



Improving Accessibility and Inclusiveness of Digital Mobility Solutions: A European Approach

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Abstract. This paper presents the main results of the co-creation activities carried out in the first phase of INDIMO (INclusive DIGital MOBility solutions), a three-year EU-funded Horizon 2020 project that aims to extend the benefits of digital mobility and delivery solutions to vulnerable people that currently face barriers in using such solutions due to physical, cognitive and socio-economic limitations. On the one hand, results concern needs, capabilities and requirements of vulnerable-to-exclusion users and non-users of digital mobility and delivery services that have been collected in the five pilot sites of the project. On the other hand, findings highlight drivers and barriers for the development and deployment of inclusive and accessible digital mobility services from the viewpoint of developers, operators and policy makers. These results are the basis for the development of the main outcome of the project, i.e. the Inclusive Digital Mobility Toolbox.

Keywords: Digital mobility and delivery solutions · Accessibility · Inclusiveness · User and non-user needs · Requirements · Universal design

1 Introduction

The proliferation of smartphones and digital technologies have produced a quickly expanding array of digital services in mobility and logistics. While significant achievements have been made mainly in terms of improving physical accessibility of transport,

digital accessibility and inclusion have marginally been addressed. There is a risk that these new digital mobility and logistics services will not be available and accessible to all members of society. 22% of all European households still do not have access to broadband internet especially in rural areas. Mobile broadband penetration also shows a high variation within Europe with 70 subscriptions per 100 persons in Hungary as a lowest value. In some EU Member States, over 25% of the population still does not regularly go online. Almost 10% of EU citizens have never used the internet, with a high number of non-users among those with low education levels, aged over 55, retired or inactive [1]. This data shows that internet-enabled mobility is not an obvious choice for millions of Europeans although internet access is just one of the reasons why they may be excluded.

Access to digital services may be limited due to physical or cognitive barriers, but digital accessibility has so far only been addressed at the level of websites and applications. In addition, from the inclusiveness perspective, various socio-economic, demographic, financial and functional barriers may prevent people from using digital mobility and logistics services (e.g. educational level, gender, language, immigration status, poor access to transport or digital networks, affordability, etc.) [2].

Digital mobility solutions are mainly developed for general use according to the assessment of the needs of average users. This practice may, however, lead to the exclusion of several groups. Implementing universal design principles and accessibility standards could lead to more inclusive applications: past experience proved that including special features for broadening customer palette increased the overall usability.

Inclusivity features cover two main topics: service related and interface related issues. Improving service inclusivity usually results in the increase of inclusivity of the related application as well. However, improvement may require high investment on service development, especially on informatics and technologies. Development should focus on providing additional information, functions, and options for possible vulnerable users. Increasing interface accessibility refers to adapting universal design [4] in the development process of graphical user interfaces, which may lead to iterative processes and can affect previous steps (e.g., database modelling). The process also requires an extended testing phase to verify inclusiveness.

This paper addresses the lack of accessibility and inclusivity of mobility services and proposes the application of the universal design principles and a co-creation approach to overcome these barriers. It discusses needs, capabilities and requirements of vulnerable-to-exclusion users and non-users of digital mobility and delivery services, and findings highlight drivers and barriers for the development and deployment of inclusive and accessible digital mobility services from the viewpoint of developers, operators and policy makers.

2 The INDIMO Project: An Overview

The INDIMO project aims both at filling the knowledge gap about accessible-by-design digital mobility services and improving the inclusiveness and equity of the interconnected transport systems. Pursuing this mission, INDIMO explores needs, capabilities, barriers and requirements of vulnerable-to-exclusion users on the one hand, and the challenges that developers, operators and policy makers face, on the other hand.

To this aim, the main outcome of the project will be the Inclusive Digital Mobility Toolbox, which includes a universal design manual for digital mobility services, guidelines for improving the design of interfaces, guidelines for cybersecurity and personal data protection and a policy evaluation tool for policy makers.

Overall, the INDIMO methodology consists of a user-centric approach. The INDIMO Inclusive Digital Mobility Toolbox will be co-designed with local communities of practices in five pilot sites (i.e. Italy, Belgium, Galilee, Spain, Germany) and with an international co-creation community including policy makers, user representatives, industry, academia, and developers, during the three years of the project.

The INDIMO co-creation process is designed as a five-stage process. *Stage 1* is devoted both to the identification of user and non-user needs, capabilities and requirements, and the investigation of needs and concerns of developers, policy makers and operators when introducing digital mobility and delivery solutions (DMS/DDS). *Stage 2* concerns the co-designs of the INDIMO Inclusive Digital Mobility Toolbox to bridge the digital mobility gap, on the basis of needs, capabilities, requirements and barriers identified in the stage 1. *Stage 3* regards the co-implementation of the tools included in the INDIMO toolbox. Their impact and usability will be tested in the five pilot sites through the redesign of the pilots' digital mobility and delivery solutions and their implementation made according to the INDIMO toolbox guiding principles. *Stage 4* focuses on the co-evaluation, feedback and redesign. Pilots engagement will provide feedback in order to improve the INDIMO toolbox. An evaluation will be carried out, both in terms of inclusion and accessibility assessment of the pilots' digital mobility and delivery services, and of process evaluation of the INDIMO Toolbox. Finally, *stage 5* concerns the transferability assessment and the deployment of the toolbox as an online toolkit.

This paper presents and discusses the results emerged from the research carried out in the first stage of the co-creation process, whose methodology is described more in detail in the next section.

3 Identification of Needs, Capabilities, Requirements and Barriers: The Methodology

In the first phase of the project, needs, capabilities and requirements of vulnerable-to-exclusion users and non-users of digital mobility and delivery services have been collected in the five pilots. The process started with the definition of users' characteristics and the general analysis framework of qualitative data collection. Each pilot site addressed specific user profiles and characteristics and focused on certain digital mobility or delivery services that will be tested and re-designed during the project to be improved from the accessibility and inclusiveness points of view (see Table 1).

In total, 58 semi structured interviews (SSIs) with digital mobility services' users and non-users and 25 interviews with stakeholders representing users have been carried out. SSI structure was set-up according to several dimensions identified in the general analysis framework (e.g. goals/value of using the service; accessibility and inclusion: reasons for not using the service; needs; etc.). SSIs and short interviews were firstly documented in debrief documents by including the more relevant excerpts of the interviews and, secondly, analysed through a coding process. This was performed through

Table 1. Pilots' names and user profiles

| Pilot name and country | User profiles (and characteristics) |
|---|--|
| <ul style="list-style-type: none"> Introducing digital technology to enable e-commerce in rural areas (Emilia Romagna-Italy) | Older people and migrants/ foreign people who receive/send parcels (lack of digital knowledge; residing in peri-urban locations; lack of digital services; lack of dedicated network infrastructures; language barriers; low income, ...) |
| <ul style="list-style-type: none"> Inclusive traffic lights (Antwerp–Belgium) | Vulnerable pedestrian (i.e. older people; people with reduced mobility; people with reduced vision) |
| <ul style="list-style-type: none"> Informal ride-sharing in ethnic towns (Galilee) Cycle logistics platform for delivery (Madrid-Spain) | Informal ride-sharing users (ethnic minority man/women; residing in the periphery; language barrier; lack of digital skills) Healthy food delivery users (people with reduced mobility; people with reduced vision; socially isolated-unwanted loneliness; not-connected people; low income; COVID-19 isolated) |
| <ul style="list-style-type: none"> On-demand ride-sharing integrated into multimodal route planning (Berlin-Germany) | On demand ride-sharing users (caregivers of children/ impaired/ elders; women; lack of services; lack of digital skills, residing in peri-urban locations) |

the Quirkos CAQDAS (Computer Assisted Qualitative Data Analysis) software. Relevant verbatims from interviews were labelled with appropriate codes to analyse data in terms of similarities, differences, and relationships. The final step consisted of the thematic analysis to organize the identified codes in meaningful crosscutting themes [3]. The main results emerged from these research activities are relevant themes concerning needs, capabilities and requirements of digital mobility services' users and non-users (see Sects. 4.1 and 4.2).

In order to support changes that can extend the benefits of digital mobility services and applications equally to the vulnerable-to-exclusion groups, it is necessary to understand what the drivers and barriers are for the development and deployment of inclusive and accessible digital mobility services from the viewpoint of developers, operators and policy makers. For this purpose, 10 deployment case studies were performed to investigate how new digital mobility services have been introduced in European cities and regions. The case studies included desktop data collection, 20 semi-structured interviews with developers, service operators and policy makers, and a thematic analysis to determine the key barriers and drivers. The main results concerning this part of the study is described in Sect. 4.3.

4 Main Results

4.1 Identification of Users and Non-users' Needs

The insight from the pilots, with different user profiles, locations and mobility solutions, allowed us to identify needs of the users and potential users. Also, stakeholders on behalf of specific groups of population, provided their inputs to build a narrative that moves across geographies and profiles. 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 logistic problems to reach remote 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. 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 transit. 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 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 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 a good use of it appears in the different pilots. It presents a very sensitive treatment 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 doesn't 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 of 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.

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 venture into the unknown digital world. In Emilia Romagna, an assistant at the locker spot will be helpful to overcome digital-skills-related problems; in Antwerp, target population are very much depending on the help of passers-by to overcome physical obstacles, this assistance narrowed for fears raised by the COVID pandemics; 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 frequents claims to the service; and finally, in Berlin there was a request of humanity 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 provide all needs in inclusive digital services.

4.2 User Requirements Towards the Digital Interconnected Transport System

The stakeholders' interviews in each pilot underline the potential of the INDIMO mobility services to meet certain goals that increase opportunities for the target groups in each pilot site. However, the stakeholder interviews show similar basic concerns across the five pilots to meet those goals. Providing an inclusive service by solely working on an easy to use and accessible digital interface (icons, fonts, read-aloud features, etc.), although important, will not be sufficient to engage the different vulnerable end user categories.

Five key activities will be important by the pilots to meet user requirements. Building a trust relationship is the first one. It is only because a certain trusted public or private organization or a trusted individual (relative, friend) recommends using the digital system, that users will know the service and try it out. Pilots will have to develop a good "social" marketing strategy to get their service to the target audience as well as involve such organizations closely in the whole service deployment. Building trust also involves the service agent appearance, tone of voice and behaviour, important for the driver in ride-sharing services (Berlin, Galilee) and the delivery person in delivery services (Madrid). Providing dedicated assistance and support mechanisms are a second key activity. Dedicated training opportunities that go beyond an introduction will be especially needed in the case of older people to tackle digital skills (Emilia Romagna) or blind people for integrating a smart traffic light in their road usage (Antwerp). The third important key activity is being reliable. Since the pilot services are targeting people with specific needs, they also count on these services and their provision in the structuration of their lives. In the case of vulnerable pedestrians, a non-working traffic lights either keeps the person at home (reduce mobility) or forces him to take another route (mobility hindrance). In case the service is not functioning sending out a warning message is important as well as communicating when the service is working again. The fourth activity will be to provide a service that in its strategic choices builds in "flexibility", meaning that it can't be too rigidly organized but should be able to incorporate unanticipated events at the end user side (for example cancelling a ride close to the agreed time or changing a pick-up location). The final key activity is increasing awareness about privacy and data sharing in order to prevent misuse, especially in use cases working with elderly (Emilia Romagna and Madrid) and cognitively impaired persons (Madrid).

4.3 Understanding the Process of the Deployment of Digital Mobility Services

In the first stage of the INDIMO project, drivers and barriers related to the development and deployment of accessible and inclusive digital mobility services were also explored from the viewpoint of developers, operators and policy makers.

The results of our case studies and the stakeholder workshop have pointed out several key barriers to the deployment of inclusive and accessible digital mobility services. The regulatory framework is often non-existing or outdated. There may be a lack of co-operation or trust between private and public organisations. The users are often not involved in the development of services. There is a lack of knowledge among developers about potential vulnerable-to-exclusion users. Unstable market pushes development towards ‘typical’ users with no or limited inclusive features. Finally, there is limited willingness to share (mobility) related data and information with public authorities and other operators.

A number of drivers can help to make existing or new services more inclusive and accessible: stable market conditions supported by a comprehensive regulatory framework; the integration of digital services into the public transport service network where minimum accessibility and inclusivity guidelines have been set; consultation with users and their representatives to have more knowledge of potential users can all be beneficial. Using inclusive design as a cornerstone of the service development, bottom-up co-creation events; open communication with other stakeholders, which includes sharing of information about best/worst practices and local support schemes (subsidies or incentives) can further help to introduce accessibility and inclusiveness features.

The differences between the services studied showed that there is no single method to develop more inclusive services. The issues most of the services are struggling with are similar (co-creation, communication, data-sharing etc.), but they might need different approaches depending on the type of service, region and people. The results of the analysis will help to create a framework and guidelines for developing inclusive and accessible digital mobility services, which are more aligned with the needs and expectations of vulnerable-to-exclusion groups.

5 Discussion and Conclusions

The INDIMO project’s main contribution concerns the co-creation of the Inclusive Digital Mobility Toolbox. It will cover relevant aspects for fostering the Universal Design approach throughout the planning and design process of digital mobility applications and services, by integrating the perspective of vulnerable-to-exclusion groups since the beginning. Such approach represents a shift of paradigm from the design-as-usual where experts “know what users need”, thus increasing the users’ acceptance of digital mobility and delivery solutions.

We contribute to filling the knowledge gap about accessible-by-design digital mobility services and improving the inclusiveness and equity of the interconnected transport systems by exploring needs, capabilities, barriers, and requirements of vulnerable-to-exclusion users on the one hand, and the challenges that developers, operators, and

policy makers face, on the other hand. This was achieved through various semi structured interviews and co-creation workshop from five case studies in different European sites.

Concerning findings coming up from this first phase of the project, they show that providing an inclusive service by solely working on an easy to use and accessible digital interface (icons, fonts, read-aloud features, etc.), although important, will not be sufficient to engage the different vulnerable end user categories. It is crucial to build trust among users, to provide dedicated assistance and support mechanism for the service to be reliable and provide flexibility, and finally, ensure privacy and prevent misuse in data sharing. Further, the differences between the analysed digital mobility services showed that there is no singular method to develop more inclusive services. The issues most of the services are struggling with are similar (co-creation, communication, data-sharing, lack of frameworks, etc.) but might need different approaches depending on the type of service, region, and people. There is need for co-creation with potential users resulting in a bottom-up approach and improve communication between stakeholders and exchange of knowledge about potential users, especially those vulnerable to exclusion.

Overall, the results offer a qualitative take allowing for a deep grasping of various dimensions of exclusion and inclusion ranging from interface to socio-economic and cultural factors.

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