INDIMO TOOLKIT - UDM Capabilities-limitations spectrum and application to Personas

F. Di Ciommo, A. Kilstein and G. Rondinella
(cambiaMO | changing Mobility)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

Capabilities-limitations spectrum

Most of the literature dealing with the limitations of vulnerable groups towards ICT tends to underestimate or overlook the capacities that are already in place and that are the starting point for any future development. The UDM-V1 provides capabilities such as the starting point for designing for accessibility and inclusion.

Pillars of this approach include the capabilities, limitations, and requirements paths for the end users (Nowell et al. 2017) that have been identified in the INDIMO task1.3 named Analysis of barriers and opportunities for tapping the full potential of the digital interconnected transport system and developed in Deliverable 1.3 – "User capabilities and requirements of a digital transport system on users". Following the scheme of the previous Universal Design Manual (Story 1998), this section focuses on what people can do – their capabilities and their current state in respect to the options available to them. Actually, the capability set outlined by Sen's approach (1992) is not merely related with achievements; but rather to the freedom of choice and, to a person's quality of life. It is often asserted that the quality of life of vulnerable groups is improved when they adopt information and communication technology (ICT) such as the internet, mobile phones and computers. In the case of digital mobility and delivery services, they offer new opportunities to travel to work and study, to find jobs farther away from the location of home, to access health care, take care of people, to purchase products and comply with other needs of the everyday life. Most of the literature dealing with the limitations of vulnerable groups towards ICT tend to underestimate or overlook the capacities that are already in place and that are the starting point for any future development. During the fieldwork realised for the identification of capabilities, limitations and requirements a word cloud of terms was obtained and included in UDM-V1 (see Figure 1).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

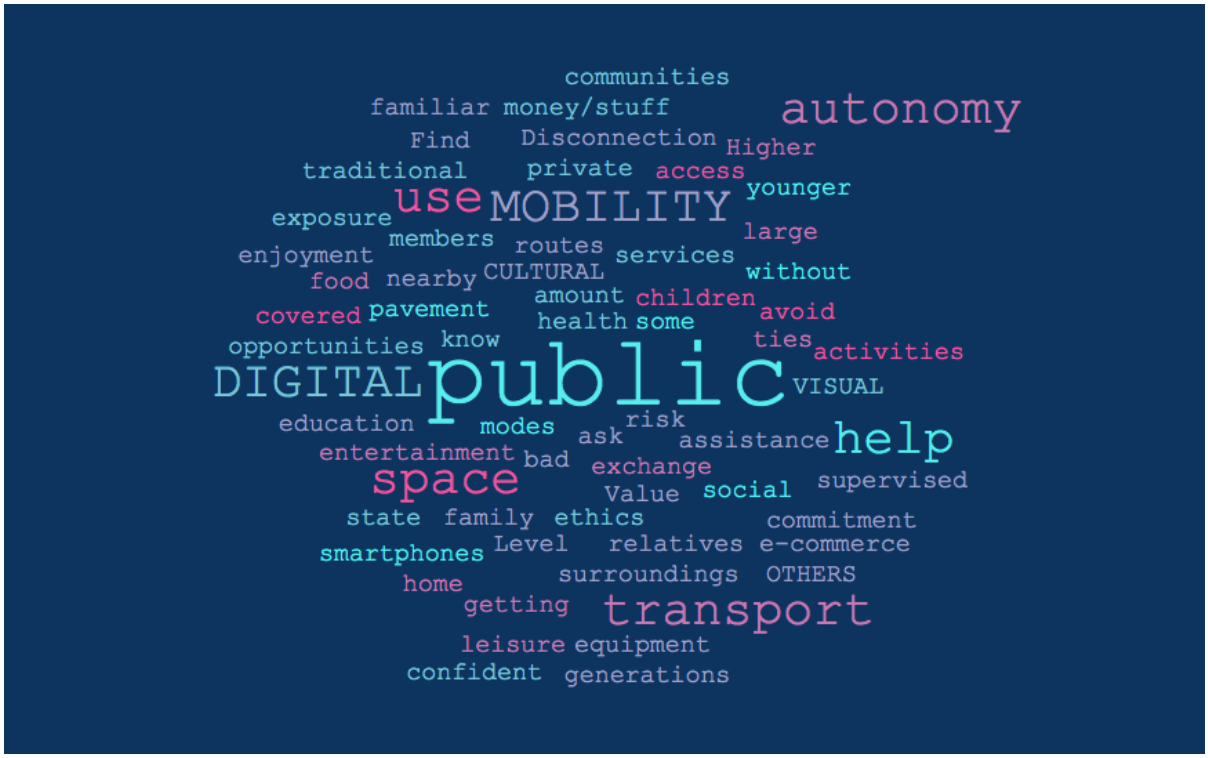

Figure 1. Word cloud of terms from capabilities-limitations and requirements paths based on the thematic analysis of user and non-user interviews (from INDIMO Deliverable 1.3)

We can observe in this cloud the keywords that indicate the meaning related to the capabilities: autonomy, opportunities, opportunities for mobility are highlighted in the verbatim of target-groups of interviewed users and non-users. Help and assistance appear as additional keywords, oriented at easing the regular activities of participants. Public is a central word, directly associated with both the public space and the public transport, addressing how the digital assistance might provide a new meaning and a new experience to these resources for the everyday activity.

In this section, we will analyse the existing capabilities and limitations regarding the use of digital platforms that in the INDIMO research we associate to the below radial diagram (Figure 2). This technique has been tested during the Community of Practice sessions related to each INDIMO pilot and associated with the persona created through the INDIMO project in the report on User needs and requirements on a digital transport system (INDIMO Deliverable 1.2).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

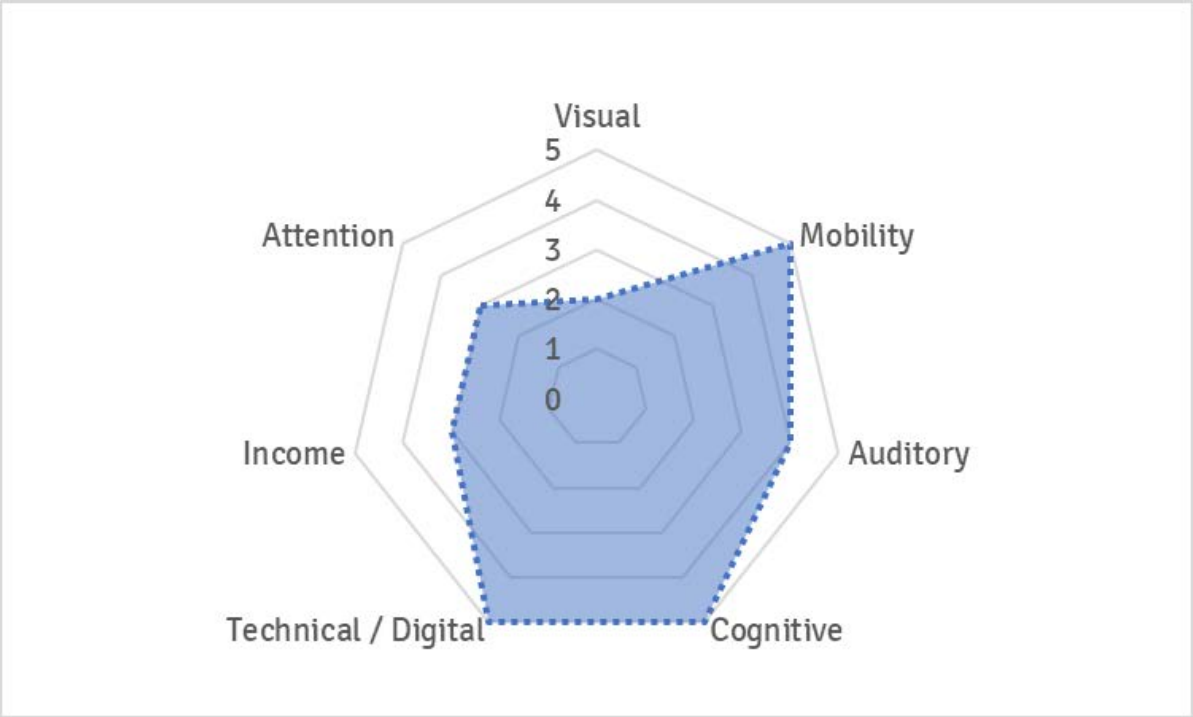

Figure 2. The axes with degrees of capability-limitation. Scale from 0 (no capability) to 5 (complete capability)

Usually, applications cover the different needs on an average basis (often below the accessibility standards), which sometimes causes that the application is only usable in ideal conditions, therefore it is not universal and/or accessible. Some applications may cover needs from vulnerable-to-exclusion people, but it strongly depends on the personal opinions of people involved during the development process. To manage this issue, we propose a different approach of assessment and development of accessible digital mobility and delivery solutions.

The first thing that we state is that it is not correct to talk about impaired people as an individualized group. All the people have certain degree of functional limitation that is overcome with personal and collective strategies. This means that the axes capability-limitation is in fact a spectrum where all people can be located. This deconstructs the old paradigm of functional "normality". For instance, there is not a group of visually impaired people separated from a majority of people with normal vision. Rather, there are different degrees of ability and limitation with regards to vision: some people are completely unable to see, others can only recognize certain shapes or certain contrasts, others are unable to see some colours, other have problems to distinguish tones, others do not see objects from afar, and others see blurry objects when they are too close. This implies that, if there is a spectrum the design should attempt to cover, it should be the largest possible portion of this axis. Some of the aspects that limit mobility may be permanent (such as a permanent disease or a physical malformation), others are temporary limitations (such as being injured and having a cast, or having just undergone surgery) and other aspects are situational (for example, being pregnant, being in the street with children or older

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

people). Design has to contemplate all these different scenarios and cater for them as much as possible.

In addition, we should consider that social factors should also be implemented in the assessment process. Affordability in the digital world may also be limiting mobility and it should also be considered in the design of services. The affordability of equipment and data plans, or the cost of additional data, may be conditioning the user's behaviour with certain apps. Attention level of users may be hard to estimate during development, but can be implemented, tested, and validated during (beta) testing.

The axes with degrees of capabilities and limitations

This section will explain what the different axes of the radial diagram cover, what the extremes on them are and how they relate to this research. These dimensions do not cover all aspects of capabilities and limitations users may potentially face. Mobility capability for example may label the challenges people meet in a wide range of different issues and levels: i.e. with only one hand or no hands, walking slowly for many different reasons, having to sit down regularly, or need to visit the toilet regularly, etc. are all different nuances that a classification like this cannot capture.

1. Visual capability level

There is a spectrum of different severity of problems in the vision that require customised solutions for the users. This axis ranges from people with minimum level of limitation, such as difficulties to read from afar or at close distance (who just need customizing the fonts) to complete blindness, where digital solutions require higher complexity.

The level of autonomy in people's everyday life is also sensitive to the degree of their impairment. In the extreme of the axis, corresponding to complete blindness, certain avoidance of screens by users has been observed, when this is an option. Also, when digital solutions do not address the needs of blind people, doing things on their own, without digital assistance, is feasible and the preferred option. The segment within this group that is not totally blind has full capacity of using mobility apps as long as they comply with a number of adaptations: enough contrast to help readability, colourful letters, customizable fonts and some characteristics that will be explored in detail later on. However, not all people with reduced vision are able to use a smartphone and its apps developed for the rest of the INDIMO target groups.

Based on INDIMO research, those who are completely blind have the ability of quick learning in the search for independence. For instance, they learn routes to go to relevant places, such as a job, and tend to repeat routes they are familiar with. They are not afraid or ashamed to ask for help on their way, and they consider that a good portion of the assistance that is provided by passers-by could be given by an app. The condition for this is that the software works properly and fits organically into their routines. If the use is complicated, they rather see it as "another gadget".

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

2. Mobility capability level

This axis goes from people with a slower motion due to temporary limitations such as injuries to people who need special equipment and conditions to move on their own (such as a wheelchair). Depending on the level of limitation, users may need the assistance of family and friends to complete some activities. Some users may require special assistance when they come across infrastructure or pavement in a bad state. Usually, these users value how route planner apps could contribute to their mobility if they informed them about these disturbances in the public space.

The analysis of the Semi-structured Interviews carried out during task 1.3 "User capabilities and requirements on users" have highlighted that similarly to the people with reduced vision, people with reduced mobility were not afraid of asking strangers for help, and thought that it would be great if apps could relieve them from this external aid. The use of the app while they are using a wheelchair may cause certain complications. When assessing smart traffic lights, the more hand-free the designed device was, the better for their autonomy. They use private means of mobility as well as public transport. For the last alternative, help from strangers might be also needed.

3. Income capability level

It is well known that the population show very heterogenous levels of income, which are correlated with their educational level and that may be correlated with their connectivity, access to equipment and level of digital skills. Even focusing on low-income groups, it is a heterogenous segment of the population. Despite their economic condition, there is a widespread use of apps and familiarity with the digital environment. In more extreme cases of poverty there are limitations arising from the equipment (e.g. smartphone), which does not have enough storage space to install new apps, and with connectivity, since they tend to have phone plans with a limited mobile internet.

4. Technical/Digital capability level

While some people had first contact with digital devices when they were small children, and they spent their childhood playing on tablets and smart phones, other people were born and raised in a world with no personal computers. As it appears in the INDIMO research, many of the latter may be aware of the need of incorporating these tools and do it gradually. Although many users do not have a fully flexible mindset towards digital technologies, a great portion of the population use apps to communicate with their relatives (mainly instant messaging) and some social networks for entertainment (e.g., Facebook). Their incorporation of technology tends to be driven and guided by a relative or someone of their trust, for instance, a family member that encourages them to have Whatsapp to communicate more easily. The word-of-mouth appropriation is specially highlighted in people with low-digital skills. But, as the research showed, mechanically learning the basic features of one app does not mean the ability to automatically transfer that knowledge to another app or environment. The digital skills of the population show

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

a clear dispersion, and although instant messaging can be the most used feature, route planners are less present.

5. Cognitive capability level

The cognitive axis moves from slight difficulties for understanding due to normal age deterioration of faculties or lack of proper education to more severe states of confusion, loss of memory or limitations to recognize people or places. Cognitive barriers imply a wide array of conditions, which render a heterogeneous landscape. During the INDIMO fieldwork, we recognized that even within one impairment, there are different levels which involve different functionalities and practical guidance. The apps and other digital interfaces have the aim of enabling users to face the lowest number of possible choices. Choices in general may be associated with stress and the possibility of losing orientation. A straightforward line of workflow and the simplification of procedures may help release anxiety. Auto-filling, suggestions, recovering previous orders and indications are contributions for the simplification of cognitive processes in the user. It is suggested also to avoid the excess of texts and the simplification of concepts through images and icons. Even in severe cognitive impairment cases, familiarity with intuitive apps and apps based on icons and steps (such as Instagram) was found.

There are also aspects of the physical interface that are associated with the axes of cognitive impairment: the speed of speech of service agents, the identification in their look to clear uncertainties etc.

6. Attention capability level (distraction level)

This axis moves from circumstantial losses of focus as a result of the presence of other stimuli to a more permanent inability to clear the attention when facing irrelevant distractions. In our research, different distraction levels are observed associated to age, dementia condition and also to people under medical treatment. In the P4 Madrid pilot, it appeared that cooking may be an activity that implies a higher level of risk for people that have memory or attention problems. Thus, a food delivery service provides a new and appropriate solution for this specific scenario. Distraction level can also increase when travelling with a children or people in need of assistance. Due to the shared attention on a navigation application and the assisted person hands-free or voice-controlled options may be helpful.

7. Auditory capability level

This axis ranges from partial deficit of auditive ability, for instance, due to the deterioration of ageing, to a deaf or hard of hearing person. The auditory impairment from early ages may imply a deficit in the access to oral language. During this research, auditory impairment was not specifically explored. For specific cases of impairment, new axes can be defined.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

Implementation of the capability-limitations spectrum. The INDIMO persona examples

In this section, we propose an exercise that can be implemented by any developer, operator or service provider. The purpose is to assess the capabilities/limitations of their potential users and think of how to make their services universal (or, at least, with a higher degree of universality).

1. The first step is identifying a spectrum of capability-limitations where people can be characterized.

2. In the second step, the operator or developer visualises the scope of the spectrum that is covered by the usability characteristics of the service. A hint to start with this visualization work is to think how the proposed axes fit into different profiles of potential users.

We are going to present the exercise using the profiles of fictional persona created in the Analysis of the requirements of users towards the digital interconnected transport system (INDIMO Task 1.2, see INDIMO Deliverable D1.2). We avoid feelings of stigmatization or private identification by working with fictional profiles.

As it was defined in the report on User needs and requirements on a digital transport system (INDIMO Deliverable 1.2), a persona is an imaginative, but accurate, representation of the user profile and all of its characteristics (Harlay, 2015). This representation enables designers to think of the user as a specific person with a name, face, and life frame, instead of treating users as a faceless profile with no identity. These creations capture the most relevant user profiles and characteristics based on the research and the insights from the semi-structured interviews with users and non-users in the analysis about the User capabilities and requirements on users (INDIMO Task 1.3). We have created six personas corresponding to our five pilot experiences (the Madrid pilot has two personas). We will present the main characteristics of each persona and assign values to them in the capability-limitation spectrum. The values are the result of interpretation and are not averages, medians nor any statistical measurement of an observable population. The main purpose of the description that follows is to illustrate how this method can be used to understand target users and the fit of a service to them.

This exercise of self-assessment was carried out during the CoP meetings in the pilots and gives the opportunity to operators and developers, together with the assistance of experienced researchers, to understand the potential users of DMS/DDS for accommodating their needs.

1. Pilot 1. Emilia-Romagna - Luisa

Persona: Luisa

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

Bio[1]: Luisa is a 76-year-old widowed woman living in Monghidoro, where she grew up. She is retired, lives in the centre of Monghidoro and has a daughter and a grandchild. Her husband passed away a few years ago. She went to school until she was 14 years old, but she had to leave school to go to work and support her family.

She mainly wants to stay in touch with her relatives and her grandchild. That's why she received a smartphone from her daughter, however she does not use a lot of functions as she finds it quite difficult. She is inclined to (try to) use something if it is recommended by her family, like her smartphone. However, she lacks digital skills and requires help from others to (learn how to) use it. Other than that, she is active in her local community. Sometimes she received packages from family and friends.

Spectrum capability-limitation representation and explanation (Figure 3):

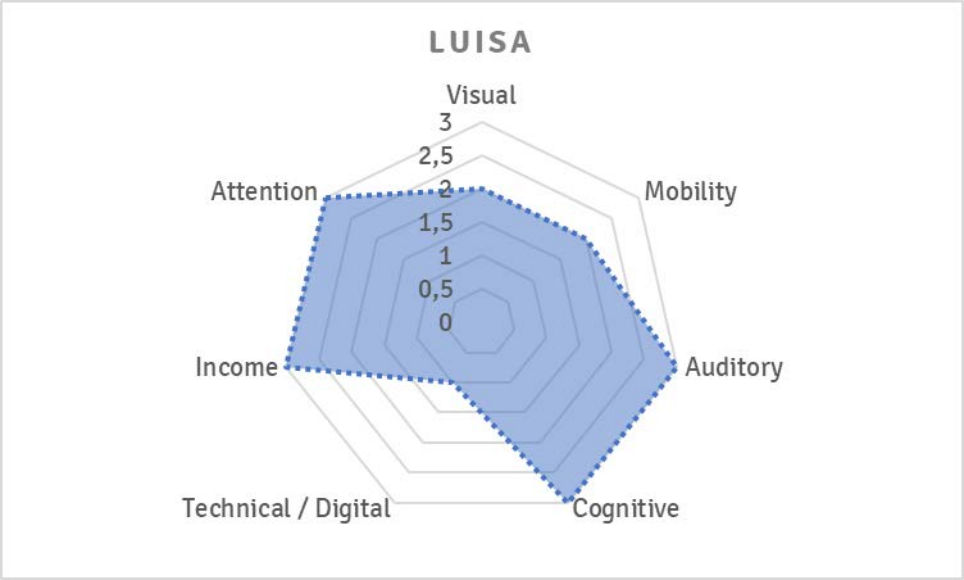

Figure 3. Spectrum capability-limitation area for Luisa

Visual capability: 2 out of 5. Luisa has worn glasses, with a high degree of magnification, for more than 25 years. She has both presbyopia and astigmatism, which implies that she has problems with reading and with focusing on images. She uses her Whatsapp app with very big fonts, which were set by her daughter. But when picking another app or web, she usually misses how to enlarge fonts and ends up holding the device close to her face.

Mobility capability: 2 out of 5. With the age, she has lost some mobility and flexibility. She prefers not to use a walking stick, as a personal aesthetic preference. But she tries to avoid walking longer distances or going out too often. When she has to cover non-walkable distances, she prefers to call a local taxi by phone or get the assistance of relatives.

[1] The personas were developed in INDIMO Task 1.2 (Analysis of the requirements of users towards the digital interconnected transport system) and are described in more detail in Deliverable D1.2.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

Cognitive capability: 3 out of 5. She shows clarity and consistency during conversations, is oriented in time and space, and has a normal verbal reasoning. She does not show signs of cognitive deterioration as a result of the age. But sometimes she has problems to memorize names or close activities (e.g., where she just left an object).

Auditory capability: 3 out of 5. She has never had auditory problems. But she started to notice, 5 years back that she has some difficulties in hearing people from afar, mainly, when people are in a next room. She requires that people talk to her slowly and clearly.

Digital/Technical skills: 1 out of 5. As mentioned before, she requires help in order to install, set up and start using a digital app. Sometimes, she even needs help during regular use of common messaging apps. She tries to avoid Whatsapp, even when it is the fastest way of contacting other relatives, like her daughter. She does it if she has no choice. She never took computer lessons, and she thinks that, given her age, she would not make a good use of instruction. However, she tries to learn from the indications of her daughter.

Income level: 3 out of 5. She receives a pension from the Italian state that covers some of her everyday expenditures. Because she owns her house and does not have to pay rent, she can have some average quality of life with her pension income. From time to time, her daughter and grandson bring her some expensive medicines or invite her to have dinner out. She could afford cheap trips for holidays, but she is not willing to make the effort.

Attention level: 3 out of 5. She can hold her attention, follow a whole conversation without losing focus, or understand a complete movie or TV series. Nevertheless, she gets tired of complex activities, such as board games, puzzles or sudokus, and quit them very soon. She is unable to stay focused when referring to complex intellectual activities.

2. Pilot 2. Antwerp - Johanna

Persona: Johanna.

Bio: Johanna is a visually impaired woman of 40 years old. She is single, lives in Antwerp and takes pride in her job as public service officer. She is frustrated with the current traffic situation and is well aware of the current inconveniences in traffic. She has an active travel pattern as she has to get from home to work and back in complex urban context. She uses a combination of public transport and travel on foot. She practiced her routes with mobility supervisors/trainers and is unlikely to travel to unknown places or use unknown routes without assistance. She is not shy to ask for help when she needs it.

Spectrum capability-limitation representation and explanation (Figure 4):

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

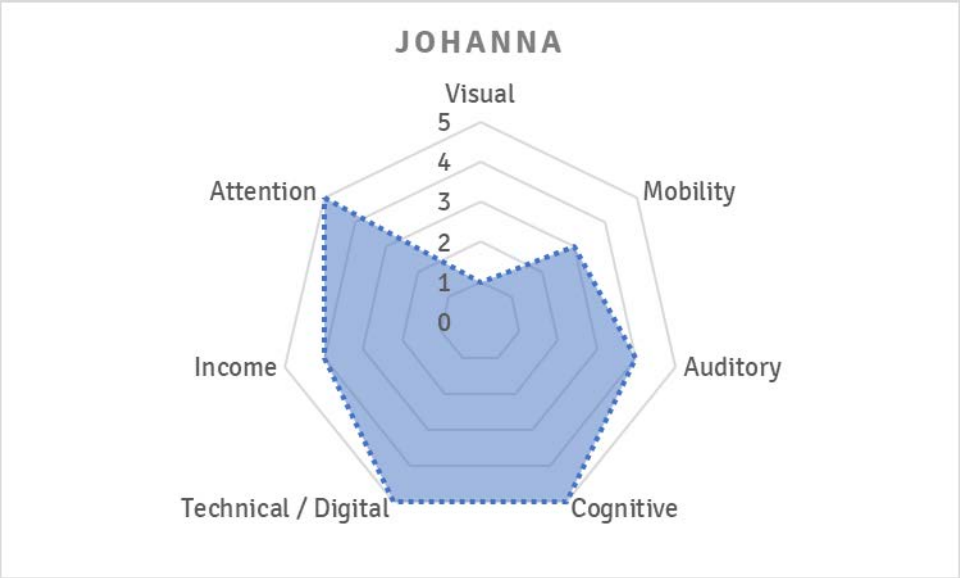

Figure 4. Spectrum capability-limitation area for Johanna

Visual capability: 1 out of 5. Her visual impairment is severe, she is completely blind, and has been since she was born. She uses assistive technology and is not shy to ask for help in the public space, as mentioned in her description.

Mobility capability: 3 out of 5. Because of her visual limitation, as previously mentioned, she is cautious at the time of venturing out of home. She has rehearsed her routes with mobility trainers and prefers to avoid travelling to unknown places or follow unfamiliar routes without requiring the assistance of a trusted person. This conditions her mobility pattern although it does not stop her from moving to the places she needs. But each journey takes a moment of meditation and planning.

Cognitive capability: 5 out of 5. She has an intellectually demanding job, in which she shows verbal and numerical reasoning and mental agility. She is able to resolve complex tasks and continuously exercises cognitive skills. She also enjoys playing chess, for which she has to picture and reconstruct in her mind the position of the pieces.

Auditory capability: 4 out of 5. She has lost 20% of hearing capacity in her left ear, due to an accident she had when she was a child. Otherwise, she has a good hearing from the other ear.

Digital/Technical skills: 5 out of 5. She is savvy with computers and technology in general. She enjoys buying the most up-to-date devices and configure them with the most up-to-date assistive technology. She was raised in a family where many people worked with technology and had fun with it.

Income level: 4 out of 5. She has a stable job in the public administration where she has been working for over 10 years. Even with a stable situation, and because of her impairment, she feels sometimes anxious about the possibility of losing her job and having trouble to find a new one. This feeling makes her often refrain from making large expenses and motivates her to save money.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

Attention level: 5 out of 5. She is attentive and very frequently exercises her memory when learning new routes or the placement of objects in the new environments she meets. Memory and attention are key factors that enable their best possible navigation of the space and overcome of physical obstacles.

3. Pilot 3. Galilee - Mariam

Persona: Mariam

Bio: Mariam is a 25 year old woman who was born and raised in a village in the area of Galilee. She is a part-time university student and combines this with a sales job at the grocery store outside her village. Before starting studying and working, she spent most of her time in her village. She has digital know-how and uses multiple apps.

Spectrum capability-limitation representation and explanation (Figure 5):

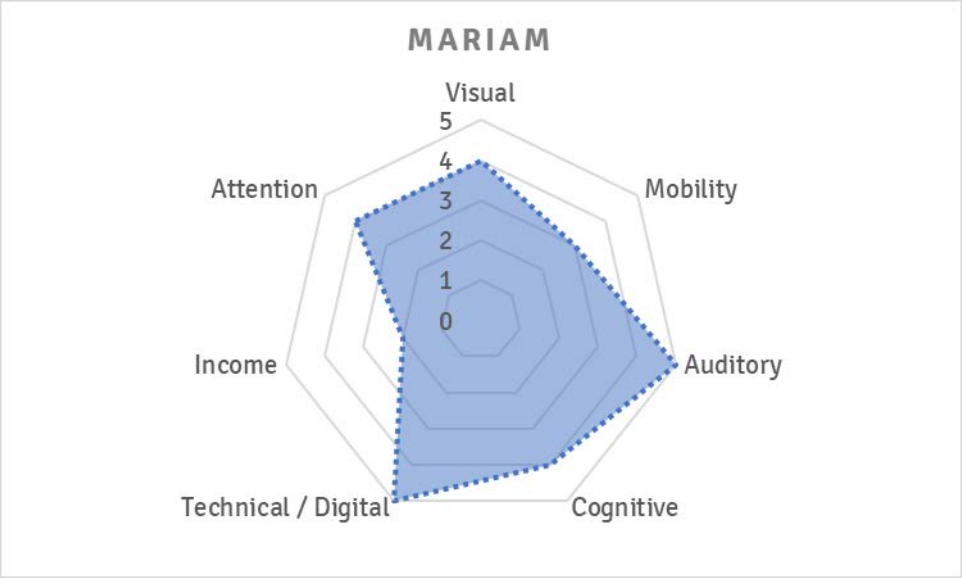

Figure 5. Spectrum capability-limitation area for Mariam

Visual capability: 4 out of 5. She has worn glasses since she started to study long hours at night. Her sight may get tired and lead to headaches. But she has a slight 1.5 grade of myopia and she can as well manage outside without her glasses, with no great consequences.

Mobility capability: 3 out of 5. Because of the place where she lives with her family, she does not have many mobility alternatives to go to her university. She has to walk 800 meters to the main road where she can take a bus that does not run frequently: she often waits for 20 to 25 minutes for the bus to come. This implies that she does not have a lot of flexibility to manage her time, to coordinate with her employment and household chores. Sometimes, she is forced to call a taxi or ride-hailing because the coordination of her schedule would be otherwise impossible. She finds limitations to move alone late at night because she is afraid of being sexually attacked or harassed. So, in a nutshell, although

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

she has no physical impairment, other factors of the social environment limit her freedom to move.

Cognitive capability: 4 out of 5. She performs complex reasoning when studying and exercises her cognitive skills. She has dyslexia which implies that she had difficulties to learn how to write when she was younger. It might also involve some problems of lateral orientation and slightly the need of additional time to complete some intellectual tasks.

Auditory capability: 5 out of 5. She does not have any auditory problems. She hears perfectly sounds of all ranges and pitches.

Digital/Technical skills: 5 out of 5. She is savvy with computers and technology in general. She needs them very much to move around; she thinks she could not do it without ride-hailing and route planning apps, given the bad coverage of public transit services in the village where she lives.

Income level: 2 out of 5. For her, working at the same time of studying is not a choice, it is a must or, otherwise, she would not be able to afford her studies. Her family members are workers and would not have the resources to cover the university expenses. Working at the grocery store is very demanding (there are customers all the time) and she cannot study while at the store. For this reason, she has little time to study for her lessons and does her homework late at night.

Attention level: 4 out of 5. She does not have special difficulties concerning attention or memory. But because she has to allocate mental resources simultaneously to her job, her classes and her homework, plus the cleaning activities that she is expected to complete at home, she may sometimes make attention mistakes. This also involves the use of a mobile phone.

4. Pilot 4. Madrid - María Carmen

Persona: María Carmen

Bio: María Carmen is a widowed woman of 60 years old. She lives in her apartment in the centre of Madrid. Her two children live in the outskirts of the city. She receives financial support from both the state and her children for everyday expenses like groceries. She is socially isolated from her family and from other people. She is very socially aware and sensitive to this kind of topics. Because of this she is not very commercially inclined as she wants to know what the social impact of things are and she does not want to be an accessory. María Carmen has basic digital skills, meaning she can use WhatsApp to stay in touch with relatives and friends.

Spectrum capability-limitation representation and explanation (Figure 6):

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

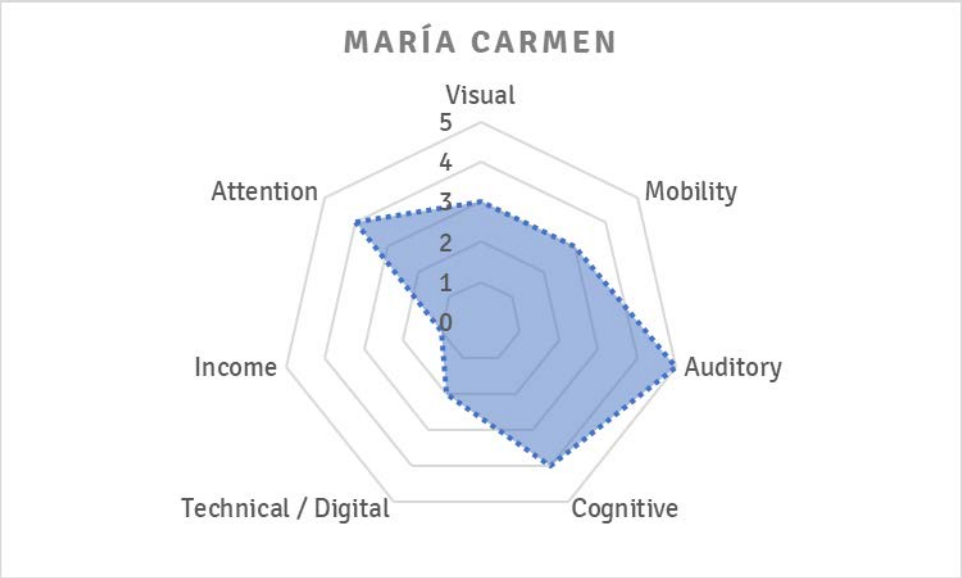

Figure 6. Spectrum capability-limitation area for María Carmen

Visual capability: 3 out of 5. She has problems focusing on text when reading but for some time she has refused to go to the optician because she does not feel comfortable with glasses. Besides, she feels that glasses for reading are for older people and she does not like to feel that way. Sometimes, she struggles with reading text.

Mobility capability: 3 out of 5. She lives in the centre of Madrid in proximity to, at least, 3 metro stations. But she finds that the many stairs and levels of the metro are very uncomfortable and prefers to avoid it and take the bus. The bus in the centre is sometimes delayed due to congestion and does not have as good frequencies and service as the metro. But every time she has to face the stairs or lifts of the metro, she ends up tired or finds it too complex. When she had COVID-19 infection and had to be stay isolated at home for 14 days, she needed the assistance of her family who could not always be there for her. Coordination was an issue.

Cognitive capability: 4 out of 5. She stays mentally active by reading novels and often listening to the radio. She does not perform complex tasks, because she does not like it and because she would not need them either.

Auditory capability: 5 out of 5. She does not have any auditory problems. She hears perfectly sounds of all ranges and pitches.

Digital/Technical skills: 2 out of 5. As we have mentioned in the presentation, María Carmen intensively uses WhatsApp to get in touch with her family. She knows and employs plenty of the functionalities of the app, such as sending images, voice messages or emojis. Nevertheless, she would not feel comfortable with downloading a different app, and she would not have all the resources to explore a new platform and integrate it in her life. In case, she would need to download another app (if she is forced, for instance, to complete some digital paperwork of the state), she would ask her children to do it for her and to write the instructions to use it in a sheet of paper.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

Income level: 2 out of 5. Her husband previously supplied the only income of the household and since he died, she has received financial aid from the state and continuous help from her children for buying everyday groceries and paying bills. She can survive with this help but does not feel so financially stable. She tries to save some money. For instance, she does not eat out often, or even walks every time she can instead of buying a transport ticket.

Attention level: 4 out of 5. She does not have special difficulties concerning attention or memory. Her personality is a bit disperse and many times, when multi-tasking, she might get distracted and produce and unexpected outcome.

5. Pilot 4. Madrid - Sara

Persona: Sara

Bio: Sara is a young woman of 26 years old. She has Down syndrome and partly lives independently in a community, partly with her guardian. She is technological and digitally savvy, which means that she has a high level of digital literacy. She knows she is different but she trusts herself. She is in need of a safe environment as she does not have the capability to react to certain situations. Sara is in need of an easy way to understand and follow interfaces which only requires one decision at the time, as she might get frustrated, angry or panicked. It is important that if she gets lost, someone can easily guide them. She needs to restrict her calorie intake due to a heart disease and the lack of feeling satiated when eating.

Spectrum capability-limitation representation and explanation (Figure 7):

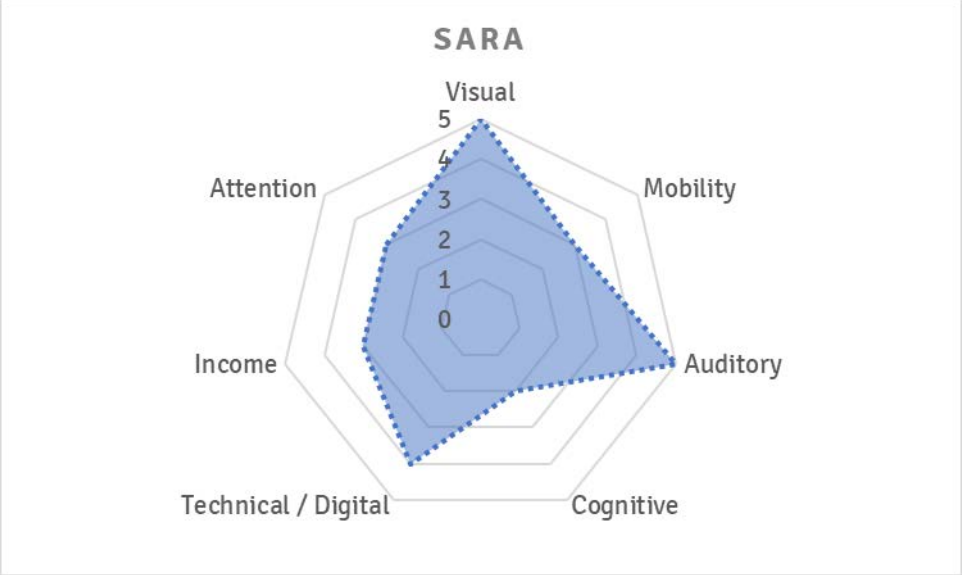

Figure 7. Spectrum capability-limitation area for Sara

Visual capability: 5 out of 5. She sees perfectly well. She does not need glasses and never complained about difficulties with her sight.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

Mobility capability: 3 out of 5. She rides public transport but she is more skilful moving overground, because she might get disoriented in the metro and experience anxiety and stress. Metro maps tend to be difficult to read for her and the feeling of lack of spatial reference intensifies in the underground walkways. Walking overground is her preferred option to get around, and then taking the bus.

Cognitive capability: 2 out of 5. She shows characteristics common to Down syndrome. As mentioned before, lack of orientation and anxiety might be a problem also for navigating web and digital environments and require solutions that require making one decision at a time. For major decisions, the intervention of the guardian is required.

Auditory capability: 5 out of 5. She does not have any auditory problems. She hears perfectly sounds of all ranges and pitches.

Digital/Technical skills: 4 out of 5. Like many other youngsters of her age, she likes being online, mainly connected to social networks. She has profiles in many platforms such as Facebook, Instagram and Tik Tok and enjoys sharing pictures and memes and using other functions. She prefers Instagram over other platforms because the process to share content is step-to-step, easy and relatively intuitive. Platforms are suitable as long as they have an easy interface.

Income level: 3 out of 5. She is supported by her family, which does not have financial problems. Nevertheless, she has the intention to find a job suitable for her impairment.

Attention level: 3 out of 5. Sometimes she may forget certain things or lose the focus while completing a task, but it is not that frequent nor that severe. She has functional capability to complete many cognitive tasks that are adjusted to her condition.

6. Pilot 5. Berlin - Marie

Persona: Marie

Bio: Marie is a 30 years old woman. She is married, has two children, one toddler and one baby. She usually works part-time, however she is now on maternity leave. She lives in the peri-urban location of Berlin with her husband, who needs the car to get to work. Her husband is very busy and her parents live an hour away, so she has little support from others to take care of her child and the husband.

There are only limited public transport options in her neighbourhood, so it is more convenient to use the ridesharing option as she wants to bring her children along. She is already a user of the ride sharing service as it helps her get everyday tasks done more swiftly and with less frustrations as the public transport is inadequate. She is now able to plan her trips to the grocery store, doctor, school etcetera without too much hassle.

She is an open-minded woman who does not mind sharing with people she does not know and she is not afraid to try out new technologies. However, she is not an explorative person and will not actively look for certain things as she is quite busy, she relies on information from others.

Spectrum capability-limitation representation and explanation (Figure 8):

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

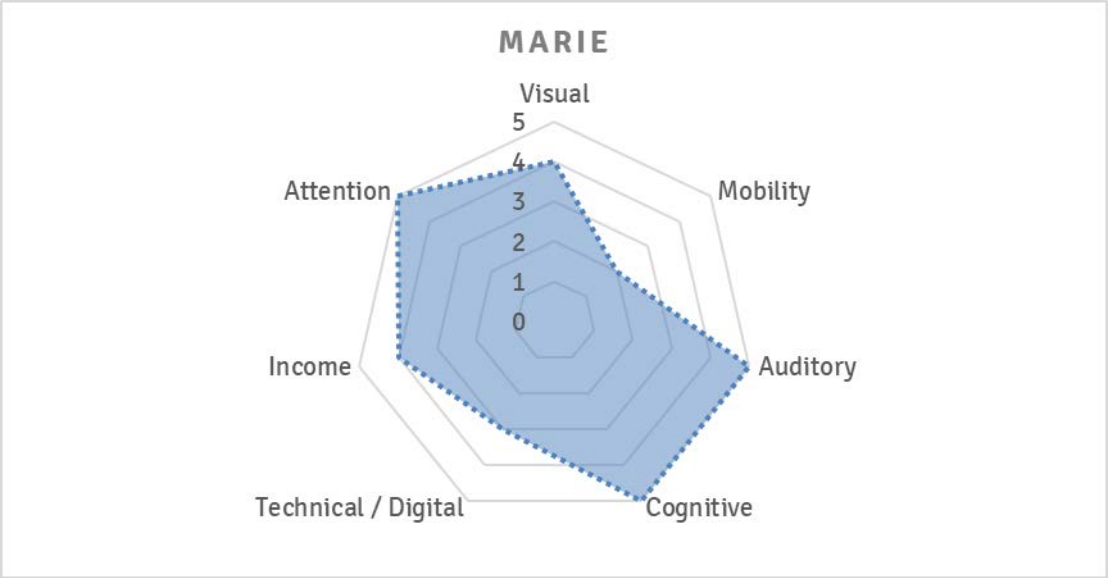

Figure 8. Spectrum capability-limitation area for Marie

Visual capability: 4 out of 5. She has never worn glasses. Some weeks ago, she noticed she saw signs from afar in a blurry way. She made an appointment with the optician to have a check.

Mobility capability: 2 out of 5. Regarding mobility her main issue is the inadequacy of the service of public transport in her area for her travel purposes, and the difficulty of using the public transport with two children. Her children are very energetic, they move, they shout, and she feels that other passengers may be disturbed. That is why she started to use ride sharing where there are fewer passengers. But she has some doubts about it every time the driver is not as willing to provide help with the two children as she would expect.

Cognitive capability: 5 out of 5. Her work implies complex reasoning and mental operations. She exercises her cognitive skills very often.

Auditory capability: 5 out of 5. She does not have any auditory problems. She hears perfectly sounds of all ranges and pitches.

Digital/Technical skills: 3 out of 5. As we have already presented, even when she is skilful with digital tools, she has no problem to download, install and execute any type of mobile app, she is not very explorative. This implies that she devotes a long time taking care of the children, working, carrying the children to places, that she does not have the strength, willingness and time to spend searching for new solutions for her life. She is busy and she relies on information provided by others.

Income level: 4 out of 5. Both she and her husband are employed, so they do not have big financial issues. However, raising two children entails a moderate level of fixed expenses and, because she has to devote time to taking care of them, she can only work part-time. Saving money is important for her to find a balance.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

Attention level: 5 out of 5. She is a very concentrated, detail-focused person. She memorizes even small facts and is very attentive to her surroundings.

Learnings and insights from the fieldwork

The finalized Analysis of barriers and opportunities for tapping the full potential of the digital interconnected transport system (INDIMO Work Package 1) and the on-going implementation in Pilots and demonstrations (INDIMO Work Package 3)implied conducting five pilot experiences, with different digital mobility solutions or digital delivery solutions, in five different places, Emilia-Romagna, Antwerp, Galilee, Madrid and Berlin. Additional field work was conducted in Budapest use case, where the general usability and knowledge gap of digital mobility solutions were assessed through the mobility patterns of selected user groups. It also complemented the evaluation of further characteristics, limitations, and requirements of those user groups, aiding the thematic and user-centric analysis of the five pilot locations. In each pilot and use case, different characteristics of vulnerable-to-exclusion target groups were identified. The insights from the pilots allowed us to identify needs of the users and potential users. Needs vary across groups, but there are threads as "**space**", "**time**" and "**trust**" that are points of contact and common areas.

The first thread is the "**space**". In the case of environments characterized by scattered rural villages, such as in the pilots of Emilia-Romagna and Galilee, digital mobility solutions (e.g. apps) may compensate the lack of infrastructure, the transport poverty and the difficulties for personal mobility. In the case of Emilia-Romagna, there are logistics problems to reach rural areas and the level of service is perceived as lower compared to the urban areas. The digital locker for deliveries could overcome distances and enhance accessibility, especially for older people for whom picking up parcels demanded a great amount of effort but also for workers that cannot go to the post office or receive a package at home due to inconvenient times. In the case of Galilee, there is a need of mobility alternatives given the lack of public transport and good connectivity in the Arab rural villages. This need is even greater for Arab women, since cultural barriers and a hostile atmosphere prevent many of them to drive and ride the public transport. But there are additional needs related to the spatial configuration of this place. Most of the mobility apps have severe difficulties to match the digital mapping with the real geography. There are rural streets with no names nor numbers; this implies a difficulty for the user to order a ride. In the Budapest use case, since the target audience includes wheelchair users and other people who have difficulties to move on uneven surfaces or on stairs, they mainly chose vehicles which provided easy alighting and boarding. Therefore, their limitations mostly concern the spatial characteristics of the service itself instead of the application connected to it.

In the Antwerp pilot, people with reduced mobility or reduced vision find a number of obstacles in the physical environment that prevent their everyday activity. The needs have to do with the adaptation of traffic lights but also the adaptation of the surroundings to overcome these limitations: the short time provided by the traffic lights, the uncertainty

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

about when it is going to change, the uneven pedestrian spaces, the height of the button to ask for a traffic light change and so on are the main needs to be addressed.

The second thread articulating needs is "**time**". Time is a valuable resource and the importance of making good use of it appears in the different pilots. It shows a very sensitive approach in the Berlin pilot, covering a ride-sharing app for caregivers (focusing on women). Time needs to be flexible: the driver and the remaining passengers should be tolerant to the fact that a mother may be delayed (because the child is more unpredictable, he/she does not want to go out, the mother spends time picking items needed by the child etc.), and also the caregiver needs the driver to be punctual (because of the difficulty of waiting in the public space with a child or the time constraints typical of the role).

In the case of Madrid, the existence of a food delivery app may save time, and the convenience of it is often remarked. The point here is that an app for delivery allows to give a different quality to time: time to relax instead of time to cook; a gained time instead of a time devoted to a domestic chore. Nevertheless, in Madrid certain vulnerable-to-exclusion groups perceived the app as an assistance they do not need; as a help that undermines their own autonomy. In Budapest, the aspect where time comes in is the availability of real-time information from the app. A person with reduced vision requires real-time information at which stop the public transport vehicle is, as stop announcement within the bus is not always reliable. Sometimes, buses do not stop at every bus stop, only when it was requested or there are waiting passengers. For these groups, real-time information in the app is a key aspect of finding spatial guidance.

Finally, the last thread that may organize the needs across the pilots is "**trust**" and having human contact behind the digital interface. Human contact is a requirement to overcome all the fears contained in the digital domain; it is the ultimate safety net for vulnerable-to-exclusion population that ventures into the unknown digital world. In Emilia-Romagna, an assistant at the locker spot would be helpful to overcome digital-skills-related problems; in Antwerp, the target population very much depends on the help of passers-by to overcome physical obstacles, this assistance narrowed for fears raised by the COVID-19 pandemic; in Galilee, having direct contact with the driver is a requirement to trust them, to overcome fears related with physical insecurity; in Madrid, the possibility of ordering food through WhatsApp or arranging details of delivery through a call to the rider were very frequent claims to the service; in Berlin there was a request of empathy directed to the driver: women need drivers to care about the needs of a mother and to help her onboard and offboard. Human contact is a key value to ensure all needs are met in inclusive digital services. In Budapest, the aspect of trust appears in relation to provision of information. It is confirmed in this fieldwork that it is not enough that vehicles and services provide inclusive conditions, if these conditions are not adequately communicated. So, inclusiveness is not only producing adaptations but, also. providing the right information about these actions.

We produced new insights offered by this research that go beyond what has been done by previous literature. First, there is limited previous research on the requirements of women

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

towards ride-sharing apps beyond the threat of violence and misconduct from drivers or other passengers. An important insight of our research is to evidence that regular mobility services address a "male individual" user and do not contemplate the specific needs of caregivers in charge of dependents. Another learning of our study is that the literature about mobility apps tends to consider a "universal user", ignoring or underestimating the many cultural barriers that prevent women from taking part in shared mobility. Our study shows that in Arab communities in the Middle East there is family disapproval of women sharing a vehicle with people other than members of their family. These cultural barriers for the use of mobility services are rarely central in previous studies, since transport is often approached from a technical and engineering perspective.

With regards to mobility and physical disability, a lot has been written about disability as a barrier to accessing certain services. Digital mobility services offer new alternatives to overcome some of these barriers. Nevertheless, some people with reduced mobility may feel that these apps are an unrequired assistance which in fact undermine their ability to have things done by themselves and would prefer avoiding any type of assistance. In the case of smart traffic lights, most of the previous articles concentrate in simulations or training to build capabilities for disabled people to cross the street, but most of the responsibility is put on the shoulders of the most vulnerable users of the street: pedestrians and pedestrian with disabilities. The pilot exposed a technology that changed priorities, from the flow of traffic to the human scale needs. But it was found as an interesting insight that no accessibility solution is only a technological solution. If smart traffic lights were not deployed along maintenance works and improvements in the surroundings of the crossing, the innovation would be perceived as "just another gadget". This is a reminder to avoid the excessive techno-optimism and to consider that digital approaches to problems have to also tackle the physical interface.

Regarding foreign people, previous literature acknowledges the difficulties that migrants may face in unfamiliar contexts, their language barriers and difficulties accessing updated equipment or packages of mobile data. However, the potential of this group to engage in e-commerce, to send money to family or exchange other documents or items, and buying typical products from their home country are not significantly stressed. A familiarity with e-commerce apps already exists and can be expanded.

Finally, there has been a lot written about the digital inclusion of older people and people with low-digital skills. There is a recognition that there is an ongoing process of population ageing and, along with it, a challenge for older people to incorporate digital tools to sustain independent living and take advantage of opportunities for societal engagement (Boulton-Lewis et al, 2007; Loos 2012). Nevertheless, we found that we cannot treat the aged segment as a homogenous segment because there are idiosyncratic elements of the environment that might be stronger factors than the generation belonging. For instance, the approach of older people towards technology may radically vary between rural environments and urban environments. At the same time, "older people" is a concept that covers a very large period of time, from 65 up to 100. This 35-year gap makes a lot of difference. Another interesting point is the willingness to learn,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

to engage in workshops or classes of capabilities building, as we will explore in the following section of capabilities of the different profiles.

How to design for inclusion? Some tips for developers and operators

In this final section some tips for developers and operators are provided in order to design digital interfaces of a physical mobility and delivery service for inclusion.

Visual capability

Digital interfaces of a physical mobility and delivery service can extend the capabilities of this group by offering more adjustable and customizable interfaces that improve navigation and assist also in the interaction with the physical environment. The ability of the development and design of the app to include external readers will also be essential for this group.

Mobility capability

Digital interfaces of a physical mobility and delivery service can extend the capabilities of people with different levels of mobility impairment by offering new opportunities and alternatives of mobility (or by replacing unnecessary mobility), anticipating obstacles and difficulties *en route*, incorporating mappings with the information required by this group and providing the required information about the physical conditions of services.

Income capability

Digital interfaces of a physical mobility and delivery service can extend the capabilities of the people of all income levels by offering new opportunities of mobility with conditions adapted to their needs. Attention should be given by developers to widening the choices of payment methods (many people have no bank accounts or debit/credit cards or only receive income in cash). and, similar to the previous profile, design apps that are low-equipment and low-resources demanding. Offering freemium services (or even exception from data consumption) may also provide additional aid for the affected people.

Technical/Digital capability

Digital interfaces of a physical mobility and delivery service can extend the capabilities of all the users with a simplified and intuitive interface where commands are sorted step by step. The presence of continuous human assistance may be an anchor for confidence (even if users do not always use it, knowing that the option exists provides confidence for incorporating the app).

Cognitive capability level

Digital interfaces of a physical mobility and delivery service should enable users to face the lowest number possible of choices. Choices in general may be associated with stress and the possibility of losing orientation. A straightforward line of workflow and the

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.

simplification of procedures may help release anxiety. Auto-filling, suggestions, recovering previous orders and indications are contributions for the simplification of cognitive processes in the user. It is suggested also to avoid the excess of texts and the simplification of concepts through images and icons. Even in sever cognitive impairment cases, familiarity with intuitive apps and apps based on icons and steps (such as Instagram) was found. There are also aspects of the physical interface that are very associated to the axes of cognitive impairment: the speed of speech of service agents, the identification in their look to clear uncertainties etc.

Attention capability level (distraction level)

Digital interfaces of a physical mobility and delivery service, e.g. a delivery food service, should provide a new and appropriate solution for this specific scenario. Distraction level can also increase when travelling with a children or people-in-need-of-assistance. Due to the shared attention on a navigation application and the assisted person hands-free or voice-controlled options may be helpful.

Auditory capability

During this research, auditory impairment was not specifically explored. For specific cases of impairment new axes can be defined.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875533.