Intermodal Transport Systems as a Chance to Enhance First Mile and Last Mile Mobility of Older Adults and Persons with Disabilities
Position Paper on Action Areas for Accessible Urban and Suburban Transport

Stefan H. Ruscher[1], Andrea Ch. Kofler[2], Vincent Neumayer[1] and Johanna Renat[1]

[1]*Multimodal Mobility, Products and Planning, Department Market / Customers,*
Wiener Linien GmbH und Co KG, Erdbergstraße 202, 1031 Vienna, Austria
[2]*Zurich University of Applied Sciences, Grüental 8820 Wädenswil, Zurich, Switzerland*

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Abstract: Accessible passenger transport and personal mobility in public transportation are essential factors of Smart Cities. While ongoing transport research focuses on covering 'first mile and last mile', it lacks the perspective of the AAL domain, enabling personal mobility for older adults and persons with disabilities. Therefore, an investigation of the current situation of transportation systems in Vienna and Zurich, analysing five mayor action areas was carried out. The identified issues are highlighted thus suggesting a policy-driven approach for implementation of an accessible and intermodal transport system based on a public transport model, which is able to tackle the first mile and last mile problem for all passengers in general, as well as for older adults and persons with disabilities in particular.

1 INTRODUCTION

In 2015, the European Commission published the European Accessibility Act (European Commission, 2015), aiming to harmonise the legislation of accessible products and services. One area of activity in the implementation of the Accessibility Act is passenger transport services. In the context of smart cities, and urban and suburban development, as well as affordable and fair mobility, accessible public transport on roads and railways are of major interest for European cities such as Vienna and Zurich. Furthermore, personal mobility at home as well as in public spaces is an essential factor of independent living.

As a matter of significant importance to transport systems, especially public transport systems – defined systems of bundled demands for shared vehicles (e.g. buses, trams, metros etc.) that operate on the basis of defined schedules and defined routes, are open for service for the general public under clearly noted terms of use (Cerwenka et al., 2017), and the coverage of the so-called first and last mile (Shaheen, Guzman and Zhang, 2010). First mile and last mile transport (FMLM transport) combines services, which cover the distance between the ultimate start and ultimate destination of a journey, by bridging the distance between the last transportation hub, like a bus or tram stop, closest to the ultimate start or end of a journey. In many cases, such connections are covered by motorized vehicles like cars, scooters or motorbikes, as well as by bicycle or by walking. Yet, the availability and accessibility of these transportation modes for older adults and persons with disabilities have been of little concern to date, for both, providers as well as policy makers. Therefore, new policymaking, as well as the integration of new concepts and new technologies is needed.

FMLM transport access is a matter of offering independence and equality, and therefore, results in a reduction in discrimination, especially in cross-reference with mobility for older adults and persons with disabilities. As every single switch between transport modes in the transportation chain causes more friction, potential hassle and higher complexity, accessible intermodal transport demands higher efforts for cities and public transport providers. Research into FMLM transportation is rare in the AAL domains. Studies providing insights into the topic in a Smart City context stress a preference for cycling and car sharing to cover the

FMLM. The AAL domain, on the other hand, has not yet focused on FMLM mobility issues. With all the technological advances, facilitating an integration process is overdue. Besides, more and more private transit companies are starting to develop and innovate new services in this field. Yet, customers still face many challenges, mostly expressed by high tariffs, which make the service overall less attractive or only of use for selected user groups. In addition, their service delivery excludes user groups with special requirements arising from age or impairment. Moreover, what is valued most, is flexibility and individuality, and is hard to obtain for low fares (King 2016). FMLM is a challenge itself, and without doubt, it is even more so, when we take into consideration the different user group needs.

As outlined in previous research (Teles et al., 2017), older adults as well as people with disabilities, cognitive impairment and long-term diseases are to be considered as equals in ongoing AAL research. The big diversity of abilities and limitations as well as assistive technology in usage make FMLM transport services an even more challenging task. In contrast, especially for these groups, new opportunities for enhancing personal mobility are arising. These people are increasingly becoming used to AAL technologies and services, which should be easy to integrate into intelligent FMLM service logics (Giampapa et al., 2017).

In order to highlight the challenges and potentials of affordable and accessible public transport systems for older adults and persons with disabilities, we will first analyse currently available transportation services in the cities of Vienna and Zurich. Then we will postulate and deepen five action areas for improvement of intermodal transport accessibility in urban and suburban areas, reflecting on international best practice. We will conclude our work with a proposal for implementation of accessible intermodal transport systems as a necessity for modern smart cities.

When working in the cross-section of AAL and transport domains, an issue with the meaning of "multimodal" arises. The scientific community in the fields of AAL have investigated into multimodal ICT products and services, which accept different input and output modes, namely touch and speech, and visual and audio, in order to enable efficient system usage to a wider range of customers (Oviatt, 2003; Richter and Hellenschmidt, 2004). In contrast, transport-oriented research refers to multimodality as the concept of employing multiple transport modes, such as public transport, cars, bikes and

walking, to cover daily journeys (Bertolini and le Clercq, 2003; Litman, 2014). In order to avoid misinterpretations, the term "intermodal mobility", is used henceforth, as found, for example, in Kemp, Avelino and Bressers (2011), who describe the interchange between transport modes during a single journey.

2 ANALYSIS

Although the consciousness for barrier-free services as well as the need for inclusive transport systems has risen within recent years, barriers still exsist when accessing the wide range of mobility services provided in Vienna and Zurich. This section identifies current measures and offers in both cities, in order to define new action areas to improve accessible FMLM mobility in future.

2.1 Vienna and Austria

Vienna public transport, the Wiener Linien has put a high emphasis on the implementation of accessible public transport stations and vessels. On one hand, an easy tariff system was created, enabling all Wiener Linien tickets to be valid for all public transport opportunities within the city of Vienna, without any 'zone' borders within. Furthermore, Wiener Linien are a member of the transport association VOR, which covers the region of Vienna, Lower Austria and Burgenland has a unified tariff system, applying to trains, subway, trams, buses and selected private shuttle services (ISTmobil, 2017) alike.

On the other hand, Wiener Linien have implemented a list of criteria for development of barrier-free stations and vessels, covering requirements of persons with impaired sight, hearing and/or immobility. This catalogue covers the construction of stations, elevators and vessels, as well as communication and the display of information, assigning one of five quality levels. These levels indicate the need for assistance, aiming to maximize independent mobility on Wiener Linien. Additionally, special training courses are offered for persons with various disabilities on how to use assistive services and navigate through the stations safely.

Two types of car and bike sharing can be distinguished in Vienna: the flexible one-way car sharing, which is often referred to as "free-floating", and the traditional two-way "station-based" system (Boyaci, Zografos, and Geroliminis, 2015; Shaheen,

Guzman and Zhang, 2010). With the traditional two-way system, the vehicle needs to be returned to a designated station, vehicles of the one-way sharing system, can be picked-up or dropped-off anywhere within a defined service area. Long-term reservations are not possible with free-floating systems, as they are intended for short-term bookings and real-time availability (Boyaci et al., 2015).

Car sharing providers offering vehicles, which are accessible by wheelchairs, are available in two Austrian cities, namely Graz and Marchtrenk. While the service in Marchtrenk enables wheelchair transport (Mobiles Marchtrenk e.V., 2017), car-sharing in Graz even allows for persons with disability to drive, as the throttle and brakes are operational by hand. Reservations with both two-way systems are possible, and vehicles must be returned to designated pick-up locations. In contrast, while current car sharing offers in Vienna are available as free-floating systems as well, they do not provide the space for wheelchair transport nor hands-free operation.

Therefore, transport of older adults and people with disabilities often depends on motorized vehicles, which offer an individual scheduled service. Specialized shuttle services within a framework of (shared) pick-up and delivery services play an important role in the Viennese transport system. Taxis or transport operators provide on demand door-to-door services, fitted to the needs of older adults and persons with disabilities. There are different journey providers, either supported by health insurance providers (i.e. for medical transport needs like a doctor's appointment) or subsidised by the City of Vienna (for leisure activities). Additionally some operators like Uber offer iOS VoiceOver, Android TalkBack and wireless braille display compatibility within their Apps, which opens the service to blind customers (Uber, 2017). Moreover, all major cities, including Vienna display barrier-free parking bays on their digital city maps, easing the need for journey planning for tourists and inhabitants alike. In contrast, bicycle or scooter sharing services are not accessible in Vienna for persons with disability to date.

The mobility mode of walking is particularly used by young and old generations. In 2014, a Viennese study analysed their needs, which can be summarized in the categories safety, comfort, cleanliness and punctuality (Ausserer et al., 2014). The City of Vienna supports walking as a mode of mobility with its own agency focused on pedestrian traffic agendas. Additionally, accessible infrastructure measures such as acoustic traffic signals and tactile guidance systems in highly frequented public areas are fostered (Frey, 2015), and provided on digital city maps.

In general, the accessible intermodal mobility is very limited in Vienna, due to accessible service offers for older adults or persons with disability currently being provided by public transport operators only. Additionally, most other service offers are not available in suburban areas, which have a lower density of public transport.

2.2 Zurich and Switzerland

Beside the fact that in Zurich, as in most parts of Switzerland, public transportation is very well developed, a variety of mobility services can be reported for the city and its neighbouring communities. Most of these mobility services support older adults and/or people with disabilities, constituting on-demand services. These services are organized either by interest groups or private stakeholders, requiring a membership to benefit from reduced prices, or by private taxi companies, which have integrated such special services in their regular portfolio.

The main weaknesses of this system are the price of the services, and the lack of spontaneity, as reservations have to be made well in advance. Some of these organizations do not focus exclusively on mobility, but also support people in doctor's appointments or in their shopping activities. Therefore, the 'wheelchair taxi' has become a well-recognized mode of transportation in the city. Public transportation companies have adapted their infrastructures or are in the process of doing so to meet with ongoing demand. Similar to Wiener Linien in Vienna, they offer courses on how to use their infrastructure.

ZVV (Zurich City Lines) stresses that its slogan "Steig ein. Komm weiter." ("Board and Go Further") addresses many different user groups. They are aware of different user needs and offer various support services for older adults as well as for people with visual or walking impairments. MobilPlus, established in 2002, aims to define measures of how to guarantee people with impairments access to information and mobility services (Zürcher Verkehrsverbund, 2002). Thereafter, in 2014, the ZVV stated that by 2024 all built infrastructure needs to be adapted in general (Zürcher Verkehrsverbund, 2014). One key statement is that accessible mobility only makes sense if people can independently get on and off

transport vessels indepenantly. With the exception of the local train service, they should be able to achieve this goal in Zurich. With the promise by 2014, i.e. 74% of all streetcar stations have been made accessible, but only 65% of the local train service stations.

Safe walking for older adults has become an issue of concern in Zurich too. '*Fussverkehr*' in particularly is engaged in training older adults not only in how to use ticket machines, but also how to cover walking distances, i.e. walking from home to the grocery store safely. Moreover, both, older adults as well as car drivers are advised on how to act accordingly in mutually used public space, in order to keep pedestrians safe. The organization attempts to promote safe walking for older adults and seeks to strengthen its awareness for the needs of pedestrians in general (Fussverkehr, 2017).

In the 'Stadtverkehr 2025' report, the city of Zurich stresses the need to reduce individual motorized traffic and to support projects and initiatives that foster safer cycling and pedestrian mobility. Yet, there is still a lack of adequate city bicycle routes, which is considered one of their biggest challenges (Stadt Zürich, 2017).

For motorized individual mobility, 220 barrier-free parking bays are available in Zurich alone, with over 9000 in Switzerland. An interactive platform informs users on their availability. People living and working in the city can make suggestions about where there is a need for more bays.

Besides, car-pooling and car sharing have both become very popular Switzerland. At present, three very strong and well-known car-sharing companies and more than ten car-pooling services are offered in Switzerland. With adequate promotion and vehicle accessibility, this would be the perfect offer for people with reduced mobility.

3 ACTION AREAS

Based on the findings in Vienna and Zurich, a gap analysis was conducted, comparing the current situation with the optimum of an affordable, available, accessible and fair transport system for both customers and operators alike. During this process, five action areas enabling accessible FMLM transport in this optimal transport system were identified: expansion of service areas for mobility services, establishment of on-demand services, improvement of service accessibility, integration of medical shuttle services into the public transport system, and policy making for a suitable framework.

3.1 Service Area

The first major action area is the expansion of service areas towards suburban districts, where the public transport service density is lower. 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 (Stadt Wien, 2016). Yet, leading bike and car sharing services are primarily available around the city center, where the subway is also operated. In the outer districts, where only a few bus lines are available, hardly any sharing opportunity can be found. Especially these suburban areas with high a percentage of older adults would benefit most from the expansion of the service area for accessible mobility services, whilst also tackling issues of marginalisation and social isolation within this population group, which was highlighted in previous research (Ruscher et al., 2018).

The issue of sharing, however, requires a suitable level of management. For free-floating fleets to be utilised, journeys are required to be made available within close distance of the customer through demand prediction (car2go, 2017). Yet, demand prediction becomes harder, as fewer customers are using cars more infrequently, as it is likely for older adults and persons with disabilities in suburban areas. Even worse, station-based sharing would suffer from low station density similar to public transport, and the need for redistribution of journeys between stations. Therefore, newer innovative business models are required.

In Switzerland, the situation is slightly different. It is less a problem of availability of service, rather than of non-transparency of their field of activities and tariff models. Services are rather regionalized and bound to canton logics, instead of a unified tariff system as in the region around Vienna. People living in the outskirts of Zurich City might be better off searching for a transport service in the neighbouring community or even the canton itself than with the cities mobility services. However, those would ask for higher transport fares, as they need to operate beyond their usual service area. Furthermore, there is a challenge of integrating the various service providers into the transportation system. Currently, a FMLM journey might cost ten times the price of a journey by public transport, which in comparison is far longer. Therefore, an integration of private operators into the regional tariff model as demonstrated in Austria is required.

As observed in Vienna, mobility services in Zurich usually only offer a limited service area

inside the city, where they operate their fleet. To make mobility services more flexible and cheaper, they would be required to further expand their fleet within and beyond the city's central boundaries.

3.2 On-demand Services

An alternative to sharing systems for the provision of accessible and economically justifiable mobility services would be pooling services, similar to those offered by Uber. Setting up accessible on-demand services in urban and suburban regions would primarily target the needs of persons who require assistive devices. The option to cover FMLM with specialised pooling shuttles enhances personal mobility, while keeping mobility itself affordable.

With the introduction of autonomous vehicles in road traffic, further steps towards accessible mobility will be achieved. While on the one hand, self-driving cars enhance individual mobility of persons who cannot drive or operate a car (Litman, 2017), space currently occupied by steering wheel, pedals and gear stick can be freed for assistive technology in autonomous shuttles, on the other hand.

Yet, while car-sharing operators are already considering conditions and preparation measures for successful implementation of shared autonomous cars (car2go, 2017), no evidence on the planned provision of accessible autonomous vehicles can be found.

3.3 Improvement of Service Accessibility

While the ongoing activities for barrier-free public spaces and public transport vessels are fostered in Vienna and Zurich, other areas relevant to personal mobility need to be improved. As already pointed out, currently available ride sharing opportunities in Vienna, as well as in Zurich do not use the full potential of being accessible to older adults or persons with disabilities.

One promising approach for improved accessibility is currently being tested in Switzerland: A specific car-sharing model was launched by Europcar Switzerland and Stiftung Cerebral. In four Swiss cities, a VW Caddy can be rented, enabling wheelchair transportation. Currently, three stations for renting these cars are available in Zurich. The price is very attractive when compared to other similar offers, and the renting service is rather flexible. While car-sharers have already recognized the need of automatic gear and manual control

vehicles on an international level, similar services still need to be fostered in Austria and Switzerland. Another option for improved flexibility can be found in a car sharing service in Austria, offering drop-off and pick-up of rented cars at the customer's home under certain conditions (Dr. Hartl Autoverleih, 2017).

Best practice from the US show that bike-sharing systems also bare potential of enabling and enhancing mobility for riders with disabilities. Since 2017, the City of Portland has provided an adaptive bicycling pilot based on customer wishes, providing a staffed-service with support for wheelchair storage and assistance including fitting. The piloted adaptive bike-sharing system fulfils customer wishes and promotes cycling accessibility for everyone (Maus, 2017).

Besides physical constraints, the digital accessibility of a transport system is another important factor (Giampapa et al., 2017). Schreder et al. (2012) point out that even ticket vending machine interfaces can drastically reduce accessibility to public transport. Though high interaction complexity, customers are prevented from buying tickets and therefore from using public transport.

With ongoing digitization, public transport operators, as well as sharing services offer mobile applications to inform customers and enable access to service offers (Giampapa et al., 2017). Nowadays, a wide spectrum of Apps, providing different pieces of information and service in varying digital accessibility levels, are available. Nevertheless, some of these services have not taken into consideration that people with impairments might be potential customers.

In Vienna, Wiener Linien currently offers three different Apps, one for public transport scheduling information, one for ticketing, and one for intermodal mobility. While the clear goal of unifying these three services into one overall digital solution called WienMobil is promising, a thorough integration of trip planning, routing and booking for other mobility services like car sharing is subject to provider policies. In Zurich, ZVV also offers digital solutions. Mobility Apps provide information on travel routes and potential barriers at stations while guiding the boarding process. A screen-reader facilitates the reading of its website. The ticket machines offer enlarged viewings, audio responses or redirection to customer service, for assistance with travel arrangements.

Centralising and enriching this digital information, ticketing and booking services of all mobility modes into a single accessible digital solution, built on Universal Design principles

(National Disability Authority, 2014) and the WCAG 2.0 Guidelines (Caldwell et al., 2008) would foster personal mobility for older adults and persons with disabilities.

3.4 Integration of Medical Shuttle Services

Several operators in Vienna as well as in Zurich offer services, which are classified as medical transport services, providing shuttle services for various purposes in order to facilitate transport for persons with mental and/or physical impairments. These shuttle services operate a door-to-door service for persons who need medical treatment while being prevented from public transport usage, but not necessarily dictating transport by emergency services, e.g. due to the necessity of recumbent transport. They offer a transport service which enables participation in rehabilitation programmes, or a school-and-work shuttle especially for children and persons with mental or physical disabilities.

Different service areas of such shuttle services are subject to different financing models, depending on the actual need of their passengers. For medical purposes, public health insurance companies provide a basic service offer, which is accompanied by a so-called prescription charge paid by the user. For shuttle services for school pupils and employed people "Fonds Soziales Wien", the administration of social services in Vienna, financially covers operations on a local level. In Zurich too, all kinds of interest groups offer distinct services to user groups for which they receive reimbursements by insurance companies or other social stakeholders. Their service model relies on a huge portion of shuttle services covered by in- advance planning and scheduled transport. Only in the context of school shuttle services, a current pooling of transport can be observed.

On a daily basis, medical shuttle services operate as car-pooling services, simultaneously collecting clients, taking one-direction journeys. Especially for school and job shuttle purposes, the efficiency of the transport, as well as car occupancy rate, is acceptable. Nevertheless, all these shuttle services show no integration into the public transport systems, neither in Vienna nor in Zurich, in order to fulfil, if feasible and practical, coverage of the FMLM within a multimodal transport network. All these shuttle services present themselves as being aimed at one specific user group, for one specific purpose. Currently, booking and information exchange processes are only conducted via phone or

an online application portal by private persons or by partner entities (hospitals, schools, etc.). An integrating control center for coordinating and bundling such services has been decided upon, and will be established in Vienna shortly.

Despite enabling mobility to persons with disabilities, there is no further integration of medical shuttle services into any other public transport related network or intermodal transport chain. Comparable systems though show opportunities to improve the overall accessibility of the transport system. As mentioned above, VOR transport association appoints a tariff system, to which every public transport operator is required to adapt. An integration of medical shuttle services into this system, accompanied by comfort surcharges, as demonstrated by the private shuttle service ISTmobil (ISTmobil, 2017) may guarantee transparency in pricing and tariff policies, while raising opportunities for technological upgrades for customer to company communication.

Without a doubt, medical shuttle services offer quality transport including personal assistance, which therefore minimizes the discrimination of passengers with impairments. Nonetheless, they bear no parallel operational structures in door-to-door transport, which shows considerable potential for further efficiency gains. Through targeted staff training, they also offer the possibility to cover specialized transport needs, which are rarely offered by other transport companies, and a good understanding of their passenger's needs.

3.5 Policy Framework

While the action areas above describe measures affecting the transport system and operators directly, the fifth action area, policymaking is in need of a suitable framework for successful implementation of an accessible transport system.

The city of Vienna defined the mission statement "new mobility for Vienna" in 2013 and declared availability, affordability and accessibility for everyone as their main goals of mobility planning. The majority of projects implemented bearing this mission statement were related to E-Mobility, renewable energy, as well as intermodal routing services – accessibility was only partly covered in terms of digital integration of mobility providers (Wiener Modellregion, 2013). As no more projects are planned with the support of "new mobility for Vienna" with the funding period ending in 2016, there is currently no framework in Vienna addressing accessibility as a main goal for mobility

planning. Besides, the mission statement of the municipality's ministry of transport regarding innovation and technology states usability and accessibility for sustainable forms of transport as key drivers of future mobility (BMVIT, 2017).

As stated earlier, Zurich also has to meet certain legal standards within the next decade. By 2024, both the city and the trans-regional transport requires adaptation to meet the requirements of the national equality act. The above-described measures do express the attempts of the city of Zurich. Besides, more and more discussions are observed - with respect to artificial intelligent developments - also on the governmental side. In a most recent governmental statement, the Swiss government stressed that self-driving transport means a combination of other effects of digitalization to guarantee a more efficient and reliable FMLM service. If this possibilities were integrated into other service models e.g. the car-sharing model, it would be an asset for all parties involved. In its evaluation, the government also assumes that the boundaries between individual and public transportation might cease to exist. However, this would also ask for new concepts in the public transportation sector (Auto-Mobilität, 2016).

4 CONCLUSIONS

In conclusion, it can be argued that two different actions need to be fostered by both policies, as well as utilizing research activities. First, existing logics, services and initiatives need to be examined more closely from the AAL and independent living perspective. Second, new technologies, with that new service logics (or even transport ecosystems) would improve the FMLM mobility of older adults and people with disabilities.

Let us first focus on the five action areas discussed earlier. These five action areas for accessible intermodal transport are key to personal mobility, a solution for the FMLM problem, and independent living for older adults and persons with disabilities, who have been postulated to be of utmost importance. When harmonizing these areas, a clear goal for future smart cities can be described: governments will be required to produce policies, which foster accessible intermodal transport, based on public transport, and enhanced by on-demand services. With sufficient policies and incentives, accessible service offers can be established and integrated into public transport systems and tariff models, in order to maximize personal mobility of

older adults and persons with disabilities. By additionally offering procurement for specific service areas, and enabling a unified open platform for booking, cities will enable on-demand shuttles, which are specialised for the needs of older adults and persons with disabilities. This would improve the FMLM mobility especially for those living in suburban parts of the city, but also for those living in the city centre.

The proposed approach fits well with smart city goals, like those of the City of Vienna, enabling available, affordable and accessible mobility for all citizens. In order to implement a sufficient intermodal transport system, public transportation is accepted as being the essential backbone of urban mobility as well as the perfect operator of digital and intermodal mobility solutions (Jonuschat, Stephan and Schelewsky, 2015). Therefore, public transport operators would also be the most relevant stakeholder in the implementation of an accessible transport system, acting as a paragon and a lever at the same time. By integrating scheduled and on-demand, station-based and free-floating service offers into their existing transport network.

This consequently leads to the second observation stressed above. With their mission to provide mobility instead of maximising 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. In contrast, private, for-profit companies often tend to ignore digital accessibility, and lack open data (Giampapa et al., 2017). A public transport provider offering a user interface built with respect to Universal Design and WCAG Guidelines, would enable all its customers, but especially older adults and persons with disabilities to achieve independent mobility in urban and suburban areas.

Therefore, an open and interoperable digital system for integration of technologically ready partners should be fostered by public authorities, while creating incentives to enable and offer accessible transport services. Funding opportunities and facilitation by digitalization in the passenger transport system will then support further amalgamation of public transportation and on demand services as mainly privately organized forms of transport, solving the FMLM problem for older adults and persons with disabilities as well.

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