ARGUS

Assisting peRsonal GUidance System for people with visual impairment

ICT-2011.5.5 ICT for smart and personalised inclusion

Grant Agreement: 288841

D1.2 State of the art of the relevant technologies and standards

Date of submission: 1/10/2012

Work Package: WP1 Technical requirements and scenario definition

Version: 1.1

Dissemination level: Confidential (CO)

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1 INTRODUCTION

Visually disabled people have striking needs for trustful navigation systems enabling for efficient mobility services, mainly considering safety and autonomy. In this context, satellite positioning and navigation technologies available are being implemented in innovative personal navigation devices. But existing products and solutions based on GNSS fail because they lack accuracy and integrity, they don't provide a suitable and efficient man-machine interface adjusted to this user segment, or rely on costly infrastructures. This lack has been identified and is topic of research in many national and international projects.

To avoid fault or duplicate development, this deliverable will give an overview on current state of the art solutions, technologies, services and related standards. The focus lies on commercial off the shelf (COTS) products and prototypes which have been or are currently under development in research and development projects. Besides devices, which are directly related to our target users this deliverable also evaluates mainstream technology which can be (easily) adapted for usage by our target users. Due to the fact that we need high accuracy GNSS data, to guide visually disabled people, this deliverable will also give an overview of the different GNSS-Signal correction services which are available in the partner countries. Based on the fact that the needs of our target user group are nearly the same in all countries, and our solutions are for an international – at least European – market, the project will use and engage in related standardization activities. Consequently this deliverable provides an overview of existing accessibility standards.

As this document is a state of the Art report (STAR) there is no guarantee of completeness. Also the focus lies on COTS products which should be usable by our target users.

2 GEOSPECIAL DATA OVERVIEW

For pedestrian navigation solutions the quality and the detail of the maps are even more important than for in car usage. All commercial map providers started with their maps for car usage. Foot paths or trails are often not included in their standard maps but these are the ways that pedestrian wanted to use. In the earlier days of navigation systems, the maps have been the same for pedestrian use - only the routing algorithm avoids motorways and highways. In the earlier days some systems even didn´t allow the usage of a one-way street in both direction when using pedestrian mode.

Navteq and Tele Atlas are the leading global providers of digital maps, and their maps can be found in nearly all navigation devices or software currently available on the market. As maps are changing – new roads are constructed, old roads are changed, etc. all provider of digital maps need to constantly update their material. According to (1) only about 15-20% of the data have been changed during the quarterly updates of e.g. the German map. To save space and CPU-power the maps are stored in a vector format together with several attributes like size of the street, direction, speed limits, etc.

With the increasing competition of Google or the community based maps the commercial maps are becoming more detailed.

2.1 Google

Google Maps, is a free online map service which can be used by either a browser, Google Earth or apps installed on many smart phones. Google provides online map data and satellite images which can be used additionally as route planer for pedestrians or cars. Since 2005 Google is offering the "Google Maps API" for using their maps. Commercial usage of Google Maps is only allowed when acquiring a commercial license from Google: Without a license from Google it is not allowed to use Google Maps "*with any products, systems, or applications for or in connection with (i) real time navigation or route guidance, including but not limited to turn-by-turn route guidance that is synchronized to the position of a user's sensor-enabled device; or (ii) any systems or functions for automatic or autonomous control of vehicle behaviour"*(2).

Google Maps API provides possibilities to include Google maps on websites and/or to adopt and customize map data and it is the only legal way to access maps or satellite images. Google Maps API is available for non commercial use only; however Google is also offering a business license for the API allowing for company internal or paying customer usage only, and for applications like fleet management, tracking, etc(3).

2.2 Navteq

The U.S. Company Navteq is active in this business since 1985 and was bought in 2008 by Nokia. As written above the update and acquisition of new map data is one of the main jobs of the company. Therefore Navteq runs about 35 mapping cars (1) which are driving through Germany. These mapping cars are equipped with lots of sensors and electronics to improve the accuracy and to detect attributes like one-way streets, speed limits, etc.

Navteq provides their data to their customers in the following extraction formats[1] to allow customers to process the data into their own format:

- Relational Data Format (RDF)
- Geographic Data Format (GDF 3.0)
- NAVSTREETS
- Points of Interest (POI XML)
- Oracle Delivery Format (ODF)
- File Geodatabase (FGDB)

Map data is only commercially via licensing available. According to (4) licensing fees are based on different factors, e.g., the area of map data, content, volume and functionality.

Navteq has recognized a growing demand for location based services on mobile devices thus for pedestrians. The new Navteq Discover Cities shall enable pedestrians "*to navigate efficiently on foot or via public transit systems. This enabling product provides the street, pedestrian and public transit network and relevant location content to bring a city to life on a mobile device*"(5). Navteq Discover Cities combines pedestrian navigation with public transport information to allow a combination of walking and using public transport. Navteq Discover Cities is currently only available for major cities around the world. During the STAR ARGUS could not figure out actual information regarding the coverage available today. Even the new Navigon Urban relies on OSM data instead of Navteq map data.

2.3 Tele Atlas

Tele Atlas is one of the leading Map data provider besides Navteq. Since 2008 it is subsidiary of TomTom the manufacturer of navigation systems. Like Google and Navteq Tele Atlas acquires and updates their maps with mapping vans, which are driving the roads that should be acquired or updated. Tele Atlas is using mapping vehicles with multi-camera systems, 3d-gyroscope and wheel sensors. According to (1) Tele Atlas has about 22 mapping vans driving through Europe. Using this technique it is obvious, that the main focus of Tele Atlas maps lies on maps for fleet management and car navigation. Since 2008 Tele Atlas does also provide maps which include information like smaller ways and pedestrian path for pedestrian navigation.

To speed up the recognition of fault map data and the time for update Tele Atlas provides a web-based reporting service called "mapinside"[2]. Using this service allows users of Tele Atlas to report new roads or mistakes in the current maps. Including users in acquiring updates should help to improve the quality of the maps and provide faster updates.

[1] http://www.nn4d.com/site/global/products_licensing/navdataformats/p_navdataformats.jsp

[2] http://mapinsight.teleatlas.com

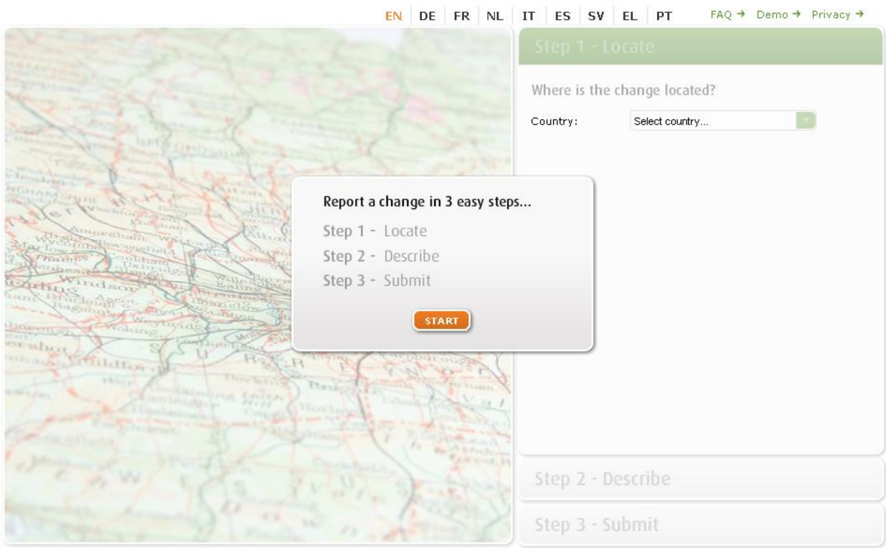

Figure 1: Tele Atlas Map Inside reporting service
Source: Screenshot by ACC

2.4 Open Street Map

OpenStreetMap (OSM) provides data that are published under the creative commons license (going to change to Open Data-base License), with the intention of promoting free use and re-distribution of the data. OSM was founded in July 2004 by Steve Coast. In April 2006, a foundation was established to encourage the growth, development and distribution of free geospatial data and provide geospatial data for anybody to use and share. The full, worldwide data is downloadable, but also excerpts are available in a variety of formats and for different geographical areas. Besides that daily (even hourly and minutely) differential files are available to grant up to date services.

The data packages are constantly updated and available to download for everybody who is interested in for free.

OSM became more and more detailed over the years and there is still a lot of activity of the “OSM-Community”. In addition to that, OSM volunteers, for a large part geospatial and IT professionals, are developing sophisticated tools to verify and improve the quality of the data and to highlight missing attributes.

The community based work also results in the addition of special attributes like wheelchair accessibility or the information if tactile markers for the blind are available, etc. Attributes which are not of common interest, but which might help a small community to better navigate. There are even communities like wheelmap.org which have specialized in gathering data about accessibility of places. These are information/attributes which are stored within OSM and which can be used for special purpose navigation aids. The fact that after 1.5 years 177.992 places have been tagged by the community of wheelmap.org demonstrates how well such a community driven approach can work.

2.5 Pedestrian navigation solutions

As mentioned in the previous chapters the accuracy of all major digital maps lies in a range of several meters. Also some very important attributes are missing, as their focus lies on car usage. To use this for blind pedestrian navigation more accurate information is needed.

The following chapter shall give an overview on available commercial of the shelf (COTS) pedestrian navigation solutions that are used / can be used by visually impaired users. Therefore this chapter does not include software or devices which are dedicated for driving, flying or sailing, nor devices which do rely on the visual channel only.

All images or photos are regarded as citations from the named sources.

2.5.1 Ariadne

With the assistance of this useful iPhone app, exploring unknown areas or taking an extensive walk outside is no longer a challenge for the blind and visually impaired people. The Ariadne GPS app (See URL http://www.ariadnegps.eu/) is an excellent iPhone app that answers the needs of the target group in an easy to use and very accessible designed user interface.

A talking map interface invites the user to investigate his environment by moving his finger around the map in a very user-friendly as well as comprehensible way. Using the exploring mode, the app indicates street crossings and intersections via vibration.

A so called “favorites” feature can be used to store personal POIs like e.g. bus stops or train stations which are then announced on-the-go. In particular blind users prefer this feature to save their own personal landmarks on their all-day routes.

Figure 2: The user interface of the Ariadne GPS app
Source: http://itunes.apple.com

The smartly designed rotating map interface continuously keeps the users centered on the screen to assist them during their exploration phase. Following this strategy, already visited areas (which are located “behind” the user) are always presented on the bottom of the iPhone screen while undiscovered districts (which are “in front of” the user (are logically placed on the top portion of the iPhone screen.

All essential control elements as well as the relevant information are completely accessible via the native screen reader solution VoiceOver.

The Ariadne GPS app provides multiple language support and works fine in all areas where Google Maps information is obtainable. This app is stated as a “must-have” app for all visually impaired iPhone users.

Many affected owners of the Ariadne GPS app recommend other users to use the application with an iPad 3G model due to the larger display size of this iDevice. This significantly improves the level of user experiences in terms of individual orientation and exploring capabilities.

2.5.2 Kapten

The Kapten appeared on the French market in 2008. Versions in Spanish, German and (UK) English followed very soon. The Kapten device, which has no visual display and a weight of 50 g, was intended to come over the safety problems for car drivers who have their COTS navigation systems sticked to their front window.

Originally it was not intended for blind users but it turned out, that the fully speech driven Kapten is an ideal navigation device for this user group.

Due to the success of the voice activated GPS navigation system, Kapsys designed the Kapten Plus (see Figure 3) in 2010.

Figure 3: Kapten Plus – A voice-controlled navigator for visually impaired and blind people
Source: Photo by K.-P. Wegge

Kapten Plus can be seen as a mainstream navigation system with some extra support for blind users for the price of a consumer product. Because information for pedestrian navigation is not fully covered by commercial maps yet, Kapten Plus doesn't know all details of the surrounding, which person with vision easily inspect by viewing around while blind people want to know from their device. It turned out that the Kapten Plus is often used by guide dog users, where the guide dog performs the near field navigation while the guided person observes the right routing.

2.5.3 Kapten Europe GPS multitransport

Many of the visual impaired users try more than one mobile navigation solution, just to find out the preferred one which fits the best for them.

Although TomTom and Navigon are very similar in their UI design and capabilities, a third iPhone app has been turned out to offer excellent VoiceOver support for blind and visually impaired iPhone users, the Kapten iPhone app (See URL http://www.kapsys.com).

This app provides a very interesting feature for most affected pedestrians. As a unique selling point the app provides the ability to include the public transit in the pedestrian route for many European cities.

Figure 4:The UI of the accessible Kapten Europe GPS multitransport app
Source: http://www.kapsys.com

The app presents comprehensive human voices which announce the street names as well as road signs. The app is also able to store personal POIs with only a finger tap, so that blind and visually impaired users are capable to safe their favorite places without any additional navigation effort. All control elements and relevant information is presented VoiceOver-friendly. An embedded map system allows the owner to use the application without an internet connection to avoid additional costs. Users are able to purchase the app in the AppStore in one of two ways: Either they can activate the app for a month for only $7.95 or they can purchase the Kapten app outright for $79.

Some user tests outlined that the integrated public transport services should be significantly improved to answer the requirements of the owners. The calculated information for public transit is sometimes not precise enough which means a loss of time for many people and in particular for blind users who really rely on this specific information. With regard to this aspect it is strongly recommended to firstly check this feature out in well-known areas to avoid any inconveniences. Moreover, to obtain the best routing results in terms of accuracy an iPhone 3GS (or higher) is required.

2.5.4 Loadstone

LoadStone GPS was developed by the Loadstone project as open source software for satellite navigation for blind and visually impaired users as a waypoint navigation (no turn-by-turn navigation). Driven by blind developers the software was developed for the Symbian platform and is available for all Symbian based phones. Due to the availability of at least two different screen readers[3] Symbian was and is very popular within the blind community. Loadstone does not provide its own text-to-speech engine therefore you need a screen reader for any voice-announcements. The Loadstone project started financed by private developers and donations of users in 2004 and was first made public in May 2006 under the GNU General Public License (GPL) (6). Loadstone comes without any maps but with tools to convert maps like OpenStreetMap into the needed format. If there are no maps available, Loadstone provides the possibility to record own waypoints together with the possibility to exchange these points' users can create their own "map" based on these gathered points.

Figure 5: Loadstone
Source: Photo by K.P. Wegge

Figure 6: Illustrated Keypad compass usage
Source: Image composed by ACC

Besides the waypoint navigation, Loadstone offers an explorer mode. Using the number keypad, this mode allows to explore the surrounding. The 5 in the middle of the keypad is the "where am I" button, which provides you with the current known position (if available) or the nearest waypoint.

[3] Talks from Nuance Communications and Mobile Speak from Code Factory

In the explorer mode the keypad can be seen as a compass (see Figure 6): Pressing the “2” Loadstone will provide you with the information about waypoints in the north pressing the “3” with waypoints in north-east, pressing the “6” with waypoints in the east, etc. Using this mechanism, the user can explore the surrounding getting a mental map of the area. One additional feature is, that Loadstone can also use GSM-Cell-Ids for navigation this can be helpful when travelling, e.g., by bus, so that the system can remind you to leave the bus when the system recognizes the corresponding Cell ID.

2.5.5 LocateMe

LocateMe is an application that allows the user to quickly view his current location in the form of an Ordnance Survey grid reference, latitude and longitude, and, if available, his current elevation above sea level. LocateMe provides the OS Grid Reference, which is appropriate for walking, cycling, and pedestrian orienteering. Having the grid reference allows the user to locate himself on good old fashioned paper maps, or if the Google Maps coverage is not great for the current location (such as in the countryside), the user can just tap to view the Ordnance Survey map online.

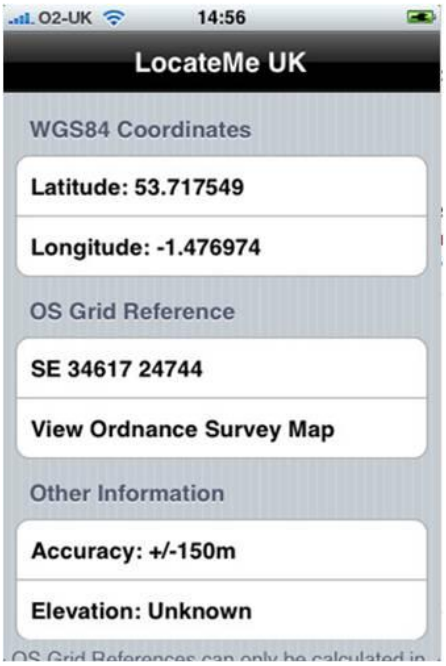

Figure 7: Screenshot of LocateMe Application
Source: Vicomtech

2.5.6 Loro Dux

LoroDux is an open source *navigation software for mobile devices for blind and visually impaired persons* (7) initiated by and based on the Open Street Map Project (OSM). To be platform independent the software is developed in Java, so that it can be used on many mobile devices including mobile phones. Lorodux does not provide navigation but guidance (linear distance), it provides directions and distances to Points of Interest (POI) which have been imported or created before. Directions are presented by means of vibration patterns

2.5.7 Navigon Mobile Navigator

With the use of the iPhone's VoiceOver screen reader utility, Navigon (see http://www.navigon.com) unveils with its MobileNavigator app an off-the-shelf GPS solution for blind and visually impaired users.

The apple iPhone provides with its powerful processor and the integrated GPS receiver an excellent and assistive platform for Navigon's portable navigation solution which really complies with the needs of the target group.

Figure 8: Navigon 1.8 on the iPhone (left: map view, right: profile)
Source: Screenshot by ACC

The function set of the mobile navigation app is in no way inferior to Navigon's hardware based products. Beside the primary function to automatically route motorists as well as pedestrians from location A to location B, the mobile app presents a lot of specific set of settings like e.g. the possibility to configure special route preferences as well as individual display options, POIs ordered by categories like hospitals, ATMs, suitable public transport information and a lot of other important locations. All of these parameters are accessible via VoiceOver, so that affected users are able to set up the app according to their special needs. All relevant information like the current location or the arrival time is presented in an accessible format and therefore can be revealed by using the screen reader VoiceOver. A congenial voice provides appropriate guidance to the affected users and prompts them to make the necessary turns in order to lead the users to their selected destination.

Navigon's MobileNavigator is available at several prices depending on the selection of the region or country users wish to explore. The navigation app can be downloaded from the App Store by using iTunes (see http://www.itunes.com) on a Mac (or PC) or directly via Wi-Fi over-the-air (OTA) on the iPhone (this requires iOS version 5.0 or higher).

The Navigon app presents a main screen with different options to enter an address, to search for POIs, to directly take the user back to home or to show the user's current location on the map.

Before entering a destination, affected users are able to select the appropriate route profile parameter that fit their needs. This option allows the users to choose between a car and different pedestrian modes (Figure 8 right image). The so called “Pedestrian with voice announcements” mode provides the most comprehensive self voicing directions.

The pedestrian modes of Navigons MobileNavigator which are configured with the route profile options are based on two different instruction procedures. The “normal” pedestrian mode guides the users in a more visual way by using the internal compass functionality of the iPhone. This method seems to work fine for a limited group of visual impaired users who are still able to cope with the comparatively small iPhone display. Blind users, on the other hand, are only able to use the speech-based pedestrian mode which prompts the users to turn to the right direction without any kind of compass information. But many of the blind Navigon users would prefer to get some information on the points of the compass to gain a better overview of their local environment. As an appropriate compromise, the compass functionality should be available as a selectable option in the speech-based pedestrian mode. Nevertheless the practice has shown that in many cases the motorcycle mode has a better performance in terms of useful voice instructions than the pedestrian mode. The motorcycle mode offers a more predictive strategy to the affected users, but normally only for partially sighted users because blind persons strictly rely on very precise route information.

Starting from the main menu, destination entering can be accomplished in different ways. Users can either use the existing contacts from the address book or they follow an easy to access step-by-step sequence to enter their destination. In both cases, hitting the “Done” button brings up the first screen for navigation.

The app now displays the destination address. A “Start Navigation” appears along with different parameters like the current temperature, a briefly report of parking availabilities and some other information. After activating the “Start Navigation” button a natural voice begins prompting.

The turn instructions are very precise and correspond with the appropriate intersection. The accuracy of the app is in particular very important for blind users, so that they can rely on it.

Points of Interest (POI) can also be used as destinations for creating a new route. These POIs are ordered in different categories including public transport details as well as many other useful information.

By using VoiceOver, all control elements of the app as well as the different options are completely accessible and clearly announced.

Note: The last update of the MobileNavigator app (up to version 2.0) was disappointing in view of accessibility features due its significantly decreased level of voiceover support. Most visually impaired owners of the app are currently not able to cope with the app because many essential control elements are not accessible through the screen reader.

Against this background , the AppleVis Group (see URL http://www.applevis.com), a discussion platform for affected users who discuss the different issues of iDevice apps and user guides in terms of accessibility, has initialized a campaign to recover the Accessibility support for the navigation app (see URL http://www.applevis.com/campaign).

2.5.8 Navigon Urban Germany

Garmin offers with its Navigon Urban Germany solution (For more details, please visit the URL http://www.navigon.com) an easy to use navigation and guidance service for the different iPhone models, in particular for blind and visually impaired users as a result of the good support of the accessibility features of the mobile devices. In spite of the fact that the app was not exclusively designed for affected users, all essential control elements are accessible out of the box.

Navigon Urban Germany is a special edition for pedestrians and bicyclists that is based on OpenStreetMap (OSM), a collaborative, open source project that develops free available and editable geographic data (for more details visit the URL http://www.openstreetmap.org). The navigation app is designated for the use in urban as well as in off-road areas and provides the users with excellent cartographical material in the different operating fields.

Figure 9: The configuration of the route profile settings

Figure 10: The Navigon Urban direction view shows a list of streets including the corresponding distances to explore the best way

Navigon Urban users are able to choose between the following three different route profiles:

- *a pedestrian mode*
- *a pedestrian mode with voice output (the preferred mode for blind and visually impaired users)*
- *a bicycle navigation mode*
- *The feature overview of Navigon Urban Germany includes the below listed functions:*
- *The complete map of Germany based on the very detailed cartographical material of the OpenStreetMap (OSM) project*
- *Google-based address search function with satellite view*
- *About 1 million POIs, including taxi stands and information about public transport systems like bus stops, underground and railway stations*

- *Support of the built-in compass for the different iPhone models*
- *Panorama view 3D as an In-App-Purchase (which is sometimes very helpful for partially sighted users who are able to use the app with their iPad 3G on the go)*

Practice-oriented tests of affected users figured out that the Navigon Urban app can be used completely “eyes-free”. The app provides a reliable GPS signal accuracy for blind users if an iPhone 3GS (or a newer model) is used. Older models do mostly not provide a sufficient accuracy due to an inappropriate GPS module which does not answer the special needs of distance tolerance limits of blind users. This group of blind users rely on a very tight tolerance range to avoid dangerous situations especially in high frequented traffic areas .

2.5.9 PocketNavigator

PocketNavigator (pocketnavigator.org) is an OpenStreetMap-based pedestrian navigation application for Android[4]. It enables the user to navigate in a foreign city without forcing him to repetitively look on his device as a usual navigation system would do. This is possible because the Pocket Navigator uses tactile feedback to guide the user through your way. Thus, your device can safely stay right inside your pocket. The PocketNavigator is one of the HaptiMap (FP7-ICT-224675) demonstrators. HaptiMap is a research project, funded by the European Commission, which aims to make map data and location-based services more accessible to visually impaired or elderly people. Because the PocketNavigator is a research demonstrator, it might be the case that it partly contains bugs or glitches. We recommend not exclusively to rely on this software.

2.5.10 Sendero GPS LookAround

Sendero GPS LookAround for the iPhone is an accessible local search app which is available in the App Store. The Sendero GPS app works fine with the iPhone 3GS and higher models. All control elements of the app are VoiceOver-friendly implemented and easy to handle in particular for blind people who exclusively rely on the screen reader functionality of the newer iPhone models. The app does not work with the iPod (due to the lack of the GPS module) and the user interface is not really optimized to be used on an iPad. For that reason, most affected users recommend to use the Sendero app only on an iPhone 4 or higher to ensure a better accuracy in terms of reliable GPS localization.

After launching Sendero GPS LookAround, a shake of the mobile phone will cause the app to search and display the following information: street name, name of the city, the next crossing street as well as the nearest point of interest found in the POI category that has been configured by the user before within the settings menu. The restaurant category is normally chosen by default. Users only have to shake their iPhone again to obtain the newest information about their current location.

The main screen of the Sendero GPS app offers 3 buttons to the users:

[4] http://wiki.openstreetmap.org/wiki/Android

The "Where am I" LookAround button: Shows the above mentioned information

The Nearest Cross Street Button: (Self-explaining)

The Nearest 5 Points of Interest button: Offers a list of the corresponding POIs ordered by their distances, including specific data like the address as well as the phone number of the presented locations.

The app is currently only available in its native English language and the quality of POIs as well as the corresponding map information highly depends on the location of the user. The best search results are presented in North America and in Europe, other countries are as well supported but their data quality seems not to be very satisfying with regard to a reliable use of the app. In particular, most rural areas are not really good represented in terms of sufficiently detailed local information. For more details please visit the URL of the Sendero Group LLC http://senderogroup.com.

2.5.11 Skobbler

Skobbler GPS Navigation for Android is a service which combines an Internet community with a free mobile phone navigation system. Use it to find the right location in the internet and when on the move. These features make Skobbler GPS Navigation for Android a search engine for special places and locations, which in conjunction with the mobile phone will guide the user to the desired destination.

Figure 11: Screenshot of Skobbler application
Source: Vicomtech

2.5.12 TomTom

TomTom West-Europe mobile navigation app for the iPhone (and iPad) is remarkably accessible, and compared with Navigons MobileNavigator, both apps are very similar in their structure and design in terms of accessibility handling. Most of the differences between both apps are subtle, but may be important to individual users and how they cope with it.

If the app is installed on the iDevice it appears as "W.Europe" on the springboard. Starting the app, the home screen opens with the main menu including the following options:

"Navigate To,"

"Mute Sound,"

"Day Colors,"

"2D Map,"

"TomTom Traffic,"

"Advanced Planning,"

"Browse Map,"

"Help Me,"

"Manage Favorites,"

and "Change Settings."

Some specific settings of the app like e.g. the "Set home location" as well as the "Voice select" options should be configured before using the app the first time. The TomTom app provides different natural sounding voices which guide the user with precise direction prompts to their destination. The recorded voices instruct the users to turn to the different directions but in contrast to the MobileNavigator app of Navigon, the human voices of TomTom do not support the announcement of street names. Nevertheless, all essential options as well as the important screen information are accessible out of the box via the native screen reader solution VoiceOver.

Regarding the home screen layout of the app, all main menu items are logically structured, the item notations are comprehensible and the corresponding buttons are very easy to control. The TomTom app provides an option to preview the streets along a walking route, this is in particular very helpful for visually impaired users who want to prepare their trip in advance.

The West-Europe app of TomTom is on a par with the accessible alternative MobileNavigator of Navigon in terms of accessibility handling.

2.5.13 Trekker / Trekker Breeze

Humanware´s Trekker was one of the first fully accessible standalone GPS orientation solution for the blind. The system consists of 3 devices, the GPS module, the Maestro PDA and a loudspeaker which can be worn at the shoulder (see Figure 12). The Maestro PDA is a standard MS-Windows mobile PDA (Dell) with a tactile overlay mounted above the touch screen. The Maestro software allows the users to use huge parts of the functionality of the PDA using the tactile overlay. Humanware sold the Maestro also separately as PDA for the blind. Together with the GPS, the loudspeaker and the Trekker software the Maestro is enhanced to a navigation system for the blind.

Figure 12: Humanware Trekker
Source: F.H. Papenmeier

Figure 13: Trekker Breeze
Source: http://www.incobs.de/produktinfos/navigationssysteme/praxistest_trekker_breeze.php

While walking, the Trekker provides spoken information about street names, intersection and if activated points of interest (POI) (which can also be added manually by the user. The maps being used were based on standard maps but have been adopted and modified by Humanware for pedestrian use only. The price, the fact that one needs three devices (that have their own power) the non intuitive UI and the seldom update of the maps resulted in a bad uptake of the device in the community. The latest version of pedestrian navigation from Humanware is the Trekker Breeze (see Figure 13). It is a further development of the trekker. Compared to the old Trekker you do not need a GPS module and a loudspeaker, Trekker Breeze is only one device which has the size of a mobile thus it is much smaller than the original device. Compared to the old device, the functionality of Trekker breath has been reduced as it contains no PDA functionality anymore. Trekker Breeze lets you follow pre-recorded routes, which can be recorded together with sighted persons or mobility trainer. Trekker Breeze already provides several points of interest when walking around, information like shops, etc, but Trekker Breeze lets the user also create own POIs. Like the original Trekker Trekker Breeze announces street names and crossings when passing them. Additionally it provides a where am I button, which announces the position and the street names, if the user feels lost, the device allows reversing the just walked way, so that the user is guided back to a safe position.

2.5.14 Wayfinder Access

Wayfinder Access is an innovative GPS solution from the Swedish company Wayfinder Systems AB. (8) It is available for Symbian phones and was designed to work with Symbian screen readers, e.g., Talks or Mobile Speak.

Highlights of Wayfinder Access include, but are not limited to:

- *A database of 20 million points of interest.*
- *The "Where am I?" feature that readily gives information about your current location.*
- *The "What is in my surrounding?" feature that initiates a scan of the immediate area to inform you of street names , intersections and nearby points of interest such as restaurants, banks, and much more.*
- *The new "Vicinity View" feature that allows you to hear audible references for an area with a scope that you can later adjust based on the radius of the scanned vicinity.*
- *Feedback on points of Interest (POI), crossings or favourites that can be restricted, prioritized, and presented according to their distance from your location.*(8)

2.5.15 Where to?

Local search as easy as it can be. The Where to? (Wohin?) app for the iPhone allows users to quickly find whatever they are looking for. The app provides its owners with more than 600 different branches to get an excellent overview over the surrounding area. By using the GPS module of the iPhone the app quickly finds hotels, hospitals, pharmacies and many other POIs which are located in the vicinity. As a new and really important feature all available opening times of the corresponding POIs are provided to the users in an VoiceOver-friendly way. Using the integrated compass module of the iPhone the app directly points into the direction of the target and offers the users a quick link which can be used with the maps app of all iPhone models.

A briefly description of the supported features:

Location based search for all iPhone models

Supports more than 600 (business) branches

Shows result on the integrated map or as a list ordered by distance

Supports augmented reality by performing a local search with the integrated iPhone camera

Shows opening times

Points with a compass into the direction of the targets

Offers direct links to Google Earth by using the maps app of all iPhone models

Offers an excellent VoiceOver-support to the blind and visually impaired iPhone owners

Is available for a price of 2,39 Euro in the German iTunes Store

URL of the app for more details: http://www.futuretap.com/whereto

The developers of the Where To (Wohin?) app really attached importance to their social responsibility in terms of accessibility since the announcement of their first release in the app store. Even the last release of the app offers remarkable accessibility improvements to the affected users. Users are provided with voice prompts which can continuously announce the direction as well as the remaining distances of their selected targets with specific hints like e.g. “Please turn left and go 200 meters” or “Please keep straight on for 150 meters”. The developers really focus on an app implementation that allows blind and visually impaired users a quick and easy to perform orientation they can cope with.

Ortwin Gentz, the managing director of the FutureTap GmbH, outlined that he and his team always think of new and interesting features for the Where to (Wohin?) app without compromising the comfortable handling of the app in terms of accessibility.

This app is a real must-have app for blind and visually impaired users. More details on features and future releases can be found on the FutureTap Homepage: http://www.futuretap.com/whereto

3 MAINSTREAM TECHNOLOGY

This chapter gives an overview on COTS solutions which are currently used or can be used for enhanced pedestrian navigation.

General technology includes technology that is used e.g., for enhancing information or the accuracy of the path finding.

3.1 RFID

Radio frequency identification (RFID) is a wide spread technology for identification purposes. Parts that should be identified are tagged with a small transponder, which nowadays could have the size of a rice corn. A special reader is then able to "activate" the tag, which then transmits the stored code. RFID tags can be found nearly everywhere in our daily life: Products in shops are tagged to prevent thievery, clothes are market to identify their origin, etc.

There are two different types of tags: active and passive tags. Passive tags (without a battery) are the most common ones at least in the area of end customer products. They are powered and activated by the interrogating signal transmitted by the reader. The maximum reading distance between reader and tag lies in cm range. To realize a bigger distance like car tracking active RFID-Tags must be used. Depending on the tag and the reader, active RFID tags can be read from within proximity of meters. Besides for tracking garments, cars and containers, RFID is also used for end-user application e.g. location based services (LBS) for tourism or in museum. There are also several research projects, where RFID is used to guide blind persons, or to provide location based services to them.

3.1.1 IT Barrier-free Project (Nedo)

The Guidance and Way Finding System Integrated with Mobile Phone for the Persons with Disabilities was a 4 years project run by 6 Japanese companies under the leadership of Meti[5]/Nedo[6].

The aim of the project was the development of a system that provides guiding and way finding for (visually) impaired persons. One main objective was to be compatible with already installed / existing and even more important already used assistive systems like RIAS (Remote Infrared Audible Sign) or PAS (Public Address System). Instead of developing just another incompatible solution, the IT Barrier-free project should be the bridge between the different solutions. Therefore the system does not rely on only one sensor, but on GPS, RFIS, Infrared and FM Radio.

While GPS is used for the rough localization and the large area information, RFID is used for an accurate localization and can be used for local information (like entrance of a building).

[5] Ministry of Economy, Trade and Industry

6 New Energy and Technology Development Organization

While FM Radio is used for the activation of local area information (acoustic signals for traffic lights or speak out systems e.g. at buildings or ATMs, infrared is used for direct information like the status of traffic lights which needs to be crossed (e.g. Remote Infrared Audible Sign ANSI A117)

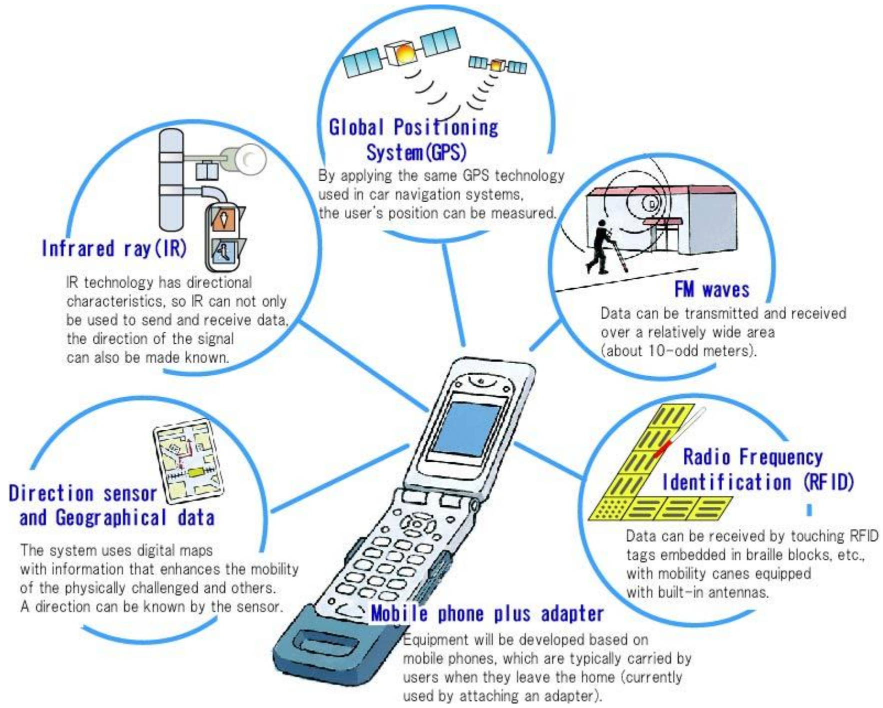

Figure 14: Interoperability of IT Barrier-Free Project
Source: http://www.itbarrierfree.net/e-image-use.html

To bring all these solutions together without having the user to carry around several devices, the ITBF solution enhances the tools and devices the users are carrying with them anyway. The RFID reader is included in the white cane, infrared sensor and FM transmitter are included in a separate box which can be mounted to a standard mobile phone. (9), (10)

As a result of this project, JIS and ISO have decided to standardize way finding under ISO TC 173 SC7 way finding

3.1.2 SeSaMoNet

SeSaMoNet (SEcure and SAfe MObility NETwork) is a prototype developed by the JRC the European Commission´s Joint Research Centre[7]. It is a 2km prototype path which was set up at the Lake Maggiore in Italy. The system consists of 5000 passive RFID tags embedded in the walkway in a single line (~ every 65cm) and a RFID-reader mounted to a white cane. A mobile phone coupled with the cane is guiding the user along the track, providing location information and guidance by means of pre-recorded voice. Based on the unique ID of the tags, the system signals that the user is still on the right way at some points the system also provides location information of the surrounding.

[7] http://ipsc.jrc.ec.europa.eu/

3.1.3 SmartCane (Central Michigan University)

A similar approach as the SeSaMoNet Project was developed by Students at the Central Michigan University (CMU). Contrary to the SeSaMoNet Project, the CMU-approach uses passive RFID tags mounted on mini flags which are sticking out of the ground. Furthermore they use a cane equipped with an ultrasonic sensor as well as a separate navigation system and a speaker which are stored in a backpack. The speaker in the backpack announces obstacles and directions to the user. A single test bed has been setup by Students at the CMU campus for the evaluation.

Additionally this solution does also support deaf-blind users by providing a special glove that gives directions by vibrating patterns at the fingers.(11)

3.1.4 Aktiv kommunizierendes Touristik Informationssystem (AkTI)

Besides using RFID tags for guiding persons along a certain path, it can also be used for providing location based services. One of the main topics of the AkTI[8] project is to provide information to visitors using RFID-technology. The idea is to tag touristic relevant buildings in the old town of Soest and provide text, video, audio information about the tagged object. Type and amount of information presented depends on the interests and the users themselves: general information, detailed information for those who are really interested in details, information for visually impaired users and information for pupils.

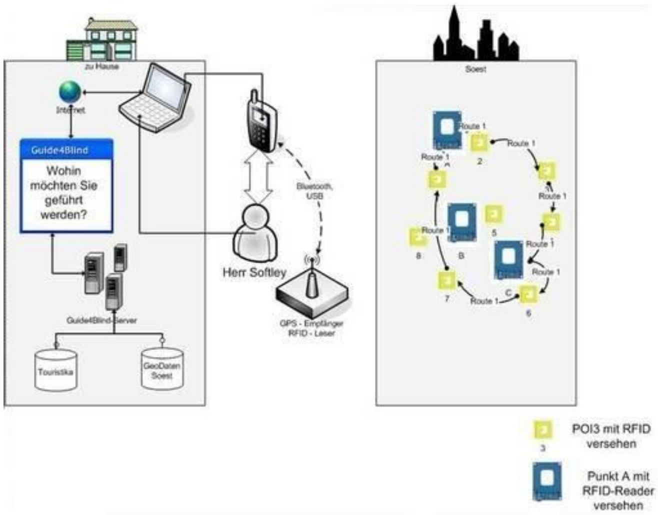

Figure 15: Oldtown city walk of Soest.
Source: http://www.guide4blind.de/guide4blind/technologie/kommunikation/117060100000054419.php

The idea is that visitors can follow certain pre-defined theme walks through Soest getting multimedia information at the historic sites. After choosing the theme walk information about the content and the length of the route will be provided to the user. Due to installation of RFID tags at public transport facilities user can choose whether to walk the tour or to use public transport. To realize this goal about 100 relevant POIs, bus stops and busses will be equipped with RFID tags.

[8] AkTI is part of the Guide4Blind project cluster.

3.1.5 Conclusion

The approach of all RFID-based projects is nearly the same:

Selected routes have to be equipped with a huge number of RFID chips in a row and have to be registered in a database together with the information they should provide. Although there are possibilities to recycle RFID-tags they still have a relatively high price especially as you need lots of them, e.g. 5000 for 2 km in the SeSaMoNet Project.
The overall result is that compared to GPS the usage of RFID can provide a very high accuracy for locating the position in the field. But on the other hand these solutions have no flexibility, as the user can only use previously marked routes. Additionally there is a huge effort as many RFID-tags have to be installed in the floor. Especially local and temporary obstacles like roadwork etc. may destroy the RFID-tags or they have to be removed before, creating additional overhead.

Due to these issues, RFID is not really applicable as a navigation solution. But in combination with other more flexible localization techniques like GPS – RFID could be used to mark POIs like dangerous crossings or buildings, tracks, etc with a higher accuracy and therefore more security and comfort.

3.2 NFC

Near Field Communication (NFC), which has similarities to Bluetooth, is a wireless connectivity technology that is based on a set of international standards and allows for contactless communication between electronic devices across short distances of 4 cm or less operating at 13.56 MHz on ISO/IEC 18000-3 [ISO18000-3] air interface and at rates ranging from 106 to 424 kbps (see (12)). The chart given in Figure 16 below shows how NFC compares in range and speed with other wireless technologies that can be used in a mobile device.

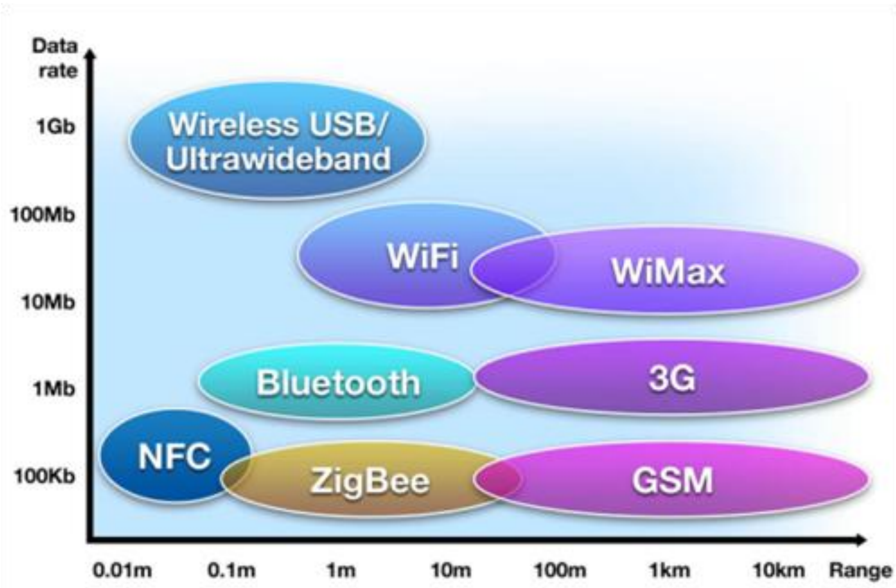

Figure 16: NFC compared with other wireless technologies
Source: http://www.nfc-forum.org/aboutnfc/nfc-other-contactless.png

"NFC always involves an initiator and a target; the initiator actively generates an RF field that can power a passive target. This enables NFC targets to take very simple form factors such as tags, stickers, key fobs, or cards that do not require batteries. NFC peer-to-peer communication is possible, provided both devices are powered." (12)

More precisely, the application spectrum of NFC comprises the following two different operational modes (see (12)):

- Passive Communication Mode: The initiator device provides a carrier field and the target device answers by modulating the existing field. In this mode, the target device may draw its operating power from the initiator-provided electromagnetic field, thus making the target device a transponder.
- Active Communication Mode: Both initiator and target device communicate by alternately generating their own fields. A device deactivates its RF field while it is waiting for data. In this mode, both devices typically have power supplies.

Since NFC works across short ranges and supports encryption, it may be more suitable than earlier, less private RFID systems to be used in electronic identity documents and keycards. If only for the latter the application spectrum of the NFC technology is versatile:

"NFC devices can be used in contactless payment systems, similar to those currently used in credit cards and electronic ticket smartcards, and allow mobile payment to replace or supplement these systems. For example, Google Wallet allows consumers to store credit card information in a virtual wallet and then use an NFC-enabled device at terminals that also accept MasterCard PayPass transactions. Germany and Austria have trialled NFC ticketing systems for public transport."(13)

The following section details several NFC-based e-Ticketing systems which have already established.

3.2.1 e-Ticketing

In Germany, Touch&Travel is a NFC-Smartphone-based eTicketing system for passengers traveling via public transit that is offered by Deutsche Bahn AG (the national leading passenger and logistics company) and other transportation companies and associations. One of the benefits of Touch&Travel is that destination stations can be modulated during travel. In order to use Touch&Travel passengers initially require to register online at www.touchandtravel.de and to download the free of charge Touch&Travel App from their provider to their Smartphone. When then staring their journey via Touch&Travel they need to present their NFC Smartphone to a Touch&Travel Touchpoint (see Figure 17).

In doing so the information about the departure station is automatically stored to their Smartphone via NFC technology (check-in). At the end of their journey the passenger once again presents his Smartphone to another Touchpoint causing information about the destination station to be stored to their Smartphone (check-out). The accordant fare is automatically calculated by the Touch&Travel system by using the information about check-in, check-out, and intermediately traversed mobile radio cells. The charges are subsequently settled on a monthly basis via direct debit. For further information see (14).

Figure 17: Using a Touch&Travel Touchpoint
Source: http://www.m-commerce-blog.de/wp-content/uploads/2009/10/Touch_Travel.jpg)

A similar system is established in London. There, "*users of Oyster travel card simply "touch in" and "touch out" their cards over NFC readers to get a lift. No, they need not touch the readers with their device (say card or phone), but one device must be close to the other*." (15)

3.2.2 General Operation Fields of NFC

The NFC Forum expects the usage of NFC mobile phones to become established and increased in many different areas of daily life (see (16)) as depicted in the chart of Figure 18 below

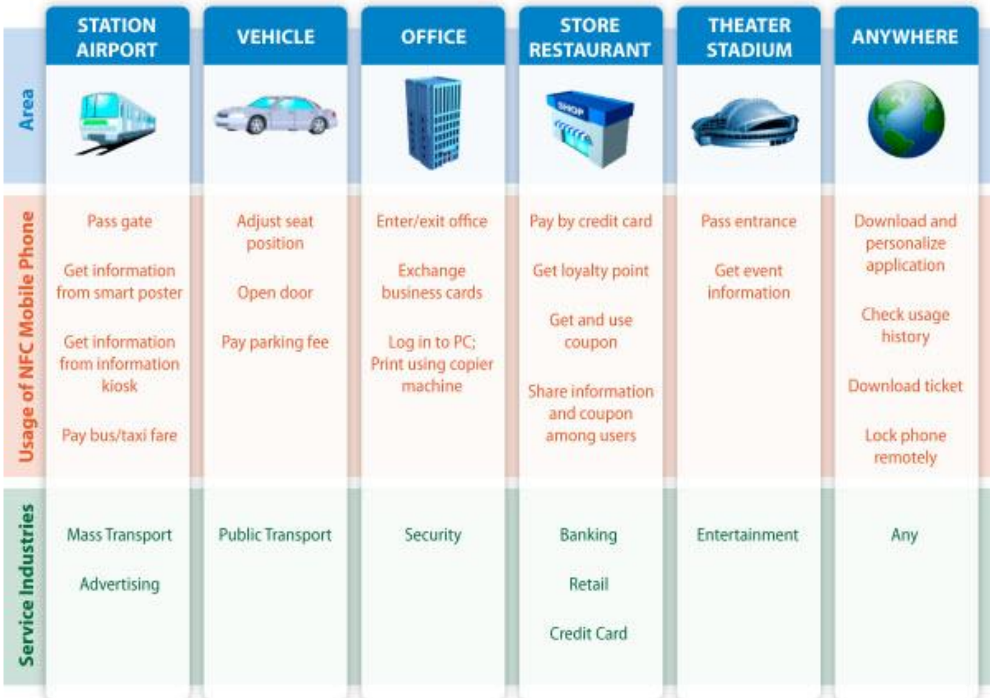

Figure 18: Operation fields of the NFC technology
Source: http://www.nfc-forum.org/aboutnfc/dayinlife.jpg

3.3 Wi-Fi

Localization based on WI-FI is realized by triangulation. Due to the Wi-Fi-Coverage a navigation system based on WI-FI – today – is only achievable in an indoor environment. A reliable system for the outside fails due to the unreliable availability or the less availability of wireless access points. The more access points available the better is the accuracy of the locating function. On the other hand airports, stations, malls and conference centers are nowadays equipped with lots of wireless access points, allowing theoretically a good calculation of the position. Anyhow the presence of other Wi-Fi devices as well as people can have an influence on the accuracy of such systems.

3.3.1 Google Indoor Maps

Google indoor maps as part of Maps 6.0 was released end of 2011.

Due to the unavailability of GPS in the indoor environment the system relies on Wi-Fi. "*Detailed floor plans automatically appear when you're viewing the map and zoomed in on a building where indoor map data is available. The familiar "blue dot" icon indicates your location within several meters, and when you move up or down a level in a building with multiple floors, the interface will automatically update to display which floor you're on."*(17)

Actually Google indoor is only available for android phones and maps are only available for a small amount of US and Japanese buildings. A list of available buildings can be found here:

http://support.google.com/gmm/bin/answer.py?hl=en&topic=1685871&answer=1685827

A tutorial for providing floor plans of new buildings can be found here:

http://support.google.com/gmm/bin/answer.py?answer=1685896

3.3.2 awiloc

Fraunhofer IIS[9] developed a self-sufficient WLAN localization tool which includes all available WLAN senders for position determination. The continuous self-localization is based on the fingerprinting technique. Therefore, measurements at reference points are recorded which contain all received WLAN base stations and the corresponding reception information. This "fingerprint" of the reception information is stored at a central server. The localizing algorithm of Fraunhofer IIS can calculate self-sufficient and continuously the current position out of received WLAN information. The WLAN localization is a pure software solution. The robust positioning algorithm of Fraunhofer IIS tolerates changes concerning the infrastructure. awiloc WLAN localization includes commercial hot spots as well as private WLAN senders and works without registration and access to the data network.

TeleConsult Austria is partner within the awiloc consortium and realized server-side WLAN positioning. That means that information about visible WLAN access points is collected by the mobile user

[9] Fraunhofer IIS

device and forwarded to the ARGUS server. The server executes the WLAN position determination by means of awiloc. If both positioning methods – GPS as well as WLAN – are available the most reliable position will be determined by the server algorithm. Therefore, awiloc enables positioning via WLAN whenever GPS signal is weak (indoors or in urban canyons) and is a suitable positioning add-on for ARGUS.

4 CORRECTION DATA SERVICES (GPS ENHANCEMENTS)

Current off-the-shelf GNSS based navigation systems have an accuracy of 5-10 m, which is OK for guidance of car drivers. For (blind) pedestrian navigation a difference of 5 m may result in walking on the street instead of on the pavement. To tackle the lack of accuracy of existing off-the-shelf (COTS) navigation systems, the ARGUS prototype needs a solution which provides either high accuracy GNSS data or a system which helps to correct the inaccurate data. Throughout Europe there are several national and international services available that helps to correct at least GPS data.

ARGUS will take advantage of Galileo Signals, and the combination with the GPS and EGNOS ADAS correction signals. Although there will no possibilities of testing the Galileo positioning in real scenarios (urban and rural) at the end of the project ARGUS will be designed to deal with Galileo + GPS + EGNOS ADAS because it is a product designed to work now and in the future. The device will be able to guide if there is no Galileo Signal on the sky, in this case, the positioning accuracy will be worse than expected for ARGUS (1 m) but still the solution will be acceptable for the users. The GPS + EGNOS ADAS solution will be tested with users.

4.1 GPS Assistance

Conventional GPS provides difficultly reliable positions in environments surrounded by tall buildings – the so-called 'urban canyon', as well as indoors, in a real canyon and under heavy tree cover. Under these conditions, the GPS signal is often of very poor quality, making it hard for receivers to obtain a position and increasing the Time to First Fix (TTFF) or the time to get the first position. It is possible to improve the ability of GPS to operate in challenged environments, by using GPS Assistance.

An assistance server (A-GPS server):

- has the ability to access information from the reference positioning network;
- provides via a wireless link, 2 types of data to the GPS receivers: precise GPS satellite orbit and clock information;
- has computing power far beyond that of the GPS receiver.

Thanks to the assistance from the network, the mobile receiver can:

- operate more quickly and efficiently than it would unassisted, because a set of tasks that it would normally handle is shared with the assistance server;
- focus on collecting range measurements since the server is also able to compute positioning solutions.

EDAS (EGNOS Data Access System) provides the access to the wide-area differential correction of EGNOS. Therefore the EGNOS data server is connected to the four Master Control Centers (MCC) via the interface INSPIRE (interface system for the provision in real-time of the EGNOS product). The MCCs are connected to the RIMS (range and integrity stations) and NLES (navigation land earth stations). The Master Control Station processes the whole information. Only one of the four MCCs is the master at a time, the others are for redundancy reasons.

This INSPIRE interface is a part of the EGNOS system. It provides access to the NOF (navigation overlay frame) for each of the EGNOS GEO satellites, RIMS measurements as well as NLES receiver measurements. Besides, the communication is in real-time within guaranteed delay security and performance boundaries. Due to security reasons no Service Provider is connected directly to INSPIRE. The EGNOS data server is the link between the INSPIRE interface and the different Service Providers.

The GPS/EGNOS positioning and the level of integrity provided by EGNOS, is well suited for the project's demand in terms of position calculation. Accuracy and integrity are crucial for a safe navigation. That is why GPS navigation uses GPS augmentation systems (EGNOS) and services (EDAS). The user terminal should have the functionality to be able to inform the user when the system could be working without integrity. For that the user terminal should use protection level algorithms and *HPE* (Horizontal Position Error) which refers to the real error of the system, *HPL* (Horizontal Protection Level), which refers to the error estimated by the system, and the *HAL* (Horizontal Alert Limit) which is defined by the user. Those figures will provide a good estimation of the system reliability on the fact that the true position is within a circle around the computed position.

4.1.1 Augmentation and Correction Server

The Augmentation and Correction Server implemented by TCA is a modular built server which uses EDAS for providing different services. The single modules are controlled via the control server which is able to start and stop the modules with its parameters or request the status of the different modules. The interaction with the user is done by the man machine interface. This interface can be installed direct on the server PC or on an external PC using a certificated connection to the server. The whole data communication between the modules (if necessary) is managed using a database (PostgreSQL). The Augmentation and Correction Server architecture with its single modules is shown in Figure 19.

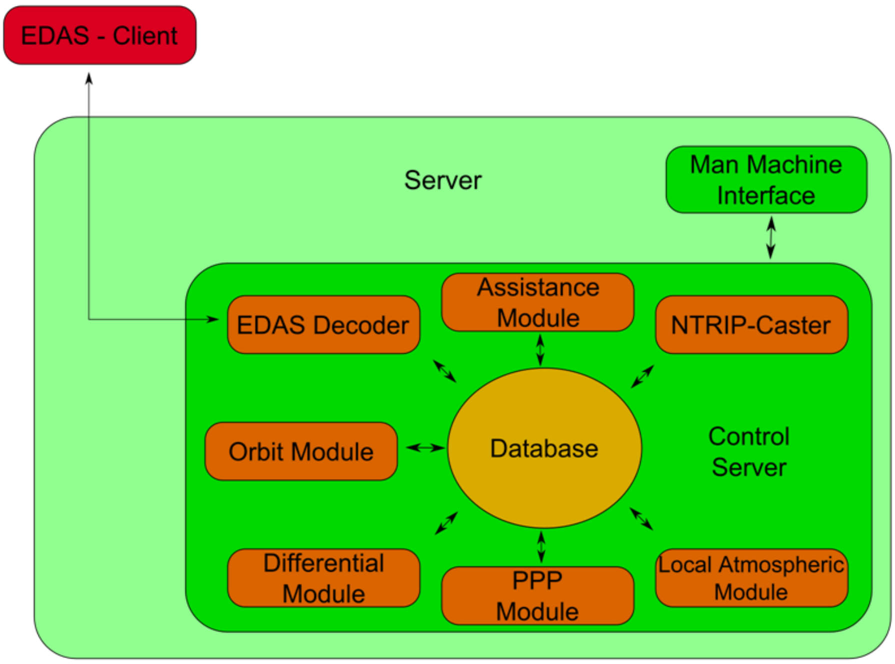

Figure 19: Augmentation and Correction Server architecture
Source: TCA

- The EDAS-Client (provided by GSA) is connected via the Internet with the EGNOS data access system. It sends the data to the EDAS Decoder which is responsible for integrity – CRC (cycle redundancy check) decoding the single messages and storing them at the database where the different modules have access to it.
- The Assistance Module collects almanac information, ephemeris, and time information from different sources (e.g. u-blox) and stores the information into the database.
- The Orbit Module calculates and provides long-term ephemeris, which are stored into the database
- Differential corrections (e.g. pseudo range corrections, range rate corrections) are calculated by the Differential Module. The differential corrections are available in the database.
- The PPP Module (Precise Point Positioning) collects correction information for precise point positioning from different sources. Those are real-time estimation of atmospheric corrections as well as calculated 'regional clock' parameters.
- The Local Atmospheric Module is responsible for the provision of atmospheric data as precise as possible.

The whole communication with the end users is done by the NTRIP-Caster using the NTRIP format. Here, a bi-directional communication will be established. Therefore, the client is able to send its position information to the server, and can receive the requested information.

4.1.1.1 EDAS data processing

EDAS provides two service levels.

- Service Level 0: it is needed either transmit data in raw format, or transmit them in a format that allows a lossless reconstruction after translation.
- Service Level 1: it is used to transmit data in an open standard. In addition, the Service Provider can split the incoming data stream into further groups (e.g., GPS, GLONASS, Augmentation, etc.)

For the Augmentation and Correction Server Service Level 1 is chosen.

The client software forwards the EDAS messages coming from the EDS to the Service Provider according to the well-known server/client paradigm. Therefore, the client (Service Provider) must request for a connection to the server (client software) which is waiting for incoming petitions. Once the server accepts the requested session, the client server communication is initialized.

No direct access to the data server is allowed and the client software has to be installed and configured. The EDAS Decoder establishes a TCP/IP connection to the client software. Once the connection is established the data are stored and decoded. These are: GPS and GLONASS Observations, GPS, GLONASS, GEO Satellite Data, GEO Observations, NLES Cyclic Feedback and RIMS APC Data. The achieved data like ephemerides, Klobuchar parameter, almanacs and EGNOS data are then available for the other modules via database and can be used for further calculations.

4.1.1.2 A-GNSS data processing

In the context of Augmentation and Correction Server, AGNSS data processing includes reference time, approximate position and ephemeris information. But this is not exhaustive. All other information as emitted in the GNSS navigation message could be extended. The advantage of using assistance information is the receiver does not have to demodulate navigation message anymore which makes acquisition in weak signal environments possible as well as results in a lower time to first fix (TTFF). In the following the parameters are described more in detail.

Reference time is to be synchronized to UTC. Regarding accuracy, the aim is to achieve a few seconds which is realized by simply querying computer system time.

Approximate user position is not in the scope of current Augmentation and Correction Server implementation but, in future, could be realized some geometrical concept of cellular network positioning, e.g., via cell identification number (cell id) leading to a position accuracy of better than 20 km.

Ephemeris information is retrieved from the database in two variants. One the one hand, broadcast ephemerides with a validity of two hours are provided by EDAS link. On the other hand, so called long term ephemerides are computed in the orbit module with a validity of some days but very limited accuracy. The task of assistance module is now to encode the orbits in different data formats, namely RTCM, XML, UBLOX, and TCA, with the latter being a proprietary format especially created by Tele-Consult Austria GmbH, and to persistently store these formats back into the database. This process is to be internally triggered in real time. Apart from the user interface to the database a separate user interface is provided to supply assistance data directly to end user requests.

4.1.1.3 NTRIP Caster

NTRIP is an application-level protocol that supports streaming Global Navigation Satellite System (GNSS) data over the internet. It is a generic, stateless protocol based on the Hypertext Transfer Protocol. The NTRIP Caster forwards the information from the NTRIP Server (for example the pseudo range correction from the Differential Module) to the NTRIP Client. The NTRIP Server writes the correction message to the database, and does not provide it in a HTTP stream to the NTRIP Caster.

In its general architecture, the NTRIP Client requests from a particular mount point (in case that several NTRIP Server are available) corrections information. The NTRIP Sources provide continuous GNSS data (e.g. RTCM-104 corrections) as streaming data. A single source represents GNSS data referring to a specific location. Source description parameters specify the format in use (e.g. RTCM 2.0, RTCM 2.1, raw), the recognized navigation system (e.g. GPS, GPS+GLONASS), location coordinates and other information.

4.2 GNSS (GPS + Galileo)

Within the ARGUS project, two navigation units will be developed:

- In an early stage of the project a 1-Frequency receiver (GPS/EGNOS/Galileo L1/E1) will be used.
- In a later stage of the project a 3-Frequency receiver (GPS/EGNOS/Galileo L1/E1, L5/E5a, E5b) will be used.

4.2.1.1 GPS

GPS utilizes a constellation of at least 24 Medium Earth Orbit satellites which transmit precise microwave navigation signals and is a fully functional Global Navigation Satellite System (GNSS).

Each satellite transmits its navigation message with at least two distinct spread spectrum codes: the Coarse/Acquisition (C/A) code, which is freely available to the public, and the Precise (P) code, which is usually encrypted and reserved for military applications. Each satellite has its own C/A code so that it can be uniquely identified and received separately from the other satellites transmitting on the same frequency. When the "anti-spoofing" mode is on, as it is in normal operation, the P code is encrypted by the Y-code to produce the P(Y) code, which can only be decrypted by units with a valid decryption key. Both the C/A and P(Y) codes impart the precise time-of-day to the user.

Present frequencies used by GPS:

- L1 (1575.42 MHz): C/A code and P(Y) code

- L2 (1227.60 MHz): P(Y) code

Currently, the GPS Standard Positioning Service (SPS) which uses the C/A-code on the L1 signal provides a global average predictable positioning accuracy of 9 m (95 %) horizontally and 15 m (95 %) vertically and time transfer accuracy within 40 ns (95 %) of UTC. (These results are based on a measurement interval of 24 hours.) In practical use, an absolute horizontal positioning accuracy of some meters can be achieved, depending on the receiver, the environmental conditions, and the current satellite constellation.[10]

In addition to the L1 C/A signal, three additional coded signals to support future civil applications will be added:

- L1C, frequency 1575.42 MHz, providing better performance than the current C/A signal being used by civilian receivers;
- L2C, frequency 1227.6 MHz; and
- L5, frequency 1176.45 MHz, to meet the needs of critical safety-of-life applications, such as civil aviation.

[10] 2008 Federal Radionavigation Plan

The L1C signal is designed to be interoperable with the European Galileo system and is being promoted as a future world standard for incorporation into GNSS. The next generation of GPS satellites, GPS III, will begin broadcasting L1C around 2014.

The L5 civil frequency planned for GPS will help mitigate the impacts of both solar activity and unintentional interference, but it may be 2018 before a full constellation of dual-frequency satellites (L1 and L5) is available. The first Block IIF satellite which provides this signal was launched in March 2009.The dual frequency capability with L5 will address ionospheric scintillation by enabling receivers to calculate actual ionospheric corrections.

These new signals provided after GPS modernization will provide improved accuracy, more redundant signals, improved signal structure for enhanced performance, and will make the signals less vulnerable against radio frequency interference.

4.2.1.2 Galileo

Galileo[11,12] will be the European contribution to the Global Navigation Satellite System (GNSS). Galileo is a global infrastructure comprising a constellation of satellites in Medium Earth Orbit (MEO) and its associated ground segment. The Galileo Programme also includes the development of user equipment, applications and services. Galileo is designed to be interoperable with other existing global radio-navigation systems. It is a civil system, operated under public control. The Galileo Programme is at present jointly managed and financed by the EC and ESA under a mandate from their Member States.

Following Galileo services will be available:

- The Open Service (OS) is accessible to all users free of charge. No integrity information is included and therefore no service guarantee or liability is provided. The OS is primarily intended for the mass market providing simple positioning and timing services. Six unencrypted signals are modulated onto three different carrier frequencies. That increases the performance in interference resistance but at the same time increases technological requirements. The frequency bands partly overlap with the frequency bands of other GSNSS to increase compatibility and interoperability. Galileo single-frequency receivers will provide a performance comparable to GPS C/A-code receivers.
- The Commercial Service (CS) will rely on data included in the navigation message in all frequency bands. The data messages will be encrypted and provide an added value compared to the OS. Additionally, a service guarantee is envisaged for the CS. The access to the data message as well as to the encrypted ranging data will be controlled by the Galileo concessionaire.
- The safety-of-life (SoL) service uses the same signals as the OS, but adds integrity information to provide a service guarantee to the users. Any failure of the system is indicated by integrity information in the navigation message and timely warnings are provided. The SoL service will also provide a noncritical service level that is less time critical but still needs integrity information.

[11] GNSS

12 Galileo HLD

- The main objective of the public regulated service (PRS) is to provide a continuous, robust, and encrypted signal that will be usable even if other services will be either deactivated or intentionally jammed. Encrypted signals on two spectrally separated carrier frequencies maximize the interference resistance, while minimizing the vulnerability. The envisaged service performance is comparable to the one of the OS, while the integrity provided is comparable to that of the SoL service.
- The Galileo search and rescue (SAR) service is Europe's contribution to the international COSPAS-SARSAT system. This system provides a means for worldwide humanitarian SAR operations. In future, Galileo satellites will detect emergency signals and forward the emergency message to the SAR ground segment.

Currently, the Galileo performance for the single services under full operational capability (FOC) is specified as follows:

	OS/CS	**SoL**	**PRS**
Coverage	global	global	global
Accuracy (95 %) *Single-frequency* *Dual frequency*	 15m H / 35m V 4m H / 8m V	 (critical) 4m H / 8m V	 - 6.5m H / 12m V
Integrity *Alarm limit* *Time-to-alarm* *Integrity risk*	N/A	 12m H / 20m V 6s $3.5x10^{-7}$ / 150 s	(critical) 12m H / 20m V 6s $3.5x10^{-7}$ / 150 s
Service availability	99,5%	99,5%	99,5%

Table 1: Performance specification for the Galileo services

Galileo will provide ten navigation signals and 1 SAR signal. The Galileo navigation signals emission is described as follows:

- 4 signals are transmitted in the frequency range 1164-1215 MHz **(E5a-E5b)**
- 3 signals are transmitted in the frequency range 1260-1300 MHz **(E6)**
- 3 signals are transmitted in the frequency range 1559-1591 MHz **(L1)**

The carrier frequency E5a coincides with the carrier frequency L5 of the GPS system. Thus, E5A and L5 are used as a synonym. Galileo has been allocated to the frequency band E1, which includes the GPS frequency band L1 and the adjoining bands 1559.052-1563.144 MHz and 1587.696-1591.788 MHz. These frequency bands have been formerly named E1 and E2, ending up in the terminology E2-L1-E1 for the complete band. Meanwhile ESA changed the terminology to E1 for the complete band, and the adjoining bands are not named separately.

In the following, the planned navigation signal service allocation is depicted.

		Navigation Services			
Signals id.	Frequen-cies	OS	CS	SoL	PRS
1,2,3,4 ,9 and 10	E5a E5b L1	X	X	X	
6, 7	E6		X		
5,8	E6 L1				X

Figure 20: Navigation signals service allocation

4.2.1.3 GNSS

With the navigation unit based on the 1-frequency GNSS receiver, accuracies in the range of 2 m shall be achieved (EGNOS/EDAS usage will provide this performance). With the navigation unit based on the 3-frequency GNSS receiver, the achievable accuracy will be improved to 1 m. The reason for considering E5b is to speed up a robust acquisition of the integrity information which is provided on E1 and E5b. So the works will be done towards this solution: Starting at L1/E1+EGNOS/EDAS and then moving towards L5/E5a.

4.3 Kalman filter and INS

Within ARGUS, a Kalman filtered tailored to visually impaired people will be developed (using the acceleration along all three axes). This Kalman filter will use the “tightly coupled” approach and thus, the integration is based on GNSS and INS raw data level. Furthermore, a dynamic movement model, one core of each Kalman filter, especially tailored to the movement characteristics of visually impaired people will be developed.

In relation to this point, TCA already has experience with Kalman Filters. In the project SARHA (technology demonstration project) – which is also described in section 7.2.6 – a Kalman filter has been used which concentrated onto step detection.

Analysis of acceleration signals may detect steps of the mobile user when walking. Depending on the user’s body, the accelerations show different characteristics. The SARHA sensor assembly measures three accelerations: vertical, along-track, and orthogonal. For step detection and step frequency derivation, three different algorithms have been developed and compared to each other: autocorrelation of acceleration function, peak detection (searching for two local maxima in the acceleration signal) and detection of zero crossings in acceleration signal. The comparison of the algorithms showed that all of them have their advantages and disadvantages. While zero crossing represents the fastest algorithm with the lowest CPU requirements, the autocorrelation function provides the most stable and smooth filtered results. Therefore, a recommendation for choosing one of those is very difficult, and mainly depends on the available CPU resources and the primary field of application. Other step detection algorithms are based on Fast Fourier Transform (FFT) or the above mentioned Kalman filtering.[13]

In a current project, TCA has developed a Kalman filter designed for automotive applications. This existing Kalman filter uses the “loosely coupled” approach integrating GNSS and INS data on position level.

4.4 Conclusion

For ARGUS, a navigation unit with a GNSS (GPS/EGNOS/Galileo) high sensitivity receiver and an inertial navigation system can be used. This unit identifies the position and orientation of the user as well as the quality and integrity parameters of the position. Using a 3-frequency receiver (and additionally EDAS) should at least provide accuracies down to 1m level and the integration with the INS ensures that GNSS signal outages can be bridged for some time.

The targeted improvements of the navigation solution will be:

- signal availability – information of signal availability while navigating with GPS+EGNOS/EDAS and 100% availability when Galileo is working
- and positioning reliability of 98% – with EGNOS data
- reliability of the navigation signal based on EGNOS/EDAS corrections and future Galileo Satellite Navigation system
- accuracy due to augmentation data provided from either EGNOS, EDAS or terrestrial augmentation system
- availability due to the use of EGNOS and Galileo Signals

[13] GPS World

5 ASSISTIVE TECHNOLOGY

This chapter shall give an overview on existing commercial of the shelf (COTS) or currently under development assistive technology in the area of navigation or orientation.

5.1 Obstacle detection

There are several solutions available that are related to smart canes. Common for all is that they are not focusing to replace the smart cane completely, but to extend the range and the security when using a cane. The following chapter will give an overview on devices which can be used to extend the range of obstacle detection of a white cane and make it more reliable.

5.1.1 Ultra-Body-Guard

The ultra body guard is a small device which can be worn around the neck, or which can be used as hand device. It is able to detect obstacles in the upper body area using ultrasonic sound. As nearly all ultrasonic obstacle detection devices the Ultra-Body-Guard should only be used as a secondary assistive device, it is not meant to replace the white cane or a guide dog.

Figure 21: The Ultra-Body-Guard
Source: http://www.rtb-bl.de/RTB/wp-content/uploads/UBG.jpg

The device has a capacity of 7 hours before it needs to be recharged and ha a range which lasts from 2 to 3 m. To get a better orientation it offers an obstacle search mode, where the ultrasonic sound is concentrated like the light of a torch, so that the user can explore the surrounding by moving the device around. Furthermore it offers a compass and a light sensor, for better orientation.(18)(19)

5.1.2 CASBlip

Within the EU-Funded Project CASBlip "*a sensor system that uses audio signals to endow sightless people with spatial perception of their surroundings*"(20) was developed.

Based on a solution that originally was designed by Siemens to recognize pedestrians by cars the CASBlip sensor system provides obstacle recognition for blind persons. Using infrared pulses the system scans the surrounding on a horizontal line up to 5 meter ahead in an angle of 60 degrees. The reflection of objects in the surrounding are used to calculate the distance to these objects which are then converted into audible signals (see Figure 22).

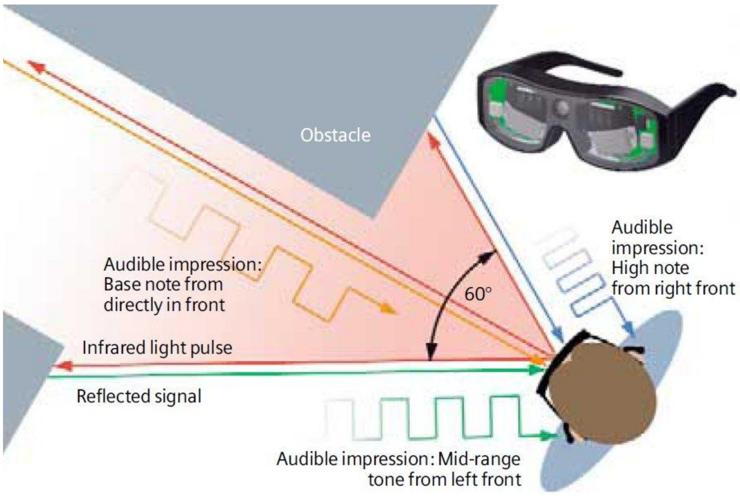

Figure 22: Seeing with Sound CASBlip solution
Source: Picture of the Future, Siemens AG

The nearer an object is, the higher the tone, combined with a left / right difference, the user can get a good impression of the surroundings. Figure 22 gives an overview on how the system works. The reflected light from the midrange distance (green) can be recognized by a mid-range tone from the left front, the orange signal from the farthest distance in the front is represented as a base tone in the centre, and the nearest obstacle is represented by a high tone from the right. As the system does only scan a single horizontal line, the user has to move the head to scan the surrounding. Doing so, the user can get a valuable audible map of obstacles from the surroundings.

5.1.3 iGlasses

The iGlasses can be used as addition to the white cane. Using ultrasonic the device detects obstacles in the upper body and head area. It can be worn as standard glasses providing protection to the eyes and vibrates when obstacles are recognized. The intensity of the vibration increases while getting closer to the obstacle. Obstacles in a distance of 3 m can be detected.

Figure 23: iGlasses
Source: http://www.marland.eu/typo3temp/pics/a1f2053167.png

Available at Marland[14] Price 199 €

[14] http://www.marland.eu/produkte/c/blindenstoecke/p/iglasses-die-ultraschallbrille-getoent/

5.2 Pedestrian navigation enhancement

In the following chapters devices and tools that support blind pedestrians either by finding doors at a bus or by identifying the traffic lights are described.

5.2.1 City Cane

The City Cane is a white cane with a special hand grip. In this grip are several color sensors, a loud speaker and a small processor. At a traffic light one holds the cane up until the hand grip with the color sensors is placed in front of the light. As soon as it switches to green the cane will announce this via an acoustic signal.

After some user studies with experienced o&m trainers and expert users the German organization for the blind (DBSV) came to the conclusion that this assistive technology should only be used if at all by experienced users after having been trained for a minimum of 10 hours. The detection accuracy especially on sunny days caused some concerns. Furthermore experts reached the conclusion that blind people who have participated in an o&m training do not need this piece of assistive technology since they can figure out the green phase of a traffic light by paying close attention to the flowing traffic and they would, if facilitating the cane, concentrate too much on it instead of the traffic and if not placed correctly this could cause an inherent danger to the user. Moreover car drivers would not recognize that a blind person with the cane held up in the air would want to cross the street thus not taking the necessary caution.

5.2.2 Step-Hear

The Step-Hear system is a customizable device which can help the blind to navigate in unfamiliar areas. The system is comprises expandable base units and an activator. When in range of a base, the user's wrist-worn activator begins to vibrate and beep. Pressing a button on the activator triggers a pre-recorded message from the battery operated base unit. An unlimited number of bases (for multiple locations) and activators (for multiple users) can be used together. Large scale applications could provide accessibility in a hotel or convention.

The improved Step-Hear system features an indoor/outdoor waterproof base unit, support for MP3 audio input for recorded messages, support for three different recordings, and automatic adjustment of playback volume according to ambient noise levels. The base unit requires AC operation. Solar powered bases can be made available upon request.

5.2.3 Passenger information system

APEX is offering an “*electronic orientation and information system for the visually impaired persons*” called TYFLOSET. The system allows visually impaired users to activate voice announcement (e.g., of the tram number and direction, or of the next stop) and to send an attention signal to the driver, that a disabled person wants to get on board. The system consists of two parts, the onboard information system and the command transmitter, a small device with six buttons which is available as handheld device or installed in the grip of the white cane.

Figure 24: TYFLOSET transmitter

The onboard unit consists of the receiver and additional speakers. To get the needed information it has to be connected or integrated in the existing onboard information system. This system is already installed and in use in the public transport facilities of several cities (e.g., Prague, Dresden).

5.3 Alternative Map representation

5.3.1 Audio maps

Within the ENABLED project it turned out, that especially visually impaired users want to prepare their journey as detailed as possible when going to an unfamiliar area. Even those who are using a personal navigation device want to prepare themselves to be able to cope with malfunctions of their device. In reality there is no solution available for blind or visually impaired to use a standard map. Of course there are tactile maps available, but they are static and neither available for every city, nor in such a detail that they could be used to prepare a trip. Therefore the partner OFFIS from the enabled project developed the audio maps prototype. Auditory Map presents tagged objects on the map by spatial sonification: *"Users perceive these objects through the virtual listener's ears walking through the presented area"*(21).

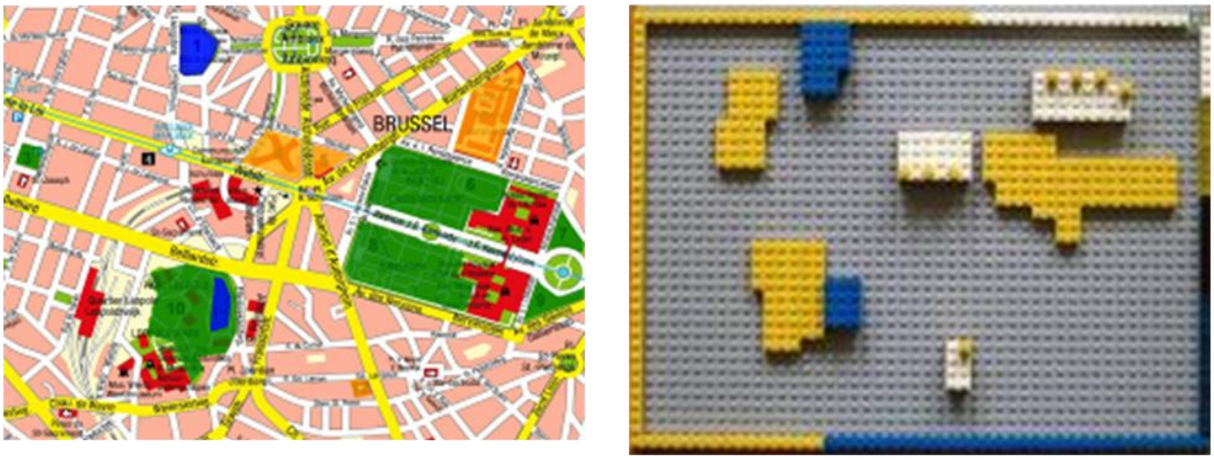

Figure 25: ENABLED evaluation: Auditory map and mental map
Source: ENABLED Project

The map is represented either on a tablet or a touch screen. Using either a pen or a finger the user can move around the map, and listen to those geographic entities that have been tagged by audio. Typically these are parks, represented by singing birds, lakes represented by plash, churches represented by bells. During the user evaluations in the ENABLED project, it turned out that users were able to create a real mental map of the area they have explored, so that they could describe the area out of their memories after the test. Figure 25 shows the map used for the ENABLED evaluation and the resulting mental map, which users had to build after exploring the map.

5.3.2 Phantom

The PHANTOM is a series of haptic devices manufactured by SenSable Technologies Inc. And offers the user the possibility to touch and manipulate virtual objects. The PHANTOM series devices are supported by the SensAbel Technologies Inc. OpenHaptics toolkit which operates on Windows 32 and 64 bit and various Linux distributions and the HaptiMap toolkit which currently supports Windows 32 and 64 bit.

The PHANTOM series consists of the more research based Omni and Desktop model and the rather industry targeted

Premium and Premium 6DOF models.

The differences between the two groups basically are in size, resolution, force feedback workspace and range of motion (from hand movement pivoting at wrist to full arm movement pivoting at shoulder).

Where the Omni and Desktop are intended for research and thus offering lower resolution and range of motion the industry versions are e.g. intended for virtual assembly, virtual prototyping, maintenance path planning, teleoperation, and molecular modeling.

A possible research application developed by the University of Lund within the HaptiMap project is a desktop application enabling blind and visual impaired people to explore the inside of buildings by moving the stylus on a virtual map and receiving some force feedback when hitting a wall or object within the building and some vibrational patterns when hitting a door.

5.4 Guidance of direction

Classical navigation systems rely on the visual and the acoustical sense only. The present the current location on an interactive map, in which the route is highlighted and give instructions by voice. Using them with neither the visual nor acoustical sense would make the device useless.

The devices presented in the following chapters are offering alternative ways (like vibration) to indicate directions to users who need to rely on other senses.

5.4.1 Tactile Belt

Developed in the ENABLED (Chapter 7.1.1) project, the Tactile Belt is used to present directions by means of vibration.

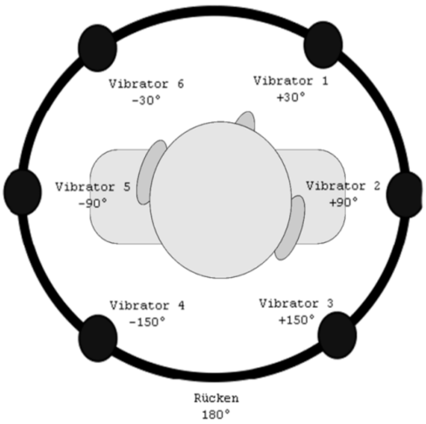

Figure 26: Vibrators in the Tactile Belt (left), photo of the Tactile Belt (right)
Source: ENABLED Project / photo by OFFIS

A belt with six build in tiny vibrators can be worn by the user freeing the hands and the eyes, as there is no need to carry something or to look at. This solution is also very unobtrusive, as the belt can be worn under the shirt. During several evaluations in the scope of the ENABLED project it turns out that the Tactile Belt is a real good source for getting directions in an unobtrusive, hands and eyes free way. See also right image of Figure 31.

5.4.2 ViFlex

The ViFlex device developed by CEA is a haptic 2D interface intended for fingertip interaction with two rotational degrees of freedom with force feedback. ViFlex has been designed with the objective of being a small, robust and low-cost device with powerful actuators and a precise positioning system. The interface can be used as an output device for orientation (active mode) perception, or as an input device (passive mode) to replace a mouse or a joystick with force feedback.

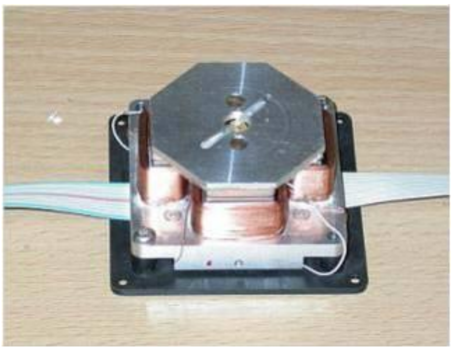

Figure 27: ViFlex device with associated PDA for guidance applications (left) and ViFlex actuator (right)
Source: CEA

The user's fingers are positioned on the moving part of a platform that exerts a force on them along the two rotational degrees of freedom. The right part of Figure 27 shows the mechanism with its casing. The platform itself is 45x45 mm and can be operated with one finger. The ViFlex communicates via Bluetooth with any mobile device (see left part of Figure 27) to provide e.g. directional information.

5.4.3 Tactile wristband

Another system developed by CEA as opposed to the ViFlex is a mere haptic output device. It consists of six or eight actuators placed in a circle of 26 mm diameter which can vibrate. The tactile device incorporates a monolithic structure of eight cantilever bars where permanent magnets are glued to one side of each extremity and a tactile stimulator to the other side of the extremity as shown in Figure 28. The magnets are interacting with the coils in order to vibrate the cantilever beams. The actuators are in a small casing attached to a wristband and put on in a way that they are lying on the skin. Like the I/O ViFlex it is connected via Bluetooth to any mobile device and can give e.g. directional information via haptic patterns. By miniaturizing it one could wear it not only as a wristband but also under a shirt and thus its use is very unobtrusive.

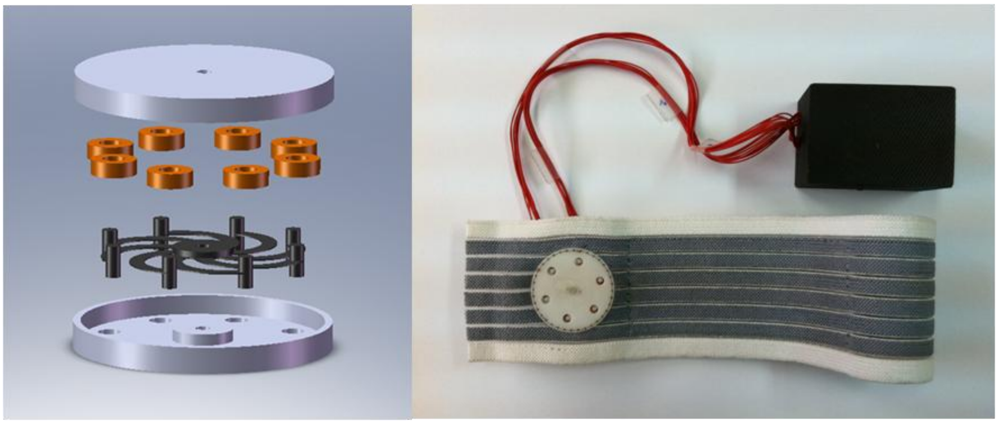

Figure 28: Actuator concept for a tactile wristband (left) and integrated actuator (right)
Source: CEA

5.4.4 Talking compass

Braille or talking compasses allow those who are visually impaired to find their way around.

Figure 29: Talking Compass
Source: http://www.lssproducts.com/product/5044/braille-compass

A Braille compass has graduations raised for each direction, with an arrow representing north and east, south and west represented by Braille letters.

A talking compass will tell the user exactly the direction he is going in. The user simply points the compass in the required direction, presses a button, and the unit immediately speaks the compass point even while running. It announces four major compass points, as well as the four interim compass points.

6 ACCESSIBILITY STANDARDS

The project has recognized that the needs of the disabled persons are nearly the same in all countries and the results of the Project are for at least for a European market. Therefore we recognize that harmonized international accessibility standards and guidelines play an important role for a successful and effective implementation of an accessible design for our Project. They build a common understanding on the accessibility needs of our target group and provide information on design methods and ergonomic data.

This chapter gives an overview on accessibility and pedestrian navigation related standards at ISO/IEC/ITU, CEN/CENELEC/ETSI or the German DIN.

6.1 Background: Demographic change, needs of persons with disabilities

The demographic change is obvious in many countries around the world. The United Nations "World Population prospects" report (2010)[15] has shown that the number of persons older than 60 years will steadily increase in the future. In 2040, the percentage increase is expected to reach about 40%. This is more of a concern in industrialized countries like Spain, Germany, or Japan than in developing countries or emerging economies.

Factors such as dexterity, range of movement, strength, vision, hearing, and cognitive functions generally start to deteriorate in older people and can affect their day to day tasks. The natural deteriorations in ability that occur as people age is increasing the proportion of people affected by some sort of disability. But these people are not officially registered disabled as long as their limitations are typical for their age.

Moreover, the United Nations estimate that about 10% of the world's population comprises persons with disabilities. This will inevitably increase in aging societies.

In 2006, the United Nations concluded on the "Convention on the Rights of Persons with Disabilities"[16] which came into force on 3rd May 2008.

This convention is functioning as an umbrella for achieving a better life for persons with disabilities. For example, product design is addressed in Articles 4 and 9:

Article 4 section 1F encourages States Parties "*to undertake or promote research and development of universally designed goods, ...*" and *"to promote universal design in the development of standards and guidelines*".

Article 9 section 2 states that "*States Parties shall also take appropriate measures to:*

[15] http://esa.un.org/unpd/wpp/index.htm

16 http://www.un.org/disabilities

a) *Develop, promulgate and monitor the implementation of minimum standards and guidelines for the accessibility of facilities and services open or provided to the public;*

b) *Ensure that private entities that offer facilities and services which are open or provided to the public take into account all aspects of accessibility for persons with disabilities; ..."*

6.2 European Policies related to Accessibility

The European Union has several programmes and initiatives aiming at *e-Inclusion policy* and e-inclusion features prominently in the *Digital Agenda for Europe* adopted by the European Commission in May 2010.

Under Pillar 6 (Enhancing digital literacy, skills and inclusion) of the Digital Agenda, the Commission proposes a series of measures to promote take-up of digital technologies by potentially disadvantaged groups, such as elderly, less-literate, low-income persons. Improving access for people with disabilities is another of the policy actions set by the Digital Agenda.

An important part of the e-inclusion agenda is also tacking *demographic ageing* with the help of ICT: a better quality of life for the elderly, reduced cost of care, business opportunities in the "silver economy". Under Pillar 7 (ICT-enabled benefits for EU society) the Commission will reinforce the *Ambient Assisted Living (AAL) Joint Programme* to allow older people and persons with disabilities to live independently and be active in society.

The *Lisbon Council* in 2000 agreed to make a decisive impact on the eradication of poverty and social exclusion by 2010. Through the Open Method of Coordination Member States are encouraged to set out concrete steps in their National Action Plans against poverty and social exclusion and to improve access to the new ICTs and opportunities new technologies can provide. The *Riga Ministerial Declaration on e-Inclusion* of June 2006 demonstrated the commitment of EU Member States. It has identified six themes which the European Commission uses to foster e-Inclusion. Overall objectives of the thematic areas include:

- e-Accessibility – make ICT accessible to all, meeting a wide spectrum of people's needs, in particular any special needs.
- Ageing – empower older people to fully participate in the economy and society, continue independent lifestyles and enhance their quality of life.
- e-Competences – equip citizens with the knowledge, skills and lifelong learning approach needed to increase social inclusion, employability and enrich their lives.
- Socio-Cultural e-Inclusion – enable minorities, migrants and marginalized young people to fully integrate into communities and participate in society by using ICT.
- Geographical e-Inclusion – increase the social and economic well being of people in rural, remote and economically disadvantaged areas with the help of ICT.
- and Inclusive eGovernment – deliver better, more diverse public services for all using ICT while encouraging increased public participation in democracy.

On 15 November 2010 the European Commission adopted a new strategy to break down the barriers that prevent the 80 million Europeans with a disability from participating in society on an equal basis.

The strategy outlines how the EU and national governments can empower people with disabilities so they can enjoy their rights. Specific measures over the next decade range from the study on mutual recognition of national disability cards, the promotion of standardization to a more targeted use of public procurement and state aid rules.

The main actions are:

- Accessibility initiative: considering how to use standardization, public procurement or state aid rules to make all goods and services accessible to people with disabilities while fostering an EU market for assistive devices ("European Accessibility Act");
- Participation: making sure that persons with disabilities and their families exercise their EU citizenship rights on an equal footing through facilitating the use of sign language and Braille when exercising EU citizens' electoral rights or dealing with EU institutions; promoting an accessible format of websites and copyrighted works, such as books; studying the possibility of mutual recognition of disability cards and related entitlements;
- Funding: ensuring that EU programmes and funds in policy areas relevant to people with disabilities are used to promote sound working conditions for professional and informal care providers and develop personal-assistance schemes;
- More cooperation between Member States (through the High Level Group on Disability) and civil society: providing a forum for the exchange of data and policy coordination, in particular on the portability of rights, such as the right to personal assistance;
- Awareness-raising such as through the European award for accessible cities;
- Data collection and monitoring while also identifying and promoting successful support structures put in place by Member States at national level.

The EU standardization mandates M376, M420 and M473 (see chapter 6.7) are part of the European Disability Strategy 2010-2020.

Related documents of the European Commission:

COM/2010/636: European Disability Strategy 2010-2020

SEC/2010/1323: Background

SEC/2010/1324: Actionlist

6.3 Why standardization for accessibility?

The accessibility needs of older people and people with disabilities are nearly the same in all countries. Companies are producing for a global market, therefore, harmonized international accessibility standards and guidelines can play an important role for the successful and effective implementation of an accessible design for mainstream products and services. They build a common understanding on the accessibility needs of the target groups, provide information on design methods and ergonomic data and can help to avoid a market fragmentation.

In 2000 ISO and IEC published their policy statement on addressing the needs of older persons and people with disabilities in standardization work. A year later their Guide 71 was published under a similar title. In 2002 ISO/IEC Guide 71 was adopted and publish as CEN/CENELC Guide 6[17]. Consequently various domain and technology specific standards and guidelines have been developed.

Inspired by the world wide implementation of the UN Convention on the Rights of Persons with Disabilities, under the umbrella of the World Standards Cooperation (WSC), ISO, IEC and ITU provided a conference on "accessibility and the contribution of international standards" in 2010. The purpose of this conference was to renew the accessibility efforts and to coordinate related standardization work. The participating organizations declared commitment to achieving greater accessibility through standardization.

Facing the demographic change and promoted by the UN Convention on the rights of persons with disabilities and the new disability action plan 2010-2020 of the European Commission, there are a lot of activities in the field of regulation and standardization.

6.4 What does "Accessible design" mean?

The term "accessible design" is defined in ISO/IEC Guide 71 as follows: *"design focused on principles of extending standard design to persons with some type of performance limitation to maximize the number of potential customers who can readily use a product, building or service. This may be achieved by designing products, services and environments that are readily usable by most users without any modification, making products or services adaptable to different users (adapting user interfaces), and having standardized interfaces to be compatible with special products for persons with disabilities."*

Terms such as "design for all", "barrier-free design", "inclusive design", or "Universal Design" are used similarly but in different contexts.

Products, services and environments should be in a condition that most persons can make use of. Therefore the term "design for all" is often used in the context of household appliances or consumer products while the term "accessible design" is often used in the context of ICT or buildings.

[17] ftp://ftp.cen.eu/BOSS/Reference_Documents/Guides/CEN_CLC/CEN_CLC_6.pdf

6.5 The hierarchy of accessibility standards

The ISO/IEC Guide 71 (2001) "*Guidelines for standards developers to address the needs of older persons and persons with disabilities*" and the accompanying ISO TR 22411 (2008) "*Ergonomics data and guidelines for the application of ISO/IEC Guide 71 to products and services to address the needs of older persons and persons with disabilities*" are general top level documents, where ISO/IEC Guide 71 is mainly for standard developers, describing well-established qualitative accessibility requirements of older persons and persons with disabilities and ISO TR 22411 is mainly for industrial designers, providing design methods and quantitative data on human characteristics and abilities of older persons and persons with disabilities.

ISO/IEC Guide 71 and ISO TR22411 are an answer to article 9 (point 2.a) of the UN Convention on the Rights of Persons with Disabilities. On the other hand they are a target group specific ergonomy based approach derived from and related to ISO 26800 (2011) "*Ergonomics - General approach, principles and concepts*". Finally, ISO/IEC Guide 71 and ISO TR22411 are on top of sector, technology and product accessibility standards. This relations and dependencies are illustrated in the figure below.

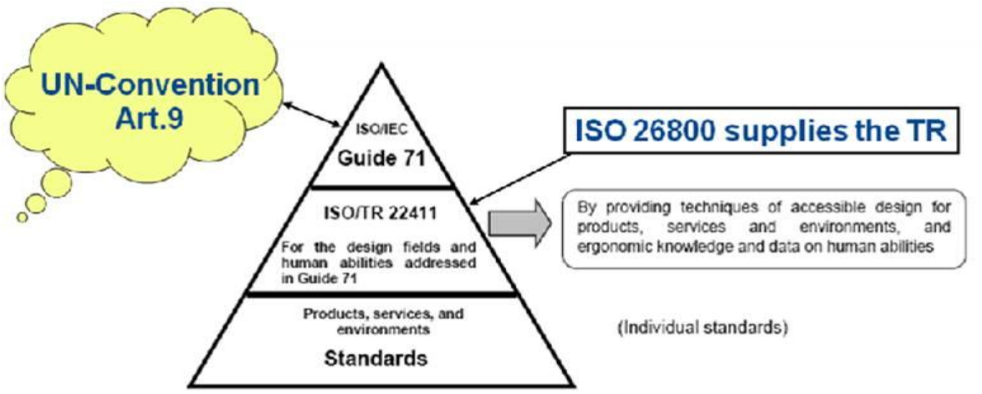

Figure 30: Relation between ISO/IEC Guide 71 together with ISO TR 22411 and Standardization

ISO/IEC Guide 71 is under revision since 2011 (ISO/IEC JTAG) and ISO TR22411 since 2008 (ISO TC159 WG2). SAG is actively engaged in both activities.

6.6 Sector, Technology or Product Accessibility Standards

There are a huge number of international, European and national accessibility standards available.

ISO/IEC TR 29138-2 (2009) "*Information Technology – Accessibility considerations for people with disabilities - Standards inventory*"[18]

[18] http://www.jtc1access.org/TR29138.htm

ETSI Draft TR 101550 "*Documents relevant to European accessibility requirements for public procurement of products and services*"[19] and

CEN Workshop Agreement (CWA) 16266 "*Curriculum for training ICT professionals in Universal Design*"[20] is listing the accessibility related standards, specifications and guidelines.

Siemens was engaged in the development of the CEN CWA and is actively engaged in the refresh of ISO/IEC TR 29138 (all parts) (ISO/IEC JTC1-SWG-A) and the ongoing development of ETSI Draft TR 101550 (ETSI STF 416 PT).

The following list provides some examples of standards which are relevant for the Argus project:

EN ISO 9241-20 (2006):

> "*Ergonomics of human-system interaction – Part 20:*
> *Accessibility guidelines for information/communication technology (ICT) equipment and services*"

EN ISO 9241-171 (2006):

> "*Ergonomics of human-system interaction -- Part 171: Guidance on software accessibility*"

World Wide Web Consortium (W3C/WAI) (2008):

> "*Web Content Accessibility Guidelines (WCAG) 2.0*"[21]

US Rehabilitation Act, Section 508 Access Standards[22], (2000)

ETSI Guide EG 202 848 (2011):

> "*Inclusive eServices for all:*
> *Optimizing the accessibility and the use of upcoming user-interaction technologies*"[23]

ETSI ES 202 076 V2.1.1 (Final draft 2009-06):

> "*User Interfaces; Generic spoken command vocabulary for ICT devices and services*"[24]

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19 http://www.mandate376.eu

20 ftp://ftp.cen.eu/CEN/Sectors/TCandWorkshops/Workshops/CWA16266.pdf

21 http://www.w3.org/TR/WCAG20

22 http://www.access-board.gov/508.htm

23 http://www.etsi.org/deliver/etsi_eg/202800_202899/202848/01.01.01_60/eg_202848v010101p.pdf

24 http://www.etsi.org/deliver/etsi_es/202000_202099/202076/02.01.01_50/es_202076v020101m.pdf

6.7 Accessibility Standards under development

The following list provides examples for standardization activities in the field of accessibility.

IEC CD 62731:

"*Text-to-Speech for Television - General Requirements*"

ISO TC173 WG8 (2011):

"*Electronic wayfinding system for people who are blind or visually impaired*"

This new work item is based on the Japan Industry Standard JIS T 0901-2010. Siemens has a guest status in TC173 WG8 and is seeking for an official membership in TC173 WG8 via DIN. The U.S. Access Board has released for public comment a revised draft of updated accessibility requirements for information and communication technology (ICT) covered by Section 508 of the Rehabilitation Act and Section 255 of the Telecommunications Act on 8. December 2011. This latest version includes changes made in response to public feedback received on an earlier draft issued last year. The released draft is available for public comment until 7. March 2012.

6.8 Standardization mandates of the European Commission in the field of accessibility

The European Standardization Organizations ETSI, CEN and CENELEC are progressing on the work for three accessibility related standardization mandates of the European Commission:

6.8.1 EU Mandate M473:

"*Standardisation Mandate to CEN, CENELEC and ETSI to include "Design for All" in relevant standardisation initiatives*" Started September 2011

Committee:
CEN SAGA (strategic advisory group on accessibility = CEN BT WG213)

6.8.2 EU Mandate M420:

"*Standardisation Mandate to CEN CENELEC and ETSI in support of European accessibility requirements for public procurement in the built environment"*

Committee: CEN BT WG 207 "Accessibility in built environment"

Draft Joint Report of Phase I (August 2011):
"*Inventory, analysis and feasibility of European and International accessibility standards in the built environment*"

Part1:
"Inventory and feasibility of existing European and International standards, building codes, technical regulations and guidance documents for accessibility in the built environment"

Part2:
"Analysis of European and International accessibility requirements and assessment of existing testing and conformity schemes"

6.8.3 EU Mandate M376:

"*Standardisation mandate to CEN, CENELEC and ETSI in support of European accessibility requirements for public procurement of products and services in the ICT domain*"

Phase II started 2011[25]

Committee: CEN/CENELEC/ETSI Joint Working Group (JWG) "e-Accessibility" plus CEN Project Team and ETSI HF STF 416 Project Team.

SAG is member of the JWG and active in the CEN PT.

List of Deliverables of M376:

D1: Draft EN 301549:

"*European accessibility requirements for public procurement of ICT products and services*", specifying the functional accessibility requirements and assessment methods applicable to ICT products and services.

D2: Draft TR 101550:

"*Documents relevant to European accessibility requirements for public procurement of products and services*", listing the standards and specifications used for the requirements and tests in D1.

D3: Draft TR 101551:

"Guidelines on accessibility award criteria for ICT products and services", providing guidelines for contract award criteria

D4: Draft TR:

"*Guidance for the application of conformity assessment to European accessibility requirements for public procurement of ICT products and services*"

D5:

"*Online Procurement Toolkit for accessible ICT products and services*"

D6:

"*Additional guidance and support material for the procurement of accessible ICT products and services*"

[25] http://www.mandate376.eu

7 PROJECTS RELATED TO NAVIGATION FOR THE BLIND

This Chapter gives an overview on currently running and/or ended projects which are in line with the scope of ARGUS. The Projects are ordered in alphabetically, and for each project we try to determine the relevance for ARGUS.

7.1 EU

7.1.1 ENABLED

The aim of the ENABLED project was to develop a bunch of tools that provides ubiquitous access to map information and networked based services. Based on commercial products, the project developed a navigation system that provides indoor and outdoor guidance for visually impaired pedestrians. To realize a whole navigation process , from route planning to following a route multimodal representations of in- and outdoor maps have also been developed.

Figure 31: ViFlex (left) and VibroBelt (right) connected to Dell PDA
Source: Haptimap Project

The navigation itself was realized based on the Trekker, a navigation system already used by blind people. To realize unobtrusive and comfortable navigation guidance, prototypes like the ViFlex or the VibroBelt (see Figure 31) have been developed. The ViFlex is a small device which can be mounted to the white cane or which can be held in the hand. It gives directions by means of a tilting Plate (the Plate tilts in walking direction). The VibraBelt has 6 build in Vibrators which vibrate in the walking direction and can be worn like a Belt. Indoor navigation was realized based on Wi-Fi maps using the Ekahau[26] system. The ViFlex as well as the VibraBelt are still used and further developed in Haptimap. They could also be useful for Argus at least as an addition for the 3D audio.

Project duration: 07/2004 – 08/2007

[26] http://www.ekahau.com

7.1.2 Haptimap

HaptiMap (Haptic, audio and visual interfaces for maps and location based services (http://www.haptimap.org)) is a research project funded within the 7th framework program of the European Commission. It aims at making maps and location based services (LBS) more accessible by facilitating several senses like touch, hearing and vision and thus availing more people to use mainstream applications in this area. The strategy to reach this goal is twofold:

1. develop tools which make it easier for developers to incorporate adaptable multimodal user interfaces (designed to improve accessibility) into their applications
2. raise awareness by collaborating in the development of new and revision of existing standards and suggest improvements of currently applied design processes

With regard to software tools a cross platform toolkit has been developed within the project. This toolkit makes it easier for developers who are not experienced in storing, handling and manipulating geo spatial data to facilitate those data in their mobile applications. Furthermore it offers various adaptable multimodal user interface components in order to avail end users to interact with the mobile application without being forced to visually interact with them, e.g. tactile and acoustic compass, baring module, etc. The toolkit is accompanied by various documents including tutorials, examples (binary and source code), a wiki, forum, mailing list and manual. The available demonstrator applications show developers what the toolkit offers in terms of alternative user interfaces.

Moreover, this package is completed by a document summarizing available standards, guidelines, tools and checklists which support developers in the effort to create and evaluate their applications with regard to accessibility. One can also find an exemplar Tory approach for a user centered development process including people with special needs.

Furthermore a small handbook “User study guidelines” has been compiled which briefly outlines various user centered design methodologies which could be facilitated in the above mentioned development process model.

The second point, raising awareness, has been targeted in two ways. With regard to standardization the consortium has been involved in various European standardization efforts to develop new standards e.g. the CEN/CENELEC “Curriculum for training ICT professionals in Universal Design” and, after a survey amongst industrial developers, several standards and technical reports were revised in order to shorten the main part of the document thus complying with the main critics that those parts were too long and too complicated to use in an industrial setting (operating under severe time and financial constraints with respect to accessibility related issues).

Furthermore the survey reviled that most developers are not aware of the fact that end users could have physical limitations e.g. visual or hearing impairments. Thus, from a practical point of view, several simple but very effective materials have been developed.

A context trail poster which can be placed in the office of developers reminding them every time they look at it that they develop mobile applications for people in a mobile situation. This poster is accompanied by a context card deck where on each card a picture and a short text describe one possible situation in which “normal” users might need to interact with a mobile application.

This set of practical tools is completed buy a workbook “Dynamic User Experience” which in a very ostensive manner introduces abilities and situation induced limitations, the concept of mobile context and the advantages of multimodal user interfaces to the ingenuous developer, since most of them tend to forget, when they are sitting in their office and developing mobile applications in accordance with the functional specification, that their target users operate in a mobile context and cannot or mostly should not rely on visual information alone.

7.1.3 PERNASVIP

PERNASVIP (PERsonal Navigation System for VIsually disabled People) had the aim to develop a GNSS-based mobility service dedicated to visually disabled pedestrians in urban environment, which meets the 4 m level of accuracy and reliability they need for improving their day-to-day life autonomy. This project focuses on improving an existing prototype of portable guiding device with EGNOS/Galileo capabilities in three ways: Increasing positioning accuracy and integrity, reducing the time to first fix, developing specific multimodal routing algorithms. The PERNASVIP platform will offer services all along the three travel stages i.e. before (planning), during (visiting destination) and after (remembering and sharing experiences) in order to:

- Prepare their itinerary at home, taking into account multi-modal public transport routes.
- Manage their itinerary in real-time, with an accurate positioning.
- Contact the call centre for any technical or practical request.
- Share experiences with other users, improve the system and enrich the locations database.

PERNASVIP will be implemented in six verifiable objectives:

- Users' requirements definition, with a particular attention to the three "accuracy, reliability and service availability" targets.
- Improvement of the existing portable device with EGNOS/EDAS data treatment filters and algorithms in order to locate visually disabled pedestrian in urban environments within 4-meter accuracy, 95% of time, with less than 15 seconds time to first fix.
- Development of multimodal itinerary computation algorithms which take into account walking constraints and optimization parameters of importance for visually impaired pedestrians.
- Design of the appropriate IT infrastructure and interface in order to combine the application with multi-layer data content such as public transportation databases, GIS or users' community geo-referenced information.
- Test and validation of the service by 30 users in two pilot cities, with an objective of 75% satisfied users.
- Dissemination of the project results and confirmation of the conditions for a successful business model.

7.2 National

7.2.1 NAV4BLIND / Guide4Blind

NAV4BLIND (navigation for blind and low vision people) is an initiative of the land registry office Soest, a city in North-Rhine-Westphalia, Germany. It is a cluster of projects related to pedestrian navigation for the blind. The main goal of the cluster is the development of an affordable GNSS based navigation system with decimeter accuracy for blind and low vision persons. The land registry office has recognized that the high detailed and accurate maps of the land registry office may be very helpful for the development of blind pedestrian navigation. The knowledge of the exact position of every public lamppost, public dustbin, curb or tree planted in the streets would create new possibilities for a secure and detailed map for (blind) pedestrian navigation. One of the Cluster projects is HaptiMap (Chapter 7.1.2).

7.2.2 NAPA

Navigationsempfänger Chipsatz für **P**ersonennavigation mit **A**nwendungen bei erhöhter Genauigkeit (NAPA) is a national project founded by the federal ministry of education and research in Germany. The main goals of the project are to develop new high precise GNSS receiver, new high detailed maps and the according software to realize a demonstrator for high precise pedestrian navigation including relevant attributes like pedestrian underpass, traffic lights etc.(22)

7.2.3 AmauroMap

AmauroMap researches accessible city maps for the Internet and aims to help blind people to live more independent lives. While the results of route planning can be made available for blind people as spoken instructions, the use of online city maps remains prohibitive for blind people. Conventional routing instructions such as “turn left after 150 meters” offer a very linear means of accessing spatial information. Although blind people are directed from A to B, a great deal of spatial information passes them unnoticed. AmauroMap offers a new form of spatial description in that it attempts to show blind people an area as a whole.

AmauroMap attempts to prepare digital city maps for the blind in such a way that they are transformed into cognitive maps (mental maps) that bring city structures closer to them. Descriptions of housing blocks, streets, and green spaces as well as audible, tactile and “smellable” locations and their combination to cognitive maps will automatically be derived from modern vector maps so that an application covering a large area can be created.

The project AmauroMap is supported by the Internet Foundation Austria IPA within the Netidee program.

7.2.4 Inredis

INREDIS Project was approved in July 2007, it is a CENIT Project within the Spanish initiative INGENIO 2010, which is managed by CDTI.

INREDIS developed basic research in accessible and interoperable technologies during period 2007-2010. The aim of INREDIS is to develop basic technologies that allow creating communication channels and interaction among people with a kind of special need and their environments.

The main technical objectives of INREDIS are centered in ICT area. The research is based on nine main activities or work packages, covering main aspects that reach the objectives.

7.2.5 Elisa

The project ELISA "Entorno de localización inteligente para servicios asistidos (Intelligent Localization environment for assisted services)" has the aim of defining, designing and implementing new services mainly focused on Accessibility and Localization. Such services are based on mobile technologies and location based services in both outdoors and indoors.

Target groups of users can be:

- Elderly, with physical disabilities (physical, sensory, cognitive and language related)
- People with slow devices

This project has the target of knowledge generation, which allows to generate services to the person.

This Project has been founded by Spanish Industry, tourism and Commerce Ministry in Avanza environment (PROFIT): FIT-350503-2007-10. It has also been co-financed by European FEDER funds.

7.2.6 SARHA

SARHA is a former project led by TeleConsult Austria that is focused on pedestrian navigation. In pedestrian user environments like dense urban canyons or indoors, the satellite positioning performance approaches its technological limits. However, these limitations may be overcome by adding additional information sources. The purpose of the project SARHA was the combination of a modern satellite navigation receiver with augmentation sensors and the integration of hybrid navigation software directly on the GNSS receiver and a low-performance microcontroller, to minimize dimension and weight.

The project concentrates on the decisive factors for user acceptance:

- higher integration of components to reduce dimensions and weight
- easy handling and high automation
- robustness of the system
- maximum use of commercial components to reduce cost
- integration of data communication functionality

To increase position accuracy and availability, especially in difficult environments, the system incorporates beside a u-blox GPS/EGNOS receiver, autonomous sensor technology for a dead reckoning (DR) approach, measuring the distance travelled and the direction. In case of GPS outages, the dead reckoning component is responsible for positioning. As autonomous sensors, a magnetometer and gyroscopes are responsible for heading information, accelerometers for speed determination based on the principle of step detection and speed modeling. To provide magnetometer, gyroscope, and accelerometer data, a low cost inertial measurement unit (IMU) is used in the SARHA project. For extension to 3D positions, the system contains a barometric altimeter providing pressure and temperature information. Beside the positioning unit a man machine interface (MMI) is provided, e.g. a PDA, for user interaction and visualization purposes, which can be very useful for navigating in cities and buildings or for route guidance. Position information (NMEA data) from the mobile unit to the MMI is transmitted using a Bluetooth connection.

7.2.7 PONTES

The research project PONTES[27] was run in Austria and led by the Graz University of Technology (Institute of Navigation and Satellite Geodesy). PONTES deals with the development of a navigation system for blind and visually impaired pedestrians. Based on a digital map, a positioning module, and a portable computer, the blind person is guided by the system from an arbitrary starting point to a desired destination. Additionally, the user receives obstacle warnings along the route. All components are tailored to the special needs of blind people and are developed in cooperation with members of the Styrian Association of Blind and Visually Impaired People.

A very detailed geo-database, tailored to the special needs of blind people, is used in the navigation system. This allows the generation of accurate and safe guidance instructions. Moreover, possible safety risks for blind people are evaluated. The various influences are summarized by a specific cost function which allows the routing algorithm to automatically avoid potential, hazardous situations for blind people (e.g. pedestrian crossings without traffic lights). The use of a multisensory system for the positioning module is another innovation of PONTES. Besides a GPS receiver for single point positioning, this module includes a magnetometer triad and a gyrocompass for course determination, an accelerometer triad for step detection, and a barometric altimeter for height determination. These additional components allow dead reckoning for bridging GPS data gaps caused by shadowing effects in densely populated areas with high buildings.

7.2.8 ODILIA

The research project ODILIA[28] was run in Austria and led by the Graz University of Technology (Institute of Navigation and Satellite Geodesy) and is based on the project outcome of PONTES (see chapter 7.2.4). ODILIA deals with the implementation of an integrated overall concept with social relevance: All components – from position determination to route planning and guidance – are covered and tailored to the special needs of blind people. Besides a GPS receiver for single point positioning,

[27] http://www.cis.tugraz.at/

28 http://www.cis.tugraz.at

the positioning module includes dead reckoning. The dead reckoning component comes with an accelerometer triad for step detection, an electronic magnetometer, a gyrocompass, and a barometric altimeter. These additional components allow dead reckoning for bridging GPS data gaps caused by shadowing effects.

Within ODILIA, detailed landscape data forms the basis for the blind navigation system. A de-tailed path network graph forms the background for route planning and guidance. In addition, dangerous sections (e.g., pedestrian crossings without traffic lights and narrow pavements) are considered and preferably avoided upon route planning. The desired route can be planned at home through the desktop PC in order to allow the blind person to virtually walk along the path and study it. The bind person is guided safely and exactly to the desired destination by means of exact commands. With the aid of the mobile device, the user can search for Points of Interest (POI) and also add new obstacles and POIs to the database. A new aspect in the project is the integration of public transport into the data structure.

7.2.9 ways4all

The project Ways4All Complete[29] offers an integrated solution to simplify travelling with public transport for people with special needs (blind and visually impaired). Ways4All Complete consists of several main components: Route planning, in- and outdoor navigation, vehicle communication, and a intuitive software which combines all components. By means of timetable information (VOR, ÖBB etc.) and map data (Open Street Map, Google Maps etc.), the user plans his journey. Outdoors, users navigate with special pedestrian navigation via GPS. The used map data (e.g. Open Street Map) shall be editable in order to extend and update the existing system permanently. On leaving the reception area of satellite-based navigation – e.g. on entering a building – indoor navigation will be available. Indoor navigation will be realized by inertial navigation, RFID (Radio Frequency IDentification) tags and QR (Quick Response – 2D Barcodes) codes. The system does not need any infrastructure and is able to operate autonomously. In order to improve inertial navigation, floor plans and reference points are used. RFID tags or QR codes may be possible reference points. The advantage of QR codes is that they can be recorded with cameras integrated in Smartphone’s and therefore no separate reading device is required.

In order to complete the mobility chain, direct communication with public transport is offered (e.g. station where visually impaired person wants to get on). The final application will consist of a server and a mobile component. Route enquiries and the link with additional useful information are done via the server application (through internet connection) and sent to the mobile device. The mobile application – based on the open source platform Android – is the interface to the user and allows intuitive and barrier-free operation. Audio output and the link of real and virtual information permit reasonable operation due to the two-sense-principle. In the course of the project, a demo application is realized and evaluated.

[29] http://www.ways4all.at

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