**eCO-friendly urban Multi-modal route PlAnning Services for mobile uSers**

**FP7 - Information and Communication Technologies**

**Grant Agreement No: 288094**
**Collaborative Project**
**Project start: 1 November 2011, Duration: 36 months**

# D1.1 – User Group Definitions, User Needs, and Requirements Analysis

**Work package:** WP1 – User Requirements, Use Cases, and System Architecture Specification
**Due date of deliverable:** 30 April 2012
**Actual submission date:** 30 April 2012
**Responsible Partner:** TomTom
**Contributing Partners:** CERTH, TomTom, PTV

**Nature:** ☒ Report ☐ Prototype ☐ Demonstrator ☐ Other

**Dissemination Level:**
☒ PU : Public
☐ PP : Restricted to other programme participants (including the Commission Services)
☐ RE : Restricted to a group specified by the consortium (including the Commission Services)
☐ CO : Confidential, only for members of the consortium (including the Commission Services)

**Keyword List:** User groups, user needs, requirements analysis, requirements specifications, functional requirements, non-functional requirements

The eCOMPASS project (www.ecompass-project.eu) is funded by the European Commission, Information Society and Media Directorate General, Unit G4-ICT for Transport, under the FP7 Programme.

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| Document history | | | |
|---|---|---|---|
| Version | Date | Status | Modifications made by |
| 0.3 | 05.03.2012 | ToC draft | Dionisis Kehagias, CERTH<br>Felix Koenig, TomTom<br>Florian Krietsch, PTV |
| 0.4 | 09.03.2012 | ToC final | Dionisis Kehagias, CERTH<br>Felix Koenig, TomTom<br>Florian Krietsch, PTV |
| 0.14 | 12.04.2012 | Final review by authors | Dionisis Kehagias, CERTH<br>Felix Koenig, TomTom<br>Florian Krietsch, PTV |
| 1.0 | 13.04.2012 | Sent to internal reviewers | Dionisis Kehagias, CERTH<br>Felix Koenig, TomTom<br>Florian Krietsch, PTV |
| 1.1 | 23.04.2012 | Reviewers' comments incorporated | Dionisis Kehagias, CERTH<br>Felix Koenig, TomTom<br>Florian Krietsch, PTV |
| 1.2 | 26.04.2012 | PQB's comments incorporated | Felix Koenig, TomTom |
| 1.3 | 30.04.2012 | Final (approved by PQB, sent to the Project Officer) | Christos Zaroliagis, CTI |

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## Summary
This document details the user research conducted for the eCOMPASS project. In the Introduction, we briefly restate the project's mission, its scope, and main stakeholders. eCOMPASS aims to develop applications and services for four distinct application scenarios: private vehicles, commercial vehicle fleets, urban residents using a smartphone for multimodal route planning, and tourists using a smartphone to plan their multimodal day itineraries. We first analyze the resulting four main user groups and further refine them into different segments. Next, we describe the setup of in-depth interviews and broader user questionnaires to learn about the needs of these user groups in detail. We then evaluate the outcome of interviews and questionnaires in order to precisely define user needs to be addressed by eCOMPASS. Finally, we derive a concise set of requirements for eCOMPASS applications from these needs following the Volere methodology. We close with a summary of results and conclusions.

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# 1 Introduction

The aim of this deliverable is to provide precise definitions of the user groups and segments targeted by eCOMPASS, to characterize the needs of these groups to be addressed, and finally to analyze the resulting requirements for applications and services development. Thereby, the work described herein constitutes the foundation of the user centric design approach adopted by eCOMPASS in order to deliver usable innovative features, precisely addressing user needs, and quickly finding broad acceptance in the field.

## 1.1 Goals of eCOMPASS

Some of the most important goals of eCOMPASS are to

- Enable eco-aware and eco-friendly route planning in urban transportation,
- Raise eco-awareness among its users,
- Cover all types of human and goods mobility in urban environments.

Quite clearly, these challenges need to be approached from two sides: While a key objective of eCOMPASS is to develop novel algorithmic solutions supporting these goals, it is equally important to take the user perspective in order to find ways to wrap algorithmic advancement in attractive and easy-to-use features to gain rapid and wide acceptance by users.

A key idea in eCOMPASS, in order to facilitate rapid adoption, is to deliver its innovative features on platforms users are already familiar with today. In the four application scenarios for eCOMPASS services, these are the following:

- In **private vehicle navigation**, most users rely on a **portable navigation device (PND)**. Hence, eCOMPASS applications developed for this scenario will be delivered as PND features.
- When managing commercial **vehicle fleets**, most companies today employ a fleet management system comprising a central **back office application** used by the fleet operator, combined with an **on-board navigator** in each vehicle, quite similar to a PND. For this application scenario, eCOMPASS aims to deliver its services as features of these two existing components.
- Finally, **residents or tourists** in urban areas today are highly likely to use a **smartphone** for public transportation-based route planning. Hence, smartphone – web and/or standalone- applications will be developed in eCOMPASS to deliver features for such application scenarios: a multi-modal route planner for urban residents, and a day-itinerary planner for tourists visiting a new city.

Consequently, the user research for eCOMPASS starts with users of the above familiar platforms and aims to learn about features still lacking in them, which would contribute to serve a user need on the one hand, and facilitate eco-awareness in urban transportation on the other.

## 1.2 Objectives of WP1

The purpose of WP1 is to ensure that the solutions developed within eCOMPASS can really make a difference in reducing the environmental footprint of urban transportation through the rapid adoption of eCOMPASS services and applications by a broad user base. To achieve this, eCOMPASS must comprise algorithmic solutions supporting features which address real needs of real users, and a system architecture enabling the delivery of services to them.

Hence, the aim of WP1 is to first define the targeted users of eCOMPASS and to understand their needs towards more eco-friendly mobility. Based on this, the precise requirements for eCOMPASS services and applications will be analyzed. In a next step, use cases of these services and applications will be specified, and priorities of different application scenarios will be fixed. As a final result, WP1 will provide a concise specification of the eCOMPASS system architecture, delivering the full benefit of the innovative algorithmic solution developed to our users' needs.

## 1.3 Scope of this Deliverable

The present deliverable, D1.1, documents the first part of the work in WP1. Building on existing knowledge of eCOMPASS partners, we start with an analysis of user groups of present solutions in car navigation, fleet management, and smartphone-aided trip planning. Based on this analysis, we create interview scripts and online questionnaires to learn about refined user groups and segments for envisioned eCOMPASS features, and to distill user needs towards more eco-friendliness in urban transportation.
From a rigorous analysis of the outcome of this user research, we obtain the main results of our work to date:

- a precise definition of the user groups targeted by eCOMPASS services and applications,
- a concise specification of these users' needs related to reducing the eco-footprint of their urban transportation needs,
- an extensive analysis of the resulting requirements for the eCOMPASS system architecture.

Based on these results of the present deliverable, a use case analysis and the prioritization of application scenarios will be conducted in deliverable D1.2. Finally, the full system architecture specification for eCOMPASS will be developed in deliverable D1.3

### 1.3.1 Structure of the Document

The main body of this document comprises three parts: section 2 containing user group definitions, section 3 analyzing user needs, and section 0 conducting the requirement analysis. (Sub)sections are split up by the four main application scenarios of eCOMPASS, private vehicles, vehicle fleets, residents with smartphones, and tourists with smartphones, where appropriate.
Section 2 commences with a description of the most important stakeholders in the eCOMPASS realm. Then, we describe the different segments of targeted eCOMPASS users before delivering precise user group definitions in our conclusions for this section.
In section 3, we begin with an overview of previous work on user needs in urban transportation before detailing our user research setup. We first describe the in-depth interviews conducted, then the broader questionnaire. We close with a detailed list of user needs to be addressed by eCOMPASS as the result of our research.
Section 0 commences with an analysis of existing requirement specification methodologies. Then, after a methodology for eCOMPASS has been defined, a detailed requirement analysis based on the results of the previous sections is performed.

## 1.4 Assumptions

In order to reasonably limit the scope of our quest to learn about user groups and their respective needs, an assumption should be made on the nature of the eCOMPASS services and application. A key assumption of eCOMPASS is that new features will be developed for familiar user platforms. Quite clearly, this helps the project to stay focused on its key objectives, namely algorithms for route planning services, and not be distracted by systems development. More importantly, however, innovative new features are most likely to be rapidly adopted by users, if they ubiquitously fit themselves into the user's familiar way of doing things.

### 1.4.1 Private Vehicles

In private vehicles, eCOMPASS applications and services will be made available on a PND. PND technology has evolved significantly over the past few years, and premium models today are connected via GPRS and hence able to receive real-time data from a server. Such data most importantly includes traffic updates, but also parking availability, dynamic point of interest (POI) information, etc. Hence, for eCOMPASS applications development, we will assume that the PND used has a GPRS connection to a server providing at least detailed up-to-date traffic information.

Due to the portable nature of PNDs, there are also some technical restrictions. For one, no vehicle-specific dynamic data will be available, like the current gear used, accelerator or steering wheel position, or even accurate fuel consumption figures. This restriction will need to be taken into account in the development of eCOMPASS applications.

Moreover, processing power and memory are limited to facilitate the devices running on battery power, and also to enable competitive pricing. Finally, the cost of GPRS data traffic for connected services is still an issue today, and compared to wired internet access, bandwidth is small. Hence, our assumption for eCOMPASS applications is that computing power on the device needs to be used wisely, and GPRS data traffic should be limited to a reasonable amount.

### 1.4.2 Vehicle Fleets

The clients' transportation requests specify origin and destination, time windows for pickup and delivery, the type of good(s) to be transported and the required capacity. The task of the transport planner is then to assign these transportation requests to the available transportation resources such that the requests are fulfilled as specified by the customer and the cost of using these resources is minimized. Thereby vehicle routes need to planned.

This planning will be executed on the eCOMPASS tour planning system, i.e. a state-of-the-art back office fleet management system featuring newly developed eco-efficient algorithms. Those algorithms require accurate load-dependent emission profiles for all vehicle types, an issue that will have to be thoroughly researched.

Furthermore traffic information will be considered already in the sequencing process as the system will be able to communicate via XML Interface with the navigation back-office system of TomTom. There are, however, limitations with respect to using short time traffic information as it is not foreseeable if a traffic disruption taken into account in the planning process actually still exists at the time of delivery. Medium- and long-term traffic information will be considered, however, simplifications regarding partial time slot distance matrices must be made as the use of complete time slot distance matrices is not feasible for performance reasons.

It is assumed that communication between the fleet management system and the truck drivers' on-board navigation devices is possible at all times and there no problems arise due to insufficient network coverage.

### 1.4.3 Residents and Tourists with Smartphones

Along with the growing popularity of smartphones, multi-modal trips are becoming more and more likely to be planned using a mobile application, and this holds for both residents and tourists travelling within an urban area. For eCOMPASS applications and services, we will make the realistic assumption that phones used for trip planning are connected to the internet via GPRS or 3G, and that they have a GPS receiver enabling real-time positioning.

Moreover, multi-modal trip planning requires a large amount of heterogeneous data to be available, e.g. all timetables for different modes of public transportation, potentially the infrastructure and availability data for different car sharing services, etc. It might be inconvenient, if not infeasible, to store all this data locally on a smartphone while continuously keeping it up-to-date. Therefore, we will take into account the possibility for eCOMPASS that mobile applications transmit multi-modal route planning request to a server, where routes are planned off-board, and then transmitted back to the smartphone.

# 2 User Groups

A crucial step in the analysis of user requirements is to clearly define the different groups of users to which eCOMPASS would like to account for, as they are the primary stakeholders in our applications and services. On the other hand, however, there are also some non-primary stakeholders in the urban space which will potentially be affected by eCOMPASS innovations and hence should not be ignored.

We will commence this section with an overview of the most relevant stakeholders in urban transportation before we focus on user group definitions. Naturally, four main user groups can be derived from the four eCOMPASS application scenarios; in subsequent sections, we will then explore other criteria besides the application scenario which play an important role in characterizing our users as well.

## 2.1 Stakeholders

Due to their high population density, urban areas tend to exhibit a large degree of interdependency between people in general, and their everyday transport in particular. Hence, urban mobility decisions typically involve various stakeholders. While the primary stakeholders differ in the four eCOMPASS application scenarios, they all share an important secondary stakeholder, namely the **community of urban residents**, possibly represented by some **governmental or administrative body**. On the one hand, virtually everybody in the urban space can greatly benefit from making transportation more eco-friendly, or be heavily burdened when transport-related pollution continues to grow. On the other hand, governments or administrations, as representative of the people, may impose rules and restrictions on transportation, as well as facilitate and/or support certain means of transportation as part of their policy.

### 2.1.1 Private Vehicles

Clearly, the **PND user** is a primary stakeholder in this scenario; his goals include getting to where he wants to go in his favorite way, which could be the quickest, the shortest, the most eco-friendly, the safest, the easiest, the most scenic, etc., and also combinations of these objectives. A key objective in the design of a PND is not just to propose routes to the user, but to give him the feeling that the suggested routes are just right for him. This also means that when proposing special eco-friendly routes, great care has to be taken that these routes are presented to the user in a personalized and appealing way.

### 2.1.2 Vehicle Fleets

Commercial fleets are being operated by logistics companies which provide shipping, trucking and freight services for their clients using their available assets (trucks, drivers).

A logistics company, named hereafter ‘carrier’, receives transportation requests from its clients which are combined to a tour by a transport planner, whereas a client can be a company or a resident.

Minimizing the total landed costs (all ownership and operational costs related to forwarding freight) is of major importance for the carrier. Carriers were identified as main target group with their **truck drivers** and **transport planners** being the end users.

Moreover, when transporting goods, also transportation administrations or **governmental authorities** play also an important role. These are institutions regulating transport of goods on a national or European level. Their main concern is the compliance to regulations (e.g. emissions).

#### 2.1.3 Residents with Smartphones

**Urban residents** who might use a smartphone for multi-modal trip planning are the primary stakeholders in this application scenario. Smartphone users today are getting increasingly accustomed to being able to choose from a huge variety of applications for any given purpose. So in order to ensure the success of an application for multi-modal route planning, it is imperative that it is aligned as well as possible with the user's needs, and also presents results in a familiar and appealing way.

#### 2.1.4 Tourists with Smartphones

**Tourists visiting a city** who might use a smartphone to plan their day itineraries using multi-modal transport options are the primary stakeholders in this last application scenario. While transportation planning in this scenario is somewhat similar to that of urban residents, the scenario is extended to also include itinerary planning: tourists can use a smartphone application to plan one or multiple day itineraries in the city, e.g. starting and ending from their hotel and visiting several points of interest (POIs) throughout the day. Naturally, such itinerary planning should take into account a user's personal interests and preferences when selecting POIs to visit. Moreover, itinerary planning could also take into account more advanced data like current weather conditions, a given travel budget, etc.

### 2.2 Segmentation

TomTom has conducted user research in the broad realm of navigation and trip planning for many years. An important realization of this research is the different motivations users have for using a navigation application to aid them. We believe that the resulting user segmentation is of great relevance also to eCOMPASS, and to a certain extent applies to all four main user groups. In previous research, we have identified the following foremost objectives for using navigation devices and applications: Efficiency, comfort, certainty, and safety, see Figure 1 for an illustration.

Users fitting the **efficiency** persona are typically very comfortable with up-to-date electronic devices and use them on a daily basis. They enjoy it when technology can help them to be more efficient. This type of user is likely to use trip planning services even when moving in familiar areas, like on their daily commute, because up-to-date information like traffic, schedule changes, or events, helps them to make sure they are on the most efficient route, and additional information available can help them to find stores and business on the way more easily. The efficiency persona is typically an early adopter of novel applications and features, and his familiarity with electronic equipment helps him to quickly feel comfortable with new and advanced features and possibilities. On the other hand, this persona is very demanding regarding the quality and reliability of services, as he knows the state-of-the-art very well, and anticipates what all is possible.

The persona primarily looking for **comfort** sees route planning services and navigation applications as very nice things to have, because they make everyday life a little easier, like knowing when the next train will leave before getting to the station, and create new possibilities, like exploring different routes or new restaurants or shops on the way. Generally the comfort user does like to be on the move, because it gives him a sense of freedom to explore. Usage of trip planning services is typically more casual and not quite as frequently with this persona. New features may or may not be adopted quickly, depending on how easy to use and attractive they are.

Users looking for **certainty** in navigation and trip planning consider transport merely a necessity. This persona does not always feel fully comfortable while on the move, and getting stuck in an unfamiliar situation is a worry they have. Trip planning services and navigation can deliver this persona a feeling of security in knowing where they are going, and when they will get there, so they can focus on the details of their trip (like the road ahead when driving, or their surroundings when using public transport). Their usage of planning services and applications mostly centers on the more basic features, which they would like to be easy to understand and use. The adaption of new features and applications with this persona may be rather slow; certain new features may even be considered a distraction from the main purpose.

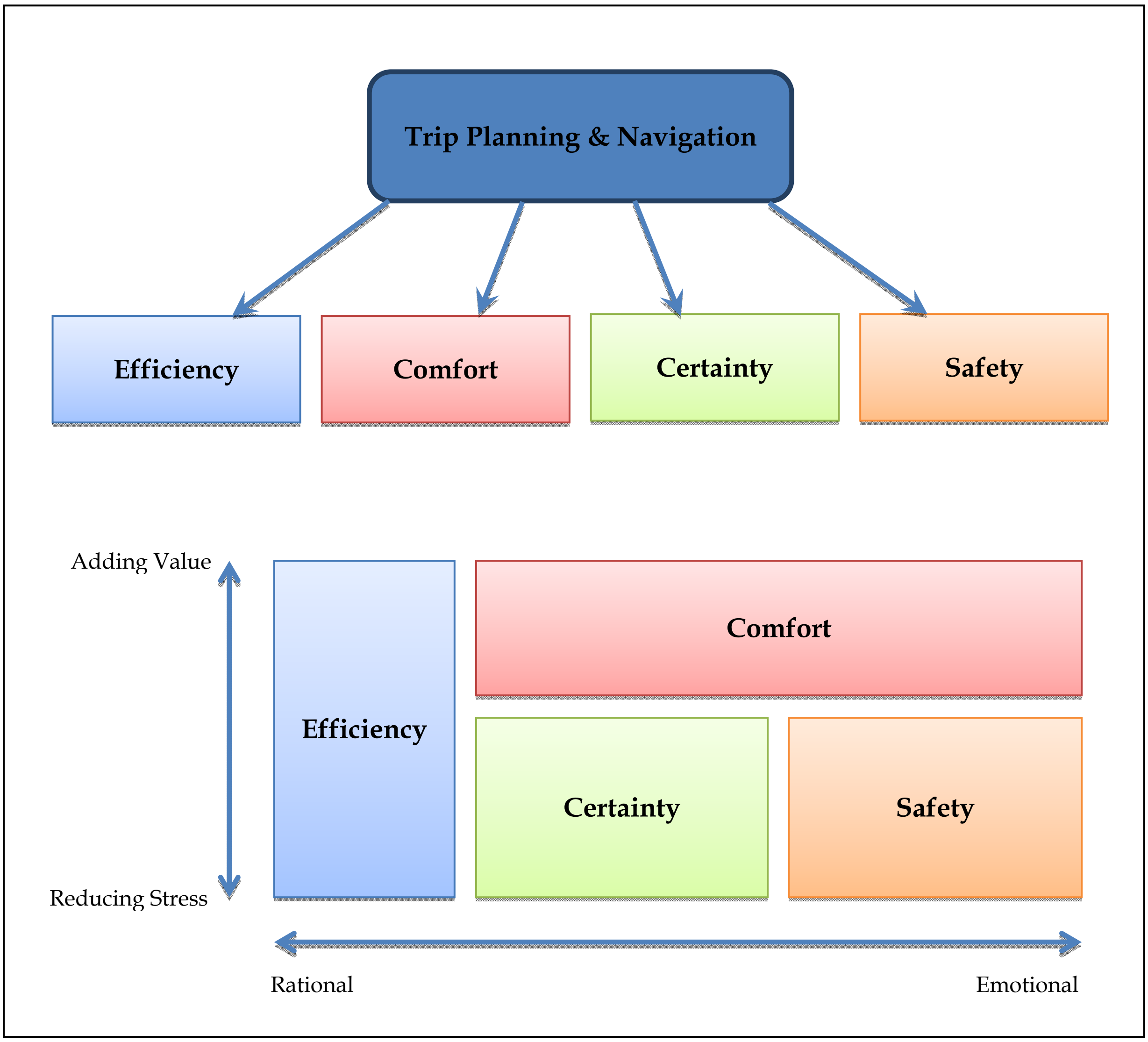



**Figure 1: Motivations to use trip planning and navigation applications and services. Users' top priorities of the different motivations define distinct user segments.**

Finally, the **safety** persona usually does not like to be on the move very much. These users are very aware of the insecurities related to transport. They worry about what would happen in an unusual situation, like a road block or a strike in public transport. Trip planning services and applications can deliver them a sense of security, that they will still know their way when something unexpected happens. On the other hand, this persona's usage of transport planning applications and services may be restricted to unusual situations only, and these users may be reluctant to adapt new features at all.

In the interplay of the four objectives: Efficiency, safety, certainty, and comfort; efficiency is the most important aspect for commercial vehicle fleets. This is directly connected with the objective of logistics companies, to reduce fuel consumption, thus costs. Moreover, certainty/reliability is of fundamental importance for commercial fleets who target “delivering on time”. User of vehicle management systems are further segmented into **truck drivers** and **transport planners,** being the end users for the logistics company.

## 2.3 Conclusions

We have identified the primary stakeholders in the four eCOMPASS application scenarios as the four main user groups of the developed services and applications: **PND users** among the private vehicle drivers, **truck drivers and transport planners** for the vehicle fleet application scenario, and both **urban residents** and **tourists visiting the city** among the smartphone users. Moreover, we have identified the segmentation into four subgroups, differentiating users in each primary stakeholder group by their main motivation for using transport planning applications and services.

While the two user groups in the fleet management application, truck drivers and transport planners, are very specific to their scenario, there is significant overlap between the other user groups. Due to smartphones becoming more and more of a commodity, a resident PND user is very likely to be a resident with a smartphone as well. And any of these two is very likely to fall into the group of tourists with a smartphone when they visit a city during their vacations. On the other hand, the segmentation of all users into subgroups looking for efficiency, comfort, certainty, or safety, seems very relevant in any case.

As a result, we will analyze user needs for private vehicle drivers jointly with those of smartphone users where appropriate in the following sections. For each user group, we will take special care to take into account users from all segments, i.e. analyze user needs catering to all relevant personas.

# 3 User Needs

This section describes how user research for eCOMPASS was set up and conducted, and which user needs we can derive from it with respect to the different user groups described above. We start by giving an overview of previous work by consortium partners outside of eCOMPASS, then detail our research setup comprising both in-depth interviews and broader questionnaires. Finally, we present our conclusions.

## 3.1 Previous Work

This section briefly summarizes work conducted and insights gained by the consortium partners in previous user research and market analysis efforts closely related to the goals of eCOMPASS.

### 3.1.1 Private Vehicles and Residents with Smartphones

TomTom's user research and market intelligence units conduct studies and questionnaires on navigation and route planning, using both dedicated navigation devices, like PNDs, and smartphones, on a regular basis. Most of this work focuses on route planning for cars, and often no significant difference is made whether users employ a PND or a smartphone for it. We proceed to give a summary of the most prominent results from three recent studies, valid for both private vehicle users with PNDs, and urban residents using their smartphone for multimodal trip planning.

Note that these studies and the results obtained are company confidential information owned by TomTom. Hence, we cannot disclose the work conducted and the results obtained in full detail here, but rather give a rough overview of the most important aspects.

**Study 1: Planning Preferences**

This study was conducted by TomTom in 2008 with roughly a thousand participants. The focus was on planning preferences and route quality in general. Regarding eCOMPASS, the most relevant question was this: "Which other planning preferences would be useful on your TomTom?" Results are depicted in Figure 2.

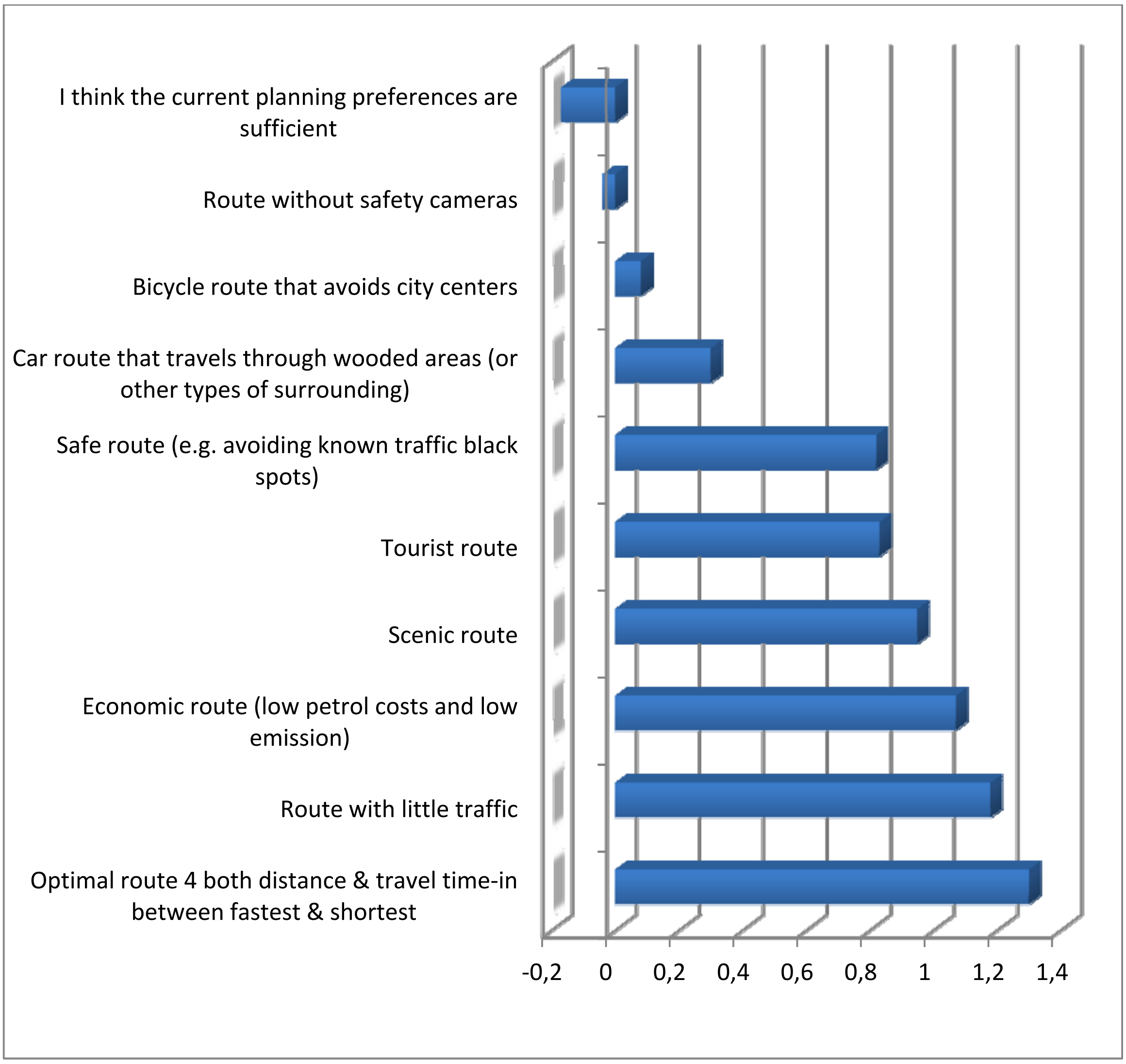



**Figure 2: Average score for the usefulness of planning preferences; "very useful"=2, "useful"=1, "no opinion"=0, "not so useful"=-1, "not useful at all"=-2.**

Among the highest rated preferences, there are several which fit well into the eCOMPASS context: route with little traffic (ranked second), economic route (low petrol cost and low emission) (third), tourist route (fifth), and safe route (e.g. avoiding known traffic black spots) (sixth).

**Study 2: Commuter Needs**

As part of a larger research project on short distance commuters, TomTom hosted a commuter focus group with thirteen participants for three sessions of two hours each in 2009. All participants had used a TomTom PND with live traffic information on their daily commute for over six months. We proceed to quote some representative statements from the corresponding focus group reports relevant for eCOMPASS:

- The overall feedback on traffic service was positive.

- The group was not so much interested in proposed routes (as they were driving in a familiar area), but more about the general overview of the traffic situation. This is illustrated nicely by the fact that five out of the thirteen participants were usually driving with the route summary screen instead of the driving view to have a better overview of the situation, see Figure 3 for an example.

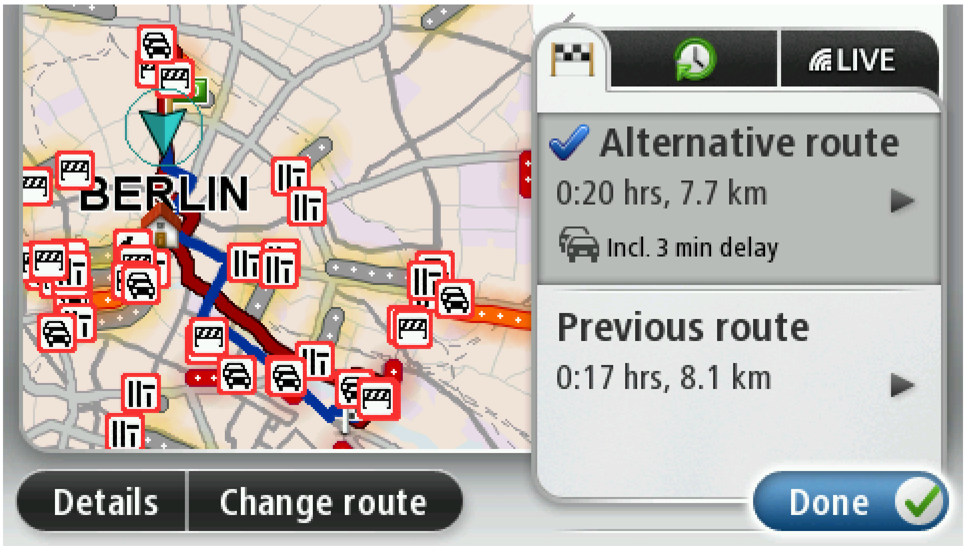



**Figure 3: Example of a route overview screen with traffic and an alternative route offered on a TomTom GO LIVE 1000.**

- Route alternatives displayed were not always taken seriously, but appreciated for the additional traffic information they revealed, see again Figure 3 for an example.
- Users' emphasis lies on deciding for themselves which route to take, based on the traffic information available.
- One user pointed out that he explicitly takes time to look at traffic information to make a route choice before he starts driving.
- A common wish is to have more detailed insight on how traffic is developing: Is a jam decreasing or increasing? A traffic jam seen on the map might have disappeared by the time they get there.
- In addition, there is a desire for departure time advice. Often times, users would like a recommendation on when to leave home in order to avoid traffic.

**Study 3: My Mobility**

This study was undertaken by TomTom in 2011. Its goal was to analyze means to

- Reduce the impact of traffic on time, people, and the environment.
- Help people to deal with traffic dilemmas.
- Inspire people in changing their behavior.

As a general theme, the study proposed to make efficient trip planning as effortless as possible, i.e. to "reduce the cost of thinking", by providing relevant personal information taking into account both the personal as well as the trip context.

In the study's user research phase, 17 in-car interviews were conducted, filmed, and subsequently analyzed. We summarize the most important results:

- Drivers tend to build their own perception of traffic, which is mostly not very accurate.
- They use a mix of different information sources, including many subjective observations - there is not one ideal source.
- There is a need for personalized information beyond turn-by-turn guidance.

- Currently, information is not provided in the right places at the right time.

**Conclusions**

There is clearly one recurrent theme in all of the above studies: Users are very much interested in understanding their given traffic situation as well as possible, and they would like to make their own driving, or even departure time, decisions based on this knowledge. Current approaches do not seem to completely satisfy this need. Receiving traffic information just for one given route, even if it may be the fastest one, is not satisfactory. Information about different routing alternatives may be suitable to yield a broader view of the traffic situation. Also, there is a clear desire to not only receive snapshots of traffic, but to also be informed about the tendency of traffic on the roads.

With respect to our goals in eCOMPASS, this is rather good news: If we can help users avoid traffic, this will alleviate congestion on the long run, reducing emissions for all. Moreover, as seen in study 1, users do tend to be interested in explicitly economical, i.e. low cost and low emission, options. However, a high cost of thinking, i.e. the right information not being delivered to users at the right time, might keep users from actually exercising the best of their options. This clearly constitutes an opportunity for eCOMPASS to innovate in how people plan their transport needs in an urban environment, and to facilitate them making more eco-friendly transport decisions in the future.

### 3.1.2 Vehicle Fleets

PTV's core business is the development of planning software and the active use of it in consulting projects. Therefore user feedback to the already established tour planning and optimization applications, and years of market research with regard to the demand of loaders, logistics service providers and transportation companies were channeled into state-of-the-art tour planning software products.

These experiences have revealed that the main requirements of transport companies for such a system are a correct mapping of their business processes (reliability of estimated driving times, compliance with all relevant restrictions), an economical use of their resources (drivers, vehicles) and potential for cost and travel time savings. Furthermore the software is supposed to facilitate the tour planner's work.

Integration of traffic information would be highly appreciated as this information is not yet available and companies have to rely on the experience of their transport planners.

Additionally ecological aspects like emission calculation and emission savings are becoming more and more important.

In the ongoing EU research project eCoMove environmental attitudes and environmentally friendly behavior of drivers of commercial vehicles have been assessed in sub-project SP4 ecoFreight & Logistics.

The analyses showed that there are often conflicts between environmentally friendly behavior and other priorities like delivery times constraints and driving time limitations. This blend of commercial and private interests determines which motives will be eventually prioritized. An evaluation of a questioning of 255 commercial truck drivers showed that according to them the two most important answers to the question "Which pre-trip actions have the most influence on fuel consumption?" are "checking of tire pressures" and "pre-trip route planning". This analysis indicates that there is a market need for ecological tour planning solutions.

The results presented in the diagram below indicate the ranking of the importance of selected measures: high (rank 1), middle (rank 2), low (rank 3).

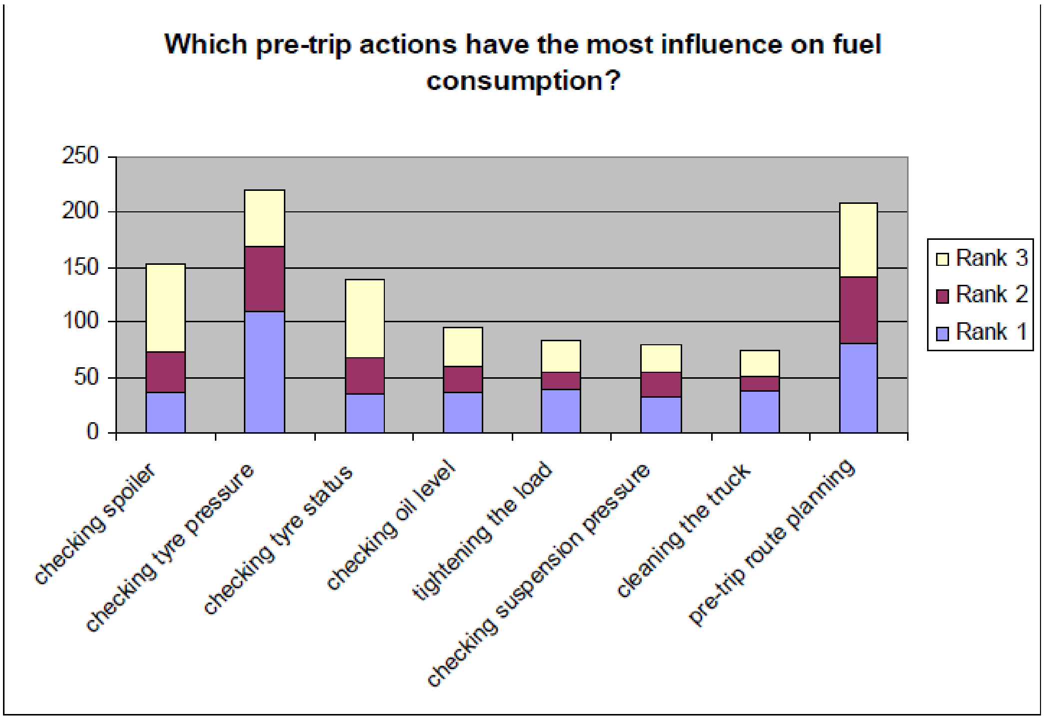



**Figure 4 : Pre-trip actions influencing fuel consumption (Höltl, 2010)**

## 3.2 User Research Setup

Our user research plan aimed at achieving two goals: On the one hand, we wanted to gain an eCOMPASS specific understanding of user needs that is deep enough to really distill the most important aspects; on the other hand, we wanted to gather input from a broad base of users in order for our results to be more representative. To achieve this goal, we took a two-fold approach. First, we conducted in-depth interviews with a limited number of individuals, steadily refining the interview script to get the most out of it. Then, while evaluating the interviews, we created a broader online questionnaire designed to reassess our findings, and distributed it to a broader audience. We describe the details of this approach for the different application scenarios in the following sections.

## 3.3 In-Depth Interviews

As a first step in our actual user research, TomTom conducted a series of in-depth interviews with private vehicle drivers and smartphone users, and PTV followed a similar course for vehicle fleet operators and personnel. The scripts for the interviews were designed on the one hand to verify and elaborate on some clear and existing user needs as resulted from our analysis of previous work in section 3.1, but on the other hand also to test for the user acceptance and attractiveness of more innovative future features envisioned as result of the research to be conducted within eCOMPASS. We elaborate on this in the following sections, specific to certain application scenarios.

### 3.3.1 Private Vehicles & Smartphone Users

Interviews were conducted with fifteen participants who all had at least some experience with a TomTom VIA LIVE 120 Europe, so they were familiar with the state of the art in in-car traffic information and traffic detouring. For their participation, they received a free one-year subscription of TomTom's LIVE services. All but one work at the Technical University of Delft, and most of them live in The Hague, Netherlands.

| Age | Sex | Profession | Tech skills | Smart phone | Commuting distance (km) |
|---|---|---|---|---|---|
| 42 | f | Organizing events | medium | yes | 16 |
| 52 | m | Associate Professor of Innovation | advanced | no | 7 |
| 41 | f | Teaching languages at university | medium | yes | 15 |
| 40 | f | Head communications on University | medium | yes | 25 |
| 42 | m | Information specialist | advanced | no | 20 |
| 57 | f | Administrative employee | medium | yes | 12 |
| 24 | m | Student | advanced | yes | n.a. |
| 54 | m | Design Engineer | advanced | no | 15 |
| 39 | m | Financial work | medium | no | 20 |
| 21 | m | Student | medium | yes | n.a. |
| 32 | m | University teacher | advanced | no | 15 |
| 28 | m | PhD student | advanced | yes | 8 |
| 42 | m | Assistant professor | advanced | yes | 20 |
| 29 | m | PhD student | advanced | yes | 15 |
| 36 | m | Technician | advanced | no | 15 |

**Table 1: Demographics of the participants in the in-depth interviews conducted by TomTom.**

A rough script was drafted for the interviews (see section A.1 in the appendix); however, in order to have as natural conversation as possible, the flow of the talk was taken as a more important guideline to the interview than the script. As a result, questions were frequently skipped, and other topics than in the script were discussed. This approach is commonly used in explorative in-depth user research, as the goal here is more to get a true feeling of users' desires than to generate statistical data. The latter will be taken care of sufficiently in the online questionnaire described in section 3.4.1.
Interviews were conducted on the phone, during business hours, and conversations were recorded for thorough evaluation afterwards.

The following are the most prominent insights gained in the first parts of the interviews as to when and how interviewees were currently using their navigation devices:

- All but one participant enter a destination when they use their device.
- Most have voice instructions enabled.
- Nine participants do not use their device on their daily commute because they feel there is no real benefit, either because they know the area and typical traffic very well themselves, or they think that detouring traffic takes just as long as sticking to the original route and just accepting the delay.
- However, all users appreciate their device and traffic information on longer trips and unfamiliar routes.
- The most prominent benefits include traffic information and safety camera warnings, knowing the estimated time of arrival (ETA), driving more relaxed, and knowing the speed limit.

- All users use their device on vacation. Then, they appreciate knowing POI locations and relevant information, as well as navigating reliably to locations found on a paper map.

Regarding route choices and alternative routes, the following were the most prominent themes in the interviews:

- Almost all participants are interested in comparing routes, but mostly for longer or leisure drives.
- Many participants mention an interest in different types of routes, like fastest, efficient (saving cost), scenic, comfortable/easy (few turns). An eco-friendly option is not mentioned.
- Only two participants always accept a faster alternative when it is available; all others inspect the alternative before making their decision.

On the topic of traffic information and its timeliness and reliability, the following issues were most prominently mentioned:

- Generally, users are really keen on avoiding traffic delays; after a good experience, getting through traffic one user states: *"Saving one minute of delay makes me live one month longer."*
- Users have their own traffic patterns in mind. They merge the external information they receive with their own knowledge from experience to create their own personal understanding of the traffic situation.
- Almost all participants would be really interested in (or even expect) traffic prediction and/or robust routes.

When it comes to multi-modal transport, participants made the following points:

- Even participants who consider themselves eco-friendly do not take eco-friendliness into account when making transport decisions or route choices.
- Park & Ride is not a very often used facility; some participants use it occasionally when on a visit to a big city. There, however, users feel that buses and trains run so frequently that knowing their timetables is only of limited extra value.
- A multi-modal planner would be very useful because it would bundle all information in one place, whereas today users have to use multiple different apps to plan and compare multi-modal journeys. It would need door-to-door info, parking information, knowledge of special events (road blocks, unusual traffic), knowledge of special days ("no cars allowed in the city center on Sundays"), focus on travel time, and awareness of driving conditions (weather). Again, eco-awareness would not be the reason for using this app.
- Many participants give multiple reasons why they do not use public transport regularly, most prominently convenience and efficiency in terms of travel time.
- Overall, multi-modal planning will probably only be used by users that want to use public transport anyway. There is no indication that by using this kind of apps, users will use public transport instead of their car.
- Several users state that they would rather use a website than an app. As one user states it: *"Apps are a hassle."*

Interviews also touched on the topic of traffic load-balancing schemes. After an explanation how average travel time and congestion could be reduced for all users when a few users sometimes do not travel on the fastest route, participants stated the following.

- Overall, users prefer to decide for themselves which route to take and not always follow suggestions. To some extent, this is valid independent of whether the suggested route is fastest or not. As one user puts it: *"If I were the type to blindly follow a route, then it would be okay, as long as the system works properly. But I won't blindly follow a route."*
- Even those who were open to the idea stated that they might quickly lose interest once they experience a few bad routes.
- Generally speaking, however, users did understand the idea and some were positive against it. One user states: *"If I know how it logically works, and if it works, then I might join."* And another: *"I am a people person. If I get a good feeling about this, I will accept it."*

Finally, participants were also asked about their opinion on an itinerary planner for tourists:

- Several users indicated that they like to take a leave from technology when they are on vacation: *"I leave my apps at home when I am on holiday." "On vacation, I just walk and bike, and then I want to find things out myself. Localized information can be annoying, such as an SMS when crossing the border."*
- Battery consumption is an issue when talking about smartphones on vacation.
- One person sees a dilemma because she would like such an app to focus on small local things (like flee markets, local butchers) and thinks that such information is hard to find (or does not even exist) in digital form. This does clearly define an opportunity.
- Most participants mention content that is already available on a TomTom, or on the world wide web (e.g. restaurant reviews).

Regarding eco-friendliness, in general and regarding transport choices, participants conveyed the following insights:

- Nobody seems to act eco-minded when it comes to their cars. There is a lot of skepticism how much effect a change in their behavior would have. For none of the participants, eco-friendliness is a strong motive to act.
- The following statements do, however, hint at the possibility to increase awareness in the future: *"Only when I save money with it." "Thinking and doing is different." "If time permits, I will consider it."*
- Two participants even had strongly averse feelings regarding eco-awareness; they definitely would not want to be educated on how much fuel they use or the eco-footprint of their route.

**Conclusions**

- Most of the participants consider themselves eco-aware. However, none seem to act eco-minded when it is about their cars or choosing a means of transport in general. Car drivers are often not even willing to do just a little to save the environment.
- The benefit of comparing routes is very clear to the participants. They can also imagine special routes suggested next to the fastest to cater for special circumstances (avoid highway, touristic, do or do not cross a border).
- For their daily commute, comparing routes seems less interesting than for other trips.
- Regarding more complex traffic information, like route reliability, they will easily incorporate additional information provided by a system, since all participants already use their own knowledge to decide on a route. They have patterns in their mind ("every morning, there is a jam on the A4") so they would not be surprised if a system could do that as well.

- Filling information gaps by providing more details, such as traffic forecasts, will ensure that more people will follow the suggested fastest route.
- Park & ride features will probably only be used by users that want to use public transport anyway. There is no indication that by using new apps, users will take public transport rather than their car.
- Regarding traffic load-balancing, users do understand the concept and some indicate that they might be open for it. However, it will be difficult to really get many users interested, and if they are, they might easily lose interest again when having a bad experience only once.
- Regarding a tourist app, the participants did not come up with many interesting ideas. A dilemma might be that they would like such an app to focus on small local things, which at the same time they believe not to be available in digital form.

### 3.3.2 Vehicle Fleets

Transport planning is a complex and wide field. Many aspects have to be taken into account. At a first glance, logistic problems are rather similar across Europe, thus depending on the industry and the activities, e.g. problems encountered in the South of Europe correspond to issues experienced in the North or East of Europe. Looking more into details, however, problems cannot be transferred directly, e.g. because of different regional administrative rules and restrictions. The eCOMPASS project will, at a later project stage, test the solutions in a field demonstration at the test site Berlin, Germany. Therefore interviews were conducted with ten participants from the Berlin area, of various backgrounds in the field of transportation planning, operational and strategic.

| Age | Sex | Profession | Tech skills |
|---|---|---|---|
| 32 | m | Transport Planner | Advanced |
| 62 | m | Owner of Courier-Express-Postal (CEP) company | Medium |
| 43 | f | Transportation Market Researcher | Medium |
| 25 | f | Transportation Engineering Student | Advanced |
| 45 | m | Manager Logistics Operations | Advanced |
| 42 | m | Information Specialist | Medium |
| 45 | m | Owner of Logistics Company | Advanced |
| 48 | m | Transport Planner | Advanced |
| 30 | f | Transport Consultant | Advanced |
| 45 | f | Marketing Specialist | Advanced |

**Table 2: Demographics of the participants in the in-depth interviews conducted by PTV.**

As the transport planning for a fleet is not a mass product, in-depth interviews were meant to indicate a direction to ask specific questions to a larger group.
To respect different aspects of work fields of the interviewees and to benefit of individual expert knowledge and expertise, interviews were topic oriented. Depending on the experts' knowledge, topics were discussed in detail or just briefly summarized.

Question fields:

- Obligatory question for background of interviewee to cluster the subject
- Important trends in transport logistics
- Important transport targets
- Targets and target ranking for tour planning
- Environmental activities for reducing carbon emissions
- Typical "Pros & Cons" of environmental protection

A rough script, indicating the question fields were drafted for the interviews beforehand the interview via email. Interviews were conducted on the phone, during business hours.

The following are the most prominent insights gained in the interviews:

- Transport activities differ largely.
- The number of employees of the companies transport branch can often give an insight to the geographical area of activities (local, regional, national, trans-national)
- Transport mass and driven km can be considered as an indicator for transport tasks (e.g. CEP, last mile, long-haul).
- Companies are aware of trends in transport logistics, anyhow the threshold for realization of specific trends is high.
- To establish a new process needs drivers; typically the more transport targets are being improved, the better the process will be accepted.
- Targets during the planning process and during transport execution correlate, but are not identical.
- The integration and restructuring of processes with respect to more ecological planning process consumes in many cases a lot of company resources. Companies tend to skip these actions, in case there is no additional value, e.g. quality improvement, cost reduction.

## 3.4 Questionnaires

Starting from the insights gained from the interviews conducted, described above, we created online questionnaires to broaden and validate our knowledge of user needs for potential eCOMPASS features. In this section, we detail the design of the questionnaires and perform a thorough evaluation of the results obtained. Again, we differentiate by application scenarios.

### 3.4.1 Private Vehicles & Smartphone Users

As an outcome of the in-depth interviews described in section 3.3.1, user needs of private vehicle drivers and smartphone users in the eCOMPASS realm circle around the following major themes:

- Users' eco-awareness and how this relates to making transport decisions: How much can we count on users consciously making eco-friendly choices?
- Daily relevance of a navigation application: How do navigation services need to improve to deliver a value that is appreciated by users on their daily commute?
- Routing alternatives, in particular the interplay of the information provided by a navigation application and users' desire to make their own decisions based on experience: How can we deliver more sensible routing options that enable users to fully benefit from the power of navigation applications?

- Traffic information, its richness, complexity, and reliability: How can we deliver traffic information in a most usable fashion, serving users' needs better than today?
- Advanced services like traffic load balancing schemes and driver coaching: How can we design such advanced systems to be accepted and valued by our users?
- Multi-modal transport: How can applications and services help users to make more eco-friendly transport choices than using their car?
- Tourist itinerary planner: Which features and characteristics does such an application need to be widely accepted and used?

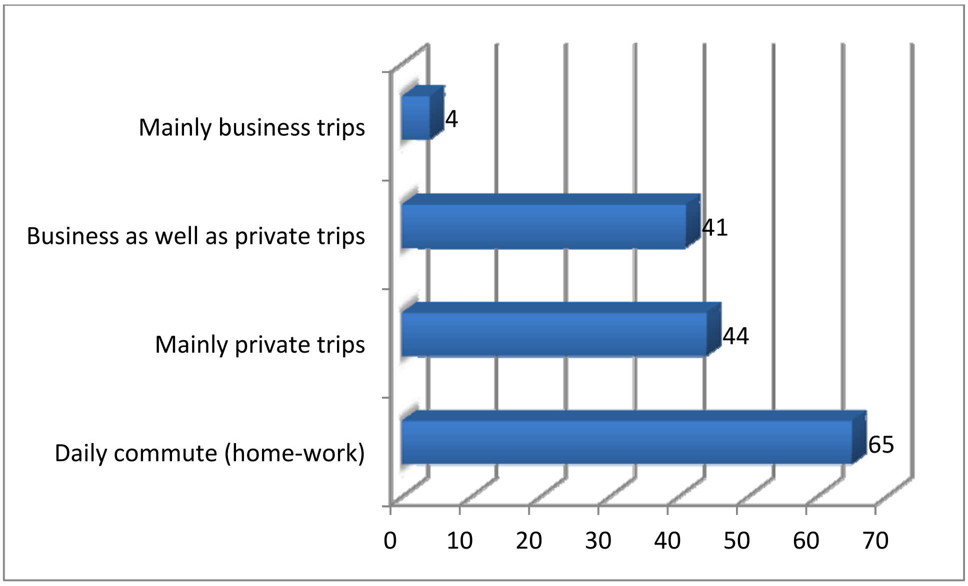
We designed an online questionnaire specifically to help answer these questions by understanding user needs in more detail; see section A.2 in the appendix for the full list of questions. Note that in the online version, there were numerous logical dependencies between the questions (e.g., only ask about driving when a candidate has a driver's license), which are not visible in the depicted print version.

In order to make our results more representative than the outcome of the interviews, we circulated the questionnaire to a total of 365 people, all subscribers to TomTom's voluntary UX research tester pool, and obtained answers from 169 participants. All but one had a driver's license, and 153 own a car.

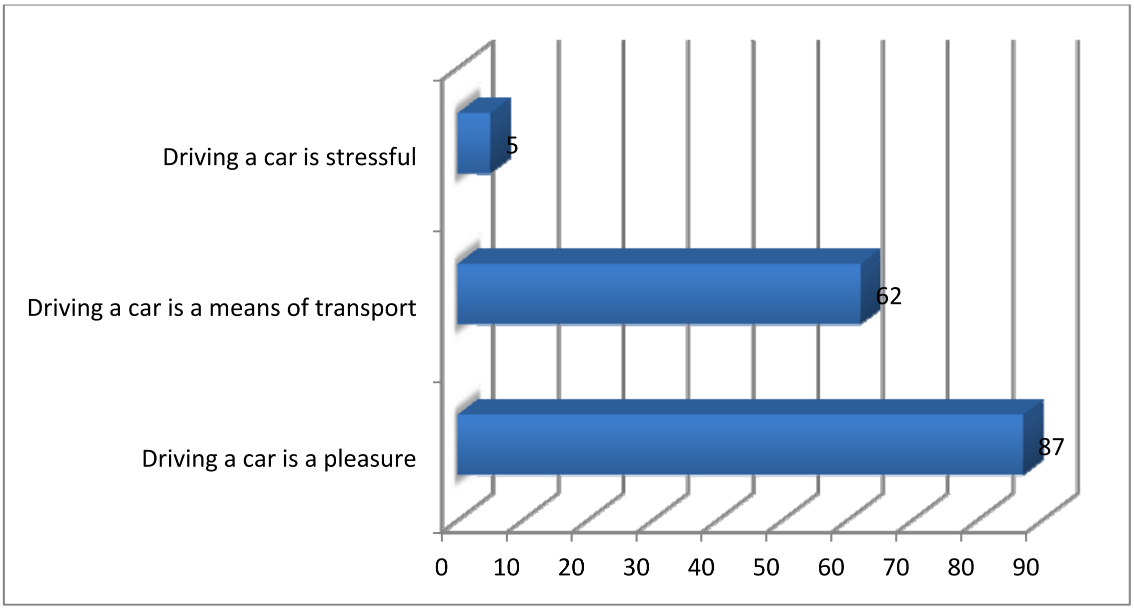
We proceed to present the survey's most relevant results, starting with an assessment of the participants' general disposition towards transport and eco-awareness.

**General Transportation Habits**

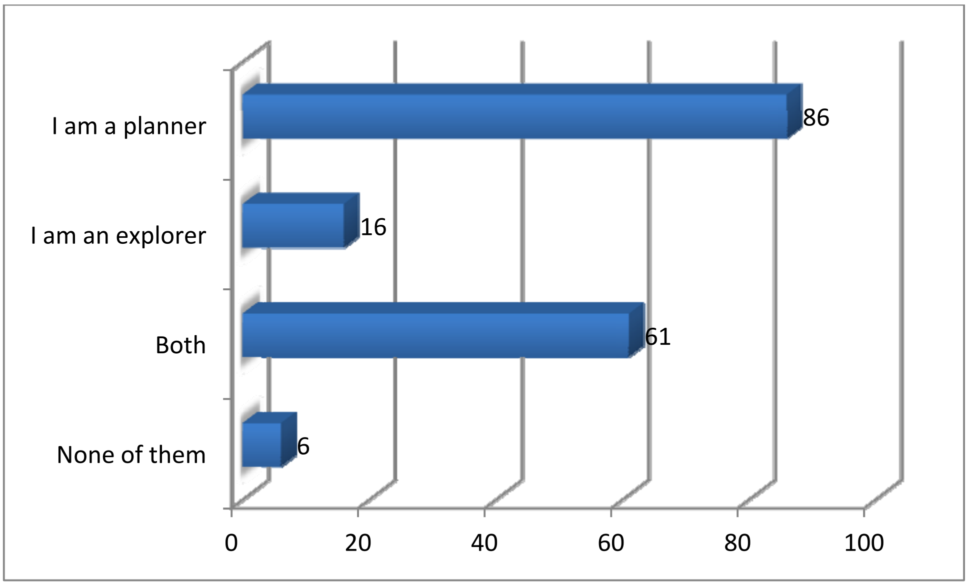
To have a better idea of who our participants are, we asked general questions on transportation and driving habits at the beginning of the survey.



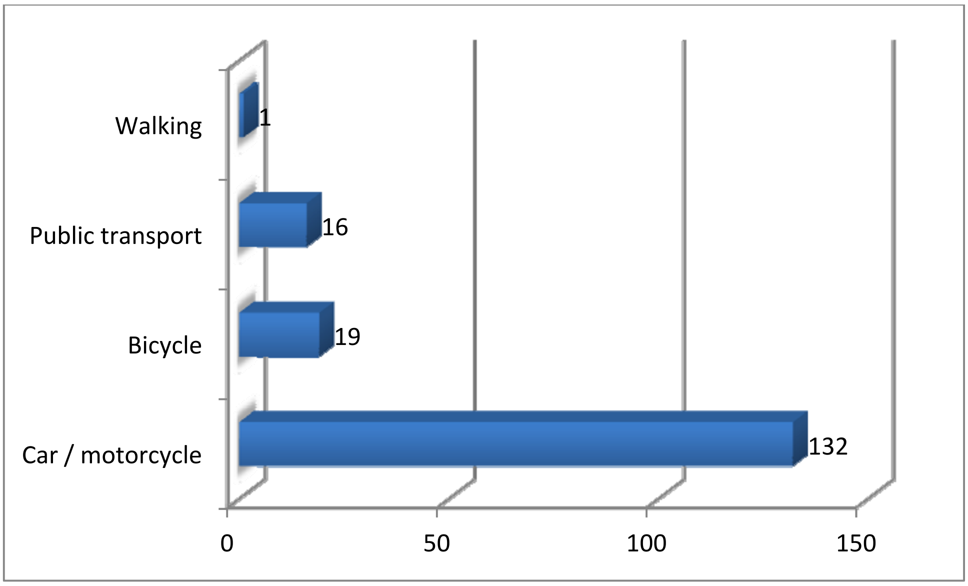

*For what reason do you mostly use your car (or other motorized vehicle)? N=154.*




*Which statement describes best how you think about driving a car? N=154.*




*How do you see yourself when you go for a long or short trip? N=169.*

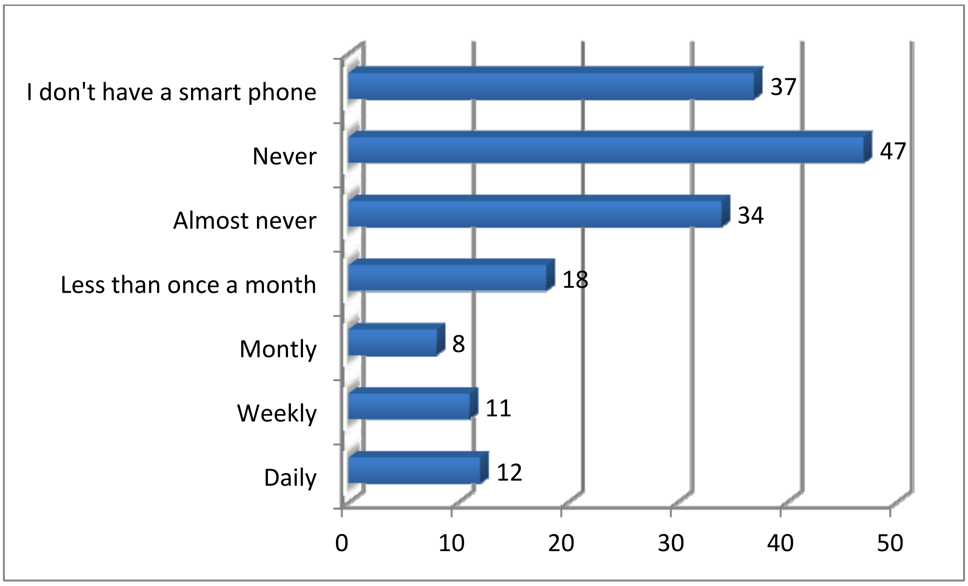



*What means of transport do you use most regularly? N=169.*

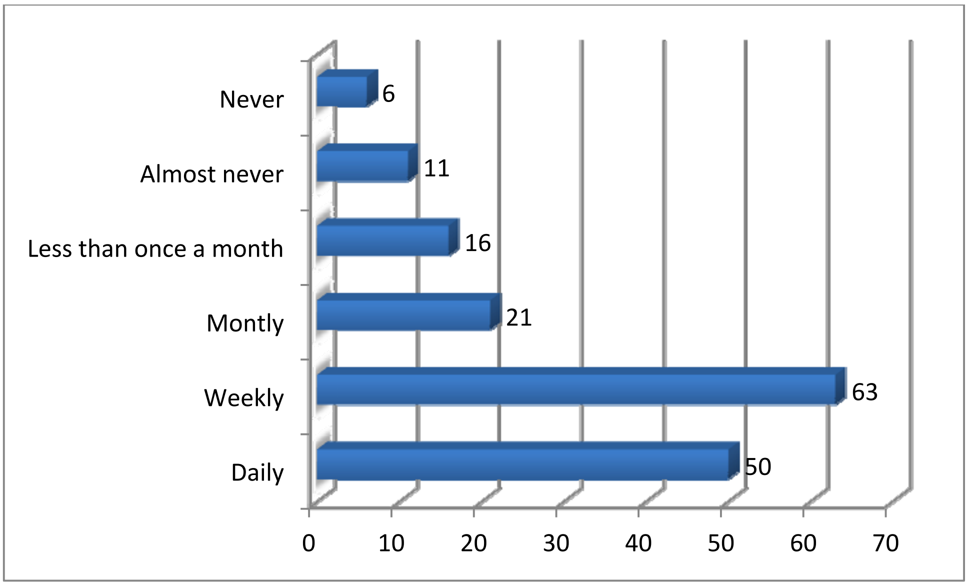
In summary, most of the participants of the questionnaire use their car mainly for their daily home-work commute. Moreover, most enjoy driving and use their car as their most regular means of transport. Finally, a majority of participants considers themselves a "planner" more than an "explorer", indicating that their focus is on efficiency when making short trips.

**Smartphone and PND Usage**

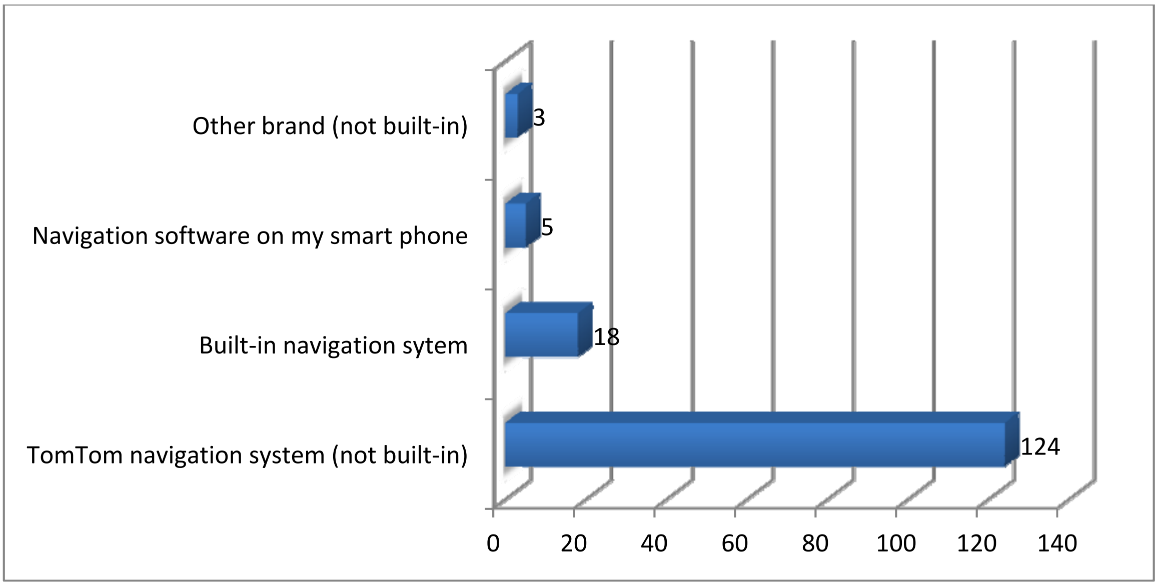
For the following questions, the thirteen participants that did not regularly have a car available were asked to imagine so.



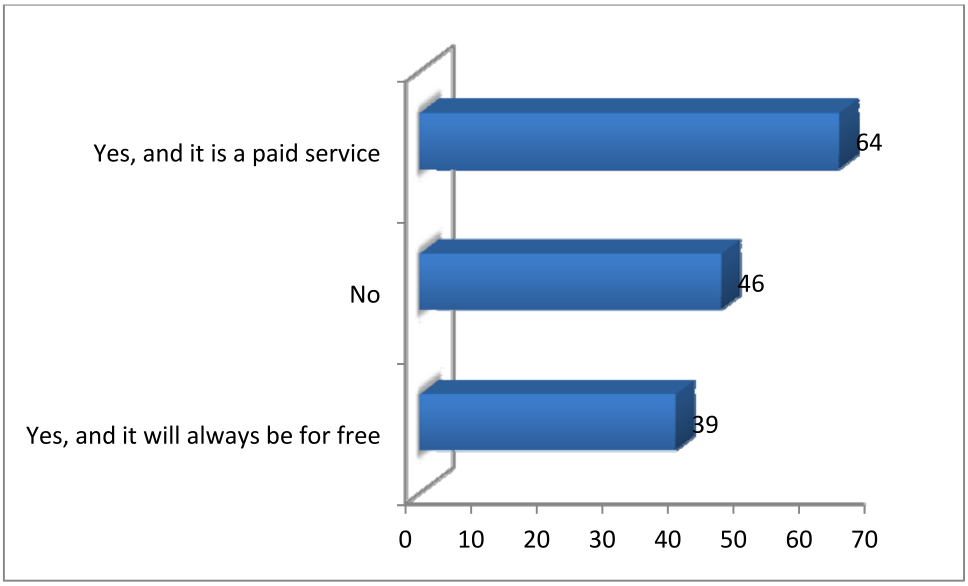

*How often do you currently use a smart phone in the car for navigation purposes? N=167.*



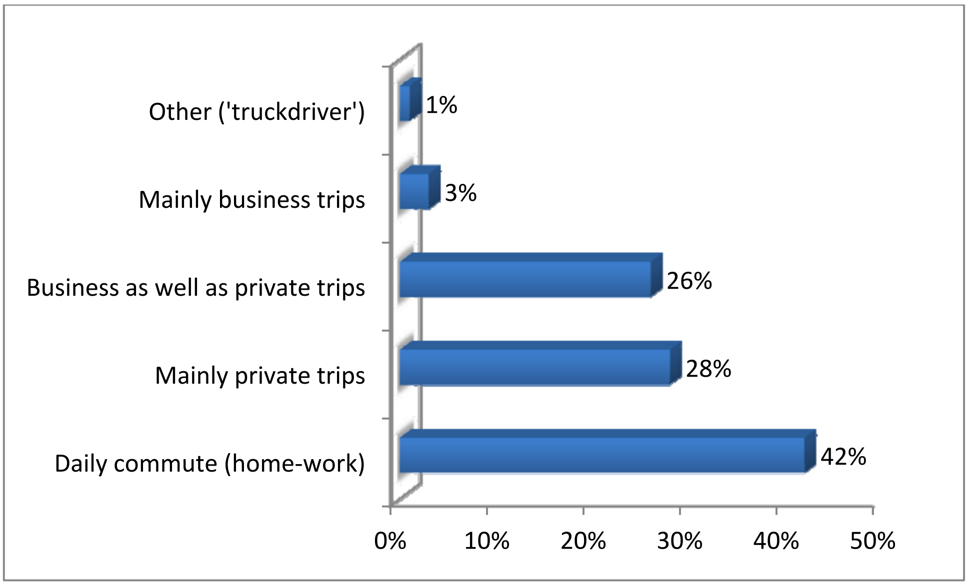

*How often do you currently use a navigation system (not a smart phone with navigation software)? N=167.*




*What kind of navigation system do you currently use most frequently? N=150.*




*Do you have traffic information on your navigation system? N=149.*

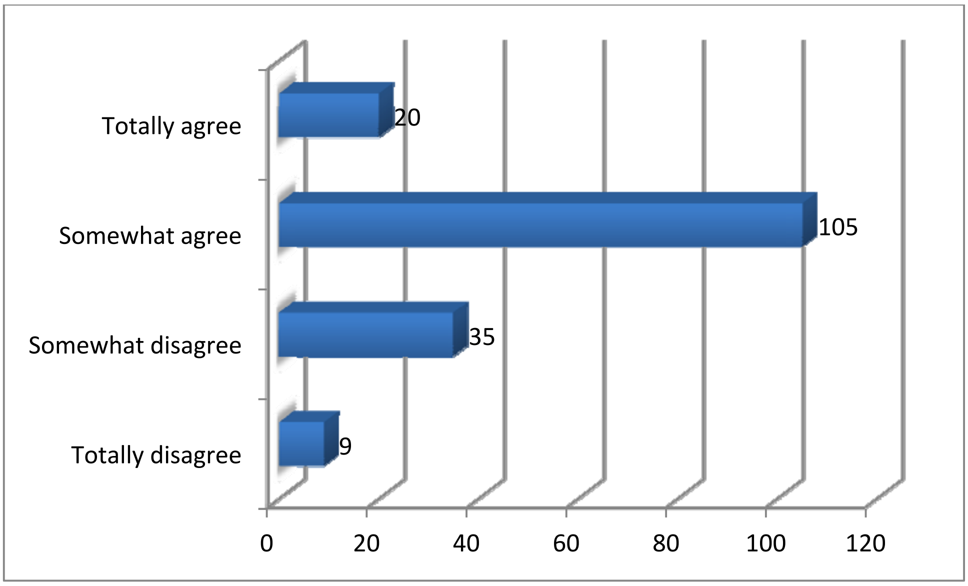



*Graph showing what kind of trip TomTom users (not built-in) make most regularly. N=118.*

Currently, 14% of the participants regularly use a smart phone for navigation, 75% use a TomTom device, and 69% have traffic service on their system. Moreover, for 42% of the users using a TomTom device, their daily commute is their most regular trip.

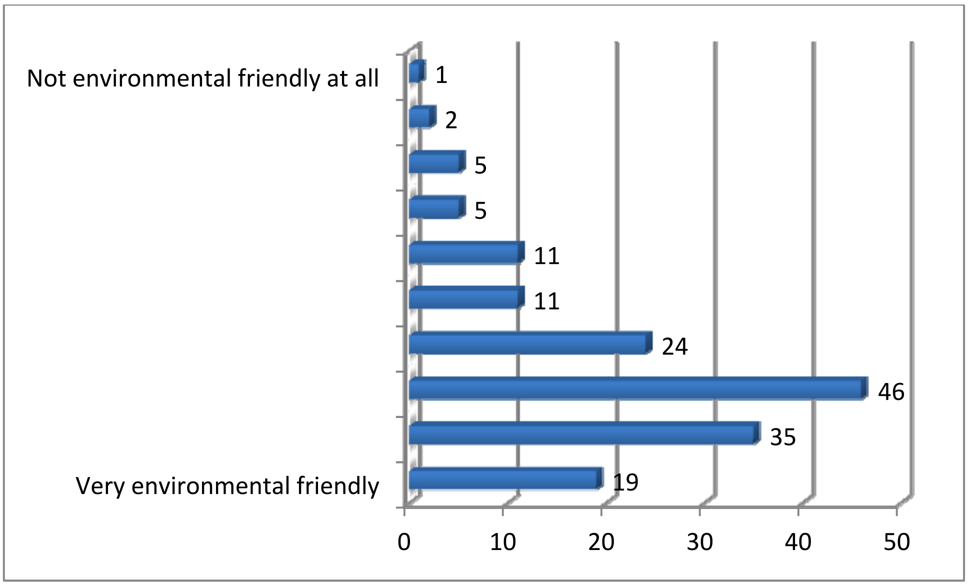
**Eco-Awareness**

Next, we were interested in knowing what our participants' stance on environment-friendliness was.

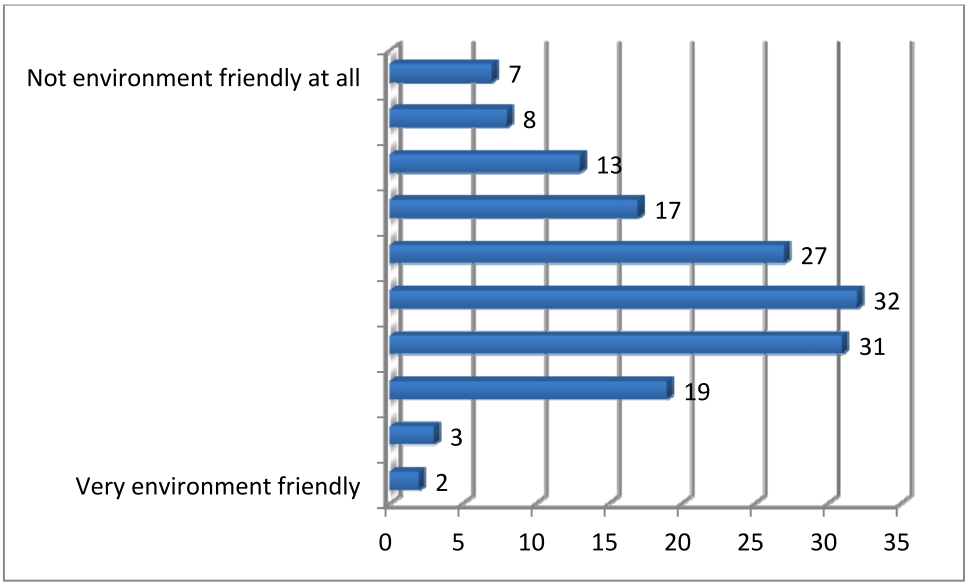



*I see myself as an environment-friendly, ecologically minded person. N=169, AVG = 1.80 (0=totally disagree; 3=totally agree; 1.5 = midpoint).*

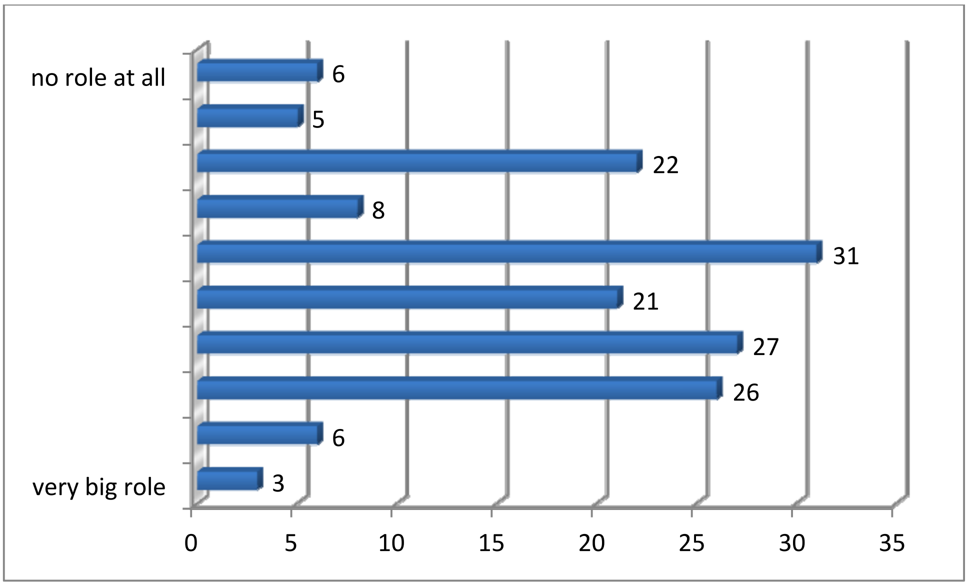
The following two questions were not shown to the nine participants who totally disagreed with being an ecologically minded person. The average values given do not take them into account.



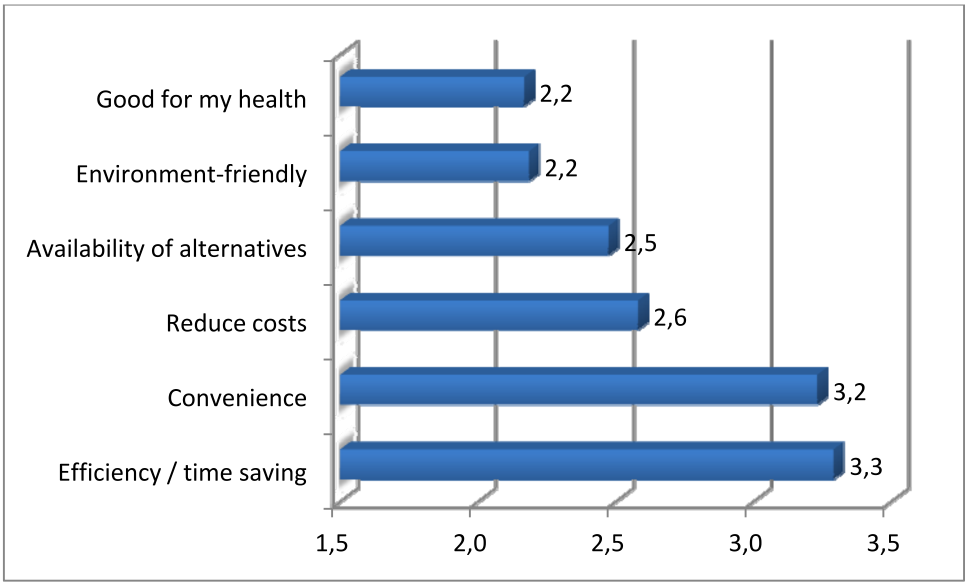

*To what extent are you environment-friendly with respect to your housekeeping (e.g. waste separation)? N=159, AVG = 6.56.*




*To what extend are you environment-friendly with respect to travel (e.g. not taking the car)? N=159, AVG = 4.49.*

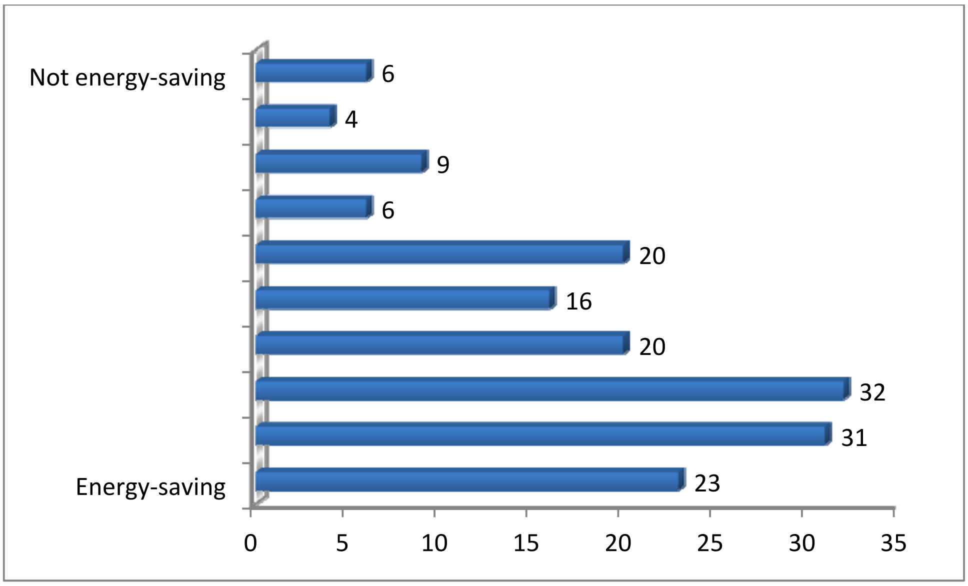



*To what extend does lowering CO2 emission play a role in your life in relation to car driving? N=155, AVG = 4.65 (0=minimum, 9=maximum, midpoint=4.5).*

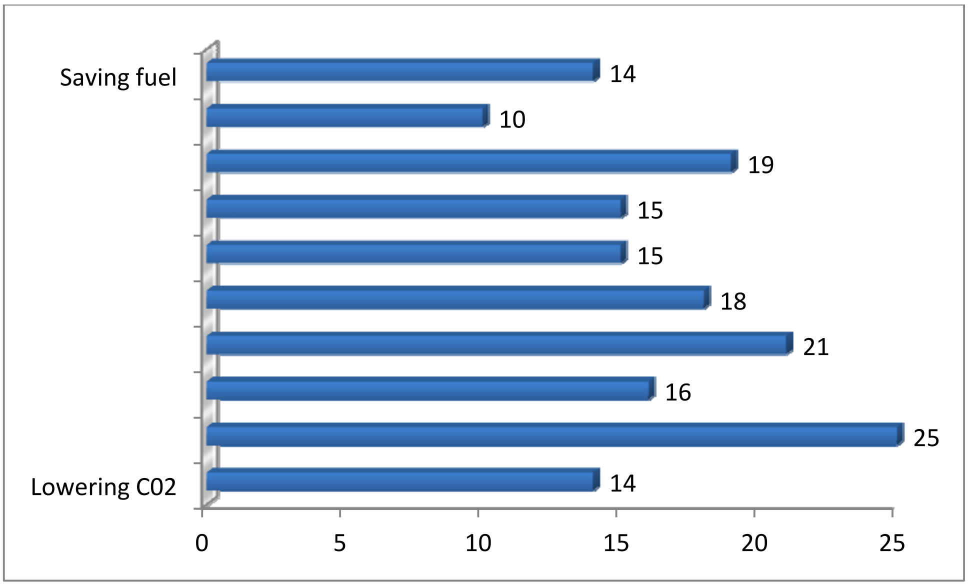



*To what extend is your choice of a transport mode determined by the following motives. N=165. Range: 0=unimportant – 4=very important.*

There is eco-awareness amongst users. When it comes to transport choices, however, users tend to be less willing to be environmental friendly compared to housekeeping. And although CO2 emissions do play a role in connection with car driving for most, the choice for transport means is least affected by environmental-friendliness.




*Suppose that you personally would have no cost for driving the car (petrol etc.). To what extent would you decide to drive an energy-saving car (e.g. an electrical vehicle) or not? N=167, AVG = 5.98 (4.5 = midpoint).*



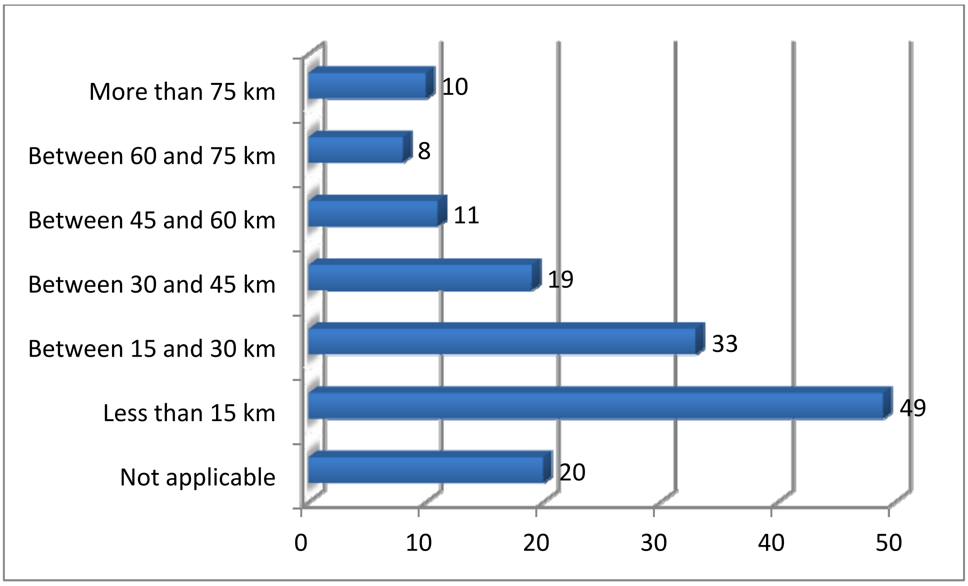

*If we were able to optimize your route economically, to what extent is saving fuel or lowering CO2 emission important to you? N=167; AVG = 4.83.*

Users do realize that saving fuel and reducing CO2 emissions go hand-in-hand. When asked for a choice, there is a very slight preference for reducing emissions over saving fuel as a motive for choosing economical routes.

**Daily Commute**

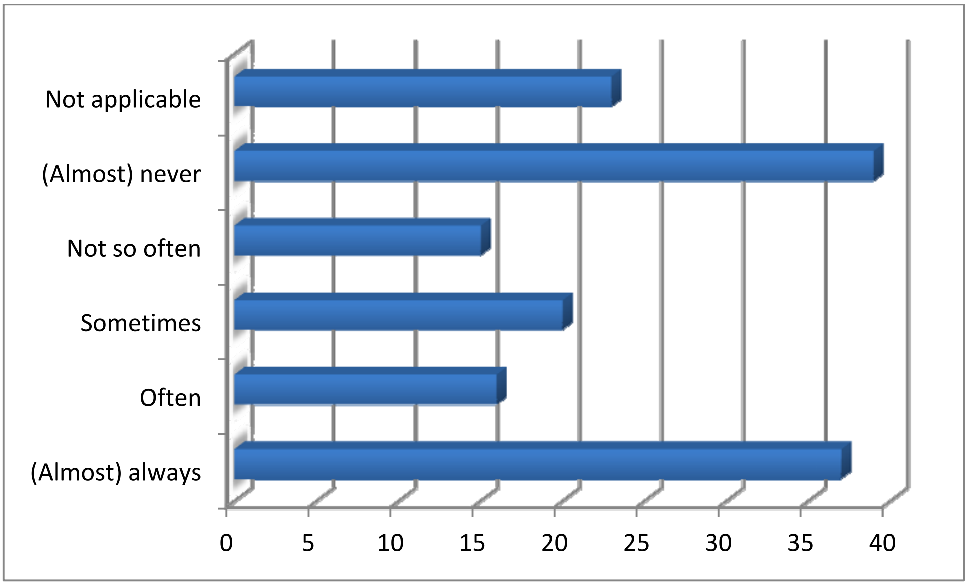
In this section, we focus on users' behavior specifically on their daily commute. Since eCOMPASS targets urban areas, and commuting accounts for a large share of the transportation needs of urban residents, user needs here are particularly relevant.

This first question was not shown to the seventeen participants who stated that they never or almost never use a PND.



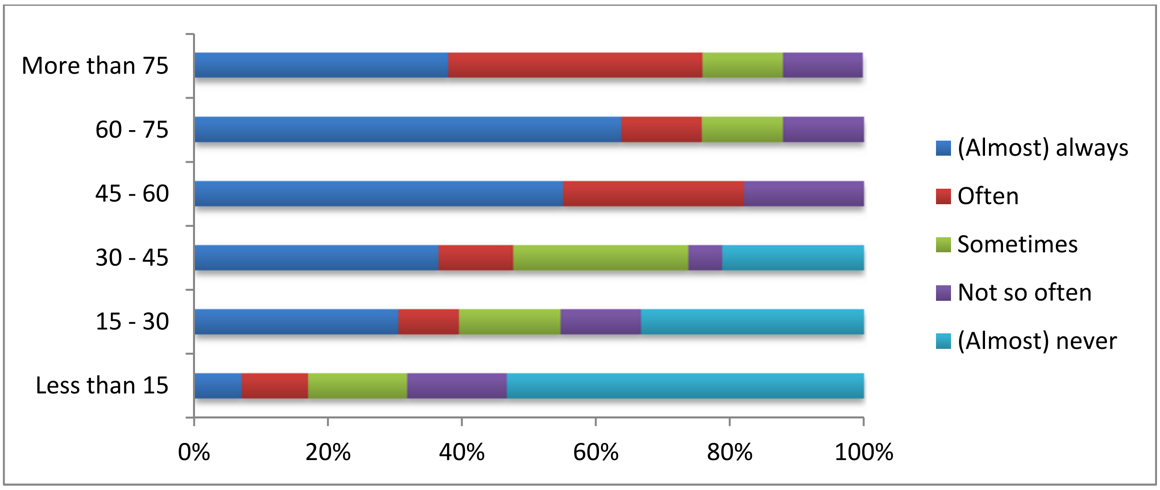

*What is the distance between your home and work location? N=150, AVG = ± 22 kilometers (more than 75 km = 75 km).*

For the majority of users, their home-work route is less than fifteen kilometers.




*How often do you use a navigation system on your home-work route? N=150, AVG = 1.98, Minimum=0 (almost never), Max=4 (almost always), midpoint= 2.*

Regarding the usage of a navigation system on their commute, users appear to be divided: Most users use it either almost always, or almost never.

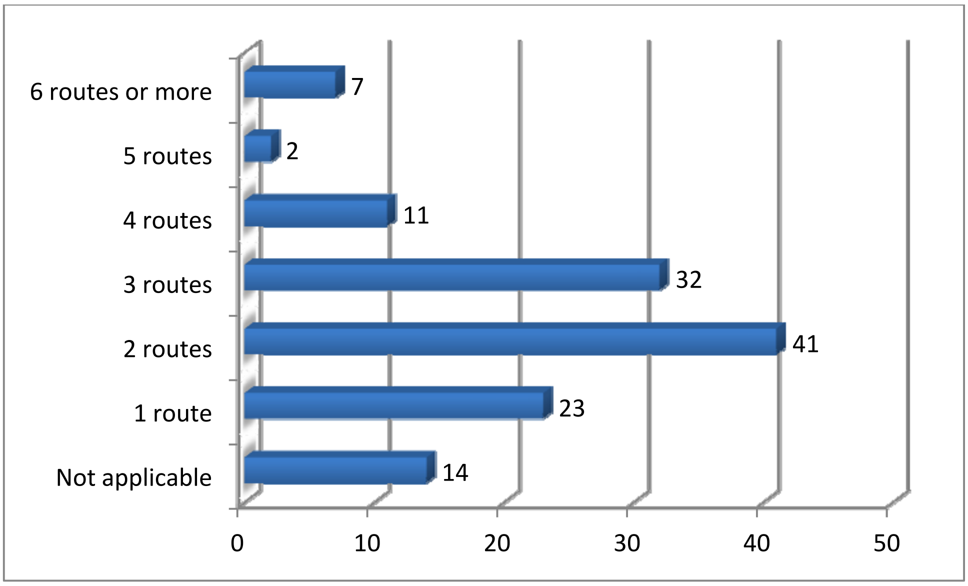



*Percentage of people (x-axis) that have a PND switched on on their home-work route more or less often as a function of the length of their home-work route (y-axis). From top (more than 75) to bottom (less than 15), n= 8, 8, 11, 19, 33, 41.*

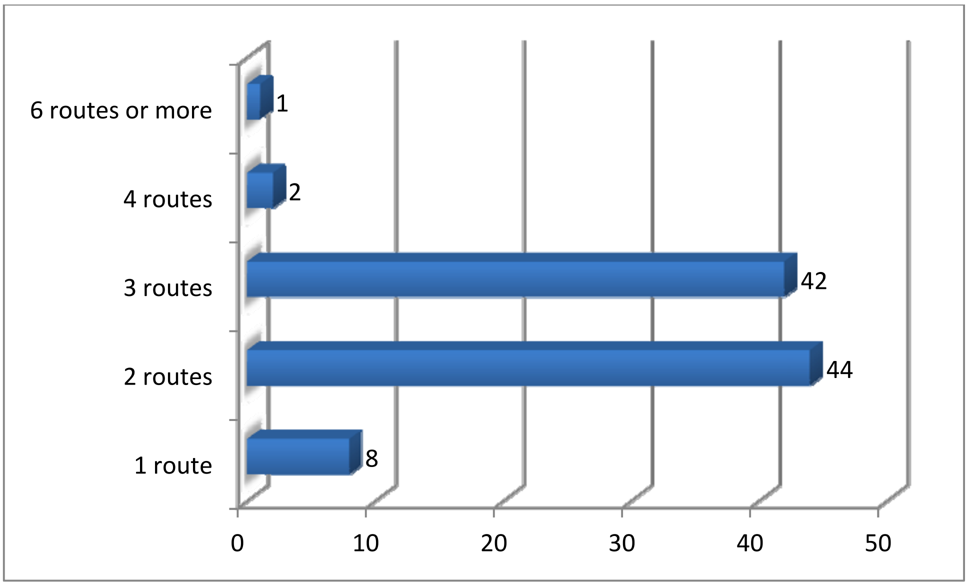
There seems to be a clear connection between the length of a user's commute, and his tendency to use a navigation system for it. The longer their home-work route, the more users turn on their PND for it.

**Alternative Routes and Route Choice**

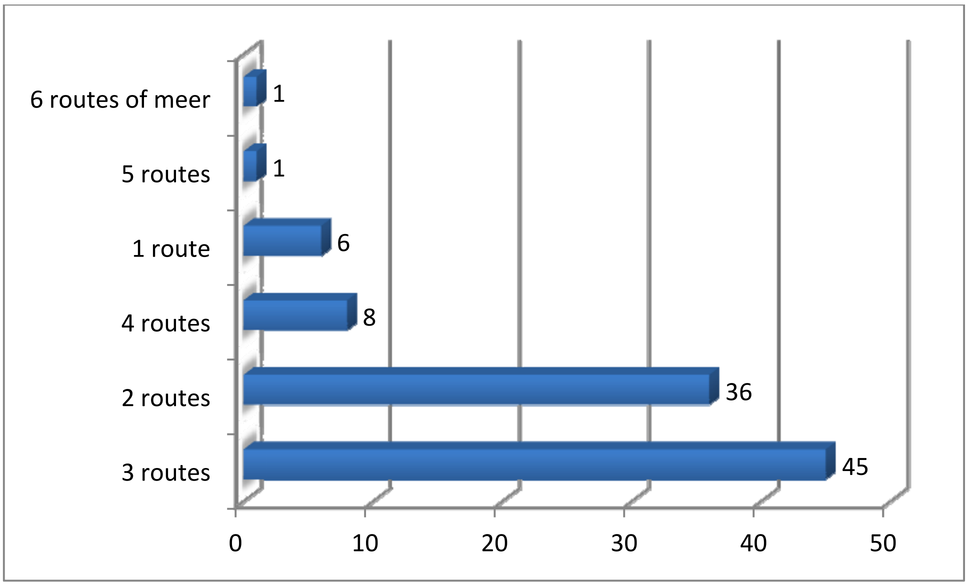
Next, we are focusing on how users deal with alternative routes, and how they currently make route choices. Where appropriate, we make a distinction between home-work routes and longer trips.



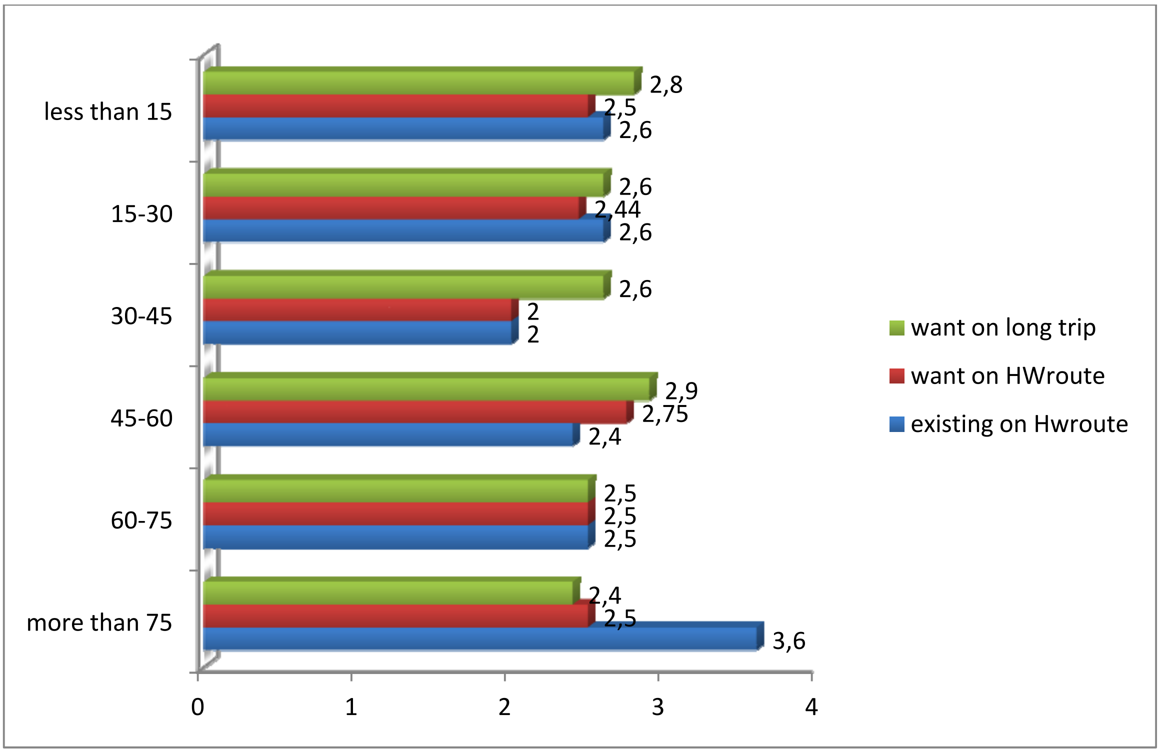

*How many useful alternative routes for the car do you have on your home-work route? N=130, AVG = 2.56 routes (6 routes or more = 6 routes).*




*Regarding your homework route, how many alternative routes would you like to compare on your navigation system in one overview, before you leave? N=97, AVG = 2.43.*



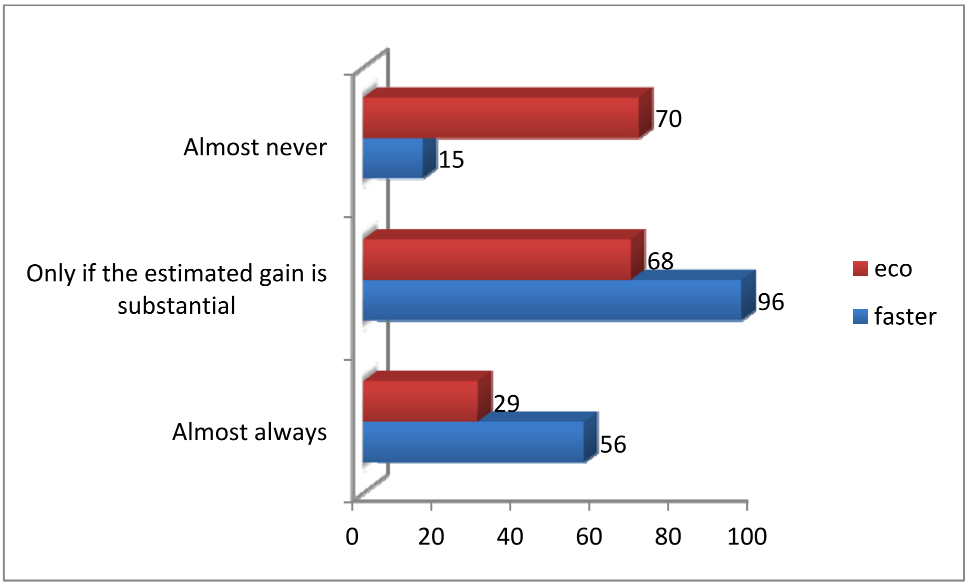

*With respect to a trip of say 1.5 hours, how many alternative routes would you like to compare on your navigation screen in one overview, before you leave? N=97, AVG = 2.64.*



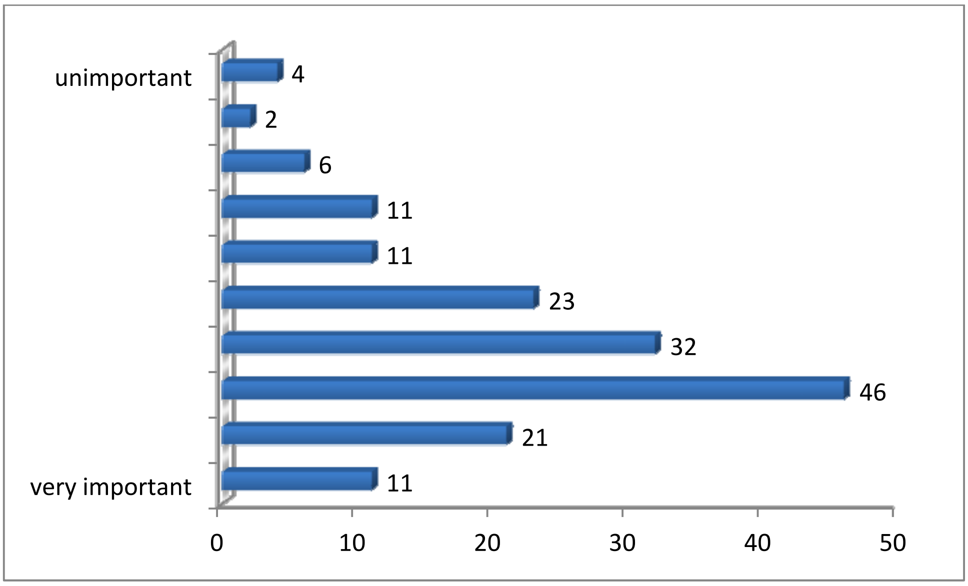

*Average number of alternative routes (x-axis), per home-work distance (y-axis), existing on homework route, wanted on homework route, and wanted for a long trip.*

On their home-work route, users think on average that there are 2.56 useful alternatives. Quite interestingly, this number does not seem to be too tightly related to home-work distance, except for very long distances, where more alternatives are thought to exist. Most users feel they have two useful alternatives on their home-work route. Correspondingly, most users would like to compare two alternatives in one overview before they leave on these routes. On longer routes, the number of desired alternatives to compare increases to three.

For the following questions, all participants were asked to imagine that they used a navigation system with high definition traffic information.




*When do you tend to deviate from a route you know well if there is a faster alternative available? When do you tend to deviate from a route you know well if there is a more environment-friendly alternative available? N=167.*

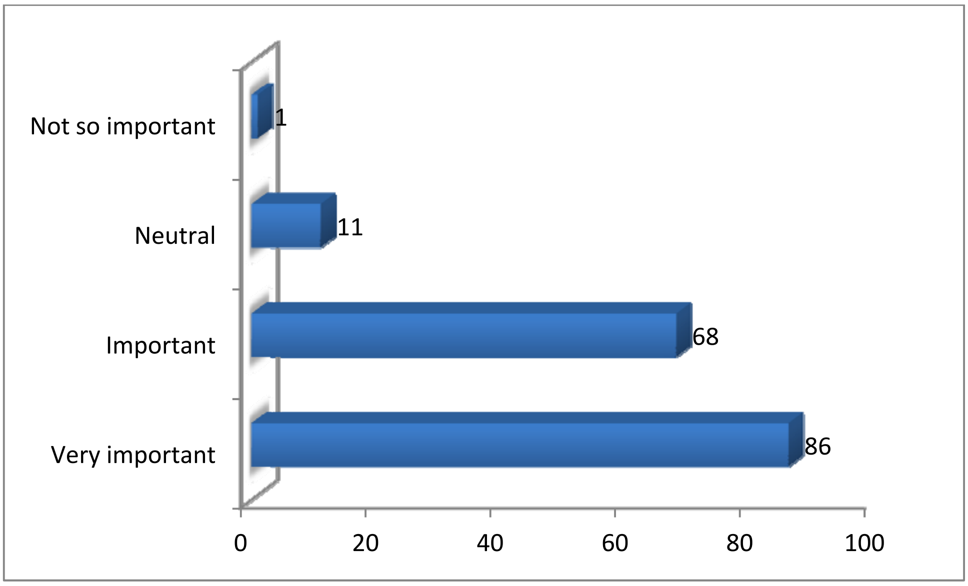



*To what extend is it important to know what this faster (or more environment-friendly) alternative entails (e.g. taking bigger or smaller roads, a detour)? N=167, AVG = 5.91 (midpoint = 4.5).*

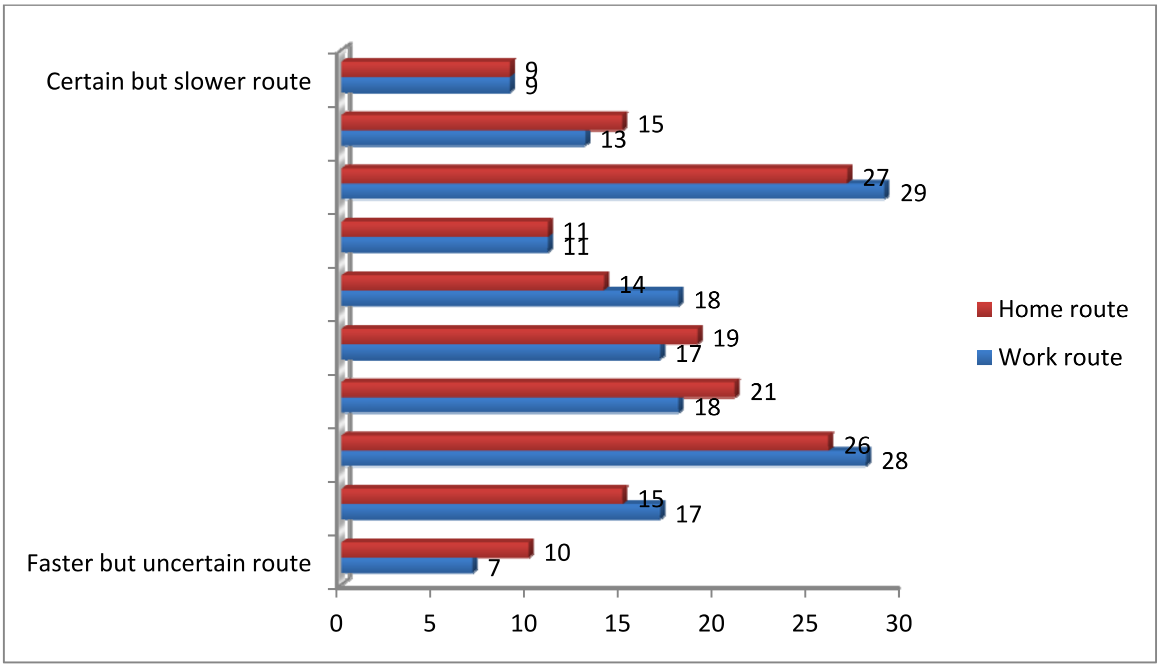
Users tend to deviate more often from a route if it is faster, compared to more eco-friendly. Also, users think it is important to know the characteristics of the alternative route. Comments indicated that they have concerns about the reliability/benefits of the alternative (time, smoothness etc.), to what extent an alternative is truly more environment-friendly, and also that their decisions depend on the goal of their journey.

**Robust Routes and Reliability of Traffic Information**

Next, we asked users about robustness of route suggestions and quality and timeliness of traffic information.




*Imagine you have traffic information on your navigation system. How important would you think it is to know that it is, say, 80% sure that that the jam further ahead is as long as it is now once you get there? N=166, AVG = 3.44 (midpoint is 2)*



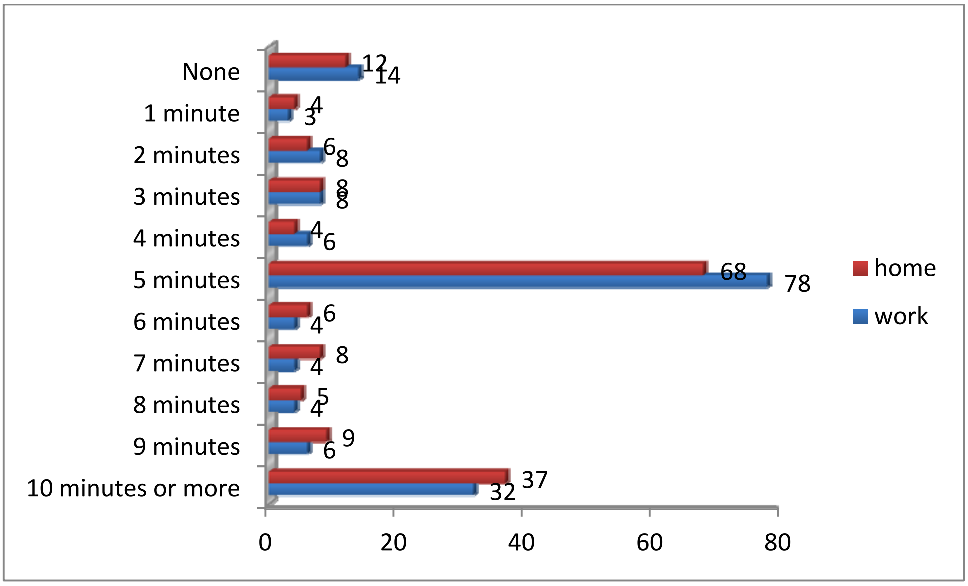

*If it is busy and you* ***go to your work*** *by car, to what extend would you choose a slower route (say 5 minutes longer) with a certain arrival time, or a faster route with a less certain arrival time? N=167, AVG = 4.57. If it is busy and you* ***go home*** *by car, to what extend would you choose a slower route (say 5 minutes longer) with a certain arrival time, or a faster route with a less certain arrival time? N=167, AVG = 4.62.*

A great majority of users (92%) think it is (very) important to have information regarding the robustness of a route. There is also clear indication that providing routes with a more certain (but later) ETA might be a successful feature, as there are roughly the same numbers of users that want a certain/slower route as compared to a faster/uncertain route. The difference w.r.t. whether users are going home or to work is negligible.

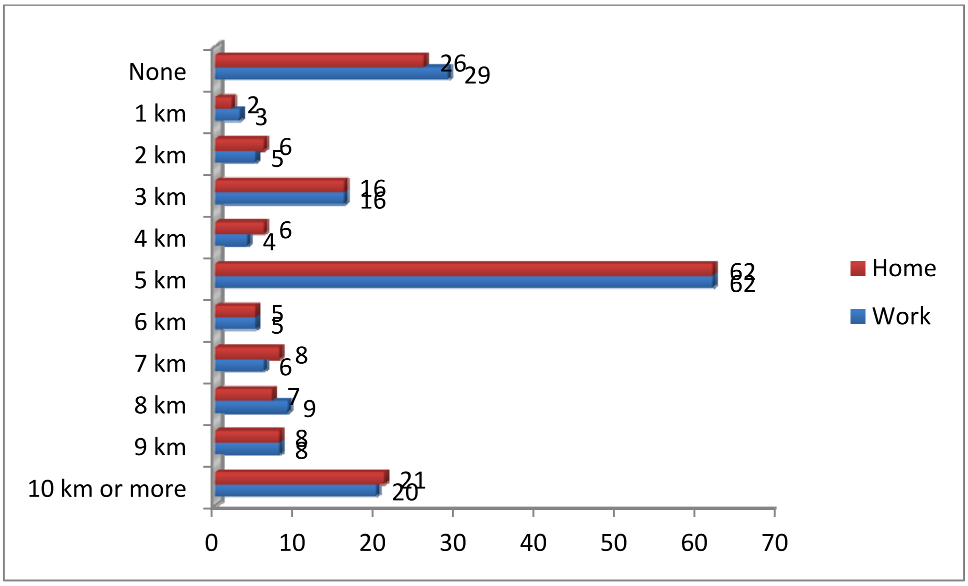
**Traffic Load-Balancing**

Before asking the following questions, we explained to participants:

For the overall traffic flow, it might be better if some people take a route that is somewhat longer or slower. Eventually, on average, everybody (including you) can profit from this. Imagine a trip of 75 kilometers that takes 1 hour...

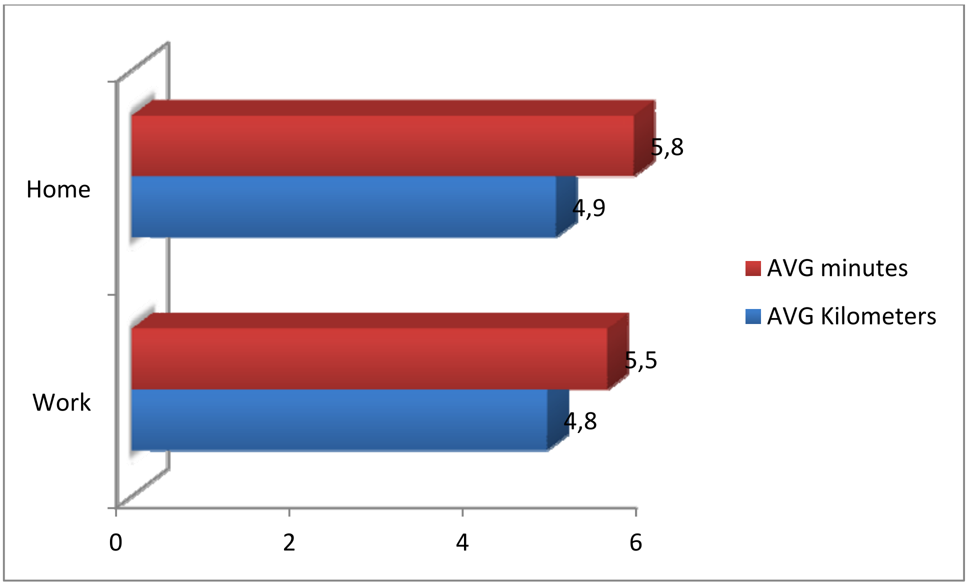



*How many minutes additional travel time would you be prepared to accept in order to reduce congestion for all, if you are on your **way to work**? N=167. AVG see graph.*
*And if you are on your **way home**? How many minutes additional travel time would you be prepared to accept in order to reduce congestion for all?*
*N=167.*




*How many extra kilometers would you be prepared to accept, on top of the 75 kilometers, in order to reduce congestion for all, if you are on your **way to work**?*

*And if you are on your **way home**? How many extra kilometers would you then be prepared to accept, on top of the 75 kilometers, in order to reduce congestion for all?*
*N=167.*

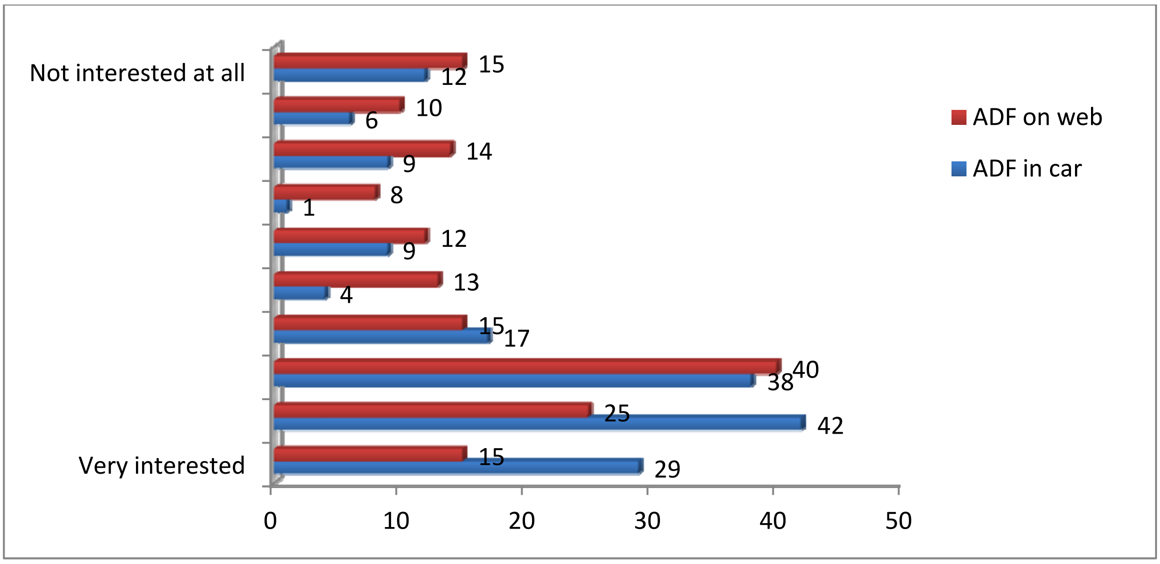



*Traffic Load Balancing: The average number of minutes / kilometers that participants are prepared to accept to reduce congestion for all, based on the above questions. N=167.*

Users do seem to be willing to accept a longer trip sometimes, if that reduces congestion for all on average. Quite a large group even seems to accept that the detour incurred at times can be quite long (more than 10 km or minutes). An interesting aspect is that ± twice as many users will not accept additional kilometers as compared to additional minutes. There are also many more users who would accept an additional 10 minutes or more as compared to 10 kilometers or more. This suggests that more willing to spend extra time than extra fuel to reduce congestion for all.

**Driver Coaching**

We also asked users about their interest in driver coaching through advanced driver feedback features.



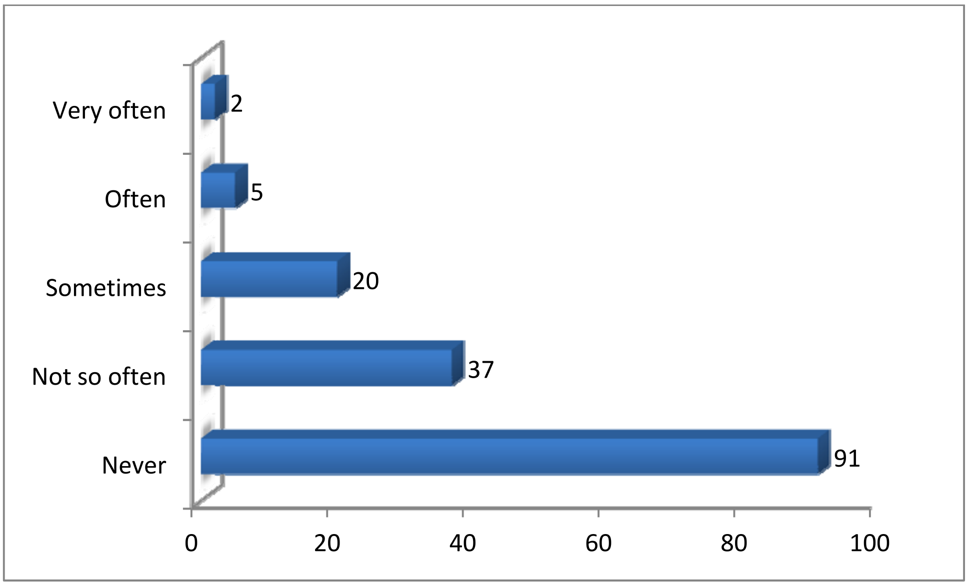

ADF = Active Driver Feedback.

*To what extent would you be interested to know 'live', while you drive your car, how much fuel your car is using, so you can try to reduce fuel consumption? AVG = 6.28. To what extent would you be interested to read afterwards, on a personal website, how much fuel you used on what part of your route, so you can try to reduce fuel consumption? AVG = 5.27.*
*N=167.*

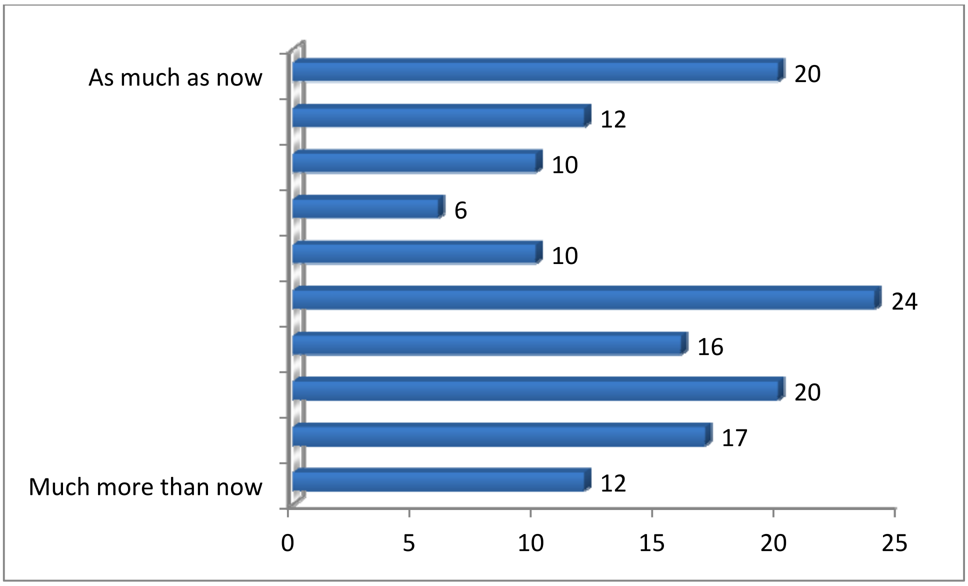
Quite interestingly, feedback about fuel consumption is the highest scoring potential eCOMPASS feature in this research. Direct feedback (in-car) is preferred above indirect feedback via a website. However, users might not be aware that feedback via a website could be much richer in content.

**Multi-Modal Route Planning**

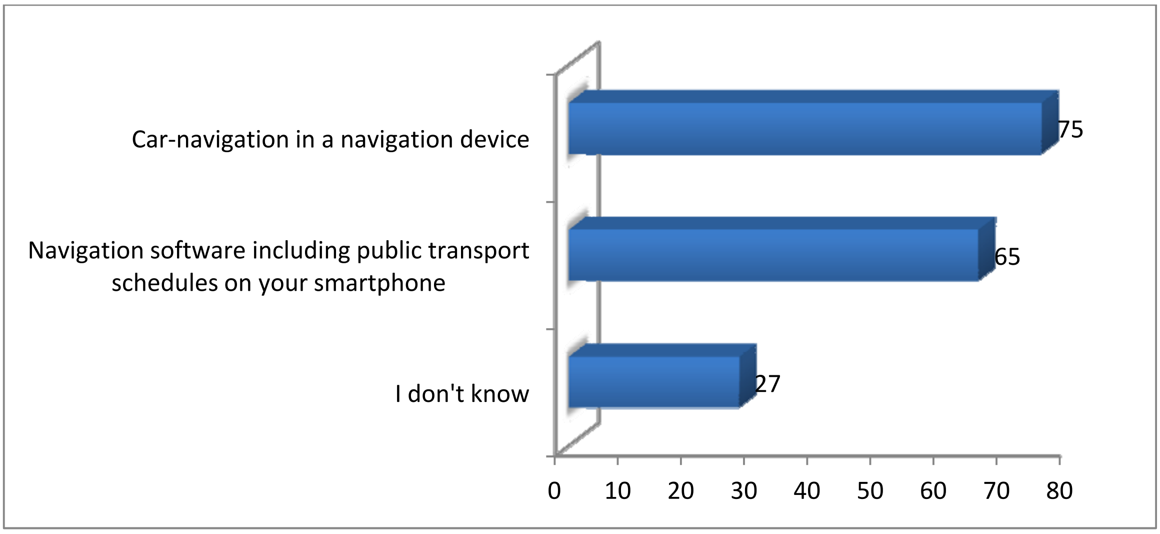
In this section, we queried participants about their preferences regarding public transportation and park & ride.




*Do you ever make use of Park and Ride (P+R), i.e. you park your car near a public transport station in order to continue your trip by public transport? N=155.*

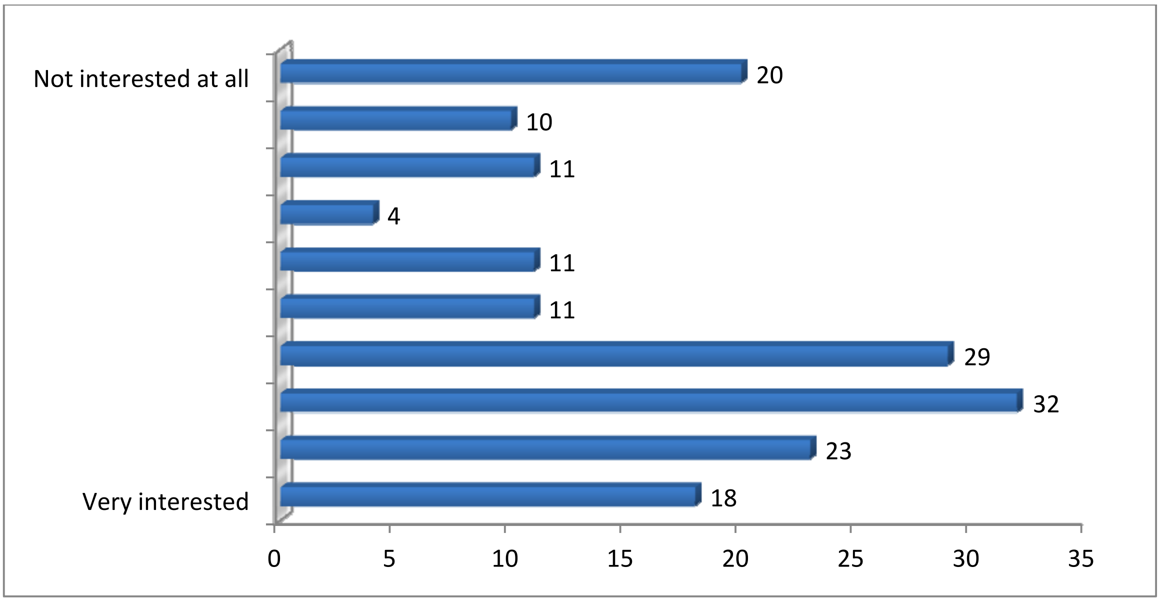



*To what extent would you (more often) use Park & Ride if you would have a navigation app for the car where public transport schedules are included? N=147, AVG = 4.69.*




*If you would have to choose between merely car-navigation in a navigation system (e.g. a TomTom device), or navigation software for your smart phone where public transport schedules are included, what would you choose? N=167.*

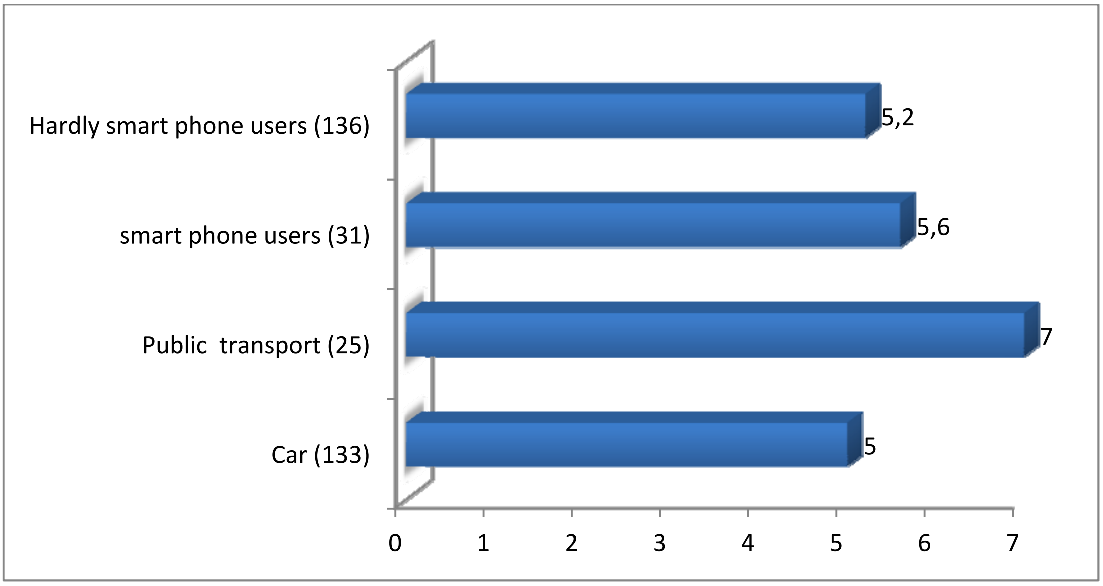
Not many users use park & ride. Making more information (schedules) available effortlessly might help some, but comments indicated that certain limitations cannot be bridged (e.g. kids on board, bad public transport). A majority of users prefer to use a navigation device over smart phone navigation with public transport schedules.




*To what extend would you be interested to use an application (app) with which you can plan and compare routes using different transportation modes (public transport, bicycle, car, etc.)? N=169, AVG = 5.25 (midpoint = 4.5).*

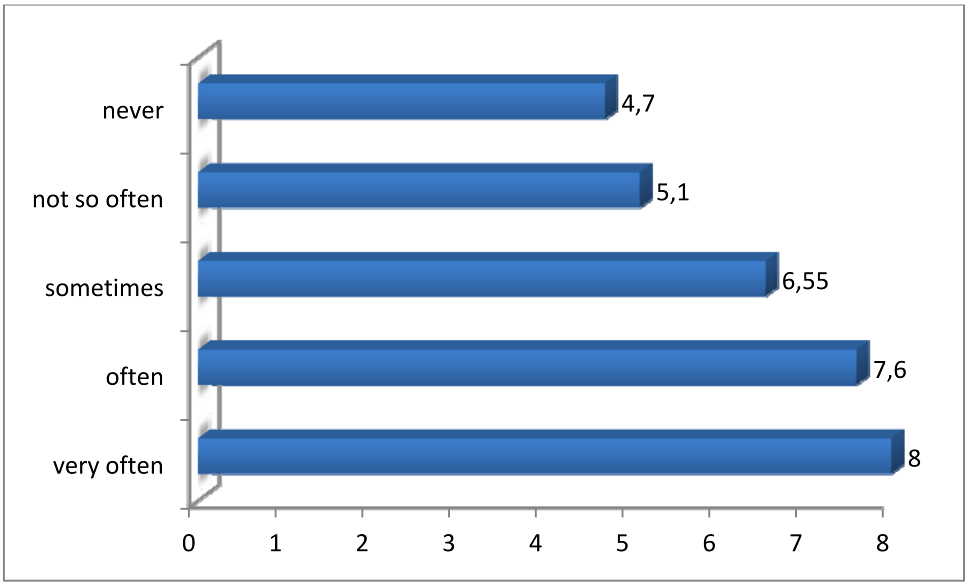
For the above question, we also look at result where participants are split into groups to see if there is difference in appreciation of this app:

- car users (N=133) versus public transport user/bike/walk (N=25)
- smart phone users (at least monthly, N=31) versus hardly smart phone users (N=136)




*To what extend would you be interested to use an application (app) with which you can plan and compare routes using different transportation modes (public transport, bicycle, car, etc.)? Midpoint = 4.5.*

Finally, we look at results grouped by whether participants already use park & ride.

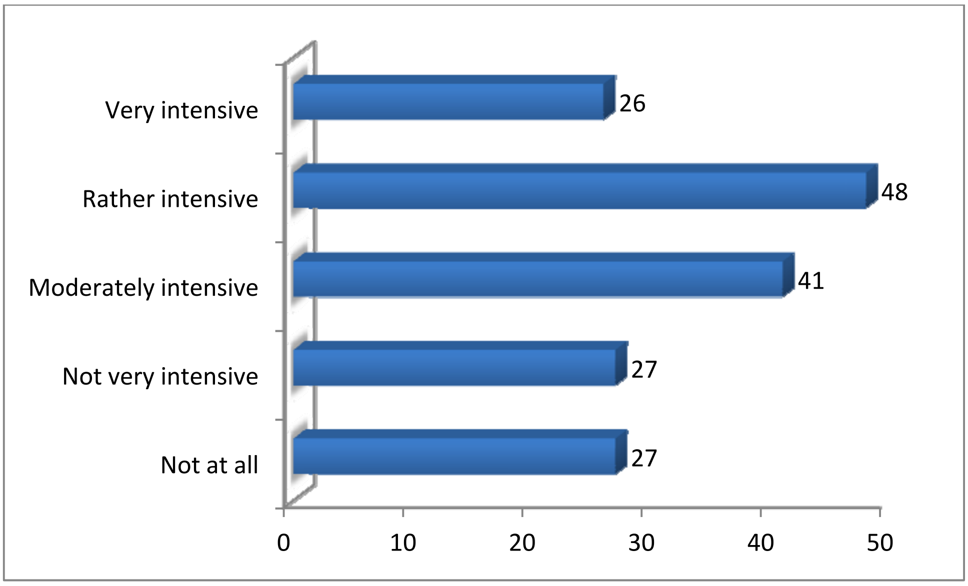



*To what extend P+R users (never – very often) would be interested to use an application (app) with which you can plan and compare routes using different transportation modes (public transport, bicycle, car, etc.)?*

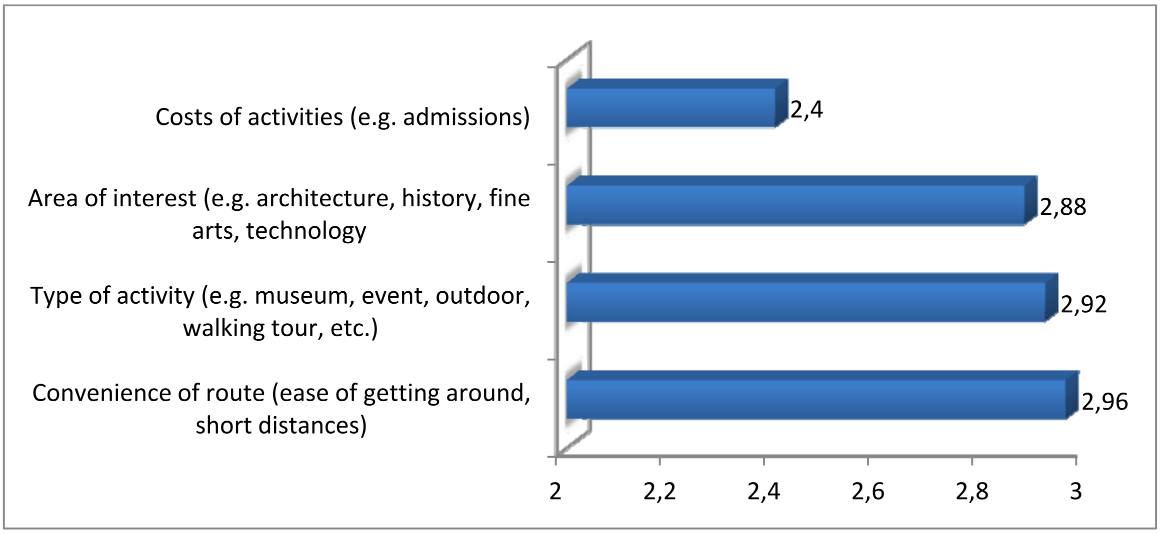
Generally, there is interest in an app that compares different means of transport. According to comments, some users already conduct such comparisons using different apps in parallel. Having a dedicated app to do it would make their life easier.
Users that do not rely on a car as most important means of transport seem to appreciate this app more than car-users. As in the interviews, there is an indication that this app is especially interesting for people that already use public transport now and then.

**Features for Tourists**

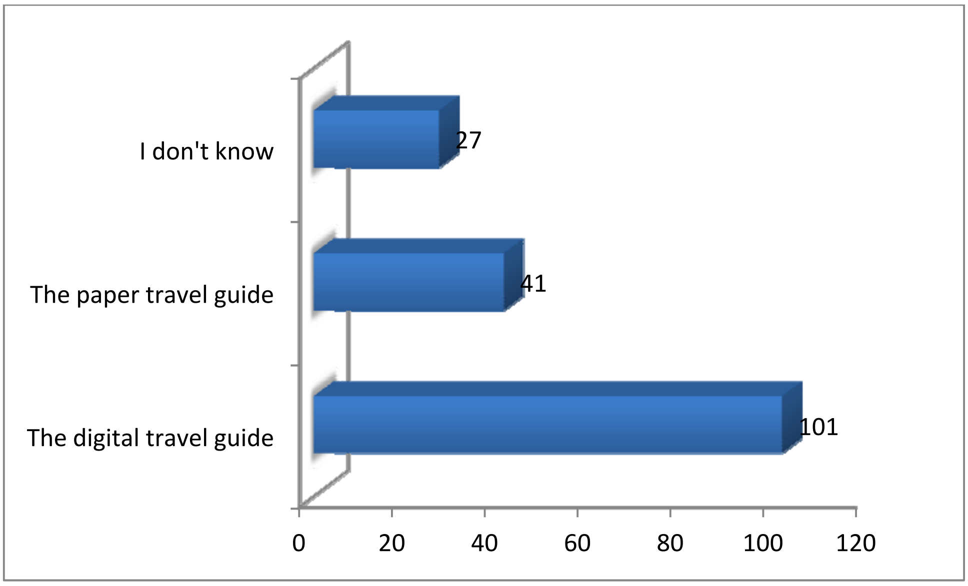
Finally we asked participants about using a smartphone on vacation and their stance towards a tourist itinerary planner.




*If you are on vacation in a new city, and assuming that roaming (data) cost is not at stake, how intensively do (or would) you use your smart phone to inform yourself about your holiday location? N=169, AVG = 2.11 (midpoint = 2; not at all = 0, very intensive = 4).*




*Imagine you want to explore an unknown city as a tourist and want to visit several locations. How important are the following? N=168.*




*If you could choose between a traditional paper travel guide and a digital version on your smart phone that includes up-to-date information, which one would you choose? N=169.*

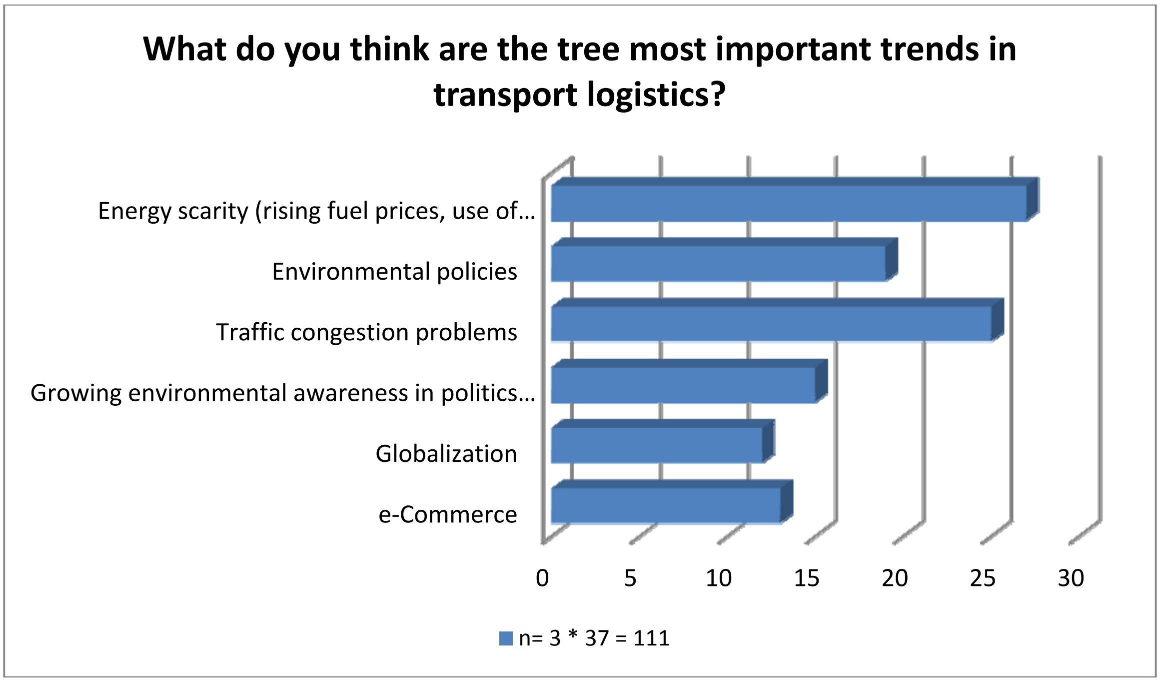
Most participants do use their smartphone when on vacation. When planning itineraries, they do so more by their area of interest and preferred type of activity than by cost. However, the convenience of the itinerary plays a major role. Most users prefer a digital travel guide on their smartphone over a traditional paper travel guide.

### 3.4.2 Vehicle Fleets

As already explained in 3.3.2 there is only a limited circle of people with the necessary background knowledge to answer questions relating to ecological issues in transport companies. In order to get a broader variety of answers we developed an online questionnaire (accessible under https://app.lamapoll.de/ECompass/), and asked customers of transport planning software to participate. The questionnaire was circulated to 127 contacts and we obtained answers from 37 participants.

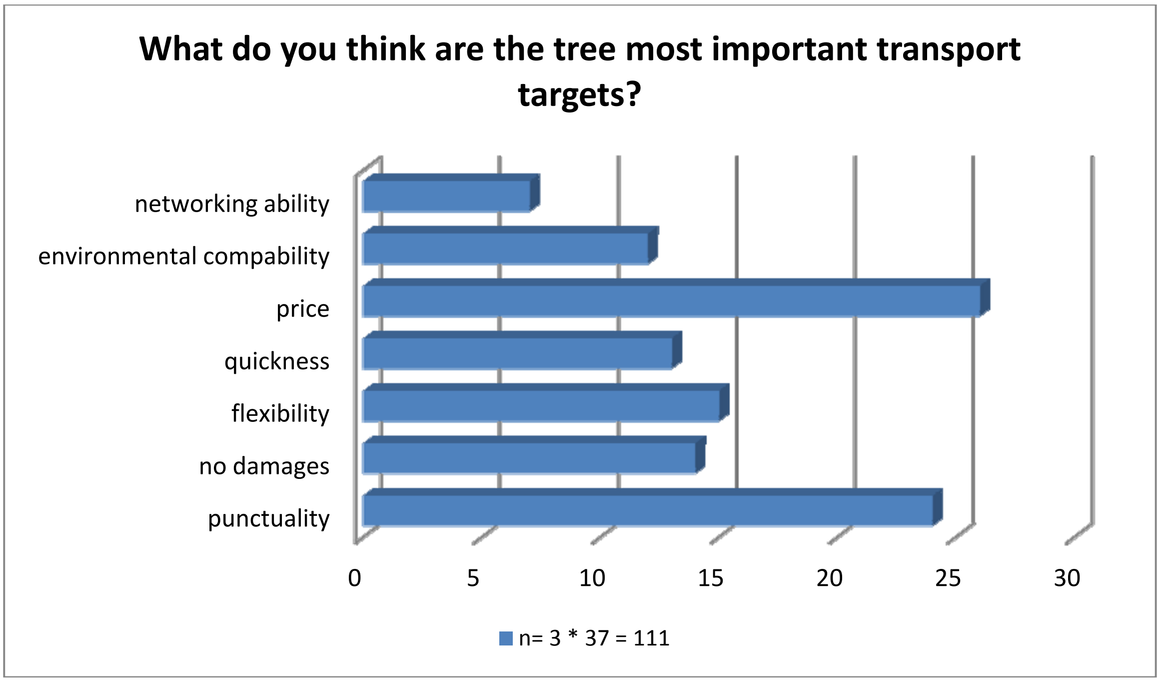
The main goal of the questionnaire was to assess whether and to what extent logistics companies today are pursuing ecological objectives.
Furthermore we wanted to validate the answers received in the telephone interviews

- Are the companies claiming to pursue environmental protection?
- What are the companies really doing in order to reduce their environmental footprint?
- How important is environmental protection compared to other logistic objectives.
- To what extent emissions are assessed when the tour is assessed in a post trip analysis?
- Are there companies where emissions are already influencing the routes in pre-trip tour planning?
- Which potential do they see for the transport sector in terms of reducing the environmental footprint?
- What are their reasons for or against investing in environmental protection?



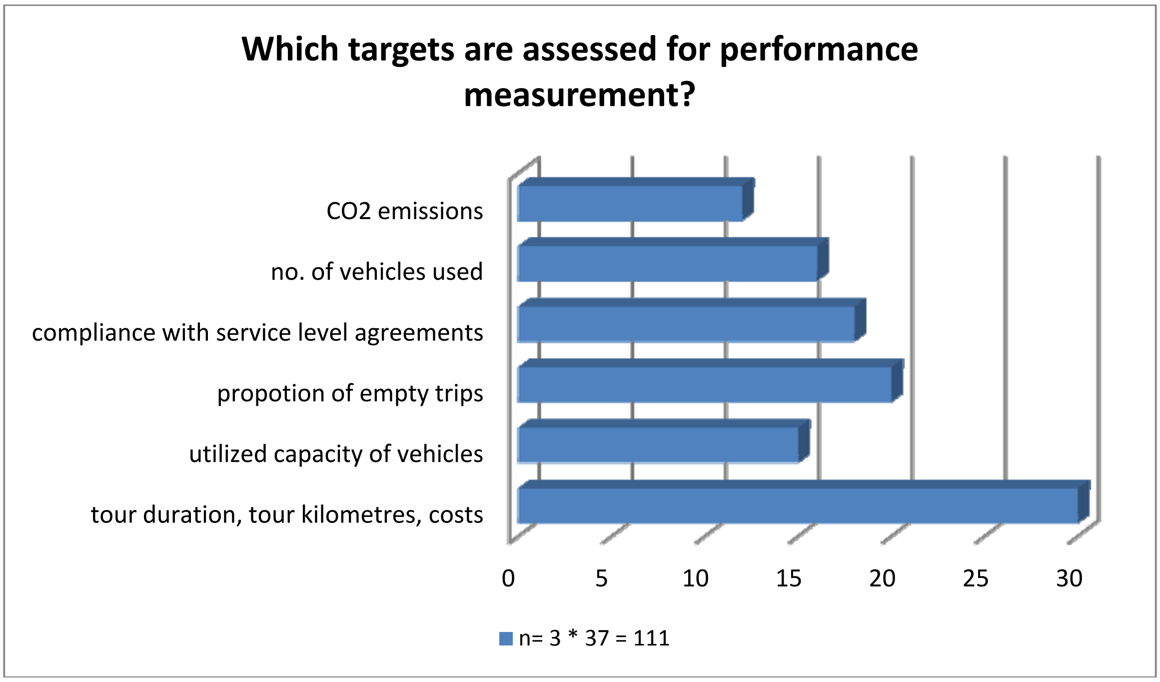

*Most important trends in transport logistics. Users' top priorities of the different proposals*

Energy costs, congestion problems and environmental policies receive the highest attention by the questioned study participants.



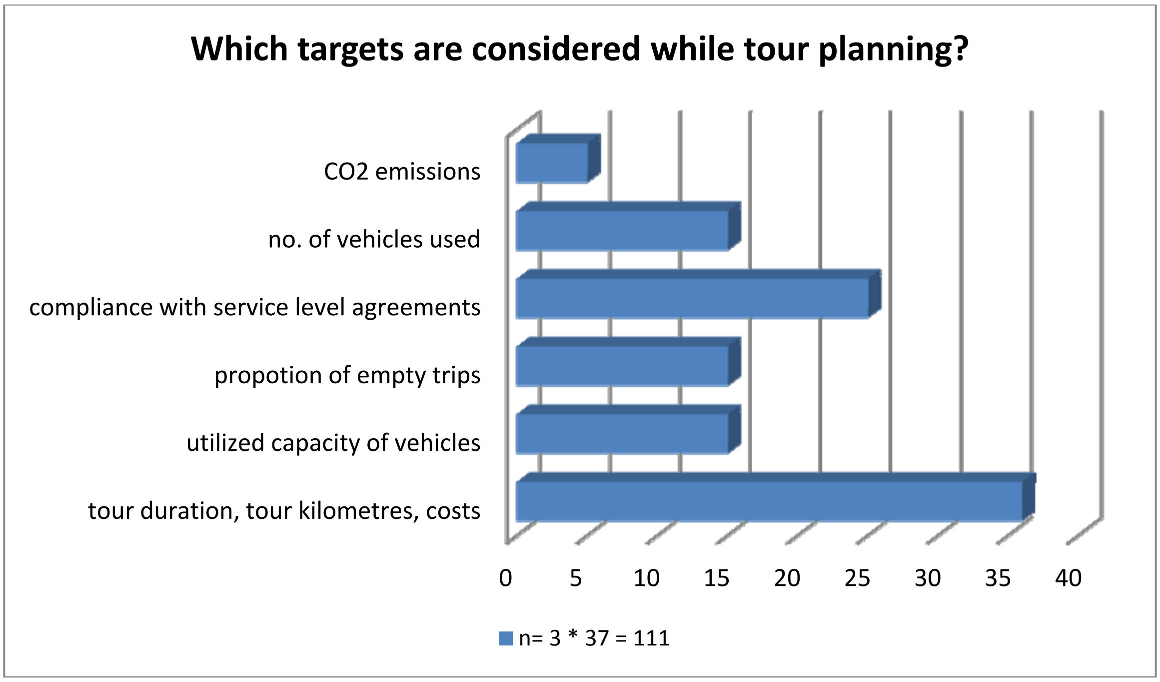

*Most important transport targets. Users' top priorities of the different proposals*

Price and punctuality (reliability) are the two dominating issues for the study participants. The other proposed issues are approximately equal.




*Importance of targets assessed during performance measurement. Users' top priorities of the different proposals*

The item "tour duration, tour kilometers, costs" is meant to be the most assessed performance measurement. Other choices are called to be important by the study participants in an equal way.



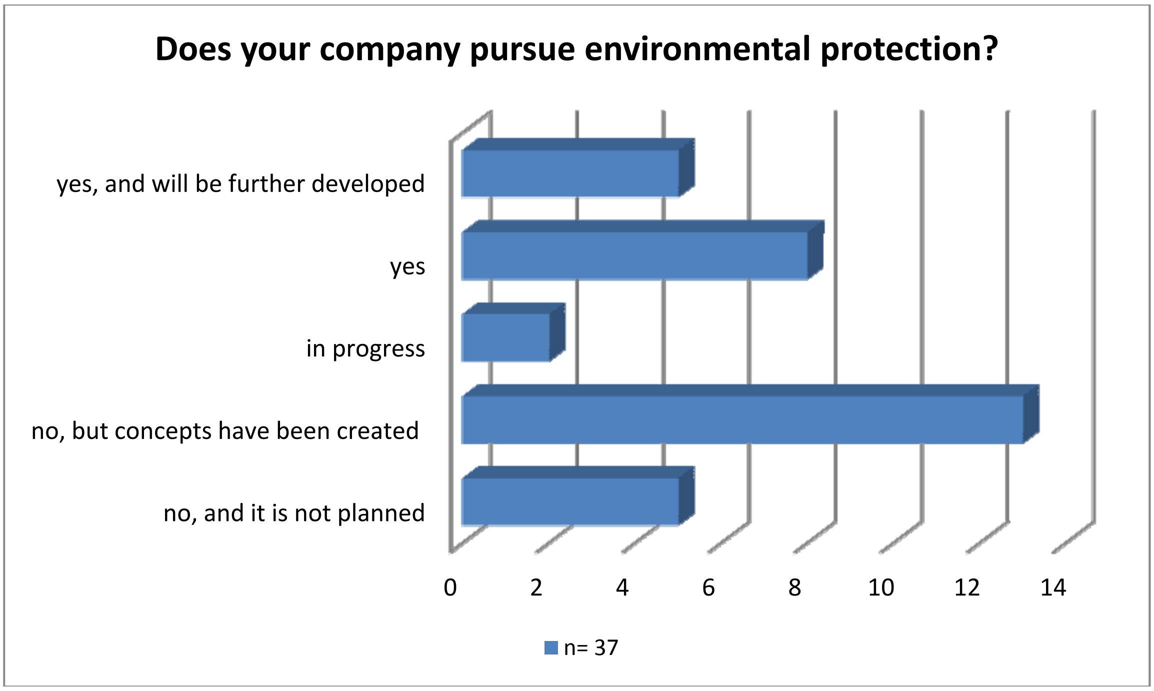

*The most important targets considered while tour planning*

As already considered in the previous question, the item "tour duration, tour kilometers, costs" is named to be most important during tour planning (building trips and allocating transport orders to them). Compliance with service level agreements has also to be named as an important factor to optimize during the tour planning.

**Is there a re-planning of the tours when new information becomes available after tour start, and if so in which cases and to which extent? (e.g. congestion, weather, ad-hoc orders, rush hour)**

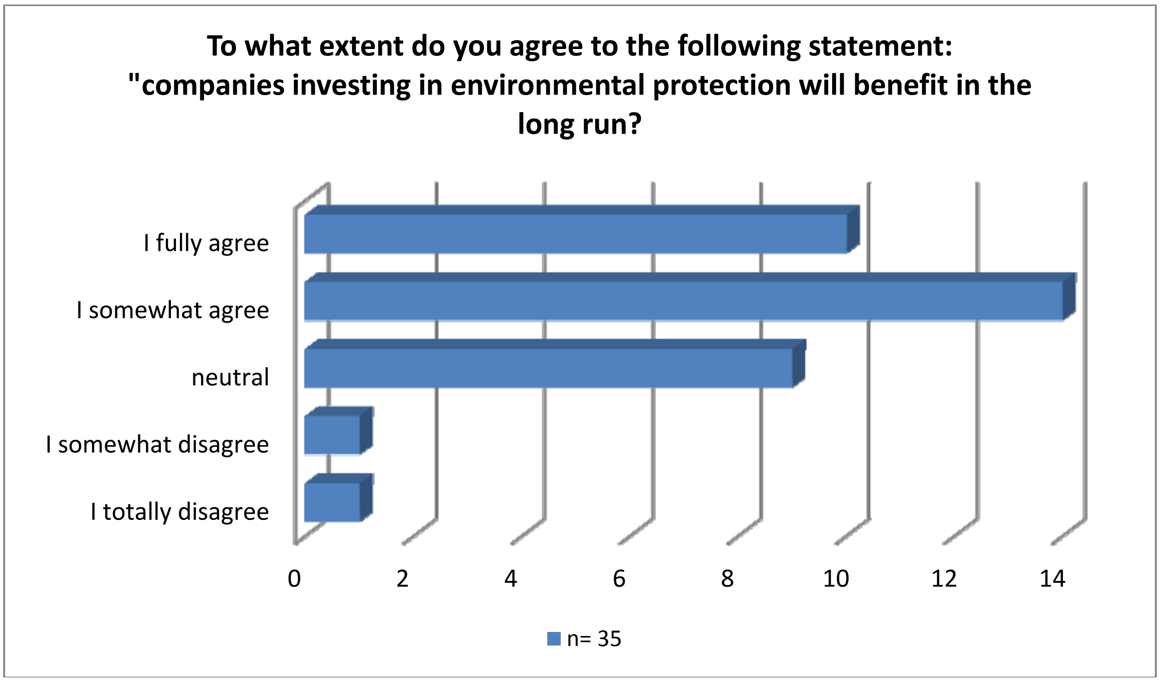
Answers given:

- Industry/branch specific: The main business consists of ad-hoc orders which force the planner to permanently plan and dispatch
- In case of significant traffic problems the transportation operations manager informs the driver to detour and /or reschedules the trips
- Drivers are allowed to detour in case of traffic congestion problems and a beneficial detour
- Activities of the transport operations manager tend to concentrate on peak hours.
- The trip sequence can change per vehicle
- A complete rescheduling of the whole fleet is unlikely
- In case of traffic congestions in an urban environment, the whole system performance in means of transportation speed is reduced for a large are at the same time, detours will not give a significant improvement, but the driver can decide for himself.



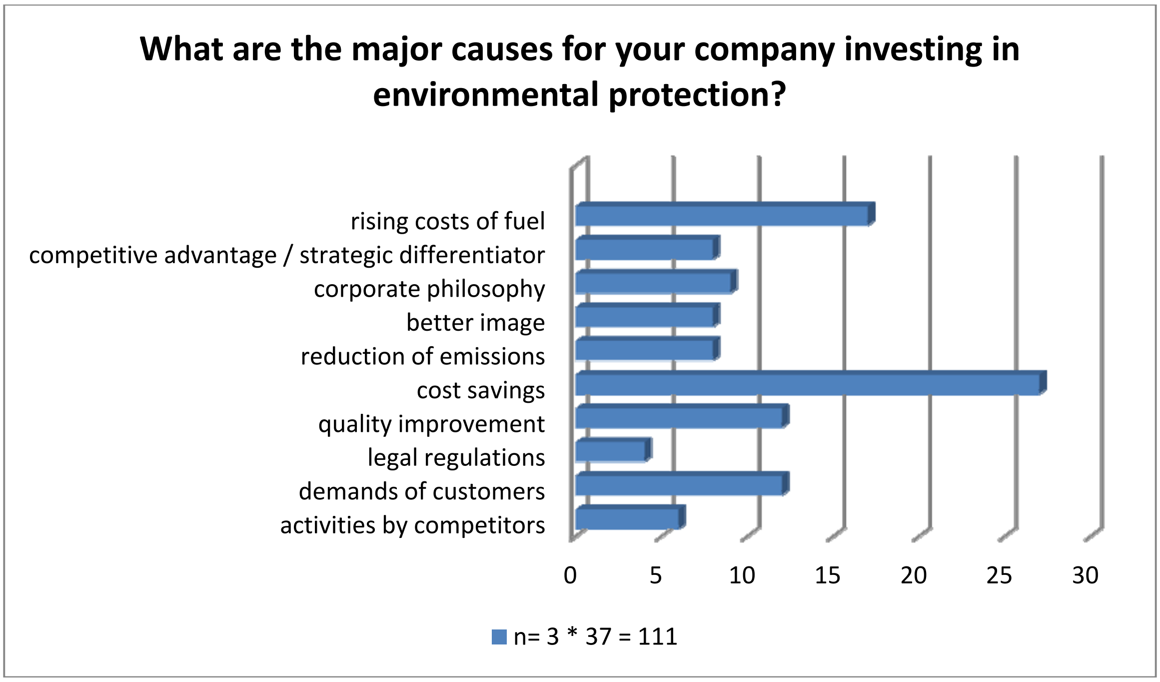

*Environmental protection actions in companies*

The study participants tend to see the importance of environmental friendly behavior. Environmental friendly behavior can be seen in this matter as resource saving behavior. Candidates refusing actions in environmental friendly behavior are a minority.



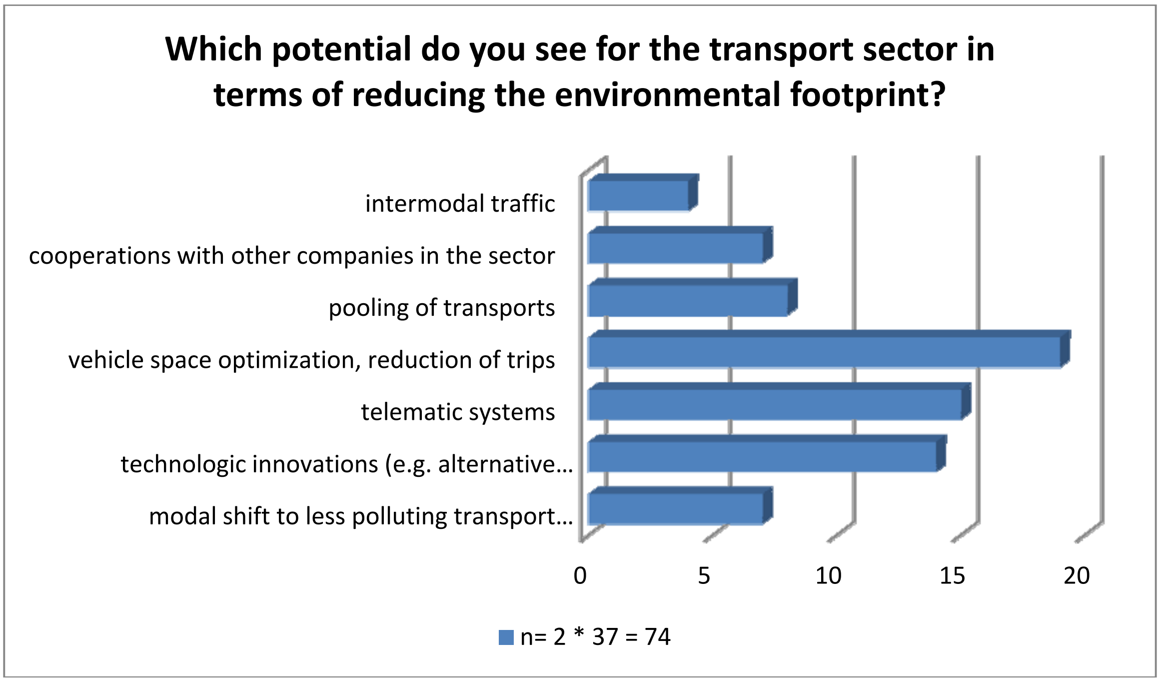

*The expected effects of investments in environmental protection in a long run perspective*

The large majority of study participants agree or state to be neutral for this question.



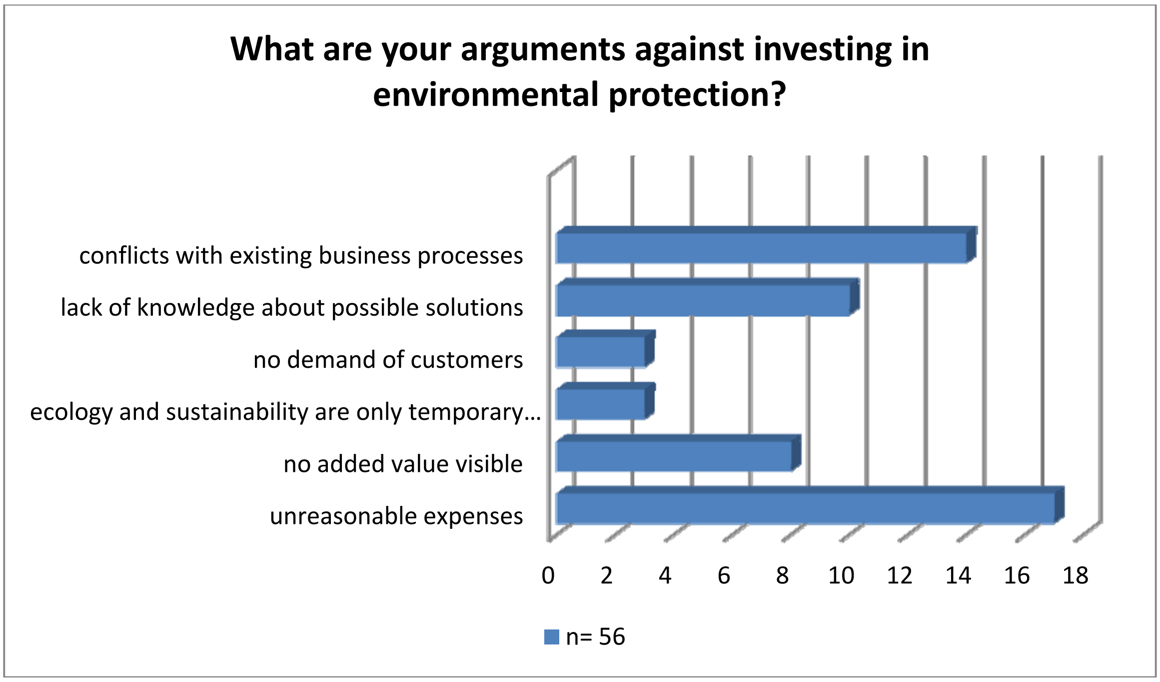

*What are the major causes for your company investing in environmental protection?*

The question result visualizes the close interplay between cost savings and rising fuel costs. Furthermore it describes the high importance of optimization needs to gain a win-win situation from the environmental and monetary point of view.




*Which potential do you see for the transport sector in terms of reducing the environmental footprint?*

The two top answers, stated by the study participants as most promising, to positively influence the environmental footprint, are issues which will be approached in the eCOMPASS project: optimization in the planning and telematics systems support.




*What are your arguments against investing in environmental protection?*

This question is one of the most important questions of the questionnaire, as it clearly shows the gaps and barriers any solution will be confronted with.
The top answer, "unreasonable expenses", can be reflected from 2 positions. On the one hand, expenses for measures are a general issue. On the other hand, expenses will be accepted, if they are reasonable, thus the benefit is dominating the expenses.
The point "conflicts with existing business processes" can be seen also as critical. In the companies of the test participants, business processes are established, which cannot be changed any.
Furthermore there seems to be a lack of knowledge for possible solutions. This seems to be neither a process nor a direct cost problem, but a point to approach by e.g. information material and discussions.

## 3.5 Results & Conclusions

This section summarizes the results from the interviews in section 3.3 and the questionnaires in section 3.4. We draw our conclusions outlining the most important user needs in the different eCOMPASS application scenarios.

### 3.5.1 Private Vehicles & Smartphone Users

An important insight from both the interviews and the questionnaires is that on the one hand, a great majority of users do consider themselves eco-aware in general, but on the other, environmental considerations do not play a significant role when they make transport decisions. In fact, convenience and efficiency in term of time are by far the most common motivations when deciding on a means of transport. This has substantial consequences for eCOMPASS services and applications: Since there does not seem to be a pronounced desire to consciously act eco-friendly in transportation, features and applications developed need to emphasize convenience and efficiency towards the user, while eco-friendliness has to be realized as a secondary objective. In other words, while eco-friendliness can still most likely add value to eCOMPASS applications from the user's perspective, it should not be the first or even sole differentiator from existing services. E.g., enabling users to smartly avoid traffic can deliver a great benefit in terms of both efficiency and convenience, while also being eco-friendly. In order to achieve rapid adoption of such a feature, the added efficiency and convenience should be emphasized most in the user experience, with the extra eco-friendliness as a bonus.

A second important realization concerns the daily relevance of navigation and trip planning services. While their daily home-work route is the most prominent transportation need for most urban residents, both our interviews and questionnaires clearly indicate that users tend to not use navigation or trip planning services at all in their daily commute. In fact, the shorter their route, the less likely users are to use navigation, and most users' home-work routes are short (below 15 kilometers). This means that in order for eCOMPASS services and applications to make a difference in the future of urban transportation, they need to appeal to short-distance commuters in a way current application do not, as to increase the use of navigation and trip planning applications and services in commuting in general.

Fortunately, our research also yields some clear indication as to how eCOMPASS applications could assist users in their daily commute. According to both our interviews and questionnaires, users are very aware that usually several different route options are available for their trips, and they do value the potential to make a choice. On the other hand, current applications and services seem to provide neither the right alternatives, nor enough relevant information about them. Users emphasize that they want detailed information about their options, and that different objectives for different alternatives can be interesting. Most users would like a choice of two or three routes pre-trip, and more options while they are on the go. Again, eco-friendliness seems to be less of a motivation to deviate from a given route than, say, travel time or traffic.

Another concept which turned out to be very appealing to users is the concept of robust routes, i.e. routes which are less likely to incur traffic incidents and delay. Users who are already used to high definition traffic information almost expect their device to provide information on how reliable a given ETA is, and many users would regularly sacrifice a few minutes in travel time in order to travel on a more robust route.

Even the somewhat futuristic concept of traffic load-balancing, where users would agree to sometimes taking a longer route in order to reduce congestion and travel times for all on average, was understood by most users, and most of them indicated that they would be willing to take detours at times if such a system would improve the overall traffic situation. However, users also indicate that they are rarely willing to blindly follow suggestions and usually prefer to make their own route choices, which does constitute a major challenge to this idea.

Another feature very popular among users is advanced driver feedback, coaching users to more economic driving. Most users would prefer such a feature to be "live", i.e. available in the car, as opposed to post-drive feedback. And again, for most rapid adoption, the focus in the user experience should be on reducing fuel-consumption and cost, with reducing emissions as an extra benefit.

We also queried users about their stance towards multi-modal trip planning. Users do remark that an integrated application, comparing trips using different transportation modes, would be a benefit over the current state of the art, where multiple different apps and services have to be used. However, most users who are interested in such application already use public transportation now and then, while many regular car drivers indicate that they would be hard to convince to switch means of transport. On the other hand, many users would like to see a park & ride trip planner integrated with their car navigation system and indicate that this might increase their acceptance of park & ride, in particular more than a similar application on a smartphone.

Finally, we investigated the need for a smartphone itinerary planner for tourists in urban areas. Our research shows that smartphones are on their way to become a regular vacation companion, and that convenience, i.e. the ease of getting around, plays a big role in choosing which sights and activities to visit. Hence, an integrated trip planning application for tourists would address a strong user need. As input for itinerary planning, users' desires center on their individual areas of interest, and the types of activity they prefer.

### 3.5.2 Vehicle Fleets

***Many specific problems***

The logistics field offers a wide spectrum of planning problems depending on the sector and task field and the underlying company process, e.g. long-haul transports, last mile transports, courier express, etc. Also in-between countries within the European Union, problems are different due to specific restrictions among the countries, e.g. toll, driving hour restrictions. Even with a more local focus, problems can be very specific, due to e.g. city access concepts. Therefore, measures need to be on the one hand generic enough and on the other hand be able to be modified and applied adequately. Furthermore the logistics market consists of a limited number of market players: some are big companies while some are small and are built up on one person.

***Agreement that service quality is an important key performance indicator (KPI)***

Interviewees agree in most cases that service quality is a highly important KPI. Service quality can be described in means of e.g. a physical transport as: deliver/pick up in-time, perform the transport safely, and deliver/pick up at envisaged time. The in-time delivery is seen as important as the price factor. Depending on the service, price and service quality may differ, but in general, both KPIs are described as of same importance.

***Planning and Mission support***

Support in the planning phase is often stated to be the backbone of a logistical optimization. A well-tuned planning system generates a significant improvement in comparison to a no planning system case. Interviewees agree at a large majority that the more complex the planning problem, the more improvement a planning system can lead to. Furthermore for the mission execution, a system to support the driver is stated or expected to be very valuable at a large majority level.

***The importance of traffic information***

For the planning and especially for the mission execution knowledge of the traffic state and the traffic state prediction are seen important. For the planning, it seems that high quality historic data and on a daily basis, major traffic network changes, are most important to the interviewees. During the mission execution, traffic information at real time level is highly welcome, in particular for urban areas. Also an interface for the automated exchange of mission information from the back-office to the vehicle and vice versa is expected.

***Environmental awareness is growing, but is being dominated by competitive market needs.***

Companies do agree that ecological behavior is important. There is a wide agreement among the interviewees, that task fields logistical planning and execution of transports, offer a lot of reduction potential. Anyhow changes in the existing systems have to respect existing given restrictions. Otherwise the solution will not be accepted widely.

Another aspect is the competition in the market. Logistic companies and service providers are most often in a competitive situation towards each other. There is a tendency to check almost every (investment) measure to be implemented in a commercial surrounding in a benefit-cost analysis. As an improvement of ecological indicators is implicitly followed by a reduction of KPIs, e.g. km driven, fuel consumed, it seems that there is no general conflict with market targets. Anyhow, as mentioned, restrictions need to be fulfilled mandatorily and the "service level" of the fleet has to remain as is or even increase.

# 4 Requirement Analysis

The purpose of this Section is to perform the requirements elicitation, documentation and analysis processes for the user groups specified in Section 2 and based on the user surveys that were presented in Section 3. These processes are part of the Requirements Engineering (RE) procedure, which comprises a set of activities concerned with identifying and communicating the purpose of a system, and the contexts in which it will be used. Hence, as it is shown in Figure 5, RE acts as a bridge between the real-world user needs (as they are reported in Section 3) and other constituencies affected by the system, such as the capabilities and opportunities afforded by technologies. Therefore RE is constructed on the one hand as a result of the knowledge acquisition process whose purpose is to collect the real user needs about the envisaged product, and on the other hand has a significant impact on the design of the system to take place during the system architecture phase (Task 1.4).

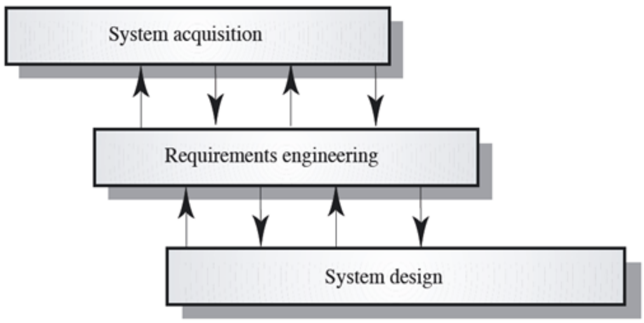



**Figure 5 : Interactions of Requirements Engineering activities**

This Section begins by outlining the most well-known requirements specification methods. The goal of these methods is to suggest a formal way for describing the system requirements, often laid out as a separate document or as part of the overall RE procedure document, in a way similar to the one presented in this deliverable. The purpose of this side-by-side presentation of the various requirements specification methods is to compare them in sufficient detail and finally select among them those characteristics that fit the needs of the eCOMPASS requirement elicitation process in the best possible way. After reviewing the most representative approaches, we comprise the eCOMPASS requirements specification structure and requirements gathering template, selecting the most appropriate features from each one of the underlying methods, justifying our selection. In Subsection 4.2 we present the requirements specification templates that we apply for recording and documenting the functional and non-functional specifications. Finally, in Subsections 4.3 and 4.4 we present in detail the functional and non-functional requirements, respectively, based on the previous templates, highlighting the operations that should be supported by the eCOMPASS framework, as well as their technical aspects of the eCOMPASS framework in terms of user interface look and feel, usability, performance, maintainability, security, etc.

## 4.1 Requirements specification methodology

### 4.1.1 Purpose and Scope of Requirement Analysis

The purpose of the requirement analysis is to record system requirements of the eCOMPASS platform based on user needs in order to describe the functionality and the services provided by the system, as well as any constraints imposed on the offered services. The system requirements along with the use cases to be defined in Task 1.3 will guide the specification of the system architecture in Task 1.4. The requirements determine the needs and conditions to meet for the eCOMPASS platform for the main target user categories as they are roughly specified in DoW and defined in more detail in Section 3. Moreover, the purpose of the requirements analysis is to provide clear, complete, consistent and unambiguous requirements resolving any apparent conflicts.

Requirements elicitation is a necessary step conducted prior to the requirements specification phase. By requirements elicitation we refer to the process of gathering and collecting user requirements through appropriate user surveys and questionnaires, workshops between experts and users, etc, for identifying the user needs and translate them to specific functionalities supported by the system. Therefore, the user survey process and the extracted results presented in the previous Section comprise an essential part of the requirements elicitation process. Based on this process, an analysis of the collected requirements should follow that will lead to the final specification of the requirements that should be recorded in a formal and easily readable format, since they intend to facilitate the design of the system architecture and the development of the envisaged system.

The expected outcome of the requirements analysis is to produce precise and detailed descriptions of the required eCOMPASS framework functionality and accompanying constraints. The particular level of detail for the extracted requirements is intended to be communicated to system architects and developers and serve as the basis for the definition of system architecture that will guide the system development process. Therefore, the purpose of the requirements' definition , which is the subject of this Section, is to specify the external behaviour of the eCOMPASS framework, describing the services that the system should provide (in the form of functional requirements), as well as the potential constraints on the services and functions offered by the system (in the form of non-functional requirements).

### 4.1.2 Requirements Specification Methods

For the requirements specifications process of the RE procedure, a few methodologies have been proposed. Although there is not a consensus on requirement analysis methodologies evaluation, some comparisons have been conducted with respect to specific aspects of the software engineering methodology. For instance, in (Bass, 2006) five requirements specification methods are compared from a software architecture perspective on a three-fold basis, according to criteria related to (i) how they fit into the development process, (ii) artifacts produced, (iii) ease of use. The comparison of these methods is essential in order to identify potential shortcomings and select those methodologies that are suitable to deal with the eCOMPASS specific needs for documenting the requirements specification. Based on this comparison, the following methodologies are outlined:

#### 4.1.2.1 The Shall&Will approach

The *Shall&Will* approach (IEEE-SA, 1998) is basically the specification of requirements using natural language. This approach derives its name by the fact that requirements are generally described in the form:

*<entity> shall (or will) <textual description of specific requirement>*,

where *Shall* traditionally indicates the requirement is mandatory and *Will* is used to express a declaration of purpose.

The result of this approach is the production of "contract-style requirements list". The biggest advantage of this approach is that it is highly expressive. However, there are some practical shortcomings that prevent the use of this method in large-scale projects, e.g. this method results in lists spanning hundreds of pages, making the requirements hard to check for completeness and consistency. One major disadvantage of the Shall&Will approach that was seriously taken into account in the eCOMPASS project is that the list of requirements that are exposed in natural language lack the required formalism that could make them useful at the architecture design and software development processes, because of its free representation form.

#### 4.1.2.2 Use Case Analysis

The Use Case Analysis as a requirements specifications method aims at organizing how external entities interact with the system, emphasizing on gathering the functional requirements of a system (Armour, 2000). This method is based on the creation of a series of scenarios that provide a description of how the system will be used. These scenarios are called use cases. The main steps of the Use Case Analysis include the identification of the different types of people or devices (i.e. *actors*) that use the system or product. These actors represent roles undertaken by real users or involved devices as the system operates. In fact a use case describes how an actor interacts with the system in all possible ways that are external to the system per se. As actors and users are not always the same thing, the Use Case Analysis in addition to the target user groups, has to identify all actors involved in the system, as well as their different roles. Because requirements elicitation is an evolutionary activity, not all actors are identified during the first iteration. It is possible e.g. to identify primary actors (Jacobson 1992), during the first iteration and secondary actors during the second one, as more information about the operation of the envisaged system becomes available. Primary actors interact with the system in order to achieve the required functionality, whereas secondary actors support the primary actors in doing their job.

Use case diagrams can be provided as written that describe the role of an actor as interaction with the system occurs. However the commonest way for describing use cases is by using their graphical representation in the Unified Modeling Language[1] (UML). Figure 6 represents an example of a UML use case diagram that involves three actors, including a real user (Vehicle Driver) and two software entities (Data Collector and Data Manager Agents) for a dummy routing scenario. It should become obvious that for the full description of the system a large number of use case diagrams is required resulting often to non-manageable or difficult to organize documents.

According to the use case analysis, in order to identify the actors a number of questions have to be answered, such as (Jacobson 1992):

- What main tasks or functions are performed by the actor?
- What system information will the actor acquire, produce, or change?
- Will the actor have to inform the system about changes in the external environment?
- What information does the actor desire from the system?
- Does the actor wish to be informed about unexpected changes?

From the above list it becomes apparent that the Use Case Analysis method is not always easy to check for completeness and consistency, because it is not always obvious when the possibilities for creating new scenarios should end. As the number of new scenarios increases, a heavy burden with respect to the achieved consistency is introduced. On the other hand, the definition of different actors and their roles requires, even an initially rough knowledge of the technical aspects of the system which is not always desirable at the requirements elicitation and analysis stage.

[1] http://www.uml.org/

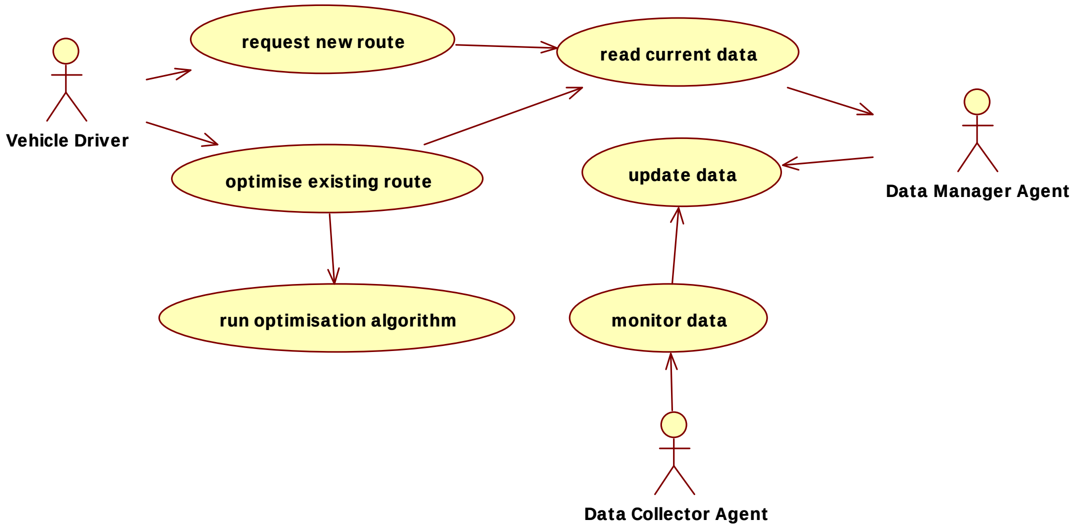



**Figure 6 : A UML Use case diagram example**

One of the advantages of use case scenarios is that they can be used for functional testing and generating test cases. Also, the generation of use cases is well supported by today's existing CASE tools. Given the characteristics of the use case analysis method, its advantages and disadvantages, we believe it is a method more suitable to be used for the definition of the usage scenarios to be deployed at the eCOMPASS pilot cases and be used for demonstrating the results of the project. According to the project work plan this process will be undertaken in Task 1.3 that will follow the user requirement analysis phase (Task 1.2) and will run in parallel with the System Requirements, overall architecture and system specification (Task 1.4) taking into account the structural characteristics of the eCOMPASS framework's architecture.

#### 4.1.2.3 The Quality Attribute Workshop

The Quality Attribute Workshop (QAW) (Barbacci, 2003) requires a one or two-days meeting with the stakeholders for the collection of requirements. It emphasizes on the quality attributes of the system, i.e. any property of the system, which is not related to functionality. The importance of quality attributes to the QAW method is justified by the fact that quality attributes define the system properties, provide system working conditions and drives the architectural design. Therefore, from an architectural point of view he QAW provides support for discovering architecturally significant requirements that are also quality attribute requirements, having also a process for prioritizing quality attribute requirements. Thus, QAW helps the system architects to get maximum possible information about the quality and also helps in the definition of the system structure, as well as in the discovery, documentation and prioritization of a system's quality attributes early in its life cycle.

The inputs/outputs and actors of the procedure adopted in QAW is illustrated in Figure 7. The QAW collects, prioritizes, and refines scenarios that can be used to test if the architecture will meet the requirements. The QAW procedure receives business drivers/missions and architectural plans as input and produces refined scenarios as output. The steps required for translating the inputs to appropriate scenarios are undertaken by the analysis team after interviews and meetings with stakeholders. The QAW procedure begins with presentations of the business and mission context and architectural plans to the stakeholders. In the next step a facilitator enumerates a list of key architectural drivers and asks the stakeholders for clarifications, additions, deletions, and corrections. Then, the procedure progresses by the

generation of the scenarios after brainstorming, followed by scenarios consolidation, prioritization and finally refinement. The refined scenarios are then used for the development of the test cases.
The steps that constitute the QAW method indicate that prior knowledge of the architecture design even in its rough form is considered essential. This is expected by such a method, as it focuses on the quality attributes of the system comprising an approach which could be characterized as not being so much functional requirements-oriented, as opposed e.g. to the Shall&Will approach. Based on its nature, one disadvantage of QAW is that it does not deal with the collection of functional requirements. On the contrary, it is a method tied to the identification of the main architectural components and their quality attributes. In addition to this limitation, there are a few other issues against this method, such as the difficulty to check its completeness and consistency, the lack of existing support tools, the requirement for high architectural skills on behalf of the analysis team and its hard traceability.

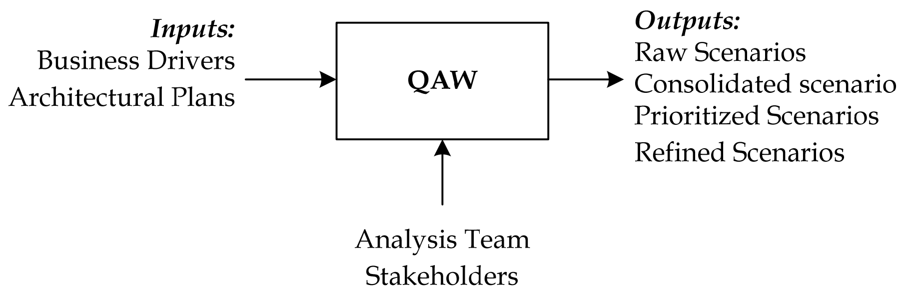



**Figure 7 : Quality Attribute Workshop input, output and participants**

4.1.2.4 Global Analysis
Global Analysis (GA) (Hofmeister, 2000) (Hofmeister, 2005) is based on the Siemens Four View approach (Soni, 1995), whose purpose is to reduce the complexity of designing and understanding the architecture. GA aims at identifying and analyzing the technological, organizational, and product factors that have a global influence on the architecture. The technological factors comprise technical standards, development frameworks to be adopted and in general decisions concerning technical aspects of the system. Organisational factors encompass project's schedule and budget, software processes in use and developers' skills. The requirements specific to the product being designed, including functional requirements, as well as quality attributes, comprise the product factors.
Figure 8 illustrates the information that is captured as the different stages of the GA procedure. The various information artefacts are built based on specific templates defined in (Hofmeister, 2000). GA may be conducted as an iterative process in conjunction with the architecture design and thus be refined after a number of iterations. Based on the received information a set of Factor tables are constructed to group the information that is captured.

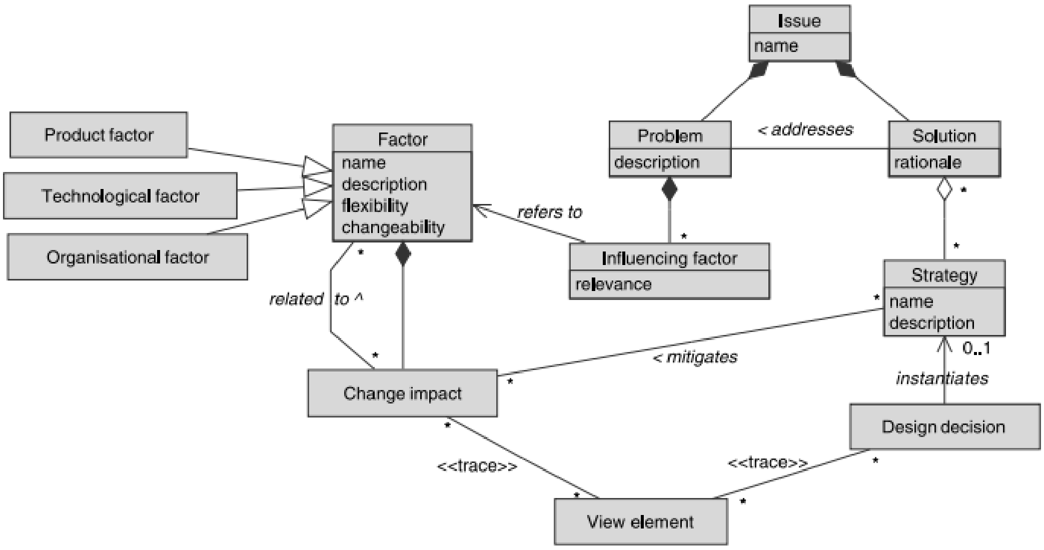



**Figure 8 : UML model of Global Analysis artefacts (adopted by: Hofmeister, 2005))**

The GA approach, as in the case of the QAW, also requires a rough knowledge of the structure of the system that makes it unsuitable for collecting the functional requirements prior the design phase (as in the eCOMPASS approach). Indeed, what Hofmeister, et al. (2005) ultimately learned from the GA experience was that it played an integral part in architecture design. In addition to this issue, a GA evaluation procedure, reported in (Bass, 2006), revealed the following shortcomings:

- Moderate expressiveness (does not prescribe structure or well-formed rules for specifying factors)
- Not easily traceable
- Difficult to check for completeness and consistency
- Moderate support for testing
- No tools are available
- Little support for variability (does not include specific provisions for handling multiple systems simultaneously)
- Requires high technical skills
- Moderate support for prioritization

Due to the aforementioned characteristics and especially the fact that GA is also a architectural design-oriented procedure, the GA approach is not deemed suitable for covering the needs of the eCOMPASS requirements specification procedure.

#### 4.1.2.5 O'Brien's Approach

The O'Brien method (O'Brien, 2004) provides guidance for linking architectural decisions to measurable quality attributes that flow from explicitly capturing business goals. The main purpose of this approach is to capture a business case of the system to be designed, which leads to the identification of functional and quality attribute requirements. When this occurs, both types of requirements are used for updating the architecture in an iterative fashion throughout the development lifecycle.

A thorough evaluation of the O'Brien method from an architectural point of view (Bass, 2006) reveals that this approach suffers from low expressiveness, moderately difficult ability of organization, lack of existing tools, moderate support for prioritization, whereas it requires high technical skill level, as well as the GA and QAW approaches do. On the contrary, it has been noted that O'Brien method is easy to trace. Provides some help in checking completeness and consistency, as well as high support for testing.

Based on the previous analysis the O'Brien method is not 100% suitable for the purposes of eCOMPASS requirements specifications, as its main priority is not the collection of functional and non-functional requirements, based on the users' needs, but it is mostly used in conjunction with any requirements elicitation method, for improving the architecture design process. The O'Brien method subsumes that the functional requirements are already gathered and uses them for refining the system architecture. Even though this approach is rejected for the needs of Task 1.2, it could be usefully applied for the refinement of the system architecture, in thee context of eCOMPASS Task 1.4.

#### 4.1.2.6 The IEEE/ANSI 830-1998 standard

Many organisations and standardisation bodies, such as the US Department of Defence, the National Bureau of Standards, the IEEE, etc. have issued candidate formats for software requirements specifications. The most widely known standard in this respect is IEEE/ANSI 830-1998 (IEEE, 1998). According to this standard, the structure shown in Figure 9 is proposed for the requirements specification document. The IEEE standard is very generic but may form the basis for the structure of the eCOMPASS Requirements Analysis Section. In addition to the proposed structure, a more detailed one is necessary for outlining the contents of Section 3 of the IEEE standard ("Specific Requirements"), thus shedding more light on the specific types of requirements to be presented under the categories of functional and non-functional requirements. According to (Sommerville, 2001) the information contained in the requirements specification document depends on the specific characteristics and idiosyncrasies of the system to be developed.

**IEEE/ANSI 830-1998 std. Requirements Specification Document (IEEE, 1998)**

**Table of Contents**

*1. Introduction*
- *1.1 Purpose*
- *1.2 Scope*
- *1.3 Definitions, acronyms and abbreviations*
- *1.4 References*
- *1.5 Overview*

*2. Overall description*
- *2.1 Product perspective*
- *2.2 Product functions*
- *2.3 User characteristics*
- *2.4 Constraints*
- *2.5 Assumptions and dependencies*

*3. Specific requirements*

It includes functional, non-functional and interface requirements. This is obviously the most substantial part of the document, but because of the wide variability in organisational practice, it is not appropriate to define a standard structure for this section. The requirements may document external interfaces, describe system functionality and performance, specify logical database requirements, design constraints, emergent system properties and quality characteristics.

*Appendices*
*Index*

**Figure 9: Structure of the software requirements specification documents proposed by the IEEE/ANSI 830-1998 standard**

The templates proposed by Sommerville and the Volere method (Robertson, 2006) presented in the following subsection provide a more detailed structure of the requirements specification document. Such a detailed presentation of requirements is necessary when the project involves many different interoperable hardware and software parts.

#### 4.1.2.7 Sommerville's Template

According to the Sommerville's textbook (Sommerville, 2001) the requirements document should describe the functional and non-functional requirements so that they are understandable by system users with no detailed technical knowledge. Moreover, the user requirements should leave out as much as possible the design characteristics of the final system. Sommerville also stresses in his book that when the envisaged software is part of a large system engineering project that includes interacting hardware and software systems, as eCOMPASS does, it is often essential to define the requirements to a fine level of detail. To this end he proposes a more detailed structure of the requirements specification document that is presented in Figure 10.

**Sommerville Requirements Specification Document (Sommerville, 2009)**

**Table of Contents**

*Preface*

*1. Introduction*
*2. Glossary*
*3. User requirements definition*
*4. System architecture*
*5. System requirements specification*
*6. System models*
*7. System evolution*

*Appendices*

*Index*

**Figure 10: Structure of the software requirements specification documents proposed by (Sommerville, 2009)**

Sommerville's structure introduces the Chapter called "User requirements definition" in order to include the services provided by the system to the user and the non-functional system requirements. The description of the requirements in this Chapter may use natural language, diagrams or other notations that are understandable by customers. The "System architecture" Chapter presents a high-level overview of the anticipated system architecture showing the distribution of functions across system modules, highlighting the architectural components that are reused. The "System requirements specification" Chapter describes the functional and non-functional requirements in more detail. If necessary, additional details may be added. In the "System models" chapter a system model is proposed with the relationships between the system components and the system and its environment. Finally, the "System evolution" chapter describes the fundamental assumptions on which the system is based and anticipated changes due to hardware evolution, changing user needs, etc.

#### 4.1.2.8 Volere

The Volere (Robertson, 2006) Requirements Specifications template is presented in Figure 11. Compared to the other templates, namely the IEEE/ANSI 830 standard and Sommerivile's template, shows the most detailed structure. The first edition of the Volere Requirements Specification Template was released in 1995. Since then, several updates have been released that resulted in refinements of the previous ones, based on feedback from an affiliated network of organisations from all over the world that have used the Volere template in order to discover, organise, and communicate their requirements. The subsequent updates reflect more specific needs imposed by those organisations. The template is distributed under a commercial license and it is copyrighted by The Atlantic Systems Guild Limited. Some older versions are available on the Web.

**Volere Requirements Specification Template (Robertson, 2006)**

**Table of Contents**

*1. Project Drivers*
- *1.1 Purpose of the project*
- *1.2 The Client, the customer and other stakeholders*
- *1.3 Users of the product*

*2. Project Constraints*
- *2.1 Mandated Constraints*
- *2.2 Naming Conventions and definitions*
- *2.3 Relevant Facts and Assumptions*

*3. Functional Requirements*
- *3.1 The Scope of the Work*
- *3.2 The Scope of the Product*
- *3.3 Functional and Data Requirements*

*4. Non-Functional Requirements*
- *4.1 Look and Feel Requirements*
- *4.2 Usability and Humanity Requirements*
- *4.3 Performance Requirements*
- *4.4 Operational and Environmental Requirements*
- *4.5 Maintainability and Support Requirements*
- *4.6 Security Requirements*
- *4.7 Cultural and Political Requirements*
- *4.8 Legal Requirements*

*5. Project Issues*
- *5.1 Open Issues*
- *5.2 Off-the-Shelf Solutions*
- *5.3 New Problems*
- *5.4 Tasks*
- *5.5 Migration to the New Product*
- *5.6 Risks*
- *5.7 Costs*
- *5.8 User Documentation and Training*
- *5.9 Waiting Room*
- *5.10 Ideas for Solutions*

**Figure 11: The Volere Requirements Specification Template (Robertson, 2006)**

According to the Volere template of Requirements Specification, the following types of requirements are supported:

- *Functional requirements* which describe which are the functions of the product.

- *Non-functional requirements* which describe the properties that the functions must have, such as performance and usability.

In addition to the requirements types, Volere introduces the following constraints:

- *Project constraints*, which are restrictions on the product e.g. due to the budget or the time available to build the product.
- *Design constraints* impose restrictions on how the product must be designed.

The Volere template also refers to:

- *Project drivers* (in the beginning), which reflect the business-related forces. For example, the purpose of the project is a project driver, as are all of the stakeholders each for different reasons.
- *Project issues* (at the end) including the conditions under which the project will be done. The purpose of this section is to present a coherent picture of all factors that contribute to the success or failure of the project and to illustrate how managers can use requirements as input when managing a project.

The advantage that the Volere template offers over alternative approaches is that it defines in more detail the specific types of the functional and non-functional specifications that should be identified and provided as the outcome of the requirements elicitation and analysis processes. The Volere template provides a facilitated way for organising and recording the various types of system requirements.

In addition to the Requirements specification template, Volere suggests a formal way for collecting the requirements in tabular format through its "requirements shell" (also called a "snow card"). The suggested template is illustrated in Figure 12.

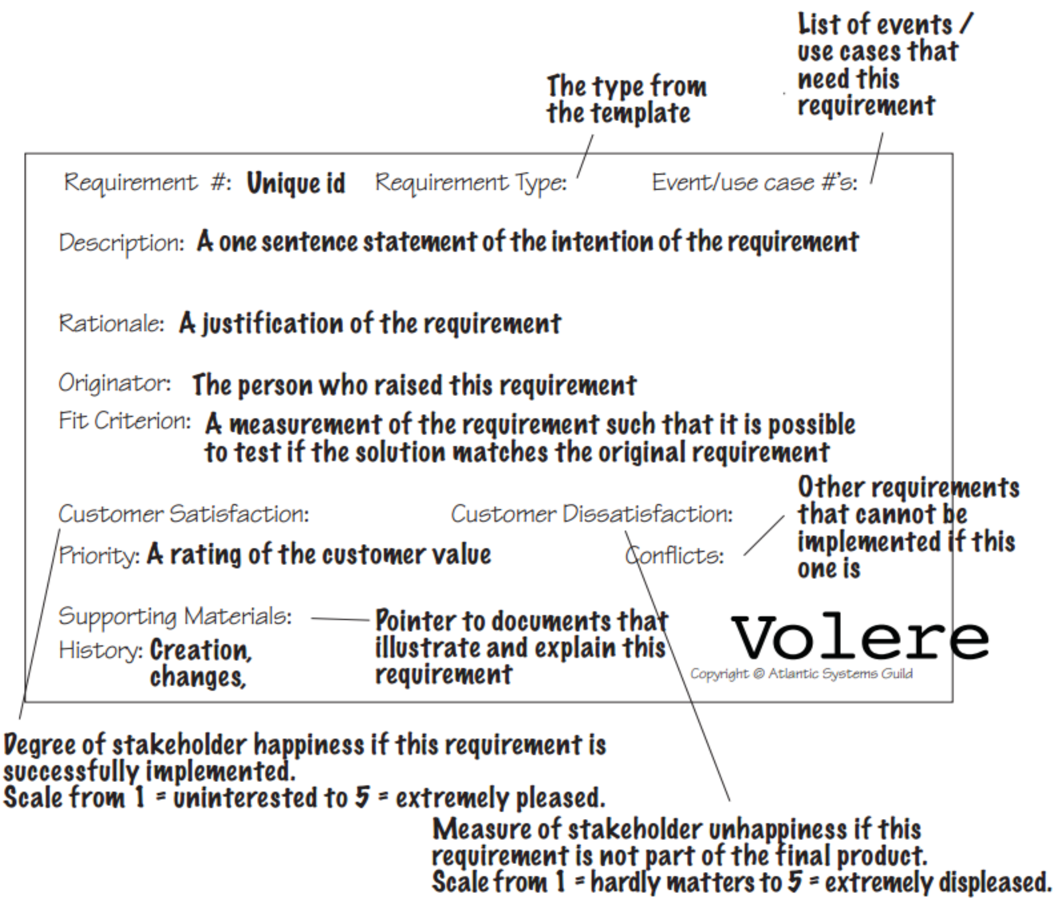



**Figure 12: Volere Requirements shell as a guide to writing each atomic requirement. Adopted from (Robertson, 2006).**

### 4.1.3 Requirements Engineering Standards

Apart from the requirement engineering processes that were described in previous section, we have also examined several requirement specifications standards in order to be used for the adopted methodology and the requirements templates that are presented in the next sections. Thus the following Table 1 describes the technical standards that were taken into account for the eCOMPASS requirements specification activity.

**Table 2 : Table of Requirements Engineering Standards**

| Standard | Standard Name | Use | Reference |
|---|---|---|---|
| IEEE 830 | Recommended practice for Requirement Specification | Used to classify requirements between functional and non functional:<br>*Functional*: A requirement that specifies an action that a system must be able to perform, without considering physical constraints; a requirement that specifies input/output behaviour of a system.<br>*Non-functional*: A requirement that specifies system properties, such as environmental and implementation constraints, performance, platform dependencies, maintainability, extensibility, and reliability. | IEEE (1998) |
| IEEE 1233 | Guide for Developing<br><br>System Requirements Specification | Used for defining well-formed requirements and designing the requirement templates:<br>*"A well-formed requirement is a statement of system functionality (a capability) that must be met or possessed by a system to satisfy a customer's need or to achieve a customer's objective, and that is qualified by measurable conditions and bounded by constraints."*<br>Rows such as "ID"(unique identifier), "Priority", "Revision" and "Requirement Type" were added in the template due to IEEE 1233. | IEEE (1996) |
| IEEE Std 610.12 – 1990 | IEEE Standard Glossary of Software Engineering Terminology | Used for requirement's terminology:<br>*"A requirement is a condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed documents."* | IEEE (1990). |
| SMART Goals | Specific, Measurable, Achievable, Realistic and Time-Bound Analysis | Used during requirement documentation and design of requirement templates. Rows in the templates such as "Specific Description", "Tests to be performed (Measurable)", "Constraints (Attainable)", "Relevant" and "Time-bound/Status" were added due to SMART analysis. | (Meyer, 2003) |
| IETF | Key words for | The keywords "MUST", "MUST NOT", | (RFC, 1997) |

| Standard | Standard Name | Use | Reference |
|---|---|---|---|
| RFC 2119 | use in RFCs to Indicate Requirement Levels | "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" throughout this deliverable are to be interpreted as described in RFC 2119. | |

## 4.2 The eCOMPASS approach

The eCOMPASS requirements analysis mostly relies on the Volere methodology. The Volere methodology comprises a general template for presenting the layout and structure of the requirements specification document, as a result of the requirements elicitation and analysis processes. Not all elements of the Volere template were considered to be suitable for our project. Therefore, a number of Sections from the Volere template about the description of functional and non-functional specifications were chosen. These sections that were considered more suitable to the eCOMPASS requirements are the following:

- *Functional Requirements*
    - *Functional and Data Requirements*
- *Non-Functional Requirements*
    - *Look and Feel Requirements*
    - *Usability and Humanity Requirements*
    - *Performance Requirements*
    - *Operational and Environmental Requirements*
    - *Maintainability and Support Requirements*
    - *Security Requirements*
    - *Cultural and Political Requirements*
    - *Legal Requirements*

This deliverable adopts the aforementioned structure by reporting the corresponding types of requirements in Subsections 4.3 (Functional and Data Requirements) and 4.4 (Non-functional requirements).

For the description of each atomic requirement that belong to each one of the aforementioned subsections we provide a tabular template based mainly on the Volere requirements shell (Figure 12), after applying the following modifications:

Addition of the following fields:

- *Name*, this field has been added in order to provide in addition to the *ID* field, a short name that describes the specific requirement in human readable format.
- *Constraints*, which describes potential constraints / conditions for the requirement to be executed.
- *Difficulty,* which indicates the level of difficulty for the implementation of this requirement (estimation from a technical point of view). Difficulty ranges on a scale from 1 (=low difficulty) to 5 (=extreme difficulty).
- *Actors*, indicating either those persons or things that interact externally with the system or one of its components, or are reacted by the systems of its components.

Removal/replacement of fields:

- *Event/use case#:* This field has been omitted from the original Volere requirements shell because the use cases, to which it refers, will be defined in Task 1.3 and it will be reported in deliverable D1.2, which comes later (it is due to M12), therefore this field cannot be filled in at this stage.

- *Supporting materials:* This field has been also removed because some of the documents that are related to these requirements are subject to IPR (e.g. the companies that have conducted the surveys keep them as internal reports with restricted access).
- *Originator* (the person who raised this requirement), has been replaced by the *Author* field (the owner of each recorded requirement).
- *History* field has been replaced by *Revision* (indicates versioning).

Table 3 summarises the eCOMPASS "requirements shell" (i.e., requirements gathering template) in tabular format, after the application of the aforementioned changes on the Volere shell.

**Table 3 : eCOMPASS Atomic Requirements Gathering Template**

| **ID** | *A unique identifier.* |
|---|---|
| **Name** | *Title of the requirement.* |
| **Requirement Type** | *Whether it is a functional or non functional requirement and in case of non-functional requirements the specific type of requirement according to the Volere notation, see e.g. (Robertson, 2007).* |
| **Description** | *A requirement must say exactly what is required.* |
| **Rationale** | *A justification of the requirement* |
| **Fit Criterion (Measurable)** | *By measurable we mean is it possible, once the system has been constructed, to verify that this requirement has been met. In other words this means the tests which must be performed in order to satisfy the requirement.* |
| **Customer satisfaction** | *Degree of stakeholder happiness of this requirement is successfully implemented (Scale from 1=uninterested to 5=extremely pleased).* |
| **Customer dissatisfaction** | *Degree of stakeholder unhappiness of this requirement is not implemented (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *The requirement is ranked according to the customer value. (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | *Any requirements whose implementation is blocked by this one.* |
| **Constraints (Attainable)** | *An attainable requirement will usually answer the question:*<br>How can the requirement be accomplished?<br>*Hence, here we provide any constraints / conditions for the requirement to be executed.* |
| **Difficulty** | *Level of difficulty for requirement implementation (estimation). (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | *An actor is someone or something outside the system that interacts with it or with one of its components (primary actor). If the actor is interacted by the system or one of its components is a secondary actor.* |
| **Author** | *The owner of each requirement that was recorded.* |
| **Revision** | *This section lists when a version of the requirement was created.* |

The following notation is used for the requirement ID field:

- *Functional Requirements: FRx, x*=1,2,…, *n*
- *Data requirements*: *DRx, x*=1,2,…, *n*
- Non-functional requirements are indicated as follows:
  - *Look and Feel Requirements: LFRx, x*=1,2,…, *n*
  - *Usability and Humanity Requirements: UHRx, x*=1,2,…, *n*
  - *Performance Requirements: PRx, x*=1,2,…, *n*
  - *Operational and Environmental Requirements: OERx, x*=1,2,…, *n*
  - *Maintainability and Support Requirements: MSRx, x*=1,2,…, *n*
  - *Security Requirements SRx, x*=1,2,…, *n*
  - *Cultural and Political Requirements: CPRx, x*=1,2,…, *n*
  - *Legal Requirements: LRx, x*=1,2,…, *n*

## 4.3 Functional and Data Requirements

This section lists the functional and data requirements using the template presented in Table 3. It is split into two subsections: 4.3.1 represents only the general functional requirements based on user surveys and 4.3.2 lists the Data Requirements, i.e. those functional requirements that are related to the different types of data that are communicated within the eCOMPASS framework.

### 4.3.1 Functional Requirements

| **ID** | FR1 |
|---|---|
| **Name** | Specific Traffic information |
| **Requirement Type** | Functional |
| **Description** | The system should be able to provide online traffic information on all roads relevant to the driver's current route. Traffic conditions should be reported for each type of optimal routes (e.g. for the fastest route) |
| **Rationale** | Based on TomTom's studies reported in Section 3.1.1, users are very much interested to understand their given traffic situation as well as possible, and they would like to make their own driving, or even departure time, decisions based on this knowledge. This requirement will also satisfy requirement FR2 which is based on users' need for receiving more broader view of the traffic situation. |
| **Fit Criterion (Measurable)** | Each time a user requests a route a traffic info option should be available. On activation of this option current traffic info should be provided on the end user application. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *1 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | -- |
| **Constraints (Attainable)** | Real time traffic info should be available; User in car with GPS-enabled PND. |
| **Difficulty** | *3 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR2 |
|---|---|
| **Name** | Traffic Information Overview |
| **Requirement Type** | Functional |
| **Description** | The system should provide an overview of transport information for all routes. |
| **Rationale** | TomTom's study 1. |
| **Fit Criterion (Measurable)** | The user wants to get an overview of the traffic information within the area in which he/she is moving, (i.e., not only the one that corresponds to his/her current route), in order to be able to change routes e.g. in case congestion gets denser on the current route but is released in a nearby route. |
| **Customer satisfaction** | 5 *(Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | 5 *(Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | 5 *(Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Real time traffic info should be available; User in car with GPS-enabled PND. |
| **Difficulty** | *3 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver |
| **Author** | D. Kehagias |
| **Revision** | V01, 10/4/2012 |

| **ID** | FR3 |
|---|---|
| **Name** | Alternative routes based on traffic |
| **Requirement Type** | Functional |
| **Description** | The system should provide alternative routes based on current traffic conditions. For each alternative route, the corresponding traffic situation should be reported for all routes. |
| **Rationale** | TomTom's study 1. |
| **Fit Criterion (Measurable)** | A number of options available upon user request that corresponds to different traffic conditions. |
| **Customer satisfaction** | 5 *(Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | 5 *(Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | 5 *(Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Real time traffic info should be available; User in car with GPS-enabled PND. |
| **Difficulty** | *3 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR4 |
|---|---|
| **Name** | Traffic Tendency Prediction |
| **Requirement Type** | Functional |
| **Description** | The system should provide the capability of displaying trends or tendencies of the traffic situation, which is going to take place in a |

| | |
|---|---|
| | timely fashion within a short or medium term (e.g. in the next 30-45 minutes). The system should be able to report e.g. if the traffic is expected to be denser or be reduced within the next minutes. |
| **Rationale** | Also, there is a clear desire to not only receive snapshots of traffic, but to also be informed about the tendency of traffic on the roads. This also satisfies the users need for understanding their given traffic situation as well as possible, and make their own driving, or even departure time, decisions. |
| **Fit Criterion (Measurable)** | After generating traffic forecasts the system keeps monitoring current traffic in order to cross check the forecasted traffic with the real one. Forecasting error should be at an acceptable level. |
| **Customer satisfaction** | 5 *(Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | 5 *(Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | 1 *(Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Real time traffic info should be available; User in car with GPS-enabled PND. |
| **Difficulty** | 5 *(Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR5 |
|---|---|
| **Name** | Departure Time Advice |
| **Requirement Type** | Functional |
| **Description** | The system should provide, upon request, further suggestions to the users based on the current traffic prediction, about when to leave home in order to avoid congestion, for a given route. |
| **Rationale** | Based also on TomTom's Study 2 Section 3.5.1 (Commuter Needs), there is a clear desire by users not only to receive snapshots of traffic, but also to be informed about the tendency of traffic on the roads. This also satisfies the users need for understanding their given traffic situation as well as possible, and make their own driving, or even departure time, decisions. |
| **Fit Criterion (Measurable)** | After generating traffic forecasts the system keeps monitoring current traffic in order to cross check the forecasted traffic with the real one. Forecasting errors should be at an acceptable level. |
| **Customer satisfaction** | *4 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *4 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *4 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Real time traffic info should be available. |
| **Difficulty** | *4 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND |
| **Author** | D. Kehagias |

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| **Revision** | V01, 3/4/2012 |

| **ID** | FR6 |
|---|---|
| **Name** | Economical Route Suggestions |
| **Requirement Type** | Functional |
| **Description** | The system should generate suggestions on which is the most economical route both in terms of monetary cost and low emissions providing the opportunity to the user to select among alternative options. |
| **Rationale** | As seen in study 1, users do tend to be interested in explicitly economical, i.e. low cost and low emission, options. This feature will fulfill this identified user need. |
| **Fit Criterion (Measurable)** | The suggested routes as more economical should adhere to the real consumption and be cross-checked with current prices and car consumption. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *4 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *1 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Access to car data (consumption rate, etc.), online access to a gas price update service. |
| **Difficulty** | *4 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR7 |
|---|---|
| **Name** | Personalised recommendations beyond turn-by-turn guidance |
| **Requirement Type** | Functional |
| **Description** | The system should provide recommendations to the driver about which route to take e.g. by ranking and presenting first on top of a list of possible routes the one that matches the current driver's behaviour in the best possible way. Environmental footprint of each alternative route should be reported. |
| **Rationale** | Moreover, as seen in study 1, users do tend to be interested in explicitly economical, i.e. low cost and low emission, options. |
| **Fit Criterion (Measurable)** | Drivers provide positive feedback on the route suggestions. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *4 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *1 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | FR16 – Could be part of eco-coaching or use similar or the same mechanisms. |
| **Constraints (Attainable)** | Driver to confirm that the system will monitor her behaviour. A long training period might be required for more accurate recommendations. |

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| **Difficulty** | *5 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND |
| **Author** | D. Kehagias |
| **Revision** | V02, 7/4/2012 |

| **ID** | FR8 |
|---|---|
| **Name** | Multimodal route planning |
| **Requirement Type** | Functional |
| **Description** | The system should support multi-modal route planning providing it in one place, i.e. in the same application. Multi-modal information should support door-to-door info, parking information, knowledge of special events (road blocks, unusual traffic), special days, travel time, driving conditions/weather, as well as information about POIs and type of activities (latter two are for tourists). |
| **Rationale** | For achieving more eco-friendly commuting through the use of PT and environmental friendly transportation means (e.g. bicycles). |
| **Fit Criterion (Measurable)** | The users should be able to get alternative routes based on the different transportation means available at their area. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *4 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Access to PT data (e.g. timetables). |
| **Difficulty** | *5 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND; Tourists with a smartphone |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR9 |
|---|---|
| **Name** | Convenience and Efficiency in Time |
| **Requirement Type** | Functional |
| **Description** | The system should provide the most convenient and efficient route to the user, whereas eco-friendliness should not be emphasized as a first place feature but to provided as a bonus and accompanying information. |
| **Rationale** | The users are not familiar with eco-friendly navigation systems, therefore putting emphasis on this would potentially keep users from using it. According to TomTom's survey users prefer to take the most convenient and efficient route over the most eco-friendly one, therefore eco-friendliness should not be the discriminate characteristic of the suggested routes, but it should be provided as a bonus feature. |
| **Fit Criterion (Measurable)** | The user should be able to request and get alternative routes based on convenience and efficiency in time. User feedback is required for validating the suggested routes. |
| **Customer satisfaction** | 4 *(Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | 5 *(Scale from 1=hardly matters to 5=extremely displeased).* |

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| **Priority** | 5 *(Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | Some times the most convenient and efficient route may not be the most eco-friendly one. |
| **Constraints (Attainable)** | Real time traffic info should be available; User in car with GPS-enabled PND. |
| **Difficulty** | 3 *(Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR10 |
|---|---|
| **Name** | Eco-friendliness as a bonus rather than a distinct objective |
| **Requirement Type** | Functional |
| **Description** | For each calculated route according to the user selection (e.g. when the user requests to have the most efficient route in terms of time) the system should also provide information on how eco-friendly each option is. |
| **Rationale** | The majority of the users are not interested in selecting a route because it is eco-friendly. They prefer other criteria (e.g. Convenience and Efficiency, see also FR8). Therefore, in order to make the users become more sensitive w.r.t. environmental affairs, and more rapidly adopt the eco-friendly features of eCOMPASS, relevant information (e.g. emissions-related gain) should be provided as a bonus. |
| **Fit Criterion (Measurable)** | Eco-friendliness related information should appear as a secondary option or make a distinctive appearance next to the requested results. |
| **Customer satisfaction** | *3 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *2 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *4 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | The user might ignore this option if it is too distinctive. |
| **Constraints (Attainable)** | |
| **Difficulty** | *(Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR11 |
|---|---|
| **Name** | Detailed information on route options |
| **Requirement Type** | Functional |
| **Description** | The system should provide detailed information for each one of the available route options recommended to the user. The provided information could include ETA, traffic, cost, emission. |
| **Rationale** | The vast majority of the users prefer to make personal decisions rather than blindly follow a route suggestion without further examining it. |
| **Fit Criterion (Measurable)** | The user should be able to easily request and clearly read all the details of the route in order to decide which one to follow. |

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| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *4 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Access to all data sources related to each type of information should be available. |
| **Difficulty** | *4 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR12 |
|---|---|
| **Name** | Different optimisation objectives |
| **Requirement Type** | Functional |
| **Description** | The system should provide alternative routes to the user based on different objectives that the user selects (e.g. ETA, traffic, cost, emission). |
| **Rationale** | The user should be able to request more focal routes according to a specific criterion of interest (e.g. fuel consumption). |
| **Fit Criterion (Measurable)** | Appropriate elements should be available for allowing selection of the objectives that the user prefers to be taken into account on route calculation. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *4 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *4 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Access to all data sources related to each objective should be available. |
| **Difficulty** | *2 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR13 |
|---|---|
| **Name** | Number of pre-trip routes |
| **Requirement Type** | Functional |
| **Description** | When the user selects pre-route planning the system should return 3 routes maximum, but it should give to the user the option for more routes. If the user agrees, then more routes will be returned. |
| **Rationale** | Most users prefer 2 or 3 routes. |
| **Fit Criterion (Measurable)** | The list of returned routes should be limited to 3 max. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *4 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints** | |

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|---|---|
| **(Attainable)** | |
| **Difficulty** | *1 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver; tourists (for pre-planning) |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR14 |
|---|---|
| **Name** | Number of routes on the go |
| **Requirement Type** | Functional |
| **Description** | While on the go, the system should return no more than 3 routes. |
| **Rationale** | Most users prefer 2 or 3 routes while on the go. |
| **Fit Criterion (Measurable)** | The list of returned routes should be limited to 3 max. |
| **Customer satisfaction** | 5 *(Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | 4 *(Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | 5 *(Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | |
| **Difficulty** | 1 *(Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR15 |
|---|---|
| **Name** | Robust routes |
| **Requirement Type** | Functional |
| **Description** | The system should support the calculation and suggestion of "robust routes", i.e. routes less likely to incur traffic incidents and delay. |
| **Rationale** | Users who are already used to high definition traffic information almost expect their device to provide information on how reliable a given ETA is, and many users would regularly sacrifice a few minutes in travel time in order to travel on a more robust route. |
| **Fit Criterion (Measurable)** | A highlighted option for getting robust routes should be available on the user interface. The route that the system suggests should be the one that leads to rarer traffic incidents and delays. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *4 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | Some times the robust route may not be the most eco-friendly one. |
| **Constraints (Attainable)** | Real time relevant info should be available; User in car with GPS-enabled PND. |
| **Difficulty** | *4 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR16 |
|---|---|
| **Name** | Load balancing |
| **Requirement Type** | Functional |
| **Description** | The system should provide as an option the capability of returning longer alternative routes estimated to reduce congestion. In case there is an estimated gain in terms of eco-friendliness this should be clearly indicated to the user, as a bonus (in accordance to FR10). |
| **Rationale** | The majority of the users indicated that they would be willing to take detours at times if such a system would improve the overall traffic situation. |
| **Fit Criterion (Measurable)** | A list of alternative longer routes should be returned to the user upon request. |
| **Customer satisfaction** | 4 *(Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | 4 *(Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | 5 *(Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Real time traffic info should be available; User in car with GPS-enabled PND. |
| **Difficulty** | 3 *(Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR17 |
|---|---|
| **Name** | Eco-coaching |
| **Requirement Type** | Functional |
| **Description** | The system should receive driver feedback in order to be able to recognise the driver's behaviour and provide personalised recommendations that aim at improving the driving style so that it results in more eco friendly behaviour. |
| **Rationale** | This feature is necessary for coaching users (especially those who don't drive in an environment-friendly manner) to adopt more economic driving behaviour. |
| **Fit Criterion (Measurable)** | After the system receives sufficient user feedback it returns recommendations to the user on eco-friendly driving. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *3 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | FR7 |
| **Constraints (Attainable)** | |
| **Difficulty** | *5 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR18 |
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|---|---|
| **Name** | Park&Drive |
| **Requirement Type** | Functional |
| **Description** | The system should provide integrated in-car Park&Drive trip planner functionality. |
| **Rationale** | For many users a Park & Ride trip planner integrated with their car navigation system might increase their acceptance of Park & Ride functionality, in particular more than a similar application on a smartphone. |
| **Fit Criterion (Measurable)** | The system should provide accurate parking information upon request. |
| **Customer satisfaction** | 3 *(Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | 2 *(Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | 3 *(Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Real time parking info should be available; User in car with GPS-enabled PND. |
| **Difficulty** | 3 *(Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR19 |
|---|---|
| **Name** | Multi-modal route comparison |
| **Requirement Type** | Functional |
| **Description** | The system should provide the functionality of comparing trips using different transportation modes. |
| **Rationale** | Informing the user on which is the optimal route according to user-specified criteria. |
| **Fit Criterion (Measurable)** | Different trip options should be returned for different transportation modes. |
| **Customer satisfaction** | 5 *(Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | 5 *(Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | 5 *(Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | The system should give priority to eco-friendly routes. |
| **Difficulty** | *3 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR20 |
|---|---|
| **Name** | Real-time incidents for multi-modal route calculation |
| **Requirement Type** | Functional |
| **Description** | The system should take into account real-time dynamic events before calculating any route that involves multiple transportation modes (e.g. weather a bus stop is available or out of order due to works). |

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| **Rationale** | To receive valid and not outdated information while planning a route (either pre-trip or on the go). |
| **Fit Criterion (Measurable)** | If an incident dynamically occurs this should be taken into account by the multi-modal routing application. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Access to real-time relevant information should be available. |
| **Difficulty** | *5 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Driver with a PND |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | FR21 |
|---|---|
| **Name** | Major Traffic Change Prediction |
| **Requirement Type** | Functional |
| **Description** | The system should be able to provide traffic state prediction and particularly to notify the driver when traffic changes are anticipated to occur. |
| **Rationale** | Especially useful in fleet management use cases when the delivery time is considered as a highly important KPI (through service quality). |
| **Fit Criterion (Measurable)** | When rapid traffic changes are about to occur the system should notify the driver about this situation by posting e.g. sound alerts, or other means of user notification. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Real time traffic info should be available. |
| **Difficulty** | *5 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Drivers, Fleet drivers with a PND. |
| **Author** | D. Kehagias |
| **Revision** | V01, 10/4/2012 |

| **ID** | FR22 |
|---|---|
| **Name** | Automated exchange of mission information |
| **Requirement Type** | Functional |
| **Description** | The system should be able to provide an appropriate interface for exchanging information between the vehicle and the back-office (and vice versa) in an automatic way. |

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| **Rationale** | To facilitate the driving experience of fleet drivers and to allow flexibility in missions. |
| **Fit Criterion (Measurable)** | An appropriate interface to provide such facility. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | |
| **Difficulty** | *5 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private Vehicle Drivers, Fleet drivers with a PND. |
| **Author** | D. Kehagias |
| **Revision** | V01, 12/4/2012 |

### 4.3.2 Data Requirements

| **ID** | DR1 |
|---|---|
| **Name** | Traffic Data |
| **Requirement Type** | Data |
| **Description** | Access to real time traffic data should be available |
| **Rationale** | To fulfill requirements FR3, FR4, FR5,. |
| **Fit Criterion (Measurable)** | Traffic data should be displayed on the end user device in all relevant use cases. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Real time data. |
| **Difficulty** | *3 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Route calculation modules for private vehicle and fleet drivers |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | DR2 |
|---|---|
| **Name** | PT data |
| **Requirement Type** | Data |
| **Description** | Access to PT should be available (i.e. timetables for various PT) |
| **Rationale** | To enable efficient multimodal routing. |
| **Fit Criterion (Measurable)** | The system should be able to guide the user through routes in conjunction with Public Means for Transportation. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *4 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Real time changes in data is required (for instance when a bus stop is out of order to construction works, the system should be aware). |

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| **Difficulty** | *4 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Multi-modal routing algorithms and modules |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | DR3 |
|---|---|
| **Name** | Parking data |
| **Requirement Type** | Data |
| **Description** | The system should interface with valid Parking data (for reading) |
| **Rationale** | To enable efficient multimodal routing in which private vehicle is also involved. |
| **Fit Criterion (Measurable)** | The system should recommend to the user to park her vehicle in a nearby parking place when such a place is available. |
| **Customer satisfaction** | *4 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *4 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Online information should be updatable e.g. in order for the system to avoid recommending a parking place which is full. |
| **Difficulty** | *(Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Multi-modal routing algorithms and modules |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | DR4 |
|---|---|
| **Name** | Real time fuel cost data |
| **Requirement Type** | Data |
| **Description** | The system should connect online and retrieve fuel cost data. |
| **Rationale** | In order to be able to perform valid calculations on the required cost by a specific route. |
| **Fit Criterion (Measurable)** | Validate precision of the calculated cost by comparing it against real fuel consumption. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | The system should be adaptable to price fluctuations. |
| **Difficulty** | *2 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Energy Optimization routing algorithms |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | DR5 |
|---|---|
| **Name** | User location data |
| **Requirement Type** | Data |
| **Description** | The system should be able to retrieve user location data. |
| **Rationale** | In order to be able to perform route optimization by any means. |

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|---|---|
| **Fit Criterion (Measurable)** | To properly display the real user's location on a digital map. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | GPS coverage |
| **Difficulty** | *1 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Energy Optimisation routing algorithms |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | DR6 |
|---|---|
| **Name** | Environmental data |
| **Requirement Type** | Data |
| **Description** | The system should be able to read various types of environmental data. |
| **Rationale** | In order to be able to perform route optimization in terms of environmental footprint when required. |
| **Fit Criterion (Measurable)** | The system reads data from environmental data gathering stations at real time. |
| **Customer satisfaction** | *4 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *3 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *4 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | The system should interface Environmental data sources. |
| **Difficulty** | *2 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Energy Optimisation routing algorithms |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | DR7 |
|---|---|
| **Name** | Fleet management data |
| **Requirement Type** | Data |
| **Description** | The system should be able to retrieve various data on the status of the fleet. |
| **Rationale** | In order to be able to perform fleet management planning. |
| **Fit Criterion (Measurable)** | To be able to know the position of other vehicles in the fleet. |
| **Customer satisfaction** | *4 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *4 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *4 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | The vehicle on which the system will be installed should belong to a fleet. |

| | |
|---|---|
| **Difficulty** | *2 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Fleet managers, drivers. |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

## 4.4 Non-Functional Requirements

This section lists the non-functional requirements using the template presented in Table 3. Non-functional requirements determine how the functional requirements are reflected on specific attributes of the system.

### 4.4.1 Look and Feel Requirements

| **ID** | LFR1 |
|---|---|
| **Name** | Appealing to short-distance commuters |
| **Requirement Type** | L&F – Appearance |
| **Description** | The application should be more appealing to short-distance commuters. |
| **Rationale** | In order for eCOMPASS services and applications to make a difference in the future of urban transportation, they need to appeal to short-distance commuters in a way current application do not, as to increase the use of navigation and trip planning applications and services in commuting in general, as TomTom's interviews and questionnaires results clearly indicate that users tend to not use navigation or trip planning services at all in their daily commute. |
| **Fit Criterion (Measurable)** | When the user requests a short route (below 15Km) the application's view becomes more user friendly, |
| **Customer satisfaction** | *4 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *3 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *4 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | |
| **Difficulty** | *4 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | All users |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | LFR2 |
|---|---|
| **Name** | Familiar appearance |
| **Requirement Type** | L&F – Appearance |
| **Description** | The system's appearance should be similar to existing navigation systems. |
| **Rationale** | The users are familiar with those systems and there is no clear indication that they would expect any dramatic changes. |
| **Fit Criterion (Measurable)** | User interface looks familiar to e.g. TomTom's PNDs. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *4 (Scale from 1=hardly matters to 5=extremely displeased).* |

| | |
|---|---|
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Some functionalities that are not supported by existing systems should be hidden. |
| **Difficulty** | *1 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | All users |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | LFR4 |
|---|---|
| **Name** | Internationalisation |
| **Requirement Type** | L&F – Personalisation and Internationalisation |
| **Description** | The system should be adaptable to country-specific measurement units and currencies, including the symbols and decimal conventions. |
| **Rationale** | To ensure that the users will not have to struggle with the different conventions to each country. |
| **Fit Criterion (Measurable)** | Support for all conventions within EU. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *4 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *3 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Some functionalities that are not supported by existing systems should be hidden. |
| **Difficulty** | *2 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | All users |
| **Author** | D. Kehagias |
| **Revision** | V01, 12/4/2012 |

### 4.4.2 Usability and Humanity Requirements

| **ID** | UHR1 |
|---|---|
| **Name** | Ease of use |
| **Requirement Type** | Usability and Humanity - Ease of Use |
| **Description** | The system should be easy to use even by people who are not very familiar with PND. |
| **Rationale** | Ease of use and better adaptability. |
| **Fit Criterion (Measurable)** | To be understandable by users who are not familiar with PND devices. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | |
| **Difficulty** | *2 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | All users, user interfaces |
| **Author** | D. Kehagias |

| | |
|---|---|
| **Revision** | V01, 3/4/2012 |

| **ID** | UHR2 |
|---|---|
| **Name** | Easy to learn |
| **Requirement Type** | Usability and Humanity - Learning |
| **Description** | The system should be easy for a non IT expert to learn. |
| **Rationale** | Ease of use and better usability. |
| **Fit Criterion (Measurable)** | To be understandable by users not familiar with PND devices. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | |
| **Difficulty** | *2 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | All Users |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | UHR3 |
|---|---|
| **Name** | Use common symbols and words |
| **Requirement Type** | Usability and Humanity - Understandability and Politeness |
| **Description** | The product shall use unambiguous symbols and words generally understandable by the user community. |
| **Rationale** | To allow wide acceptance and usability. |
| **Fit Criterion (Measurable)** | The UI includes only naturally understandable symbols. |
| **Customer satisfaction** | *4 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *4 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *3 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | |
| **Difficulty** | *2 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

### 4.4.3 Performance Requirements

| **ID** | PR1 |
|---|---|
| **Name** | Real-time response |
| **Requirement Type** | Performance – Speed and Latency |
| **Description** | Performance should be at the best possible level for real-time response. |
| **Rationale** | Private Car users are not willing to accept more than 5 minutes delay for an alternative route in order to avoid congestion. Almost the same amount of time holds when they are travelling back home. |

| | |
|---|---|
| | The decision should be at a fast human level, therefore the response of the system should be not more than a few seconds. |
| **Fit Criterion (Measurable)** | Time from the submission of request to the response |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *3 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | |
| **Difficulty** | *4 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | D. Kehagias |
| **Author** | V01, 3/4/2012 |
| **Revision** | |

| **ID** | PR2 |
|---|---|
| **Name** | Appropriate time response on the delivery of traffic prediction information. |
| **Requirement Type** | Performance – Speed and Latency |
| **Description** | The response of the traffic tendency, as well as the current traffic report should be at a human acceptable level so that the right information is delivered to users at the right time. This would prevent users to have to re-plan their routes again and again in order to meet possibly new needs based on updated information. |
| **Rationale** | Derived from TomTom's studies, which draw as a conclusion that a high cost of thinking, i.e. the right information not being delivered to users at the right time, might keep users from actually exercising the best of their options. |
| **Fit Criterion (Measurable)** | Users' satisfaction |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | |
| **Difficulty** | *4 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | All users |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | PR3 |
|---|---|
| **Name** | Accurate Suggestions |
| **Requirement Type** | Performance – Precision or Accuracy |
| **Description** | The system should provide accurate suggestions regarding the alternative routes. |
| **Rationale** | Derived from one of TomTom's studies, even those users who were open to the idea of getting route suggestions stated that they might |

| | |
|---|---|
| | quickly lose interest once they experience a few bad routes. |
| **Fit Criterion (Measurable)** | Users' satisfaction |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | |
| **Difficulty** | *4 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | All users |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

### 4.4.4 Operational and Environmental Requirements

| **ID** | OR1 |
|---|---|
| **Name** | In car use |
| **Requirement Type** | Operational and Environmental - Expected Physical Environment |
| **Description** | The product shall be able to be docked in a car. |
| **Rationale** | For enabling all of the foreseen functionalities on the go. |
| **Fit Criterion (Measurable)** | Suitable docking equipment to allow the device to be attached in the vehicle. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | The docking mechanism should provide stability. |
| **Difficulty** | *1 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | All drivers. |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | OR2 |
|---|---|
| **Name** | Internet access |
| **Requirement Type** | Operational |
| **Description** | The system should have a direct connection to the Internet. |
| **Rationale** | For enabling real-time updates of required information (e.g. traffic data). |
| **Fit Criterion (Measurable)** | To be online at the operational level. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | The docking mechanism should provide stability. |

| | |
|---|---|
| **Difficulty** | *1 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | All drivers. |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

### 4.4.5 Maintainability and Support Requirements

| **ID** | MSR1 |
|---|---|
| **Name** | Automatic updates |
| **Requirement Type** | Maintenance |
| **Description** | The system should be able to automatically update to the latest version |
| **Rationale** | To guarantee stability in performance |
| **Fit Criterion (Measurable)** | Relevant functionality to allow automatic updates. |
| **Customer satisfaction** | *4 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *4 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *4 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | Online Internet access |
| **Difficulty** | *(Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | All users |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

### 4.4.6 Security Requirements

| **ID** | SR1 |
|---|---|
| **Name** | Driver authentication |
| **Requirement Type** | Security - Access |
| **Description** | The system should support driver authentication so as to be able to provide personalized recommendations, when necessary. |
| **Rationale** | As required by FR17 (eco-coaching) |
| **Fit Criterion (Measurable)** | The system asks for user's credentials in order to allow access after a long time of inactivity. |
| **Customer satisfaction** | *3 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *3 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *4 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | |
| **Difficulty** | *1 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | SR2 |
|---|---|
| **Name** | Data privacy |
| **Requirement Type** | Security-Privacy |

| | |
|---|---|
| **Description** | Any personal data should be protected. |
| **Rationale** | Protection of sensitive data |
| **Fit Criterion (Measurable)** | Access of personal data should be restricted to the device |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | User should be aware of any privacy issues. |
| **Difficulty** | *2 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | All users |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

| **ID** | SR3 |
|---|---|
| **Name** | User aware of information practices |
| **Requirement Type** | Security-Privacy |
| **Description** | The system shall make its users aware of its information usage practices before collecting data from them. |
| **Rationale** | Protection of sensitive personal data |
| **Fit Criterion (Measurable)** | User should be notified and confirm before the system will be allowed to collect data. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | User should be aware of any privacy issues. |
| **Difficulty** | *2 (Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | All users |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

### 4.4.7 Cultural Requirements

| **ID** | CR1 |
|---|---|
| **Name** | Comply with country-specific restrictions |
| **Requirement Type** | Cultural |
| **Description** | The system should be able to provide information across the cultural boundaries between countries within European Union, e.g. tolls, driving hours, city access, etc. |
| **Rationale** | Fleet drivers who drive across European cities should not decline from their mission due to such issues. |
| **Fit Criterion (Measurable)** | The system should provide country-specific information when the driver enters a new country along his route. |
| **Customer satisfaction** | *4 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |

| | |
|---|---|
| **Priority** | *4 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | The scope of countries in which the system will operate should be defined in advance (e.g. EU). The different country codes should be taken into account for all the countries to be included. |
| **Difficulty** | *(Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Fleet drivers |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

#### 4.4.8 Legal Requirements

| **ID** | LR1 |
|---|---|
| **Name** | The recommended routes should comply with law restrictions. |
| **Requirement Type** | LR |
| **Description** | The system should provide only those route recommendations that are in line with law restrictions e.g. taking into account driving allowed times, restricted roads, etc. |
| **Rationale** | To protect users from violating the law. |
| **Fit Criterion (Measurable)** | The recommendations should adhere to law restrictions for each specific area-country. |
| **Customer satisfaction** | *5 (Scale from 1=uninterested to 5=extremely pleased)* |
| **Customer dissatisfaction** | *5 (Scale from 1=hardly matters to 5=extremely displeased).* |
| **Priority** | *5 (Scale from 1=low priority to 5=highest priority).* |
| **Conflicts** | |
| **Constraints (Attainable)** | The legislative regulations of each supported country should be known. |
| **Difficulty** | *(Scale from 1=low difficulty to 5=extreme difficulty).* |
| **Actors** | Private car, Fleet management drivers. |
| **Author** | D. Kehagias |
| **Revision** | V01, 3/4/2012 |

### 4.5 Conclusions

This Section presented a survey of the commonest state-of-the-art methodologies and relevant standards on requirement analysis. The requirements specification methodology and presentation template adopted by eCOMPASS mostly relies on the Volere approach because it is broader in scope and fits better to the requirement elicitation needs of the eCOMPASS project. The Volere methodology comprises a general template for presenting the layout and structure of the requirements specification document, as a result of the requirements elicitation and analysis processes. Based on this methodology the eCOMPASS requirements specification process was performed addressing the user needs and preferences that are described in Section 3 after performing user surveys, and also based on information from existing or previous projects in the field. The surveys were conducted on behalf of two industrial partners PTV and TomTom in the fields of fleet management systems and general personal navigation devices, respectively.

The results of the user needs analysis based on the Volere template are outlined in different types of requirements. On the one hand we have documented the functional requirements that represent the specific functionalities expected to be supported by the envisaged eCOMPASS platform and applications. On the other hand we have recorded the non-functional requirements that represent specific constraints of the system that should be satisfied for the functional requirements to be fulfilled. Along with the functional requirements, we also recorded specific data requirements that represent specific data sources, with which the system should be interfaced in order to allow the envisaged functionality to be implemented as it is described by the functional requirements. All requirements are prioritized.

The overall requirements elicitation process resulted in:

- 22 functional requirements for all users of the system (e.g. private vehicle, fleet drivers and tourists)
- 7 data requirements
- 18 Non-Functional Requirements of which:
    - *4 Look and Feel Requirements*
    - *3 Usability and Humanity Requirements*
    - *3 Performance Requirements*
    - *2 Operational and Environmental Requirements*
    - *1 Maintainability and Support Requirement*
    - *3 Security Requirements*
    - *1 Cultural and Political Requirement*
    - *1 Legal Requirement*

The most important functional requirements refer to the system's support for traffic data for all available routes, which reflect the user need to decide on his/her own about which route to take, as well as traffic prediction mechanisms and notification on rapid traffic changes. Also personalized recommendations beyond turn-by-turn instructions seem to be a desirable feature as well as convenience and efficiency in time. As eco-friendliness is not listed among the most popular features that users look for, this leads to the requirement of having this option as a subtle characteristic of the user interface. Other more advanced functionalities include Park&Ride and eco-coaching. When it comes to non-functional requirements, priority is given to ease of use and usability, especially by non-experts, as well as easiness to learn. Moreover performance and prediction accuracy are listed among the most important non-functional requirements. Other non-functional requirements include: online access, personal data privacy, automatic updates.

# 5 Summary & Conclusions

In the previous sections, we have documented the design, execution, and evaluation of the user research conducted for the eCOMPASS project. After a brief stakeholder analysis, user groups and their segmentation for the four eCOMPASS application scenarios were analyzed:

- Private vehicles
- Vehicle Fleets
- Urban residents with smartphones
- Tourists with smartphones

Based on previously conducted related research, in-depth interviews were scripted and conducted with 25 representative users. Based on the results, a broader online questionnaire was designed, to which a total of 206 participants responded.

The issue addressed and question asked centered around the participants' urban transportation needs and habits in general, and their stance towards acting eco-friendly. More specifically, among other topics, we queried users about

- Daily relevance of route planning services and applications
- Alternative routes and means of transport
- Importance of traffic information and forecasts
- Park & ride services
- Multi-Modal alternatives
- Traffic load-balancing schemes
- Active driver feedback systems
- Tourist itinerary planning
- Fleet management.

Results and conclusions were rich and diverse, some outstanding points being:

- Users are reluctant to consider eco-friendliness a key factor in transport decisions, even though many participants did consider themselves eco-friendly in general. Convenience and efficiency in terms of time are the most prominent considerations in transport for most. Hence, eCOMPASS features should focus on improving the user experience in these fields in ways, which also benefit the environment. For instance, helping drivers to avoid congestion increases convenience and efficiency, while also reducing emissions.
- Daily relevance of route planning services is mediocre, since many users feel they know their daily commute well enough. In order to increase the use of applications and services on a daily basis, a prerequisite for them to help reduce the eco-footprint of transportation, the information and features provided for daily commuters and drivers in familiar areas need to be improved. This is a clear opportunity for eCOMPASS.
- Conveying traffic information and traffic forecasts to users not only for a planned route, but for all roads relevant for their journey, seems key to an improved user experience and more daily relevance. Many users long for a way to monitor all relevant traffic so they can make their best decisions, but no current solution can really provide this – another clear eCOMPASS opportunity.
- When confronted with more complex ideas to reduce congestion for all, like traffic load-balancing schemes, users seem to be surprisingly open-minded. In fact, most users stated that they would be willing to take longer, slower roads at times, if they knew that this would improve routes for all users on average. Hence, this topic is worth investigating further in eCOMPASS, as there is a good chance that resulting features would find acceptance among users.

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# A Appendix

## A.1 Script for Interviews with Private Vehicle Drivers and Smartphone Users

### Introduction

1. First I want to ask how your experience is with the TomTom device?
2. Are there things you find unexpectedly good or bad?
3. How many years of experience do you have with a TomTom device?
4. How often do you use the device? When? Do you have other navigation equipment?
5. For which purposes do you drive? When and where do you use the device most?
6. How often is the device switched on while you are on the go? For familiar and unfamiliar journeys? Short and long distances?
7. Do you always have a voice enabled to hear driving directions?

### Traffic and Route Choices

8. If the unit is turned on during the trip, do you always enter a destination? If not, why not?
9. How do you determine your route?
10. Do you sometimes deviate from your original route? When and why? How?
11. How do you deal with traffic? Do you use your device for it? Do you use other information?
12. In driving view, do you use 2D or 3D?
13. How do you deal with alternative routes offered? How long can you wait for an alternative (calculation time)? Are there alternatives to which you are averse? Why?
14. Do you get enough information to make a good choice between different routes?
15. Do you have a sufficient overview of the traffic relevant for your route? How about the trade-off with route instructions?
16. Are you getting traffic information on time?
17. How exactly do you determine which route to take?
18. Does eco-friendliness play a role?
19. Would you want a choice of alternatives? How many?
20. To what extent are CO2 emissions an issue here?
21. Is it important to work with forecasts? Are some roads more sensitive to congestion than others? Would you like richer, but more complex information on traffic?
22. Would you sometimes choose a route that has a more reliable ETA, even if it was a little slower?
23. Would you like to receive an indication of the eco-friendliness of routes?

### Multi-Modal Transport

24. Do you sometimes use or consider public transportation? What about park & ride? Should corresponding public transportation timetables be included in car navigation?
25. Would you like a multi-modal trip planner on your smartphone which compares routes using different means o transport? Should such an application provide feedback on the eco-footprint of a route?

### Tourism Features

26. Would you like a smartphone app which can suggest itineraries when you are on vacation in a new city?
27. Which type of information would be relevant for you regarding such tourist itineraries?
28. To what extent does eco-friendliness play a role for you here?

## A.2 Online Questionnaire for Private Vehicle Drivers and Smartphone Users

Dear participant of the TomTom testers pool!
We would like to ask you some questions on:

- new mobility concepts,
- optimization in route planning, and
- the role of the environment.

The questionnaire takes about 20 minutes.
We would like to thank you in advance; we really appreciate your opinion.

1. Do you have a valid driver license? *
   (Yes/No)
2. Do you have a car at your disposal (or another motorized vehicle)? *
   (Yes/No/Other vehicle, namely:)
3. For what reason do you mostly use your car (or other motorized vehicle)? *
   (Daily commute (home-work)/Mainly business trips/Mainly private trips/Business as well as private trips/Other, namely:)
4. Which statement describes best how you think about driving a car? *
   (Driving a car is a pleasure/Driving a car is stressful/Driving a car is a means of transport/Something completely different:)
5. To what extent does lowering CO2 emission play a role in your life in relation to car driving? *
   (No role at all=1…10=A very big role)
6. How do you see yourself when you go for a long or short trip? *
   (I am a planner/I am an explorer/Both/None of them)
7. What means of transport do you use most regularly? *
   (Car / motorcycle/Public transport/Slow motorized traffic (e.g. mopeds, micro cars, scooters)/Bicycle/Walking/Other, namely:)
8. I see myself as an environment-friendly, ecologically-minded person. *
   (Totally disagree/Somewhat disagree/Somewhat agree/Totally agree)
   Feel free to explain your choice:
9. To what extent are you environment-friendly with respect to your housekeeping (e.g. waste separation)? *
   (Not environment-friendly at all=1…10=Very environment-friendly)
10. To what extent are you environment-friendly with respect to travel (e.g. not taking the car)? *
    (Not environment-friendly at all=1…10=Very environment-friendly)
11. To what extent is your choice of a means of transport determined by the following motives:
12. (Good for my health/Reduce costs/Environment-friendly/Convenience/Efficiency (time saving)/ Availability of alternatives), (Unimportant=1…5=Very important)
13. How often do you currently use a smart phone in the car for navigation purposes? *
    (I don't have a smart phone/Daily/Weekly/Montly/Less than once a month/Almost never/Never)
14. How often do you currently use a navigation system (not a smart phone with navigation software)? *
    (Daily/Weekly/Montly/Less than once a month/Almost never/Never)
15. What kind of navigation system do you currently use most frequently? *
    (Built-in navigation sytem/TomTom navigation system (not built-in)/Other brand (not built-in))
16. Do you have traffic information on your navigation system? *

(Yes, and it is a paid service/Yes, and it will always be for free/No)

17. How often do you use a navigation system on your home work route? *
    (Not applicable/(Almost) always/Often/Sometimes/Not so often/(Almost) never)
18. What is the distance between your home and work location? *
    (Not applicable/Less than 15 km/Between 15 and 30 km/Between 15 and 30 km/Between 30 and 45 km/Between 45 and 60 km/Between 60 and 75 km/More than 75 km)
19. How many useful alternative routes for the car do you have on your home-work route? *
    (Not applicable/1 route/2 routes/3 routes/4 routes/5 routes/6 routes or more)
20. Regarding your home-work route, how many alternative routes would you like to compare on your navigation system in one overview, before you leave? *
    (1 route/2 routes/3 routes/4 routes/5 routes/6 routes or more)
    Feel free to comment:
21. And with respect to a trip of say 1.5 hours, how many alternative routes would you like to compare on your navigation screen in one overview, before you leave? *
    (1 route/2 routes/3 routes/4 routes/5 routes/6 routes or more)
22. Can you indicate what kind of information you would like to see about this route, or routes? Assume traffic information is available.
23. When do you tend to deviate from a route you know well if there is a faster alternative available? *
    (Almost always/Only if the estimated time gain is substantial/Almost never),
    Feel free to comment:
24. When do you tend to deviate from a route you know well if there is a more environment-friendly alternative available? *
    (Almost always/Only if the estimated time gain is substantial/Almost never),
    Feel free to comment:
25. To what extent is it important to know what this faster (or more environment-friendly) alternative entails (e.g. taking bigger or smaller roads, a detour)? *
    (Unimportant=1…10=Very important)
    Feel free to comment:
26. Imagine you have traffic information on your navigation system. How important would you think it is to know that it is, say, 80% sure that the jam further ahead is as long as it is now once you get there? *
    (I don't know/Very important/Important/Neutral/Not so important/Not important at all)
    Feel free to comment:
27. If it is busy and you go to your work by car, to what extent would you choose a slower route (say 5 minutes longer) with a certain arrival time, or a faster route with a less certain arrival time? *
    (Certain but slower route=1…10= Faster but uncertain route)
    Feel free to comment:
28. If it is busy and you go home by car, to what extent would you choose a slower route (say 5 minutes longer) with a certain arrival time, or a faster route with a less certain arrival time? *
    (Certain but slower route=1…10= Faster but uncertain route)
    Feel free to comment:
29. For the overall traffic flow, it might be better if some people take a route that is somewhat longer or slower. Eventually, on average, everybody (including yourself) can profit from this. Imagine a trip of 75 kilometers that takes 1 hour... How many

minutes additional travel time would you be prepared to accept in order to reduce congestion for all, if you are on your way to work? *
(None/1 minute/2 minutes/3 minutes/4 minutes/5 minutes/6 minutes/7 minutes/8 minutes/9 minutes/10 minutes or more)

30. And if you are on your way home? How many minutes additional travel time would you be prepared to accept in order to reduce congestion for all? *
(None/1 minute/2 minutes/3 minutes/4 minutes/5 minutes/6 minutes/7 minutes/8 minutes/9 minutes/10 minutes or more)
31. How many extra kilometers would you be prepared to accept, on top of the 75 kilometers, in order to reduce congestion for all, if you are on your way to work? *
(None/1 km/2 km/3 km/4 km/5 km/6 km/7 km/8 km/9 km/10 km or more)
32. And if you are on your way home? How many extra kilometers would you then be prepared to 1 km accept, on top of the 75 kilometers, in order to reduce congestion for all? *
(None/1 km/2 km/3 km/4 km/5 km/6 km/7 km/8 km/9 km/10 km or more)
Feel free to comment:
33. Suppose that you personally would have no cost for driving the car (petrol etc.). To what extent would you decide to drive an energy-saving car (e.g. an electrical vehicle) or not? *
(1= Not energy-saving…Energy-saving=10)
Feel free to comment:
34. If we were able to optimize your route economically, to what extent is saving fuel or lowering CO2 emission important to you? *
(Saving fuel=1…10= Lowering CO2 emmision)
Feel free to comment:
35. Do you ever make use of Park and Ride (P+R), i.e. you park your car near a public transport station in order to continue your trip by public transport? *
(Very often/Often/Sometimes/Not so often/Never/I don't know)
36. To what extent would you be interested to know ‘live’, while you drive your car, how much fuel your car is using, so you can try to reduce fuel consumption? *
(Not interested at all=1…10=Very interested)
Feel free to comment:
37. To what extent would you be interested to read afterwards, on a personal website, how much fuel you used on what part of your route, so you can try to reduce fuel consumption? *
(Not interested at all=1…10=Very interested)
Feel free to comment:
38. To what extent would you be interested to use an application (app) on your smartphone with which you can plan and compare routes using different transportation modes (public transport, bicycle, car, etc.)? *
(Not interested at all=1…10=Very interested)
Feel free to comment:
39. To what extent would you (more often) use Park & Ride if you would have a navigation app for the car where public transport schedules are included? *
(As much as now=1…10=Much more than now)
Feel free to comment:
40. If you would have to choose between merely car-navigation in a navigation system (e.g. a TomTom device), or navigation software for your smart phone where public transport schedules are included, what would you choose? *
(Car-navigation in a navigation device/Navigation software including public transport schedules on your smartphone/I don't know)

Feel free to comment:

41. If you are on vacation in a new city, and assuming that roaming (data) cost is not at stake, how intensively do (or would) you use your smart phone to inform yourself about your holiday location? *
    (Very intensive/Rather intensive/Moderately intensive/Not very intensive/Not at all)
42. What kind of information do (or would) you look up on your smartphone on your city vacation?
43. Imagine you want to explore an unknown city as a tourist and want to visit several locations. How important are the following?
    (Area of interest (e.g. architecture, history, fine arts, technology, sports, etc.)/Type of activity (e.g. museum, event, outdoor, walking tour, etc.)/Costs of activities (e.g. admissions)/Convenience of route (ease of getting around, short distances)), (Unimportant=1…5=Very important)
44. If you could choose between a traditional paper travel guide and a digital version on your smart phone that includes up-to-date information, which one would you choose? *
    (The paper travel guide/The digital travel guide/I don’t know)
45. If you have any general comments, feel free to write them down here:

Thank you very much for your help!