GUIDE 2 WEAR
mobile devices for the future traveller

Public transport services with wearable devices for different mobility types

ERA-NET TRANSPORT III **Flagship Call 2013 "Future Travelling"**

Final Report

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1 Executive Summary

The project Guide2Wear (Public transport services with wearable devices for different mobility types) was an ERA-NET supported project with national funding within the flagship call initiative 2013 „Future Travelling". Seven partners from research institutes and companies of five countries or regions (Germany, Austria, Sweden, Flanders, and Basque Country) worked together. The consortium united experts from many different faculties, e.g. psychology, sociology, transport, computer science, geography, economy, and jurisprudence.

Guide2Wear mainly dealt with the idea of improving intermodal mobility for passengers. The main objective was to increase the understanding of individual mobility behaviour and facilitate the use of environmental friendly transport modes by providing required information for passengers fast, correct and conveniently.

Information is an important aspect for mobility decisions, dealing as driver or barrier for specific modes of transport. Besides content, the presentation of the information is particularly significant for the acceptance. New media, such as wearable devices, offer new ways of presenting information in a convenient manner. However, they are rarely used for this purpose, yet. The project took a major step forward in information providence, support and passenger guidance by using wearable devices (especially smart-watches).

The first year of Guide2Wear was mainly related to providing an overview on technological aspects of wearable devices, transportation related IT services as well as on user requirements and legal aspects. Besides, the research focussed on gaining a deeper view into the influence of new technology on mobility behaviour. For this purpose, mobility patterns of users of new mobility services were observed in a tracking study. The combination of all relevant findings – from a technological, system-related, legal, and user-centred perspective – led to the selection, and specification of hardware, software functions and design, manifested in the prototype description.

During the second year the prototype of a PT-passenger navigation system on smartwatches was developed, tested and demonstrated. Test users consider the prototype to be intuitively understandable, helpful, and convenient, but see potential to improve the utility of the information provided. The project was evaluated and a handbook with recommendations was prepared.

The Final Conference took place in Vienna in June 2016. All deliverables including this Final Report will be available on the Guide2Wear website http://www.guide2wear.eu/.

2 Project Context and Objectives

Mobility can be considered a basic need. For a long time, the transport system has been dominated by the antipodes of individual car transport and public transport. During the last decade, information systems emerged either supporting car transport (GPS based navigation systems, mobile phone parking) or public transport (navigation, real-time information, smart cards, and mobile phone tickets). Today, we are facing a change of the traditional transport system, as new “semi-public” transport modes like bike-, ride- or car-sharing are becoming more and more important across Europe. Moreover, many European cities experience a “renaissance” of walking and cycling (nowadays also electric cycling) that is also combined with other transport modes, as well.

Travelling with more than one mode of transport still makes a journey and the associated payment procedures fairly complex. Currently, information systems for multi- or intermodal travelling are fragmentary and often not adapted to the travellers’ needs. This is also a reason, why some user groups are still reluctant to use public transport. The overall goal of Guide2Wear was to support intermodal mobility behaviour by providing appropriate information in a comfortable way.

Available applications include intermodal routing apps or integrated smartcards for both public transport and bike- or car-sharing schemes. The state-of-the-art navigation functionalities differ significantly, ranging from pre-trip information systems to solutions providing interactivity and real-time reaction on unexpected situations as known from car navigation. But in contrast to car drivers, public transport users, who either walk or cycle to and from the station or bus stop, cannot use devices which are permanently fixed. Instead they might have to carry a smartphone in their hand or pocket which makes keeping an eye on the smartphone very difficult, especially if luggage is carried or a walking aid is used. Wearable devices as navigation tools offer a solution to this problem.

Besides, with respect to the rise of smart cities and ubiquitous computing, the next generation of information and communication technologies will dramatically change our way of access to information. In the transport sector of the future, new wearable devices, such as watches, glasses, or buttons will actively interact with the passengers as well as transport vehicles, information systems, access and payment points etc.

As a step into this direction, Guide2Wear developed a public transport navigation system on a wearable device to showcase applicable mobile services for the traveller of the future using wearable devices. Starting point of the development was a thorough examination of all relevant circumstances and framework conditions including technological aspects of the hardware, legal prerequisites, available PT related (competing) services, and current behaviour as well as unfulfilled demands and expectations of supposed users of mobility services. These examinations started with the analysis of different wearable devices, their suitability and barriers to be a platform for mobility services as well as their potential impact. Afterwards, the relevant regulatory frameworks that differ throughout Europe were analysed with regard to the social and legal questions dealing for example with data privacy, responsibility and compensation. Additionally, service-related demands of different user groups as well as requirements of relevant stakeholders were identified. In order to develop a PT service meeting the demands of supposed users, the (mobility) behavioural impacts of some innovative PT services were analysed. For this purpose, an innovative smartphone based data collection tool in terms of a tracking app developed by InnoZ adapted and improved for Guide2Wear was applied. It allowed automatically identify routes and distances of trips as well as transportation modes.

In all of these examinations, smartwatches turned out to be the best suited wearable devices. On-trip navigation as well as support in ticket purchase and the connection to other transportation modes were identified as most important and helpful functions. The PT navigation system used in Guide2Wear was developed by Fraunhofer for smartphones in a former project. It identifies and suggests door-to-door connections for public transport including the first and last mile to and from the PT stops using another mode of transport. While keeping a high standard of accuracy, it is as comfortable as a car navigation system. In Guide2Wear, this system was adapted to smartwatches as additional user interface, providing additional functions such as information about bike sharing and a showcase for ticket purchase.

3 Project Structure

The project Guide2Wear (Public transport services with wearable devices for different mobility types) was an ERA-NET supported project within the flagship call initiative 2013 „Future Travelling“. It was officially started 2014, September 1st and lasted for two years. The core consortium was composed of experts from

- Fraunhofer Institute for Transportation and Infrastructure Systems IVI, Dresden, Germany
- Innovationszentrum für Mobilität und gesellschaftlichen Wandel, InnoZ, Berlin, Germany
- FACTUM Chaloupka & Risser OG, Vienna, Austria
- University of Natural Resources and Life Sciences, BOKU, Vienna, Austria
- Swedish National Road and Transport Research Institute, VTI, Linköping, Sweden
- Transport & Mobility, TML, Leuven, Belgium (Flanders)
- CodeSyntax Internet Solutions, Eibar, Spain (Basque Country)

The participants covered multiple disciplines, such as psychology, sociology, transport, computer science, economy and geography.

Two additional partners worked as subcontractors:

- Tecnalia Research & Innovation, Derio, Spain (Basque Country)
- Kanzlei Dr. Gerfried Höfferer, Vienna, Austria

The project was supported by a large number of associated partners, including transport operators who provided their data for the prototype (Wiener Linien, Dresdner Verkehrsbetriebe), service providers, public institutions, research institutes, as well as research and transport cluster organisations.

3.1 Work Packages

The project was divided into six work packages, including four scientific work packages (see Figure 1), one management work package and one dealing with dissemination activities.

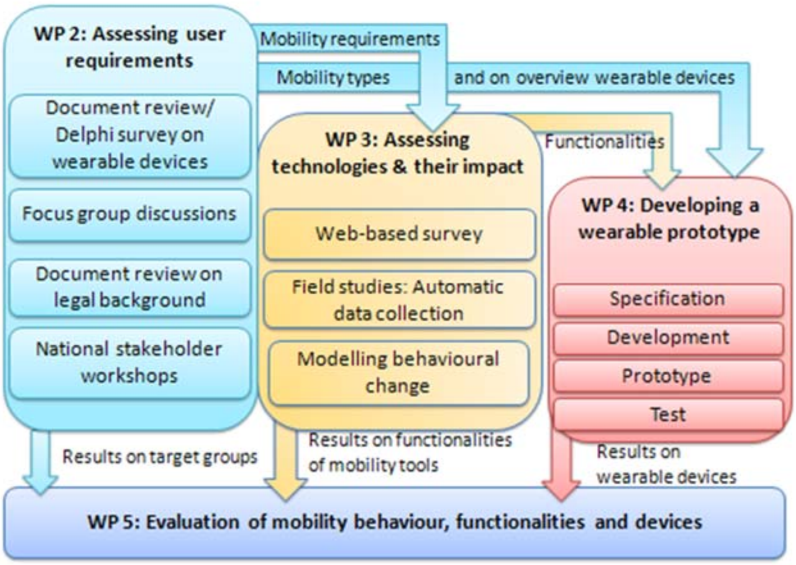

Figure 1: Guide2Wear Project Structure

WP1: Management (WP leader: Fraunhofer)

This work package was related to coordination and management. Quality assurance, schedule monitoring, risk management as well as steering the management committee and organisation of meetings were part of the work in WP1. Besides, the WP leader was responsible for the provision of deliverables and for all communication activities with the ERA-NET office.

WP2: Evaluation of sociological, legal and technical background (WP leader: VTI)

WP2 focused on the customer and provided an in depth understanding of intermodal travellers' needs and behaviour, both present and future. A further aim was to analyse future trends and technologies.

The first step was therefore to identify mobility groups who would benefit from a Guide2Wear application for intermodal trips. This was done using various sources including literature reviews and an analysis of websites. The next step was to carry out 8 focus groups discussions in Sweden, Austria, Belgium and Spain. Within the focus group the participants discussed problems a future device should solve but also what aspects would make the device more desirable, purposeful, usable and last but not least affordable.

Thereafter a Delphi survey amonst software and mobility experts as well as workshops were organized inviting experts whose input was regarded to be of relevance for the development and implementation of the Guide2Wear prototype. Challenges and barriers, which could prevent a successful implementation were discussed including the topics 'access to data' and 'users' privacy'. Legal issues played an important role since the prototype can include personalized information. WP2 therefore included a close co-operation with a lawyer who provided advice on legal issues and an overview over important legal issues and how they are handled in different countries in Europe.

WP3: Technologies and tools for intermodal mobility (WP leader: InnoZ)

The focus of WP 3 was the evaluation of mobility apps on the user's mobility behaviour. First, current technologies and apps supporting intermodal mobility have been analysed with regards to their functionalities and integrated transport modes. An outlook given on future wearable devices and their potential use for mobility services helped to develop the field study design (Tracking) and has moreover been the basis for the prototype development in WP4.

The main part of WP3 was dedicated to the field study in Germany, Austria and Sweden. On the one hand, the field study aimed at exploring requirements of potential users of intermodal mobility services on Wearable Devices. On the other hand, the field study revealed potential impacts of interventions like the introduction of a new intermodal mobility service on the personal mobility behaviour. Eventually, these results have served as a basis for an agent-based modelling of impacts on mobility behaviour, which simulates an extrapolation of these effects for Flanders. All results on user requirements of mobility apps on wearable devices have been used for the prototype development in WP4 and for the quantitative and qualitative evaluation of project results in WP5.

WP4: Prototype development and test (WP leader: Fraunhofer)

The Guide2Wear prototype was planned and developed in WP4. It is a smartwatch based intermodal navigation app with a focus on public transport including other modes as well as a showcase for a ticketing function. The selection and conceptualisation was made based on the results gained in the former work packages. The development process included the evaluation and selection of the appropriate wearable devices and functions, the preparation of the concept as well as the programming of the application and the functional tests.

WP5: Project evaluation and recommendations (WP leader: BOKU)

This work package included two key tasks: a test for usability, utility, user acceptance and supposed behavioural impacts of the Guide2Wear prototype and synthesizing the experiences and insights gained in the previous tasks and to derive recommendations.

User tests were conducted in May and June 2016 in Dresden and Vienna. They aimed on analysing usability, utility, user acceptance and likely impacts on their mobility behaviour. Participants were asked to conduct several trips with the prototype. Before, during and after the testing procedure, they were asked to answer questionnaires mainly dealing with their user experience.

The handbook aims at sharing the experiences gained within the project Guide2Wear of following an integrated, user-centred approach of mobility app development for a wearable device. It summarizes different project findings on a general and methodological level by giving recommendations in terms of an instruction and not of a final report. Based on the approach of user centred design, the role of mobility behaviour for mobility services is highlighted before discussing user needs regarding mobility services. Afterwards, wearable devices and mobility solutions based on wearable and portable devices are introduced while keeping the perspective of the users in mind and highlighting methodological considerations. The handbook concludes with a more technological overview of the process of developing a mobility app for a wearable device.

WP6: Dissemination (WP leader: FACTUM)

This work package aimed at raising awareness of the Guide2Wear results on national and EU levels. A number of dissemination activities were conducted in an effort to present and promote results to all relevant stakeholders on national and international levels. In order to meet this purpose, a variety of appropriate activities were conducted including developing a project logo, developing and maintaining a website, producing and distributing a leaflet, preparing the templates needs, writing and publishing an electronic newsletter as well as presenting results at international conferences, workshops and events.

3.2 Interaction of Project Results

The results gained in WP2 and WP3 were used as a base for the prototype selection, specification, and development. The flow of information is visualised in Figure 2. This figure also shows the role of WP3, the evaluation of the influence of new technology. WP3 deals as background research, providing an estimation of the potential impact of a future product, derived from Guide2Wear.

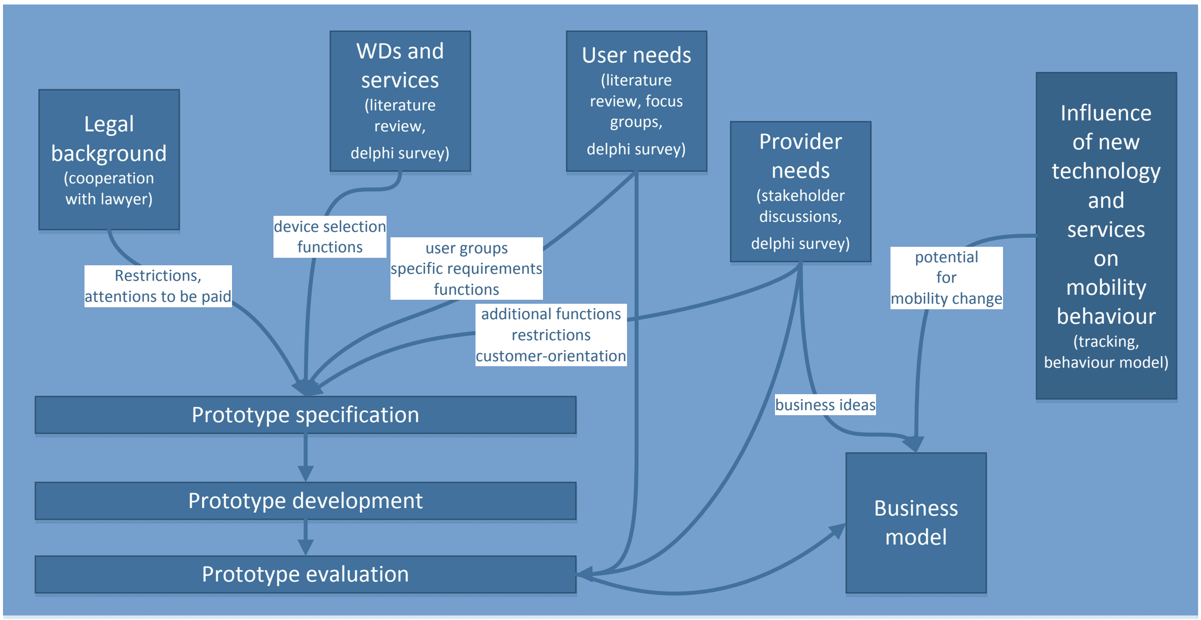

Figure 2: Flow of information in Guide2Wear

All relevant results and findings were collected and published in deliverable 5.1 “Handbook on user characteristics and user requirements for seamless travelling”, see chapter 3.3.

3.3 Deliverables

The deliverables in Guide2Wear were prepared as planned in the proposal. With few exception (e.g. program code D 4.2) they were published on the Guide2Wear website. The following tables provide an overview over the research related deliverables as well as the material prepared for dissemination activities.

Table 1: Research related deliverables

No.	Title	Content
1.1	Description of Quality Management and Risk Processing	The report describes the procedure aiming to guarantee a straightforward project progress and prevent risks from becoming problems or solve them otherwise.
2.1	The future use of Wearable Devices in the mobility sector	The report summarises the results of the Delphi survey and of main trends on the mobility service market.
2.2	Seamless travel: Customer requirements	In course of focus groups discussions and expert workshops a broad set of potential barriers, expected functions and benefits and future potential were collected. By taking the expertise of professionals in the fields of implementation, technology, planning and policy, as well as the view of potential users of WDs into account the qualitative basis for the prototype development was deduced.
2.3	Exploration of data protection and privacy laws	This report aims at outlining the relevant aspects of both private law and privacy law with regard to the development and market introduction of the prototype. Especially in private law a wide range of issues (liability, copyright, competition law, etc.) was evaluated.
3.1	Overview on functionalities of technologies for seamless travelling	The report on current technologies supporting intermodal mobility behaviour represents the state of the art of mobility apps and devices addressing intermodal travellers and gives an outlook to the future.
3.2	Overview on mobility patterns and requirements of lead users	Results from the field studies in Germany, Austria and Sweden are summarised in this report.
3.3	Impact assessment of technological interventions on mobility patterns	This deliverable focuses on different impacts of intermodal mobility services, e.g. regarding multi- and intermodal mobility behaviour or waiting times at stations.
4.1	Prototype Definition and Specification	The decision to use smartwatches for the prototype is described as well as the relevant control concepts and hand-overs between watch and phone. Besides the architecture of the prototype is explained.
4.2	Prototype Software	This non-public deliverable contains the software (frontend and backend) for the realisation of the prototype and the connections to different regions.
5.1	Handbook on user characteristics and user requirements for seamless travelling	The handbook explains and demonstrates how a mobility application for wearable devices can be developed. This is done by summarizing lessons learnt and insights gained during the projects' lifetime.

No.	Title	Content
5.2	Recommendations for organisational and legal improvement	This deliverable presents the main findings of the Guide2Wear project with regard to high potential measures on both legal and organisational level to support market uptake and deployment of wearable devices and information services based on these new technologies.
6.5	Business plan	This report summarizes recommendations to maximize the commercial value of the work done in Guide2Wear. It contains a financial business plan for a prototype of an intermodal information service, which can provide guidance to public transport providers in service provision for wearable devices.

Table 2: Dissemination material

No.	Title	Content
6.1	Project Website	The project website served as a major project dissemination tool by presenting project news, deliverables, publications and conference presentations. Contact information of the partners were accessible during the course of the project.
6.3a	Flyer	A project leaflet presenting relevant information about the project objectives and its approach was designed, in order to be disseminated during internal and external project events.
6.3b	1. Newsletter	An electronic newsletter was prepared every half year, reporting the news of Guide2Wear to the general research society but also to the general public and relevant stakeholders. The first newsletter presented the project structure, first results of WPs 2 and 3 and initial results of the user tracking and the development process of the prototype.
6.3c	2. Newsletter	The second newsletter provided information on current and upcoming project meetings and dissemination events and first updates on the prototype definition and specification.
6.3d	3. Newsletter	The final newsletter summarises the final project results as well as the outcome of the project expert workshop.
6.4	Final Conference	The major findings of Guide2Wear were presented at a final conference in Vienna, at the University of Natural Resources and Life Sciences, on June 13th, 2016. Participants were decision makers as well as key stakeholders at national and European level.

Besides, there exist a number of management related deliverables such as the dissemination and exploitation plan, and interim reports of the progress as well as milestone reports.

4 Project Research Subjects, Challenges, and Results

4.1 WP2: Evaluation of sociological, legal and technical background

The main objective of WP2 was to focus on the customer and provide an in depth understanding of intermodal travellers' needs and behaviour, both present and future. A further aim was to identify and analyse future trends and technologies regarding wearable devices. Additionally, legal issues were analysed and an overview was given over important legal issues and how they are handled in different countries in Europe. In order to achieve these aims various methods were used including a literature review, Delphi study, focus group discussion and stakeholder workshops. This WP also included a close co-operation with a lawyer.

Understanding of customer needs is essential, if the satisfaction with the services provided should be increased. Studies show that the choice of transport is not always controlled by the so-called 'rational factors', emotional or 'irrational factors' are just as important, if not more so. Hence, willingness to use alternative modes depends not only on whether this is possible, but also whether they are perceived as attractive. When it came to a discussion about the sole provision of information on public transport, it was argued, that this was is not enough to make more people willing to use the same. However, a number of studies found that information provision is important and that it can increase the perceived quality of public transport quality. In order to achieve higher quality and greater satisfaction the studies highlighted a few key requirements include: the possibility to buy tickets and to integrate ticketing, real-time information, information about the whole journey including transfer and personalized information.

A Delphi survey was conducted in order to reach professionals that are familiar with new technologies and/ or new mobility patterns. Since the aim of the Delphi survey was to provide the consortium with a general hint on the development of wearable devices, the recruitment was very broad. In total 91 respondents participated. The results showed that the smartphone will still be the main device for phone calls and music, although half of the respondents also assumed that smartwatches would be used for phone calls in the future. The majority argued that all wearable devices will feature GPS and sensors for Human Environment Interactions (HEI). Hence, this seems to be an important feature of wearable devices and perhaps also a unique selling point in comparison to smartphones. On the long-term, i.e. in about 15 years, smartwatches could also provide services like routing or booking a sharing car that are today only available on smartphones. Smartwatches are supposed to feature nearly the same functions as smartphones – from intermodal routing over car- or bike-sharing bookings and local navigation to access and payment functions. The last part of the Delphi survey was dedicated to potential user groups for wearable devices. More than half of the respondents believed that smartwatches and smart glasses could be interesting for all user group identified, while smartwatches are expected to be more familiar

Focus groups were carried out in the four cities San Sebastian/Donostia (ES), Leuven (BE), Linköping (SE) and Vienna (AT). In total 34 participants discussed their mobility behaviour with focus on intermodality as well as their needs for and use of information when travelling. The main results from the focus group could be summarized with one word "simplicity". The participants' current mode of travel is to a large extent what they perceived to be the easiest and most practical option. The simplicity and ease-of-use of information plays an important role in the choice of transport modes (offline and online information) and probably also in the use of wearable devices when planning intermodal routes. This issue was important regardless the purpose of the trip (leisure or work commuting). Another crucial point derived from these discussions was the integration of data. Reliable and updated information were also seen as very important but also being able to pay for the whole journey even if they use different modes of transport. Barriers that could stop the increasing trend of using smartphones for supporting mobility behaviour were privacy concerns and cost. Some participants are willing to pay for accurate information and even a specific device for intermodal journeys that provides reliable information although the willingness to pay for roaming is very low. *Stakeholder workshops* were held in: Austria, Belgium, Germany and Sweden covering a broad range of experts from a wide variety of professional backgrounds including software and mobility information providers, public transport operators, governmental bodies, research institutes and associations representing affected groups such as car drivers or visually impaired people. The goal of these four national events was to discuss relevant issues and problems of these new technological solutions on different levels. This included data needs, legislation, social acceptance and broad scale deployment which potentially prevent the implementation of WDs, but also their general potential to solve mobility issues was touched upon. The participants argued that the rapid development of WDs must not distract from the fact that WDs are a comparably new technology. Current WDs still have several weak points such as data quality, limited usability or concerning the hardware. Nevertheless, all workshops highlighted the potentials of WDs of providing information and services and, by that, facilitating public transport and intermodal mobility behaviour. This was expected to become more important in the future and affect the mobility behaviour of travellers.

Overall the expert workshop presented a wide variety of essential information on the question where the development of wearable devices in an intermodal mobility context is standing, where it is expected to be heading and which aspects still need further discussion and research. The need to provide accurate information before and during the trip was a concern shared by all public transport providers and stakeholders active in intermodal transport. Today, limited resources and integration of data from multiple IT systems and data sources are still challenges for PT providers. These challenges entail that the focus is mainly on the provision of basic information to travellers, preferably real-time information on the vehicles which are driving in the public transport network. There was a consensus amongst the experts that the application that runs on the device was more important than the device itself. Most experts expect smartphones to remain the most important WD in the next years. Smartwatches might also gain in importance since they might offer a more comfortable handling than smartphones. It was believed that applications running on future WD would be easy to understand and provide real-time services.

Legal report: There are several legal aspects linked with the activities of the Guide2Wear (G2W) project. The relevance of these aspects depends mainly, but not exclusively, on the type of Wearable Device (smart glass with integrated camera vs. smartwatch) and provided functionality. At an early stage within the project, Guide2Wear therefore needed to consider a number of important aspects including private law, commercial aspects, and data privacy. Hence WP2 included an exploration of data protection and privacy laws. The results highlighted the importance of paying special attention to private law related to the companies whose services/applications will be used in the project. In addition, the terms of service/standard form will need to determine what kind and what amount of personal user information is collected and how it is used. The user agreement should be composed broadly and include a right to the removal of one's personal information.

Data privacy is regulated by EU and the Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995. This Directive protects individuals with regard to the processing of personal data and on the free movement of such data. The EU Directive was edited during the Guide2Wear lifetime and replaced by the General Data Protection Regulation (GDPR). The GDPR changes the rules for the processing of personal data by private companies and EU authorities. The aim is a more consistent application of privacy law throughout the EU. The regulation also includes the “right to be forgotten” and a “data portability” obligation. The right to be forgotten obliges that personally identifiable information is not permanently available. Data portability means that users should be able to transfer their data between information systems. The completeness of the data and the structured and standardised format are important aspects. Low data portability increases a user's dependency on one system since it complicates change to another. This new Regulation is also supposed to apply to companies who have their registered seat outside of the EU if their services are targeting EU citizens.

Overall the results of WP 2 not only provided a comprehensive set of aspects covering the state of the art, as well as actual experiences and attitudes towards these solutions, but also provide insight in expected changes and upcoming challenges for WDs on societal, technological, organisational and political actors. The Smartphone is the central WD for the time being with reliability and ease of use being major aspects that need to be supported by integrating different sources and ticketing schemes into one central app. Hence, the actual applications and their functions are more important than the device they are used on with the opportunity to adapt the provided information and user experience to trip purpose and user group. Open questions mainly remain in view of data sources and privacy issues.

4.2 WP3: Technologies and tools for intermodal mobility

First, the state of the art of current mobility services and devices has been analysed on basis of a literature survey and a benchmarking study. For the benchmarking study, 192 predominantly European mobility apps available in app stores were assessed according to 70 indicators. 94 of them have been included in the Guide2Wear benchmark study on intermodal apps aiming at detecting best practices for intermodal routing apps.

The field test design in Germany and Austria combined a web survey with a smartphone tracking survey. First, users of intermodal mobility services in Germany and Austria as well as a control group were asked to fill in a web survey and to record their trips twice for at least six days in spring and autumn 2015. For recording their trips, the study participants used the smartphone app modalyzer, which has been adapted to the project context ("Guide2Wear tracking app"). Austrian participants have moreover received an additional questionnaire after the second tracking phase.

500 Austrian and German public transport users took part in the web survey. The web-based questionnaire included questions on mobility behaviour as well as on opinions and attitudes towards mobility services. Half of this sample (n=254 persons) has recorded their trips between May and August 2015 and 185 of them for another six days in October 2015.

Among the Austrian web survey respondents, 91 have ordered the WienMobil card. They participated in the web survey and the first tracking period after they have ordered the card, but before the card was delivered. 60 German participants had access to the Touch&Travel system. Both groups are lead users of intermodal mobility services in terms of von Hippel's (1986) definition, since they are obviously amongst the first persons who have shown an interest in intermodal mobility services. 349 public transport users were recruited as control group. In total, 44 Austrian and 22 German lead users as well as 117 Austria and 71 Germans from the control group recorded their trips in the first tracking wave. The respective numbers account for 107 persons in Austria in the second tracking period of which 39 own the WienMobil-card. 82 people answered the second questionnaire in Vienna. 52 of them owned an annual public transport ticket, while the other 30 participants were holders of the WienMobil card.

The data resulting from the web survey and the tracking study has been combined with further mobility related and socio-demographic data and has been used for an Agent-Based Modelling for the region of Flanders in order to calculate potential impacts of intermodal mobility apps on wearable devices on a larger scale.

Overview on functionalities of technologies for seamless travelling

By providing travel information "on the go", the smartphone has already considerably changed the travel behaviour in big cities. With regards to the strong development activities in interface design and mobile devices, we can assume that wearable devices will at least complement (or even substitute) the smartphone as interface for intermodal mobility services.

The functionalities of current intermodal mobility apps have two different dimensions (see Figure 3):

- The horizontal integration of different transport modes, i.e. buses, trams, subways, trains, walking, cycling, carsharing (CS) or bikesharing (BS).
- The vertical integration of main functions, i.e. routing, booking and reservation, payment, access, and navigation.

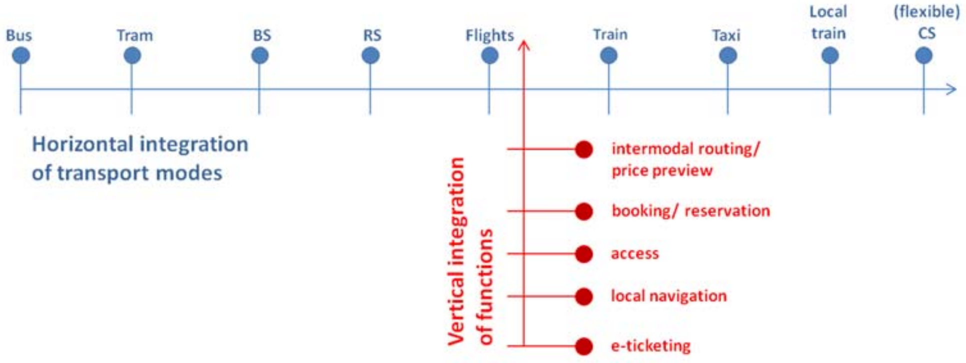

Figure 3: Horizontal and vertical integration of intermodal mobility app functions (own figure)

Mobility apps limited to public transport modes and routing functions are called as *public transport planners*. Actually, about three quarters of the journey planners included in our benchmarking study can be considered as mere public transport planners.

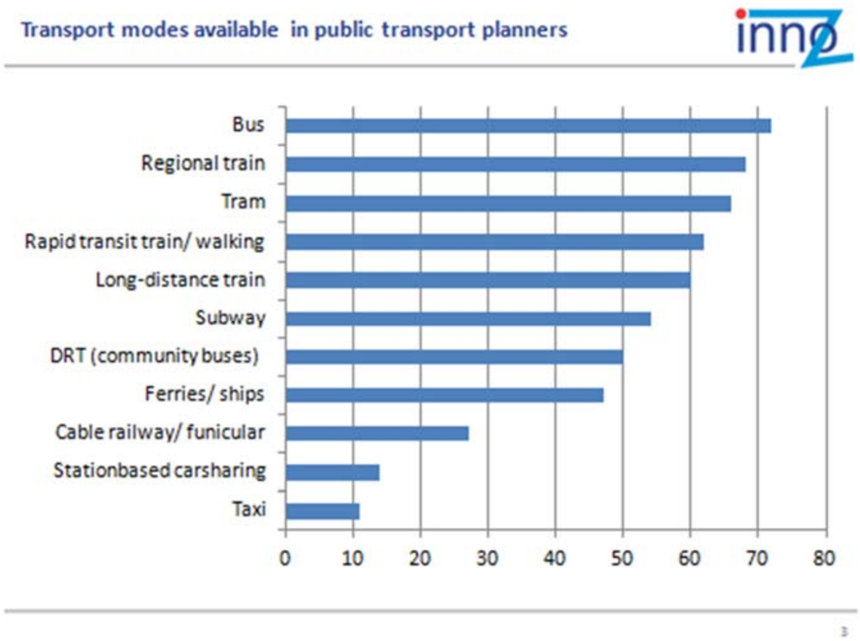

Figure 4: Transport modes available on routing apps (own figure)

During the last years, some mobility app providers have added cycling and car trips to the next public transport station or from the station to the final destination in their routing algorithm. These “door-to-door” routing planners can be considered as “real” intermodal trip planners, since they integrate different transport systems and different data sources. In our study, only 14 apps have integrated carsharing and 5 apps bikesharing stations in their routing function. 7 apps have integrated flexible carsharing in their routing. Currently, OpenStreetMap is the most common basis for location functions used for integrating bike and car routes.

Overview on current and future Wearable Devices

In the future, new interfaces will probably also contribute to new mobility service concepts. The following section provides a short overview on currently existing and future wearable devices.

Fitness trackers/ fitness bands/ smart bracelets/ smart bands			
Worn…	**Usage configuration**	**Likely user type**	**Time-to-market**
Around wrist or around upper arm	Mainly focused on fitness & health monitoring; Allow to gather information and data - need an external screen (PC, tablet, smartphone) to visualize the acquired data via e.g. Bluetooth; They have a battery live of 3-5 days; New projecting bracelets will project the smartphone screen on the forearm with access to all functions  *www.cicret.com*	Fitness trackers: elderly & athletes Projecting bands: same users as smartphone, but mostly youths	Fitness bands are available; Projecting bands are not yet available

Smartwatches			
Worn…	**Usage configuration**	**Likely user type**	**Time-to-market**
Around wrist	They have access to network services by mobile apps and allow dialling/answering calls, viewing/sending messages, managing contacts; Future smartwatches are expected to evolve more towards standalone device with their own SIM cards - they can also remain auxiliary systems interacting with a smartphone; Smartwatches are currently useful for fitness tracking and health related purposes; Smartwatches provide nearly the same features as smartphones; Smartwatches can collect data activity through several sensors e.g. altimeter, UV, barometer and GPS; Connectivity is provided by several technologies including Bluetooth, WiFi, Infrared and NFC  www.samsung.com	Commuters, business travellers, tourists, youths, seniors, athletes.	Since 2013 several smartwatches were launched; the price is between 50 € and 800 € (more for luxury versions).

Smartglasses			
Worn…	**Usage configuration**	**Likely user type**	**Time-to-market**
On the head	Modern smartglasses are effectively wearable computers which can run self-contained mobile apps; Some can communicate via natural voice commands, others uses touch buttons; The Vandrico wearables database presents almost 20 different models of current or planned smartglasses; Some of them featuring similar functions like Google Glass augmented reality or multi-sensor data caption via GPS, accelerometer or gyroscope; Sony has introduced eye-wearables using a different concept of a single-lens display module with OLED technology that can be attached on any eyewear; The Sony module includes an electronic compass, accelerometer and touch sensors, Bluetooth and WiFi; The optical display offers a high image quality even in bad light conditions; A glass-shaped wearable device is the Hololens from Microsoft, a cordless device with a high-definition 3D optical head-mounted display using holographic lenses and spatial sound for augmented reality applications.  *Hololens, www.microsoft.com*	Business travellers, tourists, youths, people with disabilities	They are not mainstream yet; after a two-year test period Google decided to close the Explorer program and removed the Google Glass from sales

Smart rings			
Worn…	**Usage configuration**	**Likely user type**	**Time-to-market**
Around the finger	They support the interaction with the smartphone, other wearable devices, but also household equipment or TVs; An example is a gesture control ring, allowing controlling devices with the movements of the hand via Bluetooth.  *www.mota.com/doi-smart-ring*	People with disabilities	Several smart rings are available

Smartclothes			
Worn…	**Usage configuration**	**Likely user type**	**Time-to-market**
Depending on the device	There exist smart shirts, jackets, socks etc.; Smart shirts are mostly used for fitness purposes or medical purposes and measure data such as muscle effort, heart rate, balance.  *static2.i4u.com/sites/default/files/images/content_images/hedokko.png*	Youths, people with disabilities, elderly, athletes / sportsmen	Some devices are available

Further wearable devices			
Worn…	**Usage configuration**	**Likely user type**	**Time-to-market**
Depending on the device	There exist helmets, earphones, implants etc.; Depending on the specific device, different usage configurations are possible; Some are standalone devices.	Depending on the specific device	Many are already on the market

Within different stakeholder workshops, advantages and disadvantages of each type of wearable device has been discussed. Finally, smartwatches appeared to be currently the most interesting interface for future intermodal mobility apps.

Overview on mobility patterns and requirements of lead users

In order to get a picture of requirements of future customer groups, mobility behaviour and preferences of lead users of intermodal mobility apps was analysed.

For this purpose, a smartphone tracking tools was used to identify mobility patterns: The app used (Guide2Wear-app or modalyzer (www.modalyzer.com)) does not only calculate time and length of a route, but also automatically detects the transport mode used. This tracking data reveals how people generally use different transport modes (multimodal mobility) and how they combine different modes on one trip (intermodal mobility).

The field study in Austria and Germany revealed that lead users of intermodal mobility services like the WienMobil Card or the Touch&Travel app do not differ considerably with regards to the share of people who use different transport modes during a time span of six days (see Figure 5).

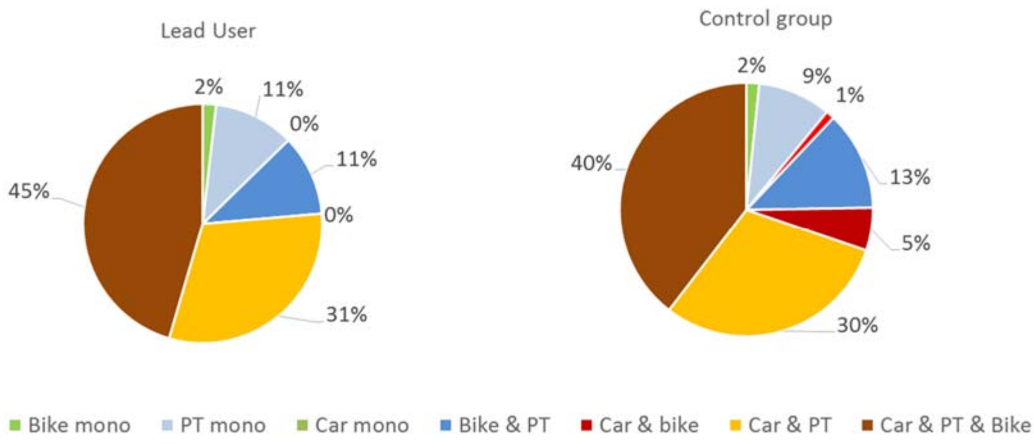

Figure 5: Share of multimodal mobility types among lead users and control group; first tracking wave Austria & Germany

With regards to intermodality, there are however more obvious differences between lead users and control group members (Figure 6). 13 percent of the control group, but only 2 percent of the lead users have not combined different modes of transport on one trip during the six days. In total, three quarters of the lead users, but only two thirds of the control group have combined different transport modes on more than 5 percent of their trips. Thus, lead users seem to be more open to intermodality than the control group.

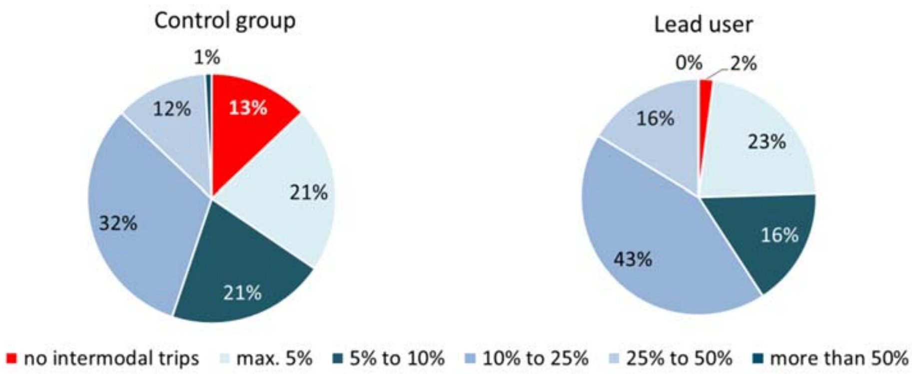

Figure 6: Share of intermodal trips per person including changes within public transport; first tracking wave Germany and Austria

As a preliminary thesis, we can therefore conclude that the use of intermodal mobility services correlates to intermodal mobility behaviour.

Impact assessment of technological interventions on mobility patterns

The comparison of the lead users' mobility behaviour with the behaviour of a control group reveals that impacts of mobility services can mainly be expected with regards to intermodality. On basis of the available data, about three thirds of the future public transport users will combine different transport modes on every tenth trip. Actually, the lead user group that participated in the pre-post-study have indeed reduced their car trips and increased their bike trips. This is good news with regards to the environmental impact of transport in general, since a higher share of intermodal trips correlates to a higher share of bike trips and a lower share of car trips.

Since average bike trips are about as long as tram, subway and bus trips, they could probably substitute part of the public transport trips, although this would not have a considerable effect on the environmental impact of transport. A better strategy would be to animate car drivers to reduce their car trips or car trip distances by combining different transport modes. Here, certain functions of intermodal mobility apps for wearable devices could be an incentive for car drivers to diversify their mobility behaviour.

From the comparison of the lead users opinions and actual use of certain mobility app functions, we can conclude for future customer groups of intermodal mobility apps on wearable devices that

- They will generally have an interest in smartwatches.
- They will use e-ticketing, navigation as well as routing and booking functions on about 40 percent of their routine trips.
- They demand information on car- and bikesharing stations as well as information on available bikes and cars at the destination.
- They probably also would appreciate a navigation function to car- and bikesharing stations or vehicles.

These assumptions on needs of future travellers with regards to mobility services can give a hint on the acceptance of intermodal mobility services on wearable devices that could indirectly support the impacts observed in the field study.

Finally, we have analysed the effects of intermodal mobility services of wearable devices on mobility patterns and mode choice and found the following:

- An increase in mode share for public transport modes, mainly compensated by a decrease in private motorized transport (and partly also by a slight decrease in active mobility)
- A quantitative effect on modal share that is relatively small, up to 0.7% - 0.8% point increase or decrease at most
- An effect that is stronger in urban environments than in less dense areas
- An effect that is slightly stronger for leisure trips and for “social relations” trips, relatively speaking, and less important for business or education-related trips
- An effect that is stronger with higher market penetration rates for wearable devices

In summary, in order to support openness towards a multi- and intermodal mobility behaviour as well as the actual use of intermodal mobility services, mobility apps should particularly

- Show available bikesharing or carsharing options at the destination,
- Include a general price information and a ticketing function,
- Calculate optimal travel fees, waiting and travel times,
- Give real-time information on disturbances and suggest alternative routes and
- Navigate to the public transport stop.

4.3 WP4: Prototype development and test

Most information relevant for the prototype such as user needs, expert views, legal aspects etc., were collected in WP2, while the required functionality was evaluated in WP3. The technical side, the human perspective and the legal situation were thoroughly analysed. This information formed the base for the prototype development.

Selection of smartwatches and functions

In the beginning there was no predetermination of the project team for a certain wearable device. Thus, platform for the Guide2Wear prototype could have been smart glasses, bracelets, rings, clothes and watches. Beside smartwatches, especially smart glasses were expected to be an attractive tool for information in the sphere of public transport. On the one hand they allow to fade in the information into the visual field and on the other hand the integrated camera can be used for localisation as well as for supporting task (e.g. handling of ticketing machines). However, the results of the evaluation, especially the analysis of expert and user prospects indicated advantages of smartwatches connected with smartphones. The reasons are described in detail in deliverable 4.1.

Right from the beginning the main function planned was passenger navigation in public transport with additional functions. This navigation system was developed for smartphones in a former project (FP7 SMART-WAY). But even though there are smartwatches available on the market, which have reasonable displays, information providence and control functions cannot be simply taken from smartphone applications. New control concepts had to be taken into account as well as a sophisticated distribution of information and the hand-over process between smartphones and smartwatches.

Guide2Wear works with the most common control concepts available on most watches (with different operating systems) such as icons, text display and vibration for output. For some smartwatches there is also a map available to support the passenger's orientation. Input is mainly restricted to taps on selection lists. However, if available, crowns as well as bezel rings are also used. Furthermore speech input and audio output (on earphones) is supported if possible.

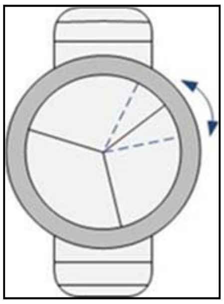

Figure 7: Rotable bezel

While for smartphones a concentration on a few operating systems is noticeable and cross programming is supported by frameworks, the situation is still instable for smartwatches. In the first phase of the project, Android Wear[1] seemed to be the most common and comfortable system. During the project lifetime, this turned to Tizen (Samsung)[2] at least for some aspects. In the latest phase of Guide2Wear market analyses forecasted the success of watchOS (Apple)[3]. Since the project could not support all different smartwatches, the consortium decided to focus on Samsung watches (with Tizen operating system) and provide only draft solutions for smartwatches based on Android Wear or watchOS. In particular this decision applies to the components running on smartphones and smartwatches (see Figure 8) while the background server remains unaffected.

Architecture of the Guide2Wear prototype

The Guide2Wear system is based on different system components. This is also reflected in the software architecture. On one hand, there is the distribution between data provider, navigation background system and smartphone app as it is fixed in the SMART-WAY-app and on the other hand there must be an additional level providing the information on the watch.

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[1] https://en.wikipedia.org/wiki/Android_Wear

[2] https://en.wikipedia.org/wiki/Tizen

[3] https://en.wikipedia.org/wiki/WatchOS

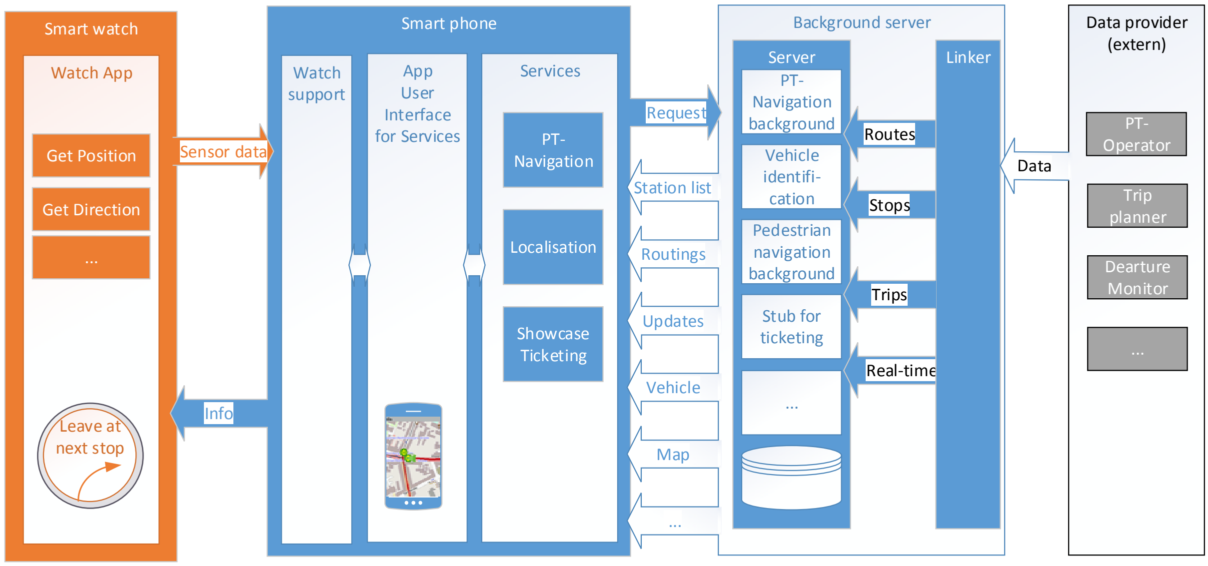

Figure 8: Architecture of Guide2Wear Prototype

The **smartwatch** works as interface to the user. It is used for both, entering input and providing output. Particularly, it can collect data such as the selection of a specific route from a list, or the orientation of the watch gained from a compass, and it can provide important information and notifications to the user. This function can be extended in future prototypes or products when the watches will be able to take over work currently assigned to the smartphone. However, for Guide2Wear there must be a smartphone connected to the smartwatch to provide the full functionality.

Three software components are realised on the **smartphone**:

- the support of the watch, which is different for different operating systems of the watches,
- the app as user interface, allowing to take over those parts of the interaction that are not performed on the watch (either by user decision or by restricted functionality), and
- the services providing the logic behind, for example keeping the user status, the decisions, the planned routing, the situation in the PT network etc. in a state machine[4].

The **services** part is the heart of navigation, based on a state machine. In principle, it must not necessarily be provided on the smartphone, but can also be shifted to the background server. This might be a good solution for adapting watches without linked phones or unsupported operating systems. Nevertheless, for Guide2Wear the preferred solution is to have the services part on the smartphone for two main reasons:

- The interaction between the app and the services is very close. That means, shifting the services to the background server would increase communication traffic.
- The services part knows a lot about the user, for example current position, waiting for departure, unplanned exit etc. This information should be kept on the smartphone for data privacy reasons. In this case the server gets as few user related data as possible.

The **background server** holds all necessary information which is not user related and must not be available on each smartphone, for example the knowledge about the network and the current situation within. To keep the communication traffic as small as possible, it also holds copies of relevant information about trips, but without being able to assign it to a person or a smartphone.

[4] https://en.wikipedia.org/wiki/Finite-state_machine

The background server takes the information from external **data providers**. This includes geographical network information, for example stop ids and coordinates, platform positions, if available, and polylines showing the courses between two stops (or platforms). This information must be provided once in the beginning and may be updated in case of changes.

All other available data must be accessible online. Since there are various sources for such data, a software component between the server and the data providers ensure the compatibility. This component is called **linker**. It takes the external data and prepares it for the usage in the server. Three different linkers were realised in Guide2Wear, one for each demonstration area (Vienna, Dresden, and San Sebastian).

Navigation with the Guide2Wear prototype based on Samsung devices

As described above, the frontend of the Guide2Wear prototype is divided into an app provided on a smartphone and an app running on a connected smartwatch. Both components are connected. Input provided on the watch also influences the app on the smartphone and vice versa. Both components share the same information level, but out of usability reasons and hardware restrictions they provide the information in different manners.

The first step of user action is the input of start, destination and time for the planned ride. This can be done with full functionality on a smartphone, while the smartwatch application is restricted to the current position and time for the starting point and a list of favourite destinations (see Figure 9).

Figure 9: Input of start, destination and routing options on smartphone and Samsung Gear S2 smartwatch

During the navigation process, the information is shared between smartphone and smartwatch. Passengers get the same information concerning walks, trips, exits, etc. However, on the smartwatch, the information is limited to the most relevant aspect, showing the next step only instead of the whole route (see Figure 10). Also the map provided on the watch is much simpler than the one available on the smartphone.

Figure 10: Navigation on smartphone and smartwatch

Notifications describing the next step (get off or change) as well as questions to be answered by the user are always provided on both devices, see Figure 11

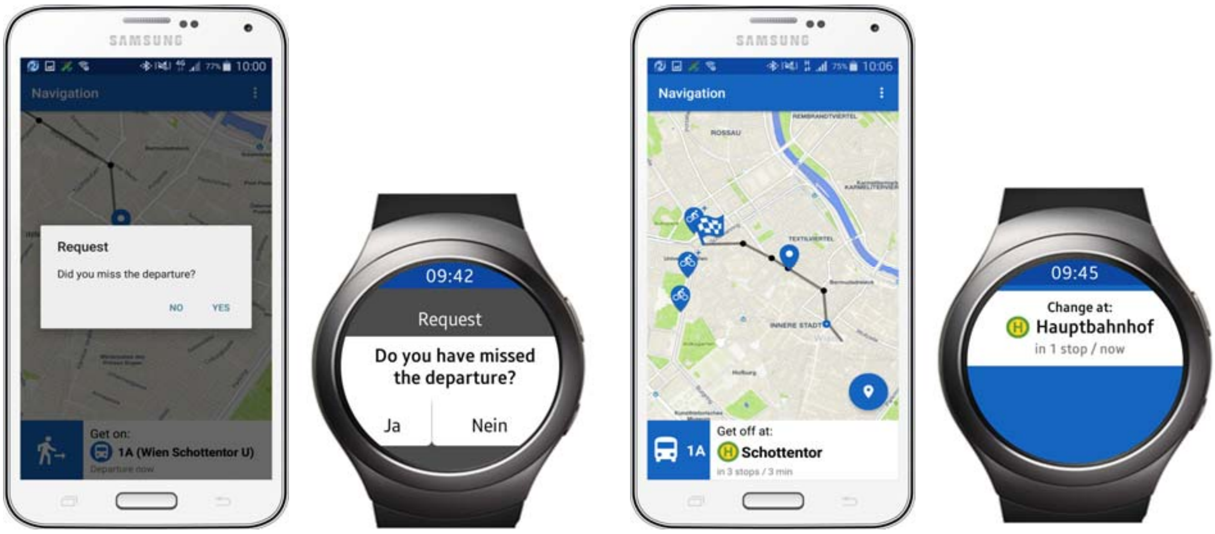

Figure 11: Notifications on smartphone and smartwatch

Support for different smartwatches

As described above the Guide2Wear project focussed on Samsung devices. Nevertheless, the smartphone app is working on all devices using a current version of the Android operating system. Contrary, the component provided on the smartwatch is only runnable on Tizen watches.

To analyse transferability also different watches were tested. Two different ways to support other watches were identified: sending only notifications or providing a specific native version for each watch operating system. The use of notifications was implemented for watches using Android Wear. The result is less stylish, but the most important information can be transported to the user (see Figure 12).

Figure 12: Notifications on watches using Android Wear operating system

The usage of an Apple iWatch with operating system watchOS is closely connected to an iPhone. This combination requires a dedicated component for the smartphone besides the adapted smartwatch application. Although this was not part of the project plan, a pre-version was developed to show, how the prototype could be prepared (see Figure 13). This pre-version is not fully functional, but provides a navigation based on the PT timetable.

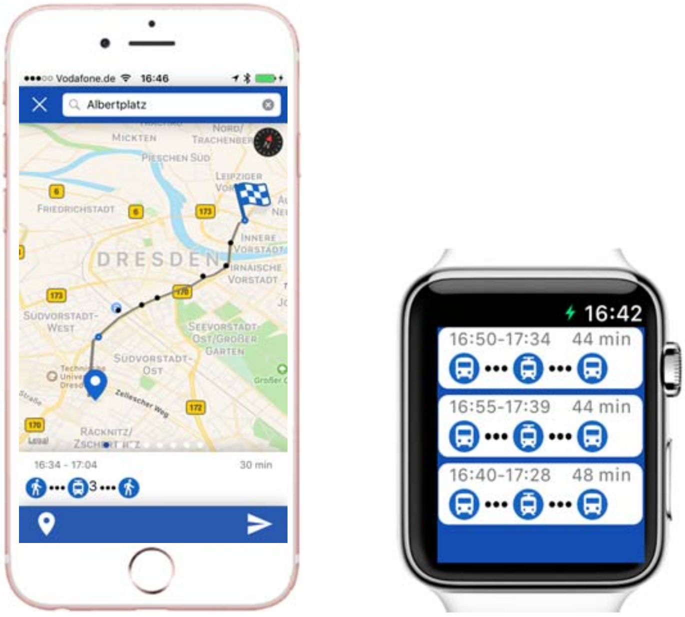

Figure 13: Pre-version of Guide2Wear on iPhone and iWatch

For future usage of the Guide2Wear prototype, and even more for the development of a product derived from this prototype the support of smartwatches using Android Wear or watchOS is an urgent next step.

4.4 WP5: Project evaluation and recommendations

Evaluation: Prototype test

The Guide2Wear prototype supports public transport use and intermodal mobility by providing easy access to information when searching a route or navigating in the transport network. This prototype was subject to a user test in order to identify user experiences and analyse usability, utility and user acceptance of the navigation system, but also of the smartwatch as platform for the prototype and identify supposed mobility behavioural impacts.

Core of the user tests were predetermined public transport trips to be conducted using the prototype. Several questionnaires concerning the user experience had to be answered. The prototype tests took place in Vienna and Dresden in May and June 2016, most of them between 13th and 17th of June, 2016 in Vienna. Test users were recruited by three approaches:

- Staff members of the project partners carried out a friendly testing. This served as a pre-test. The results are not taken into account in this report.
- Participants to the final Guide2Wear conference and the WalkSpace conferences in Baden tested the prototype and gave their feedback. All participants work in mobility-related areas and are thus regarded to be experts.
- A group of volunteers tested the navigation system. They belonged to one of the target groups identified in Guide2Wear. Thus, they were tourists, business travellers or occasional PT riders.

First part of the user test was an initial questionnaire including questions on general mobility behaviour, current use of wearable devices, use of information pre- and on-trip as well as socio-demographics. Different questions were asked for tourists/business travellers and occasional PT riders.

The on-site testing procedure started with a short explanation of navigation system, smartwatch and smartphone. The description was deliberately kept short in order to analyse if the handling was intuitively understandable. Afterwards, the participants had to reach predefined destinations by using the navigation system on the smartwatch. Those familiar with the local situation should start with a well-known trip in order to learn how to deal with the devices and to compare the instructions of the devices with their usual mobility patterns. Afterwards, two predetermined trips should be conducted; persons without known trip also conducted three (unknown) trips. All trips were “shadowed” by a member of the project team accompanying the participant. All trips included at least one interchange in order to use the full scope of the functions of the navigation system. Starting point and final destination as well as all in-between interchanges and intermediate destinations of the single trips were public transport stops where at two least public transport lines operate and if possible, a complicated structure of departure and arrival areas would force test users to use the navigation function. Only bus and tram could be used since the navigation system did not work underground. After each trip, a short questionnaire (intermediate questionnaire) had to be answered on the smartphone. The questions referred to the user experience, the information and instructions given and the understanding of the navigation system. Additionally, the voice recording function of the smartphone should be used to provide feedback in terms of experiences, problems as well as potentials for improvement.

After completing all trips, a longer paper&pencil questionnaire (final questionnaire) was to be answered summarizing all experiences made. It also aimed at assessing user acceptances and usability. The questions referred to the smartwatch, technical problems of the navigation system, usability of the navigation system, supposed impacts of the navigation system on their mobility behaviour and the strengths and weaknesses of the navigation system.

32 persons answered at least one questionnaire. 27 persons filled in the initial questionnaire, 23 persons answered at least one intermediate questionnaire and 20 persons the final questionnaire. 18 persons answered all three kinds of questionnaire.

Usability: The participants were asked after completing the first trip about their perception of the handling of the navigation system. A clear majority (65 %) considers the handling to be intuitively understandable. Only few persons (rather) disagreed to this statement. Participants agreeing to this statement were more often familiar with the route travelled: All persons (rather) disagreeing travelled the route for the first time, while almost every second person (rather) agreeing conducted the trip at least once before. Students and full-time employed persons gave clearly more positive ratings. The same refers to men and younger persons and to those often using public transport and walking. Persons who currently use their wearables or portables more often for mobility-related purposes do not rate the handling better: The persons (rather) disagreeing use their devices in average for 2.8 purposes on all trips and for 3.3 purposes on unfamiliar trips, while the persons (rather) agreeing use 2.3 (all trips) and

3.2 (unfamiliar trips) functions. However, all differences are not significant due to the small sample size. After each of the following trips, the question was asked if the participants can handle the navigation system better than in the beginning. From 17 answering persons, 5 stated after the second trip that their ability to handle the navigation system worsened, while 9 had the impression of improved skills. After the third trip, 7 persons perceived their skills to be improved while 4 think the navigation system would be more difficult to use now. Thus, a training effect can be proven. A majority of the participants (more than 60 %) understood the instructions of the navigation system during the first trip well. Within the test stages the participants improved their skills to deal with these instructions. However, some test users (strongly) denied the statement “Did you understand the instructions of the navigation system well”. Problems were mainly related to unclear walking trips. The items “searching a route/connection” and “selecting a route/connection” received a positive rating.

Handling and usability of the navigation system received an overall positive rating. One of the most often mentioned problems refers to the limited display size, which makes it hard for some persons to control the system and to recognise its instructions. Additionally, the limited display size makes it impossible to provide the full range of functions available for the smartphone. Thus, the smartwatch is perceived as just a kind of an extended auxiliary device which has a negative impact on usability and utility in the perspective of many users. A larger display allowing an extended functionality such as the free selection of start and departure place as well as a zoom-function and further opportunities related to voice control are regarded to significantly improve usability and also utility. A suggested solution to the limited display size is also a customisation of the device to the individual needs by e.g. fixing more than three PT stops as favourites or switching on or of the bikesharing symbols. Additionally, certain technical errors that have to be fixed as well as problems related to the used smartwatch (that has no compass which makes pedestrian navigation quite difficult) or unprecise travel and departure times were frequently mentioned. However, most of these problems including those related time data, the system crush downs or the pedestrian navigation are not related to the Guide2Wear prototype itself but to the data sources or the smartwatch used; in general, the smartwatch is considered to be a helpful device by a majority of the users, since it allows quick and easy information gathering while allowing hands-free operation at the same time. In particularly, the intuitive handling of the system regarding searching and selecting a connection or route, as well as the clear instructions given was mentioned often.

Utility: A useful device or system supports its users to fulfil their intended action. This also includes aspects related to the handling of the device – the utility will be limited if the device cannot be used in the intended way or if the instructions given cannot be understood. However, since these aspects were already dealt with, the term “utility” is used with regard to the content of the instructions given by the navigation system.

The main statement describing the perceived utility of the navigation system was: “I could easily conduct this trip using the navigation system” to be answered after each trip. After the first trip, half of the respondents each (rather or strongly) agreed or disagreed. After several applications, the navigation system is considered more useful; The share of persons answering “rather agree” or give an even more positive assessment increases to 56 % after the second trip and 60 % after the third trip (Figure 14). Reasons frequently mentioned by the respondents for a rather negative rating refer to the already mentioned problems with pedestrian navigation and navigation at interchanges. Due to the missing compass of the used Samsung Gear S2, only small maps can be used for pedestrian navigation while arrows adapting to the arm movement and the walking direction cannot be implemented – this, of course, limits the usability and utility of the navigation system. Additionally, the implementation of voice control was again mentioned.

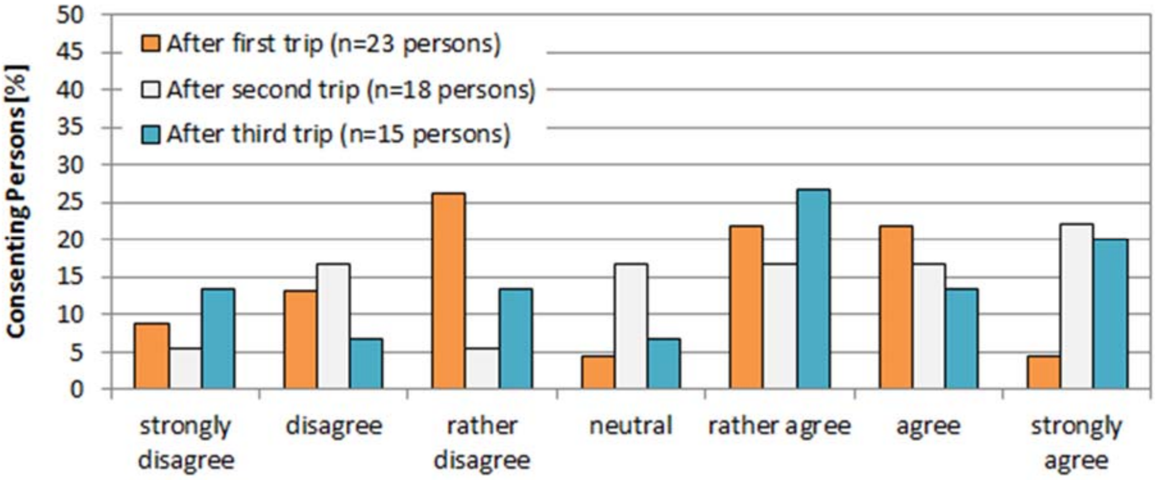

Figure 14: Answer to the statement: “I could easily conduct this trip using the navigation system”

Three questions were asked after each trip regarding the information provided by the navigation system: if all information required was provided, if information not required was provided and if the information provided was correct. The information provided is overall rated as correct and sufficient. In case of missing information, persons often referred to the aforementioned problems related to pedestrian navigation and at interchanges. There is also a broad consensus that almost no redundant information was given. This mainly results from the intentions of the prototype developers to limit all functions to those absolutely required. Answers concerning the accuracy of the provided information are twofold. More than one fourth of all respondents strongly agreed that the information provided is correct. However, more than one third of the respondents disagreed or strongly disagreed with this statement after each trip. Incorrect information are wrong instructions of the navigation system resulting from a programming error or insufficient data basis including incorrect real-time data.

User acceptance: User acceptance means the overall satisfaction of the test users with the navigation system and the smartwatch as platform for the navigation system. However, questions referring to the smartwatch are somehow hard to answer since the respondents have to abstract from the current prototype and its shortcomings. Most participants (70 %) consider the smartwatch to be a (rather) comfortable device. Only few disagree with this statement. There is no remarkable difference if the test user stated to regularly wear a watch or if they are familiar with wearable or portable devices. Women and older test users more likely disagree or have a neutral position.

Although the Samsung Gear S2 is rated as a comfortable device, the suitability of a smartwatch as a platform for a navigation system is partly doubted. The ratings given to this statement (“The smartwatch is a comfortable navigation device”) are equally distributed. Some participants consider the screen to be too small to be helpful or referred to handling problems since the functionality is limited and the smartwatch cannot be used as standalone device. However, others consider the smartwatch to be a comfortable device for navigation since it allows hands-free operation and there is no fear that the smartwatch can fall to the ground or get stolen.

The ratings to the aforementioned statements are confirmed if the smartwatch is compared to a smartphone with regard to its suitability as navigation device. Almost all test users prefer the smartphone. These answer patterns are partly due to the common familiarity of the test users with the smartphone while the handling of the smartwatch is new to them; that is why they lack skills to properly use the device and, since the smartwatches are just rental devices, the instructions and device settings are not individualised to their needs.

The key statement concerning user acceptance asked in the final questionnaire is: “I can well imagine using this or a comparable navigation system on a smartwatch”. 10 % strongly agree, while 30 %

strongly disagree. 20 % are neutral, while the remaining ones are slightly more open-minded towards such a navigation app. From these results can be followed, that there is currently a market, although just a niche market for such a product, while the majority is sceptical. In principle, this is a pattern to be expected since often technical innovations are firstly adopted by a rather small group before they distribute to other persons and groups.

Supposed impact on mobility behaviour: The navigation system intends to facilitate information gathering and thus support public transport use and intermodal trips. Its real impacts can only be observed in field tests over a longer period of time. Since such an approach could not be applied within the project Guide2Wear, the assessment of the supposed impact of the prototype or a comparable navigation system is based on the expectations of the test users concerning hypothetical future behavioural changes.

In the final questionnaire, five questions were asked concerning the most likely impacts of the navigation system on the mobility behaviour. Only persons who can imagine to use the Guid2Wear navigation system or a comparable app on a smartwatch after passing through the test procedure could answer these questions. In principle, a negative answer to one of these questions can have two meanings; either that test users have the impression that the navigation system does not support a travel pattern or that the travel pattern stays unattractive although it is supported by the navigation system.

The least likely impact of such a navigation system is to increase the number of transfers within a trip a person is willing to accept. This refers to both, public transport trips and intermodal trips. From the two aforementioned possible explanations for negative answers, the second one is more likely since the navigation system supports persons when interchanging the public vehicle. Obviously, test users regard transfers to be rather annoying. The navigation app does not change this perception. Regarding intermodal trips, this also depends on the fact that the current prototype does not really support intermodal mobility since related functionalities (intermodal ticketing or routing) are currently not included.

The overall willingness to use public transport is slightly increased by such a system (30 % expect at least a small impact on the frequency of their public transport trips), particularly PT routes and connections with shorter waiting times will be chosen. The most likely explanation is that the navigation system supports its users to find the connecting vehicle or that users recognise by easy-to-gather real-time information or vibration alerts when to hurry up. One person stated that if the departure and arrival times would be better synchronised with the Wiener Linien the function would be extremely useful. An impact of the navigation system is also to be expected on walking trips. Almost 30 % consider longer walking trips to be more probable when they are supported by the navigation system.

Finally, the test users were asked in which situations they would most likely use such a navigation system on a smartwatch. Most answers refer to unknown trips (n=18 persons), while also certain modes of transport (tram and busses), all trips as well as short trips and travelling in case of a hurry were rarely mentioned. This means, that the navigation system on a smartwatch is expected to be used for nearly the same purposes as a smartphone based navigation system.

Handbook

The handbook collects and summarises the findings of the different working steps of Guide2Wear and gives recommendations for further processes and developments. However, the handbook is not a final report, but focuses on methodological aspects and theoretical considerations based on the experiences gained in Guide2Wear. Target groups are all stakeholders involved in the development of mobility apps for wearable devices. Following the approach of a holistic user-centred design, the handbook always keeps the perspective of the users in mind. The structure of the handbook explains how to develop a service concept that is able to guide the development process of a mobility app on a wearable device. This includes insights to four main areas:

The role of mobility behaviour for mobility services: Mobility services have to be compatible to the individual mobility behaviour. By providing information on different transport options, intermodal mobility apps can influence the personal mobility behaviour. Hence, a thorough understanding of the mobility behaviour of relevant customer groups is a key success factor for intermodal mobility apps.

The role of mobility needs for mobility services: New mobility services have to meet user needs in order to be accepted. Not questioning the aforementioned initial aspect, new mobility services have to provide an extra benefit and thus address unsatisfied mobility needs. Current mobility behaviour is just a weak indicator for mobility needs and related intentions; barriers preventing people from changing their mobility behaviour have to be taken into account. Therefore, an intermodal mobility app has to address needs and expectations of different customer groups. The analysis of user needs can give important insight on group specific demands for a comprehensive service concept.

Wearable devices as interface for mobility apps: A wearable device symbolises a ”service desk” as well as a “personal travel assistant”. In comparison to smartphones, wearable devices have the advantage to be literally always at hand, providing hands-free operation as an important added value. However, each wearable device provides specific opportunities and barriers for mobility services. Hence, a mobility service concept has to be adapted to the device in order to be useful. In addition, some devices are subject to legal aspects. Thus, the selection of a certain wearable device as interface sets the main framework for the mobility app.

Specific functions of mobility apps: A service concept has to define technical functions of the app. Here, the range and combination of functions is an important success factor for user acceptance. At this stage, it is important to identify specific user needs for mobility service functions: What mobility app functions are familiar? How could the intended app satisfy the identified user needs and support or improve their mobility behaviour? What functions have to be offered in which way?

Organisational and legal recommendations

In course of the Guide2Wear project an iterative stakeholder and expert involvement process was applied in order to not only collect opinions and attitudes of potential users of the developed service in all stages of the development process but also to collect information on issues and barriers as well as recommendations from experts beyond the scope of the project. The engagement of legal experts not only provided an overview over regulations relevant in the context of location based services and wearable devices but also on strategies to avoid legal challenges and on how to adapt to rapid changes in an increasingly complex market. Based on this a number of recommendations on organisational and legal levels was collected in relation to the challenges that current development of LBS and wearables are faced with.

Several barriers in view of a sustainable development of services need to be considered to provide a satisfactory user experience and avoid potential privacy and data issues. These include traffic data quality, usability issues, involved costs, legal aspects, and privacy issues of collected user data.

Aspects related to data quality and data availability: The current barriers regarding WDs are mainly seen in the context of missing data for accurately providing information to (intermodal) travellers, which are not only needed for seamless navigation but also for reacting on deviations and delays.

Potential users demand reliable, timely and accurate information especially in case of deviations and schedule changes. Here consistency and reliability of the used data sources have been a barrier for development. The central aspect in this regard is interoperability and fostering of standards to support a broader user base. On an organisational level the three main strategies for successful and sustainable developments are mainly aiming at ensuring backwards compatibility. These are promoting industry standards and open data initiatives and supporting an increased efficiency by bridging gaps.

Moreover, topics such as lack of comprehensive integration of different transport options and the missing consideration of different ticketing schemes must be taken into account. Especially integrating best-price offers or the opportunity to transfer tickets among devices to utilize the full potential of an integrated routing and intermodal travel service are still mostly untouched concepts.

Aspects related to usability issues: The general focus on actual user needs must remain a central goal of service development. The opportunity to adapt a service to ones needs while remaining simple and streamlined by also exploiting the benefits of different devices and their specific possibilities of interaction are perceived as essential for a high degree of usability.

Aspects related to costs: Cost for services on Wearable Devices are on the one hand related to the purchase of the device and on the other hand to communication costs or roaming fees. Even though most of these costs cannot be influenced by a specific service, the restrictions must be taken into account. This can be done by for example the support of cheaper Wearable Devices or the limitation of the amount of transferred data.

Aspects related to legal aspects and privacy concerns: Privacy aspects involved in the Guide2Wear project as well as current research express scepticism mainly on how data is handled in the context of location based services. The specific characteristics of wearable devices increase the need for internationally accepted standards in this regard. Users are usually supposed or expected to have them ubiquitously available. As they are also monitoring individual behaviour and collect information on a personal level the sensitivity of the data stored by service providers is a high topical field of discussion. The strategies and measures discussed by both experts involved in the Guide2Wear project and legal professionals in current papers vary in view of responsibility and the respective approaches to data handling. Generally, experts are demanding development and organisation processes which support the minimization of data collection requirements of services. Information asymmetry between service providers and their clients can be avoided by also providing notice and choice measures which disclose which information is collected and stored and how it is used. In this context the two general paradigms *the right to be forgotten* and *data portability* are supported by legal experts and are not only applicable to location based data. These strategies on the one hand demand that personal information and individual user profiles are not permanently available and accessible. Literature points out that privacy by design, social norms and the awareness and self-regulation of users are essential strategies to support these developments on both societal and legal levels.

The specific characteristics of WDs pose a number of challenges that still need to be addressed. They are related to the personal nature of location based data and refer to legal and regulatory level. Here focussing on actual user needs can help to address remaining usability issues by addressing the heterogeneity and changing attitudes among potential consumers. Supporting and promoting industry standards and harmonization are expected to improve data and interoperability issues. In view of the discussed legal issues in the context of data privacy European regulatory developments and raising awareness among both developers and end users can support sustainable developments by ensuring secure use of these novel approaches to routing and information provision.

5 Potential Impact and Main Dissemination Actions

5.1 Methodological novelties as input for further research activities

Within WP3 a pre-post-control group approach including a tracking study and up to two questionnaires was used. Particularly in Vienna, the behaviour of subscribed users or a new intermodal mobility service could be analysed before they actually had the opportunity to use this service. This allows for a real pre-post-comparison and thus for an impact analysis. Such an approach is from a theoretical point of view compulsory, however, this clear pre-post study approach combined with a control group is rarely applied within the international research community since it is not often possible to identify future users before the actually use a service – but if they actually use a service, a pre-post-comparison is not possible anymore. Important lessons were learnt by this approach – this also includes the methodological level.

Guide2Wear applied a smartphone tracking tool with automatic transport mode. During the project, the tool has been adapted to the specific national context, improved and upgraded with the result that the next version called "modalyzer" has become a reliable and user-friendly smartphone tracking tool. Modalyzer is indeed currently the only tool that is able to distinguish a broad range of different public transport modes such as trams, subways or regional trains. Apart from the technical upscaling of the tool within Guide2Wear, the project has also contributed in getting important insight on processing smartphone tracking data on the one hand and on chances and restrictions of scientific contributions to mobility research on the other hand.

Here, Guide2Wear has pioneered in a mobility research method that will gain importance during the next years, since digital tools for collecting mobility related data on an individual level are needed in order to determine environmental or health-related impacts of the personal mobility behaviour. Furthermore, mode detection is viable for future intermodal e-ticketing systems.

5.2 Impact on users of intermodal mobility apps

The field study has provided important data for new mobility services. Wearable devices will be interesting for all travellers, if future devices will be customer friendly, simple to use and easy to understand and if they provide additional benefit.

Generally, wearable technology is expected to improve outdoor mobility by increasing the comfort level (faster, easier, and cheaper) by providing information and increasing general efficiency of travel. In addition, the potential to increase travel safety by providing safety relevant input in high risk situations and even warn the user is especially relevant in the context of the internet of things. However, novel WDs are expected to not offer other information than smartphones currently do, but to mainly change how information is provided. New developments such as augmented reality to route intermodal travellers have already been evaluated comprehensively in real world scenarios.

There is a consensus that the quality of provided information is generally more important than the device itself. Only timely and reliable information have the potential to increase and support public transport and to provide access to mobility services which are otherwise only hard to access. Thus, wearable devices are expected to become a prerequisite for flexible intermodality and modern transport systems. Applications in the area of infrastructure2WD and WD2WD-communication might provide potential for new mobility solutions as well.

Nevertheless, smartphones are expected to remain the most important mobile device in a medium-term perspective, since other wearable devices are still missing unique selling arguments that offer a major benefit and can only be used on a certain device. This additional benefit will be crucial for the success of a wearable device. Such an advantage could be augmented reality on a smart glass, but also hands-free interaction, e.g. for access and ticketing, for navigation functions and for alerts when approaching a public transport stop or a POI. It seems that smartwatches currently offer advantages as user interface for intermodal mobility apps compared to other wearables, since they provide a wide range of interaction options. Fitness trackers are also already a quite popular device and could therefore be also interesting for mobility services. One step beyond the already available, the technology experts consulted in Guide2Wear discussed the unique opportunities of smart clothes. Use of technology integrated into fabric could in future allow for reacting on the temperature basis in different vehicles. Smart rings and smartwatches are seen as entry devices and access providers to vehicles or buildings and by concurrently being connected to ticketing functions in conjunction with different wireless technologies.

Although all persons can benefit from easy access to information, wearable devices can particularly address information needs of certain groups or these groups are expected to be open-minded towards the use of wearable devices. These groups include according to the experts participating in the Delphi survey and the stakeholder workshops:

- **Occasional public transport users and commuters:**
    - Requests: real-time navigation including disruption management suggesting alternative routes
    - Relevant product specifications/options: internet access; gamification such as collecting points in case of public transport use
    - Impact: support and security especially at interchanges, in case of disturbances and for ticket purchases, increased use of PT
- **Tourists and business travellers:**
    - Requests: multifunctional devices (with voice control) including information on tours, restaurants, events or sightseeing;
    - Relevant product specifications/options: augmented reality; offline applications for points of interests; gamification
    - Impact: being informed, additional touristic information available, support and security, translation
- **Youths:**
    - Requests: Use travel time as pleasure time or for communicating
    - Relevant product specifications/options: gamification and encouragement systems; social networks; on-trip chats
    - Impact: improved travel experiences
- **People with special needs:**
    - Requests: specific support in several ways according to the needs
    - Relevant product specifications/options:
        - people with limited visual ability: wearable device with voice control and voice output; WD-communication with tactile ground surface indicators or traffic lights
        - people with limited mobility: specific routing information including for example elevators, hands-free usage when a walking aid is used, communication with infrastructure
    - Impact: guaranteeing equal mobility for impaired people and independent mobility

Specific demands of several user groups can be addressed by different kinds of wearable devices. Willingness to buy a Wearable Device is rather high among young people, with especially fitness trackers and smartwatches being at the centre of interest. Functions expected from wearable technology are mainly related to health and shopping purposes rather than simple information collection. However, these aspects can be easily integrated into travel and navigation information on intermodal routes. Here providing mode-specific trip information with focus on different trip characteristics can help to better adapt to the actual demands of these user groups. Gamification has become an incentive not only used by infrastructure providers and public agencies to activate certain user groups, but also needs to be taken into account in the context of travel information and point of interest information provided to specific user groups.

5.3 Impact on the transportation system

Guide2Wear developed a behavioural model to analyse the potential mobility effect of intermodal information services; the service can take the form of a public transport application for wearable devices. This agent-based model focuses on people's mode choice decision, as a result of individual and trip characteristics. This means that the project models the decisions taken at individual and trip level, but it observes the aggregate outcomes of these decisions at societal level.

The model has led to following results:

- Improved intermodal information will lead to a slight increase in public transport model share, and a slight decrease in individual transport (both active transport modes and motorized transport)
  - However, the size of the effect is relatively small. The maximum estimate is up to 0.7% - 0.8% increase in public transport use (all PT modes combined: train, tram, subway, bus)
  - The reason for the small effect size is that there are many determinants of the mode choice decision (time constraints, financial elements, location of trip origin and destination, etc.), from which availability of PT information is only one of these elements.
- The mobility effect of improved PT information is probably strongest in urban areas with a good PT availability and less important in rural areas.
- The effect on mode choice is most important for occasional trips, such as leisure activities or social relations, and less important for work-related or education-related trips.
- However, changes in mode choice may carry over from one activity to another. For instance, a higher tendency to take public transport for leisure may also lead to a higher tendency to use public transport for work commute.
- The effect is stronger as the market penetration for intermodal information services increases.

5.4 Impact on PT operators

Within the project Guide2Wear a financial model and business model for a prototype of an intermodal information service on a wearable device or a product derived from it were developed. For this purpose, the effects of improved intermodal services on revenues and profits of public transport providers were calculated. The basis for this are the modal choices computed in the Behaviour Model. The consortium also discussed a number of qualitative aspects of business strategy associated with launching an intermodal information app on a wearable device.

The financial analysis was developed in two case studies, one for the Flemish region in Belgium and the other one for Bizkaia region in Spain. It predicts the effects of improved intermodal information on revenues generated by the train operating company and the local public transport (bus-tram) company. The analysis has shown that the direct revenue increases for public transport companies, from sale of additional tickets, is likely to be relatively small. This is in line with the observations made in the mobility behaviour model. In addition, effects on profits will probably be even smaller since all public transport operators only cover part of their costs from ticket revenues. Government subsidies are a more important source of revenues, and are not affected by increased public transport use. So the effect on profits is attenuated by the question whether additional demand for public transport can fit within the current transport offering.

Cost coverage ratios may improve by 1% to 3% (estimates of the maximum potential) following the launch of improved intermodal information services. The computed effects are more important for train travel than for local public transport (bus – tram). This follows from the relatively stronger increase in train mode choice (in the Behavioural Model) and the relatively higher cost coverage ratios for train in the case studies.

When interpreting the financial results, one should keep in mind, however, that the direct financial elements are only a part of the expected effects. Elements such as increased customer satisfaction, customer loyalty, health effects and reduced environmental impacts are not taken into account here.

When interpreting the financial results, one should keep in mind, however, that the direct financial elements are only a part of the expected effects. Elements such as increased customer satisfaction, customer loyalty, health effects and reduced environmental impacts are not taken into account here.

5.5 Recommendations

Recommendations from Guide2Wear are provided on the level of those stakeholders, who are not only responsible for the development and research on new applications and innovations in the mobility sector, but also on the level of those who need to maintain and innovate information systems and collect and store user data. The main barriers currently identified by experts in the context of development and market introduction are generally related to the following aspects:

- Data quality – current, reliable, comprehensive
- Usability issues – human-machine-interface and interaction with the device
- Costs – especially in view of roaming costs and data usage
- Technological state of the art – rapid changes on hard- and software levels
- Legal aspects and open privacy issues – regarding data collection, storage and use

In order to overcome these barriers, recommendations on technological, societal and legal level were collected. On the technological level high potential solutions mainly focus on the quality of the service, the need bandwidth and the future potential of deployable technology:

- dynamic distribution of access to bandwidth based on the location and data demand
- standardization and harmonization procedures serve as basis for quality assurance
- mobile infrastructures which can be deployed on an ad hoc basis

Two general paradigms avoid the asymmetry between those who provide a service and their clients:

→ The right to be forgotten demands only limited availability of personal information over time

→ Data portability means that users should be able to transfer their data between information systems, hence decreasing dependency on one service provider.

In order to increase safety and awareness aside from legal regulations increased awareness and consciousness of both service providers and users by being alert in view of the terms and conditions provided and accepted data privacy can be positively affected and ensured. However this also needs to be routed in accepted norms and corresponding standards.

5.6 Dissemination Activities and Exploitation of Results

In course of the Guide2Wear project every dissemination activity was accomplished by means of a well-defined and standardised four step approach based on: Identification, Evaluation, Selection and Implementation. However, not all steps had to be implemented at each dissemination activity, as a step may already be part of another parallel or combined activity. Moreover, the dissemination activities were structured according to whether they considered the active participation of the likely audience (active dissemination) or if the audience was expected to become acquainted with the project results via published material, e.g., web site, poster, leaflets etc. In addition, the activities were considered as global, internal or cross-fertilisation type, according to whether they were carried out at international level by the Guide2Wear consortium (workshops, and organised events), or they were aimed at developing solid links amongst Guide2Wear partners, or at identifying other European or national research projects with topics of interest for Guide2Wear.

Global activities included international events and publications by the project consortium. International events are mainly participation to workshops and conferences related to Guide2Wear domain. Concerning publications, a list of journals, magazines and newspapers pertaining to Guide2Wear topics had been identified in the early stages of the project. Both events and publications were an effective way to widely disseminate the project results among the appropriate communities. In addition virtual networking activities via the project webpage in particular and the presentation of specific project results at the web presences of the project consortium supported the range of the dissemination activities.

Table 3: Publications, presentations and participations at conferences and workshops

Event title / Journey title	Main leader	Type of Activity	Place / Date	Additional Information
Mobilität im Wandel – VCÖ Preis 2015	FACTUM	Application for the VCÖ Mobilitätspreis 2015 (mobility price) Destribution of project information during the event	Vienna Deadline: June, 2015; Event: September, 16, 2015	https://www.vcoe.at/de/netzwerk/vcoe-mobilitaetspreis
NECTAR conference	InnoZ	Presentation/ WS	Ann Arbor/MI 14.-16.06. 15	WP2.1/ 3.1 http://www.nectar-eu.eu/2015-nectar-conference/
Mobile Tartu	InnoZ	Presentation/WS	Tartu/ Estonia 29.6.-1.7. 16	WP 3 http://mobilitylab.ut.ee/mobiletartu/2016/
InnoZ Baustein	InnoZ	Publication	Berlin Spring 2016	WP2 and 3 German publication on results from the field study
Crowd Dialog München	InnoZ	Presentation	München 26.11.15	WP 2 and 4: WD and stakeholder perspective http://www.crowddialog.de
	VTI	Publish the results from the focus group interviews	to be decided	
	VTI	Present a paper at a conference	Linköping, and outside Sweden Various events during 2016	Present the results from the study conducted in Sweden
European transport conference 2016	TML	Presentation	Barcelona, Spain 05.-07.10.2016	https://etcproceedings.org/conference/venue/
HUMANIST conference 2016	FACTUM BOKU	Presentation	Loughborough, UK 30. June 2016	WP1 & 2 http://conference2016.humanist-vce.eu/
HUMANIST conference Proceedings	FACTUM BOKU	Paper	June 2016	WP1 & 2 http://conference2016.humanist-vce.eu/
Walk Space Conference 2016	FACTUM BOKU	Presentation	Baden, Austria 16. -17. June 2016	http://www.walk-space.at/
ERA-Net Newsletter	Fraunhofer	Interview	July 2015	
	CodeSyntax	Press Release	Spain February 2015	
mobilitaet21	Fraunhofer	Article	Germany January 2016	www.mobilitaet21.de
Verkehrszeichen	FACTUM	Paper	Austria/Germany/Switzerland	http://www.verkehrszeichen-online.de/vz.htm
Nordic Traffic Safety Academy	FACTUM	Presentation	Sweden May 2016	http://www.tft.lth.se/en/ntsa/seminars/2016/

Table 4: Virtual networking activities

Activity	Website	Organiser(s)
Website	www.guide2wear.eu	FACTUM
Facebook	https://www.facebook.com/Guide2Wear-888477601186798/?ref=hl	FACTUM
LinkedIn	https://de.linkedin.com/in/ingrid-nagel-b6248a67	Fraunhofer
Website	https://www.innoz.de/de/guide2wear	innoz
Website	http://www.ivi.fraunhofer.de/de/projekte_produkte/projekte/forschungsgebiet_2/guide2wear.html	Fraunhofer
Website	http://www.tmleuven.be/project/guide2wear/home.htm	TML
Website	https://forschung.boku.ac.at/fis/suchen.projekt_uebersicht?sprache_in=de&menue_id_in=300&id_in=10295	BOKU
Website	http://www.codesyntax.com/en/blog/new-project-started-guide2wear-public-transport-services-with-wearable-devices-for-different-mobility-types	CodeSyntax
Website/App	https://play.google.com/store/apps/details?id=de.innoz.innoztracker.guide2wear&hl=de	innoz
Website/press release	http://www.vti.se/sv/pressrum1/#/pressreleases/hitta-baesta-resvaegen-paa-vaegen-1059188?utm_source=rss	VTI
Website	http://www.factum.at/content/internationale-projekte.html	FACTUM

Table 5: Overview of all national and international G2W events

Event Title	Participants	Date	Venue	Organiser(s)
Kick-Off-Meeting	All	September 26, 2014	Dresden, Germany	Fraunhofer
Internal Workshop Austrian partners	BOKU, FACTUM, Wiener Linien	November 14, 2014	Vienna, Austria	FACTUM, BOKU
2nd Partners Meeting	All	November, 25-26, 2014	Stockholm, Sweden	VTI
Meeting with associated partners	VTI	December 18, 2014	Linköping, Sweden	VTI
Stakeholder workshop, Austria	BOKU, FACTUM, Wiener Linien, external Stakeholders	February 6, 2015	Vienna, Austria	FACTUM, BOKU
Stakeholder workshop	InnoZ, Fraunhofer, IVI, external Stakeholders	March 05, 2015	Berlin, Germany	InnoZ
3rd Partners Meeting	All	March 12-13, 2014	Leuven, Belgium	TML
Stakeholder workshop	VTI, external Stakeholders	March 31, 2015	Linköping, Sweden	VTI
Stakeholder workshop meeting	TML, external Stakeholders	April 24, 2015	Leuven, Belgium	TML
4th Partners Meeting	All	September 04-05, 2015	San Sebastian, Spain	Code Syntax
Internal Workshop Austrian partners	BOKU, FACTUM	February 18, 2016	Vienna, Austria	FACTUM, BOKU
5th Partners Meeting	All	February 25-26, 2016	Dresden, Germany	Fraunhofer Institute
6th Partners Meeting	All	June 14, 2016	Vienna, Austria	FACTUM
Meeting with associated partners	VTI	August 19, 2016	Linköping, Sweden	VTI
Final Conference	All, external Stakeholders	June 13, 2016	Vienna, Austria	FACTUM, VTI, InnoZ, BOKU

6 Website and Contact

6.1 Website

The Guide2Wear website can be found at the following link:

http://www.guide2wear.eu/

6.2 Coordination

The project was co-ordinated by Fraunhofer

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6.3 Project Logo

GUIDE 2 WEAR
mobile devices for the future traveller

6.4 List of Participants with Contacts

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