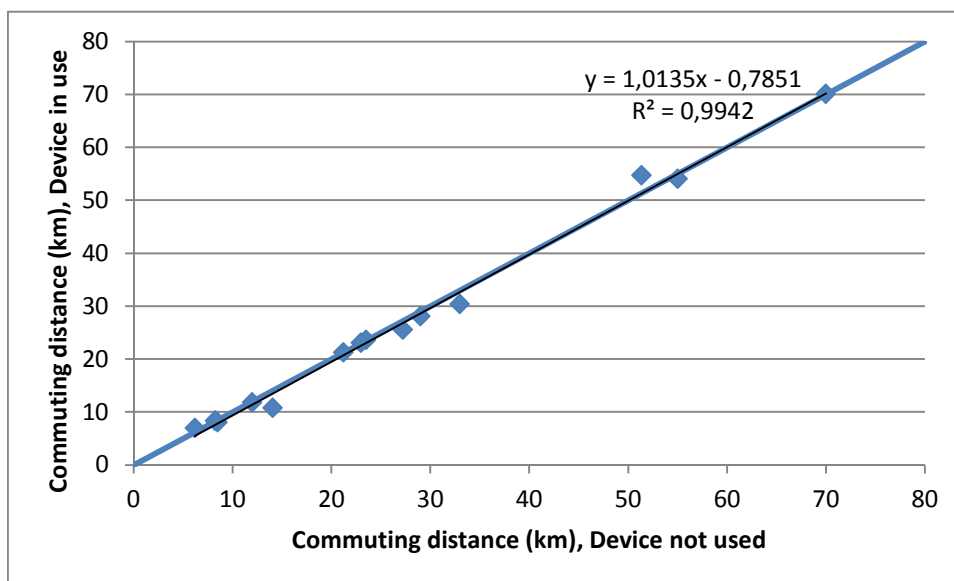
By contrast, participants only reported 148 journeys with the GD function activated (regardless of timing of use). From these journeys, the following results can be derived:

- Minimum length: 0.10 km
- Maximum length: 178 km
- Mean length: 11.54 km
- Standard deviation: 22.72 km

Journeys with and without the GD functions were compared (ANOVA). In this case, statistical differences were found ( $p=0.005$ ) between both situations, such that the length of the journeys was higher when the GD function was not present.

The length of journeys between comparable origins and destinations was studied as commuting distance for direct journeys between permanent residence and participant's own working place in addition to the overall analysis of lengths given above. Distances were compared between journeys when the device was not used and when it was reported in the travel diary to have been used. Two participants out of 15 in total (13.3%) had on average a longer distance travelled for commuting when using the device compared to when it was not used, and eight participants (53.3%) had a shorter distance. However, the differences in distance were small, at most 3.3 kilometres. The

trend line fitted to the plot ( $y = 1.0135x - 0.7851$ , Figure 27) showed that on average, distances were very close to each other.



**Figure 27 – Average distance travelled of commuting journeys when the device was in use versus when it was not used, a trend line (black thin line) and  $x=y$  line (blue line)**

In the final analysis, the length of the journey should be studied considering not only the travel diary but also objective data from the data loggers, since the distances reported in the diaries are only estimates made by the participants. Moreover, considering data from the data loggers, the variable should be derived from the GPS Data Minimum Record (GPS coordinates) and Event Data Record (Trip Id). General averages etc. can be calculated from the logger data in any case. If it becomes possible to distinguish commonly used locations from the logger data, logger data can also be used to analyse changes in the length of regular journeys.

In the pilot, analysis of the length of journeys, considering use or non-use of the function, was done considering the data from the pre-test phase, but further analyses should consider the comparison between pre-test and post-test phases. In addition, the option “truck/lorry” could be also be included in the analyses in addition to the main primary mode in focus “passenger car or van, as driver”.

In the final analysis the (more) objective results based on travel diaries and logger data will be complemented by participants’ subjective assessment of the change in distance travelled to reach destination because they have access to the device (i.e. results of User uptake hypotheses UU-H3.2 “Participants report a change in the distance travelled

between comparable origins and destinations because they have access to the device” and S-H2.3 “Participants report a change in the distance travelled between comparable origins and destinations”).

### 5.2.2. Duration of journeys

The duration of journeys did not directly appear in the travel diary data, although it could easily be obtained considering origin and destination times. Considering only journeys made as driver of a car or van, participants reported 1,119 journeys without the TI function. Considering this overall figure, the following figures were calculated:

- Minimum duration: 1 min
- Maximum duration: 6h 39 min
- Mean duration: 24 min
- Standard deviation of the duration: 37 min

By contrast, 226 journeys were reported with the TI function active and the following figures were obtained:

- Minimum duration: 1 min
- Maximum duration: 2h 55 min
- Mean duration: 22 min
- Standard deviation of the duration: 24 min

Considering the comparison between with and without the TI function, a mean comparison (ANOVA) was done. No statistically significant results were obtained with a 95% level of confidence ( $p=0.588$ ).

Similarly to the TI situation, only journeys with primary mode as driver of a car or van were considered. Thus, participants reported 1,197 journeys where the GD function was not present. The descriptive figures obtained are shown below:

- Minimum duration: 1 min
- Maximum duration: 6h 39 min
- Mean duration: 24 min
- Standard deviation of the duration: 36 min

By contrast, only 148 journeys were reported with the GD function. In this case, the following figures were obtained:

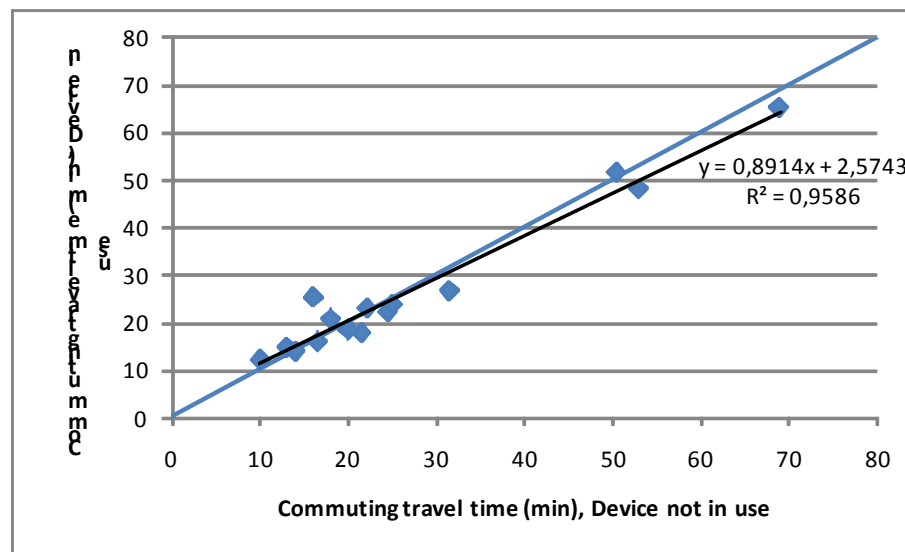
- Minimum duration: 2 min
- Maximum duration: 2h 03 min
- Mean duration: 15 min
- Standard deviation of the duration: 16 min

A mean comparison was done (ANOVA) considering the journeys where the GD function was activated or deactivated. Statistically significant results were found ( $p=0.005$ ): the duration is higher when the GD was not present during the journey.

The duration of journeys between comparable origins and destinations was studied as commuting duration for direct journeys between permanent residence and participant's own working place in addition to the overall analysis of durations given above. All 1,739 journeys reported in the travel diary included 243 commuting journeys from permanent residence to own place of work or vice versa made by car as driver by 46 participants. Specifically, there were 147 commuting journeys reported in the travel diary to have been made with a passenger car or van as driver without using the TeleFOT device, and 96 commuting journeys when the use of device was reported. Altogether 15 participants had reported commuting journeys both with the use of device and without it. No separation was made between services, nor whether the use of service took place before the journey, during the journey or after it. Used services included SI/SA, TI, GD and NA.

The average duration of commuting journey was longer for eight participants of 15 (53.3%) in total when the device was in use compared to non-use. For two participants (13.3%) the difference was more than 10 percentage points. However, for six participants (40.0%) the average duration of commuting journey was longer when the device was in use compared to non-use. For four participants (26.7%) the difference was more than 10 percentage points.

Average duration of commuting journey was plotted for journeys when the device was in use versus journeys when it was not used (Figure 28). A trend line was fitted. The equation  $y = 0.8914x + 2.5743$  tells us that when the average duration of commuting journey without use of the device was longer than 23.7 minutes, use of the device decreased the duration on average. For commuting journeys on average shorter than 23.7 minutes, the average effect was the opposite. However, it must be noted that the number of samples, especially of those representing longer travel times, was very small.



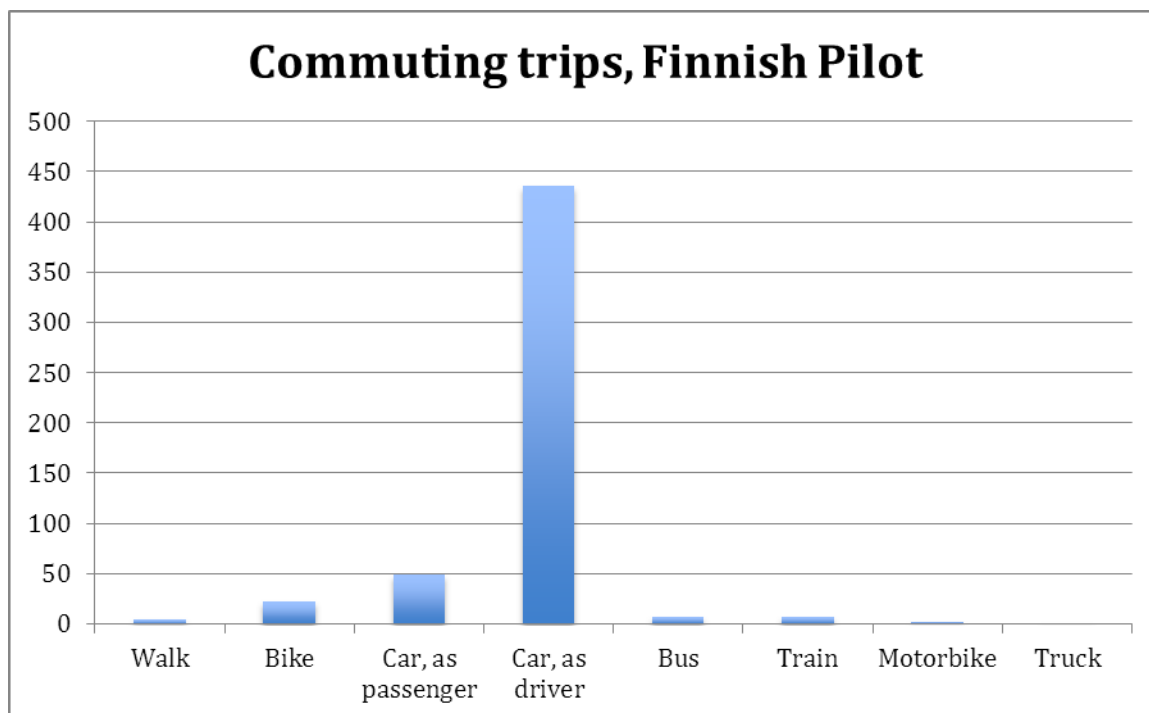
**Figure 28 – Average duration of commuting journeys when the device was in use versus when it was not used, a trend line (black thin line) and x=y line (blue line)**

In the final analysis, the duration of the journey should be studied considering not only the travel diary but also objective data coming from the data loggers. Moreover, the analysis of the duration of the journey, considering the use or not of the function, was done considering the data from the pre-test phase, but further analyses should consider the comparison between pre-test and post-test phases. General averages etc. can be calculated from the logger data in any case. If it becomes possible to distinguish commonly used locations from the logger data, logger data can be used also in the analysis of changes in the durations of regular journeys.

In the final analysis, the (more) objective results based on travel diary and logger data will be complemented by participants' subjective assessment of the change in duration because they have access to the device (i.e. results of UU-H3.3 "Participants report a change in the duration of journeys travelled between comparable origins and destinations because they have access to the device" and S-H2.5 "Participants report a change in the duration of journeys travelled between comparable origins and destinations").

### 5.3. M-RQ3.1 Is there a change in commuting mode of travel?

The most common mode of travel for commuting was driving a car or a van, covering 82% of commuting journeys reported in the travel diary (Figure 29). Nine percent of commuting journeys were made as passenger of a car or a van and 4% by bicycle. The rest of the transport modes covered at most 1% of commuting journeys.



**Figure 29 – Number of commuting trips by transport mode**

The changes in the mode distribution of commuting journeys could not be analysed with the single travel diary dataset available for piloting. However, it was confirmed by the pilot analyses that it is possible to analyse the mode distribution. In the final analyses of M-RQ3.1, the difference in number of mode distribution between the pre-phase and later phases on the LFOT will be calculated in addition to the statistical significance of the results. Consequently, the absolute numbers presented here are not significant from the point of view of the final analysis but as regards the changes in the numbers.

#### 5.4. M-RQ4.1 Is there a change in route choice in commuting?

The hypothesis cannot be answered using the logged data only. Map-matching is required. Definition is needed for a route in a way that makes analyses possible. The legs tables have information on start and end points that can be used to get common legs. In addition two tracks are needed, i.e. a common route and an alternative route for it. The easy way would be to use the distance driven; a more complicated, but probably better way would be to create "corridors in space" that define routes, rather than connecting GPS data to maps. These analyses options will be further researched.

If route choice is interpreted as type of road, than analysis becomes much easier using start and end points from the legs tables and connecting the data to the map-matching tables to get road type.

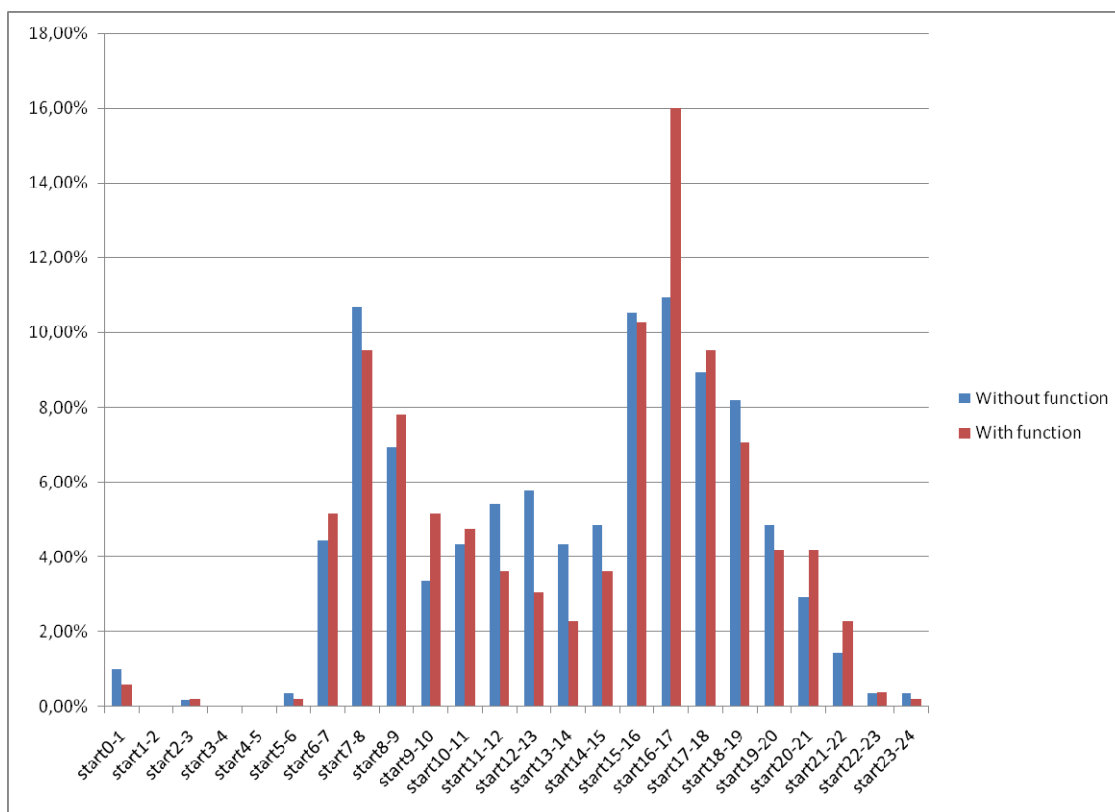
The hypothesis cannot be answered using data from user uptake questionnaires. However, the final results can be complemented by analysing user uptake questionnaire data regarding subjective reports on change in route choice in general (i.e. results of UU-H.3.4. “Participants report a change in the choice of routes (road type) when the device is used compared to when it is not”).

Most of the participants assessed that having access to GD application would have no change in their use of highways/motorways (90.2%) or rural roads (95.1%). There were more participants who expected that their use of highways/motorways (7.3%) would be slightly increased than those who expected it to decrease (2.4%). The proportion of participants assessing that there would be no change in their use of highways/motorways or rural roads (92.7% for both) due to having access to SI/SA was greater for SI/SA than for GD. Likewise, there were more participants expecting their use of highways/motorways (7.3%) or rural roads (4.9%) to increase slightly than to decrease (rural roads, 2.4%).

#### 5.5. M-RQ6.1 Is there a change in departure time of a commuting journey?

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The departure time distribution of the commuting journeys reported in travel diaries had the typical two-peaked curve corresponding to the morning and evening peaks (Figure 30). The distribution of departure time, using at least one of the functions (TI, SI, SA, GD, NA) is indicated in red. For the pilot analysis, no statistical evidence for the discrepancy between the two distributions was tested for. However, it seems that functions were used, especially, in the evening peak hour. During the less congested daytime hours, the functions were not used as much as for commuting during peak hours.



**Figure 30 – Distributions in the departure time in commuting journeys**

In the final analysis, the following points should be addressed: The objective is to track evidence of a change of habits at the aggregated level of the fleet of drivers. During the analysis, the impact of each function on the departure time will be taken into account: it is expected that the use of NA or TI functions will have – if any – a greater impact than the others. Separated analyses will be generated for each function.

If the data enables it, the final analysis will be performed at the individual level, analysing the change of habits of single drivers: postponing/anticipating the usual departure times. In this case the evolution of the departure time for single drivers will be analysed and statistically relevant differences will be assessed.

### 5.6. M-RQ6.3 Is there a change in travelling in adverse conditions (dark, fog, slippery road, etc.)?

The pilot analysis was based on the GPS data stored inside the TeleFOT central database. An algorithm was made to calculate the time of sunrise and sunset depending on the position stored inside the GPS data. With the associated timestamp a comparison between actual time and sunrise and sunset time respectively was carried out. Hereby



driving in daylight or at night was determined and stored as a Boolean variable. With this variable the absolute and relative time and distance driven during the day or at night could be calculated afterwards.

The algorithm provided by the Astrollexikon (2011) is described below. The first step of the algorithm determines the day number from the timestamp given in the central database. The number ranges from 1 to 365 (1 to 366 days for leap years respectively) and is calculated from the year, for the determination of leap years, the month and the day number. The next step consists of the time equation with the variables time ( $t$ ) and day number ( $d$ ).

$$t = -0.171 \cdot \sin(0.0337 \cdot d + 0.465) - 0.1299 \cdot (0.01787 \cdot d - 0.168)$$

Subsequent to the time equation the declination ( $dec$ ),

$$dec = 0.4095 \cdot \sin(0.016906 \cdot (d - 80.086))$$

and the horizontal height ( $h$ ) are determined.

$$h = -50/60 \cdot (\pi/180)$$

With these parameters the time difference can be calculated with the degree of latitude ( $lat$ ).

$$t_{dif} = 12 \cdot \arccos((\sin(h) - \sin(lat) \cdot \sin(dec)) / (\cos(lat) \cdot \cos(dec))) / \pi$$

With these parameters the global time for sunrise and sunset for the given degree of latitude can be determined.

$$sunrise = 12 - t_{dif} - t$$

$$sunset = 12 + t_{dif} - t$$

To get the local time, the degree of longitude ( $lon$ ) and the time zone ( $tzone$ ) have to be taken into account.

$$local\_sunrise = sunrise - lon/15 + t_{zone}$$

$$local\_sunset = sunset + lon/15 + t_{zone}$$

The evaluation of the GPS data was based upon a simplified algorithm, so that the calculation of sunrise and sunset would be defective. The algorithm was tested with some positions displaying the range of positions that can be anticipated during the testing phase of the project. Consequently, calculations were carried out for GPS positions in

Germany, Spain, Finland and Greece. The comparative values (left value in Table 4) was determined via Hamburger Sternwarte (2011).

As a result, a failure between 0 and 15 minutes was identified (Table 4). This seemed sufficient for the further evaluation of the TeleFOT data, for dusk and dawn are also affected by other environmental conditions, like e.g. fog or cloudy weather.

**Table 4 – Test calculation of sunrise and sunset for different days and positions in the EU**

	Aachen market place		Oulu marcet place		Athen Akropolois		Valladolid main place	
longitude	6°5'1.1" E		25°27'48.58" E		23°43'38.66" E		4°43'42.92" W	
latitude	50°46'34.96" N		65°0'44.61" N		37°58'17.61" N		41°39'7.01" N	
	reference value	calculated value	reference value	calculated value	reference value	calculated value	reference value	calculated value
date	19.01.2011		19.01.2011		19.01.2011		19.01.2011	
sunrise	08:25	08:27	09:47	09:43	07:38	07:37	08:41	08:37
sunset	16:52	17:06	15:12	15:14	17:33	17:33	18:17	18:15
date	19.04.2011		19.04.2011		19.04.2011		19.04.2011	
sunrise	05:31	05:34	04:29	04:29	05:45	05:44	06:33	06:30
sunset	19:33	19:35	20:07	20:04	19:04	19:03	20:03	19:59
date	19.07.2011		19.07.2011		19.07.2011		19.07.2011	
sunrise	04:41	04:43	02:28	02:25	05:17	05:16	06:00	05:57
sunset	20:36	20:41	22:18	22:22	19:45	19:45	20:49	20:47
date	19.10.2011		19.10.2011		19.10.2011		19.10.2011	
sunrise	07:01	07:05	07:22	07:23	06:37	06:37	07:34	07:32
sunset	17:33	17:36	16:42	16:42	17:42	17:42	18:32	18:29
date	19.01.2012		19.01.2012		19.01.2012		19.01.2012	
sunrise	08:25	08:27	09:47	09:43	07:38	07:37	08:41	08:37
sunset	16:52	17:06	15:12	15:14	17:33	17:33	18:17	18:15

In conclusion, as regards the information contained inside the central database, the timestamp and GPS location are sufficient for the determination of this needed value (driving during the day or at night). Only the format of the data has to be adjusted, which has been implemented within the algorithm.

Other adverse conditions cannot be evaluated because of lacking reliable data about e.g. slippery roads, fog or rain. This information cannot be gathered inside the car or from other sources, like weather stations, for each and every GPS position throughout the test runs. However, an analysis of a subjective assessment of a change in driving in adverse weather conditions can be made based on the post-test user uptake questionnaire ("Do you think that any of the following has changed due to your access to the NA support system? → Your driving in adverse conditions). In addition, subjective assessment of changes in driving in the dark can be analysed from the same questionnaire.

5.7. M-RQ10.1 Is there a change in user stress?

M-RQ10.2 Is there a change in user uncertainty?

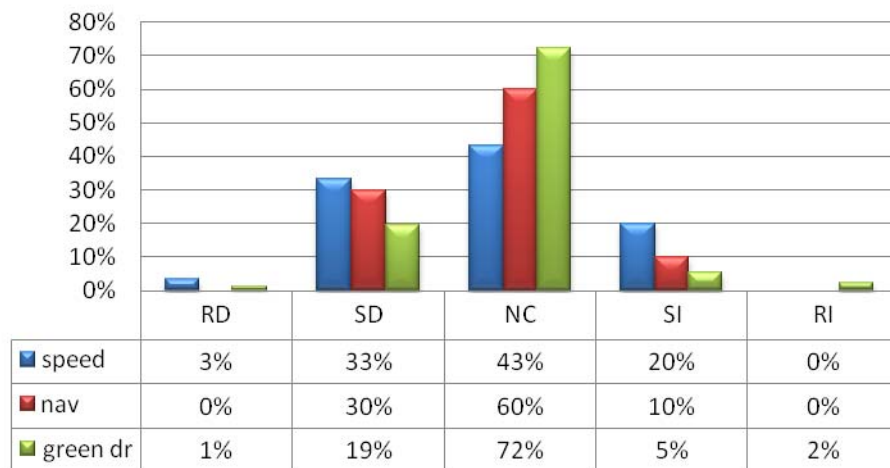
M-RQ11.1 Is there a change in feeling of subjective safety?

M-RQ12.1 Is there a change in feeling of comfort?

#### 5.7.1. User stress

The pilot analysis was made based on pre-test (i.e. User Uptake - Before) questionnaires filled in by Italian Large Scale FOT participants, 30 respondents in total. The analysis was based on question 4, “Do you think that any of the following will change with your access to the NA/SI/SA”), sub-question III “Your stress associated with travelling?” of pre-test user uptake questionnaires of NA and SI/SA. Analysis of the GD function has been carried out on the basis of results in the Finnish Large Scale FOT (82 respondents in total).

Results of the pilot analysis showed that most of the users expected no change in stress associated with travelling due to having access to any of the three functions (NA, SI/SA, and GD). In particular, 43% of the users expected no change in stress associated with use of the SI/SA function, but this percentage is even higher when associated with NA (60%) and GD functions (72%) (Figure 31).



**Figure 31 – Participants’ expectations of changes in user stress. Proportion of different opinions (RD = radical decrease, SD = slight decrease, NC = no change, SI = slight increase, and RI = radical increase) were calculated for SI/SA (speed), NA (nav) and GD (green dr)**

A minimal percentage of users (from 0% to 3%, Figure 31) expected a radical increase or radical decrease. Expectations of slight changes (slight increase or slight decrease) in

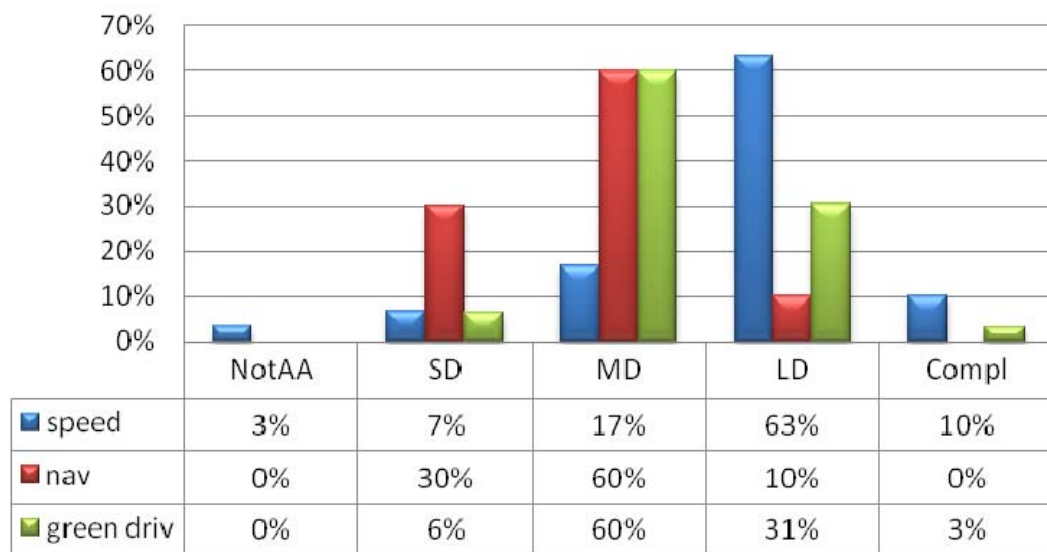
stress were quite low. The maximum value (33%) was registered for expectation of a slight decrease of user stress associated use of the NA function.

The change in user stress could not be analysed with a single questionnaire's dataset available for piloting. However, it was confirmed by the pilot analysis that the change in user stress is possible to analyse. The final analyses will calculate the difference between this pre-phase use and use in the later phases of the LFOT and test its statistical significance. Specifically, user stress will be determined as the mean score of answers given by participants in each in the first administration rounds of the user uptake questionnaires (i.e. user uptake before/during/post questionnaires). Changes in responses related to questions about one's stress associated with travelling (before phase and during phase) will be compared with the participants' (subjective) post-study assessment of the change.

#### 5.7.2. User uncertainty

At the time of pilot analysis, there was no question in the user uptake questionnaires related to user uncertainty. However, there were questions in the user uptake pre-test questionnaire that asked participants to report to what degree they trust the function to provide them with accurate information (Question number 3: "To what degree do you, based on your present knowledge, trust the NA/SI/SA/GD to provide you with accurate information?"). Consequently, although reported change in uncertainty related to use of functions does not exist in the current version of the questionnaires, a change in the reported trust in the functions/devices could be analysed. Analysis of the GD function was carried out based on the results of the Finnish Large Scale FOT (82 respondents in total). Otherwise the pilot analysis was based on Italian data.

The results of the pilot analysis showed that most of the answers concentrate between trusting to a moderate degree (in particular NA and GD) or to a large degree (in particular SI/SA) in the functions. In particular, most of the users show trust in the GD function to a moderate degree (60%, Figure 32) and large degree (31%). A lower percentage (30%) of the users showed trust in the NA function to a small degree. A minimum percentage of users (from 0% to 3%) trusted the functions or not at all. Complete trust in the functions was reported by a low number of users as well, even if it should be noted that the values were higher than for "not at all" (up to 10% for SI/SA and GD functions).



**Figure 32 – Participants' expectations of changes in trust that a function provides accurate information. Proportion of different opinions (not at all (NotAA), to a small degree (SD), to a moderate degree (MD), to a large degree (LD), and completely (Compl)) were calculated for SI/SA (speed), NA (nav) and GD (green driv).**

The pilot analysis was based on questions in the user uptake pre-test questionnaire that ask participants to report to what degree they trust the function to provide them with accurate information. A suggestion was made to add a question about a (subjective) assessment of a change in user uncertainty to the post-test user uptake questionnaires.

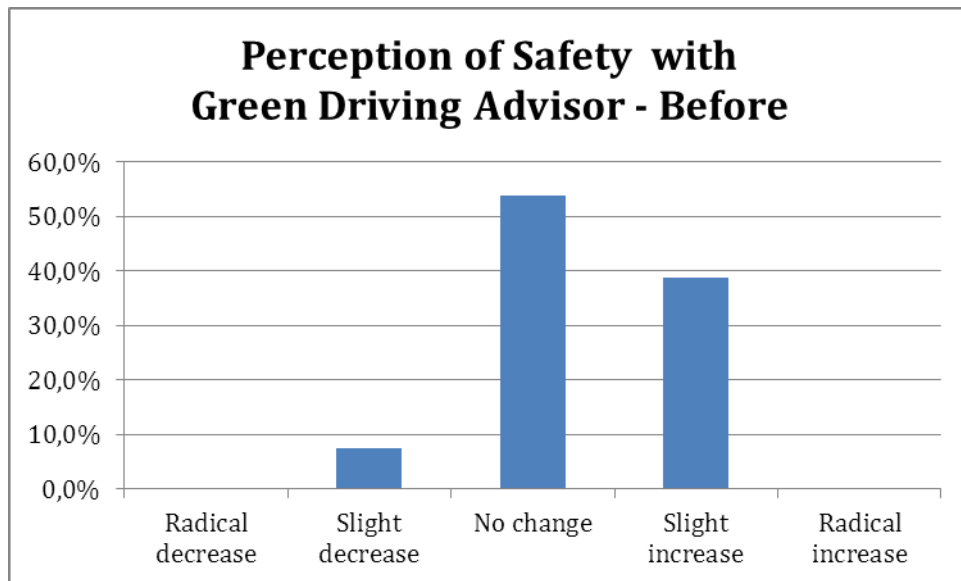
The final analyses will calculate the difference between this pre-phase use and use in the later phases of the LFOT and test its statistical significance. Specifically, user uncertainty will be determined as the mean score of answers given by participants in each of the first administration rounds of the user uptake questionnaires (i.e. user uptake before/during/post questionnaires). The results will be analysed by variables to interpret the results (considering possible impact-specific events such as accidents that might have occurred during the testing period).

### 5.7.3. Feeling of subjective safety

Participants were asked in the user uptake questionnaires whether they thought their 'safety' during driving would change following installation of the device to be tested. In particular two functions were assessed – GD advisory systems and SI/SA systems. The participants were asked to rank the likely changes in perception of safety on a 5-point

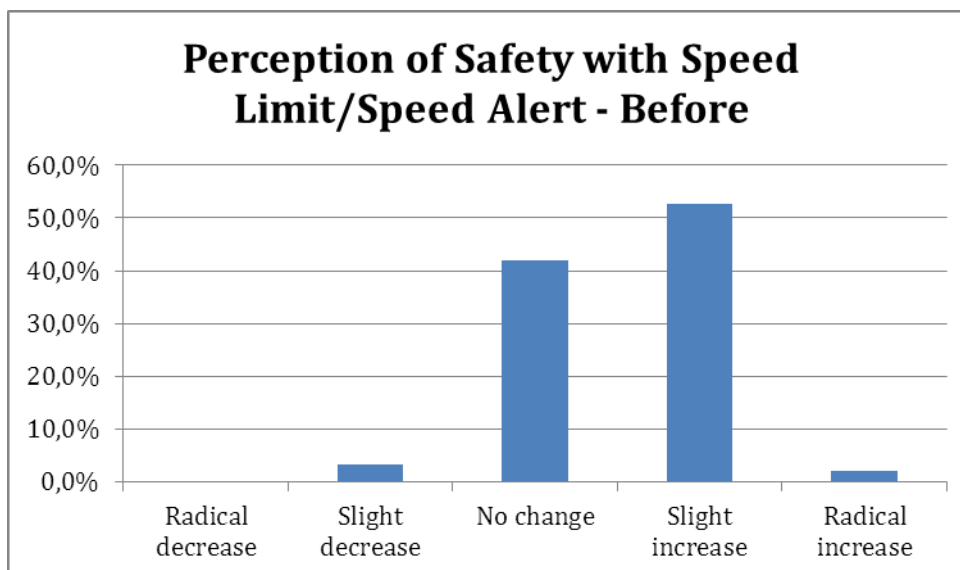
scale where '1' represents a radical decrease in safety and '5' represents a radical increase.

Figure 33 shows the initial expectations in terms of perceptions of safety with GD advisory systems. The vast majority of participants reported that they thought the GD advisory system would make no changes to perceived safety (53.8%) or would slightly increase safety (38.7%).



**Figure 33 – Perception of change in safety with the GD Advisor – Before**

A similar analysis for the SI/SA system is shown in Figure 34. Here the figures are even more in favour of no change (41.9%) or slight increases (52.7%) in subjective safety. 2.7% of respondents actually thought that the system would lead to a radical increase in perceptions of safety.



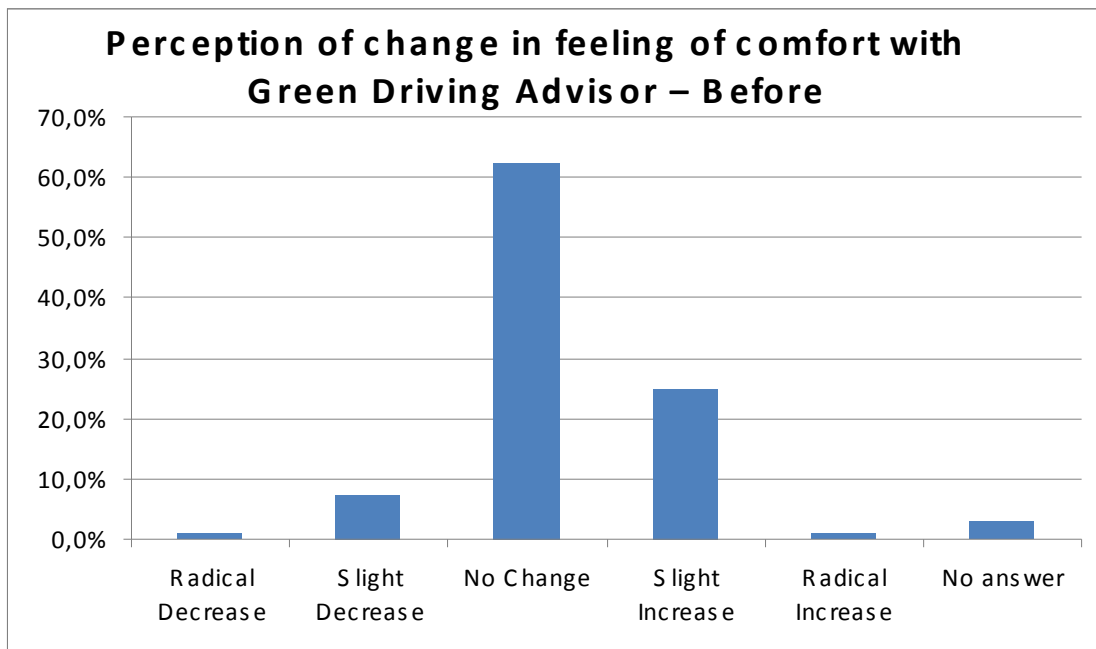
**Figure 34 – Perception of change in safety with the SI/SA system – Before**

Regardless of what the figures tell us at this stage, in the final analysis it is important to determine whether these perceptions change over the course of time. Therefore, when the second user-uptake results are available these will be used as a comparison with the first results.

#### 5.7.4. Feeling of comfort

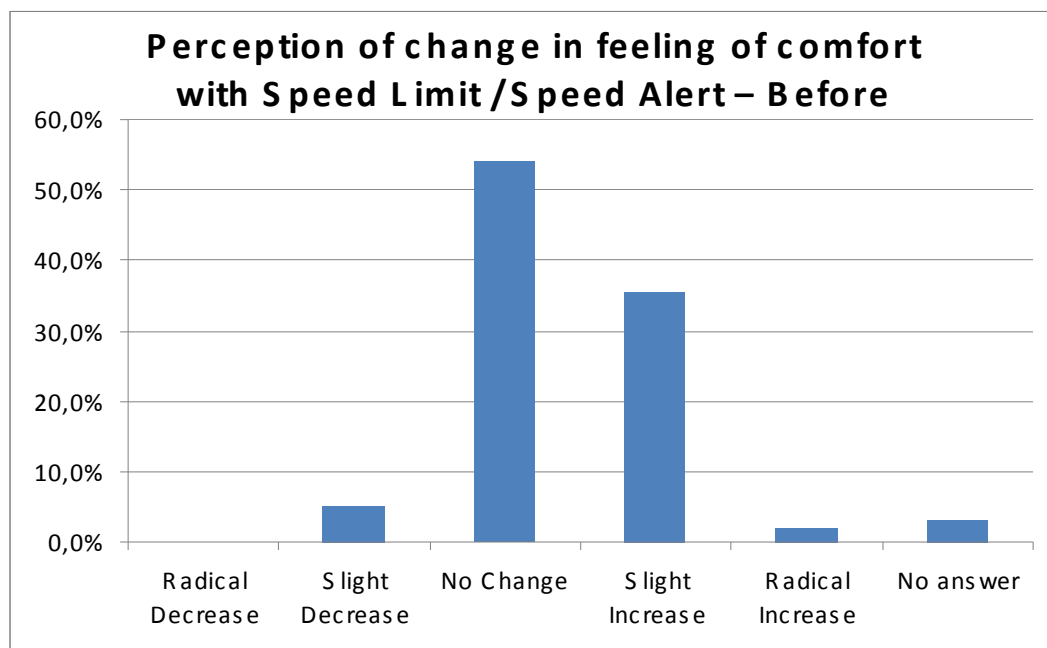
Participants were asked in the user uptake questionnaires whether they thought their 'feeling of comfort' while driving would change following installation of the device to be tested. In particular, in the pilot analysis two functions were assessed – GD advisory systems and SI/SA systems. The participants were asked to rank the likely changes in perception of feeling of comfort on a 5-point scale where '1' represents a radical decrease in feeling of comfort and '5' represents a radical increase.

Figure 35 shows the initial expectations in terms of perceptions of feeling of comfort with GD advisory systems. The vast majority of participants reported that they thought the GD advisory system would make no changes to the perceived feeling of comfort (62.5%) or would slightly increase it (25.0%).



**Figure 35 – Perception of change in feeling of comfort with the GD Advisor – Before**

A similar analysis is shown in Figure 36 for the SI/SA system. Here the figures are even more in favour of no change (54.17%) or slight increases (35.42%) in the subjective feeling of comfort. 2.08% of respondents actually thought that the system would lead to a radical increase in perceptions of feeling of comfort.



**Figure 36 – Perception of change in feeling of comfort with SI/SA – Before**



In the final analysis, regardless of what the figures tell us at this stage it will be determined whether these perceptions change over the course of time. Therefore when the during-test and post-test user-uptake results are available these will be used as a comparison with the first results. In addition, the ON/OFF events will be taken into account as well.

## 6. FINAL ANALYSIS

### 6.1. Research questions and hypotheses

The posed research questions and hypotheses were modified to correspond better to the hypotheses in other impact areas. The final research questions and hypotheses are presented in Table 5.

**Table 5 – Final formulation of hypotheses**

Research Question	Old version of hypothesis	Final hypothesis
RQ1.1 Is the number of journeys undertaken affected in total?	M-H1.1 Number of journeys undertaken is likely to increase (NAV, TI) / decrease (GD) when device in use compared to when not in use	M-H1.1 Number of journeys undertaken increases (NAV, TI)/decreases (GD) when device in use compared to when not in use
RQ1.4 Is the number of other home-related journeys affected?	M-H1.4 Number of other home-related journeys undertaken is likely to increase (NAV, TI) / decrease (GD)	M-H1.4 Number of other home-related journeys undertaken than commuting increases (NAV, TI) / decreases (GD)
RQ1.5 Is the number of other journeys affected?	M-H1.5 Number of other journeys undertaken is likely to increase (NAV, TI) / decrease (GD)	M-H1.5 Number of other journeys undertaken than home or work related increases (NAV, TI) / decreases (GD)
RQ2.1 Is the length of journeys in distance affected?	M-H2.1 There is likely to be an increase (TI) / decrease (GD) in travelled distance. NAV is likely to decrease distance in matched origin/destination but increase other distances	M-H2.1 There is an increase (TI) / decrease (GD) in travelled distance. NAV decreases distance in matched origin/destination but increases other distances
RQ2.2 Is the duration of journeys affected?	M-H2.2 There is likely to be an increase (SA, SI, GD)/decrease (NAV, TI) in time spent travelling	M-H2.2 There is an increase (SA, SI, GD)/decrease (NAV, TI) in time spent travelling

Research Question	Old version of hypothesis	Final hypothesis
RQ3.1 Is there a change in commuting mode of travel?	M-H3.1 There is likely to be an increase (NAV, TI) / decrease (GD) in the use of private car for commuting	M-H3.1 There is an increase (NAV, TI) / decrease (GD) in the use of private car for commuting
RQ4.1 Is there a change in route choice in commuting?	M-H4.1 There is likely to be different route choice in commuting (especially TI, NAV, GD)	M-H4.1 There is a different route choice in commuting (especially TI, NAV, GD)
RQ6.1 Is there a change in departure time of a commuting journey?	M-H6.1 Users postpone/start earlier (especially TI, GD) their commuting journeys	M-H6.1 Users postpone/start earlier (especially TI, GD) their commuting journeys
RQ6.3 Is there a change in travelling in adverse conditions (dark, fog, slippery road, etc.)?	M-H6.3 There is likely to be an increase in journeys in the dark due to NAV and TI	M-H6.3 There is an increase in journeys in the dark due to NAV and TI
RQ10.1 Is there a change in user stress?	M-H10.1 There is likely to be an increase (GD, SA)/decrease (NAV, TI, SI) in user stress	M-H10.1 There is an increase (GD, SA)/decrease (NAV, TI, SI) in user stress
RQ10.2 Is there a change in user uncertainty?	M-H10.2 There is likely to be a decrease in experiencing uncertainty	M-H10.2 There is a decrease in experiencing uncertainty
RQ11.1 Is there a change in feeling of subjective safety?	M-H11.1 There is likely to be an increase in user feeling of safety	M-H11.1 There is an increase in user feeling of safety
RQ12.1 Is there a change in feeling of comfort?	M-H12.1 There is likely to be an increase in user feeling of comfort as the user is better informed and prepared to meet any problems	M-H12.1 There is an increase in user feeling of comfort as the user is better informed and prepared to meet any problems

## 6.2. Interpretation of the results

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The impacts found in the final analysis will be analysed with relevant background variables, road type, changes in mobility needs and economic situation, having access to the system (before vs. after), actual use of the system (journeys when system in use vs. journeys when system not in use), by function, and by FOT/community according to Table 6 and Table 7. In practice this means that it will be analysed if a change in a certain variable like duration takes place for example in a certain road environment, only when the system is activated or only for a certain type of user. As average changes in the mobility due to TeleFOT functions are probably rather small, they may be more definite if the results are analysed separately for the different conditions and variables listed above.

**Table 6 – Background variables likely to be used as explanatory variables in the final analysis**

<b>Background variables likely to explain the results</b>	RQ1.1 Number of journeys in total	RQ1.4 Number of other home-related journeys	RQ1.5 Number of other journeys	RQ2.1 Length of journeys in distance	RQ2.2 Duration of journeys	RQ3.1 Commuting mode of travel	RQ4.1 Route choice in commuting	RQ6.1 Departure time of a commuting journey	RQ6.3 Travelling in adverse conditions	RQ10.1 User stress	RQ10.2 User uncertainty	RQ11.1 Feeling of subjective safety	RQ12.1 Feeling of comfort
Gender, age	X	X	X	X	X	X	X	X	X	X	X	X	X
Ownership of car	X	X	X	X	X	X	X						
Visual and hearing aid						X		X	X	X	X	X	X
Total annual kilometres, driving experience	X	X	X	X	X	X	X	X	X	X	X	X	X
Road type driven				X	X	X	X	X	X	X	X	X	X
Driving style					X		X	X		X	X	X	X
Speeding					X		X	X		X	X	X	X
Incidents					X	X			X	X	X	X	X
Use of transport modes	X	X	X		X			X		X	X	X	X
Previous familiarity with devices and functions					X	X	X		X	X	X	X	X
Opinions	X	X	X			X				X	X	X	X

Table 7 – Factors by which impacts will be analysed

Impacts will be analysed by	RQ1.1 Number of journeys in total	RQ1.4 Number of other home-related journeys	RQ1.5 Number of other journeys	RQ2.1 Length of journeys in distance	RQ2.2 Duration of journeys	RQ3.1 Commuting mode of travel	RQ4.1 Route choice in commuting	RQ6.1 Departure time of a commuting journey	RQ6.3 Travelling in adverse conditions	RQ10.1 User stress	RQ10.2 User uncertainty	RQ11.1 Feeling of subjective safety	RQ12.1 Feeling of comfort
Road type				X	X								
Change in mobility needs	X	X	X										
Change in economic status	X	X	X			X							
Having access to the system (before vs. after)	X	X	X	X	X	X	X	X	X	X	X	X	X
Actual use of system (journeys when system in use vs. journeys when system not in use)				X	X		X	X	X				
Function	X	X	X	X	X	X	X	X	X	X	X	X	X
FOT/Community	X	X	X	X	X	X	X	X	X	X	X	X	X

### 6.3. Statistical tests

In general, statistical tests will be applied that compare the situation ‘before’ (system not in use) with the situation ‘after’ (system in use) in order to test the hypothesis that a change has occurred in a particular direction. If the sample size is sufficient then parametric testing is possible, typically  $np > 5$  where  $n$  is the sample size and  $p$  the probability of the conditions of interest occurring; e.g.  $np > 5$  would need to be satisfied for the proportion of people indicating no change, and also satisfied for the proportion

indicating a change in a given direction. If  $n_p < 5$  then a non-parametric alternative will be used.

In the case of LFOT data, the main source of data for the mobility RQs, data types can be seen as discrete (typical of questionnaires and some travel diary data) or continuous (more typical of logged data). Where two groups are being compared, with simple “with” and “without” analysis, then the parametric t-test or the non-parametric Wilcoxon would be used. Where more than two groups are compared (e.g. before, during and final) then the parametric test would comprise an ANOVA and the non-parametric alternative would be the Friedman analysis of variance by ranks test. However, the Friedman test will only inform us whether one of the conditions varies from the others, but will not identify which condition (e.g. before, during or after). Therefore it will be necessary to apply a further test to assess the critical differences between the sum ranks.

Checks for normality of the data will be undertaken for continuous data before the t-test or ANOVA can be applied. If a non-normal distribution is found, the data will be transformed (typically a log transformation for distance / time data) in order to attain a normal distribution. If this is unsuccessful, non-parametric testing will be used. Discrete data can be treated as continuous provided the sample size is large.

In order to include an explanatory variable, for example characteristics from the background questionnaire, regression analysis will be used. For binary data the appropriate test is logistic regression; for continuous data linear or nonlinear regression will be used depending on the data distribution.

It should be noted that it is not yet possible to assign a definitive test to each RQ since the exact sample sizes and data distributions are unknown.

#### 6.4. Implications for mobility

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The final analysis will be finalised by interpreting the implications that the changes found in the analysis will have on mobility. The basic principles in the interpretations will be the following:

- Mobility improves as the number of journeys increases.
- Mobility deteriorates as the length of journeys measured in distance or as duration increases.
- Change in used modes either improves or deteriorates mobility based on user preference (whether they favour a car, public transport, etc.).

- Route choice either improves or deteriorates mobility based on user preferences (whether they favour a motorway, rural roads, etc.).
- Mobility improves as the time budget is narrowed i.e. as departure time of commuting is shifted.
- Mobility improves as travelling in adverse conditions like darkness increases.
- Mobility improves as comfort improves in terms of less stress and uncertainty or a better feeling of safety or comfort.



## 7. CONCLUSIONS

The objective of this deliverable was to provide preliminary results of mobility impacts for mobility assessment in TeleFOT. Specifically, the objective was to discuss the concept of mobility, to validate the method proposed for mobility impact assessment, and to pilot the mobility research questions.

Mobility is concluded to be the willingness to move along with potential and realized movement rather than just physical movement of vehicles, people and goods. Along with transport and infrastructure it encompasses people's and road users' attitudes, opinions and choices in their daily travelling and movement. The concept of mobility is versatile. However, it is often reduced to transport or confused with accessibility or efficiency.

In TeleFOT, a travel diary was developed to fulfil the information needs in order to address research questions and hypotheses related to mobility impact assessment. The travel diary is filled in paper form, one paper a day. Diaries are collected once in the before-phase of the FOT and two or three times in the after-phase depending on the length of the FOT. The length of each travel diary data collection period is one week. A supplement to the travel diary is filled in during the after-phase travel diary data collection periods to acquire essential information about major changes in the mobility needs and possibilities of the test users and their families due to factors other than TeleFOT functions.

Travel diaries were returned by 73% of test participants. In general the travel diaries were filled in diligently by users, with 96.3% of travel diaries returned fully completed. However, only 66.6% of trips were found in both travel diary and logger data. 41% of trips reported in the travel diary were missing the corresponding logger data. Eight percent of logged trips were missing the corresponding travel diary entry. The results proved that participants had the skill to use data loggers and travel diaries quite well, but it was forgotten or chosen not to be used by many participants on many trips. The length of a logged trip had no effect on whether the trip was reported in the travel diary or not. However, 15% of trips missing a corresponding travel diary entry were shorter than 200 metres, which should be regarded as cases where the trip should be filtered from the logger data.

Trip starting times corresponded in the data better than did ending times (91.9% versus 83.0%). Based on the results, driving transportation and personal business trips were more prone to be unlogged in proportion to their total number made. However, there

were still a greater number of commuting and leisure trips left unlogged than transportation and personal business journeys.

The number of fragmented logged trips, i.e. trips that were logged as a sequence of trips, was alarmingly high (18.0%) in the logged data. Fragmentation creates trips of false length and duration, and impairs the reliability of logger data results. The reasons for data fragmentation can be attributed to both human and technical sources but they should be addressed to improve the validity of data logging.

Interestingly, when the test participants were divided into three groups based on their amount of travel diary and logged trip pairs, differences emerged. The same division corresponded to their results in matching of travel diary and logger data variables, such as accuracy of the trip timing or trip length, only participants from the best group scoring the best results and every participant from the poorest group having poor results. No specific group demographics were found, but it would be interesting to study whether demographic-specific groups would emerge in a larger number of participants. The results indicate wide personal differences in test participants' diligence and accuracy in answering the travel diary and using the logger device.

The pilot analyses of the research questions indicated no problems for the final analysis. All research questions regard a change in something. The change itself could not be analysed based on the first data sets available for the pilots. However, it was confirmed that most the variables needed could be obtained from the data. The only exceptions were RQ4.1 "Is there a change in route choice in commuting?" and RQ10.2 "Is there a change in user uncertainty?". Map matching was not completed at the time of pilot analysis and therefore the final variables to be used in the final analysis could not be decided. Nevertheless, it will be possible to determine route choice from the map matching variables. Consequently, we do not expect problems in the final analysis. There was a question related to user uncertainty missing from the questionnaires. However, such a question was accepted to be added to the post-test user uptake questionnaires.

Test participants made on average 4.3 journeys per day in total. The average number of other home-related journeys than commuting or business-related was 1.7 per day and of other journeys than commuting, home-related or work-related 0.8 per day. The mean length of a journey reported in the travel diary was 21.2 km. The average length of those journeys when the GD application was activated was statistically significantly shorter than those when the GD application was not in use. The mean duration of journeys was 24 minutes. The average duration was shorter for journeys with the GD application activated. However, the comparisons were based on all reported journeys – not only

comparable journeys such as commuting. The vast majority of commuting journeys were made by car, either as driver (82%) or as passenger (9%). Functions were used for commuting more often during peak hours than at other times.

For all the piloted functions — SI/SA, GD and NA — most participants expect the use of functions either not to change user stress or to decrease it slightly. The SI/SA function is expected to decrease user stress more than GD or NA. Participants expect either no change or a slight increase in feeling of safety as well as comfort with the GD or SI/SA system. Consequently, early expectations were not very high; however, they were positive rather than negative, which is to be expected since the participants had volunteered to use the systems.

Most participants expect accurate information to a moderate degree for NA and GD applications, and to a large degree for SI/SA applications. The pessimistic view of the accuracy of information provided by (static) NA or GD may be related to the systems not being able to take the traffic situation into account. If the systems give instructions not applicable to the current traffic situation, the user may lose trust in the systems.

In conclusion, the mobility impacts of TeleFOT functions should be able to be analysed for the final results as planned. Preliminary results show no high expectations among test participants concerning the impacts of services provided by nomadic devices.

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## ANNEX I TRAVEL DIARY AND ITS SUPPLEMENT

[illegible]



## TeleFOT Travel Diary

**Write down all trips made during the survey days in the diary.**

### INSTRUCTIONS

A trip is moving from one place to another for an end purpose. A trip can comprise one or more modes of transport. **Remember that most trips include a walking part.** A trip that includes only walking should also be logged. However, short walking distances (e.g. less than 5 minutes) at origin or destination should not be included, if you are uncertain whether you should report your travelling as one or two trips, report it as two.

The purpose of a trip home is the original main purpose for leaving home.

Example:

	Origin	Destination	Purpose
TRIP 1	From home to children's day care	1	7
TRIP 2	From children's day care to work	7	3
TRIP 3	To a meeting outside the office	3	5
TRIP 4	Back from the meeting	5	3
TRIP 5	From work to a eye doctor	3	9
TRIP 6	Home from the eye doctor	9	1
TRIP 7	From home to a petrol station	1	8
TRIP 8	From petrol station to a swimming pool	8	11
TRIP 9	Home from the swimming pool	11	1

You may complete the diary using the codes shown on the back cover or verbally.

THOSE TRAVELLING ON A PREDEFINED ROUTE (like bus drivers) should only log trips that are not related to these predefined route selections. The trip to and from work should be logged.

THE SURVEY DAY starts at 4am and ends at 3:59am the following day. Your personal survey dates are stated in the covering letter. This means that you should log the trips you make during those days (separate diary table for each day).

TRIPS are logged in the chronological order (sequence) in which they were made during the day.

TeleFOT functions:

- Green driving provides support to the driver in order to reduce the environmental impact of driving where possible.
- Speed alert displays the current speed of the vehicle and the current speed limit of the road/street. A warning is issued when the speed limit is exceeded.
- Speed information displays the current speed of the vehicle and the current speed limit of the road/street used. No warning included.
- Traffic information is a system that provides drivers with real-time information about the status of the traffic system independent of navigation.
- Navigation guides the user to a destination set beforehand. Dynamic navigation takes into account the actual (and real time) status of the traffic system or other pre-selected topics, static navigation does not.

Origins and destinations	
1 Permanent residence (own home)	8 Supermarket, shopping centre or other retail location
2 Other residence (including holiday/weekend residence)	9 Location related to personal business (bank, office, doctor, etc.)
3 Own place of work	10 Restaurant, cafe or similar
4 Own school or place of study	11 Place of leisure activities
5 Business trip related location	12 Hotel or similar
6 Place to pick up person or goods	13 Other location, describe
7 Day care, children's school	

Travel modes	
1 Walking, running, kick sled, kick bike, walker, wheelchair, skis, rollerblades etc.	9 Train
2 Bicycle	10 Taxi, inva-taxi
3 Passenger car or van, as passenger	11 Aeroplane, helicopter
4 Passenger car or van, as driver	12 Motorcycle
5 Local bus (including service lines), school transport	13 Moped, moped car
6 Long distance coach	14 Skidoo, all-terrain vehicle
7 Metro	15 Water transport (boat, ship, ferry)
8 Tram	16 Truck/lorry
	17 Tractor/self propelled, (road maintenance vehicles etc.)
	18 Other form of transport, describe

Trip purposes	
1 Commute to work, commute home (or to other residence)	5 Personal business (to/from)
2 Business trip (usually a work related trip paid for by one's employer, to/from)	6 Lunch/eating/restaurant visit (to/from)
3 Trip to/from school, place of study	7 Transporting another person or goods (to/from)
4 Purchase of daily goods, shopping trip (to/from)	8 Leisure activities (to/from)
	9 Vacation travel (to/from)
	10 Other trip, describe

TeleFOT functions	
GD Green Driving	TI Traffic Information
SA Speed Alert	NS Navigation (static)
SI Speed Information	ND Navigation (dynamic)





### Supplement to TeleFOT Travel Diary

Country:	City / FOT:	Person:	Date (DD/MM/YYYY):
			/ /201

- Have you changed the location of your permanent residence comparing to the last time you filled TeleFOT Travel Diary?
  - ☐ Yes
  - ☐ No
- Have you changed the location of your work comparing to the last time you filled TeleFOT Travel Diary?
  - ☐ Yes
  - ☐ No
- Has the number of vehicles in your family changed comparing to the last time you filled TeleFOT Travel Diary?
  - ☐ Yes, increased
  - ☐ Yes, decreased
  - ☐ No
- Has there been a change in the ownership of your vehicle (privately owned car vs. company-owned car with complementary fuel and service) comparing to the last time you filled TeleFOT Travel Diary?
  - ☐ Yes, from privately owned to company-owned
  - ☐ Yes, from company-owned to privately owned
  - ☐ No
- Have there been changes in your own transport needs (due to new hobbies, illness/injury etc.) comparing to the last time you filled TeleFOT Travel Diary?
  - ☐ Yes, increased
  - ☐ Yes, decreased
  - ☐ No
- Have there been changes in the transport needs of your children comparing to the last time you filled TeleFOT Travel Diary?
  - ☐ Yes, increased
  - ☐ Yes, decreased
  - ☐ No
- Have there been changes in the transport needs of your spouse comparing to the last time you filled TeleFOT Travel Diary?
  - ☐ Yes, increased
  - ☐ Yes, decreased
  - ☐ No







- Have there been changes in your work situation (vacation, unemployment, telecommuting, etc.) comparing to the last time you filled TeleFOT Travel Diary?

*Last time*

- ☐ *On vacation*
- ☐ *Unemployed*
- ☐ *Telecommuting*
- ☐ *Working outside of normal office*
- ☐ *Sick leave*
- ☐ *Working normally*

*This time*

- ☐ *On vacation*
- ☐ *Unemployed*
- ☐ *Telecommuting*
- ☐ *Working outside of normal office*
- ☐ *Sick leave*
- ☐ *Working normally*

- Have there been major changes in your personal economic situation comparing to the last time you filled TeleFOT Travel Diary?

- ☐ *Yes, economic situation has improved*
- ☐ *Yes, economic situation has worsened*
- ☐ *No*

