Moving Ahead: Elaboration on Cumulative Effects on Urban and Suburban Transport Ecosystems by Enhancing Last Mile Mobility of Older Adults and Persons with Disabilities

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Abstract. Provision of fair, affordable and accessible transport is an essential objective of Smart Cities. In previous research, we outlined five action areas to enhance Last Mile Mobility for older adults and persons with disabilities. Following up, we expand our view towards a wider Smart City context, reflecting on needs of other target audiences of urban and suburban transport systems. By analyzing the effects of an enhanced Last Mile Mobility on children, adolescents and marginalized persons, we conclude to review the transport ecosystem as a whole. Based on this holistic view, we elaborate further on previously identified action areas, focusing first on the three action areas, which describe a transport system's service quality: spread of service areas, accessibility of provided services, and availability of demand-driven services. We continue to deepen our view on the potential role of paratransit services within the urban transport ecosystem (action area 4), and finally delve into policy needs and recommendations to maximize Last Mile mobility in Smart Cities (action area 5). We conclude our work with a suggestion for future pilot implementation based on our findings.

Keywords: Intermodal mobility · Accessibility · Last Mile transport · Public transport · Paratransit

1 Introduction

The provision of fair, affordable and accessible mobility is commonly understood as one of the core tasks of Smart Cities [1]. With the European Accessibility Act [2] outlining a special focus on passenger transport, especially public transport operators are required to improve the accessibility of mobility services in urban and suburban areas. A core challenge for the stakeholders in public transport is the coverage of the so-called "Last Mile", describing the distance between a public transport station and the

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ultimate destination of a trip [3], which typically involves other forms of mobility, like walking, biking or a car ride. These modes of transport require a certain level of physical or cognitive ability. Therefore, when considering the accessibility of a transport system, the importance of an accessible Last Mile transport cannot be underrated.

In order to tackle the challenge of such an accessible Last Mile transport service provision, we first investigated the chances to enhance Last Mile mobility for older adults and persons with disabilities in Vienna, Austria, and Zurich, Switzerland [1]. Our work focused primarily on current shortcomings in the available mobility service offers, on potential gains for older adults derived from the services, and on suggestions for actions to be taken in order to enhance personal mobility. Specifically, we proposed five action areas: (1) to expand service areas, (2) to establish on-demand services, (3) to improve service accessibility, (4) to integrate medical shuttles into the public transport network, and (5) to foster the establishment of a policy framework [1]. We concluded that public transport operators play the key roles in the implementation of such actions, without yet delving into the needs of all passengers and customers.

The design of accessible products and services is generally accepted to be related to the overall customer experience [4–6]. As the public transport's "product" is to provide mobility to all citizens alike, we identified the need to expand our research on the accessible Last Mile mobility towards further customer groups as well. By doing so, further effects like the customers' social inclusion or minimization of marginalization should be analyzed, reflecting upon mutual benefits as well as potential conflicts arising from the needs of different customer segments and transport service operators.

Subsequently we explore potential user groups, who, besides older adults and persons with disabilities, would also benefit from advances in the three service-quality related action areas proposed before (expanded service area, established on-demand services and improved service accessibility) [1]. Then we extend the scope to the analysis of the service quality of transport systems, extending the findings with the requirements by the stakeholders towards an inclusive transport ecosystem. We proceed by investigating the stakeholder groups' communication and information needs within the ecosystem with the aim of enabling an enhancement of the overall mobility within transport ecosystems. Going a step beyond, we evaluate, based on our findings, the potential role of medical shuttles services – also described as paratransit [7] – within the transport ecosystem. This refers to our proposed fourth action area. Finally, contributing to the fifth action area (policy framework), we make concrete suggestions for an expanded customer-centered view on the proposed transport ecosystem. Based on our analyses we conclude by making suggestions for future activities to improve transport ecosystems.

2 Potential User Groups

Our previous research was originated from a Smart City context, but focused primarily on the benefits of demand-driven mobility services to cover the Last Mile in an AAL (Active and Assisted Living) context [1] - not yet transferring the findings back into a wider context. To tackle this shortcoming, we explored additional stakeholder groups

within a Smart City context, who might face limitation in their mobility, which not directly results from a jeopardized health condition or impairment.

Lubitow et al. [8] criticize that transportation infrastructure is "oriented toward an 'ideal rider' who is an economically stable, able-bodied, white, male commuter" [8]. There are, however, many others, who rely on a transportation system, which offers accessibility, affordability, and individualized mobility services. The latter can be shared mobility services.

A starting point for finding potential beneficiaries of shared mobility concepts can be their articulation in previous research in the AAL domain, where, besides decline in physical and mental abilities, also the limiting effects of marginalization on older adults is described [9]. Yet, marginalization and poverty do not only affect older adults. Younger mobility groups e.g. kids and students, mobility groups with reduced budgets or people in distinct living situations e.g. parents travelling with their children and in need for strollers, and people with sensory and/or physical impairment would also gain from a more affordable and accessible transportation system. Both, pricing and accessibility are overall societal issues, especially in urban and suburban areas, where people depend upon a sufficient public transportation system. Users would benefit from a wide spectrum of mobility services, which also helps them to reduce transport costs. Affordable and easily accessible mobility is crucial for marginalized residents in order to participate in society and to stay active and independent [10].

Furthermore, Quodomine [11] underlines that public transportation is of similar importance for younger and older adults, as both use public transportation in lack of alternatives and financial means. Additionally, public transportation mobility provides more and more services as add-ons. Younger adults appreciate services like free Wi-Fi. The study also revealed that younger adults still consider public transportation more sustainable compared to going by car not the least for ecological reasons. The negative perception of public transportation by this user group is constantly decreasing. When it comes to the older adults, public transportation is favored because of economic reasons and decreasing driving capacity [11]. As for older adults and persons with impairments, enhanced last-mile services also improve mobility for adolescents.

Finally, safety in terms of safe and secured infrastructure is an issue not to be underestimated. Lubitow et al. [8] describe women sharing their negative experiences when riding buses and their children injured while the bus drivers not taking care of them. Obviously, safe and secure transportation infrastructure is a key concern and not to be underestimated, when it comes to the different user groups with their specific needs in this domain.

Even when discussed in a broader context, Lavadinho [12] clearly confirms the need for transportation providers to become more than just enablers for people to get from A to B. As stated above, the accessibility to Wi-Fi makes a bus or train more than just another mean of transportation. She summarizes: The "added value of the transportation system derives as much from whichever activities can be deployed along the way than from reaching the final destination. A new mind-set is therefore needed, where the success of city-access policies regarding public transport is measured by different metrics" [12]. These effects of enhanced means of transportation with regard to their customer- and ultimately stakeholder-satisfaction can also be observed with regard to enhanced station infrastructure (e.g. bus/tram stops providing Wi-Fi, snack-

machines, shelter, sitting possibilities etc.) [13]. Younger generations can expect further positive side effects: Stone et al. [14] report that enhancing independent mobility for children has a preventive health effect, as improvements in personal mobility correlate with higher physical activities, as they are more likely to roam the city and participate in physical activities.

When considering these customer segments, it is obvious, that, like mobility itself, their way-finding too is more than just getting from A to B. It is about orientation, emotions, and customer satisfaction. Customers typically also evaluate their routes based on whether they feel safe and comfortable. Referring to a wide field of research, Meurer et al. [15] describe mobility as something that has spatial as well as place related dimensions. In this sense "spatial" refers to people moving around within cities, suburbs or other clearly defined environments and to terms of geographical dimensions. "Place" on the other hand refers to emotional ties, social interaction and interdependencies. A neighborhood is considered to be a place in that people have built up social networks and where they are emotionally and socially embedded. They report, that for older adults mobility in particularly has a social aspect, that it is also about interaction with others.

Similarly, Stone et al. [14] report that the social situation in neighborhoods has an influence on the mobility behavior and patterns of children. In summary, social interactions as well as the physical environment allow people to have very different mobility experiences; these experiences and expectations are affecting how they move in space. With their research, carried out in Germany in 2016 with 19 older adults, Meurer et al. [15] attempted to learn about way-finding practices and how these can be better supported by assistive technologies. The study provides insights on various different levels. Most prominently, they show that depending on the purpose of mobility, way-finding varies. They identified five different mobility situations with distinct way-finding practices: (1) weekly routines (e.g. to see their grand-children, to go to the sports club), (2) first time journeys (e.g. to see a specialist), (3) visits of beloved and attached places (e.g. a church, a park), (4) places of specific kinds (e.g. the supermarket, a restaurant) and (5) when they purposely do ridesharing. From a mobility and assisted technology perspective, it is important that they might always take the same modes of public transport for mobility situations 1 to 4. Yet, they are differently motivated and need different support and information. From a mobility and assisted technology perspective, it is important to note, that due to differently motivated mobility activities different support and information is expected. At one moment, it can be the information on the schedule, vehicle accessibility and maps, at another moment it can be a need for navigation or safety [15].

By looking at older adults and their mobility reasoning we learn that this group accesses places and uses means of transportation with distinct mind-sets and capabilities, which might vary depending on where they intend to go, how familiar they are with the place and how much support they need. Compared to other user groups, older adults create "new rhythmic mobility patterns" [15], which differ from those of commuters and students, as they visit different places at different times because of their daily routines. Therefore, addressing transportation issues for older adults also means to look at their specific transportation paths and radiuses [15]. The challenge however lays in a transportation system that deals not only with the older adults mobility behavior

but also with the more flexible and ever-changing one of other users with their distinct expectations and optimizes the overall benefit to all stakeholders at any time and place.

3 Enhancement of Transport Service Quality

To address all the customer needs of older adults, younger people, persons with disabilities, and marginalized groups of people, the transport service logic needs to be more serenely analyzed. Therefore, hereinafter three action areas are discussed in more detail. Firstly, the service areas, which need to spread across urban and suburban spaces; secondly, demand-driven services, which need to be established to cover off-peak loads in a sustainable way; and thirdly, the overall accessibility of the transportation services provided. Subsequently, we will elaborate those areas in greater depth, outlining their significance to as well as implications for a transport ecosystem.

As pointed out in our first action area before, private mobility service providers usually use a pre-defined zone of operation in city centers, limited to those urban areas, which have the highest commuter and therefore customer density [1]. Yet, many older adults are living in the outer, suburban districts, where the public transport offering is limited. In Vienna for example, more than 20% of the population in the 13th, 19th and 23rd district are 64 years or older, with the majority of inhabitants being 40 years and older [16]. Leading bike and car sharing services in Vienna are primarily available around the city center, where the subway also operates [1]. In the outer districts, where only a few bus lines are available, hardly any sharing opportunity can be found. As proposed, these service areas need to be expanded towards suburban districts [1], and even further to rural areas [17] to ensure available and accessible mobility.

An expansion of operation zones for sharing services would require innovative business models to cope with the associated higher costs for relocation or the increased number of vehicles needed to retain the availability. Predicting the demand is also becoming more difficult "as fewer customers are using cars more infrequently, as it is likely for older adults and persons with disabilities in suburban areas" [1]. Nevertheless, this might result in a higher price as the service is carried out beyond the current service area. Such considerations underline the importance of an integration of private operators in the regional tariff models as a requirement to offer flexible and affordable mobility outside of the city centers.

As reported before [1], in the greater Zurich area, public transportation networks are well developed; train and bus services are well coordinated. The streetcar network is in the process to be expanded into the suburban areas. In combination with the city bus system, it provides users an extensive public transportation system. The 'Travel Time Map' provides a digital service. The user adds a departure point, the maximum journey and walking time [18]. As a user, you are offered advanced travel options, you learn about travel hubs, and you are informed about traffic routes and costs. The service is not only offered for the Zurich area, but is available for all of Switzerland, also including touristic sites. Within Switzerland the focus of actions however must be on the periurban areas, describing those areas located between urban and rural areas. Recent surveys for Switzerland confirm that 66% commute as either drivers or passengers to urban areas [19]. Based on their data Marconi and Schaad [19] further

summarize that 45% of urban households within Switzerland benefit from a very good or good public transport offering, which contrasts with only 4% in the periurban areas. The authors conclude that motorized individual car transportation is still the preferred mean of transport for commuters when traveling from a periurban area to work, and that the comparatively underdeveloped public transportation network services in the periurban area results in a high number of car holders. This of course leaves us with the question of what happens if people no longer are capable to drive their own cars to see a doctor downtown, meet friends or grandchildren.

Our second action area covered the establishment of sustainable on-demand shuttle services [1]. These combine the benefits of public transport, such as environmental friendliness, pooling possibility and cost consciousness, with those of owning a vehicle like flexibility and comfort [20]. Pooling services offer mobility for older persons or persons in need of assistive devices as well as for other user groups as explored above. Compared to other sharing services like car sharing or bike sharing, on-demand shuttles offer more flexibility and provide a wider service range with better accessible vehicles [1, 21]. Yet, the associated time and cost aspects need to be considered. To attract new user groups to such (paratransit) shuttle services, individual rides should not take more time than a private car or any other transport opportunity available.

As stated before, the fares should be integrated in the prevailing public transport tariff systems [1] and furthermore should be lower than the taxi fares to provide pari passu access to all customer segments alike. The immense cost factor of shuttle services being available in all areas of a region [17] will most likely be reduced with the introduction of autonomous vehicles. Self-driving cars enhance individual mobility of persons who cannot drive or operate a car [22], as space currently occupied by steering wheel, pedals and gear stick can be made available for assistive technology [1]. Nevertheless, tariffs should be fair and affordable, in order to avoid a two-tier society, where marginalized persons are excluded from mobility services.

Thirdly, when discussing accessibility of transport services [1], we found that besides physical constraints, the digital accessibility of a transport system and its offerings is another important factor [23]. Schreder et al. [24] point out that even ticket vending machine functionalities and interfaces can drastically reduce accessibility to public transport. Additionally, a wide spectrum of apps, providing different pieces of information and service at varying digital accessibility levels, are important. However, some of these service offerings have not taken into consideration that people with impairments or minor digital experience might not be able to use these services due to their constraints [1].

When researching mobility assistance, a wide field for analysis opens up, including mobility issues from within one's own home to the independent travelling across neighborhoods and cities. Meurer et al. [15] have summarized various technological inventions and AAL solutions that are available for older adults as well as for people with sensory and/or physical impairments: Walking aids of any kind, skeletons, GPS equipped walkers, apps that guide through neighborhoods or emergency services for people who get lost. Obviously, cars and other means of transportation have become smarter too. These innovations are predominantly aiming at enhancing accessibility of places, increasing of people's mobility, navigation, safety, and security in mobility.

People remain reluctant however, when it comes to car and ride sharing, as this could have a negative impact on older adult's independence and autonomy [15].

Besides the issue of accessibility, Lavadinho [12] claims awareness for an often-ignored issue in the context of the public transportation debate. She discusses the interrelation between different public transportation services, as already discussed earlier, in optimally adapted networks. She also reflects upon the accessibility of transportation hubs. In this setting, providing "walk-friendly environments" is the responsibility of the transport authorities and should not be underestimated in its relevance for planners and decision makers: "Well, for one reason, public transport clients are walkers, first and foremost" [12]. Though her focus lays on the 'in-between-mile', her research reveals some important insights also for the 'first-' and 'last-mile' discussion. She puts the concept of the 'economy of speed' vis-a-vis the 'economy of place' [12]. The latter guarantees different user groups' satisfaction along the line of accessibility in terms of functionality, e.g. clear signage, services and infrastructure, like seating opportunities. The TransitCenter foundation too, stresses the importance of the mode of walking when accessing public transport stations [25]. We suggest these factors to be considered within intermodal transport systems, i.e. when changing from public transport lines to sharing or shuttle services in transport hubs.

When reflecting on these three quality-related action areas, our integrative view on transport systems, their customers and interlinking components among each other, expands into a transport ecosystem. Due to technological developments, individualized mobility patterns, new transport modes and options, and innovative business models new mobility services appear. As described by Litman [26], in order to fulfill todays mobility demand, transport systems are especially in need of new forms of cooperation between private and public transport operators (e.g. public transport providers and car sharing operators, PT-contractors and paratransit operators etc.), while the role of transport infrastructure management- and public authorities continuously changes and develops. Our shift in perception interweaves the "old school" transport system thinking with the chances and opportunities of new mobility services in a user-focused multi-stakeholder environment, taking into consideration ecological, social and economic frameworks and conditions.

4 Communication and Information Needs

More and more cities promote themselves as 'smart'; be it in the area of economy, governance, living or mobility. Smart mobility is about sustainability, inclusive services, and safe as well as secure mobility systems. Full use of ICT has become an indispensable must when providing mobility in a smart manner. In their study Bifulco et al. [27] confirm that "ICT is a tool for mobility because it can facilitate the use of public transport by providing logistical information, and it can even encourage a switch between different methods of transportation" [27]. Furthermore, they also stress the importance of apps facilitating smooth and uninterrupted journeys, real time information and flexibility. Apps also allow integrating information from different service providers.

As stated before [1], the digital transformation in the transport industry has become an important factor when it comes to the accessibility of mobility services [23]. Buying a ticket successfully increasingly is a question of having the right app stored and operational on your mobile devices. At the same time information becomes readily available, more and more complex, and options manifold. Above all, vending machines, which are currently accepted to be a requirement for public transport, can actually drastically reduce accessibility to public transport [24].

With ongoing digitization, both public transport operators as well as providers of shared services and their customers use the same mobile applications. Customers are informed in real-time, get navigation hints when arriving in a transportation hub, etc. These apps enable access to service offers beyond the pure mobility [23]. The wide spectrum of apps, which provide different pieces of information and services at varying digital accessibility levels, clearly improve the travel experience but also cause additional hassle and barriers. Not all customers are equally experienced and capable to use and interact with apps [1].

Nevertheless, access to communication and information channels is an important asset for all customers within a transport ecosystem. The "mobility2know" project [28] gives important insights into the quality of information customers would expect to know about a mobility service; even though from a technology usage point of view, this might no longer be relevant. Depending on the social situation and the physical environment, as well as the housing situation and location (combined depicted as so called mobility milieus), mobility behavior and therefore mobility information needs vary [28]. This also has to be taken into consideration, when designing accessible mobility solutions within a transport ecosystem. Besides, as pointed out in other ecosystem-related research in the AAL domain, trust as a key concern in the digital debate [29, 30] must not be neglected. Trust in the transportation service industry is not limited to fiath in punctuality and guaranteed connections. It is about relying on trustworthy options to access and book mobility services, on secured payment systems and on operators who enhance mobility, especially on the Last Mile. We strongly argue [1] that both centralizing and enriching the digital information available as well as integrating the ticketing and booking services of all mobility modes into a single accessible digital solution built on Universal Design principles [31] and the WCAG 2.0 Guidelines [32] would foster personal mobility for older adults and persons with disabilities. The customer group of the younger generation definitely would appreciate the digital transformation. Yet, only a smart integration of digital and non-digital information available would remove barriers to mobility.

While in Switzerland the population is well served by sharing services, customers are limited in their choice of destinations and are facing higher prices because of the lack of integration into a unified tariff model across city or canton boundaries. "People living in the outskirts of Zurich City might be better off searching for a transport service in the neighboring community or even the canton itself than with the cities' mobility services" [1]. By providing proper integrated and digital and non-digital information, access and payment within a unified tariff system, urban shuttle services are opened up to a wider audience, instead of creating parallel systems to public transport, as described by Neumann [7].

5 The Role of Shuttle Services and Paratransit

In order to enhance Last Mile mobility of older adults and persons with disabilities, we proposed the integration of (medical) shuttles into the public transport network [1]. Following the approach of previous sections, we expand our perspective on demand-driven paratransit towards other customers segments and their role within an urban transport ecosystem.

When investigating paratransit, there is a particularly interesting aspect: In European countries, like Austria and Switzerland, paratransit describes medical shuttles fulfilling the transport needs of persons with physical or psychological impairments. In contrast, African and Asian countries understand paratransit as a motorized transport service for all commuters within an urban area [7, 33], not focusing on needs of older adults or persons with disabilities. Yet, for the purpose of our work, paratransit is to describe those transport services, which are specifically organized and equipped to meet the needs of commuters with physical or mental disabilities.

The core business of paratransit operators, such as the Wiener Lokalbahnen Verkehrsdienste in Vienna, is the transportation of persons with reduced physical or mental abilities for work, school or medical purposes as well as leisure activities [21]. Paratransit services are, of course, also available in rural areas; there they are mostly offered to older adults [34]. Due to opening and business hours not only of workplaces, but also of schools and medical centers, paratransit shuttle services are concentrated in the mornings and in the evenings on workdays too. Above all, they do passenger pooling [17]. Like in public transport, the transport volume is lower during non-peak times of the day as well as during weekends and public holidays. One would think that paratransit shuttle services therefore should rather be offered in the non-productive times. We would however argue that similar passenger frequency in public transport and paratransit shuttles could be employed in a mutually beneficial way. In times when reduced service frequency and longer intervals are provided by public transport, an integrated paratransit operator would enable the replacement of the larger vehicles with more cost efficient shuttles. Moreover, it is in particular the Last Mile transport that can be covered by paratransit shuttles [1].

This, however, requires close collaboration and a comprehensive integration of the (medical) shuttle services into the public transport system [1]. By doing so, the current transport systems could be expanded to meet the needs of transport ecosystems. New stakeholders on both sides, provider and customer side, would be integrated. Such a transport ecosystem would also need to deal with new sources and qualities of information, with different service qualities and various means of transportation. Only through adequate digital platforms would the customer's experiences of planning, booking and paying become a fully accessible and manageable experience, without risks of loss of control. In addition, other operational aspects will need to be changed. The staff needs to be aware of their customers with special needs, of different payment modes, as well as (flexible and varying) pick-up and drop-off points for pooled rides. In this context, without doubt, digitization is and will be a pre-eminent driver and enabler.

Another important aspect is the need for some sort of service level agreement between public transport and paratransit operators. The proposed integration into the

tariff system [1] needs to support the business goals of both parties. Otherwise, the risk of paratransit only covering the most profitable routes would arise [7], creating a "cannibalization effect" [35] between the operators. Therefore, it is important to stress, that the proposed integration of shuttles into the transport system [1] is an expansion of the paratransit operator's role beyond its core business. On one hand, covering the Last Mile transport only would force non-profitable operations onto paratransit businesses. On the other hand, it would exclude those passengers from transport, who are in need of additional service for the full transport required by their physical or mental state. Additionally, it has to be considered, that only if public transport accessibility is increased continuously, a sustainable and accessible transport system with on-demand shuttles can be established and maintained [17].

Schiefelbusch [36] investigated the involvement of volunteers in public transport in Germany, stressing the need for more flexibility and the reduction of costs. In addition, he concluded that rural and periurban areas are lacking a sufficient and dense transportation service network. In his understanding specific transport needs can be best serviced in an urbanized context. Here different and more transport providers operate. He clearly supports the respective claims by Glaeser [10]. Nevertheless, Stiefelbusch [36] criticizes that most transport logics hardly ever consider the customer needs with respect to their travel preferences. Moreover, independent from the spatial reference (urban, suburban or periurban), we can widely observe a need to foster the development of flexible and user-friendly services. This could be amended by volunteer service offers. Collaboration between public and private and/or volunteer providers however, is only successfully accepted and trusted, when it is well known, promoted and made accessible to the public [36].

6 Policy Needs and Recommendations

As concluded in our previous work, an open and interoperable digital system for the integration of technologically ready partners should be fostered by public authorities, while creating incentives to enable and offer accessible transport services [1]. Based on "their mission to provide mobility instead of maximizing profit, public transport operators can foster a unified and impartial integration of services into an interoperable and open digital platform, to be accessed by customers through a single user interface, i.e. a mobile App or a responsive website" [1]. We argue, this not only fosters the integration of different services and service providers but also makes public transportation more attractive and promotes it as a valid alternative to motorized individual transportation. In parallel, public transportation authorities should take the lead in setting the standards for accessible transportation. From a customer's point of view, the better integrated a transportation system is, the smoother the travel planning and the mobility itself become. We should critically assess the question whether public or volunteer based transportation services are more appropriate and efficient in serving the different customer needs.

In this context, Schiefelbusch [36] discusses the volunteer-based paratransit services in contrast to public transportation. He criticizes the lack of integration of user perspectives when developing public transport systems. He describes the volunteer-

based paratransit system being a bottom-up service, tackling local mobility needs. These are the drivers for developing individualized and localized solutions. Similarly, Neven et al. [17] report that in the Flanders Region, Belgium, paratransit services originate from local ad hoc needs. In contrast, public transport is planned and operated based on mass transportation needs, driven by policies, urban development and occupancy rate.

Transportation policies and the development of a transportation ecosystem have to take into consideration that mobility is "actually not a matter of only providing transport. It is embedded in discourses of community life, social needs, preventing exclusion, maintaining and securing local identity" [36]. So, the digital integration of different service providers is only one aspect among others. In order to provide mobility in a transport ecosystem, additional measures must be taken in order to promote the services and to make them sustainable.

Participating in a transport ecosystem, which most likely would be dominated by public service providers, guarantees private and/or volunteer mobility service providers better marketing and operation with an umbrella branding. The individual brand identities must not be given up though. Such a common umbrella brand with established public and private transport offerings would have various positive effects for mobility services and their customers. It can be expected that in future travelling becomes even cheaper and smoother. As the specialized service for people with impairments will no longer only be provided by specialized and clearly branded service providers, but will be integrated in an overall service package, stigmatization of such users will also be reduced. Most notably trust in the service will increase. Trust in the brand of public transport operators in Switzerland and Austria is generally high and can thereby be leveraged towards the services of other providers. In summary, by visibly integrating paratransit into the transport ecosystem as a service to be used by everyone under a common umbrella brand, social inclusion of people with impairments and older adults is enhanced, beyond the cost-saving effects already described by Neven et al. [17].

Joining forces in mobility services and branding strategies, operators can pave their ways towards true Mobility-as-a-Service (MaaS) offerings. MaaS alliances and the respective projects and initiatives have arisen all over the world: Europe, USA, Canada, Australia and Asia [37]. MaaS, so the alliance, not only facilitates the access to mobility but it "should be the best value proposition, by helping them meet their mobility needs and solve the inconvenient parts of individual journeys as well as the entire system of mobility services" [37]. Furthermore, linking to what we discussed earlier, MaaS services are successfully developed and implemented along the line of new business models. Hoadley [38] claims that with MaaS personal mobility needs are best satisfied. Successful MaaS initiatives are, among others, digital pathfinders. Naturally, the importance of ICT to the transport industry is not new. When it comes to the individual mobility, from a technology point of view, various technological innovations, support people in using transportation systems [39]. Besides, smart navigation systems and online, real-time travel information, word processors to reduce the typing barrier etc. are in use as well as so-called smartcards, which guarantee free access to all means of transportation within the mobility service as well as a reduction of costs [39]. However, unifying access to various means of transportation is only the first step

towards an overall MaaS service. Hoadley [38] summarizes four requirements for a successfully realized MaaS initiative. First, mass transportation services will not cease to exist, but they will need to adapt to changing requirements with respect to customer expectations and new technological possibilities. Second, service is best provided when you know your customer, when you know what each partner in the transport ecosystem is contributing. Data, which is available and accessible in real time, helps the customer to optimize services, routes, schedules. Digital platforms are considered a key to a successful implementation of superior business models and mobility services. Third, trust is a key concern in the new business relationships. This applies even more when customers no longer directly approach service providers and when the services are promoted and sold by other partners within the transport ecosystem. Fourth, marketing is key, as customers will no longer buy a train ticket to go from A to B but will optimize their overall service experience provided by different partners. Besides improved accessibility, the extension of mobility services into the suburban and peri-urban areas, the reduction of costs, and the integration of different customer group into the transportation ecosystem are advantages of smart MaaS projects.

There are various app and platform solutions for MaaS available. For instance, an app that reduces travel costs, as only the actual travel distances is paid for. “lezzgo” is promoted by the Swiss train company BLS. Customers no longer buy fixed-price tickets [40]. With the HaCon Kids App “VBB jump”, in Berlin-Brandenburg, Germany, children are supported in their door to door travelling. Up to eight destinations can be planned in advance. When children miss a bus or take the wrong route, the app is informing their parents in real time. This app was co-developed with children [41]. In Oxford, a demand-responsive bus services was recently introduced. Via a “PickMeUp” app customers can request a pick-up at a virtual bus stop within a clearly defined service area [42]. In summary, in partnerships of different providers, customers would profit from a multimodal and intermodal transportation mode. However, Hoadley [38] clearly stresses: “Given the different circumstances in different cities and regions, it seems unlikely that a single MaaS model would be universally applicable.”

In contrast to the new possibilities of the fast changing digital technologies - with the app and platform solutions - the actual transport technologies seem to change relatively slowly. This difference in pace will become critical when industry and suppliers move beyond telematics for car-2-car and car-2-X communication as well as autonomous driving [43] towards fully integrated transportation technologies [39]. When reaching this point, policies and road infrastructure will be required to be “smart” as well.

The developments in digitization ensure that both availability and accessibility to means of transportation are improved. Yet, progress in digitization implies the potential to outrace the actual implementation of transport ecosystems. Therefore, transport operators are required to enlarge the scope and their perspective of their core business providing mobility. While physical infrastructure and vehicle change happens slowly, operators need to accept methods and concepts like agile management, as well as technologies such as autonomous driving, in order to become more flexible and to adapt faster to shifting customer needs.

Nevertheless, even though very promising innovations in autonomous shuttles are already introduced in some cities and smaller communities, these will neither be

sufficient nor will it be fast enough to solve all the challenges most European countries face. Connecting urban, suburban, periurban and rural communities sufficiently and tackle the problem of integrating people with very different mobility needs at present is best achieved with a holistic approach and by fostering public-private partnerships beyond the pure focus on transport automation [44].

7 Conclusion

In this article, we deepened and expanded our research on demand-driven mobility, covering five action areas proposed in our previous work [1]. We outlined that needs for and gains of enhanced (Last Mile) mobility of older adults and persons with disabilities align with those of marginalized persons, as well as children and adolescents. To ensure maximization of effects on personal mobility, we reviewed our analysis on Last Mile transport services and delved into information and communication needs of the customer segments. Based on our findings, we re-evaluated and deepened our previous position on the role of paratransit shuttles and policy making in this spectrum.

As public transport accessibility is increasing, on-demand paratransit shuttles are becoming an important, yet sustainable [17] component of the transport ecosystem. Fostering cooperation and umbrella branding activities, as well as opening up to new trends in technological developments, Last Mile transport service offers become more trustworthy and integrate into real MaaS solutions. By opening paratransit towards the general public within the transport ecosystem, stigmatization of customers with disabilities should be reduced, while social inclusion is enhanced.

Given these explored potentials, we propose the pilot operation of modern, accessible and ICT-supported on-demand transport service, covering Last Mile transport as well as end-to-end transport, integrated into a public transport ecosystem. Those pilots will demonstrate the mutual benefits of public transport service operators and on-demand transportation providers, which can be forwarded to their customers, supporting the achievement of a fair, available, accessible, affordable, and efficient transport ecosystem.

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