Public transport services with wearable devices for different mobility types

ERA-NET TRANSPORT III Flagship Call 2013 “Future Travelling”

Deliverable D 2.1 The future use of Wearable Devices in the mobility sector

Author Institution

Helga Jonuschat Innoz
Juan Garcia Canales Tecnalia
Lars Akkermans TML
Deliverable 2.1: The future use of WD in the mobility sector

Deliverable information

- **Project acronym**: Guide2Wear
- **Project title**: Public transport services with wearable devices for different mobility types
- **WP**: WP2 - Evaluation of sociological, legal and technical background
- **Task**: T2.1 Analysis of wearable devices and their impact on travel services

Partner

- [Fraunhofer IVI](#)
- [CODESYNTAX](#)
- [TRANSPORT & MOBILITY LEUVEN](#)
- [vti](#)
- [tecnalia](#)
- [ECTRI](#)

Supported by

National Funding Agencies
## Content

1  INTRODUCTION: HOW WEARABLE DEVICES WILL CHANGE OUR WAY OF TRAVELLING .......................................................................................................................... 5

2  SOCIAL AND TECHNOLOGICAL TRENDS AND THEIR IMPACT ON WEARABLE DEVICES .................................................................................................................. 6

   2.1  TRENDS SUPPORTING THE DIFFUSION OF WEARABLE DEVICES ................................................. 6

   2.2  TRENDS RESTRICTING THE USE OF WEARABLE DEVICES ......................................................... 12

3  MOBILITY TRENDS: HOW MOBILE ARE WE? .............................................................................. 16

4  RESULTS FROM THE DELPHI SURVEY: FUNCTIONS AND POTENTIAL USER GROUPS OF WEARABLE DEVICES ............................................................................................. 20

   4.1  THE SAMPLE: MOBILITY AND IT EXPERTS UNDER 40 YEARS ................................................. 20

   4.2  DEVICES AND FUNCTIONS: HEALTH MONITORING, GPS AND HEI ........................................... 22

   4.3  MOBILITY SERVICES: LBS, NAVIGATION, ACCESS AND TICKETING ........................................ 24

   4.4  USER GROUPS OF WEARABLE DEVICES: YOUNG PEOPLE AND TOURISTS .......................... 25

   4.5  CONCLUSION: USER SCENARIOS FOR MOBILITY SERVICES ON WEARABLE DEVICES ...... 28

5  CONCLUSION: REQUIREMENTS FOR WEARABLE DEVICES SUPPORTING INTERMODAL MOBILITY .................................................................................................................. 32

6  ANNEX ........................................................................................................................................... 34

   6.1  REFERENCES .............................................................................................................................. 34
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADAS</td>
<td>Advanced Driver Assistance System</td>
</tr>
<tr>
<td>AR</td>
<td>Augmented Reality</td>
</tr>
<tr>
<td>ARAS</td>
<td>Advanced Rider Assistance System</td>
</tr>
<tr>
<td>BS</td>
<td>Bikesharing</td>
</tr>
<tr>
<td>CARE</td>
<td>Community database on Accidents on the Roads in Europe</td>
</tr>
<tr>
<td>CS</td>
<td>Carsharing</td>
</tr>
<tr>
<td>FGI</td>
<td>Focus Group Interview</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>HEI</td>
<td>Human Environment Interaction</td>
</tr>
<tr>
<td>IGW</td>
<td>Interest Group Workshop</td>
</tr>
<tr>
<td>ISA</td>
<td>Intelligent Speed Adaptation</td>
</tr>
<tr>
<td>ITS</td>
<td>Intelligent Transport Systems</td>
</tr>
<tr>
<td>LBS</td>
<td>Location Based Services</td>
</tr>
<tr>
<td>NFC</td>
<td>Near Field Communication</td>
</tr>
<tr>
<td>POI</td>
<td>Points of Interest</td>
</tr>
<tr>
<td>PT</td>
<td>Public Transport</td>
</tr>
<tr>
<td>PTW</td>
<td>Powered Two Wheeler</td>
</tr>
<tr>
<td>RFID</td>
<td>Radio Frequency Identification</td>
</tr>
<tr>
<td>SDP</td>
<td>System Description Paper</td>
</tr>
<tr>
<td>UGC</td>
<td>User Generated Content</td>
</tr>
<tr>
<td>VRU</td>
<td>Vulnerable Road User</td>
</tr>
<tr>
<td>WS</td>
<td>Workshop</td>
</tr>
</tbody>
</table>
1 Introduction: How Wearable Devices will change our way of travelling

This report aims at summarising the results of the Delphi survey and of main trends on the mobility service market in order to select a prototype for further development and specify the Human-Machine-Interface (HMI). This report also refers to results of the stakeholder workshops that have already been organized in Germany and Austria, since the discussions gave valuable hints on interesting user scenarios and Human Machine Interfaces for intermodal mobility services from the provider’s perspective.

With regards to the Delphi survey (see chapter 2), one has to acknowledge that they only represent experts’ opinions on probable future developments. The resulting theses will give only give a general hint on what the scientific or practical communities familiar with certain technologies think about the application of future technologies. This has to be reflected in the light of general social trends that will be discussed in chapter 3 as well as in further expert discussions, particularly the stakeholder workshops organized in Germany, Austria, Spain, Belgium and Sweden. In this report, we will therefore also integrate the results of the German and Austrian workshops that have already taken place in February and March 2015. In chapter 4, we will finally discuss requirements for wearable devices used for supporting intermodal mobility in order to define further development activities within the project.
2 Social and technological trends and their impact on wearable devices

The aim of this chapter is to describe technological or social trends that could potentially support the use of wearable devices among travellers using different transport modes. Since wearable devices are still a niche technology, the integrated perspective on social and technological trends can reveal potential future user demands for technological support while travelling. From these demands, we can conclude which combinations of mobility services and wearable devices will probably meet the demands of intermodal travellers.

In the context of the Guide2Wear project, current wearable devices and mobility services have already been analysed in order to show how wearable devices can contribute to helping intermodal travellers in the daily use of public transport, car- or bikesharing systems (see Deliverable 3.1 - Overview on functionalities of technologies for seamless travelling). On basis of these results, the research done in this section is trying to identify social and technological trends that could be regarded as external drivers to push the diffusion of wearable devices in the mobility sector.

Thus according to this approach, there are four major trends that can be connected to the use of wearable devices:

- **Smart travelling in smart cities**: The city is an important arena for implementing new technology-based solutions in public spaces and for daily life.
- **Information from everywhere and from everything**: In the future, people will interact with many objects, which incites a demand for new and better services developed and improved with the integration of wearable technologies.
- **Next mobile revolution**: With regards to the smartphone considered as the first wearable device, it is obvious that other wearable devices could profit from its success and experience a comparable diffusion process.
- **Cloud computing and the need for personal identification**: Since services that really satisfy people’s needs are the key element for adopting new technologies, the internet will be a big mall for e-services.

This chapter will conclude with the description of potential social or technological developments that could result in “anti-trends” restricting the further diffusion of wearable devices.

2.1 Trends supporting the diffusion of wearable devices

**Smart travelling in smart cities**

The term *smart city* has been introduced in connection with sustainable urban planning objectives supported by using information and communication technologies. In this context, the reduction of CO2 emissions is one of the main targets that can only be achieved when public authorities manage to increase the use of public transport by delivering new and better transport services. Thus, during the next years, sustainability policies will be an important driver for the development of new solutions for improving public transport services and infrastructures.
New services supporting sustainable mobility behaviour will considerably depend on the development of new information systems for public transport users, including both local residents and tourists. While moving in urban areas, traveller need a lot of information, e.g. on departure and arrival times, alternative routes, ticket prices, navigation at transfers, real-time notification about delays or incidences, booking of shared transport modes (car and bikesharing), walking routes etc. Here, mobile devices can help to access the relevant data on the route. Wearable devices have a great potential for integrating functionalities in a user-friendly way, which will considerably improve the user experiences on public transport.

![SwissPass, swiss public transport smart card](Thinkinghighways, 2014)

Smart devices will not only help travellers to get the appropriate information for their trips, but also support public transport staff in controlling tickets or assisting travellers.

**Information from everywhere and from everything**

Another trend supporting the use of wearable devices will be the implementation and integration of several technologies that will allow a continuous exchange of information between people and their environment. This will enrich people’s daily interaction with any object or service. Nowadays, there are already several technologies like RFID or NFC supporting these human environment interactions in the context of ubiquitous computing, context aware or location-base services, augmented reality applications or the internet.

An example for such an human environment interaction is car parking system in Westminster’s Council (London). Here, RFID sensors are integrated in the parking area, building a sensor network that allows people to access data through a mobile application (Smart Parking 2014), showing a map with the vacant spaces (see Figure 1). For paying the fee, the app provides a link for accessing another app with payment function.
Figure 2: SmartPark app screenshot (Play Store, 2015) and RFID sensor on the ground (The Telegraph, 2014)

Regarding another set of technologies for improving human interaction with the urban environment, augmented reality and internet of things technologies are discussed, but they can rather be regarded as proofs of concept than as fully deployed applications (see Figure 3). Augmented reality applications may, though, be very useful to access information on Points of Interest (POIs) objects and resources. Here, smart glasses seem to be the most suitable wearable device for user interaction, but smart glasses as a gadget still have to get over the barrier of usability, design and data protection issues. In 2013, a survey of Bite Interactive has revealed that 90% of respondents will refuse to wear on google glasses because of “social awkwardness” (c|net 2013).

Figure 3: An example of augmented reality implementation for the enrichment of information (Nokia City Lens, 2012)
In conclusion, if augmented reality applications should improve our way of moving in urban areas, wearable devices may contribute strongly as they allow completely new ways of human interaction to access information and services.

**Next mobile revolution**

How will we use mobile devices in 10 years? Will they look like the current ones? Currently, they almost seem very similar to smart watches or glasses with regards to shape, design and hardware specifications. Regarding the hardware, innovation can be expected by getting faster and bigger processing capacity as well as solving the energy consumption. With respect to the software and particularly the operating system layer, there are only two big players, Apple and Google, leading the market, which from the perspective of consumers, almost look like the same and provide equal functionalities. But what can we expect from hardware and software to reach breakthrough innovation in the mobile sector?

Almost everyone has a smartphone, so this gadget has turned into an “essential” personal device with functionalities assisting users in daily life: Socialization (calls, messages, social networks), agenda, weather forecast, internet access, traffic, shopping, multimedia and entertainment. In this sense, the smartphone has become a very personal device. Thus, future mobile devices should focus on strengthening this intimate connection between human and technology by avoiding disorders, by stimulating interfaces and by learning from the user’s behaviour or context. Mobile devices have got many sensors that may learn what the conditions are for adapting to the context and provide users with best services for each situation. This new opportunities will be an important requirement for the next mobile software generation, which will include context aware capabilities in the operating system.

Context awareness functions support the transformation of mobiles into a mobile version of computers, which are not anymore focused on phone calls, but become a personal information manager or even a personal life assistant. Google’s Ara project, (www.projectara.com), for instance, introduces a modular mobile device composed of several modules for the screen, camera, memory or sensors, that can individually replaced and customised. In this way, a new concept of mobile devices will be available, totally customizable to each user – or as Google’s slogan says: “Designed exclusively for 6 billion people”.
With regards to this trend of customising mobile phones, future mobile personal assistants will probably rather consist of different sets of modules, which can be complemented by a set of different wearable devices. Thus, depending on the context, users can flexibly decide on a suitable set of modules – or on using them all together. In this context, some user groups will prefer to use a smart bracelet, for example, for basic personal services such as identification, electric keys for the home keys or e-wallets in addition to the main communication device with a screen (smartphone, smart watch or smart glass).

**Cloud computing and the need for personal identification**

Internet and related services is an important driver for the wearable development and their diffusion. For instance, most wearable devices already include social networking services, such as alerts for new postings. Simultaneously, cloud computing for personal data storage is facing a substantial growth. Today, one of five Europeans already cloud services (see Figure 5).
This growth of cloud computing is an important indicator for the growth of wearable devices, since cloud services will allow more usage capacity on these small devices with limited processing capacities. Hence, data collected with wearable devices could directly be uploaded to a personal data repository, facilitating users to control their data management under higher data privacy standards than on the device itself.

Another e-service market with dynamic development rates is the electronic payment sector. NFC or RFID technologies are currently implemented to support traditional shopping activities with contact-free payment for goods in a physical store. In addition, Apple and Google launched their mobile payment apps (Apple Pay and Wallet consecutively), every credit card company have as well its own system (V.Pay for Visa, PayPass for Mastercard, under RFID, ExpressPay for American Express), banks offers their own payment systems and even telecommunication companies have started to enter the payment market. Particularly, PayPal has currently extended their mobile payment options, e.g. by sending borrowed money to friends via their app.

Though, payment services are particularly in the focus of consumers and consumer associations. A study conducted by Infoscout revealed that five weeks after the launch of Apple’s revolutionary payment method in October 2014, more than 90 percent of those who could have used Apple Pay, have not given it a try (pymnts 2014). Hence, easy and simple payment with wearable devices, e.g. via RFID or NFC with smart rings, could support both the use of simple mobile payment schemes and of wearable devices. However, buying goods completely electronically requires a screen, which is big enough to see product details. In the case of e-ticketing for intermodal mobility services, it is required to integrate different providers’ platforms and to consent to collaboration agreements. In conclusion, this complexity is a major restriction for the provision of this kind of e-services in the mobility sector.

Another important factor for the future use of wearable devices is how the variety of access points to mobile networks will change. Since the introduction of tablets and smartphones,
PCs are not the unique screen to interact with the e-world anymore (see Figure 6). With regard to the growth of cloud computing services, users will probably use a unique screen for accessing information. Today, people are familiar with alternately and sometimes simultaneously using smartphones and tablets. Tomorrow, it is likely that we are used to be surrounded by multiple screens as access points: In the car, at home, at work, across the city services. Since people are already accustomed to webmailing services, people will probably also demand to get access to their personal profile and data for transactions from each private and public internet access point.

![Many People Will Use Five Screens](image)

*Figure 6: The Future mobile industry (Business Insider 2014)*

In summary, wearable devices could also be used as a communication tool for safe personal identification and payment processes in order to interact with various screens in private and public spaces.

### 2.2 Trends restricting the use of wearable devices

Apart from supporting trends, wearable devices will also face important barriers, threats or competitive technologies.

**Limited battery life**

Battery live is a major barrier for the adoption of wearable devices. With the increasing integration of functionalities and the need for designing wearable devices that really fit right to the body, reduced size and ergonomic shape, power issues should be solved at the same speed. On the long term, it is important to find solutions for energy harvesting, in terms of capturing and storing energy from external sources (e.g. solar power, thermal energy, wind energy, salinity gradients and kinetic energy) in order to supply power for small, wireless autonomous devices. Currently, shortcut solutions such as small solar cells and multi power-adapter cabins providing energy e.g. at airports or transport hubs become more and more popular as an emergency power supply for mobile devices.
Deliverable 2.1: The future use of WD in the mobility sector

Figure 7: Some solutions for power supply: Solar cell (sold at Mercadolibre.com 2015) and a multi power adapter cabin (100ideasparaemprender.com 2008)

However, smart watches, bracelets or glasses will not be accepted, if they consume a lot of energy.

**Biometrics**

Since biometric recognition from the iris, fingerprints or the face is currently an important development area, wearable devices may face a substantial competitor for the field of identification services. Several studies have stated an increasing implementation of iris recognition systems. The Acuity Market Intelligence Consultancy assumes, for instance, that “the iris recognition category will achieve a 16% market share -- the largest of any single biometric modality -- generating $1.5 billion in annual revenues".

![Iris Recognition Annual Revenue](image)

Figure 8: Expected market growth for iris recognition system adoption (Acuity Market Intelligence Consultancy 2007)
Data privacy and security

Data security in terms of protection against intrusion, e.g. by hackers, is a necessity for any digital service, since attacks can ruin an e-commerce business within a day. Furthermore, data privacy is important for users, since their data could be misused by the service provider by selling private data to other companies, detective agencies or even (undemocratic) governments. Thus, if personal data privacy or security is compromised, users will not adopt wearable devices. In the case of Google glass, the risk of recording videos without consent has been the main acceptance barrier.

Anti-wearable devices

A new concept has been developed that is directly attacking the idea of wearable devices, which is therefore called “anti-wearable devices” (Opensource.com, 2015). All anti-wearable device concepts have been mainly developed in the “open hardware” community, although some of their networks (Arduino and openBCI for example) are also contributing to the wearable development. The anti-wearable concept may be inspired by the book *Enchanted Objects*. This book is written by David Rose, who is an instructor at the MIT Media Lab, focusing on the future of the internet of things, and how these technologies will impact the ways we live and work.

The idea of the “anti wearable device” basically refers to the deficiencies of wearable devices: users need to remember to wear them, they need to be frequently recharged and they may not suit to the personal style. In order to avoid these inconveniences, anti-wearable devices are thought reversely, by embedding health and self-tracking devices into the surrounding environment rather than on the body of the user. Some anti-wearable devices products have already been published:

- App for contactless heart rate measurement, recently launched by Philips (Vital Signs, 2014)
- A computer keyboard that continuously monitors the Electrocardiography (ECG) of the user, developed by CardioID, a startup company based out of Lisbon, Portugal (CardioID, 2013)
- A car seatbelt for heart rate and respiration monitoring, developed by research center IBV together with biomedical engineering company PLUX and other partners (IBV, 2014)
- A bicycle handlebar fitted with a 3-axis accelerometer and an ECG sensor (BITalino, 2014)
In this sense, anti-wearable devices can be interpreted as tool to integrate self-tracking more seamlessly in our daily life.
3 Mobility trends: How mobile are we?

Information in relation to mobility trends within the context of the use of mobile or wearable devices as a travel assistant should mostly be found when looking at public transport, bicycle (or similar) navigation or pedestrian navigation. Uses may vary from payment devices, over routing and navigation services, to the providing of additional context information or even augmented reality.

Although the use of such mobile devices\(^1\) within the context of privately owned and operated motorized vehicles is currently mostly prohibited by law, the combination of mobile devices as travel assistant for such vehicles should however not be completely discarded. The use itself during the operation may be limited, but services such as payment or subscription identification in case of rental vehicles, shared vehicles, etc. and limited routing or navigation services should remain possible.

A very concise overview (per mode) of recent and expected mobility trends insofar as different modes are concerned, is presented in the following paragraphs.

**Public transport**

Insofar as public transport is concerned, the overall current trend for the use of public transport (in terms of both passenger kilometers as well as vehicle kilometers ran by bus, rail or variants thereof), is that a slight yearly increase in the use of public transport could be found over the past decade.

When looking at the future, different relevant trends that influence the use of public transport can be identified. In particular, this concerns population trends such as population increases or decreases and changing population profiles (ageing, occupation level, etc.). Also, trends in land use have an influence on public transport. For example, the ongoing trend towards more urbanization (urban sprawl) can be linked to an increased use of public transport. In addition, general economic trends and income levels are also linked. Each of these trends influence the (need for governments to) finance sustainable urban mobility, and in effect increase the use of public transport.

**Motorized, non-public transport**

Similar to public transport in the EU28, a trend can be identified of an increased use of vehicles such as cars and motorbikes over the past decade. Short term (2020-2030) projections indicate a continuation of this trend. However, several drivers can be identified that at least should make it possible for alternatives to private motorized transport to exist. Examples thereof are: policy drivers such as the EU White Paper on Transport (high policy

\(^1\) Assuming that the current emphasis of wearable devices is mostly smartphones.
level), national mobility policies and regional initiatives; monetary drivers such as (public or private) support for the use of shared vehicles (shared cars, ride-sharing, etc.), etc.; technology drivers such as an evolution towards electric vehicles or autonomous vehicles. It is perhaps mostly in the latter two drivers that a potential beneficial benefit for the use for wearable devices lies.

**Soft modes (pedestrians and bicycles)**

Insofar as biking and walking are concerned, no studies were found that provide a direct quantified estimation of the evolution of biking or walking towards the future. However, similar drivers compared to public transport can be identified and the existing policies aimed at reducing external costs as a result of transport should also favor the use of soft modes.

In summary, we may expect that the overall mobility of persons will probably increase, although differences across modes may exist. Such differences may occur as a result of public policies but also as a result of technologies that are available. It is within this context that wearable devices may prove to provide valuable assistance to the benefit of particular modes or variants of existing modal uses. Typical functions that may assist travelers are discussed in the next chapter.

![Figure 9: Historic & Forecast Population Trends for EU Member States – 2000-2016 (Source: IMF, World Economic Outlook Database)](image-url)
Figure 10: Population pyramids in the EU28 for the years 2001 and 2013 (in % of the total population) (Source: Eurostat Statistics Explained, Population structure and ageing)

Figure 11: Employment rates by age group in 2013 (Source: Eurostat Statistics Explained, Employment statistics)
Figure 12: Total resident population in the Urban Audit core cities (Source: Eurostat regional yearbook 2014)
4 Results from the Delphi Survey: Functions and potential user groups of wearable devices

The first empirical task within the project was the Delphi survey. The Delphi approach has been developed in the late 1950ies by the RAND Corporation and is basically a forecasting technique using a panel of experts. There are several variations, but the most common process is that the expert group gets the same questionnaire with several theses on future developments for three times. After each round, the panel members get a summary of the results and probably also comments or reasons given by the other respondents. Finally, the experts are encouraged to rethink their answers and to potentially adapt their opinion on basis of the results. Since future developments are always uncertain, the Delphi method should help to iteratively decrease the range of opinions and achieve a higher consensus among experts on probable future developments.

The Delphi results should not be taken for granted, e.g. as user perspective in the future. It is rather a method to find out, if there is a certain consensus on future developments among experts or not. Although the panel is important for the results, the group is only limited and results should therefore be discussed with further expert groups within the project. Here, the workshop with German stakeholders (on March, 5th 2015 in Berlin) has been used to interpret and enrich the results from the Delphi survey, so we refer to these opinions where appropriate.

The next chapters reflect the main structure of the questionnaire. Firstly, we will give an overview on socio-demographic characteristics and expertise of the sample, which we have asked for at the end of the survey (see chapter 4.1). Secondly, the respondents were asked for their opinion on future general functions of wearable devices (see chapter 4.2) and on mobility services available on these devices (see chapter 4.3). Finally, we will present the experts’ opinions on probable user groups of wearable devices (see chapter 4.4), which will be used as a basis for the conclusion on potential user scenarios (see chapter 4.5).

4.1 The Sample: Mobility and IT experts under 40 years

All project partners have disseminated the link to the Delphi study within their professional networks in November 2014. The goal was to reach professionals that are familiar with new technologies and/ or new mobility patterns. Since the Delphi survey should only give a general hint on the development of wearable devices, the recruitment has been very broad. Finally, 91 respondents have filled in the complete questionnaire. More than half of them came from Germany (see Figure 13).
Deliverable 2.1: The future use of WD in the mobility sector

Since the market for mobile applications for long-distance and local trips is particularly developed in Germany (see also D 3.1), the overrepresentation of German respondents does, however, not considerably falsify the results.

Due to the general recruitment, the questionnaire included one multiple choice question on the respondents’ expertise. Here, it was remarkable that more than half of the respondents considered themselves as mobility or software experts and most of them as expert for both (see Figure 14). All experts for wearable devices have also been software experts and two thirds of them experts for mobility services.

Figure 13: Country of residence of the Delphi survey respondents

Figure 14: Expertise of the respondents
The sample is therefore indeed generally qualified to estimate future developments at the link between ICT and mobility. Finally, we have also asked the respondents about their age and gender (see Figure 15).

4.2 Devices and functions: Health monitoring, GPS and HEI

If a main characteristic of a wearable device is to be wearable, i.e. to be always attached to the body, smartphones would not be considered as wearable device. Nevertheless, in the survey, the smartphone has been added to the choice of devices for three reasons. First, it is probable that wearable devices will be equipped with the same functions like smartphones, although not always in the same combination. Hence, wearable devices will at least for the next decade follow rather the path of the mobile device evolution and are not considered a completely new technology. Second, respondents are familiar with smartphones and can therefore better estimate functions of wearable technologies in comparison to the smartphone. Third, many wearable devices will still be connected to mobile internet via smartphone in the future. Thus, it is also of interest to see what role the smartphone will play in the future.

The experts were asked to give their opinion on the general functions that WD will assumingly provide in the future. We did not ask for an exact date in the future, since this question rather refers to general functions that are partly already available on current prototypes and first device generations. With respect to the functions, the respondents made a clear distinction between devices, namely smartphones, smart watches and glasses, which
are connected to mobile internet and which therefore show a broad variety of functions on the one hand and devices with limited functions, i.e. smart bracelets, rings and clothes, on the other hand (see Figure 16).

Figure 16: General functions of wearable devices

According to the respondents, the smartphone will still be the main device for phone calls and music, although half of them also assumes that smart watches will also be used for phone calls in the future. More than 40 % think that phone calls and 70 % that music will be an important function of “other devices”. Here, we have not asked for a specification of “other devices”, but for another question, the respondents named potential other devices like smart pens and lenses, implants an tattoos or computer-brain-interfaces. Moreover, in the German stakeholder workshop, smart headphones have been lively discussed as an important device for e.g. phone calls. Thus, respondents in the Delphi survey could have had also smart earphones in mind, when thinking of “other devices” for phone calls or music in the future.

In comparison to the other devices, the smartphone is also to be expected the main device for games, multimedia and, of course, internet connection. This is obvious, since smartphones have a much bigger screen than wearable devices. Since projections on smart glasses can also display pictures and quite a lot of information, they are assumed to be the only device that can compete with smartphones in the future with regards to the functions of gaming and multimedia. Regarding, Augmented Reality functions, they seem to be even more suitable than smartphones, since nearly 90 % of the respondents think that smart glasses will be used for augmented reality, but less than 60% think that smartphones will feature AR functions.

GPS functions and sensors for Human Environment Interactions (HEI, e.g. RFID sensors or NFC) are the basis for both Location Based Services (LBS) and sensor based
communication processes for e.g. payment or access functions. Actually, according to about two thirds of the respondents, all wearable devices will feature GPS and sensors for HEI. Hence, this seems to be an important feature of wearable devices and perhaps also a Unique Selling Point (USP) in comparison to smartphones. Equally, in the future, wearable devices seem to be more suitable for health monitoring functions than smartphones.

4.3 Mobility services: LBS, navigation, access and ticketing

In addition, the survey has included a question on future mobility services on wearable devices (see Figure 17)

![Figure 17: Mobility services on wearable devices](image)

Here, it is obvious that, apart from smartphones, smart watches are supposed to feature nearly the same functions as Smartphones – from intermodal routing over car- or bikesharing bookings and local navigation to access and payment functions. About three thirds of the respondents assume that smart glasses will be interesting for navigation and LBS, and nearly 60 % still think that smart glasses could be used for intermodal routing. About the half of the experts suppose that smart rings and bracelets will be used for access and ticketing functions. The same question can be also evaluated according to range of mobility services that will presumably be available per device (see Figure 18).
Here, we can also see that smart watches are supposed to be a multifunctional device like the smartphone, whereas rings, clothes and bracelets are regarded as devices that will be used for access and ticketing functions, rings and bracelets also for booking functions. Glasses are the most suitable wearable device for LBS and local navigation services, probably because AR is particularly useful for these services.

4.4 User groups of wearable devices: Young people and tourists

The last part of the survey was dedicated to potential user groups for wearable devices. Here, we have asked, which user groups could be interested in which device (see Figure 19).
More than half of the respondents think that smart watches and smart glasses could be interesting for every user group, though mostly with higher rates for watches. About a half also assumes that smart clothes could be interesting for seniors and people with disabilities. At least one third still believes that smart bracelets could be useful for all user groups except of business travellers. Smart rings only play a minor role, although a third thinks that they could be interesting for people with disabilities.

The same question evaluated according to the main user groups per wearable device also shows that smart watches and glasses could be interesting for all user groups (see Figure 20).
According to the respondents, business travellers, tourists and young people, however, would rather wear a smart watch or – with the exception of business travellers – also glasses. For people with disabilities, each device is supposed to be interesting.
4.5 Conclusion: User Scenarios for mobility services on wearable devices

From the Delphi study, we can conclude that each user group will use different wearable devices that particularly fit to their information needs as well as to their wearing habits. An additional user group that has not been specifically part of the Delphi survey, but turned out to be an important user group for public transport providers are occasional public transport users. From the Delphi survey, though, we could also extract hardware and service preferences for this group (see Figure 21).

![Figure 21: Occasional public transport users](image)

Occasional public transport users are defined as users that have no routines for a certain route with public transport. This includes travellers that only use public transport every now and then, but also users that are generally familiar with public transport, but use an unfamiliar route. This user group travels locally, but needs information on adequate routes for the according situation and local information at transfers between different transport modes. Moreover, they particularly need information in case of disruptions, e.g. on alternative routes or transport modes like cycling or carsharing. Some Location Based Services, for example information on waiting rooms, are also of interest for them.

Occasional public transport users will probably have a preference for devices that they could wear every day, like smart glasses, rings or bracelets and, in case of a need for pedestrian or cycling navigation, potentially also for smart glasses. While smart watches can be used for routing, booking and navigation functions, smart rings or bracelets will rather be useful for push services, e.g. in case of disruptions, or access functions, e.g. for using spontaneously a new transport mode. In this case, watches, rings or bracelets complement particularly smartphones or tablets by making certain interactions easier. Hence, travellers do not have to take out their smartphone for checking disruptions, entering a station, renting a shared
bike or opening a carsharing car. In fact, this could also be an incentive for routine public transport users such as commuters to use smart watches, rings or bracelets.

**Business travellers and tourists**

- **Profile:** No orientation, potentially no language skills, high need for information & navigation, high interest in intermodal mobility → (shared) bike & car = individual mobility away from home, interested in efficient & functional applications

- **Devices & mobility services:**
  - **Smart watches/glasses** → Navigation, LBS (restaurants, sightseeing etc.); in 2030 also routing & booking
  - **Smart ring/bracelets** → Payment + positioning (no internet = no costs) (Bewegungssteuerung über Ring, AR)

![Business travellers and tourists](image)

**Figure 22: Business travellers and tourists**

Business travelers and tourist are defined as users that are not familiar with the local transport system (see Figure 22). They have therefore a higher need for local and mobility related information than occasional public transport users. They also might to be more open for shared mobility offers, since they provide the option for individual transport in situations, where the own car or bike is not available. If they get information on these new transport modes, they will probably more likely use them.

Wearable devices are particularly important for both groups, since they can provide more information on different interaction modes without bothering the user. While, for instance, smartphones have to be constantly checked for navigation services on unfamiliar routes or for Location Based Services, smart watches, rings or bracelets can unobtrusively send an impulse before transfers or in case of passing by a POI. For both services, navigation and LBS, smart glasses are also more practical than smartphones. In spite of reservations towards smart glasses, tourists wearing smart glasses could probably face less resistance, since they often document their trip on film or photo anyway.

On the long-term, i.e. in about 15 years, smart watches could also provide services like routing or booking a carsharing car that are today only available on smartphones. Another special demand of international business travelers and tourists that has been particularly discussed in the stakeholder workshop is to use mobility services that do not require an internet connection, which could result in high roaming costs. Therefore, particularly unconnected devices like smart rings or bracelets could be used for positioning or payment functions on private or business trips. Differences between tourists and business travelers...
are that business travelers potentially prefer a less obtrusive device than tourists and that they also need different information.

Another user group that could mainly be interested in wearable devices is people with disabilities (see Figure 23).

![People with disabilities (seniors)](image)

**Figure 23: People with disabilities**

In general, travelers with disabilities have principally higher information needs than the average population in order to manage their trips, since travelling usually means a higher effort than for other people. They moreover need particular information, e.g. on help desks, lifts or transfers that can be provided by special LBS or navigation services adapted to this user group. For them, navigation and assistance functions provided by smart watches or glasses as well as more simple interactions can therefore be an important incentive for using wearable devices.

Apart from that, certain wearable devices can compensate physical deficiencies such as movement disorders, deafness, blindness or poor eyesight. Here, smart glasses or smart earphones are particularly important for people with visual and acoustic impairments. In contrast, smart rings or bracelets could be of particular interest for physically impaired people. Moreover, user groups with health issues could be interested in health monitoring functions on wearable devices.

On the opposite, young people will probably find other wearable devices functions interesting (see Figure 24).
Youths

- Profile: Very open for innovative and „fancy“ mobility services & WD (gamification, social media, UGC), WD = „accessoire“, data privacy maybe not very important; pt + bike!!!

- Devices & mobility services:
  - Smart watches/ glasses → Navigation, LBS (social networks etc.)
  - Smart clothes: GPS & HEI, also music & games

Figure 24: Young people

Similar to people with disabilities or elderly people, young people are particularly dependent on the public transport. In addition, cycling is also especially popular among this user group. In this context, we also have to consider that giving young people positive public transport experiences can significantly help to keep young people as public transport customers after reaching the age for driving a car. With regards to this user group, attractive mobility services on wearable devices could indeed provide such an experience, e.g. by integrating gaming or social media functions. Moreover, young people could also be particularly interested in wearing smart watches, bracelets, glasses or clothes as fashion accessory. Since youths tend to be less aware of data privacy issues, they could also be open to use social media in combination with location services, e.g. for finding social network friends at a station or in a train.
5 Conclusion: Requirements for wearable devices supporting intermodal mobility

In the light of the trends described in chapter 2, the Delphi study results on functions, mobility services and user groups lead to more specific requirements for designing mobility services for wearable devices. Service scenarios should, for example, consider that the Internet of Things will probably lead to completely new Location Based Services that will not require same computing capacities as smartphones show today. Hence, it could be particularly interesting not to regard wearable devices as smart technologies, but rather as “dumb” devices with limited functions that rather gain information from their environment. Wearable devices could rather be used for simple functions connected to the user like identification or positioning services that are only used in combination with an intelligent and connected device at a certain location. For instance, RFID equipped rings or bracelets could only send information, e.g. on the user’s public transport or carsharing account, when triggered at a certain access point. For all other situations, the device is “only” a personal item that is always at hand. This kind of wearable, but not very smart devices could indeed be the basis for the “next mobile revolution” adapted to smart environments.

On the opposite, smart watches and glasses that are connected to cloud services could profit from the ongoing exponential growth of capabilities of electronic devices by providing context aware services that automatically react on the according situation. This requires powerful calculation processes and intelligent algorithms that are shifted to the cloud. Though, mobility services will only be successful, if they meet the user’s basic demands (see Figure 25).

![Figure 25: Demands for mobility services on wearable devices (sources: https://karenarmstrong.com.au)](https://karenarmstrong.com.au)
With regards to the upcoming field studies, WP3 results will help to define typical situations and locations, in which users need a wearable device: Which transport mode combinations are common for intermodal travellers? Where are typical transfer locations and how can we classify them? What are the main characteristics of the future customer group of intermodal mobility services on wearable devices? Furthermore, the outcome of the field study will also help to estimate the impact of innovative mobility services on travel behaviour.
6 Annex

6.1 References


The Telegraph (2014): Smart parking app begins rollout in London’s West End, 
Thinkinghighways (2014): Swiss public transport smart card to be introduced next year, 
http://thinkinghighways.com/swiss-public-transport-smart-card-to-be-introduced-next-year/