DELIVERABLE

Project Acronym: **CAP4Access**

Grant Agreement number: **612096**

Project Title: **Collective Awareness Platforms for Improving Accessibility in European Cities & Regions**

D1.1 Conceptual and methodological framework

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Project co-funded by the European Commission within **FP7-ICT-2013-10**		
Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Services	
RE	Restricted to a group specified by the consortium (including the Commission Services	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Status, Abstract, Keywords, Statement of Originality

Date of delivery	Contractual:	28/2/2014	Actual:	31/3/2014
Status	final ☒ /draft ☐			
Peer Reviewers	empirica, Sozialhelden			

Abstract (for dissemination)	The conceptual and methodological framework presented in this deliverable clarifies key concepts of relevance for the work in the project, including inclusion, mobility, accessibility, models of disability, barriers and independence. It also introduces the methodological aproach taken by CAP4Access, i.e. participatory research going beyond merely collecting data from or about end users but including end users in all phases of the research process beginning with defining the research challenges up to the exploitation of outcomes. The main part of the deliverable is comprised by a discussion of CAP4Access' seven research streams, including information on the state of the art, the remaining gaps and also the implications for the work to be done in CAP4Access.
Keywords	Accessibility, disabilty, mobility, barriers in the built environment, independence, participatory research, Scrum methodology, participatory tagging, volunteered geographical information, wheelchair routing, OpenStreetMap, Collective Awareness Platforms for Social Innovation (CAPS), Geoweb, citizen science, Personas

Statement of originality

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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Executive Summary

The conceptual and methodological framework presented in this deliverable gives an overview of collective approaches to improving accessibility, which form the background to the research and development work foreseen in CAP4Access. It also clarifies key concepts related to the accessibility challenge such of social inclusion, physical mobility, barriers in the built environment and independent living. Indicators to assess physical accessibility and questions about how to map those are discussed. It is important to address this variety of terms in order to have a good foundation for future discussions about requirements and their prioritisation within CAP4Access.

From a methodological point of view CAP4Access takes the position that participatory research needs to go beyond collecting data from or about end-users and that including end-users in all phases of the research process beginning with defining the research challenges up to the exploitation of research outcomes is paramount. The SCRUM approach briefly introduced in this deliverable uses new tools such as confluence wikis and Jira, as these are essential pipelines for managing the development work while having an optimum amount of collaboration and dialogue. Furthermore, this deliverable makes a first attempt at structuring future workflows not only in terms of research areas, but also in terms of future end-users (Personas) and future application areas (life-worlds).

The main thrust of the deliverable is the discussion of the seven research streams, including information on the state of the art, the remaining gaps and also the implications for the work to be done in CAP4Access. The following overview, grouped by research streams, gives a short wrap up of main tasks and challenges to be addressed.

Collective tagging includes the design and implementation of a tagging management system. The system will be developed to support the collection of user-generated data on the accessibility of places, points of interest and roads through participatory sensing. For instance, contributors will be able to provide data on road surface, obstacles, etc. A second challenges related to the design of the tagging management system is the choice of appropriate Semantic Web technologies, including query and representation languages and reasoning tools, to implement the system.

Participatory sensing will focus on two different types of sensing: the sensing of objective features of the environment using smartphone functionality, and the sensing of subjective features of the environment using the smartphone as a means of collecting survey-like data. We will call these “hard sensing” and “soft sensing” respectively. ‘Hard sensing’ functionality will include an app that enables a user to measure inclines in public spaces. This will draw on the inclinometer and the accelerometer of the phone. Soft sensing will include mapping the emotions that are felt in geotagged places (also referred to as *emotional mapping).*

Quality assessment of crowd sourced data involves the development of a data quality management component. The work in this stream will include the testing of different quality assurance methods and the triangulation of various data source to determine data quality. Visualisations will also be part of the quality assessment component.

Integration of public sector information (PSI) requires a systematic review of existing data sources and the engagement of target end-users to understand the relevance and importance of different datasets to their needs and practices. CAP4Access will design and

develop a methodology as well as pilot-test appropriate tools to integrate existing publicly available and other sponsored data about the built environment into the OSM-based accessibility tools.

Routing and navigation services extend and improve the OpenRouteService.org OSM routing service so that it can be used by persons with limited mobility with various profiles.

Additionally an appropriate representation of users' needs and representation of the spatial environment according to cognitive requirements needs to be developed. Cartographical symbolization and other stylistic displays can be used, such as different degrees of generalization, faded usage of colours, various label size, etc..

Visualisation of accessibility related geodata will strongly support the user in getting new insights or ideas, and will then engage him in further exploring the idea by navigating through the world of related data. Possible visualization tools are heatmaps, spatio-temporal visualisations, comparison tools, etc.

Instruments and methods for awareness raising aims to provide suitable methods for different stakeholders. Within this research strand we will explore and eventually provide different tools and methods for raising awareness, e.g. visualisations. Further on, best practise examples for improving accessibility are part of guidelines for a diverse set of mapping and volunteering events.

1 Introduction

This deliverable captures the current state within each of the seven research strands to which RTD within CAP4Access will contribute. The primary objective is to set the scene in terms of conceptual clarity, scope of project activities with regard to the seven research activities, an overview of the methodology applied in general and scrum and agile development in particular and an outlook on impact evaluation.

Not aiming to provide final answers to the points mentioned above, this deliverable serves as an orientation and consolidation instrument for the whole consortium. Research experts and facilitators put a stake in the ground and outline the next steps in the context of our overall objective, which is to gather spatial information in order to foster awareness of barriers and encourage actions for removing these barriers. However, many of the points made in this deliverable will be picked up again as mandated by our iterative approach to development.

The deliverable is structured as follows:

- After this brief introduction, **Chapter 2.1** will give an outline of recent developments in the field of collective approaches to improving accessibility, which form the background to the research and development work foreseen in CAP4Access.
- **Chapter 2.2** discusses the accessibility challenge, which is situated at the intersection of related concepts such of social inclusion, physical mobility and independent living. Indicators to assess physical accessibility and questions about how to map those are discussed.
- **Chapter** 3 [Methodological Framework] describes participatory research as an underlying value set crucial to implement a new model of collaboration between researchers and society within CAP4Access.
- **Chapter** 4 [Scope of Project Activities] describes the seven research strands of the project: Collective tagging, Participatory sensing, Quality assessment of crowd sourced data, Integration of public sector information (PSI) in OSM, Routing and navigation services, Visual analytics, Tools for awareness raising and collective action. For each of these, the chapter includes an overview of the state of the art, the most important gaps requiring additional research, and the implications for the work to be done in CAP4Access.
- **Chapter** 5 [Agile development methods and personas] set the framework for the approaches towards methods of data collection. The method of agile development emphasizes user-centred design, the need to quickly adapt to change, as well as the importance to collaborate with end-users. Additionally, the role of personas as archetypes of end users as well as methods to gather and interpret data are discussed.
- Ultimately, **Chapter** 6 presents a short summary drawing on main points of discussions and concerns brought up in the presented document.

2 Conceptual framework

2.1 Background: Collective approaches to improving accessibility

2.1.1 Social Innovation

Social innovation is increasingly being seen as a way of compensating for insufficiencies of both state and market to address societal challenges such as ageing societies and climate change. Social innovation takes place where application and spreading of new social ideas contribute significantly to the solution of real societal challenges or the satisfaction of an unmet social need in society. In this sense social innovation is part of cultural development and societal change.

We define social innovation as "innovations that are social in both their ends and their means. Specifically, we define social innovations as new ideas (products, services and models) that simultaneously meet social needs (more effectively than alternatives) and create new social relationships or collaborations. They are innovations that are not only good for society but also enhance society's capacity to act"[1]. Recent work at ZSI, partner in CAP4Access, has taken into account issues of acceptance and diffusion of new practices by the groups concerned as a constitutive element, thus formulating an equivalent to market success of technological or economic innovations. Social innovation is then understood as "new concepts and measures to solve social challenges, which are accepted and implemented by the societal groups concerned". This point is of particular relevance for CAP4Access as it deals with improving social inclusion and quality of life of a particular group of people, namely persons with limited mobility such as people in wheelchairs.

Another recent definition sees "Social innovation [...] as a process of change emerging from the creative re-combination of existing assets (social capital, historical heritage, traditional craftsmanship, accessible advanced technology) and aiming at achieving socially recognized goals in new ways. **A kind of innovation driven by social demands rather than by the market and/or autonomous techno-scientific research, and generated more by the actors involved than by specialists**."[2] This is exactly the approach taken by CAP4Access.

Digital social innovation (DSI) has emerged as a new topic around the turn of the century, triggered by a number of advances in Internet technologies.

2.1.2 The Internet and commons based peer production

At the time of the media craze about the Web 2.0, a number of authors have published highly influential accounts of the impact of the **participative web**[3] and **social computing**[4] on the ability of societies to generate innovation. The ensuing discussion mong academics and the wider public made it very clear that these practices represent more than "just another" wave of Internet-triggered innovation. Possibly the most important of these books, as far as the

1 Bureau of European Policy Advisers (2011)

2 DESIS Network (2011)

3 See for example:OECD (2007)

4 See for example:: Pascu, C. (2008)

focus of CAP4Access is concerned, is Yochai Benkler's book on "The Wealth of Networks"[5]. Benkler put his spotlight on the way through which "the declining price of computation, communication, and storage have, as a practical matter, placed the material means of information and cultural production in the hands of a significant fraction of the world's population – on the order of a billion people around the globe". One outcome has been what he termed "**commons-based peer production**", very well-known examples of which include software development projects such as **Lynux**, the online encyclopedia **Wikipedia**, and **OpenStreetMap (OSM)**, which forms the basis of the RTD to be carried out within the CAP4Access project.

Commons-based peer production is particularly suited for activities which meet the following requirements:

- "First, the potential goals of peer production must be **modular**. That means, objectives must be divisible into components, or modules, each of which can be independently produced. This allows production to be cumulative and asynchronous, merging the individual efforts of many people, with diverse backgrounds and skills, who are available at various places and times.
- Second, the **granularity of the modules** is essential. Granularity refers to the degree to which objects are broken down into smaller pieces (module size). Different levels of granularity will allow people with different levels of motivation to work together by contributing small or large grained modules, consistent with their level of interest in the project and their motivation.
- Third, a successful peer-production enterprise must have **low-cost integration** — the mechanism by which the modules are integrated into a whole end product. Thus, integration must include both quality controls over the modules and a mechanism for integrating the contributions into the finished product at relatively low cost."[6]

Related concepts are **collective intelligence**[7] and the "**wisdom of the crowds**"[8] which can be exploited via ICT-enabled practices including **social tagging**, i.e. "the practice and method of collaboratively creating and managing tags to annotate and categorize content"[9].

The **relevance of commons-based peer production for social innovation** results from the greatly enhanced possibilities of people to engage in "social practices of nonmarket production and cooperative sharing of information, knowledge, and culture". Whereas traditionally the "practical individual freedom to cooperate with others in making things of value was limited by the extent of the capital requirements of production [which meant that innovation was predominantly taking place in the market and state sectors], in the networked information economy, the physical capital required for production is broadly distributed

[5] Benkler (2006)

[6] Source: http://en.wikipedia.org/wiki/Commons-based_peer_production [Retrieved 2013-01-03, 15:15], based on Benkler and Nissenbaum (2006)

[7] See for example: Rheingold (2002)

[8] Surowiecki (2005)

[9] Source: http://en.wikipedia.org/wiki/Social_tagging [Retrieved 2013-01-03, 16:30]

throughout society"[10]: the Internet, mobile telephony, smartphones et al. are acting as major facilitators of nonmarket, i.e. social innovation, they have "democratised innovation"[11].

This effect can cleary be witnessed by looking at the emergence of OpenStreetMap as the backbone of myriads of individual and collective mapping activities.

2.1.3 The OpenStreetMap (OSM), the Geoweb, and Citizen Science

Maps are enormously effective tools for raising awareness and for influencing people's concept of the place and time they live in[12]. This means that – as critical theory approaches to mapping[13] have made clear – maps are very powerful tools not only for *representation* but also for *creation* of reality. Maps always represent the interests of particular groups. It is against this background that the OSM project is of major relevance for social innovation.

The OSM project, founded in 2004 at the University College London (partner in CAP4Access), has the goal to create a free database with geographic information of the entire world. A plethora of spatial data such as roads, buildings, land use areas, or points of interest is entered into the project's database. Similar to other community-based projects on the Internet (e.g. Wikipedia), any user can start contributing to the project and editing data after a short online registration.

This simple approach has allowed the project to gather more than 640,000 registered members by June 2012[14]. The contribution of new data to the project can be accomplished in different ways. The most classical, yet still most common, approach is to record data using a GPS receiver and edit the collected information using one of the various freely available editors. The user provides additional information about the collected data by adding attributes and stores the final results in the OSM database. It is important to note what type of data provided by the OSM project has been used and how to retrieve it. The major OSM components include the database server containing the membership administration, the GPX tracks, and, of course, all spatial data of the project.

While work on participatory digital mapping began in the 1990s, under the term 'Public Participation GIS', only with the emergence of Web 2.0 and the **participatory geoweb** it started to become available to a wider group of participants and more integrated into everyday life. Of particular importance to the CAP4Access project is the emerging area of **citizen science**. Together with modern web technologies citizen science harnesses the Internet to enable citizens to participate in scientific projects. It is now providing new ways of doing science and stimulating scientific creativity. Right now, over a million Europeans are taking part in a spectrum of research, collecting environmental data on their phones, folding proteins on their PCs or digitizing old manuscripts on their laptops.[15]

From volunteer computing projects where citizens contribute the spare capacity of their computers, like ClimatePrediction.net, and volunteer thinking projects like Galaxy Zoo and Stardust@Home. These projects, of which there are now dozens, create active social

[10] Benkler (2006), p.6.

[11] von Hippel (2005)

[12] Wood (1992)

[13] For example, c.f.: Crampton (2010)

[14] OSM Statistics. Available online: http://www.openstreetmap.org/stats/data_stats.html (accessed on 28 June 2012).

[15] Neis and Zipf (2012)

networks of citizens who focus on specific research questions like the impact of climate change and how to reduce the burden of disease.

Mobile communication allowed the fusion of citizen science and participatory sensing, and enable participants to collect biodiversity records through platforms such as iSpot, or turn their phones into noise meters using WideNoise (which is used by FP7 project EveryAware[16]). Likewise, mobile communication in combination with collective approaches to map editing enable totally new ways for citizens to engage in innovation processes for social inclusion – as will be demonstrated in CAP4Access.

2.1.4 The Internet of Things

The ongoing, rapid penetration of the Internet in all spheres of life can well be observed looking at the spread of the "**Internet of Things**", which is about connecting the physical world – things – to networks and tying them all together with the Internet. This requires smart objects, i.e. a device that combines local processing power with communications capabilities. Today's Smartphones are such devices. A recent survey of the field[17] summarised the new possibilities this brings: "The recent wave of sensor-rich, Internet-enabled, smart mobile devices such as the Apple iPhone has opened the door for a novel paradigm for monitoring the urban landscape known as **participatory sensing**. Using this paradigm, ordinary citizens can collect multi-modal data streams (e.g., audio, video, sound, location coordinates, etc) from the surrounding environment using their mobile devices and share the same using existing communication infrastructure (e.g., 3G service or WiFi access points). The data contributed from multiple participants can be combined to build a spatiotemporal view of the phenomenon of interest and also to extract important community statistics. Given the ubiquity of mobile phones and the high density of people in metropolitan areas, participatory sensing can achieve an unprecedented level of coverage in both space and time for observing events of interest in urban spaces."

For CAP4Access it is of particular relevance that today's smartphone comes with a rich set of embedded sensors, such as an accelerometer, digital compass, gyroscope, GPS, microphone, and camera. "Collectively, these sensors are enabling new applications across a wide variety of domains [...] and give rise to a new area of research called mobile phone sensing."[18] CAP4Access will exploit these emerging possibilities by enabling lay persons to become "human sensors", collecting and sharing cityscape data of relevance to accessibility by using their own smartphones.

2.1.5 Collective Awareness Platforms for Social Innovation (CAPS)

The role that ICT can play in support of social innovations to take place is enormous. There are numerous examples available which proof that through ICT indeed advantages can be achieved that otherwise would not have been possible[19]. People can be reached who would otherwise not benefit from such initiatives and Social innovations can up-scale and be transferred to other countries due to the use of ICT. Social media play an increasingly

[16] http://EveryAware.eu

[17] Kanhere (2011)

[18] Lane et al. (2010)

[19] C.f. http://ec.europa.eu/digital-agenda/en/projects-and-initiatives-driving-sustainable-behaviours [retrieved 2013-01-04, 17:30]

important role in campaigning and disseminating. Web2.0 has allowed collecting and promoting ideas on a grassroots-level.

The European Commission has for some time promoted the notion of "**Collective Awareness Platforms for Sustainability and Social Innovation**" (CAPS), i.e. "ICT systems leveraging the emerging network effect by combining open online social media, distributed knowledge creation and data from real environments (Internet of Things), in order to create new forms of social innovation". The promise of CAPS rests on the distributed situational awareness enabled by such platforms, which – as a number of real-world examples have shown – can have tangible impacts, for instance in empowering (and motivating) citizens to make informed decisions and consumer choices, in real time, fostering collective behavioural changes towards improved social sustainability and more direct democratic participation. [20]

Collective Awareness is defined by the EC as comprising:

- Gathering of big data about what's going on and other people's actions: (a) From humans as well as from sensors; (b) Made available to all citizens as open data; (c) Enriched and interrelated with other sources of information/statistics/simulations.
- Providing an extended awareness of the social world, the environment and the consequences of our actions, thereby changing our behaviours towards ways which are more sustainable socially as well as environmentally.

CAP4Access is a research project for exploring how the CAPS approach can be made to work for the purpose of raising awareness about and tackling barriers to accessibility within the built environment.

2.1.6 ICT for Social Innovation: Challenges

In spite of its huge potential, the spread of ICT in general and social computing, the participative web and CAPS in particular do **not automatically** result in societally beneficial practices of social innovation.

The evolution of social innovation takes place in different phases from idea generation to intervention, implementation and finally impact on change. The challenges social innovations thereby have to face in each of these stages are manifold and this applies also to DSI. [21]

In addition to these challenges which SI and DSI share, there are a few challenges specific to DSI and the CAPS approach. CAPS live from user engagement on a grassroots level in terms of crowd-sourcing – which is also true for the domain in which CAP4Access will operate, as users are asked to feed in and geo-tag their observations on the virtual map. When a platform or app such as CAP4Access is newly introduced no or only a limited amount of data can be retrieved. Users accessing the platform do not want to be the first ones to enter data as they do not want to expose themselves or do not see the benefit as there is still a long way to go. This behaviour constitutes a vicious cycle: Before there are no users, there is no data. As long as there is no data, there are no users.

This phenomenon has been described in the **Collective action paradox**[22]. Collective actions, which emerge from non-profit contexts and which aim to achieve social innovation,

[20] http://ec.europa.eu/digital-agenda/en/collective-awareness-platforms [retrieved 2013-01-04, 17:30]

[21] European Commission, DG Enterprise & Industry, Special Business Panel (2009)

can be undermined by the collective action paradox, also known as the "free-rider paradox". This states that “any rational self-interested individual will not take part in collective action, since he will in all cases benefit from its benefits, when his own involvement has a cost in time and money. When all individuals make the same rational calculation, no collective action can ever take place, and the group objective will never be achieved”. Whether third sector organisations manage to overcome the collective action paradox depends on a number of factors[23] – such as the capacity of the organisation to mobilise resources; the extent to which the surrounding political and cultural environment is supportive, and the level of engagement of social innovators. This also relates to the general question faced by initiatives relying on crowdsourcing and commons-based peer production.

With regard to commons-based peer-production, a number of authors have put the spotlight on the limits to which “crowd wisdom” can be expected to play a relevant role in social innovation. Jaron Lanier, for example, has argued that crowd wisdom is best suited for problems that involve optimisation, but ill-suited for problems that require creativity or innovation[24]. According to Lanier, the collective can be expected to be smarter as individuals only when:

- it is not defining its own questions;
- the goodness of an answer can be evaluated by a simple result (such as a single numeric value); and
- the information system which informs the collective is filtered by a quality control mechanism that relies to a high degree on individuals.

The EC’s Fabrizio Sestini has listed a range of such open questions and challenges which need to be addressed in order to fully exploit the potential of CAPS to make a real difference in their field of interest[25]:

- (1) technological aspects (e.g. Availability of global pervasive networking and data handling infrastructures, allowing ubiquitous, broadband),
- (2) stakeholder aspects (e.g. Which ones are the "agents of change" which would be seen by the public opinion as the most credible?),
- (3) governance aspects (e.g. Which models would be more easily accepted?),
- (4) ethical aspects (How to address, possible beforehand, the privacy implications of a network of people and sensors and the sharing of individual data?),
- (5) sustainability aspects (e.g. How will this platform be set up, how will it be sustained?) and
- (6) international aspects (e.g. Could we achieve the necessary recognition at worldwide level to have an impact at planetary scale?).

[22] Oliver, P. E., & Marwell, G. (1988). The Paradox of Group Size in Collective Action: A Theory of the Critical Mass. II. American Sociological Review, 1–8.

[23] See Hache and Centento (2011)

[24] Lanier (2006, 2010)

[25] http://ec.europa.eu/digital-agenda/collectiveawareness/background [retrieved 2013-08-13, 12:00]

The CAP4Access project is designed to gather experience and contribute to best practice in addressing these challenges faced by efforts to leverage collective awareness and intelligence for fostering social innovation. It will do so by exploiting the lessons learned by established, successful examples of CAPS (Wheelmap, CommunityMaps).

Our observations about challenges faced by collective mapping projects in this section have important implications for the design of a platform which is to support social innovation using participatory approaches, i.e. also for the CAP4Access platform to be developed in the project. To avoid the vicious cycle described above, the project will deploy and pilot the CAP4Access tools on well-established portals which have existing user base; both Wheelmap and CommunityMaps have large numbers of regular users, most of them active contributors to collective mapping. This means that users of the new tools already from the beginning on can rely on available data. Furthermore, WP1 investigates and analyses potential incentives and motivating arguments to mobilise and engage the two main user groups of the project. The benefit to be derived by active use of CAP4Access tools from users' viewpoint will be carefully be elaborated in advance as to be crystal clear.

In line with Lanier's arguments users will not be asked to find creative solutions for lacking accessibility but to note down where they have problems accessing a building for instance. Via peer-checking and rating the quality of data the information can be validated. The quality of data is highly relevant as users finding incorrect data on the platform might become frustrated and might turn away from using CAP4Access tools, as well as the platforms on which these are piloted. Critical voices might be sceptical towards collective collection of data on accessibility as it might lead to incorrect data because the understanding of accessibility might be very different among potential users. Therefore, the question how to achieve a high quality of the data is crucial and has to be answered when designing the platform and its procedures.

2.2 The challenge of accessibility

> *"Accessibility […] is a slippery notion […] one of those common terms which everyone uses until faced with the problem of defining and measuring it." (Gould 1996, 64)*

2.2.1 Accessibility and mobility: Restating the challenge

Accessibility supports mobility, which in turn has a strong impact on the degree of social inclusion. Let's start by defining both mobility and inclusion as they are understood in the context of the CAP4Access project:

- The term **mobility** is understood in different ways. Basically it defines a change of position, either in bodily-geographical, social or economic meaning. Therefore the term mobility covers more than the mere ability to move, from point A to point B. Weert Canzler et al. formulate mobility as a change of condition. Their concept of mobility has three dimensions: movement, network and motility. In that case movement refers to the act of positional change. The term network is used for either a technical infrastructure (transportation, communication, etc.) or in a social context. Motility is in that case the ability or capacity to move (Canzler, Kaufmann, & Kesselring, 2008).

- The term **inclusion** or social inclusion refers to equality of opportunity and participation. Therefore inclusion covers not only the equality of opportunities, e.g. in the labour market, but also full access to participation regarding social activities and being a recognised and respected part of society.

According to these two definitions we can state that the ability (and possibility) to change one's position, either in bodily-geographical, social, or economic matters is a necessary precondition for people to be part of society. Anybody who has either a physical impairment that reduces their geographical motility, or a psychological, mental or emotional disability or loss, is at risk of being excluded from society.

CAP4Access deals with overcoming barriers to mobility in the bodily-geographical meaning of the term: the main purpose of CAP4Access tools is to address **space-related challenges**. Reduced mobility in this sense bears risks that mainly affect people with disabilities, but also other groups of persons such as elderly people and individuals who negotiate the built environment with small children – especially in pushchairs.

The extent of a person's mobility exerts a strong influence on how much she or he feels to be part of society, but is also a necessity for the self-esteem and personal development (Uhlmann & Unbehaun, 2013).

It is against this background that the right to personal mobility is recognised globally as a human right, as reflected in the **Convention on the Rights of Persons with Disabilities of the United Nations**, which states that nations:

> *"must take measures to ensure that persons with disabilities have equal access to the physical environment, to transportation, to information and communications, and to other facilities open or provided to the public. States Parties also must ensure "liberty of movement" and freedom of disabled persons to choose their nationality and residence on an equal basis with others.*[26]

What is challenging about making inclusion a reality is the fact that mobility is always embedded in a very individual way in lived experience, related to a specific space (socially and geographically). Different life-worlds (e.g. work; education; every-day activities such as shopping, doctor visits, postal services etc.; and leisure) suggest different forms of mobility and different conditions such as more or less time pressure, different needs in terms of accuracy etc. An additional aspect to consider is the combination of personal capabilities and personal determination. Negative experiences, based on barriers in the past, or simply the increased effort that goes into mobility related activities can lead to 'shrinking worlds', meaning that people limit their planning horizons (Pelizäus-Hoffmeister, 2014). For example, planning vacations is limited to a context where accessibility is known to be less of a problem. Creating a network of people and information for more transparency in mobility conditions on a European or even world-wide level can help to avoid 'shrinking worlds'.

[26] See the full text of the Convention at http://www.un.org/disabilities/default.asp?navid=15&pid=150

2.2.2 Accessibility of the built environment

In consideration of the 'sole' built environment (as is the emphasis here) accessibility may be defined "*as the potential for reaching spatially distributed opportunities (for employment, recreation, social interaction, etc.)*" (Páez, Scott & Morency 2012, 141)

One of the aims of CAP4Access is to collect (physical) accessibility indicators that are broadly applicable and that cover important aspects of an accessible built environment primarily important for people with limited physical mobility, and more specifically wheelchair users. CAP4Access concentrates primarily on one user group (people with limited physical mobility, wheelchair users); however, findings and implications are believed to benefit a much broader population (older people, families with small children etc.). In regards to physical accessibility measures, a need to identify possible (generalized and standardized) indicators in order to enable a choice of physical measures is needed.

Whether in regards to a building, a street, a bus stop or any other physical elements of the so called 'travel chain' that considers all the tourism resources that could interact with an individual from the beginning of the trip until the end (Ferri, 2011). It's most likely that more than one accessibility indicator plays a crucial role. In addition, different types of activities (e.g. going to the public library; commuting to work; visiting a soccer stadium) alongside technical and personal capabilities (e.g. types of wheelchair, physical strength, mood etc.) ask for different accessibility needs and demands. Carlsson (2002, 39) identifies three components when discussing physical accessibility: Person*Environment*Activity.

***Everyone** Welcome? Physical accessibility plays a crucial role in accessing opportunities to fully take part in society*[27]

The following pages should enable a somewhat shared understanding of main architectonic barriers, as well as foster fruitful discussions about applicable criteria to assess the accessibility of places and routes in the city. Despite the complexity and multitude of physical accessibility measures, applicability in regards to should be at the fore of the discussion. Following Clark "some knowledge of impairment-related needs is essential – yet "*it should be up to the individual to dictate their own access*" (Clark 2014, 14). To also escape the proclaimed tendency of "*relying on theoretical solutions, rather than lived experiences*" (Heaton 2014, 2), 'CAP4Access' will expand, test and discuss standardized accessibility indicators with end users.

[27] http://masangcaysandra.wordpress.com/2012/02/11/my-views-on-people-with-disorder-pwd/ [picture retrieved 2017-03-17]

The general lack of a universal definition of accessibility results in a large variety of indicators and measures. All indicators and measures are based on different theoretical backgrounds and complexities. Hence many faces of accessibility measures have been introduced in empirical studies, policy recommendations and accessibility guidelines.

A glance into the historical development of the use of the accessibility and its measurements proves interesting as it makes current discussions more clear. Historically accessibility has been merely used and grew as a tool within planning, and more specifically, transport planning disciplines. Thus accessibility indicators have been mainly emphasizing the built physical infrastructure and more concretely statistically and mathematically ascertainable measures (e.g. time of travel from point A to point B). Following this description a place is considered accessible if it is connected to other locations through a road or other infrastructural elements (e.g. railway network). Such indicators don't address 'what happens in between' Point A and B. Further, a generalizable prototype of a travelling individual is assumed. However, questions in relations to 'who' can reach certain destinations and what are the 'actual experiences' of users are gaining increasing attention in the past decade(s).

Moving towards people-oriented measures of (physical) accessibility

> *"Good design enables, bad design disables"*
>
> *"A good design should enable everyone including persons with reduced mobility to:* ***Reach*** *all places;* ***Enter*** *all places;* ***Use*** *all facilities"*[28]

Up until today debates about the extent of what accessibility encompasses and the scope of its practical applications (i.e. measurements and indicators) are ongoing. Various accessibility checklists, minimum criteria and legal standards of barrier-free buildings and city planning have been adopted by (inter-) national and local authorities. How and by whom such guidelines and 'accessibility standards' are created and implemented in city planning can (partly) be answered by experiences and situations encountered by people with limited physical mobility. Existing mobile apps and online maps using crowd-sourcing to show physical barriers and accessible places/routes in the cities (e.g. wheelmap.org) operate with different accessibility indicators.

Example: "Visiting and Mapping the public library"

> *"In order for a system to be truly accessible, it must be accessible at all links in the transport chain." (King, 2013)*

Taking the example of visiting the public library, possible accessibility indicators to consider are listed below and should serve as food for thought in regards to scopes of physical accessibility/mapping accessible building and places.

Approach to a building

How do I get to the library building? Use of public transport – ramps/low-level bus; (available) space for wheelchair

Access into a building

Can I enter the public library? No stairs, ramps, flat entrance; width of the entrance door

[28] http://www.svayam.com/Inclusive_Environment.aspx [retrieved 2014-03-15]

Circulation within a building

Can I reach all levels of the library? Availability of (functioning) lift

Use of facilities in a building

Is there an accessible toilet? Can I do a search on the available computers? Availability of accessible toilets; height of computers and book shelves

MAGNUS (Modelling Access with GIS in Urban Systems), a project carried out in the UK in 2002, identified common urban barriers for wheelchair users. Different user groups (in regards to age and types of wheelchair: manually assisted, manual self-propelled, motorized, scooter) were identified. Through questionnaires, focus groups discussions and on-site observations during joined excursions through urban areas (in Northamptonshire) the following 10 most cited urban barriers were identified (Matthews et al. 2003, 40).

- Steps
- High kerbs
- Deep gutters
- Gravel surfaces (from high to low hindrance score: gravel – grass – brick – tarmac concrete)
- Lack of dropped kerbs
- Narrow pavements (<1 meter)
- Steep gradients
- Adverse cambers
- Poor pathway maintenance
- Cobbled Surfaces

In his study on accessibility in public transport in Sweden, Carlsson (2002, 38) identifies various environmental barriers that stress different aspects and viewpoints of indicating the accessibility of places and routes. An interesting aspect here is not only the question of existence of accessible features but the distinct design as well as the interplay with other environmental elements.

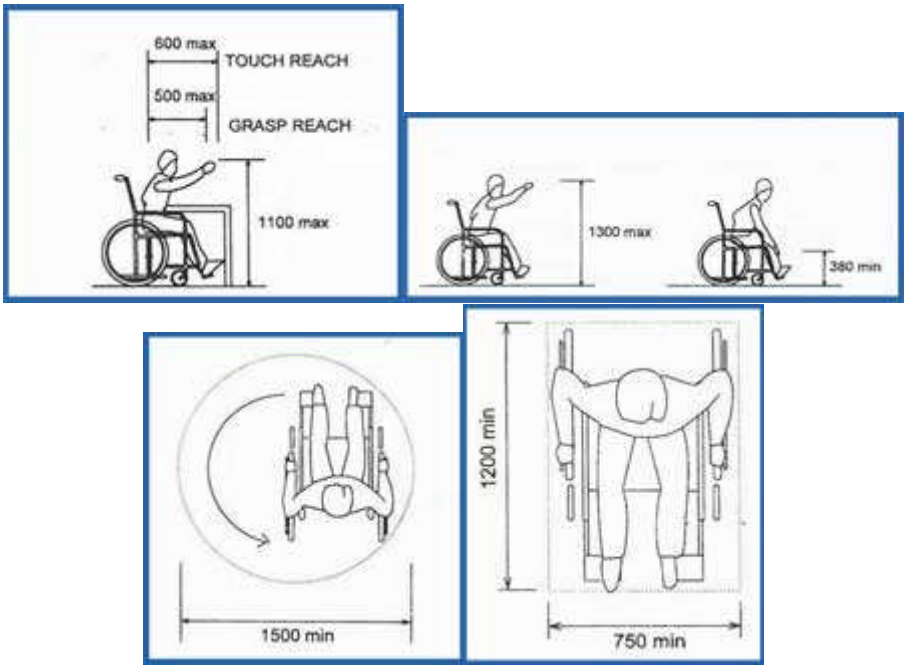
- Absence of environmental elements (e.g. elevator, no ramp)
- Presence of environmental elements (e.g. step, staircase, construction site)
- Design of a physical feature (e.g. space for wheelchair can't face the route display on the bus; can't reach the stop button)
- Dynamic barriers (e.g. no free wheelchair space in the metro/bus)

Another list of 'essential accessibility criteria' published by the National Disability Authority in Ireland[29] lists the following elements. The list provides different aspects of what a commute may entail – thus what 'hides' behind assertions about accessibility indicators (like "The interior design should be accessible").

[29] http://www.nda.ie/website/nda/cntmgmtnew.nsf/0/07361736B7D0594480256F85005348CA?OpenDocument [retrieved 2014-03-15]

- *Management* - Access handbook, access and safety, responsibilities and commitment
- *Transport* – Getting to the building, location, set down areas
- *External Environment* - car parking, routes, ramps, steps and doors
- *Vertical and Horizontal Circulation* - steps and stairs, lifts, corridors and internal doors
- *Facilities* - reception, toilets, seating areas, changing rooms, restaurants and refreshments
- *Interior Design* - lighting, color and contrast, fixtures
- *Evacuation* - emergency equipment, alarms, signage, evacuation equipment, evacuation plans
- *Communication Facilities* - signage, telephones, tactile features, acoustics

Indicators measuring (standardized) *space allowance for people in wheelchairs*[30] can serve as (additional) accessibility indicators.



Other approaches differentiate levels of accessibility exceeding the mere physical environment. The indicators listed below also integrate people with visual and/or hearing impairments.

- **Accessible**: element that can be used and enjoyed for anyone in safety and autonomy.
- **Practicable**: element that does not obey all the requirements to be accessible but it allows its autonomous use by people with reduced mobility or other functional limitation.

[30] http://www.svayam.com/Inclusive_Environment.aspx

- **Not accessible**: element that cannot be used by all the population because does not present a universal design.

Rovira-Beleta and Folch (2010) for instance distinguish between:

Adapted: resources that meet the functional and dimension requirements that guarantee the independent and comfortable use for people with any type of limitation

Practicable: resources that, without complying with the requirements mentioned above, do not prevent their independent use with enough comfort for people with any type of limitation

Visitable: resources that do not respond to the above criteria but allow its timely independent use or with minimal assistance of third personas to people with reduced mobility.

Convertible: resources that with simple minor changes and low cost can became practicable or visited.

Inaccessible: resources that do not allow people with reduced mobility its independent use or with minimal assistance from third parties.

The Spanish standard and certification organization (AENOR) establishes in its normative UNE 1700001-1: 2007 the **MGLC criteria**:

Moving: set of specifications designed to enable all moving, taking into account the status and conditions: floors, maneuvering space, circulation areas and changes of plane.

Grasping: its aim is to facilitate users' handling of mechanisms, objects and products, taking into account all the elements that are reachable and can be easy manipulated.

Locating: the objective of this specification is to facilitate the orientation and location of places and objects, considering elements such as lighting and visual, acoustic and tactile signals.

Communication: this requirement aims to exchange information, both interactively (customer service, sign language, sound alerts, etc.) and non-interactive (panels, light, sound, etc.).

2.2.3 Non-physical barriers

"The hardest obstacle for my independence has been the attitude of the people."[31]

"Negative attitudes towards disabled people can be as much of a barrier to inclusion as an inaccessible building." (Clark 2014, 15)

Removing physical barriers is a crucial aspect towards creating more inclusive and accessible environments. However, not only physical barriers disable people to fully participate in society. There are much more barriers besides architectonical obstacles.

[31] Statement from Adva mentioned in WHO report 'World report on Disability', Chapter 6. ‚Enabling environments'.

Being able to access a building doesn't (necessarily) mean to be able to participate in activities, join meetings, or access the information desk in the building, chat with staff members etc. Many non-physical barriers, stemming from cultural and/or political attitudes and stereotypes can hinder or exacerbate the inclusion of people with disabilities. Clarke (2014, 15) identifies *attitudinal* and *cultural or systemic barriers*. Whereas the former often results from misplaced pity, inaccurate stereotypes, lack of knowledge and mutual reservations, the latter is based upon inflexible laws, policies and practices.

'CAP4Access' aims to not only indicate and at best remove (in-) accessible places and routes in the city but to also discuss accessibility in a broader public context. Discussing and identifying existing (physical and) non-physical barriers is a crucial piece throughout the entire project.

> *"When people identify disability as a problem with the way society is organized, they will work to remove the barriers by which we have been prevented from taking part in society" (Clark 2014, 14)*

Following an integrated approach to accessibility also means to discuss accessibility in a broader context (i.e. as exceeding physical barriers) and to include all aspects that are relevant. Often 'attitudinal barriers' inhibit mutual dialogues and discussions. Enhancing common understandings and perspectives about accessibility concerns may help to debunk common myths about disability and people with mobility impairments in order to overcome such barriers.

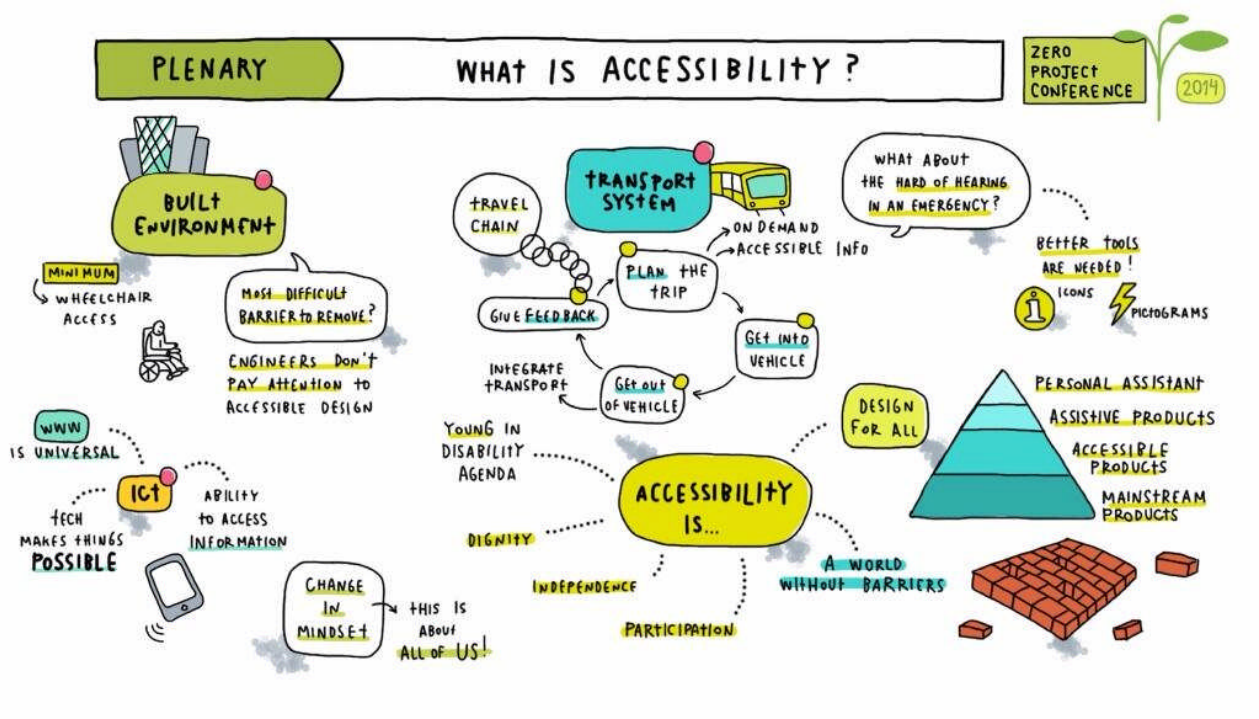
The complex topic of accessibility has been the theme of this year's ZERO project conference held in Vienna. Identifying the multiple aspects and (often unseen) domains of accessibility – beyond physical barriers – is at the core of the sketch in Exhibit 1[32] .

It captures important domains of accessibility and stresses the importance to not only be aware of the multiple dimensions of accessibility but to also understand their interconnectedness. A tool – as developed by CAP4Access that aims to support independent choices of mobility and transportation throughout a city – needs to critically reflect upon many 'accessibility domains' (mobility, feelings of security and comfort during commuting, attitudinal barriers towards disability etc.). In regards to 'CAP4acess' and the aims of the project accessibility, as sketched above, entails a lot of issues.

So, what it is all about? It is about getting from point A to B and being able to access a café, restaurant or library (importance of the built environment and transport system). It is about providing accessible information (through ICTs) to find out about accessible transport routes, buildings and facilities in the city. It is about discussing travel experiences and the importance of encountering comfortable and safe (physical and social) environments that foster inclusion (as opposed to segregating spaces and activities) and to enable discussions about accessibility.

[32] 'The Open Society Mental Health Initiative', source derived from https://twitter.com/elizabethadrina/status/440734556132769792

Exhibit 1: Approaching the Many Faces of Accessibility



2.2.4 Accessibility in different sections of life

Instead of addressing 'life' in general, the following paragraphs discuss concrete sections of life (leisure/tourism, work and education). Each of the three sections may put other barriers to the fore – barriers which might remain unseen when focusing on solely one area or 'life' in general. Keeping the different modes of life and peculiar challenges in mind is also crucial when discussing and creating personas (see section 5.2).

The following subsections briefly summarize current barriers and efforts to overcome those. Subsequently possible impacts by CAP4Access in all three modes of life are discussed. It is important to keep the interrelatedness and fluidity between the modes of life in mind when discussing for instance work trips (work – tourism) or activity spaces during or after school (education – leisure (playgrounds)).

Leisure

> *"Recreation and leisure activities are a critical dimension of the quality of life for all people." (Walker, 1999)*

Recreational activities and leisure spaces often serve as integral to foster social interaction and to establish relationships besides work and family. Generally, the role of leisure and mutual recreational spaces in tackling social exclusion has been largely recognized and resurfaces on various research agendas. However, in regards to disability and leisure, Aitchison (2003, 956) criticizes a "*lack of recognition of the role and value of leisure in the lives of young disabled people*." Often leisure and sport-related policies in regards to disability, as some scholars argue, have resulted in separate and segregated provisions of leisure activities and spaces. Separate recreational facilities, and inaccessible leisure spaces

may partly be ascribed to "*discourses and models of disability that remain dominant within leisure provision*".

Exhibit 2: Accessible Playground in Spain[33]

Physical access, cultural attitudes and social identities construct everyday leisure patterns and experiences (Aitchison 2003, 959). An accessible playground for instance (see below) enable children with different mobility needs to utilize the same space. Including the domain of leisure and talking to people involved in various sport communities within CAP4Access can help to understand 'specific' barriers (e.g. opportunities of available activities in each city; accessible leisure spaces). Then again approaching accessibility through discussing leisure and tourism also provides interesting examples when talking about awareness rising in schools for instance.

Tourism

Tourism as an integral part of leisure, whether inter-, or national travel is concerned, whether visiting an unfamiliar town on the weekend or making a trip to the local museum. A lot of destinations impose manifold barriers for people with mobility impairments which also make the preparation and planning of trips (e.g. transportation, accommodation, activities, restaurants) in unfamiliar cities very exhaustive and time consuming. A number of cities and initiatives in Europe provide comprehensive online tools (e.g. guides[34]; lists of accessible accommodation, beaches, trails etc. in the vicinity) to ease the planning of 'accessible vacations and trips'.

[33] https://www.facebook.com/photo.php?fbid=10151952642722423&set=a.227342312422.146102.163567972422&type=1 [retrieved 2014-03-15]

[34] 'Discover the barrier-free Vienna' (http://en.wien-guide.at/pages/home) or 'Accessible Tourism Spain' (http://www.spain.info/en/informacion-practica/turismo-accesible/) [retrieved 2014-03-22]

Exhibit 3: Accessible "Fiaker" in Vienna[35]

So called ‘tourism for all’ or ‘accessible tourism’ has been gaining increasing political attention. Besides demographic developments (i.e. an increasing number of older travelers), also economic factors and benefits of moving towards an ‘accessible city’ branding has been growing. The European Commission together with the European Disability Forum (EDF) yearly announces ‘Access city’ awards (launched in 2010). The award is given out to cities with great commitments towards ‘creating cities (and tourism) for everyone’. ‘Social Tourism’ or ‘Tourism for all’ programs at a European level consider four target groups, among them elderly and people with disabilities (European Commission, Calypso Report 2010).

Oftentimes societal expectations and ‘mental barriers’ invoke perceived unbridgeable circumstances. Old historic city centers and buildings for instance (with cobble stone pavement and old building structures) are not immediately thought of as accessible places - ‘*How could an old city center even be accessible*?‘

Growing awareness towards making touristic sights and services accessible as well as online tools (search engines) to find out about those, can lead to open-minded solutions like an accessible horse-drawn carriage ride in Vienna[36].

Within CAP4Access accessible touristic sights and services (e.g. a ride on the ferries wheel in Vienna) can be made visible – through specific event maps for instance; as well as the provision of platforms for information exchange about travel experiences. In addition, accessibility concerns in the tourism chain can be discussed with public officials, private businesses active in the tourism sector.

Work

Work and employment opportunities are crucial sources of identity, financial stability (and independence) to “*enhance wider life opportunities and is seen as a key indicator of social inclusion*” (Roulstone 2004, 195).

[35] http://www.wien.gv.at/rk/msg/2009/0406/013.html [retrieved 2014-03-19]

[36] For more information, see http://www.fiaker-barrierefrei.at/fiaker.html [retrieved 2014-03-24]

The UN Convention on the Rights of Persons with Disabilities, Article 27, states

> *"the right of persons with disabilities to work, on an equal basis with others; this includes the right to the opportunity to gain a living by work freely chosen or accepted in a labour market and work environment that is open, inclusive and accessible to persons with disabilities"*

When discussing employment opportunities for people with disabilities, there is a lot more at play than questions of an accessible commute (peculiarities of the labor market; employment policies etc.). However, often "*chances of landing and retaining a job* [are limited] *because many workplaces are still physically inaccessible.*" (Clark 2014). Although a lot has been achieved in regards to integration in the labor market (e.g. disability employment policies and quota regulation), a lot of 'employment barriers' and disadvantages for people with disabilities remain. The 'benefits trap' is one example which describes why "*some disabled people choose not to work because the loss of their social housing support and income from benefits* [due to additional income] *would mean that they are worse off overall*" (Clark 2014, 16).

In the context of CAP4Access different aspects of the domains 'work and employment' are important. In order to facilitate inclusive employment, physical barriers as well as stereotypes regarding employment and disability (e.g. when abilities to pursue certain tasks or jobs are mainly ascribed to a person's disability) are important pillars. Discussion and gathering spatial data about opportunities and barriers faced when commuting to the workplace, as well as indicators of inclusive work spaces (e.g. buildings, office spaces), will enrich the tool to be developed within CAP4Access. In addition, possible specific needs and claims when planning work related trips are interrelated with concerns relevant in the 'accessible tourism' sector.

Education

> *"Education benefits not just children, but families and communities, and whole countries" (Miles & Singal 2010)*

Equal access to education for persons with disability, like employment, and leisure is crucial to foster social inclusion. Ideas around 'inclusive education' have been moving away from ideas and principles of 'special education' as ideas of someone having special needs can be used to enhance and perpetuate segregation measures by addressing specific needs as solely personal/body-related needs (Benson 2014).

> *"Inclusive education is an approach that ensures the presence, participation and achievement of all students in education. This may be in formal schools, or in non-formal places of learning, such as extra-curricular clubs and humanitarian camps. It often involves working to change the structures, systems, policies, practices and cultures in schools and other institutions responsible for education, so that they can respond to the diversity of students in their locality." (Sightsavers 2011)*

Further, education seen as a life-long (learning) process, rather than solely focusing on education in schools, emphasizes the importance of accessibility throughout different phases of life (senior learners, advanced vocational training etc.). Oftentimes, physical barriers inhibit possibilities to access facilities and thus opportunities for education. A lack of data in regards

to information about accessibility of higher education institutions has been currently pointed out by the EU-project 'MapAbility'.[37]

In regards to education institutions the collection of information and spatial data on accessible schools, education buildings ('from kindergarten to universities') through CAP4Access is crucial and will ultimately serve broader groups of end-users. Groups of end-users for whom such accessibility information is relevant include for instance pupils, students and professionals working in the domain of education. Possible impacts can be achieved through: awareness raising and discussing accessibility in schools; discuss issues of how to support students with disabilities in school activities with staff members; cooperatively collect experiences through touring the school/university building, neighboring area with different devices (wheelchair, walker); introduce and test tools like wheelmap.org with students.

The importance of including 'design for all' and discussions about user-centered design in the curricula of urban planning disciplines frequently resurfaces in discussions about (physical) accessibility. CAP4Access can initiate discussions about 'inclusive design' in education and practices of architects and urban planners in the four test site cities (e.g. professionals working in city administrations; educational institutions).

2.2.5 Independent living

Independent living firstly emerged in the 1970s in the UK and US as a response to institutionalization and segregation experienced by people with disabilities. It raised questions and concerns about normative ideas about caring and shook notions of physical independence and self-reliance of people with disabilities (Garabedian, 2014). An essential aspect of independent living defined by people with disabilities concerns having meaningful choices to get support and assistance to participate in society. Thus, it doesn't mean "*living by yourself or fending for yourself*"[38] – an idea sometimes associated with the term independent living.

The UN Convention on the Rights of Persons with Disabilities, Article 19, states

> *'Living independently and being included in the community' sets out "the equal right of all persons with disabilities to live in the community, with choices equal to others, and shall take effective and appropriate measures to facilitate full enjoyment by persons with disabilities of this right and their full inclusion and participation in the community."*[39]

The European Network on Independent Living (ENIL) describes independent living as

> *"the daily demonstration of human rights based disability policies. It is possible through a combination of environmental and individual factors that allow the disabled person to have control over his/her own life, which includes the choice of: whom to live with, how to organize daily activities, where to get the support needed. Independent living requires*

[37] http://exchangeability.esn.org/ [retrieved 2014-03-20]

[38] http://www.ilis.co.uk / [retrieved 2014-03-20]

[39] http://www.un.org/disabilities/default.asp?id=279 [retrieved 2014-03-21]

accessibility of the built environment, accessible transport, availability of technical aids and access to personal assistance for everyone in need."[40]

Three important pillars of 'Independent Living' are:

Personal Assistance: allows for independent living, provided individual needs assessment

Deinstitutionalization: shift from institutionalized, isolating care; take control of own life (with support if needed)

Community-based services: requires a political and a social approach, consists of policy measures to make public services (housing, education, transportation, health care and other services and support), available and accessible to disabled people in mainstream settings

'As we age we will all face disabilities'

When discussing independent living, concerns about who actually lives independently as well as dichotomies of dependent – independent along similar lines of ability – disability need to be reflected upon critically. Everyone, to a greater or lesser extent needs some help and assistance. Help and services supporting people to navigate through and manage daily life don't only concern people with disabilities. Critical disability studies for instance probe notions of ablism as a normative hegemony with disablism being on the other end of the spectrum. Scholars within critical disability studies contest and critically discuss prefixed categories (ability – disability) and stress a rather fluid process. Davis (1995, 11) stresses that "*the human diversity continuum of dis/ability is carved into oppositional poles of disability and ability."*

Independent Living is a very broad vision which can't be realized with the realms, aims and capacities of CAP4Access. Nevertheless, ideas around 'independent living' and an emphasis on independence of people with disabilities, set an important frame and reference point to the project. CAP4Access can trigger discussions about independent living as a much broader issue exceeding prevalent notion of it being a 'people with disabilities only concern'. This is stressed with the projects aim to discuss accessibility beyond physical barriers, as well as creating a tool which ultimately serves a much broader population (seniors, people with small children, people with temporary mobility impairments - broken leg etc.).

"Independent living is the outcome of much more than an individual service user's relationship with any particular services. The achievement of independent living requires […] innovative approaches to the creation of service responses" (Garabedian 2014, 83)

Further with creating a tool to support and ease transportation and trip planning for people with limited physical mobility in cities, independence through providing information and travel choices can be enhanced. Thus, maybe partly CAP4Access has - on a very small-scale - a bearing on independent living for at best all or at least many end-users.

[40] http://www.enil.eu/wp-content/uploads/2011/04/ENIL_ENG_web.pdf [retrieved 2014-03-22]

3 Methodological framework

3.1 Participatory research

Participatory research is an 'umbrella' term that is used to describe an approach that seeks to engage individuals and communities in research, and in the process strives to create equitable partnerships between community members, stakeholders, other organisational representatives and researchers. All participants contribute expertise and share decision making and ownership (Bergold & Thomas, 2012). Participatory research aims to break away from the linear model of conventional research and democratise the research process - placing the researcher and "subject" on an equal footing. Now adopted across a wide range of scientific and social science domains, a generic review of the literature where researchers have adopted PR reveals a range of sub-categories and definitions framed by the epistemological framework of PR:

PAR – Participatory Action Research – where the aim of research is transformative action that will influence the participants in the research or their community

CBPR – Community Based Participatory Research – where the research involves communities of place, interest or identify

PIR – Participatory Inclusive Research – where research seeks to include people who are traditionally viewed as research 'subjects' as co-researchers

For the purposes of the CAP4Access project with its emphasis on public participation, technological development and crowd-sourced data the application of PR to scientific research in the form of Citizen Science and in the associated areas of Public Participatory GIS (PPGIS), Participatory GIS (PGIS) and Volunteered Geographic Information (VGI) are included here, together with participatory and inclusive approaches to design.

More than a methodology

Participatory research in whatever context refers to an attitudinal approach to problem solving as well as to methods and techniques:

"More than a set of research methods, community based participatory research is an orientation to research that focuses on relationships between academic and community partners, with principles of co-learning, mutual benefit and long-term commitment and incorporates community theories, participation and practices into the research efforts" (Wallerstein & Duran 2006, S.312).

The defining characteristics of participatory research is not so much the methods and techniques employed, rather its aims are to turn on its head the conventional hypothesis testing and knowledge production of conventional research and put the 'subjects' of the research encounter in positions of effective decision making, transforming research from a top-down, expert-driven process into one of co-learning and co-production to provide better solutions to the priorities and needs of the target community (Balazs & Morello-Frosch 2012).

Research findings can then be tested by changed practice and further research developed to evaluate those changes on an ongoing basis throughout the research process with the

ultimate aim of empowering change and bringing about transformative action to improve quality of life.

As Pain and Francis emphasised, *"Participatory approaches did not originate as a methodology for research, but as a process by which communities can work towards change"* (Pain & Francis 2003)

This cyclical, iterative approach can help communities better understand their worlds and lived experiences and improve services for them. Critically this approach helps understand not only what happens as a result of an intervention, but how it happens so that learning can be shared and effective practice replicated. The research process influences the development of the project during the lifespan of the research rather than after a final research report.

A fundamental principle of participatory research is the belief that knowledge is embedded in the lived experiences of the people who are the focus of the research, by giving a high value to community knowledge traditional power relations are challenged.

Exhibit 4: Participatory and Conventional Research a Comparison of Process

	Participatory Research	**Conventional Research**
What is the research for?	Action	Understanding with perhaps action later
Who is the research for?	Local people	Institutional, personal and professional interests
Whose knowledge counts?	Local people's	Scientists
Topic choice influenced by?	Local priorities	Funding priorities, institutional agendas, professional interests
Methodology chosen for?	Empowerment, mutual learning	Disciplinary conventions, 'objectivity' and 'truth'
Who takes part in the stages of research process?		
Problem identification	Local people	Researcher
Data collection	Local people	Researcher, enumerator
Interpretation	Local concepts and frameworks	Disciplinary concepts and frameworks
Analysis	Local people	Researcher
Presentation of findings	Locally accessible and useful	By researcher to other academic funding bodies
Action on findings	Integral to the process	Separate and may not happen
Who takes action?	Local people, with / without external support	External agencies
Who owns the results?	Shared	The researcher
What is emphasised?	Process	Outcomes

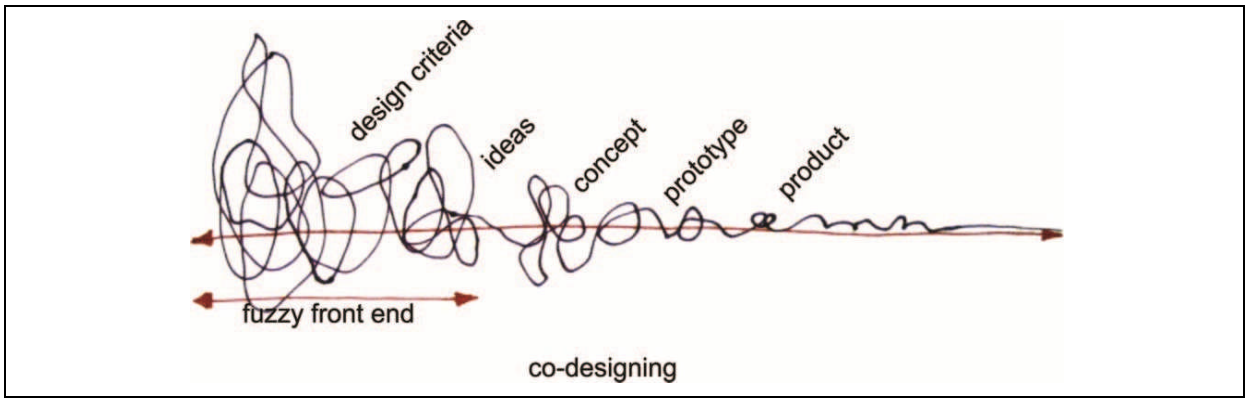
Source: Cornwall & Jewkes (1995)

3.2 Participatory or inclusive design

Participatory approaches are increasingly adopted in the design of products and services as designers seek to put end users at the centre of the design process, as opposed to more traditional approaches involving them in product testing. The principles of participatory research that pertain to citizen science and community mapping methodologies apply also to the design process.

In a paper entitled 'Co-creation and the New Landscapes of Design' Sanders and Strapper (2008) outline the move away from a user-centred design towards participatory design. Themes to emerge show a now familiar shift from an 'expert lead – users as subject' design methodology to a 'user as partner approach' and contrast with traditional designer led processes in which end user participation is limited to testing and refining products that have been conceptualised and developed by designers. Sanders and Strapper (2008) diagrammatic representation of a participatory design process emphasises the unpredictable nature of the early consultation phases. The front end of the design process has been growing as designers move closer to the future users of what they design.

Exhibit 5: The growing front-end



Source: based on Sanders and Strapper (2008)

The fuzzy front end represents the 'pre-design' phase that take place in order to inform and inspire product development and is followed by the traditional design process where the resulting ideas for product, service, interface, etc., are developed first into concepts, and then into prototypes that are refined on the basis of the feedback of future users.

There are clear parallels with the CAP4Access public engagement process where we would expect to find initially that the "front end" of the consultation will inevitably be "fuzzy" but the process of engagement will enhance the understanding of users and the contexts of use, as well as the exploration and selection of technological opportunities and information technologies.

Parker et al. (2013) extend the concept of participatory product design into a service design context which is particularly useful when considering appropriate methodologies for the CAP4Access project. Through a series of case studies undertaken with people requiring enhanced accessibility the study demonstrates the use of Volunteered Geographical

Information (VGI) or crowd sourced data as an integral part of future inclusive service design. The results show that in using this approach service outcomes can be more efficient, intuitive and relevant to a wider population. Particularly relevant to the design of multi-faceted public services such as transport and public health where users interact with a wide range of variables in order to achieve their goals. An example used by the authors is that of train travel - ticket purchase, navigation of the station, encounters with staff and other passengers, finding a seat and travel information all shape the overall experience of train travel. By adopting an inclusive service design approach there is great potential to improve the accessibility of transport services. A key element of the service design approach is the involvement of users through the use of co-creation methods.

3.3 Typologies of participation and involvement

In an effort to establish a clearer framework for participatory research, many authors in over 50 years of research (for example, Arnstein 1969, Bonney et al. 2009, Wright, von Unger and Block 2010, Fiorino 2012), propose typologies of participation which seek to define the boundaries between non-participation, degrees of minimal participation such as knowledge gathering and exchange, and genuinely inclusive participation in which participants are involved in decision making and co-design.

The stage model of participation (Wright, von Unger and Block 2010) defines levels of participation on the basis of decision making authority with the highest level of empowerment as one of self-organisation, where the individual or community are able to act autonomously.

Exhibit 6: Stage model of Participation

Self-organisation	Beyond participation
Decision making authority	Participation
Partial delegation of decision making authority	
Shared decision making	
Inclusion	Precursor to Participation
Consultation	
Information	
Instruction	Non-participation
Instrumentalisation	

Souce: Wright, von Unger and Block (2010)

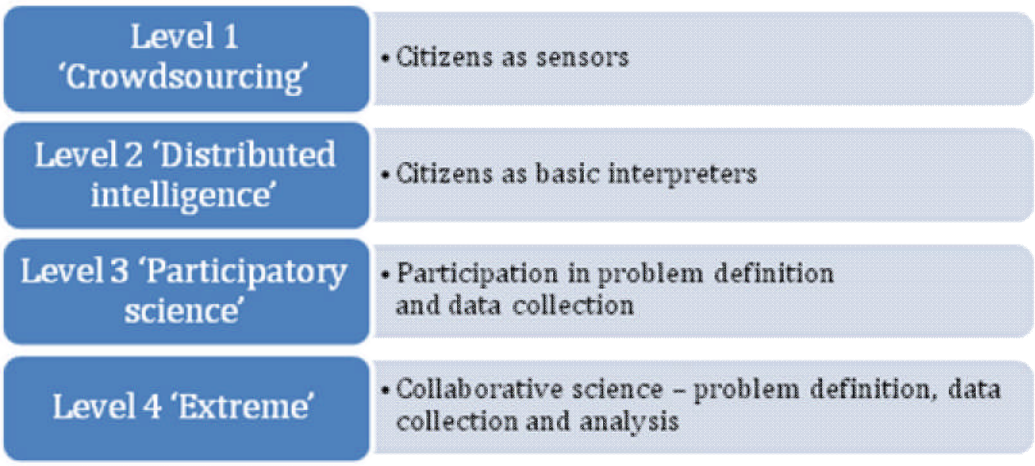
However Cornwall (2008) suggests that rather than referencing 'ladder' models researchers ask questions about the research process:

> *"What they participate in, and, as a corollary, who participates in which activities and at which stages in the process"*

This approach is adopted in The Guidelines and Categories for Classifying Participatory Research Projects in Health Promotion which serve to appraise the extent to which research projects align with principles of participatory research (Green, 1995).

The typology of participation based on Haklay (2013) is of particular relevance to the CAP4Access project as it places levels of involvement and participation in a citizen science context. *Citizen Science* is hardly a new concept with origins in the 19th century, but the last decade it has seen a rise in both academic and popular interest for the topic. This trend is in part driven by an increased interest for open paradigms, as well as, Information Communication Technology (ICT) innovations such as smartphones, mobile Internet and cloud computing. This has given rise to growing and highly diverse crop of new – and often innovative – initiatives that are being, or could be, labelled as Citizen Science. Related terms include: Community Science, Citizen Cyber Science, Community Sensing, Participatory Mapping, Participatory (Mobile) sensing and so on (Haklay, 2013). Taking the characteristics of citizen science into account, Haklay suggest a typology of participation that can be used across the range of citizen science activities, and any one project will not be classified in only one category. For example projects, in volunteer computing, where people download software that uses the unused CPU cycles on their computers, most of the participants will be engaged at Level 1 – Citizens as Sensors, while participants who become committed to the project might move to the second level and assist other volunteers when they encounter technical problems. Highly committed participants might move to a higher level and communicate with the researchers who coordinate the project to discuss the results of the analysis and suggest new research directions.

Exhibit 7: Levels of participation in citizen science projects



Source: Haklay (2013)

Modes of engagement will vary as it is important to appreciate that partners involvement will vary depending on limiting factors, such as other commitments; available time to invest in the project and health implications. There will be some partners actively involved in higher levels of participation such as decision making and problem definition (Level 4) whereas others will contribute via lower stages of involvement, such as data collection, providing feedback, or dissemination and awareness raising activities such as promoting collective activities so they may want to comment / share / disseminate the project, opportunities.

The guiding principles of participatory research (above) frame the conceptual and methodological framework of participatory mapping processes and are especially relevant to the CAP4Access project with its emphasis on on-line mapping technologies. The participatory framing of public participation GIS (PPGIS) and participatory GIS (PGIS) especially crowd sourced data collection or volunteered geographic information (VGI) in the creation of geographic knowledge fit well within the participatory research paradigm.

> *The drive to understand and describe the world using maps is central to the human condition. From sketches in the dirt to paintings on cave walls, humans have evolved and refined methods for transmitting experience, knowledge and inspiration about places that sustain them physically and spiritually (Brown & Kytta 2014)*

Sui et al.(2013) in an overview of volunteered geographic information (VGI) discuss the recent technological advances that have transformed how geospatial data are produced and disseminated through the growth of related technologies known collectively as Web 2.0, (cloud computing, crowd sourcing, user generated content, semantic web). The definition by Brown & Kytta (2014) focus on the use of the Web to create, share and analyse geographic information via multiple computing devices such as laptops, smart phones and tablets. Together with technological advancement in GIS mapping of spatial data we have seen the growth of maps enhanced with digital information layers or “rich” information that includes geo-tagged personal location information such as Flickr photos, YouTube videos, Soundcloud music files, and Facebook / Twitter postings.

Technological developments have also challenged the traditional knowledge creation hierarchies, as citizens and not just government or educational agencies, are now generating “rich data” through a bottom up, crowd sourcing process. Both PPGIS and PGIS promote the inclusion and empowerment of marginalized or under-represented populations in the development and use of spatial information.

The distinctions between PPGIS and PGIS largely reflect the situational context (developing vs. developed country) in which the methodologies have been developed. In developing countries, the focus of PGIS has been on social learning and community engagement, with the resulting maps a potentially useful, but secondary outcome. PGIS is used as a development tool to encourage community identity, empowerment, and the creation of social capital. The promotion of social justice and equality is often an implicit goal of the process. In many cases, the participation component is more important than the resulting maps (Brown & Kytta 2014).

Exhibit 8: Characteristics of PPGIS, PGIS and VGI

	PPGIS	PGIS	VGI
Process emphasis	Enhance public involvement to inform land use planning and management	Community empowerment foster social identity Build social capital	Expand spatial information using citizens as sensors
Sponsors	Government planning agencies	NGO’s	NGO’s ad hoc groups, individuals
Global context	Developed countries	Developing Countries	Variable

	PPGIS	PGIS	VGI
Place context	Urban and regional	Rural	Variable
Importance of mapped data quality	Primary	Secondary	Primary
Sampling approach	Active: probability	Active: purposive	Passive: voluntary
Data Collection	Individual (e.g. household sampling)	Collective (e.g. community workshops	Individual
Data ownership	Sponsors of the data	People and communities that create data	Shared (e.g. data common licence
Dominant mapping technology	Digital	Non-digital	Digital

Source: Brown and Kytta (2014)

In the context of the CAP4Access project participatory mapping offers scope in the pilot areas as a means to facilitate solutions and involve end users in the following ways:

- To gather local knowledge
- To create new/alternative maps
- To educate and communicate with external agencies and decision-makers
- To identify key issues for action planning
- To assist with data gathering for research
- To facilitate decision-making process
- To identify data gaps
- To expose complex social/spatial interactions

3.4 Examples from the disability and mobility domain

In an overview of research methods in disability studies Kitchin (2001) and more recently Goeke & Kubanski (2012) have argued persuasively that disability research fails to represent disabled peoples' experiences and knowledge, largely because disability discourse has been dominated by people who are not disabled themselves and the vast majority of research is conducted by non-disabled researchers. In an early paper expounding this view, Oliver (1992) cited in Kitchin (2001) argued that traditional research methodologies represent a model of research that disempowers and disenfranchises disabled people by placing their knowledge into the hands of the researcher to interpret and make recommendations on their behalf. Similarly Goeke and Kubanski (2012) contend that all too frequently people with disabilities have been excluded from participation in research activities that explore the lives of people like themselves. They appeal for the comprehensive inclusion of people with disabilities in the conception of research projects as well as in the operation of surveys and the evaluation and interpretation of data, and that linguistic barriers as well as the balance of

power should be reviewed. The adoption of research strategies that are emancipatory and empowering offer pathways to inclusion for disabled people:

- Research should be used as a tool for improving the lives of disabled people;
- There should be greater opportunities for disabled people to be researchers;
- Researchers must adopt a more reflexive stance regarding their work;
- The democratic organisations of disabled people should act as commissioners and funders of research;
- Researchers should be accountable to the democratic organisations of disabled people.

Where a participatory approach is adopted researchers have found that the process is enabling for both participants and other stakeholders such as service providers and policy makers. For example Ollerton and Hossfall (2012) used an inclusive participatory action research approach in a study for which they utilised the Convention on the Rights of Persons with Disabilities (CRPWD) as an engagement tool in a study which considered the rights of people with disabilities to be involved in disability research. The study was prompted by the researcher's awareness of the gap between the rhetoric of rights and the reality of people's lives. The research design sought to engage and support disability service users to discover the social limitations to their self-determination and then assisted them to take action against those limitations.

The methodological approach used in the study was influenced by a focus on the right of people to be actively involved in policies and programme decision making that directly affects them. The researchers stress that as an approach it has no defined formula but rather seeks to take into account the voice of disabled people as experts in "what life is like for them" rather than having their experiences interpreted by a professional researcher. The research methodology also incorporated participatory action research methods of iterative cycles of research, action and reflection with the ultimate aim of bringing about action for positive change. Of particular relevance to the CAP4Access project were the findings relating to public transport raised by the co-researchers, particularly in relation to inappropriate signage and limiting accessibility. With their findings it was possible for the co-researchers to lobby relevant transport authorities and to communicate and publish the outcomes of their work.

In this brief overview of participatory research the aim has been to show how the guiding principles of inclusion, empowerment and co-determination that define participatory research as an approach to public engagement are drawn together in the related domains of Citizen Science, Participatory Mapping and Inclusive Design and how the three principles provide an appropriate conceptual and methodological framework for CAP4Access engagement with people with mobility needs in the pilot areas.

4 Scope of project activities

This chapter covers an overview of the seven research streams in CAP4Access. The objective is to include information – for each research and development area - on the state of the art, the remaining gaps and the implications for the work to be done in CAP4Access.

4.1 Collective tagging

One of the tasks included in collective tagging is the design and implementation of a tagging management system. The system will be developed to support the collection of user-generated data on the accessibility of places, points of interest and roads through participatory sensing. For instance, contributors will be able to provide data on road surface, obstacles, etc.

The collective tagging approach has already been applied to the accessibility theme through the Wheelmap platform. Wheelmap is a map for wheelchair-accessible places that was created by Sozialhelden. In Wheelmap, places are rated according to a traffic light system. CAP4Access will contribute to the improvement of Wheelmap by contributing information about the needs that will be identified by primary user groups in the first phase, and ensuring that the tagging system enables to provide required information to assess the accessibility of places. Exploring the possibilities of integrating or linking up new tagging functionality with the existing Wheelmap system is then a further step.

A first challenge, while the tagging system must be easy to use, the data provided through the tagging system should also be easy to process and integrate with other data. Therefore, it is preferable that users **employ a recommended terminology for the tags, as it is already recommended to OSM** contributors through a folksonomy, a flexible nomenclature that enables contributors to suggest new terms and organize terms into a taxonomy (Wal 2007). By enabling knowledge discovery and information filtering, folksonomies can help to handle the large amount of user-generated data that the participatory platform will raise.

A second challenges related to the design of the tagging management system is the choice of appropriate Semantic Web technologies, including **query and representation languages and reasoning tools**, to implement the system. For example, semantic web technologies can be used to annotate ambiguous tag content to formal description using the OWL DL ontology language (Krötzsch and Vrandečić 2011), the language recommended by W3C for formalizing semantics (Bakillah et al. 2013b). Annotations can be automatically generated with matching systems as described in Bakillah et al. (2013a) or similarity measurements (Janowicz et al. 2007; Ballatore et al. 2012). This will facilitate further processing and integration of the data provided through tags by the other CAP4Access services.

Collective tagging is also a form of ‘crowdsourcing’, a term coined by Howe (2006) who spoke to companies about how people used their spare resources to create content and solve problems. Crowdsourcing means work is outsourced to the crowd. However, rather than resembling a contract-like relationship, crowdsourcing involves a wide range of incentives (money, reputation, learning opportunities, networking etc). Prominent examples include GalaxyZoo (citizen science in astronomy), OpenStreetMap (charting navigable trails),

Threadless (t-shirt design competition), UTest (software testing) and InnoCentive (solving R&D problems). Hence a third challenge lies in **motivating the 'crowd'** without which no noticeable impact can be achieved. Common motivation strategies include, reputation among peers, tokens as part of gamification, competitions, fun etc. Additionally good user interface design and **user experiences** will be crucial in order to not deter potential participants.

4.2 Participatory sensing

In this section we will outline the theme of participatory sensing.

Participatory sensing will be defined as any form of human or mechanically sensed features of the environment where those features can be objective features of the physical world or subjective features of the social world. Accordingly, we will focus on two different types of sensing: the sensing of objective features of the environment using smartphone functionality, and the sensing of subjective features of the environment using the smartphone as a means of collecting survey-like data. We will call these "hard sensing" and "soft sensing" respectively.

Current Status

In terms of hard sensing, it is not an understatement to say that sensing technologies, particularly in creating "smart" cities, have undergone a revolution in the last five years. Our research in fact will use very basic smartphone technologies to sense particular features of the objective environment. A variety of forms of "wearable tech" have emerged recently which mediate between the user and some aspect of the environment.

Meanwhile in regards to soft sensing, there has also been a revolution in the last 10-15 years in terms of the measurement began with the publication of the landmark volume *Well-Being: The Foundations of Hedonic Psychology* (Kahneman, Diener, and Schwarz, 1999). Since this pivotal publication, the field of research for measuring SWB or happiness (Layard, 2005) has spread enormously, and has even been incorporated to form a substantial area of research undertaken by the UK's Office of National Statistics (Dolan, Layard and Metcalfe, 2011).

A particular finding of this research is that subjects are very bad at recalling their past experiences in terms of how much happiness they experienced with respect to a particular point in time. For this reason, a new approach to collecting data on well being has emerged which is called ecological momentary assessment (EMA) and is sometimes also known as experience sampling (Stone, Shiffman and DeVries, 1999; Shiffman, Stone and Hufford, 2008). The key here is that the respondent is providing an assessment of their well being *in real time* (the "momentary" part of EMA) and *at a particular location* (the "ecological" part of EMA).

As an example, an EMA might be that your smartphone might prompt you when you pass a particular location and opens an app which asks you to quickly tick a category that best responds to how you feel *at that particular moment*. The mode of data collection varies and can include written diaries. The time frame for sampling of experiences can be *event-based*, such as passing a particular location or the occurrence of a particular event, or *time-based*

such as being prompted to provide an assessment at specific intervals or based on a random time interval (Shiffman, Stone and Hufford, 2008: 13).

Remaining Gaps

We have identified two gaps in the area of sensing that our research will address. First, there has been little in the way of linking hard and soft sensing. That is, there is relatively little research that connects both an objective measure of a feature of the built environment and a subjective assessment of that feature of the environment. Our view is that by linking both the hard and soft aspects of sensing that we will be able to better understand aspects of accessibility that truly matter to users.

Second, most research on experience sampling or EMA uses categories that are of interest to and hence defined by the researchers. Instead, our research will focus on the emotional categories that the users *themselves* define as important and that represent *their* experience. This is in keeping with CAP4Access's overall ambition that the tools that address accessibility should reflect the relevant experience of the users themselves, not what the researchers think is relevant.

Our Research Approach

We will develop a very basic functionality for an app that will enable a user to measure inclines in public spaces. This will draw on the inclinometer and the accelerometer of the phone. Research participants will use a variety of devices (wheelchairs, push chairs for children) and approach any given incline from a flat surface, approaching at normal speed. We then can infer from this data the difficulty of overcoming the incline by looking at the actual incline based on the inclinometer data. We can also infer the difficulty by looking at how the speed of the user has changed by examining accelerometer data.

As stated above our research seeks to better represent disabled people's experience and knowledge. Therefore, we will invite respondents to develop their own categories of emotions that they might experience in different situations they face (not unlike the folksonomy discussed in the collective tagging work). The respondents will be asked in focus groups to think about different types of positive and negative emotions that they experience at particular places, which itself may or may not be related to issues of accessibility. We are trying to understand how those with some kind of accessibility issues feel about particular places. We will refer to this as the *emotional vocabulary* for assessing accessibility-related well-being (ARWB).

Using this emotional vocabulary derived from the research participants we will then undertake EMA in a given area with a limited number of specific features of the built environment for which we would like respondents to undertake both hard and soft sensing. As we will be using these responses to map the emotions that are felt in particular places and are also geotagged we will refer to this procedure as *emotional mapping.*

In our research we will also pilot other functionalities that pertain to determining the emotional feel of a place which entail a more collaborative form of participatory sensing, some of which may include: Photo sharing capacity; possibility of posting to message boards; Check-in capabilities; Messaging capacities.

Our approach is to have a fuller objective and subjective understanding of what matters in the built environment. By employing a dynamic data capture system for human emotions and features of the built environment we will attain a greater understanding of the kind of accessibility that contributes to the well being of the users.

4.3 Quality assessment of crowd sourced data

Ensuring the quality of crowdsourced data is of particular significance for this project in order to make sure that the routing and navigation services offered are accurate. It is also crucial since the acceptance of such data as input to policy-making and formal planning procedures rests on the trust placed the validity of the information.

Crowdsourcing applications support the dissemination of real-time or near real-time information directly from the field where things are happening, with a flexibility that contrasts with traditional data production methods (Goodchild 2007). Routing and navigation services for people with limited mobility can benefit from information on new obstacles to navigation provided by involved communities.

However, crowdsourced data has significant differences from traditional geospatial data, which are created by specifically dedicated organizations and experts, according to standardized structures and languages. For example, crowdsourced data is likely to be produced using natural language, which can impact semantic accuracy (Grossner and Glennon 2007). Users of crowd-sourcing applications may have a vague memory of the geographic phenomenon they report on, or they could perceive only a certain portion of it (de Longueville et al. 2009). Especially for the routing tools to be developed in CAP4Access, spatial accuracy is of great concern to ensure proper routing and live navigation support.

The development of a data quality management component is therefore a crucial objective of the CAP4Access project. The **scope of the activities** involved in the development of a data quality management component is encompassed within the following questions:

- **Which data quality aspects are important and must be assessed?** Geospatial data quality standards have been defined in the International Standardization Organization (ISO) Technical Committee (TC) 211 codes 19113 and 19114. Typical quality standards are: lineage; positional accuracy; attribute accuracy; logical consistency; completeness; semantic accuracy; usage, purpose and constraints (fitness-for-use); and temporal quality (van Oort 2006). Of note, however, is that these traditional aspects of geospatial data quality are not the only ones that can be considered for CAP4Access. Additional quality aspects have been proposed for crowdsourced geo-data (Mooney et al. 2010; Barron et al. 2013). For example, Barron et al. (2013) have developed 25 methods and indicators to assess OSM data quality based solely on the data's history. Examples of indicators include "development of OSM features and tags," "currentness of data," "syntactic attribute accuracy," "road network completeness," "development of POIs," etc. Such quality indicators are useful to assess the intrinsic quality of the data in the absence of reference data (commercial or administrative datasets). In the context of the CAP4Access, a first activity will be to choose which quality aspects will need to be

monitored and dealt with, based on the impact they might have on the services delivered.

- **How can these data quality aspects be assessed?** A common method for assessing data quality is to compare it with reference data (commercial or administrative datasets) (Girres and Touya 2010; Haklay 2010; Helbich et al. 2012; Mooney et al. 2010; Neis et al. 2012; Zielstra and Hochmair 2012). The comparison process can be conducted in different manners. For example, the (relative) completeness of a road network can be assessed by comparing the total length of the first dataset's roads with the total length of roads of the reference dataset within the exact same region of interest (Haklay 2010; Zielstra and Zipf 2010). As another example related to the quality of building footprints in OSM, the completeness can be assessed by comparing the surface covered by OSM buildings with that covered by buildings in the reference dataset (Fan et al. 2014). However, accessibility to high quality reference datasets can be costly or limited due to licensing restrictions. Alternative solutions include methods for measuring intrinsic data quality indicators based on the analysis of the history of the data, as mentioned above (Mooney et al. 2010; van Exel et al. 2010; Barron et al. 2013). Also, model-based methods can enable quality assessments without reference data (Foody 2012). The profile of contributors can also be taken into consideration while assessing the data quality, whereby contributors can be classified as "beginners," "regular mappers," "intermediate mappers," "experts," and "professional mappers" (Jokar Arsanjani et al. 2013). When the profile of a contributor is characterized, this contributor can be assigned a "level of trust" that can help predict the quality of its future contribution (Fichman 2011). Systems where contributors review each other's' contributions also exist (Raykar and Yu 2012). Foody (2013) provides an alternative quality assessment method where crowdsourced contributions are considered as "imperfect indicators of the actual phenomenon under study"; a latent class analysis method is employed to extract underlying information and quality of the contributions. Based on the quality aspects that will be selected in the first place, as well as on the nature of the different data sets that will be used, a combination of data quality assessment methods based on comparison with reference data and intrinsic data quality assessments may be considered for the current project.
- **Once data quality aspects have been assessed, how can data quality be improved or dealt with?** Approaches to deal with data quality can be classified as preventive or corrective approaches. Preventive approaches try to prevent quality issues from arising by controlling the data production process. For example, some crowdsourcing applications use editors with templates to control data production (Foody 2013). However, some authors report that a clear correlation between data accuracy and the use of editors has not been observed (Yaari et al. 2011). Therefore, further research is needed to determine if such editors would be efficient within the CAP4Access platform. Corrective approaches aim at improving the data quality once problems are identified. For example, in order to deal with issues of completeness in OSM data, Hagenauer and Helbich (2012) propose a framework for predicting urban areas in Europe that are currently not mapped or only partially mapped. The framework is based on a machine learning technique that combines artificial neural networks and genetic algorithms. According to the results obtained with this method,

the accuracy of predictions of urban areas strongly depends on location. In the CAP4Access project, the method that will be employed to deal with data quality will depend on the nature of the data and on the acceptable quality threshold for each quality aspect.

- **How can the data quality management approach be implemented and integrated with the CAP4Access platform?** In a paper entitled *QualEvS4Geo: A peer-to-peer system architecture for semi-automated quality evaluation of geo-data in SDI*, it is proposed that a data quality system be implemented as a web processing service that coordinates several technologies, tools and knowledge bases (Mobasheri et al. 2013). Each of these technologies and tools is designed to evaluate a given quality indicator. Tools and technologies can exist, open source software that already performs tasks related to data quality assessment. The services are organized into a peer-to-peer infrastructure. In the CAP4Access project, research will continue in this direction to implement the quality management component as a workflow of web services.
- **How can data quality be visualized in order to facilitate its management?** Concerning the management of geospatial data quality, Devillers et al. (2002) argue that using metadata to help users to evaluate if a dataset is suitable or not is not an efficient approach. They suggest including data quality visualization tools to help users assess fitness-for-use instead (Devillers et al. 2002, 2007). Visualisation of data quality assessment will facilitate its management to ensure it is suitable for routing and navigation tasks. The GIScience Research Group at the University of Heidelberg has developed a visualisation tool for VGI quality. It is a technical framework for visualizing spatiotemporal quality metrics of VGI called OSMatrix (Roick et al. 2011). It has been implemented to assess the quality of data in OpenStreetMap. It is portraying several attributes on user activity, topicality of data as well as the occurrence and distribution of certain feature types across Europe. The research conducted demonstrated that the approach is suitable for providing a quick visual overview on certain quality characteristics. In addition, the tool has been extended to support processing, storage and management of spatiotemporal quality metrics.

4.4 Integration of public sector information (PSI) in OSM

New mobility related spatial data will be created trough participatory sensing and collective tagging processes as discussed earlier. These data will be fed into the OSM world by applying suitable formats and APIs as defined by the project itself. While these data may become uniquely available through these crowd-source activities, other relevant data already exists primarily within the public sector. Also specific industries might have created potentially relevant data sets, e.g. for the automotive, energy or real-estate sector. If available and made accessible to the project, the re-use of such data is clearly preferable over generating it anew. In particular, public sector information is usually of high quality, has a good coverage in terms of completeness, and it will be regularly updated.

The Directive on the re-use of public sector information (Directive 2003/98/EC, known as the 'PSI Directive') provides a common legal framework for a European market for government-held data as public sector information. It is built around two key pillars of the internal market:

transparency and fair competition. Entering into force on 31 December 2003, it focuses on the economic aspects of re-use of information rather than on the access of citizens to information. It encourages the Member States to make as much information available for re-use as possible.

The EC's 2011 Communication on " Open data – An engine for innovation, growth and transparent governance" (European Commission report, 2011) calls for all public data, i.e. all the information that public bodies in the European Union produce, collect or pay for, to be made accessible free-of-charge for use, re-usable for commercial and non-commercial purposes. In regards to Open Data, The Digital Agenda for Europe states:[41]

- Public data has significant potential for re-use in new products and services. Overall economic gains from opening up this resource could amount to< € 40 billion a year in the EU;
- Addressing societal challenges – having more data openly available will help us discover new and innovative solutions;
- Achieving efficiency gains through sharing data inside and between public administrations;
- Fostering participation of citizens in political and social life and increasing transparency of government.

Specifically regarding spatial data, or geodata, the EC has launched a European effort on harmonizing and sharing spatial information with its INSPIRE Directive from 2007 the EC. While the initial focus was towards creating a major standard for the exchange of environmental geodata, the current and later stages also address other thematic categories of types of data. INSPIRE prescribes standards for web services, which must be adopted by all public data providers.

These standards are useful because they offer one common interface for many data sets of all European countries. A connection to OSM is thus facilitated at an intermediate level of access regarding service APIs. On the other hand, not all spatial data are available with this standard. Every municipality, region and member state may still have further relevant data sets, in different formats and under different licenses.

Integration of public and sponsored data in CAP4Access will require a systematic review of existing data sources, the willingness on the part of public administrations to disclose the data, and the engagement of target end-users to understand the relevance and importance of different datasets to their needs and practices. The project will pilot-test methods for selected data sets which have the most impact regarding relevance, open data formats, availability, licenses and effort of transformation and integration. For instance, steepness of roads is important for routing and consideration of energy consumption. If not explicitly given as average or mean slope values of street segments they could be automatically derived by interpolation from digital elevation models, which will become available as INSPIRE Annex II data. While these derived values would probably be available for whole areas or cities, as an interpolation of the lowest and highest value of a street they would not really provide accurate information for wheelchair users. The street could include a very steep part, posing

[41] Homepage: http://ec.europa.eu/digital-agenda/en/open-data-0

a serious threat, while being quite level on average. In that respect, this is a good example of a situation where participatory sensing and collective tagging would provide more accurate and detailed information and therefore still be useful in spite of the availability of public data.

Against this background, the CAP4Access project will design and develop a methodology as well as pilot-test appropriate tools to integrate existing publicly available and other sponsored data about the built environment into the OSM-based accessibility tools. The selection criteria for data sets to be accessed and imported into OSM will be established with the user groups. The criteria may include importance/relevance of the data, open formats, availability and licenses, effort of transformation, matching and integration. To take up the above example, data on the slope of roads might not be directly given, but they might be inferred from an existing digital terrain model. For a specific municipality, such a model might be available according to the INSPIRE specifications, but not for free. Alternatively, the municipality may have elevation data for its own road network and provide them for free, but not in a non-standardized format. A decision must be made which way is preferable in terms of effort, data quality, procurement, sustainability, etc. As another example, Deutsche Bank has already shared data on the accessibility status of their 1.600 German affiliates. In order to handle the import, a tool is needed to avoid duplicates in the database. With such a tool, other owners of comparable data shall be motivated to share their information too.

The general data integration strategy will address the following challenges:

- selecting the type of integration model (centralized model with federated data model, decentralized model, etc.);
- resolving the syntactic heterogeneities (differences between formats, integrating of streaming data);
- resolving the structural heterogeneities (differences between data structures of the different sources);
- resolving the semantic heterogeneities (differences between the meanings of data).

After such clarifications it must be exactly fixed how the new data can be amalgamated with OSM. The exact procedure of intake will depend on the following circumstances:

The type of object to be integrated already exists within OSM. Then decide if a new attribute will be needed for this object, or if an existing attribute can be (re-)used.

The type of object does not yet exist, and a new type and attributes must be introduced.

Generally, a Tag in OSM consists of a 'Key' and a 'Value', e.g. ”highway=motorway”. Each tag describes a specific feature of a data element (nodes, ways and relations) or change sets. In principle, both the key and value are free format text fields. In practice, however, there are agreed conventions of how tags are used for most common purposes. So it is important to follow accepted paths of good practice when introducing new items in the OSM world.

The project cannot, of course, guarantee translations from all formats into OSM. In some cases the effort might be prohibitively high. Fortunately, the OSM community has already provided translators for several formats in more common use, such as shape-files (ESRI format), KML (Google Earth), or SVG (Scalable Vector Graphics (W3C).

The European regulation of INSPIRE is more and more requesting public bodies to apply standards originating from the Open Geospatial Consortium (OGC). Chances are that spatial data from public – but also private – organizations will increasingly provide their data using these standards, which include data formats (GML – Geography Markup Language) and standard services for metadata descriptions, data retrieval, search, visualizations, etc. The project will be prepared to support these services if needed.

The following table shows currently supported imports and exports for OSM

Exhibit 9: Tools to convert data formats to and from Open Street Map (OSM)

File type	Extension	To import into OSM	To export from OSM
Adobe Illustrator	.ai	No	osm2ai.pl
ArcGIS (by ESRI)	several	ExportToOSM.py	ArcGIS
E00	e00	Partial	Partial
Dafif	?	dafif2osm	No
DXF (by AutoCad)	.dxf	Partial	No
GADM	?	gadm2osm	No
Garmin maps	.img	No	OSM Map on Garmin
Geobase	?	geobase2osm	No
GeoJSON	.geojson	?	OSM2GEO, osmtogeojson
GML	?	gml2osm	XSLT, Python, GeoConverter (online tool)
Google Earth (Keyhole) Markup Language	.kml	JOSM/Plugins/OpenData	OSM in Google Earth, Osm2KML, GeoConverter (online tool)
GPX	.gpx	Import as layer in main site, josm, gpx2csv->csv2osm	traceosm, GeoConverter (online tool)
Image (non georeferenced)	.png, .jpg, *etc.*	Geo Things Map Rectifier	Main map program
Mapserver	.map	No	Convert to GML first
MATLAB	.mat	No	OpenStreetMap functions [1]
MP (Polish format)	.mp	mp2osm PFM2OSM	Osm2mp
NKF	?	Nkf2osm	No
PGSQL	?	No	osm2pgsql,imposm
QGIS	.qgs	No	Convert to GML first
Shapefile	.shp	JOSM/Plugins/OpenData	Partial, GeoConverter (online tool)
SRTM	?	Srtm2Osm	No
SVG	.svg	JOSM/Plugins/ImportVec	Main map program

Source: http://wiki.openstreetmap.org/wiki/Converting_map_data_between_formats [retrieved: 2014-02-06]

4.5 Routing and navigation services

Routing and navigation services are the main services provided by the CAP4Access platform to improve the mobility of people with various types of disabilities. Routing is defined as “the movement process of people from one location to another” (Zhu 2012). It involves both the generation of a “routing plan” and a “routing map”: the former provides the best route based on user's preferences or constraints, while the routing map assists users who are traveling in a given environment by displaying detailed route descriptions as well as a graphical representation of the route and surroundings (Zhu 2012).

The objective of CAP4Access is to extend and improve the OpenRouteService.org OSM routing service so that it can be used by persons with limited mobility with various profiles. A first prototype for wheelchair routing, Rollstuhlrouting.de, has already been developed, but it is based on very limited data. Since OpenRouteService.org is built according to open standards from the Open Geospatial Consortium (OGC), it can easily be integrated in other applications or regional web sites.

The **scope of the activities** involved in the development of the routing and navigation services is encompassed within the following questions:

- **How to generate the road network?** The routing graph is at the core of the routing and navigation service. The routing graph is a representation of the street network with a model such as nodes and edges. One of the main challenges consists in gathering the data for generating this graph with all the attributes that are required to assess the accessibility of a route. In most cases, available data is proprietary and licensed by the data provider and covers only a few local areas; therefore, the development of applications with this data is limited. For this reason, CAP4Access will rely on crowdsourced information and sensor data in addition to available public data. This choice is also based on the assumption that local inhabitants know their commute area and neighborhood better than traditional routing services that rely on commercial digital roadmaps and shortest path algorithms (Hendawi et al. 2013). This will also enable that the input of users be considered. In terms of indoor data, the OSM-3D and IndoorOSM project has already begun gathering data on the indoor situation of buildings for the purpose of routing (Goetz 2012). Meanwhile, this data is likely to be incomplete with respect to obstacles for persons with limited mobility; this is why the input of those users is an important part of this project as well. Once the raw data is collected, the challenge will be to generate the road network itself. Multiple challenges are to be considered: first, it the graph must be built from a topologically correct dataset, so that junctions can be identified (Schmitz et al. 2008). The generated network will also have to integrate data on elevation. However, existing routing systems often do not integrate the steepness of roads (Schilling et al. 2009). In Schilling et al. (2009), an approach for automatic generation of the network based on detailed digital terrain models is proposed. In order to identify optimal roads, methods for inferring road maps from GPS traces can also be considered (Liu et al. 2012a), including methods meant for GPS traces that have relatively low resolution and sampling frequency (Davis et al. 2006; Liu et al. 2012b). However, achieving

these goals is very challenging in the CAP4Access context, where data will be heterogeneous in terms of format and quality.

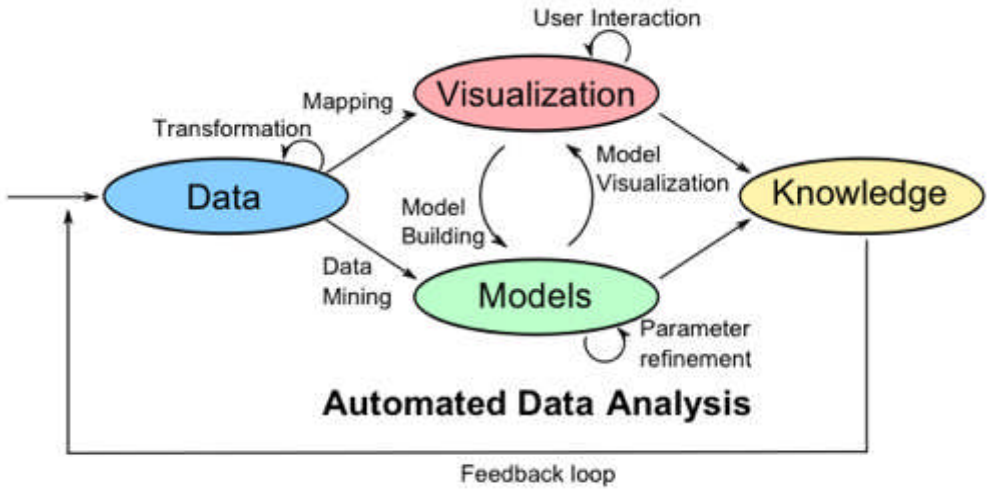
- **How to develop a routing algorithm that integrates various user profiles associated with the different types of disabilities?** While the focus is on people with wheelchairs, the routing system must be applicable for people with various types of disabilities or characteristics that limit their mobility. Accessibility depends on the ease of reaching a given destination, which is influenced by the different obstacles and route characteristics (Handy and Niemeier 1997), but also by a user's profile. To develop an appropriate routing system, the different user profiles must be integrated. Once the mobility impairments of the primary target group and their associated characteristics are identified, the modelling of different user profiles will help the routing service to adapt the proposed trajectory accordingly. The mobility limitations associated with the different user profiles can be formalized as constraints. The routing service will rely on these constraints to determine the optimal trajectories for a given user and its associated profile. In addition, users must be able to specify their own personal constraints and preferences.
- **How to develop a hybrid outdoor/indoor routing service?** The routing system must support indoor routing for large public buildings such as train and subway stations, hospitals, malls, universities or airports. Existing routing systems for people with special needs exist, such as rollstuhlrouting.de (http://rollstuhlrouting.de), Routino (http://www.routino.org), and HopStop (https://www.hopstop.com), but they do not offer indoor navigation capabilities. Some approaches to assess the accessibility of buildings have already been proposed (Han et al. 2002) and could be instrumental in developing the indoor component of the routing system. Some prototypes for indoor routing are also available (Goetz and Zipf 2011) that can be adapted for persons with limited mobility. Others indoor routing systems do take into account users' special needs and preferences (Papataxiarhis et al. 2008), but their path algorithm is limited to starting point and destination on the same floor. Another challenge that will be addressed is the integration of indoor/outdoor services to support seamless transitions during routing and navigation. The objective is therefore to go beyond existing systems to provide routing services that will fully benefit persons with limited mobility.
- **How to develop a mobile navigation assistant that is adapted to the cognitive capacity of the user?** The representation of space plays a major role in successful navigational activities. Therefore, navigation for wheelchair users must rely on appropriate representation of users' needs and representation of spatial environment according to cognitive requirements. Generally, the navigation service requires information about the surface of road, sidewalks, traffic lights, small obstacles such as urban furniture, etc. The concept of focus maps (Zipf and Richter 2002) is useful to establish what features should be displayed during navigation, based on user's profile. The focus map concept establishes that some regions or features of the map are of higher interest to the user. These regions or features should consequently stand out and contrast with other elements of the map, more particularly for mobile applications with limited displays (Li et al 2014). For this purpose, cartographical symbolization and other stylistic displays can be used, such as different degrees of

generalization, faded usage of colours, various label size, etc. (Neis and Zipf 2008). Meanwhile, some symbols may overlap and cause a cluttering problem, so choosing the appropriate granularity levels of a navigation map is a challenge (Zhu 2012). At the same time, it is necessary to ensure fast rendering of the appropriate amount of navigation-relevant environment information that corresponds to the cognitive capacity of the user (Zhu 2012).

4.6 Visual analytics

Visual analytics is an outgrowth of the fields of information visualization and scientific visualization that focuses on analytical reasoning facilitated by interactive visual interfaces (Thomas and Cook 2005, Wong and Thomas 2004). Visual Analytics (VA) adds a powerful dynamic component to Information Visualization. The general idea is that VA will strongly support the user in getting new insights or ideas, and will then engage him in further exploring the idea by navigating through the world of data. The user will thus be guided through an iterative and incremental process of information exploration, which is represented in the widely-used figure shown below.

Exhibit 10: Visual data exploration



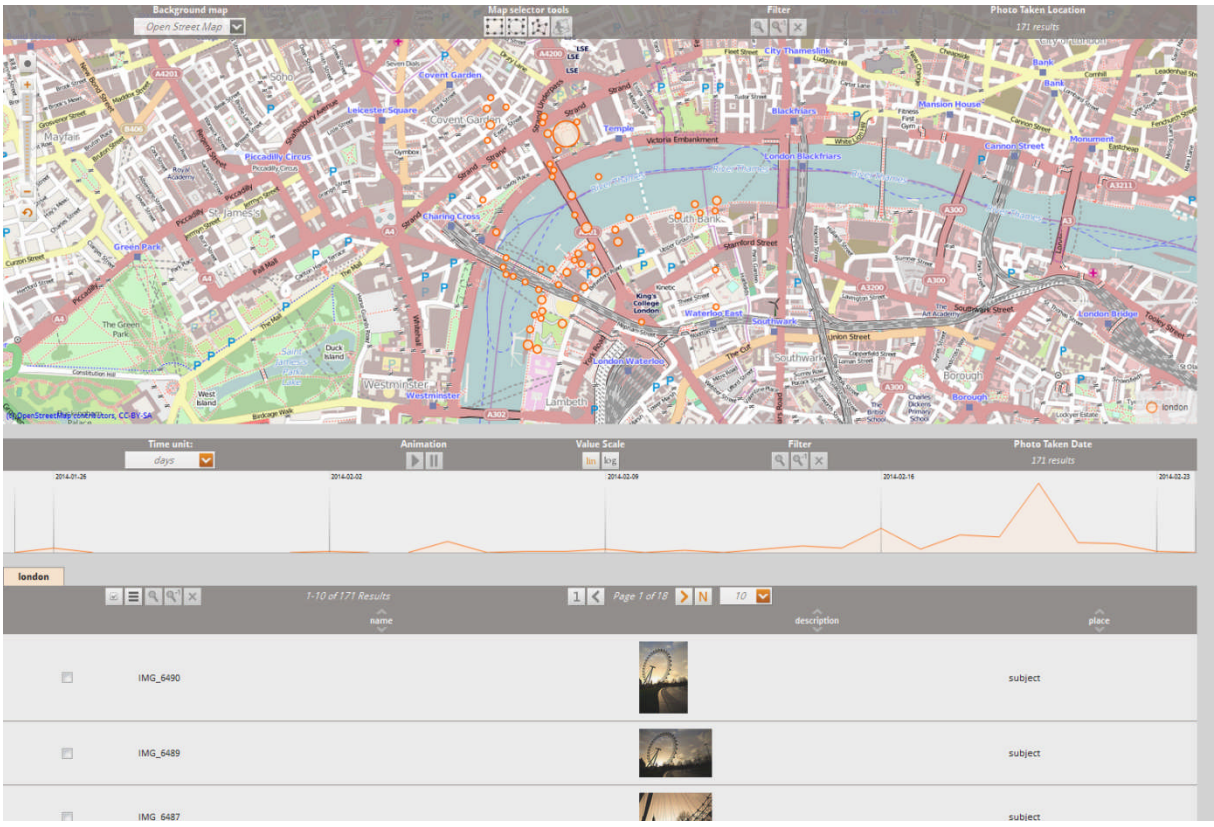
Source: Keim et al. (2010)

It is in the name that Visual Analytics is an analytical tool. As such it is often regarded as a tool that comes as an addition to or extension of classical analytical tools such as statistics, optimization or data mining, albeit it will generally not require a comparatively deep mathematical background. In this project, we will not need to apply any complex statistics or other type of analysis, yet we could imagine providing some useful and intuitive basic and comparative analyses for measuring the success and progress of the pilot studies, of user engagement, and the status of the permeation or coverage for regions under study. These kinds of tools, if ever, will only be used by team members of the project partners. Results of related analyses would be used for project-internal progress analysis, but could also be used for communication with external stakeholders and the general public.

As an example of what this might look like, the following screenshot shows a set of points in London South Bank area, which in this case represent geo-tagged Flickr photos in the period of one month in the beginning of 2014. The figure comprises three interlinked areas: the map with the “events” (photo locations), a time line in the middle showing the temporal occurrences of the photos within the selected 30-day interval, and a list of descriptions of the events including the respective photos. The tool that was applied for this scenario is called GeoTemCo (Jänicke et al. 2012), which stands for “Comparative Visualization of Geospatial-Temporal Data”. It is an open source toolkit, particularly suited for the co-representation of spatial and temporal data and the comparison of different developments over space and time. It could well later be applied in CAP4 Access. Fraunhofer IAIS is one of the co-developers of this tool.

In general, relationships between time and space, representation of dynamical behaviors both in space and time, the intricacies of both concepts and common features of them, the right interpretation of observations and events in terms of dependencies and causality, and identifying the right scales of observation, are essential topics of much historic and current research, particularly now within the Visual Analytics Community (Andrienko et al 2010).

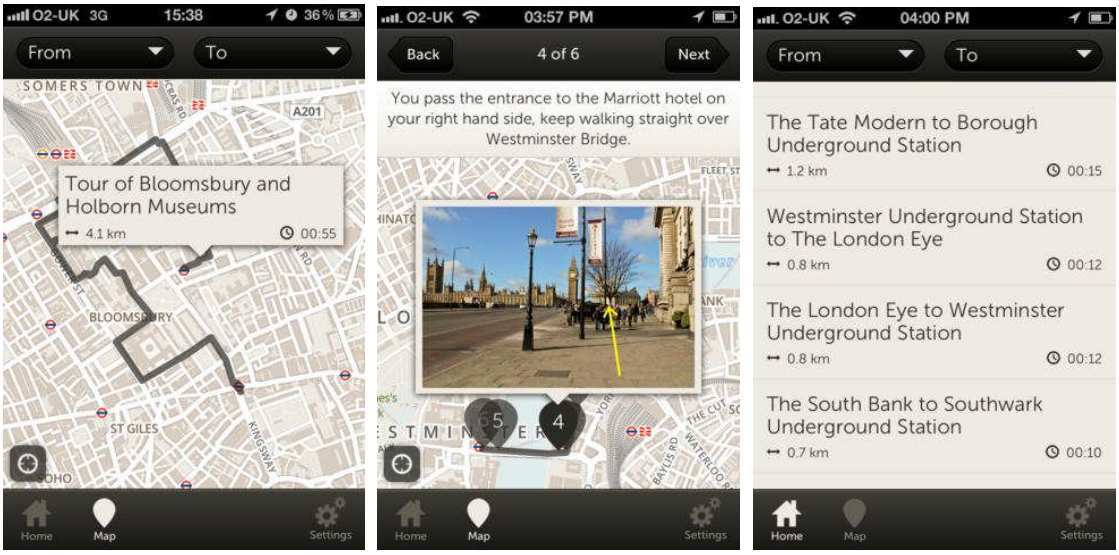
Exhibit 11: Space, time and visual analytics



Dynamical analysis like this is typically not an option for casual users, and thus not applicable to the end-users as the persons with mobility impairment. They will normally only work with static information, there will be no more complex interactive behaviors involved. However, there might be one exception, which has to be and will be discussed during the project, namely how the routing support will be realized. Routing systems should allow some kind of flexibility, introduce options, and let the user decide. At least once, these options

should be customized so that only one route will normally be displayed. Fortunately, routing support systems provided as in-car systems, web-based, or as Apps meanwhile have been smoothened by many years of experience and development, and their usability has reached a good level of acceptance. So there will be good examples to consider, like the one shown in the figure, which is an example for a successful App: The PhotoRoute London Lite, developed by "Enabled City"[42].

Exhibit 12: Photo Route London



Source: enabledcity.com

Awareness Raising: Visualisation of accessibility

Accessibility related geodata are shown on maps, aggregated and suitably visualized for the project's three primary "consumer" groups:

- End users as people with mobility impairments who want to be supported in the planning of a trip (end-user visuals) in order to
  - assess potentially possible destinations {of a given category}
  - assess the accessibility status of the destination
  - assess the optional routes to the destination in terms of distance, duration, difficulties, and energy consumption.
- stakeholders, administrators and planners etc. (stakeholder visuals) who want
  - to identify, explore and prioritize possible activities for improving accessibility
  - to assess the status of accessibility of a specific route, location or region
  - to compare the status of accessibility of a specific route, location or region in relative or absolute terms to other routes, locations or regions
  - to analyze, explore, understand and present the past, actual, and future development of accessibility situations

[42] http://enabledcity.com/

- the public will be informed about projects and activities by stakeholders or planners (public visuals).

All visualizations must be intuitive and easy to interact with by the respective target groups. How to visualize the data will finally be agreed upon and elaborated with the various user groups. Currently used data visualization tools for OSM are rather constrained when compared to those available from industry-standard GIS tools. The project will certainly result in the development of some more useful visual tools such as heatmaps, spatio-temporal visualisations, comparison tools, etc.

Information Visualisation

End-user visuals as tools for the primary target group of the project pose the highest requirements in terms of ease of use, attractive style and usability. In the collective tagging project wheelmap.org, for example, tagging is intentionally constrained to assigning one of three accessibility values to POIs (points of interests): wheelchair accessible, not wheelchair accessible, partially wheelchair accessible. Icons for POIs with assigned values are shown respectively in green, red, or orange color. They are shown in grey if so far no value was assigned. In addition to assigning an accessibility value the user can also leave a photograph of the POI. The providers of wheelmap.org very strongly argue that things must be kept simple. And definitely, this is one cornerstone of their current success.

On the other hand, it is the aim of the CAP4Access project and also a serious concern to provide the end users with more detailed accessibility information. “More” is meant here in terms of new types of information and also in terms of more precise information. As a major addition, accessibility-aware route planning shall become an option to be developed within the CAP4Access project.

Exhibit 13: Examples of Barriers

OSM itself already foresees keys and values for accessibility information. For example there is a key called “Barrier” which takes values such as “kerb”, where kerb can be tagged additionally with a value of its height: `height=*`,. Many more values are foreseen for “Barrier”, including e.g. cattle-grid, debris, turnstile. Also, the surface of a street or pathway

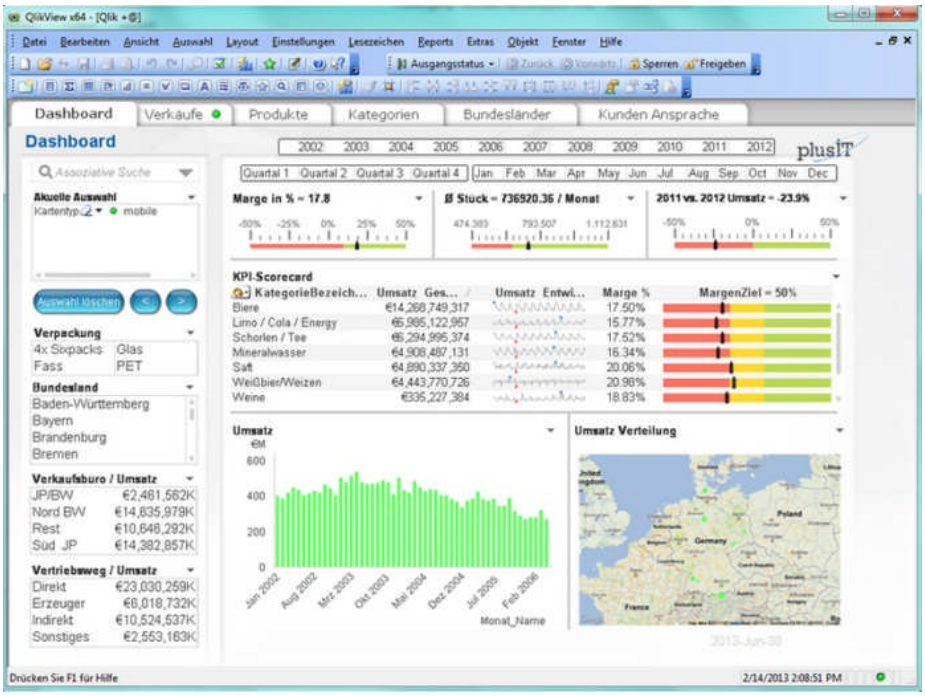
can be described with attributes such as paved / unpaved / asphalt / concrete / paving_stones / cobblestone / metal / wood / grass_paver / gravel / pebblestone / grass / ground / earth / dirt / mud / sand. Adding such more precise information, not only about places but also about the streets and pathways connecting places will allow users to make their own assessment about potential risks or problems they might face depending on their own abilities.

While extending the scope of visually presented information the principle approach towards the group of end users should remain “Keep it Simple”. That will definitely become a serious challenge for the project, as it will always be very tempting to add “another nice” feature.

Why are good visual presentations so important? The objectives and techniques relevant for visual information representation fall in the scope of the research field of Information Visualization, which has emerged from research in human-computer interaction, computer science, and computer graphics. Some important objectives are to

- represent abstract data in a visually appealing way.
- let the user intuitively understand a fact or situation.
- get a quick survey of a situation.
- create persuasive visual representations to support an argument or recommendation.
- support the comparison and evaluation of different facts or situations.
- easily detect outliers/clusters/anomalies/surprises in the data.
- easily describe and analyze trends – for time series data.

Exhibit 14: QlikView



With such objectives in mind visual presentations have become key components of all business analytics tools, particularly challenged by several primarily visual BI innovators

such as Tableau Software[43] and QlikView[44], cf. the figures. These tools provide only rather basic thematic mapping functionality and recommend considering extended options as systematically described in T.Slocum's textbook (Slokum et al. 2009). However, recently QlikView has acquired the company NComVA AB, founded and owned by Prof. Mikael Jern (Quan et al. 2012) from Sweden's Linköping University. It has such considerably enriched its map-based visualization and exploration assets with some more advanced interactive and dynamic geo-visualization techniques and coordinated multiple views.

With the current rise of big data technologies, the field of information visualization is encountering another boost. Here it seems to be immediately plausible and convincing to many that good visual representations are needed in order to communicate and understand intricate relationships within terribly big volumes of data. So visualization is named as one of the key technologies of almost every complete "Big Data package".

Exhibit 15: Tableau Software

A visual representation of information can have many positive aspects compared to sheer numbers or facts. It can just be nice, informative, appealing for the human eye, inspiring, motivating, unforgettable, etc. At its best, it is a perfect carrier of the meaning behind a certain set of figures. If it comes to an evaluation process or assessment of a chosen set of visual presentations, then the following criteria will become relevant:

- Functionality - to what extent does the system provide the functionalities required by the users?
- Effectiveness - do the visualization provide value? Do they provide new insight? How? Why?
- Efficiency - to what extend do the visualizations help the users to achieve a better performance?

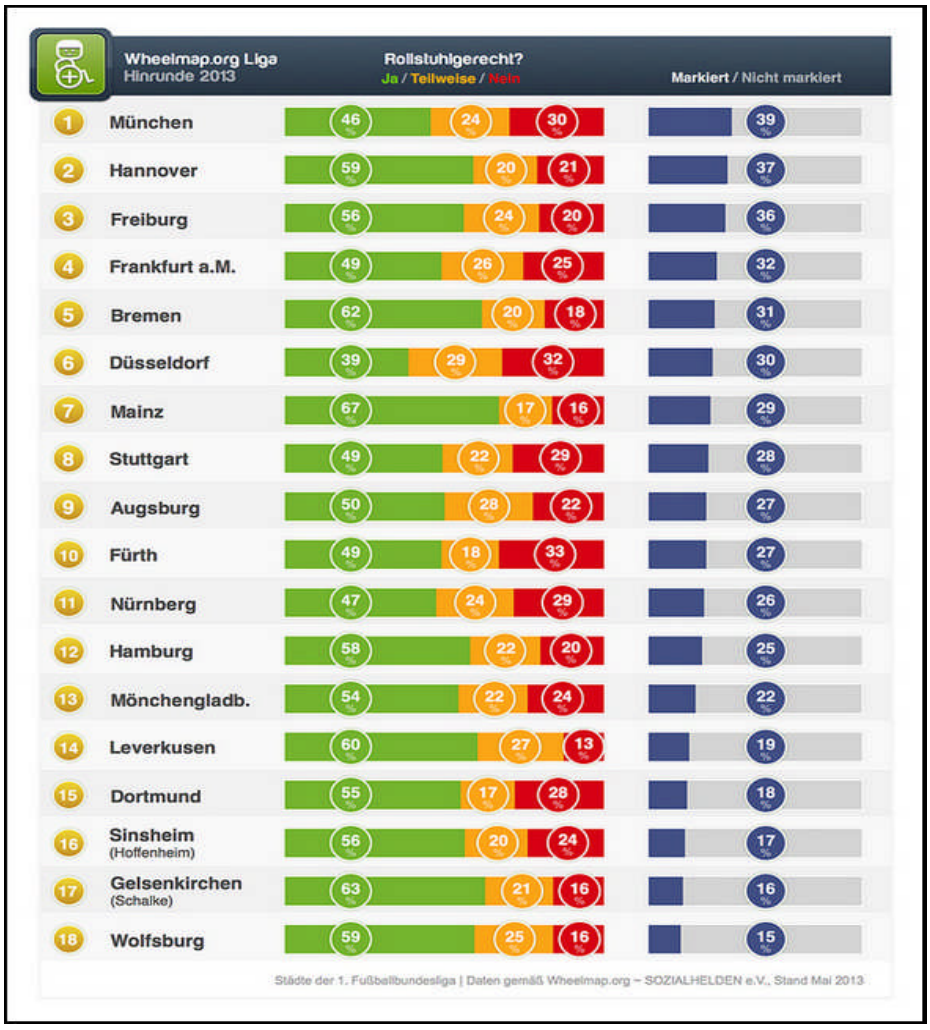
[43] http://www.tableausoftware.com Qlik Technologies Inc.

[44] http://www.qlik.com

- Usability - how easily the users interact with the system? Are the information provided in a clear and understandable format?
- Usefulness - are the visualizations useful? How may benefit from it?

The project will pursue such evaluations during the pilot studies.

Exhibit 16: German cities with regards to percentage of tagged POIs



Note: The ranking list in the figure shows how advanced German cities are with regard to their percentage of tagged POIs. It is a good example how "cities" could be challenged and motivated. Source: Sozialhelden e.V. (CC Lizenz. Certain rights reserved by SOZIALHELDEN e.V.)

4.7 Methods and tools for awareness raising and collective action

It is crucial to become aware of the interests of people with mobility impairments or any other disability. Inclusion is an ongoing process of enabling people with a disability to have role in society where they can use their individual skills. The aim of inclusion is for people with and without disabilities to be able to take part in common activities. Barriers (physical and mental) play a huge role in why people with special needs cannot participate fully in life. One aspect

of this is that people with disabilities can only use a certain percentage of a city due to a myriad of barriers. To make the different stakeholders (e.g. politicians, city planners, architects) aware of these shortcomings and to appeal to their responsibility, we need to make them aware of this important matter and to get them to care about it.

Awareness raising is a crucial part of “Collective Awareness Platform 4 Access”. In CAP4Access this seventh strand does not a stand alone but rather is a cross-topic matter.

Examples of how awareness raising is relevant to the other research strands:

- every time we engage the community we are sensitizing them at the same time for the importance of becoming engaged;
- during the collective tagging process within the mapping events, people become aware of barriers as they mark them in the apps;
- in the best case mapping events will be inclusive; people with and without a disability will map together. This is an important experience as people without disabilities often do not otherwise have contact with people with disabilities;
- When asking for public sector information (PSI) on accessibility we will most likely identify cities or regions who do not possess qualified data. Whenever we meet such deficits of information or services our aim is to encourage those responsible to counter these deficits e.g. by organising a mapping party.

We also want to combine awareness for certain status-quo situations (e.g. by means of visualisations as described) with an element by which we offer viable solutions for changing the status quo. Instead of only pointing out what is lacking, it is also important to provide suggestions for a following step. That is why we intend to offer different stakeholders suitable methods for implementing measures to actually improve accessibility.

Examples of how to change the status quo:

- City 1 does not possess any data on accessibility -> we encourage the city and/or schools to organise a mapping event to collect the missing information and we provide manuals on how to go about doing this.
- City 2 already has a guide on accessible tourism -> we invite them to share their data with us and to import the PSI in suitable ways.
- Once the mapping event in City 1 is finished, we provide alternative forms for visualising the data collected to help city officials identify districts that are highly non-wheelchair accessible so they can be prioritised in city development. Potential measures, such as providing mobile ramps, can be offered as best practise examples.

Making responsible policy makers and stakeholders aware of these possibilities is a crucial part in actually reaching a next level of accessibility.

Due to this approach, awareness is not just a cross-topic matter between the first six research strands but also a connecting element between displaying the status quo and bringing about change.

Within this research strand we will explore and eventually provide different tools and methods for raising awareness - such as the described visualisation - and we will offer best practise examples for improving accessibility.

5 Agile development methods and personas

The project will apply Agile Development methods for the development of the CAP4Access tools. This will enable the RTD to be driven by the needs and preferences of the beneficiaries and user groups rather than following a “waterfall model” sequential process as it is often used for technical development projects.

5.1 Agile development: Method and manifesto

Agile development methods put utmost importance on iterative and incremental development, where requirements and solutions evolve through collaboration between self-organizing, cross-functional teams. It promotes adaptive planning, evolutionary development and delivery, a time-boxed iterative approach, and encourages rapid and flexible response to change. It is a conceptual framework that promotes foreseen interactions throughout the development cycle. Key characteristics of Agile Development include:

- Self-organisation and motivation are of key importance;
- Working products (e.g. software) are considered much more useful, and will therefore attract much more feedback from users, than just presenting concepts and descriptions to the target audience;
- A high degree of collaboration with the target group is sought, as requirements cannot be fully collected at the beginning of the development cycle with traditional top-down methods; therefore continuous stakeholder involvement is very important.
- Built-in capability to respond to change: Agile development is focused on quick responses to change (e.g. user needs which have not been foreseen in the conceptual phase) and continuous development.

5.1.1 The Agile Method

Agile Development methods as so-called lightweight software development methods were first positioned in the 1990s as a solution against the serious problems incurred with the classical heavyweight waterfall-oriented methods. The major difficulties witnessed with the classical methods were that costs and duration of projects often significantly exceeded the original plans – although those plans themselves required a lot of time and money. Not only did projects exceed their given resources but also left customers unsatisfied with the results. A major problem occurring every so often was that original customer expectations were not met in the end because those expectations changed in the course of the project. It sounds like a paradox but the truth behind this statement is that the customer’s expectations grow or at least change during the project period. The customer – through the involvement with the project - learns over time what exactly he can or should expect from the developers, what this should look like, and – in consequence - what else would be needed or just be nice.

5.1.2 Agile Manifesto

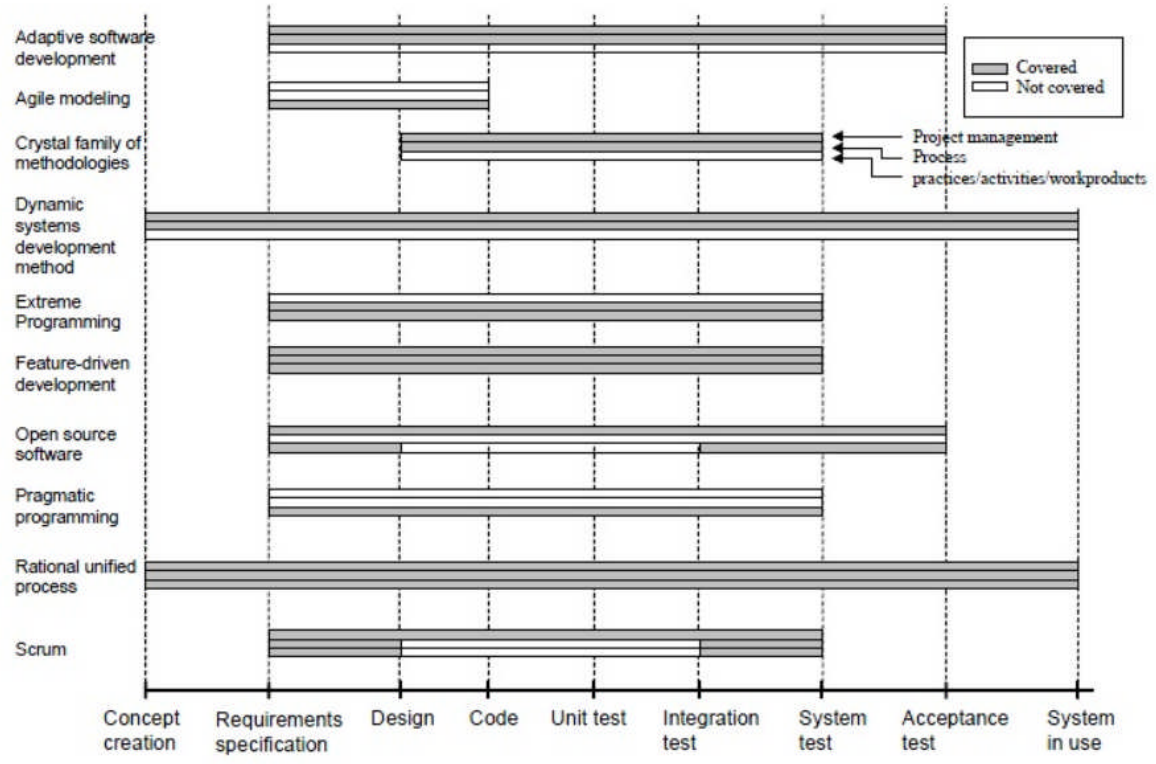
The so-called Agile Manifesto was written in February of 2001, at a summit of seventeen independent-minded, highly valued expert practitioners of several programming methodologies. It was an answer to the problems that they commonly experienced with

waterfall-oriented development. The participants did not agree about much, but they found consensus around four main values[45]. Their Agile Manifesto reads, in its entirety, as follows:

> *We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value:*
>
> - ***Individuals and interactions*** *over processes and tools.*
> - ***Working software*** *over comprehensive documentation*
> - ***Customer collaboration*** *over contract negotiation*
> - ***Responding to change*** *over following a plan*
>
> *That is, while there is value in the items on the right, we value the items on the left more.*

The generic concept of agile development methods has been founded into various concrete process frameworks. Most of them highlight and specifically support iterative, short-term spirals of user-developer interaction, collaborative development phases (sprints) of typically 2-6 weeks, and openness for change. In its most extreme form in Extreme Programming (XP), adaptability is interpreted as situation-appropriateness in a way that the methods themselves can be dynamically adapted to specific project characteristics.

Exhibit 17: Agile methods and their relations to the SDLC



Source: Abrahamsson (2012)

[45] The declaration may be freely copied in any form, but only in its entirety through this notice. http://www.agilealliance.org/the-alliance/the-agile-manifesto/ [retrieved 2013-01-20].

The figure in Exhibit 17 shows that agile methods are focused on different aspects of the software development life-cycle.

5.2 Personas as development foundations

> *"User" is a catchall and ultimately mean-nothing word. It reflects a technology-centric view. The phrase "user-friendly" should never have had to be invented. (Gerry McGovern in Cooper, 1999)*

"Personas are not real people but they represent them throughout the design process. They are hypothetical archetypes of actual users … They allow us to see the scope and nature of the design problem. They make it clear exactly what the user's goals are, so we can see what the product must do" (Cooper, 1999)

There are primary personas, which represent the main target group and secondary personas, which can use the primary personas' interface but which have specific additional requirement (Casas u. a., 2008).

Personas have characteristics like names, ages, and professions to make them look realistic and alive. However, they are not complete inventions but grounded in well-understood data gained through observations, interviews, task analysis etc. in order to find a common set of motivations, behaviours and goals among the end-users.

What are the challenges of using personas?

An intuitive response to claims of user-centred design is often the question 'Which user?'. This indicates that users themselves are complex and varied.

Reducing complexity is not always a straight forward process, where needs and requirements can be compared and ranked. Under these circumstances, **Personas are boundary objects** that help to maintain the workflow between the different groups involved (users, designers, developers). Analyses of design and development processes have shown that raw data on users, impersonal market segments or lengthy requirement reports are not optimal tools in driving software development. The richness of initial user descriptions gets lost during the development process (Pruitt & Adlin, 2010, S. 9). The objective is to go beyond user interfaces or features and create user experiences.

A second challenge is the **creation of Personas**, as the required diversity of users often can't be extrapolated from personal experiences and more systematic methods are required. These methods need to bridge the fictious side of Personas with their foundation in rigorous data gathering. The latter doesn't refer to statistical analysis – needed for correlational predictions – but to contextualise design discussions (Pruitt & Adlin, 2010, S. 191). Put differently, one thing is to say '70% users need information about wheelchair adequate parking spots' and another thing is to actually design acquisition, presentation and usage of information about wheelchair adequate parking spots.

Ultimately, descriptions of Personas can include narratives, quotes, diagrams, photos and other recordings. On top, Personas often include 'life-worlds' rather than pure demographic

data. These segments can include ‘work environment’, ‘leisure activities’ or ‘daily needs such as shopping and service consumptions’.

A related challenge is the **reduction of personas**[46]. It seems counter-intuitive to restrict features so that potentially less people are satisfied (Pruitt & Adlin, 2010, S. 16). However, Schwarz argues that what matters is the question of which functionalities should be included rather than asking how many functionalities could be included (Schwartz, 2004). Additionally, software design is also subject to choice theory where the acceptability of decisions can be framed differently (e.g. ‘best’ vs ‘good enough’ decisions or ‘focusing on possibly lost opportunities’ vs ‘focusing on actually gained possibilities’) (ibid). An interesting point in case is the mapping of accessibility within the Wheelpmap tools. Accessibility data is crowd-sourced and participants get three choices – red, green, yellow – indicating inaccessible, accessible and partly accessible. However, especially ‘partly accessible’ can depend very much on individual needs and situational conditions (e.g. height of smaller steps, wet surface) – in such cases, more specific information would be more useful, which in turn would require more choices at the point of data entry.

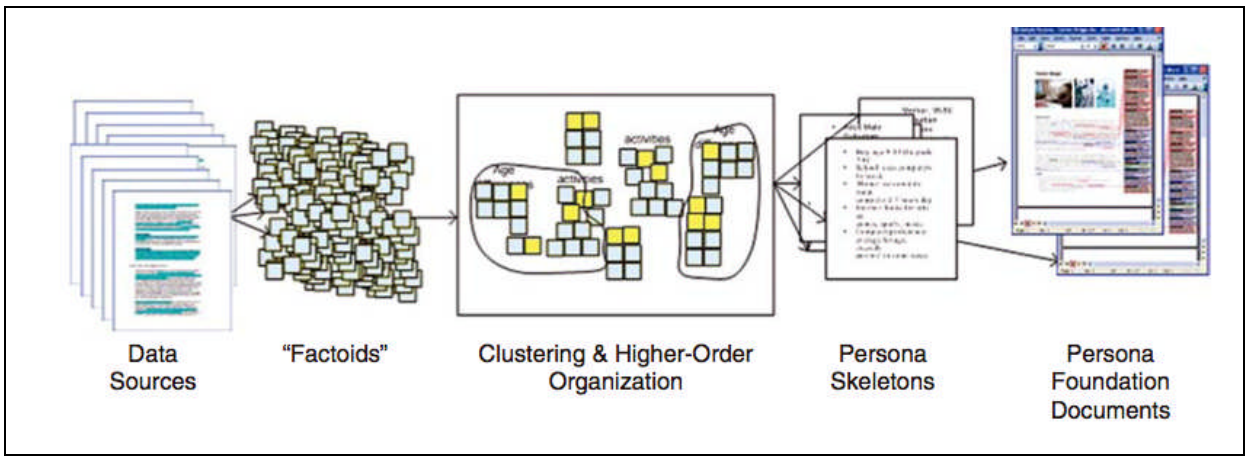
A first draft process for creating and communicating personas

Personas are likely to undergo changes over the lifetime of a project, as they are used for different purposes ranging from product design, to implementation, to testing and to dissemination and awareness raising.

Pruitt & Adlin (2010, S. 165) suggest a six step process to conceive a persona:

- Discuss potential categories of users
- Map and process data informing persona descriptions
- Identify and create persona ‘skeletons’ (first bullet points)
- Evaluate and prioritize persona ‘skeletons’
- Develop ‘skeletons’ into personas
- Validate the personas

Exhibit 18: From data to personas



Source: Pruitt & Adlin (2010), p. 165

[46] For example, Ford online presence is built upon 3 personas representing all new car buyers (Pruitt & Adlin, 2010).

The figure in Exhibit 18 illustrates how different data sources are themed and put into relations by various assimilation techniques, until personas emerge. Final personas can start with one defining sentence such as 'I want to get the information as quickly as possible', other characteristics would be added later according to the clusters created during the affinity exercise.

Forming personas can take everything from 3 hours to several weeks. The difference is made by the amount of data available, the communication needs within the team and the clarity of objectives, needed to prioritize personas chronologically.

A challenging question is often 'How many personas are needed?'. Here a few clarifications might help; the point of prioritizing personas is not to discard user requirements but to create a coherent and smooth user experience with a core set of functionalities and maybe to take advantage of low hanging fruits. Other user profiles might be subsumed under existing personas or postponed to a later time according to developer capacities.

Another reason to aim for relatively few personas is the fact that each persona requires a unique interface, paying attention to specific information and interaction needs.

Pruitt & Adlin (2010, p. 178) list three ways for organising personas:

- by roles, e.g. travel minimalist, frequent commuter, outdoor enthusiast;
- by goals, e.g. plan my trips easily, have safe trips, networking with people, exploring new sites;
- by segment, e.g. age, gender, type of wheelchair / walking aid.

Following is a list of example Personas, including demographic information (age, gender, relationships, education) but also roles (e.g. employment) and goals in life (e.g. family, cultural experiences).

Brigitte K.

- female
  30-45 years
  lives in a partnership
  Assistant in a doctor's surgery (reception, administration, Administrative)
  Education: HAK-Matura (High School for Economics)
- Uses a wheelchair due to an incomplete paraplegia after an accident 15 years ago. Though she is in need of her wheelchair in sports activities and for long distances, she is able to overcome short paths and steps on crutches. As a very sportive woman, even when using her wheelchair steps between 5 and 10 cm dirt roads and steep roads are manageable. Her family and activities with her siblings are most important for her. Regarding cultural events she likes to go to swing, and Rock'n'Roll concerts. Furthermore she participates in wheelchair-basketball and wheelchair-dancing competitions.
- When it comes to personal mobility she is able to drive a car by herself, which is her most frequently used means of transport

Gottfried K.

- male
  50-60 years
  lives alone
  retired:
- Has used a wheelchair for 40 years
  Tetraplegic paralysis (paralysis at the height of the cervical vertebra, with impairment of all four limbs, limited the coordination of the fingers and minor sensitivity when it comes to key something) due to a traffic accident 40 years ago.
  He is very active: participating in various events, different sports, travelling, etc., although slopes, opening heavier doors, driving on unpaved paths, overcoming curbs and small steps are quite difficult due to his impairment.
  Most of the time he uses transport services, even though he owns and is able to use a car.

Theresa K.

- female
  14-20 years
  lives with her parents
  student (Bundesrealgymnasium – grammar school)
- She has cerebral palsy (non-progressive impairment or caused by damage to the developing brain).
  She has great difficulties in coordinating her limbs but she has no cognitive impairments.
- She spends most of her leisure time with her parents.
  She is able to overcome short distances and steps on foot, but generally she has to use an active wheelchair. Unpaved roads and steps are only manageable to a very limited extent when riding her wheelchair.

Eva-Maria N.

- female
  20-30 years
  lives with her parents
  Part-time employee in the municipal office (administration and coordination)
- She has been affected by multiple sclerosis (MS) since the the age of 10 and has used a power wheelchair for almost 15 years. Both at work and during her leisure time she is in need of a personal assistant, as even the lifting of her arms is not possible on her own anymore. Nevertheless she likes to travel, particularly to museums, cinemas and other events, such as fairs and concerts.

5.3 Development processes: Scenarios, user stories, features

Development in the project will essentially be cyclical with rather short feedback loops. Based on very good experiences within the European FP7 project BioVel (grant agreement number 283359), a variant of the Kanban methodology, possibly with some aspects of the Scrum methodology is proposed. The development will proceed in sprints, which may vary in lengths of typically 4-6 weeks. Sprints start with a planning session and end with a review session, in-between time is dedicated to focused implementation of the agreed upon tasks. Each sprint produces a prototype. Three prototypes will be particularly stable releases, which will be published and presented at annual reviews and milestones.

Agile development has also a document centric dimension. How exactly each document will be used during the CAP4Access project will be a matter of fine-tuning after initial trial periods. Some tasks are very local in nature – requiring shorter sprints - others are distributed across several teams and may need more explicit steering and documentation.

Following an initial overview of formats used, their intentions and necessary tools to capture and monitor the documents. The objective is to use a coherent vocabulary while avoiding over-burocratizing the development processes. As indicated in the table, work can start with suggesting a feature (e.g. when looking at an existing prototype), a use case (e.g. when talking about daily life mobility and related barriers) or user stories (e.g. when having a clear picture of what is needed to address a barrier).

We suggest to write user scenarios and user stories in a Wiki as here multiple media can be included and formatting options are richest. User stories – which tend to be shorter and less verbose, could also be written in the Wiki or directly captured within JIRA (including links to relevant stories and scenarios in the wiki). JIRA is the project's management planning and documentation – though it does not exclude planning and documentation in other tools.

The benefit of JIRA is, among other things, that development work can be tracked and larger groups of people can be automatically updated about the ongoing progress per task. However, a more detailed description of workflows using the wiki and JIRA will be included in deliverable D3.2.

A feature could link to multiple user stories and a user story could lead to multiple features, as there are multiple ways for using a functionality or completing a task. Moreover, all three formats can be used for different purposes, e.g. discovering new requirements or reflecting about the possible improvement of existing functionalities. Hence, scenario writing is also a very useful technique for the elicitation of complementary user requirements. Using a technology in everyday life will sometimes uncover requirements not seen upfront. Scenarios can help to identify as many 'surprise requirements' as possible, as early as possible.

Exhibit 19: Development processes: Scenarios, user stories, features

Format	Description & Benefit	Tool
User Scenario **(Use Cases)**	**Description:** User scenarios are "informal narrative descriptions" about personas (hypothetical archetypes of actual users) and their activities, emphasizing the goals the user wants to reach with a specific product. The persona's expectations concerning particular systems and the most critical tasks that she wants to execute. Scenarios can be described in different ways including text, speech, photographs and video clips. **Benefit:** Scenario are very useful for the elicitation of user requirements, based on the analysis of multidimensional situations	Wiki
User Stories	**Description:** User stories describe features in a functional context. The structure of a story is: *"As a <user type> I want to <do some action> so that <desired result>"* " As a wiki user I want a tools menu on the edit screen so that I can easily apply font formatting." User stories are independent, negotiable, valuable, estimable, small, testable requirement ("INVEST"). Stories may be clustered into epics when represented on a product roadmap or further down in the backlog. **Benefit:** User stories are needed so that the development team can identify the user, action and required result in a request and is a simple way of writing requests that anyone can understand. User stories are meant to provide clear reasons for having features by showing their multiple usages.	Wiki / Jira
Features	**Description:** A feature is a distinguishing characteristic of a software item (e.g., performance, portability, or functionality). **Benefit:** Features emphasize how the system should work in order to meet users' requirements.	Wiki and / or Jira

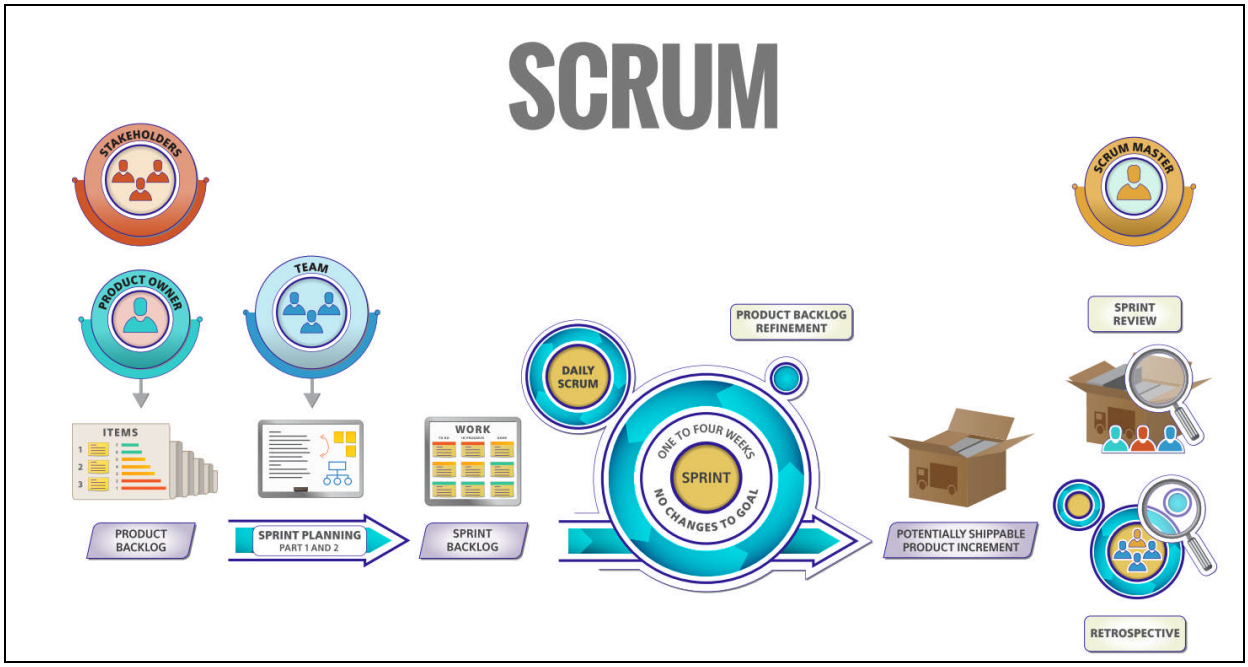
5.3.1 SCRUM

The Scrum Framework is one of the best known and best documented framework of tools and processes for supporting agile development. From the so-called Scrum Primer (Deemer 2012) we cite this concise overview of the process:

> *"Scrum is a development framework in which cross-functional teams develop products or projects in an iterative, incremental manner. It structures development in cycles of work called Sprints. These iterations are no more than four weeks each (the most common is two*

weeks), and take place one after the other without pause. The Sprints are timeboxed – they end on a specific date whether the work has been completed or not, and are never extended. Usually Scrum Teams choose one Sprint length and use it for all their Sprints until they improve and can use a shorter cycle. At the beginning of each Sprint, a cross-functional Team (of about seven people) selects items (customer requirements) from a prioritized list. The Team agrees on a collective target of what they believe they can deliver by the end of the Sprint, something that is tangible and will be truly "done". During the Sprint, no new items may be added; Scrum embraces change for the next Sprint, but the current short Sprint is meant to focus on a small, clear, relatively stable goal. Every day the Team gathers briefly to inspect its progress, and adjust the next steps needed to complete the work remaining. At the end of the Sprint, the Team reviews the Sprint with stakeholders, and demonstrates what it has built. People obtain feedback that can be incorporated in the next Sprint. Scrum emphasizes working product at the end of the Sprint that is really "done"; in the case of software, this means a system that is integrated, fully tested, end-user documented, and potentially shippable."

Exhibit 20: SCRUM Overview



Source: Deemer (2012)

Since more recently, the KANBAN software development framework, derived from the KANBAN manufacturing processes of Toyota's car production, is becoming more popular. It is not very different from SCRUM. In some sense, if SCRUM is already easy and simple, Kanban is even more easy and simple (Björkholm 2009). One difference is that, in contrast to SCRUM, Kanban does not demand the same fixed length for all individual collaborative development phases (sprints). Instead, the individual phases may adapt to the specific challenges of the tasks. The table below summarizes some of the characteristic differences, some of which clearly demonstrate why Kanban can be regarded as more simple.

Exhibit 21: Comparing Kanban and Scrum

Kanban	Scrum
No prescribed roles	Pre-defined roles of Scrum master, Product owner and team member
Continuous Delivery	Timeboxed sprints
Work is 'pulled' through the system (single piece flow)	Work is 'pulled' through the system in batches (the sprint backlog)
Changes can be made at any time	No changes allowed mid-sprint
Cycle time	Velocity
More appropriate in operational environments with a high degree of variability in priority	More appropriate in situations where work can be prioritized in batches that can be left alone

For CAP4Access, we currently envision the application of the Kanban Method, and perhaps some borrowings from the SCRUM Method. Details about the exact application will be elaborated in March 2014 during a more intensive analysis of the particular requirements from the various processes and developments of the different work packages of the project. It may very well be appropriate to foresee different variants of agile development methods for the individual but interlaced work packages WP2 (user engagement, pilot sites) and WP3 (software development). Certain mixed Kanban and SCRUM variants are not unusual (Kniberg 2010).

5.3.2 Sprints

The first week of a sprint is a warm up phase. Every group will internally assess and describe their items of work in the backlog. Items of work can be software development, but also elaboration of a use case, negotiation of access to a data source, and their activities. At the end of the week, there will be a phone conference where the planning group decides which items of work shall be moved to the sprint backlog and carried out in the hot phase during the next two weeks. After each week there will be another phone conference for coordination. The fourth week is the cool-down phase. It starts with a teleconference demonstration of the new development and discussion of the work items achieved. Comments can be supplied and new items of work can be added to the backlog during this week, which will be assessed at the beginning of the next sprint.

The **planning group** consists of a representative of each group (OSM, WheelMap, each target group at each pilot site, and each project partner) and is open to further interested persons. The representatives, also called pals, organize the work, testing and communication within their user group. The planning will be done through a collaborative workspace, an issue tracking system, a teleconferencing system and mailing lists. In the BioVel project the combination of the Atlassian Confluence wiki as a workspace, the Atlassian JIRA for issue tracking and Cisco's Webex for teleconferencing has turned out to be very efficient because they are closely integrated and automatically produce good reports documenting the process and status. For this reason, it is foreseen that the same approach will be applied for CAP4Access.

6 Summary

The primary objective of this deliverable was to clarify key-concepts for future work carried out within CAP4Access, to understand the core principles of the participatory methods to be applied and to outline the first research and development priorities in each of the seven work streams.

Key concepts were described in chapter 2, including recent developments in collective approaches to improving accessibility, which form the background to the research and development work foreseen in CAP4Access, and key concepts related to the accessibility challenge such of social inclusion, physical mobility, barriers in the built environment and independent living. Indicators to assess physical accessibility and questions about how to map those are discussed. It is important to address this variety of terms in order to have a good foundation for future discussions about requirements and their prioritisation within CAP4Access.

The methodological framework highlighted different formats of working with end-users and that participatory research needs to go beyond collecting data from or about end-users. A defining element of participatory research is the inclusion of end-users in all phases of the research process beginning with defining the research challenges up to the exploitation of research outcomes.

Beyond its functional purpose, the deliverable also sparked some discussions about the initial scope of our activities – which will focus on physical mobility impairments – and internal work organisation – which will require all partners to get familiar with methods and vocabularies different to what might be standard operating procedure within their own disciplines. The SCRUM approach in particular, requires all project partners to experiment with and learn about new tools such as confluence wikis and Jira as these are essential pipelines for managing the development work while having an optimum amount of collaboration and dialogue.

Furthermore, this deliverable made a first attempt at structuring future workflows not only in terms of research areas, but also in terms of future end-users (Personas) and future application areas (life-worlds). Personas are an important ingredient to the design process as end users are varied not only in what they require but also in terms of their objectives. In order to create a real benefit, we will need to consider diversity and, while we cannot cater for all situations at once, be clear about the situations where we can make a difference.

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