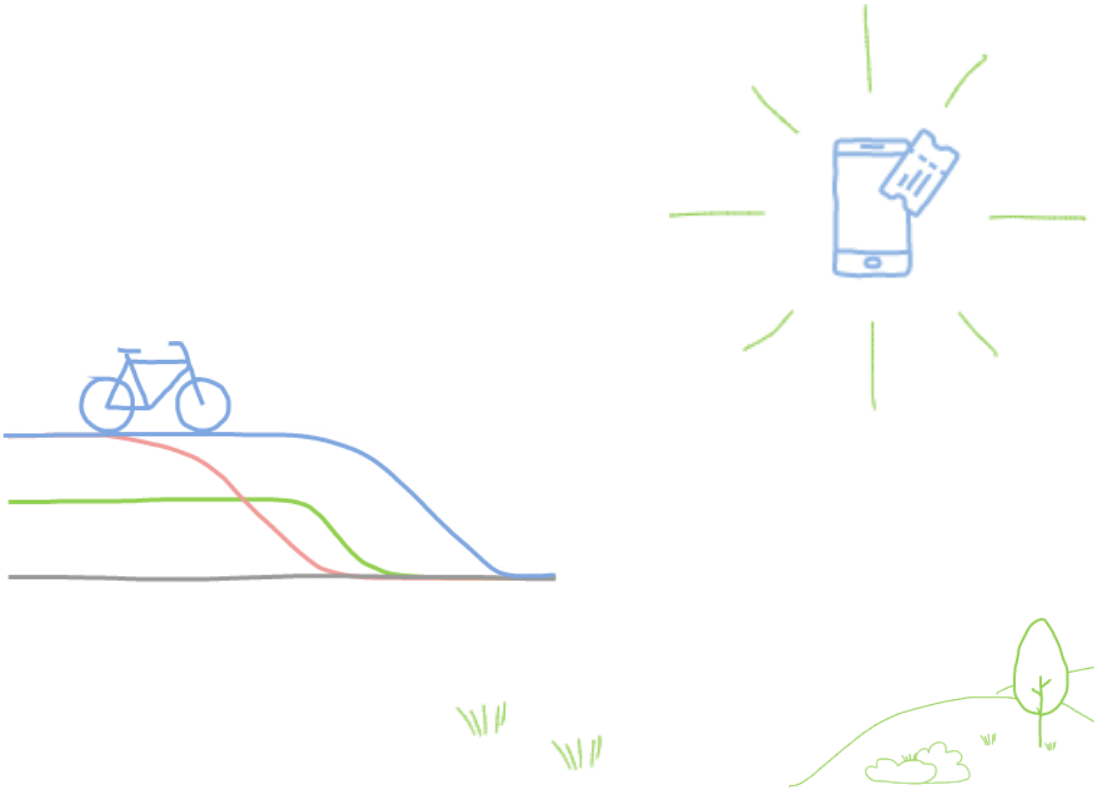
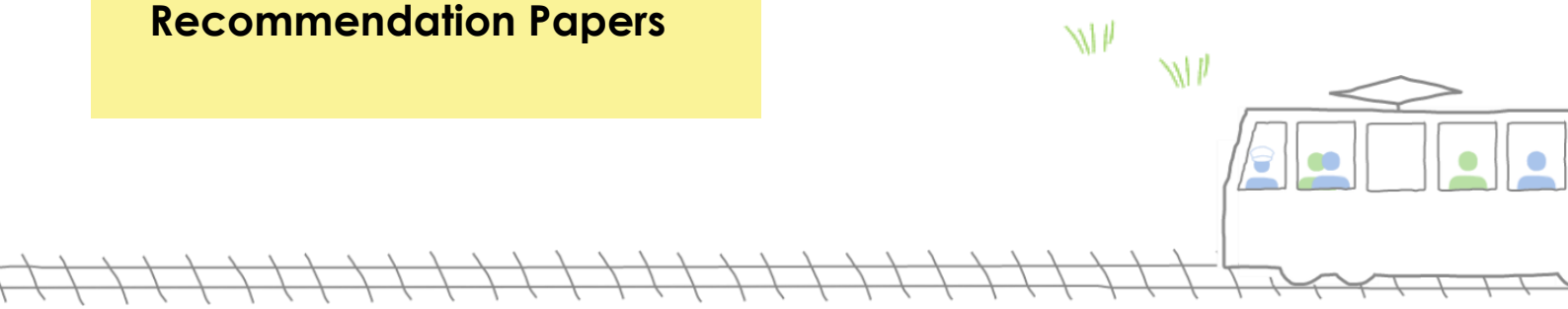


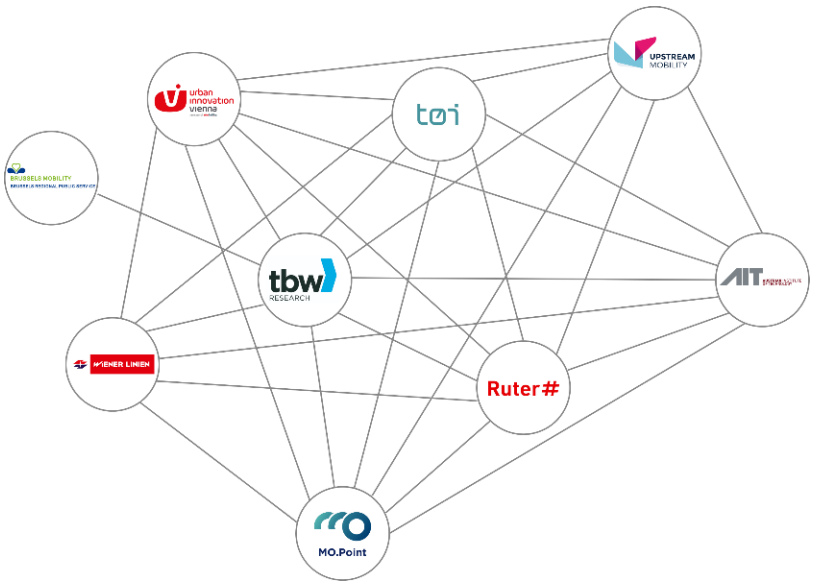
OptiMaaS

Optimised Mobility as a Service

Holistic mobility solutions for the urban periphery

Recommendation Papers





OptiMaaS Research Consortium

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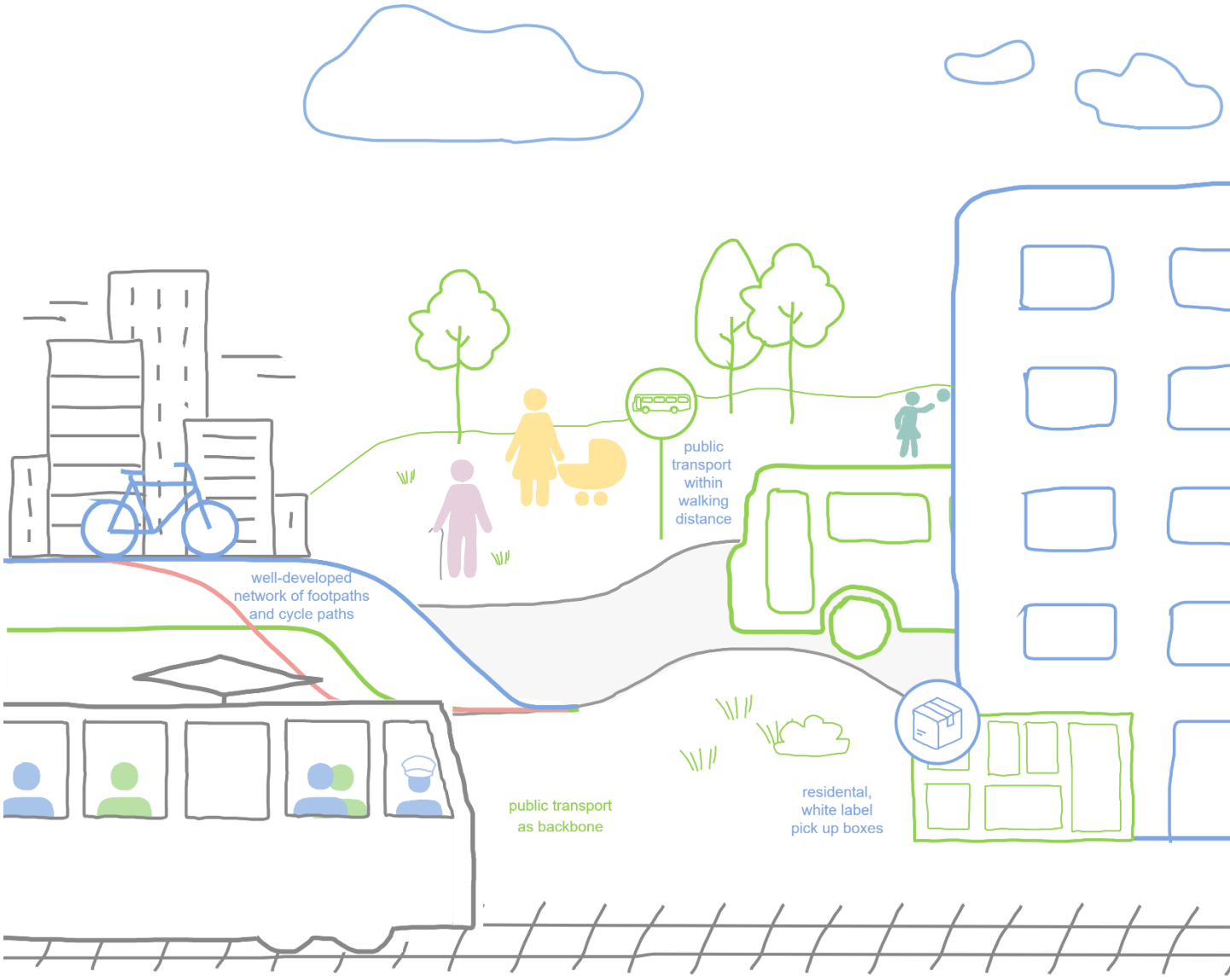
WRITING TEAM
Angela Muth, tbw research
Anna Wadström, Ruter
Benjamin Biesinger, AIT - Austrian Institute of Technology
Bianca Humer, Upstream Mobility
Bin Hu, AIT - Austrian Institute of Technology
Cyriac George, TØI – Institute of Transport Economics, Norwegian centre for transport research
Gerald Franz, UIV Urban Innovation Vienna
Thomas Vith, UIV Urban Innovation Vienna
Stefan Arbeithuber, MO.Point
Vincent Neumayer, Wiener Linien

GRAPHIC DESIGN AND LAYOUT
Daria Vidak, tbw research

PROJECT LEAD
Angela Muth, tbw research

CONTACT
Grünbergstraße 15, Stiege 1, 5.Stock, 1120 Wien
email: office@tbwresearch.org
https://tbwresearch.org/
https://www.optimaas.eu/



OptiMaaS – Vision for urban periphery (tbw research, 2021)

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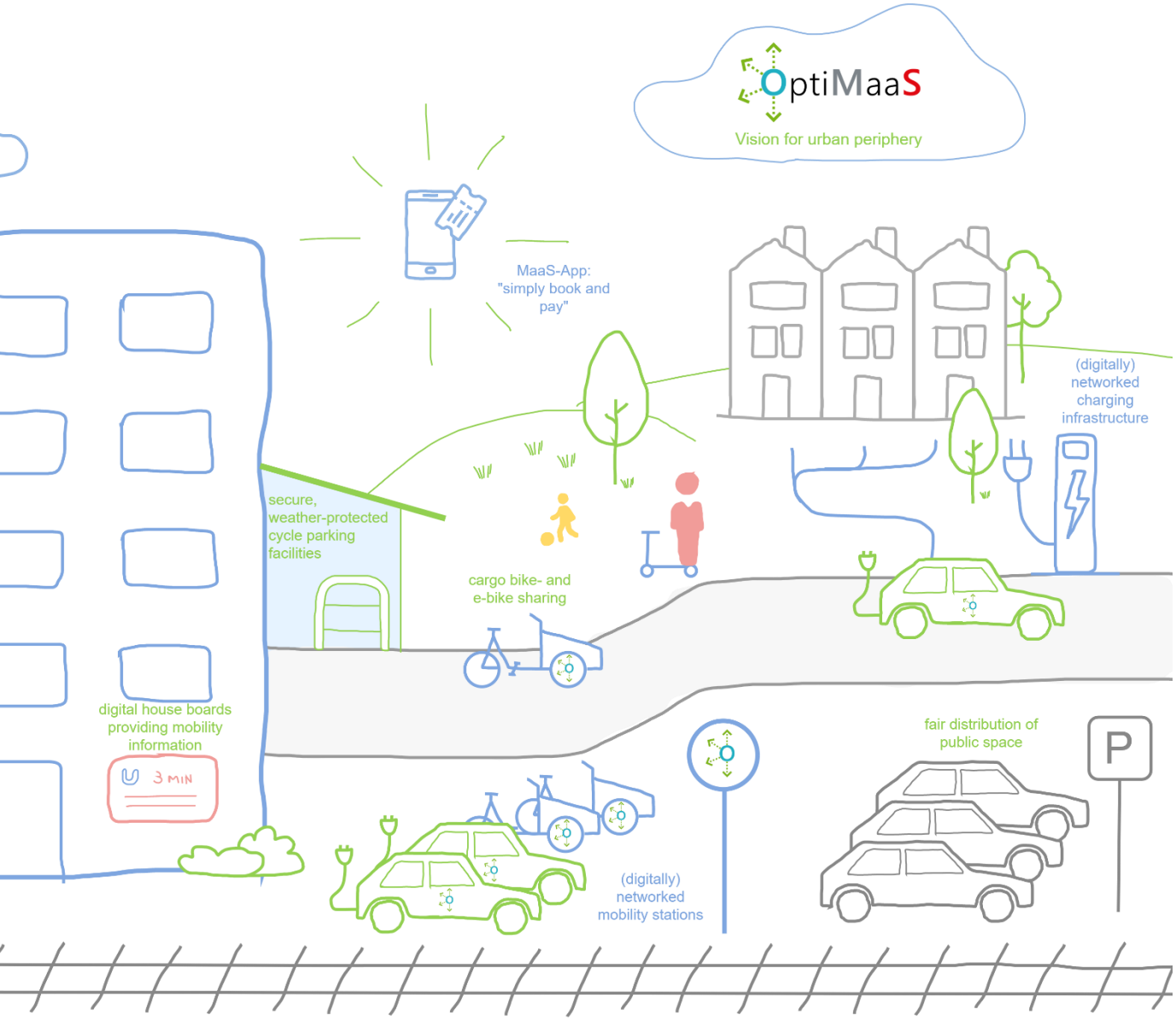


CONTENT

ABOUT THESE RECOMMENDATIONS

The objective of these policy papers is to provide an accessible text which breaks down the complexity of the development and maintenance of Mobility as a Service (MaaS) into 'bite-sized pieces': a selected number of recommendation papers which is not exhaustive regarding all issues and concerns. These insights can be seen as entry points for urban policy makers, practitioners, property developers, mobility planners, transport service providers, the research community and all other urban actors. The recommendations should inspire every stakeholder group to see their opportunity on the way to a sustainably changed traffic system.

RECOMMENDATIONS FOR READERS

› besides policy makers each paper has one or more addressee/s, these are titled in the green recommendations box at the very beginning of each paper.

Author: Angela Muth

WHAT IS MAAS?

When we are talking about "Mobility as a Service" (MaaS) everyone has a picture in mind. Often it is reduced to mobility apps, where you can book (and pay) different modes of transport with one click. In the research project OptiMaaS, we had these apps in mind as only one aspect of the MaaS-universe we were addressing in our research.

WHAT: SHARED MOBILITY, ON-DEMAND MOBILITY

Besides the classic public transportation MaaS wants to integrate a diverse set of mobility offers. Therefore, the physical availability of any kind of alternative mobility to the private automobile is a prerequisite for the (digital) integration in a MaaS-system. This includes shared mobility offers (e.g. (e-)bikes, (e-)cars, e-scooters) but also on-demand mobility, where the service does not follow a strict timetable, but can be booked and used when needed and even shared dynamically coordinated.

„Mobility as a Service must serve as a means to the end of achieving sustainable mobility!"

Angela Muth

WHY: SUSTAINABLE TRANSPORT SYSTEM

Shared mobility and on-demand services have the potential to increase the attractiveness of eco-mobility, improve last mile sustainability and reduce dependency on motorised private transport.

WHERE: MOBILITY STATIONS

Whereas MaaS-offers do not per se need to be bundled at specific locations, we still see that physical mobility stations/hubs/points do offer big efforts: visibility and connectivity.

HOW: MAAS APPS

The digital integration of different mobility services is based on an app-based integration. Usually the app is the frontend to the users and for them it does not make much difference if it is a webapp or a stand-alone android/iOS app. The complex digital (legal, financial, and organisational) integration should be invisible to the user. This underlies two implications: 1) the user should be offered a (virtual and physical) one stop shop and 2) the IT-integration in the background involves many stakeholders and interests.

WHO IS INVOLVED IN MAAS-OFFERS?

Within OptiMaaS we followed a user-centred-integrated approach. This means within our considerations we always focused on the users and their needs. To evaluate how to reach optimal and sustainable MaaS offers we were looking at: urban planning policies, the business perspective of public and private transport service providers (TSPs) and MaaS-app-

development. In connection with that we did research on the impact of different mobility measures. Still the above mentioned are not all MaaS-involved stakeholders, but within the policies of these layers we could find out, that all additional stakeholders could be addressed – for a successful implementation of MaaS – especially in urban peripheral areas.

OPTIMAAS FOCUS AREAS

URBAN PERIPHERY

The spatial structures of urban peripheral areas favour motorised private transport; often the car is the most convenient choice as parking is usually for free and there are enough parking spaces. The offer and quality of public transport is often less extensive than in inner-city areas. Cycling and walking routes are often less attractive, and distances are longer. Urban peripheries are less densely populated compared to core cities, leading to lower demand for shared mobility and on-demand services. This is why within OptiMaaS we were focusing on the challenges of the urban periphery (we use this term equivalent to urban non-core areas) and how to overcome them, when it comes to the implementation of MaaS.

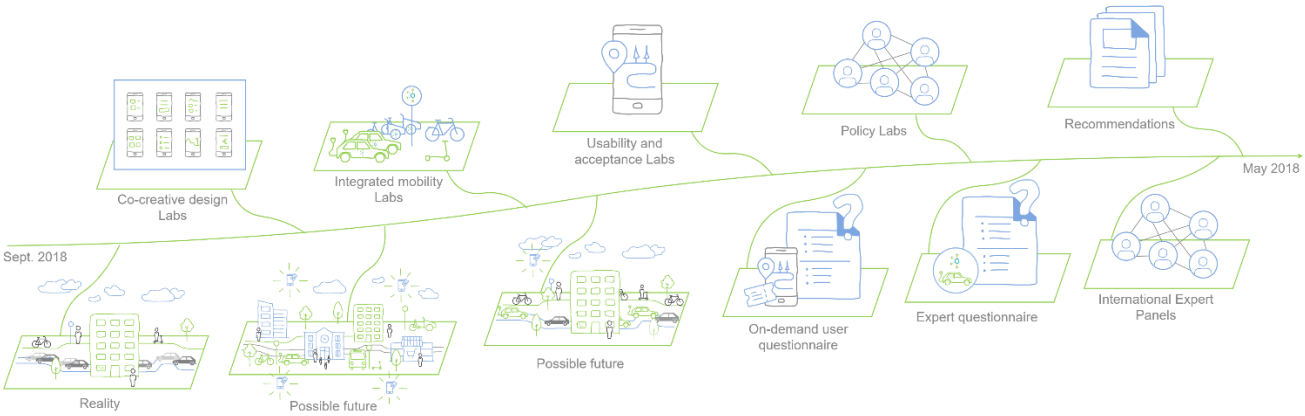
VIENNA AND OSLO

Within different labs in Vienna (and Salzburg), Austria and Oslo, Norway we analysed existing and new practices and their influence on mobility behaviour in urban peripheral areas.

MOBILITY, RESEARCH, URBAN CONCEPTS

When it comes to mobility research the terms accessibility and affordability are big "promising" terms. For quite a long time this "only" meant how many destinations (e.g. work, shops, schools) can be reached in a given time by car or by public transport. The relatively new concept of a 15-minutes-city now replaces the previous call for mixed-use cities (ref. to the concept of the 1980s "Stadt der kurzen Wege"). This concept is focussing on accessibilities via non-motorised modes-, public- and other shared modes of transport. This is why such a concept also addresses the reduction of the car ownership rate. With a reduced "need" for a private automobile the attractiveness of shared modes rises. This is why we see a big supplement of the two concepts MaaS and 15-minutes city.

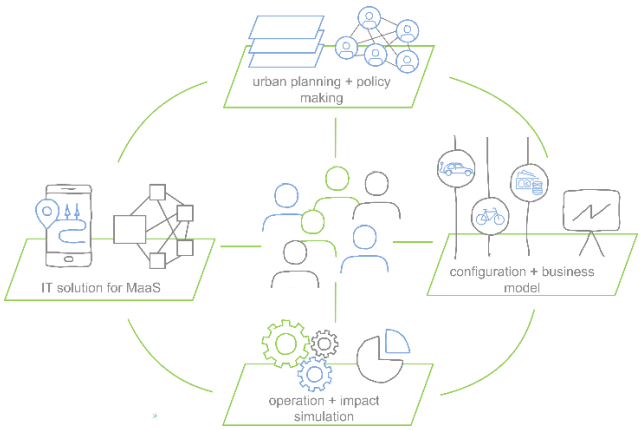
Generally speaking, we want to reduce the overall mobility demand, which consists of all the trips the population needs to perform each day. Ideally, we want to reduce the amount and the length of these trips. In addition, we want to reduce the number of trips performed by motorised individual transport - private cars.



OptiMaaS – Methods and timeline (tbw research, 2021)

USER-CENTERED INTEGRATED APPROACH

When it comes to the implementation of any kind of mobility system, we strongly suggest putting the diverse users and their needs in the centre of all considerations – please refer to SIMPLICITY – A USER'S CHOICE. Non the less when we come to giving suggestions or even recommendations, the "users" are professionals and experts who need insights to different layers of e.g. city planning, a transport system and, business models. Therefore, we are working with different "layer-visuals" in these recommendations.



OptiMaaS – Integrated approach (tbw research, 2021)

POLICY

From September 2018 on up to May 2021 we were using methods like back casting (what do we need to do and when to reach a desired future?) in policy labs, within our international expert panels but also by use of simulations. Thanks to these labs we found out how the given structures work – please refer to OFF THE BEATEN TRACK: OPPORTUNITIES FOR CITIES TO STEER MAAS IN THE CITY'S PERIPHERY - and how different stakeholders can be supported – please refer to NEW OPPORTUNITIES FOR PROPERTY DEVELOPERS FOR COOPERATION WITH MOBILITY PROVIDERS, PUBLIC AUTHORITIES AND USERS.

To sum up this process with the main insight: don't make the mistake to think that only using "popular" steering instruments will lead to a transformation towards a sustainable transport system – make use of carrot and stick!

IS IT ALL ABOUT THE MONEY?

When it comes to the implementation of new transport services of course money is one important issue, at least if you want to follow the "leave it to the market"-strategy. Private TSPs will and can only offer their service in areas where sufficient users can be addressed to maximise profit. Therefore, even in more peripheral urban areas additional mobility services (to public transport) need further supporting structures. Please refer to CAN WE STEER MAAS SCHEMES? SHARING AS A BUSINESS MODEL - HOW TO SET PLAY RULES FOR TRANSPORT SERVICE PROVIDERS?.

PLACE MATTERS!

When it comes to designing new mobility points (or stations/hubs) many surrounding factors are influencing the future use of services. Vice versa do different services attract other user groups. IT-simulation and data review can help finding optimised solutions – please refer to SIMULATING THE IMPACT OF MOBILITY MEASURES WITHIN AN AREA.

VISIONING AND SIMULATIONS

How do we get to an evidence-based decision support?

In this field we probably learned most during this project. The users of simulation models are data-experts. A missing element between data-experts and planners or policy makers are communication experts. The visual design of simulation data could help a lot in the future, when it comes to using research results or prototypes. Non the less, how to come to those impact simulations you can read in LOCATION OPTIMISATION OF MOBILITY POINTS - WHICH OFFERS FIT WHICH SURROUNDINGS?.

PERSONAS AND REAL USERS

Personas are fictional characters created to represent a target group or audience with its different user (arche)types, which are built around observed behaviour patterns among real people. Each persona is representative of a segment of the target group (Brunello

2018). We used this method especially for the development of an on-demand prototype app. Therefore, we also used real users (fitting closely to a stereotyped persona) for co-creating and testing within different lab scenarios – please refer to HOW CAN ON DEMAND MOBILITY AFFECT USERS' CHOICE?.

DO WE PROMISE SOMETHING THAT COULD NEVER BE PROVEN?

Last, but not least we are having a short discussion on why and how MaaS can make a difference when it comes to sustainability – referring to the 17 sustainable development goals (SDGs) of the United Nations, 2021 – please refer to MAAS AND SUSTAINABILITY. There we lay down, that there is no one single (MaaS) solution that fits all cities. Further evaluation, research and simulation "can enable planners to evaluate MaaS measures in a virtual environment across multiple contexts".

POLICY RECOMMENDATIONS

› the blue recommendations box at the end always addresses policy makers.

SPECIAL THANKS

I personally want to thank the **whole project-team** that made our project work so goal oriented, efficient, sustainable, and even fun!

Special thanks to all **board members/ the writing team**, it was great working together with you!

Further, we want to thank the **numerous users and experts** that gave us their insights and thoughts on MaaS during our diverse *Labs, questionnaires, and international expert panels (IEP)*. Special thanks go to **Renate Kinzl** (Zielgebietskoordinatorin, Stadtquartier Muthgasse, Stadt Wien), during our preparation sessions and Policy Labs, as well as part of the IEP we had so many insights to bring the simulation and communication on research results big steps further.

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OFF THE BEATEN TRACK:

OPPORTUNITIES FOR CITIES TO STEER MAAS IN THE CITY'S PERIPHERY

Cities around the globe are working on policies to establish MaaS solutions. While some are more advanced than others, it appears to remain a challenge for all to establish MaaS in an urban environment that is geographically peripheral. As MaaS touches a lot of different policies and affects various stakeholders, it can be difficult to identify the key issues. While some challenges are local in character, we argue that there are some common issues that need to be addressed across contexts.

RECOMMENDATIONS FOR PUBLIC ADMINSTRATIONS: How to start

› Get an **overview of the relevant public and private players,** if not done already. Enter into a **dialogue**, where **cooperation** is useful or where there is better **understanding** of those actors' **perspectives**.

› Examine if the existing **governance structures** (working groups, etc.) are sufficient, or if it might be necessary to start new **formats** and create new **responsibilities**.

› Depending on how advanced MaaS is in your city, start **strategizing on how MaaS would be established** – or work particularly on the issue of **peripheral urban areas**.

› Look at MaaS in peripheral areas in an **integrated way** and check what would need to change in your city for MaaS to meet the right foundation to thrive on.

› **Learn from others**: Connect with other cities and city networks. Many challenges show similarity in different cities. You do not need to invent a new wheel.

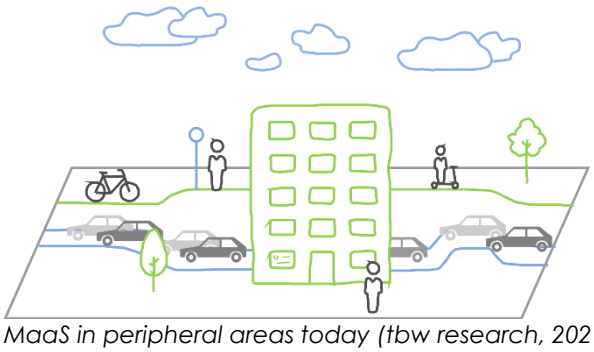
Authors: Thomas Vith, Cyriac George, Vincent Neumayer, Gerald Franz, Angela Muth

APPROACHING MAAS FROM A POLICY ANGLE

MOBILITY IN PERIPHERAL URBAN AREAS

While we sometimes get glimpses of the often envisioned and proclaimed post-carbon, vibrant and healthy urban (mobility) future, those are usually limited to a few places in a city's centre or to selected lighthouse projects in peripheral parts of a city. They are small islands in an ocean of car-dominance, that is currently fossil-fuelled.

When we look at urban non-core or peripheral areas in Europe, people mostly have very car-dependent mobility patterns. While to some degree a matter of personal preference, it is often the case that in those areas the availability of public transport is reduced or limited, and the attractiveness of walking or biking is comparably low. The ideal of the "city of short distances" (or "15 minute city" as it has been called more recently) is generally hard to find in peripheral urban areas. Malls and large-scale supermarkets surrounded by giant parking lots dominate those areas. As a result, the distances to meet even the most basic needs of everyday life are often very far.



MaaS in peripheral areas today (tbw research, 2021)

In this respect, the overall attractiveness (or necessity) of owning and using a private car appears to be higher than to not do so. Moreover, if financially feasible, households often own more than one car (VCÖ 2021). For European cities, this situation appears to be so common that to some degree it is considered as an almost "natural" and somewhat inevitable situation. However, it should not be overlooked that this is largely shaped by the existing policies and laws. We propose that this situation could also be changed by setting up the right framework conditions.

WHAT ARE WE LOOKING AT?

Ultimately, a mainstreaming of MaaS would mean a fundamental change in the mobility system and in user behaviour. That is why MaaS touches so many different aspects of public policy and administration. Often the focus appears to be on technical issues or the provision of transport services. While those issues are very relevant, the aspect of governance and policy-making shouldn't be overlooked.

In this text we define public policies as "a set of interrelated decisions taken by a political actor or group of actors concerning the selection of goals and the means of achieving them within a specified situation where those decisions should, in principle, be within the power of those actors to achieve" (Jenkins, 1978, p. 21). Policies aiming at steering Maas will have to take enabling or incentivizing and restricting components in account.

CHALLENGES AND OPPORTUNITES

Despite having a higher potential for mode shift and reduction in car ownership, peripheral urban areas are facing various challenges when it comes to the introduction of new forms of (shared) mobility. In this paper we are trying to shed some light on the complexity of mobility planning and its consequences for MaaS in urban non-core areas. Building up on this, the paper will provide recommendations on how to draft policies in order to achieve viable MaaS solutions in peripheral parts of a city.

NAVIGATING IN A COMPLEX ENVIRONMENT OF PLAYERS AND ADMINISTRATIVE LEVELS

Steering MaaS in an urban environment is challenging, because there are a diverse set of stakeholders and consequential developments on both the national and international levels, as well as the municipal and local levels.

MaaS in a simplified, but complex stakeholder network – further details on planning layers please refer to NEW OPPORTUNITIES FOR PROPERTY DEVELOPERS FOR COOPERATION (tbw research, 2021)

Looking at the stakeholders first: There is the city administration itself, with its long-term goals and strategy documents, generally oriented towards some variety of sustainable development (SUMPs, urban development masterplans, etc.). City administrations often have an incorporated public transport authority that executes rules and issues permits. Then there are the political policy makers, which have their own agenda, to which MaaS might be a useful addition or not. Regarding mobility providers, there is usually some kind of (semi-)public transport operator, often with strong ties to the city and able to look back at long years of service. There are the private mobility service providers, which can be local companies, but are often branches of international corporations. We also notice that property developers are emerging players in the field of mobility – please refer to NEW OPPORTUNITIES FOR PROPERTY DEVELOPERS FOR COOPERATION. Finally, there are also the users, with their countless individual perspectives, needs and preferences.

As there is more and more attention to the concept of MaaS, efforts to promote the development of MaaS are materialising at the European level. Also, national governments often have their own aspirations to promote standardisations (cf. MaaS made in Austria).

CREATING THE CONDITIONS UNDER WHICH MAAS CAN WORK

While MaaS is one piece of the larger puzzle of creating more sustainable mobility patterns in peripheral urban areas, it cannot be stressed enough that it needs to find the right environment. Other issues, such as access to high quality public transport offers, suitable infrastructure for active mobility, restrictive parking policies, or easy access to daily necessities are highly relevant. They form the basis on which MaaS solutions can thrive. For inhabitants of peripheral urban areas, a MaaS scheme will ultimately have to compete with the use and ownership of a personal car. Therefore, MaaS can only have a chance if the alternatives to using a car are attractive.

„MaaS offers new opportunities for cities working towards a climate-neutral and socially inclusive mobility system."

Thomas Vith

PARKING PROVISION

The importance that the availability and the price of parking has on individual mobility behaviour is increasingly gaining the attention of practitioners and policy makers. There is ample research spanning decades that show that restricted availability of parking promotes sustainable mode choices (Christiansen et al. 2017, Sprei et al. 2020).

Having a guaranteed parking spot in front of the building or in a garage under it are a major appeal for car ownership (and use, in consequence). Low prices form another significant incentive. Currently, the availability of parking options is to a high degree a matter of local policies. The presence of parking spots in public streets might follow a clear guideline or case-by-case decisions. This being said, this topic might be an area in which the national government can set up framework conditions and incentives that encourage local governments to reduce parking.

PUBLIC TRANSPORTATION

In a MaaS approach, public transportation is often considered to be the backbone of users' mobility, after walking and using personal non-motorised vehicles. Therefore, providing attractive public transportation with regards to network density, service times and frequency, as well as pricing, is essential. Shared vehicles are an important addition but are hardly a substitute for some kind of mass transport. This is due to smaller vehicles, and the focus on individual needs and destinations. Research suggests that a critical mass of shared vehicles could substitute a considerable amount of private (car) trips. However, this has not yet been implemented. Speaking of traditional public transport, it is usually the case that peripheral parts of a city have less access to and a lower quality of public transportation than core areas. This can make it difficult to establish a successful MaaS scheme. Complementary on-demand mobility offers (e.g. ride pooling) can, if set up well, be a valuable and sustainable addition to traditional public transportation – please refer to HOW CAN ON DEMAND MOBILITY AFFECT USERS' CHOICE?.

ACTIVE MOBILITY AND PUBLIC SPACES

It is crucial for residents in urban non-core areas to find attractive conditions for walking, biking and other forms of active mobility, also because those are the most sustainable ways to reach public transport. Living in an environment where those modes are hard to use, it will be difficult to promote a lifestyle that is not dependent on the car for personal mobility. Hand in hand with this goes a decentralised development, with small local centres in peripheral areas, as well the already mentioned "city of short distances". Having those public places in proximity, with local retail and other services, can reduce the travel demand significantly.

HOW TO STEER? AND WHERE?

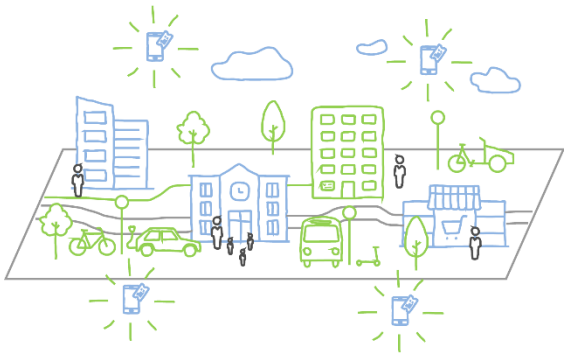
THE ROLE OF GOVERNANCE PARADIGMS

The paradigms that lie behind public governance can vary enormously and inform the questions to what extent the provision of mobility services is a public responsibility, and how much public funding should go to different services. These questions mark a major divide between different political ideologies and traditions. This is relevant, as mobility is often considered a basic human need (Caywood & Roy 2018). Accordingly, in many cities around the world, public transportation is to some degree publicly organised. This is relevant for MaaS, as it is more likely for a city government to take an active role in coordinating MaaS if there is a tradition of taking a strong lead in offering public transport services, in contrast to merely creating and maintaining the infrastructure for people to use with their private vehicles.

Offering continuity is essential for MaaS, both for users and for businesses. For people to take significant steps in their personal life (like selling their car), they have to be able to rely on certain services being available long-term. For mobility providers too, long-term planning horizons and financing models can lead to more viable business models and better services.

LONG-TERM STRATEGIZING

Although this might sound self-evident for some, cities must have a long-term vision on how MaaS is to develop (Smith & Hensher 2020). Usually, the creation of this vision will require an approach that includes various stakeholders. Even if the decision is to not take a strong lead and wait for the market to develop (or not), it is essential to know what the goal is. For cities that do decide to take a strong lead, it is even more important to gain clarity on how to reach the desired vision. The vision should not ignore or neglect peripheral parts of the city, as they have specific requirements compared with urban cores. For a city that has established processes of issuing a Sustainable Urban Mobility Plan (SUMP) this can be an easy and effective point to include MaaS.



OptiMaaS vision for urban periphery (tbw research, 2021)

PLANNING PROCESSES & LEGAL REQUIREMENTS

Looking at mobility in urban non-core areas it is relevant to distinguish between existing and newly built developments first.

When looking at new developments, the question is how to create the right conditions from the beginning that will not just enable sustainable mobility, but incentivise it. Developers are usually not experts on providing mobility solutions and have to budget well. It is important for a city administration to provide binding (legal) requirements. Voluntary suggestions are likely to not be considered. Depending on the local context, it might be necessary to establish new legal instruments or revise existing laws – please refer to NEW OPPORTUNITIES FOR PROPERTY DEVELOPERS FOR COOPERATION. Those requirements could, for instance, affect the use of a certain municipal MaaS platform or abiding to data standards, or the responsibility for developers to provide residents shared mobility options.

For existing developments, it can be rather difficult for MaaS to become a real alternative. However, new people moving in can be a natural turning point for them to change mobility behaviour. It is important to use that moment and provide alternative solutions in a timely manner. This doesn't just mean mobility services of all kinds, but also the supporting marketing of those services. Some cities have created extensive information materials regarding mobility for existing and new residents (e.g. "Gscheid Mobil" in Munich, Germany).

BRING STAKEHOLDERS TOGETHER

Depending on the local context, it can be crucial to work with regional and national

players, as they are likely to have their own agendas and ideas about MaaS that affect municipalities. Likewise, in many cities there are political subdivisions like districts, which have to be considered as well. Dedicated staff mediating between public and private mobility planners, developers, as well as political players are a possible solution to reconcile different interests and perspectives. Including users in the planning process for mobility services in new neighbourhoods is a hardly explored but potentially successful path to creating the relevant services.

PROVISION OF RESSOURCES

All forms of mobility receive financial support from the public in one way or the other. In fact, one of the reasons why many cities are very car-oriented today is that comparably big budgets have been (and are still) spent on creating and maintaining attractive conditions for driving cars. Especially when it comes to shared mobility offers in peripheral areas, this may require (financial) support, as private businesses will probably focus on the denser areas in the centre – please refer to CAN WE STEER MAAS SCHEMES?. Besides direct financial support, the provision of (public) space to position shared services is a crucial aspect. Various cities have started piloting (or are rolling out) mobility hubs, to create an easily recognisable brand for mobility services. Same goes for on-demand services, which are serving as a supplement to public transportation. All of these services require public resources of some kind.

„Owning your own parking space and your own car are not the future - urban mobility will be digitally bookable and flexible to use!"

Gerald Franz

OUTLOOK

As we tried to point out in this paper, there are plenty of opportunities to steer the development of MaaS in the city's periphery. However, some of them will require long-term and systemic changes, that won't happen overnight, as they affect some of our core planning principles. We tried to make clear, that policies aiming at steering MaaS won't only work with enabling or incentivizing policies, but also have to take some restricting components into account. Finally, it should not be forgotten, that MaaS doesn't automatically mean more sustainable travel patterns – please refer to MAAS AND SUSTAINABILITY. While MaaS can be a tremendous tool in achieving a climate-neutral, safe and inclusive mobility system, cities have to create the right framework to ensure that, both in the centre and in the urban periphery.

POLICY RECOMMENDATIONS

› In the **urban periphery, MaaS** will only work in an **environment that supports life without a private car**. Therefore, we suggest that MaaS requires rather fundamental changes in urban planning and the mobility system.

› Easier said than done: The establishment of MaaS needs to be **spearheaded by comprehensive strategizing** and included in major strategizing processes.

› The **diversity of stakeholders** in MaaS is a big challenge. It is smart to **identify the key players** and start **cooperation.**

› Especially when looking at the urban periphery, MaaS is highly unlikely to just develop by itself. It is necessary for cities to **provide the financial and spatial resources** for MaaS.

› Real-estate development and mobility provision are getting more and more interlinked. Cities have to create the **according requirements to ensure quality standards**.

› "**Push and Pull**": Policies aiming at steering MaaS won't only work with **enabling or incentivizing** sustainable mobility patterns, but will have to take some **restricting** components into account.

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SIMPLICITY – A USER'S CHOICE

We may not want to admit it, but we humans are simple-minded when it comes to our mobility decisions. If there is a choice between complexity and (apparent) simplicity for the moment, for planning my mobility, I choose the easy, simple way. But what does that mean for a sustainable mobility transformation? For Mobility as a Service (MaaS)? For decision makers?

RECOMMENDATIONS FOR USERS

› **Choose your place of living wisely.**

› **Get into action**: If there is no (attractive) bike/walking/shared mobility infrastructure near your place, write to your mayor or local government officials.

› **Big changes are happening in your life?** – Think about how you will get to work, to the kids' school, to your family and friends, to your leisure activities,…. Now is the best time for changing your routines towards sustainable mobility! **Mobility as a Service can help you and offers an easy overview of your modal choices.**

› **Establishing a new routine takes time**, often weeks or months – so keep on walking, biking, sharing,…!

› **Before buying a car, better think five times if you really need one**, if you can afford one and whether there is no better, more sustainable alternative.

Authors: Angela Muth, Cyriac George, Bianca Humer

MOBILITY DECISIONS ARE UNCONCIOUS DECISIONS

The scale and complexity of modern cities are, in many ways, at odds with some of our biological human characteristics. For example, the evolutionary psychologist Elisabeth Oberzaucher (2020) explains that we often decide in favour of the private car, due to our need for spatial distance personal space. Fostering sustainable mobility behaviour will require developing ways to steer such unconscious decision-making patterns, both by ourselves and the design of our mobility systems.

SENSE OF SAFETY AND CONTROL

When using public transport, we often sense a loss of control because of factors outside our sphere of influence, e.g. when the next vehicle will arrive. In our own cars, we are given the feeling of freedom and independence - also through advertising - even though we cannot influence traffic lights or traffic jams (Oberzaucher, 2020).

It is similar with the feeling of safety that driving an SUV (Sports Utility Vehicle) gives us; we have the feeling of having everything in view, while other road users, especially children, easily become victims of the larger blind spot (Blaha, 2020).

COMPLEXITY OF INTERMODAL MOBILITY

We know that when we have "free" choice, we usually prefer the simpler behavioural option (Oberzaucher, 2018). But what does this mean for the choice of transport mode for more complex routes, e.g. with stopovers for shopping or social commitments? – please refer to: *Mobility with or without stopovers - comparison of male and female mobility patterns (Meike Spitzner, 2020; graphic design: tbw research, 2021) page 18.*

So why don't all people make all their journeys by car then? Perceptions of simplicity and complexity are subjective, and situations can vary. Sometimes it can be straightforward and instrumental – for example many people do not have a car because they cannot afford one. In addition, the dreaded search for a

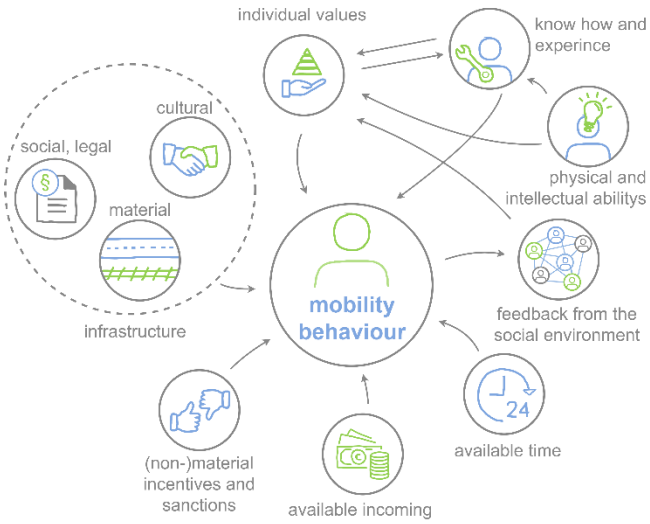
parking space at the destination increases complexity and planning uncertainty. It is often easier to opt for the regular timetable of public transport or the ease of walking or biking on (hopefully) dedicated and well-developed infrastructure.

HABITUAL BEHAVIOUR

Based on our evolutionary psychological behaviour, it is easy to see why we are attached to our habits and often find it difficult to break them: we do not think about daily routines, which saves a lot of our mental energy (Zeug, 2013). We can use this knowledge especially in life-changing situations; when we relocate, change jobs or start a new family, we inevitably have to learn new routines. But even now, in times of 'Fridays for future' or the COVID-19 pandemic, many people are increasingly thinking about their own mobility behaviour. It is important that new behaviours are more sustainable (please refer to MAAS AND SUSTAINABILITY) than old ones in order to change them in the long term (Oberzaucher, 2020).

MOBILITY BEHAVIOUR IS VERY INDIVIDUAL

As already described, there are many factors that influence our mobility behaviour. Much happens unconsciously, out of habit. In addition, the rapid technological and social change can overwhelm users.



Influencing factors on mobility behaviour (VCÖ 2017, graphic design: tbw research,2021)

NUDGING

Mobility planners and operators are increasingly incorporating the idea of 'nudging' whereby user behaviour is measurably and predictably altered through small changes in the environment rather than forbidding undesirable activities. Nudging has been shown to be an effective, but highly contextual tool (Lehner et al., 2016). Promoting MaaS through nudges must take into consideration the complexity of human behaviour both in terms of internal processes and the myriad contextual factors that influence us.

MOBILITY AS AN END IN ITSELF?

We fundamentally assume that transport is created to satisfy (basic) needs. Basic needs such as freedom and recreation often go hand-in-hand with a change of place. This means that practically no one can cover their entire spectrum of needs without a change of place. Nevertheless, change of place itself is not classified as a basic need (Schwedes et al., 2018).

MOBILITY AS A POSSIBILITY: FREEDOM VS. CONSTRAINT (POVERTY)

The means of transport available for us to reach our destinations, and how far away these destinations are, influence our mobility. Accordingly, the availability of different transport options increases the freedom of choice to meet one's own needs. This is contrasted by the restriction of options for changing location. This lack of mobility results in less participation in social life (Schwedes et al., 2018).

The existing built infrastructure (rails, roads, pavements, ...), as well as the increasing change through digitalisation (e.g. MaaS apps) and electrification (e.g. e-charging points) represent cornerstones of the current transformation process. The goal is a socially just, climate-friendly transport system. In this context, it is also essential to change the roles of politics, of the public sector and of civil society.

PUBLIC AND NON-MOTORISED TRANSPORT AS A BACKBONE

When we talk about sustainable transport, we must always start with walking. Only if we can already safely reach the majority of our destinations on foot, by bicycle or by public transport, it will be easy to do without a car. Only then will car-sharing and other new mobility offers have a real chance of being accepted by the masses. Only when new mobility offers are seen as a complement to public transport and as a way to reduce car ownership, will the sustainable transformation of our transport system succeed. (OptiMaaS, Policy Lab - Vienna, 2019).

The better the public transport offer, the freer we are in our mobility decisions. In this case, freer also means less dependent on our own cars. This is also beneficial for social sustainability and the climate (VCÖ, 2018).

PLEA FOR A MIX OF USES

Traffic arises because we want to satisfy our needs (for food, work, leisure, ...). The availability of mobility alternatives, especially near our places of residence, plays an essential role for the individual mobility behaviour and overall traffic volume i.e. number of trips and kilometres travelled. Furthermore, a mix of uses in urban neighbourhoods makes a significant contribution to resilience (resource conservation, equality, cultural diversity) (Forlati, et. al. 2017). In terms of the basic supply of goods, services and public facilities, a corresponding small-scale mix enables short distances and thus also offers environmentally compatible transport solutions (Lung, Skala, 2000).

KINDERGARTEN - SCHOOL - WORK - LEISURE TIME

Another aspect of mixed use is the accessibility of work, school, kindergarten and leisure activities. It must be considered that people with care responsibilities often cover very complex chains of routes. This complexity is still difficult to map. Nevertheless, already existing MaaS apps can support the planning and booking of mobility offers.

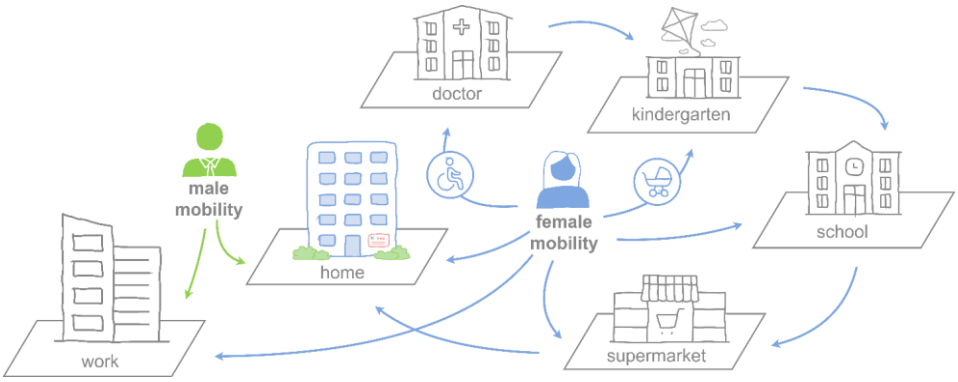
MAAS AS A HOLISTIC APPROACH

MaaS, as we understand it in the OptiMaaS project, shows both the technical possibilities of communicating with users and the challenges of incomplete, existing infrastructure.

MOBILITY OFFERS

The simple combination of means of transport at nodes (last mile solutions) through short distances and attractive parking facilities, e.g. when changing from bike to train, is important to increase freedom of choice and mobility options. However, this also signifies a higher complexity of the mobility system.

Demand-orientation in additional offers ensures economic, social and ecological sustainability in the transport system. How demand-oriented mobility offers are designed, depends strongly on the destination and the target group (Mobyome, 2021). We have taken a closer look at on-demand and shared mobility – please refer to HOW CAN ON DEMAND MOBILITY AFFECT USERS' CHOICE? and CAN WE STEER MAAS SCHEMES? SHARING AS A BUSINESS MODEL - HOW TO SET PLAY RULES FOR TRANSPORT SERVICE PROVIDERS?.



Mobility with or without stopovers - comparison of male and female mobility patterns (Meike Spitzner, 2020; graphic design: tbw research, 2021)

In addition to private everyday mobility, the possibility of designing business mobility plays a major role, especially in urban areas. A good mix of uses, offices and corporate spaces should not be neglected. Spatial proximity of several companies also allows for a wide range of shared vehicles, which saves parking spaces and thus costs (Urbane Mobilität, 2019).

In addition to the cost factor, in business mobility it is important to address the brain's reward system and to consider the image factor in the company to facilitate a change in mobility behaviour. This can be done playfully via gamification or team competitions, ("challenges") in an app or by graphically displaying when "my tree" grows due to my CO2 savings. (Doiber M., 2020) Collected mobility credits can also be used elsewhere as a means of payment (ummadum, 2021).

Mobility stations are the new, locally visible points where different mobility offers are bundled. Important for the acceptance of the offers and the easy accessibility is good connection to the local footpath and cycle path network. In addition, especially in urban peripheral areas, it makes sense to have a connection to public transport - at least for larger stations. This increases the number of potential users and thus the economic viability (Mobilitätsstationen, 2016).

Mobility stations can also be used in combination with other services. Pick-up boxes from the post office, bicycle service stations, shopping trolleys, car seats for cars/bikes and high ladders are all examples of offers that can effectively be combined to increase the attractiveness of the mobility station, especially when connected to residential buildings (MO.Point, 2020).

The integration of all these different offers is important to be able to speak of real Mobility as a Service. There are several challenges here. First, the services must be physically available, and only then can they be digitally connected. In practice, the implementation can run in parallel; however, a digital implementation without a physical offer is impossible (Drive Now, 2020).

MOBILITY GUARANTEE

Not owning a car requires that everyday mobility is guaranteed by other modes. Urban residents must be confident in the availability of and easy access to various mobility services. The actual feeling of security that is to be created by a mobility guarantee depends in turn on several factors.

In the case of public transport, a higher frequency of service is preferable to more limited service that attempts to maximise the number of passengers per vehicle (Oberzaucher, 2018). For new mobility services, it is particularly important to communicate positively and widely in the first years of operation to reach the population and build a foundation of trust (Riegler S., 2016).

PRICING

The pricing philosophy is very different for the various providers, depending on their orientation (ecological or social objectives). There are often different packages for different target groups. These range from all-in-one offers, where a monthly fee covers all transport services, to pay-as-you-go concepts. In the latter case, only mobility services that are used must to be paid for (Whim, 2021). Targeting group-specific tariffs with low basic costs and user fees according to time or distance are further tariff possibilities (MO.Point, 2021).

MAAS-APPS

Keeping track of the many different choices is not always easy. MaaS apps can help. Technically, a lot is already possible and partly already implemented. The extent of integration for different mobility offers in one app ranges from the provision of information for planning to the booking and ticketing of entire routes across different means of transport (Mobilikon, 2021).

Incentives such as collecting mobility credits can also help to initiate sustainable mobility. By redeeming mobility credits at local companies, the added value can also be kept in the region. (Ummadum, 2021)

When designing or developing apps, it is important that the expected information can be accessed quickly and easily. That is why there are currently tendencies to design different apps for different target groups, objectives or residential areas. This can but does not have to be in conflict with the comprehensive MaaS idea. For example, a bicycle navigation app could in the future suggest a quick route including a ticket for public transport in case of bad weather (Smile – einfach mobil, 2015).

The essential thing is that the systems and data are well-connected in the background, even if I don't see this as a user. I only see the information that is relevant for me from a well-connected IT system. Therefore, in the backend learning IT-systems (artificial intelligence) are becoming increasingly important (Ilichev V., 2018).

MOBILITY MARKETING

Sustainable mobility marketing is based on the latest scientific findings in communication theories, but also in behavioural psychology. It has been known for a long time that people quickly learn new behavioural patterns when circumstances change (relocation, birth, change of job, etc.) (Zeug K., 2013). Mobility marketing in cities like Vienna (Mobilitätsagentur, 2021), Salzburg, Graz and Munich builds on this.

In order to learn new, sustainable mobility patterns yourself, it is helpful to know how to learn new behaviour patterns. This knowledge can also be helpful for mobility marketing in cities or by operators. A key aspect of this is to actively work on communication on a regular basis.

James Clear's (2018) approach to learning new habits can be summarised in four steps:

(1) First, it is necessary to recognise the trigger of unwanted behaviours. In the long run, it is easier to adapt the environment than to constantly challenge one's own willpower.

(2) Sustainable mobility behaviour must be attractive to oneself, which increases the motivation and likelihood of sticking with the new behaviour. Joining a group of like-minded people can help as well. The more people move sustainably, the easier it is to join in - not least, famous role models help. Social media are becoming increasingly important and could also contribute to a sustainable change in the mobility system (Clears J., 2018).

(3) It is important to repeat new mobility patterns often.

(4) The more personally satisfying a new mobility pattern is, the more likely it is to be retained. This can be playful through the graphical representation of the tree growing due to the saved CO2, more available money in the account for other purposes, or even more endurance and fun while moving.

Recently, it was shown in Munich that financial rewards combined with digital rewards and a 'good conscience' contribute best to sustainable mobility changes (Shinde S., 2020).

POLICY RECOMMENDATIONS

› Clearly, the **choice for sustainable transport modes needs to be easier**.

› There needs to be **attractive, connected walking and cycling infrastructure** - better than for private cars.

› **Public transport** needs to be meaningfully **linked with new last-mile solutions**.

› **Shared mobility solutions** must be guaranteed over a longer period of time, which creates security and reliability.

› Every change in life phases must be used to bring about sustainable behavioural changes. **Mobility marketing for every stage of life is required.**

› **Small-scale diversity of use** is an essential factor in securing local supply and avoiding forced mobility.

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NEW OPPORTUNITIES FOR PROPERTY DEVELOPERS FOR COOPERATION

WITH MOBILITY PROVIDERS, PUBLIC AUTHORITIES AND USERS

MaaS in the urban periphery (urban non-core area) is as much a question of integration as it is in the urban core area. But framework conditions in these areas differ significantly due to less sharing mobility services in operation and reduced service quality in public transport. The reasons for this are manifold: lower density numbers in population and workplaces as well as spatial planning which encourages the use of private vehicles, especially cars. Hence the demand for sharing mobility is relatively low, too. Availability of parking, more comfort in the use of motorised means of transport and the lack of alternatives in between the city and the fringes of the city show a rough domain for (private) mobility services. For a future of sustainable MaaS-solutions in urban non-core areas a carrot & stick approach will be necessary, accompanied by nudging people into more eco-friendly mobility behaviour

RECOMMENDATION FOR PROPERTY DEVELOPERS

› Acknowledge your role in **contributing to a city of short distances**.

› Actively **push sustainable street and public space planning** by asking city officials to adopt new urban designs.

› **Refunnel savings** in investment due to new mobility services or reduced parking facility establishment into **sustainable mobility**.

› **Demand new cooperation models** between public authorities and private developers.

› Ask for **clear guidelines from city planning for integrating sustainable mobility** into your projects.

› **Moving into a new (living or working) place** is a **turning point in daily life of new residents** and might trigger changes in mobility behaviour. Acknowledge your impact by **facilitating new mobility for your residents.**

Authors: Vincent Neumayer, Gerald Franz, Anna Wadström, Angela Muth

PRIVATE DEVELOPERS AS NEW PLAYERS IN THE FIELD OF MOBILITY

Especially in urban non-core areas in the outskirts of (European) metropolis and cities, physical and spatial structures have been established, which support a lifestyle in demand of regular car use. This lifestyle is supported by comfortable and often easily affordable parking possibilities in public space and on respective housing areas. Additionally, destinations of daily routines offer comfortable facilities for using private cars, e.g. for going (grocery) shopping, dropping off pupils at school or visiting the gym or sports facilities. Within this grown environment which causes unsustainable mobility patterns, public transport and alternative means of transport, especially sharing mobility services, fight a hard battle for gaining users and customers. But the mix of lower population density, sprawl of urban development and comfortable use of car can be slowly transformed towards a more sustainable way of mobility. New urban development areas with higher population

density[1], aligned according to reduced parking obligations[2] and obligated organisation of alternative mobility offers raise the chance of changing mobility behaviour and the choice of transport modes. In order to achieve a critical mass of potential users for ne mobility services, a certain number of housing units is favourable in order to guarantee profitability of new service offers.

VIENNA

In Vienna private and cooperative property developers in more recent development projects are obliged to meet quality standards in support of more sustainable mobility. Additionally, in many development projects property developers are even asked to organise certain mobility services which both need to be initially implemented and run for a certain time with financial, infrastructural, and organisational support of property developers.

This poses a new responsibility onto property developers but as well the necessity of know-how in order to shape

- suitable
- sustainable
- integrated
- affordable
- attractive

mobility (service) offers for new residents in urban non-core areas but as well for the local population already in place.

Currently in Vienna cooperative developer(s) apply for building lots in urban development areas respectively building blocks development by handing in urban design concepts (städtebaulicher Entwurf) which usually contains a chapter about mobility and how mobility will be organised in the respective place. This is sketched in traffic concepts or integrated mobility concepts. Design concepts base on pre-defined quality parameters which are elaborated by public land use planning. Public planning authorities sometimes advised by a jury of internal city planning experts and external advisors evaluate these (design) concepts and define more precise stipulations for the winning projects which are finally cast into a mandatory land use plan. In a so-called urban development contract, property developers are committed to meet the quality stipulations in the field of mobility. These stipulations may come with reduced requirements for parking space constructions (according to the Vienna parking management law). This usually results in reduced construction costs for property developers.

„MaaS closes the gaps between digital and physical mobility services."

Vincent Neumayer

By these quite new requirements property developers face a new role which calls for solid and future oriented integration of district- and lot-specific mobility measures into city-wide mobility organisation. This integration might be eased by a well-designed MaaS-aggregation-system open for integration of small-scale mobility (service)offers.

OSLO

In Oslo, building green mobility strategies is an up-and-coming phenomenon connected to new housing development. Property developers are eager to, not only make a reduction of costs in these large projects but also to make a change for more sustainable cities and housing.

[1] 250 inhabitants/hectar and above; in Vienna density often refers to NGFZ (Nettogeschossflächenzahl) which basically describes the ration between net (housing) space to building land per building lot. Numbers in Vienna vary between 0,05 to more than 6. See MA18. 2014. Nettogeschossflächenzahl 2014. https://bit.ly/3xAL5kO

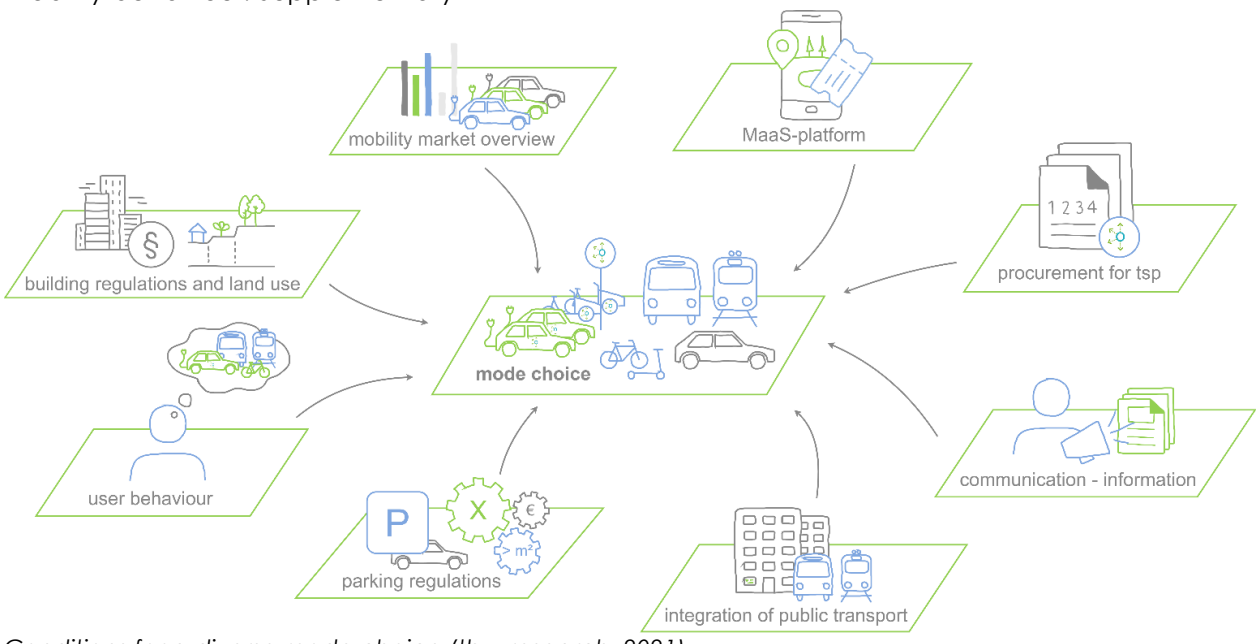
[2] According to the Vienna building regulations development plans can stipulate reductions of parking lot construction of up to 90 % (Stellplatzregulativ gemäß §5 Abs. 4 lit. b Bauordnung für Wien).

MY NEW HOME AND CHANGE IN MOBILITY BEHAVIOUR PATTERNS

The OptiMaaS recommendation paper SIMPLICITY – A USER'S CHOICE dives into the user-centric aspects of mobility as a service and gives a deeper understanding of why people choose certain transport modes and how to both change the mobility behaviour and at the same time meet the mobility needs of people in urban non-core areas. The paper comprises insights of the research project OptiMaaS and goes beyond. Nevertheless, it is important to stress again that a relocation of home is a tremendous opportunity to change mobility behaviour and moving patterns. 4 out of 5 trips start or finish at home (Stadt Wien, 2019, p.10). This underlines the importance of mobility settings in your own home and its surroundings. It also stresses the influence, and with that, the important responsibility housing developers have in this field – to give opportunity for residents to change their mobility behaviour for the better. Availability of and information about transport modes and costs for usage shape our selection for mode of transport. Well set-out (public) transport service conditions, the best circumstances for active mobility and the availability of sharing mobility services and transparent, integrated information about those services in user-friendly customer interfaces have the potential to affect a change in mobility behaviour. Supplementary infrastructure like parking facilities for cars, (cargo)bicycles and other micro mobility modes of transport might affect a switch in mode choices, too. Ideally all those features are already in place when people move to their new home in urban non-core areas. At this very time in life, change in mobility behaviour is probable: a new assessment of the financial household situation, availability of parking facilities etc. will be input factors for mode choice and change in mode choice. In that, well-placed and well-timed information about mobility (service) offers is key! Please check SIMPLICITY – A USER'S CHOICE for further information.

PRE-CONDITIONS FOR SUCCESSFUL MOBILITY MEASURES BY URBAN DEVELOPMENT SITES

As already mentioned above, property developers are not mobility planners. Therefore, clear and applicable information about service offers at hand need to be provided to (non - profit) real estate builders in order to extend engagement in influencing transport mode choices beyond the minimum obligations. The following measures and conditions (including a suggestion for the responsible party) support directly and indirectly development sites in influencing the mode choice of residents:



Conditions for a diverse mode choice (tbw research, 2021)

- On-street parking regulations decreed by **public administration.**
- Reduction of off-street parking facility construction obligation to an extensive degree by **building regulations and land use plans.**
- An ecologically sustainable **integration of new real estate developments into the public transport system,** according to size of development area and population density by providing new mobility services for current but as well rising future demand. This will be achieved via transport planning authorities and district administration in close corporation with property developers.
- A clear market overview for additional (sharing) mobility service providers which support property developers in conceptualising, planning and implementing new mobility services. This overview should be provided by **(public) consultants** to property developers and their urban / mobility planners. This advisory entity could for example be the public transport provider – having a coordinating role and a holistic and sustainable perspective of the whole transport system.
- An established MaaS-aggregation connecting all mobility offers in one digital platform. This should be provided **via public assignment.**
- Guidelines for digital integration of co-funded mobility services into one (!) (public) MaaS-aggregation platform but as well guidelines for data provision to public entities in order to improve transport system planning. These guidelines are provided by an **entity assigned by the public administration.**
- Highly recommended inclusion of mobility service planners as soon as possible in the planning process, optimally in the process step of setting up an urban design concept, in order to save space for mobility services and to integrate in cost estimations. This should be demanded as obligatory by procuring **(public) authorities asking for tenders.**
- Possibility of inclusion of (shared) mobility services into operational costs of residential buildings. This results in a re-distribution of mobility costs among residents from initial infrastructural asset costs (e.g. construction costs of parking facilities) towards service-oriented costs. **For that an adaption of respective legal acts by the responsible body is necessary** e.g. an adaption of "Wohnungsgemeinnützigkeitsgesetz" in Vienna, Austria. Alternatively, new financing mechanisms need to be established.

(LEGAL) FRAMEWORK CONDITIONS AND MOBILITY SERVICES FOR URBAN DEVELOPMENT PROJECTS

Currently only a certain set of services are allowed to be integrated into operating costs of publicly subsidised residential buildings in Vienna (Wohnungsgemeinnützigkeitsgesetz – WGG, 1979 i.d.g.F.). These are among others:

- water
- sewage
- waste disposal
- chimney sweeping
- electricity
- insurance
- gardening
- etc.

An integration of mobility service-related costs is currently not allowed. This obstructs a long-term establishment of solid and financially sustainable services for residents. But experiences from the past prove that initial inclusion of new services into operational costs is possible e.g. several internet providers offering cabled services right from start of housing.

„Mobility hubs are the physical representation of MaaS and adds great value to the digital equivalent."

Anna Wadström

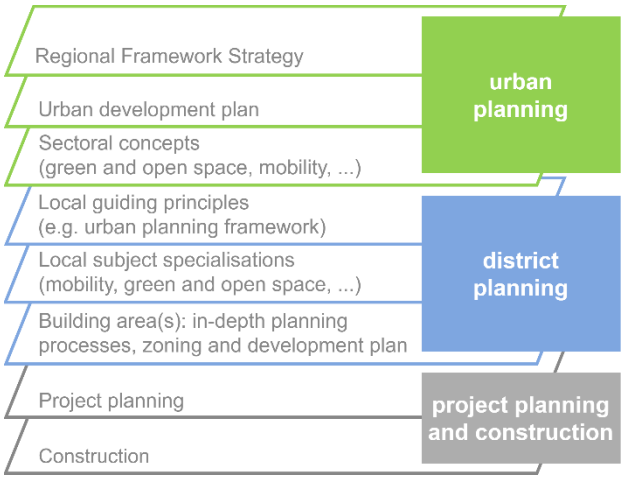
The aspects of a user friendly, digital interface, integrating all possible mobility services should be considered important, too. This cannot be

entrusted to property developers but should be at hand initiated by public administration.

In Oslo, the law stipulates a minimum parking regulation on new housing projects, but this is something being under consideration to change. The planning and building agency have just recently issued their proposal to drop this minimum parking norm and only regulate on maximum amount of parking's, also to include demand for shared mobility services in larger building projects[3]. Something that would also be beneficial to consider for the non-core areas.

According to the **Vienna off-street parking law** (Wiener Garagengesetz – WgarG, 2008 i.d.g.F.) currently property developers are obliged to build one parking lot for 100 square meters of living space. This tremendous potential of redirecting investment funds into sustainable community-oriented mobility services needs to be addressed by active application of legal flexibility via building regulations. For this, cost savings in construction of parking facilities should be at least 1:1 transferred into implementation and operations of mobility services. Additionally, electrification of parking lots needs to be addressed to meet future demand for at-home charging facilities.

Building regulations currently don't serve mobility purposes but only to a small extent. In **Vienna**, land use plans and building plans (Bauordnung für Wien – BO für Wien, 1930 i.d.g.F.) are asked to provide space "in order to fulfil mobility needs of people." This vague exclamation offers to much flexibility in offering proper mobility services and infrastructure for sustainable mobility in urban non-core areas. In **Vestre Billingstad** (Asker municipality - NOR) it is stated that the growth in passenger transport should be taken by public transport, biking, and walking implicating there should be taken measures to lower the impact on public roads, as they are already stressed. This leads to new housing projects setting a low parking norm and offering shared modes of transport – at least **1 shared car for every 100 residents**, which is the case for Vestre Billingstad.



Simplified urban development levels (MA21, OptiMaaS, graphic design: tbw research, 2021)

We can jump to the conclusion that current (legal) framework conditions partly obstruct sustainable establishment of a MaaS-ecosystem in urban non-core areas. In the following final chapter further recommendations are listed to create a satisfying mobility situation for property developer, users and public administration striving for meeting their strategic objectives of making transport more sustainable – please refer to MAAS AND SUSTAINABILITY.

OPERATIONS OF COOPERATION

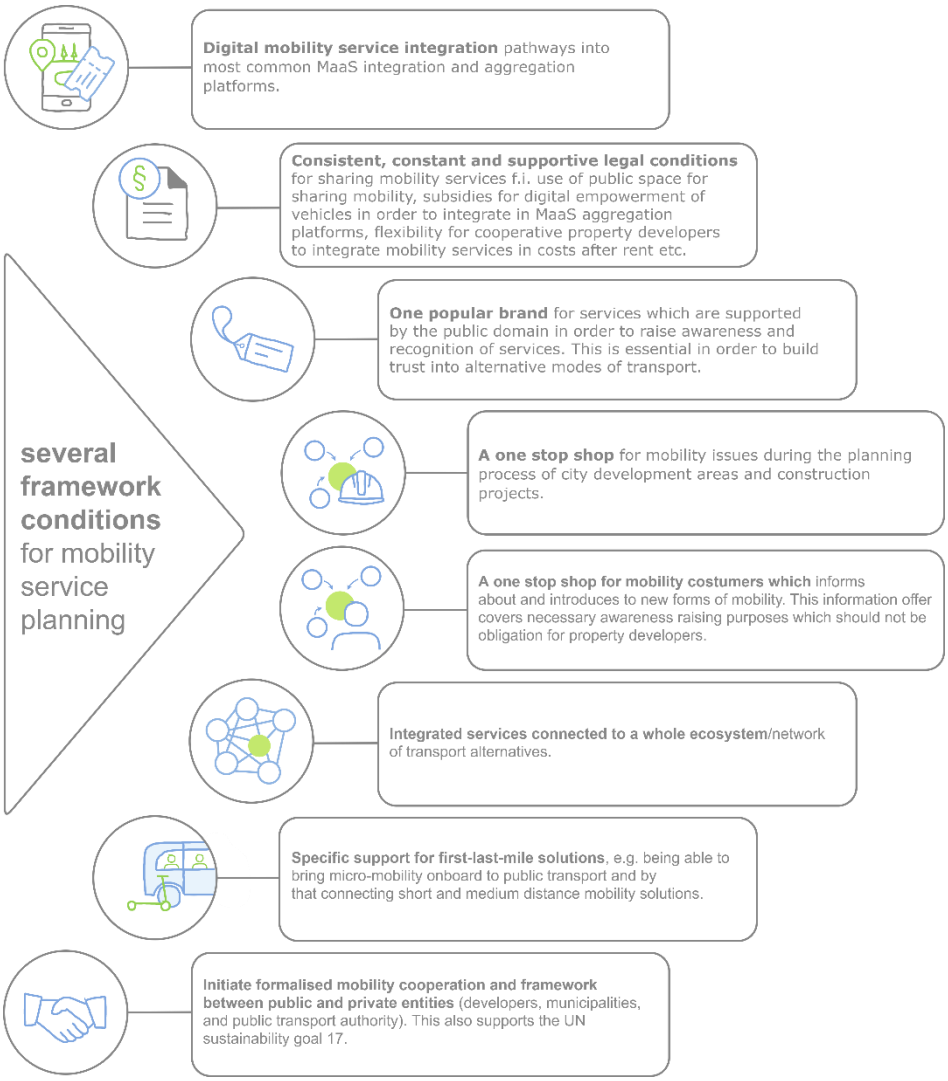
One mode of cooperation involves so called **urban development agreements** between property developer and city administration/public administration. Consensual agreement about how traditional land use planning can define good pre-conditions for mobility purposes may result in a win-win situation for both sides. The urban development agreement includes quality parameters for mobility which should be stated as precise and specific as possible in terms of kind, extent, location, and operation duration of mobility services which are (co-)funded by property developers. Transparency is key; therefore, it should be openly stated which

[3] New parking norm for Oslo on hearing to drop minimum demand for parking. https://www.estatenyheter.no/nye-parkeringsnormer-for-oslo-pa-horing-uten-minimumskrav-til-parkering/280765

investment sum is at hand for alternative mobility services. In exchange for this new integrated service as part of additional costs after rent, property developers can refunnel saved investment for obligatory parking facilities in case of reduced parking facility stipulations. Additionally, one stringent condition among others should be to oblige property developers to ensure integration of procured mobility services into (public) MaaS-aggregation-platforms, in order to guarantee easy (digital) accessibility and lowering the risk of creating "small ecosystems", only accessible for those living in one specific neighbourhood. Building a network of mobility services will be crucial to lower demand of private ownership of motorised vehicles. A city-wide solution of MaaS-aggregation-platforms for all property developers is one key factor for success of mobility services in urban-non-core-areas.

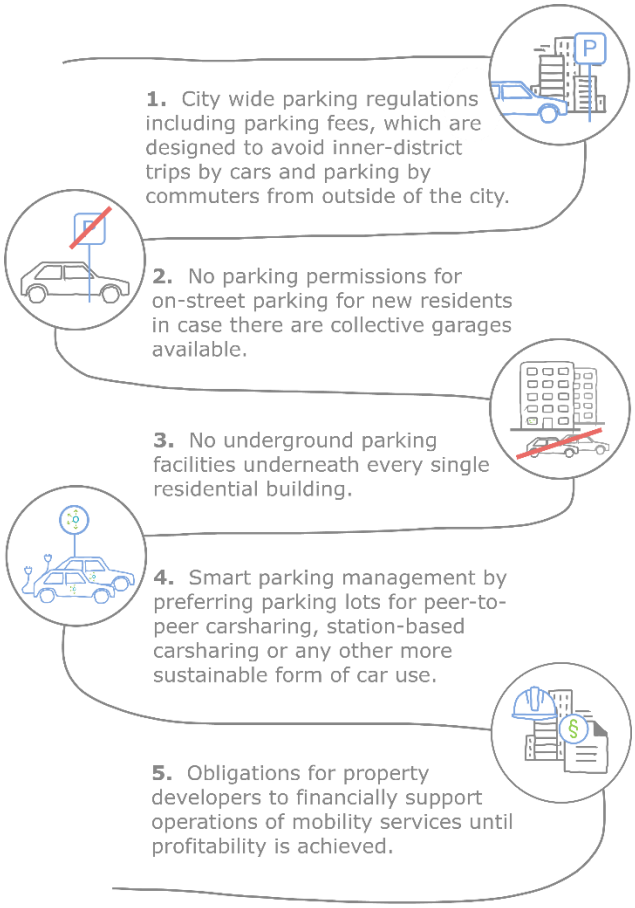
Another suitable and well-established tool and leverage in order to support long lasting integrated mobility services in urban non-core-areas is **land use planning and urban development plans** for lots and areas which determine use of space for different functions. Reduction in off-street and on-street parking space, should clearly result in better conditions of mobility services and eco-modes of transport. Additionally, mobility services in prominent ground level zones support high visibility and therefore usage numbers of alternative modes of transport, this needs to be defined in district / urban development plans.

Since property developers core business does not include mobility service planning by today, several **framework conditions** need to be organised or at least initialised by public administration:



Framework conditions supporting MaaS implementation (OptiMaaS, graphic design: tbw research, 2021)

In order to ensure accepted and demanded mobility services in urban non-core-areas aforementioned factors influencing the supply side need to be accompanied by **restrictions** as there are:



Property development framework conditions supporting MaaS implementation (OptiMaaS, graphic design: tbw research, 2021)

DYNAMIC MARKETPLACE FOR MOBILITY OFFERS

One overall goal of all these recommended measures is a dynamic marketplace for mobility offers which combines mainly strengths of different kind of mobility service providers:

Small and medium sized companies on the level of urban development areas, offering mobility services, act quite close to the customer, they know local needs and can react quickly on changes in demand but as well in case of problem. Public transport providers which evolve to integrated mobility organisers address the whole community and offer (digital) infrastructure which creates accessibility to public transport services and other eco-modes of transport. Collaboration between public transport and local mobility service providers are door openers to new segments of customers, right on time during the period of relocation. Such collaborations can be presented in different ways e.g. as license for a small mobility service provider to operate mobility services in the name of a city wide (digital) brand, supplied by public transport or by a transport authority.

The interlinkage of all these players promises fruitful collaborations and win-win situations for all stakeholders involved: customers, property developers, private mobility service operators, public transport operators, (public) MaaS aggregation platforms and public administration. Nevertheless, it still needs to be highlighted that all measures in order to improve the supply side of mobility services need to be accompanied by counter measures reducing the attractiveness of motorised private vehicles. The main countermeasure is the internalisation of external costs of car-usage. But this is another topic.

POLICY RECOMMENADTIONS

› **Creation of supportive framework conditions for property developers** to establish sustainable and integrated (sharing) mobility services in (new) urban development areas plays the major role in establishing new mobility behaviour pattern.

› Implementation of obligations for property developers to **invest savings** due to a restricted parking regulation purposely **into set-up and operations of mobility services** need to be mandatory.

› **Establishment of institutions for digital and physical integration of new mobility services**, f.i. at public transport providers and/or public administration advisers is highly recommended.

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CAN WE STEER MAAS SCHEMES?

SHARING AS A BUSINESS MODEL - HOW TO SET PLAY RULES FOR TRANSPORT SERVICE PROVIDERS?

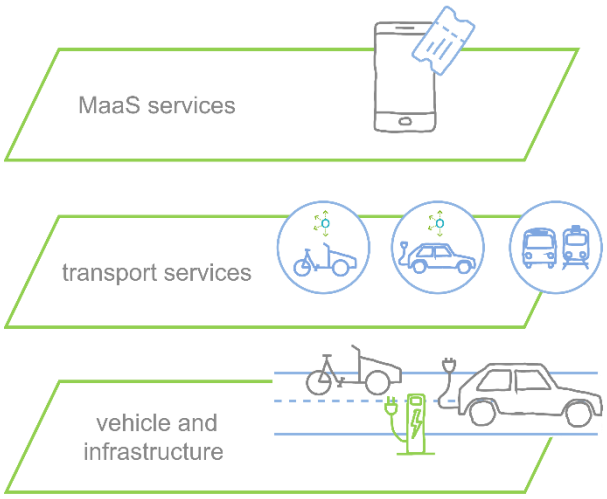
In order to implement MaaS services in urban peripheral areas, alternative business models and partnerships on the level of TSPs are needed. Public authorities and public transport service providers have basically three different options how to tackle the issue. The provision of additional transport services on their own or in cooperation with private partners seems to be promising.

Authors: Stefan Arbeithuber, Anna Wadström, Vincent Neumayer

THE CHALLENGE: ESTABLISHING THE OFFERS

MaaS is perceived as concept to increase the attractiveness of public transport and eco-mobility and to decrease the dependency on individual motorised traffic.

Prerequisite for the digital delivery of MaaS offers is the local availability of the transport services, why this factor is emphasised here.



Mobility services layers (tbw research, 2021)

Shared Mobility and on-demand services have the potential to increase the attractiveness of eco-mobility, improve the last-mile and to decrease the dependency on individual motorised traffic. Today, private TSPs of shared mobility or on-demand services focus their offer at core cities, where population density is highest. Due to less population density and greater distances urban peripheral areas are economically less attractive to them.

THE REASONS BEHIND

The spatial structure of urban peripheral areas favours individual motorised traffic, and the car is often most convenient (e.g. car parking is mostly for free and plenty of parking space is available), whereas the public transport offers and quality is often less comprehensive then in the urban setting. Biking and pedestrian pathways are often less attractive, and the distances are longer. Urban peripheral areas are less densely populated, compared to urban core cities, resulting in lower demand for shared mobility and on-demand-services.

Municipalities facing the challenge to improve the transport service quality for these urban peripheral areas have basically three policy options to implement additional transport services:

THE OPTIONS: HOW TO SET PLAY RULES FOR TRANSPORT SERVICE PROVIDERS

Two out of the following three options seem to be most promising as to the improvement of transport quality in the urban periphery. Amongst them the cooperation between public and private organisation bears the most chances and

CHALLENGES: DO IT YOURSELF

In recent years several public transport organisations have stepped into the market and started to operate station-based car- and bike-sharing services themselves. Examples in Austria are TIM Graz, TIM Linz (TIM 2021) or

Stadtwerke Wörgl (flomobil 2021). The transport services are financed from public funds. The revenues of end-consumer tickets can reduce the public expenditures, but yet the services typically are publicly financed and steered. Compared to private companies, these public funded mobility offers can fulfil societal goals (e.g. providing shared mobility services and offering very low-end consumer prices) without the urgent need to meet black numbers. The downside to this approach is, that pricing below market prices make the market unattractive for other private companies (TSPs). Besides it should be considered that monopolies tend to be less innovative than organisations competing in the market. (Arrow K. 1962)

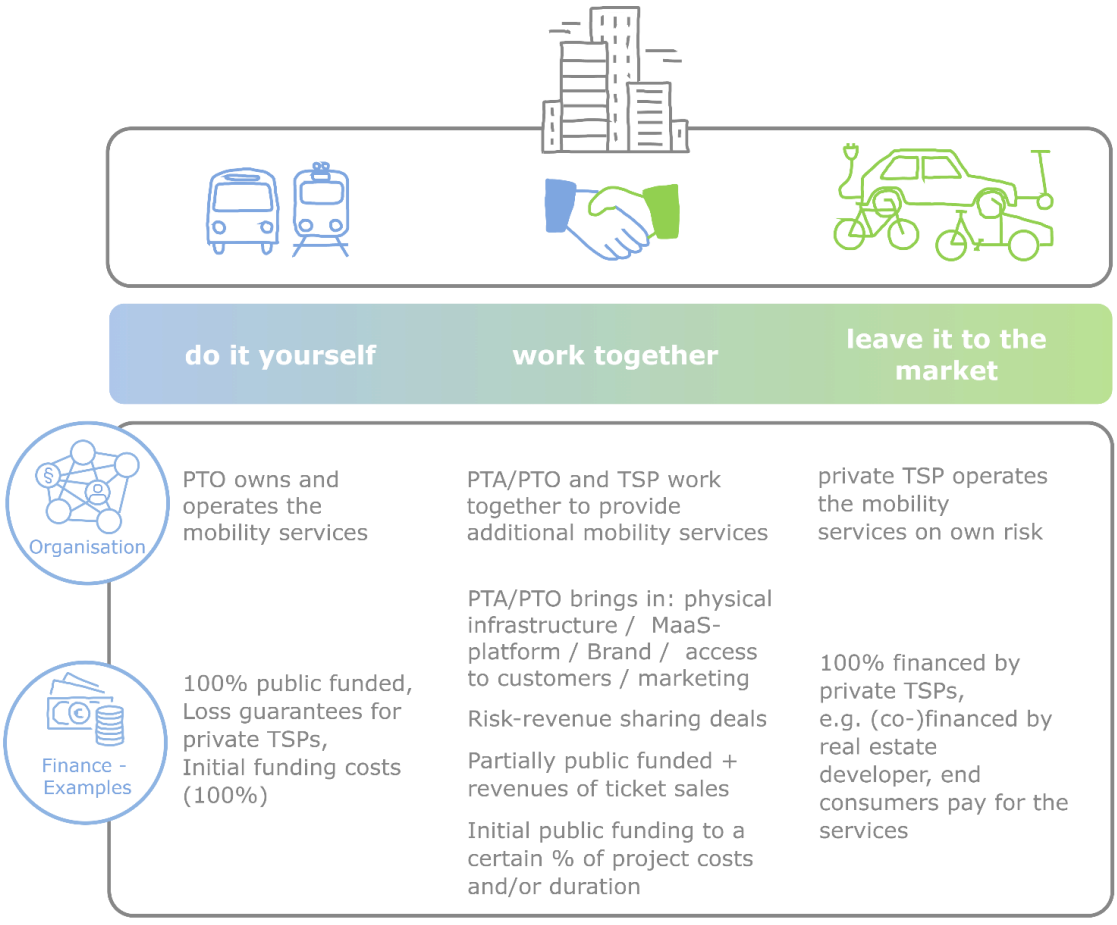
LEAVE IT TO THE OTHERS

Often decision makers expect private TSPs to start operation for a certain area or region if they just offered the parking spaces. But as lined out above private companies focus their mobility services, where the economic potential is highest. In the very few cases where mobility offers of private TSPs already exist in peripheral areas, "leave it to the market" might be a feasible strategy. In case the objective is to steer transport quality in certain urban peripheral areas to a higher level this strategy is not recommended.

WORK TOGETHER

The third option is, that public and private players work together. Public and private organisations can cooperate at eye level or they can establish a client-contractor relationship. Independent of the level, to establish a trustful cooperation between public and private partners the following aspects should be considered:

- Who finances the mobility services?
- Who bears the economic risk?
- Who brings in customers?
- Who cares for marketing and branding?
- Who provides which type of digital infrastructure?
- Who provides the physical infrastructure?
- Who brings in the know-how?
- Who earns the revenues?



Overview on organisation and finance in the different strategies of setting play rules for transport service providers (MO.Point, graphic design: tbw research, 2021)

Dependent on the answers to these questions, each cooperation will look differently. What's more, due to the fragmented market of mobility services, every region or city has to identify the form of cooperation suited to the local needs. The following examples give a good overview on different types of cooperation models. They shall inspire how to provide additional transport services and how to improve transport quality in urban peripheral areas.

ORGANISATION AND FINANCING MODELS

CONTRACTOR-CLIENT RELATIONSHIPS

One common strategy to realise option A – do it yourself is, that municipalities or public authorities mandate private companies (e.g. via tendering or concessions agreements) to operate mobility services (or parts of the services needed) on behalf of them. This is especially recommended, if the PTA / PTO has little experience in the according services and / or if his process do not permit a flexible organisation structure which is of advantage to develop new types of services. This contractor-client relationship means that the mobility services (e.g. car- or bike-sharing) are completely publicly funded. Revenues are payed to the PTA, the TSP acts as service-provider. These contractor-client relationships have the advantage, that public authorities can set the play rules (e.g. low end-consumer prices or to define the areas or stations, that have to be served). In any case municipalities should consider offering attractive conditions and aim at establishing long-lasting partnerships with private companies. Else it is quite expensive to change partnerships, processes, and digital interfaces again and again. Further examples, besides the in option A mentioned are most public bike-sharing schemes (e.g. City Bike Vienna 2021 respectively WienMobil Rad from 2022 onwards-).

COOPERATION AGREEMENTS

MaaS platforms that evolved in recent years in European cities are mainly driven by city governments and public authorities. Besides the digital bundling in the form of MaaS Apps the physical bundling of public transport with shared-mobility-services got into their interest and mobility points have been established. That are locations, where besides public transport additional mobility services (such as shared mobility, on-demand or ride-hailing services) can be accessed. Many cities offer private TSPs to offer their services at these mobility points under certain conditions. In most cases, the PTA (or other public authority) provides public spaces and the needed infrastructure (e.g. charging, electricity, internet access, racks) and provides an umbrella brand. The basic requirement is mainly the integration of the services into the MaaS platform of the PTA. Typical examples for the digital and physical integration are WienMobil App and -Stations in Vienna as physical aggregation of shared-mobility-services in one place, by the PTA Wiener Linien, Jelbi in Berlin by the PTA BVG, switch Hamburg by the PTA Hamburger Hochbahn AG or the MaaS platform wegfinder, by iMobility GmbH a company of Austria's national railway operator ÖBB. Another example of developing their own MaaS-platform is the PTA of the Oslo region in Norway, Ruter. They aim to own the customer interface to deliver *sustainable freedom of movement*. To succeed it is of importance to offer diverse, attractive, and individualised mobility services. Mobility points are viewed as a remedy in this mixture and are therefore being tested in supplement to the MaaS-service.

As public transport providers usually have a broader customer basis, the access to these customers can be very attractive for private TSPs. Further incentives, PTAs can offer to private companies are:

- Access to advertising spaces and marketing campaigns
- Cross-Marketing activities and discounted ticketing
- Exclusive rights (e.g. to be the only company offering a certain mobility mode at the mobility points or the MaaS platform)
- financial subsidies (e.g. for electric vehicles)

In these cooperation agreements, usually the underlaying business models do not change.

This means, the private operators operate on their own risk and the public transport authority does not take over financial risks of the TSPs. Revenues remain at each company. In some cases, the TSP might have to pay transaction fees for each new customer or booking to the MaaS platform operator. In other cases, the participating private companies pay a fee for using public spaces at mobility points. In general, concession agreements and licensing (e.g. for the use of public space) are a good option for public authorities to influence the 'play rules' to a certain extend.

RISK- AND REVENUE SHARING

The third option is, that the TSP works at own risk, but the mobility services are subsidised to a certain extend with public money. This reduces the risk for the TSP and in exchange gives public authorities the option to define certain 'play rules', without becoming an operator itself. Money and time - the two aspects characterise risk- and revenue-sharing deals: The amount of public subsidies (consider non-cash benefits as well) defines to which point each partner takes risks. The other aspect is the duration of the contracts. The duration of the cooperation should be long enough to build up a solid customer base and to establish a sustainable business. For the implementation of shared mobility services at mobility points, a duration of 24-36 months proofed to be useful. Further important are stable, legal framework conditions, that do not change constantly and abruptly.

One typical example for these types of cooperation in Austria is the micro-transport service ist-mobil, an on-demand platform that links local transport service providers with customers. The private company provides the digital platform, the trips are done by local transport service providers for defined tariffs. There, the costs for the mobility service provision are covered partly by the municipality or region, parts of them can be subsidised from the federal government and parts of them by revenues from end-consumer tickets. Another example is the carsharing-service of Wiener Linien WienMobil Auto. Wiener Linien give a concession to a TSP including financial subsidies to support the establishment of good business conditions in form of a solid customer base. Part of this mutual deal is Wiener Linien (WienMobil-) branding on vehicles and inclusion into the WienMobil umbrella brand. Besides, public authorities can implement subsidy programs that focus explicitly the provision of shared mobility or on-demand services. These funding frameworks usually support sustainable mobility projects to a certain percentage and for a defined project time.

„The right mobility solution is needed for every purpose: as intuitive, convenient, environmentally friendly and cost-efficient as possible."

Stefan Arbeithuber

MOBILITY AND REAL ESTATE DEVELOPMENT

In Austria as well as in many other European countries real estate developers are obligated by law to build a certain amount of car parking dependent on the number of housing units or m^2 constructed. Meanwhile some federal provinces and cities demand additional mobility infrastructures and permit a reduction of the car parking in the case that the money is invested in sustainable mobility. This can be for example well-suited pedestrian paths and cycling lanes, high-quality bicycle parking or shared mobility services.

Mobility funds for new urban development areas

Some cities established mobility funds that finance different projects for sustainable mobility in urban development areas. The funds are administered by public authorities and typically finance mobility services and related projects to a certain extend (project time and/or percentage). Examples are the mobility funds in Vienna's urban development area Seestadt Aspern (1220 Vienna, Austria), or the mobility fund of the city of Vienna, Austria, with a current focus on Sonnwendviertel Ost (1100 Vienna). In these examples every real estate developer, that is engaged in the according to new city development area had to pay a

certain amount per car parking that they would be obligated per law to build.

URBAN DEVELOPMENT CONTRACTS

Another legal instrument to cover investments into sustainable mobility are urban development contracts. In the context of new building areas, the according public authority of the city makes such a contract, including the obligation for the developer to implement and provide certain mobility infrastructure and mobility services and/or to pay a certain amount into a mobility funds.

CONLUSIONS OF OUR FINDINGS

MaaS is not about one or more mobility platform, rather we are dealing with a complex network of different players. The MaaS offers depend on the underlaying transport service provision and on locally available mobility offers. This mobility market is often dominated by local players.

In cities or regions where there are not many private mobility offers (yet) and the needed resources and know-how is accessible, it seems adequate to follow the proposed strategy A and to 'do it yourself' and to operate additional mobility services. Municipalities, that follow option C) ("work together") can take advantage of know-how and resources of already established private transport-service providers and cooperate with them. This might need less resources and public investment. But the partnerships should be chosen carefully: Due to the young and dynamic market, organisations as well as the digital platforms used might change quickly.

In general, the mobility market is very fragmented. This means that every city and region must identify the form of cooperation and financing most suited to the local needs. It requires to identify the organisation- and finance-model suited for each city or region.

POLICY RECOMMENDATIONS

› Public authorities and -transport organisations striving to improve transport quality in the urban periphery should intervene carefully into the market to create respectively maintain an **innovative market environment**.

› The market for transport services is dominated by local transport service providers and thus very fragmented. Every city and region must **identify the form of cooperation suited to the local needs**, **choose the according strategy, and stick to it**.

› Cities and public authorities basically face two options to enable the provision of additional mobility services in urban peripheral areas: They can "do it yourself" and operate additional mobility services directly or indirectly or they can work together with private Transport Services Providers (TSP). **To take no policy action and leave it to the market is not recommended to improve mobility qualities in urban no-core areas**.

› Option A "**do it yourself**" is suited if the market of additional mobility services does not exist (yet) and the **needed resources and know-how is accessible**.

› Option B is suited when municipalities can **build on the existing know-how and resources of established transport service providers**.

› The market for shared mobility and on-demand services is young and dynamic - the **digital integration into MaaS platforms should be done in the long run** and partners should be chosen carefully.

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SIMULATING THE IMPACT

OF MOBILITY MEASURES WITHIN AN AREA

Decision support systems can help decision makers in their everyday planning routine. With the amount of data available nowadays, data-based simulation models can support such decision processes by providing quantitative results to the planners. We propose to use simulation models to evaluate MaaS-measures in a virtual environment while considering user mobility behaviour and demand, the local transport system and socio-demographic data.

RECOMMENDATIONS FOR EXPERT USERS AND DESIGNERS OF SIMULATION MODELS

› **For whom do you simulate?** Be precise with defining your stakeholders and interest groups. Let them be involved as much as possible.

› Precisely define the **goals of the simulation**, which questions do you want to find answers for?

› Reflect if **simulation is the right way of finding answers** to your questions and show what the simulation can and cannot do.

› Put a significant amount of effort in the visualisation of the simulation results. If possible, **include communication and visualisation experts**.

› Be **transparent** in the communication of your **assumptions and used input data.**

› **Critically look** at the simulation results – also let your stakeholders challenge you with questions - and plan for **multiple refinement iterations**.

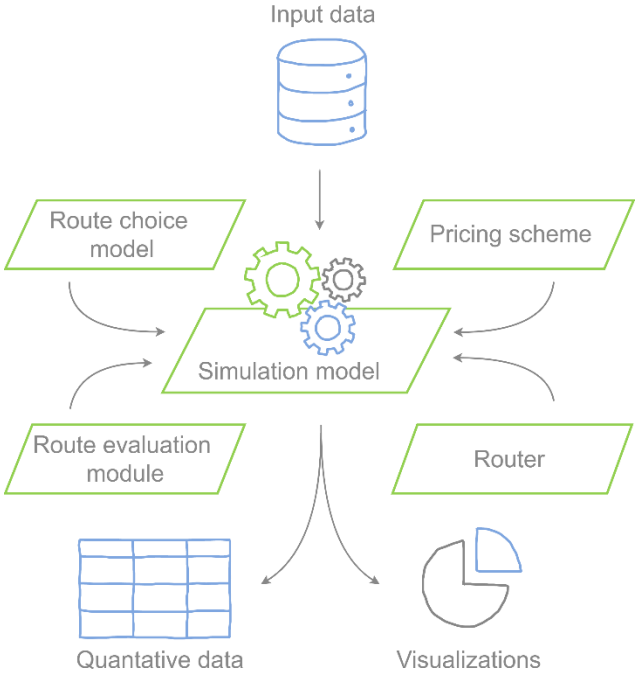
Authors: Benjamin Biesinger, Bin Hu

WHY SIMULATION?

When planning to implement new, innovative mobility measures, planners often face the problem of not knowing the impacts of their decisions. Furthermore, those decisions might be hard to undo, especially when infrastructure has to be built. Therefore, we propose the use of simulation models to have an a-priori guidance on quantifiable impacts of (variants of) measures. We focus on providing guidance how to implement and use simulation models for mobility measures as well as providing an overview of the methodology, the data requirements, visualisation possibilities, limitations, and possible performance indicators.

SIMULATION METHODOLOGY

The basic working principle of the simulation model is the simulation of user choices based on their mobility demand, their fulfilment possibilities, and their personal preferences, please refer to the following graphic.



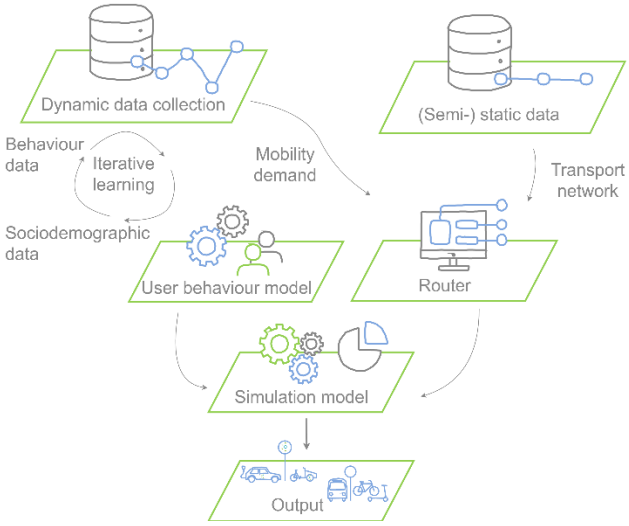
Overview of the OptiMaaS simulation model (AIT, graphic design: tbwr, 2021)

Therefore, a router module (Prandtstetter et. al., 2018) computes routes using different modes (public transport, private car if available,

bicycle, walking, …) which are subsequently evaluated using a pre-trained user behaviour model (Balac et. al., 2019) considering the users' personal preferences and the user costs. A multinomial logit model then simulates the choices of the users (Hörl et. al., 2018).

DATA REQUIREMENTS AND COLLECTION

Since simulation models are data-based methods, well-defined input data is needed. We distinguish between dynamic data slowly but steadily changing over time which should be iteratively and repeatedly collected in order to improve the quality of the simulation and semi-static data which is known and mostly fixed. The following graphic shows the interaction between the data and the simulation modules.

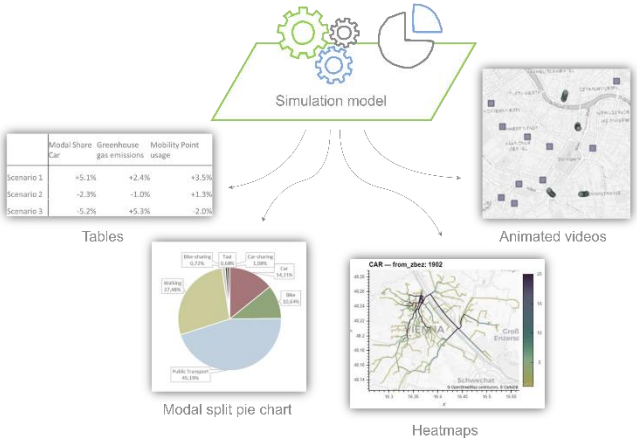


Overview of the data (collection) requirements for the OptiMaaS-simulation model (AIT, graphic design: tbwr, 2021)

The dynamic data consists of the socio-demographic data, the mobility demand, and the mobility behaviour. While demographic data is usually regularly gathered and publicly available, the mobility demand and behaviour are not. Therefore, several assumptions have to be made for any simulation model where such data is not available which reduce the output quality. The ongoing digitalisation, however, opens possibilities for automatic collection and processing of mobility demand and behaviour data. MaaS-platform provider – or transport provider in general – who make their collected data available (while considering data protection laws) could significantly contribute in improving the quality of mobility simulation models. On the other hand, the semi-static data, e.g., the public transport and the road network, does not change often and is usually readily available.

VISUALISATION AND COMMUNICATION POSSIBILITIES

To be able to communicate the model results and to gain trust in the model from the stakeholders like urban planners, policy makers, or even the broad public, suitable result visualisations are essential. These visualisations also have to be individualised depending on the target audience which often pose different requirements. Although presenting numerical results, e.g., the decrease in greenhouse gas emissions, are important to present, more visually appealing depictions are necessary. (OptiMaaS, PL-Vienna, 2020/21)



Semi-automated visualisation possibilities (AIT, graphic design: tbwr, 2021)

As the graphic above shows, we use pie charts for visualising the modal split, heatmaps for the mode-specific density on network segments, and animations can be used for visualising movement data. There are also further visualisation possibilities, e.g., Sankey diagrams for showing the flows from one mode type to another based on the simulated differences in the network. It is, however, of the utmost importance to make the visualizations as clear and appealing as possible to transport the main messages of the simulation results to the respective stakeholders. For being able to achieve this goal, it is advisable to manually

design such visualisations and to include communication and design experts.

EVALUATION CRITERIA

We use a selection of indicators to evaluate the performance of the measures and to compare the scenarios in the simulation.

- Modal split (car, car-sharing, bike, bike-sharing, walking, public transport) over all trips within the considered area. This can be further broken down to:
- Total modal split
- Modal split in a (sub-)region
- Modal split by persona type (Rasca et. al., 2019). For a persona method description please refer to HOW CAN ON DEMAND MOBILITY AFFECT USERS' CHOICE?_user needs and requirements: creating personas and scenarios
- Trip length by transport mode shows the transport performance, which is a primary indicator for computing other impacts such as CO_2 emissions, etc.
- Trip duration by transport mode shows the time people spend on different modes.
- Usage of individual transport elements shows the hotspots of the transport system, i.e., where a transport mode is used most frequently. A common visualisation approach is to use a heatmap on:
  - Public transport lines
  - Mobility points
  - Road segments

OVERCOMMING LIMITATIONS OF SIMULATION MODELS

In our approach, however, there are also several limitations in its usage:

- Without data in sufficiently good quality, many assumptions have to be made, e.g.,
  - Target modal split for training the user behaviour model
  - Mobility demand data of the target regions is artificially generated (though based on real data)
  - Estimations for sub-modules of the simulation have to be made (e.g., influence of parking space availability on mode choice)

„Mobility as a Service enables more efficient use of limited resources and thus contributes to a sustainable mobility system."

Benjamin Biesinger

To overcome these limitations, reasonable data collection strategies must be implemented as described before.

- Some indicators are hard to evaluate (e.g., attractivity for certain transport modes). A proxy function can be developed to estimate such attractivity measures, e.g., a scoring approach for bicycle routes considering the presence of bike tracks, road steepness, etc.
- Since we are considering simulations on a macro / meso level, impacts on the micro-level are not within scope (e.g., traffic lights, interaction between vehicles and pedestrians).
- This approach focuses on typical trips on a workday. If other cases (e.g., leisure trips on weekends) should be considered, other input data is necessary.

We still advise, however, the use of simulations for MaaS-measures and believe that simulations a powerful tool for supporting planners to make informed decisions.

POLICY RECOMMENDATIONS

- Informed and objective decision-making needs quantitative modelling.
- **Simulation methods require a solid data foundation** (which is often non-existent).

› Transport service providers should **share their data respecting clear rules of exchange** which respect to strategic objectives of mobility planning by public bodies and protection of (private) business models as far as possible. This increases the quality of mobility simulation models and, more generally, it helps improving the understanding of mobility behaviour.

› **Feedback loops** between collected data and simulation models need to be implemented.

› **Increase the trust in the simulation model results** by considering aspects like the development by private or public actors, visualisation, transparency, assumptions, **stakeholder involvement**.

› **Define quantifiable indicators and target values of MaaS-measures** to evaluate them first in a simulated environment, before rolling them out in the real environment (especially for larger projects).

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LOCATION OPTIMISATION OF MOBILITY POINTS -

WHICH OFFERS FIT WHICH SURROUNDINGS?

The ideal location, configuration, and mobility offers of mobility points depend on many different factors. Therefore, we want to provide a list of such factors and present the MOBILITY POINT CONFIGURATOR as a decision support tool. We discuss which factors are already included in the tool, which are not, and which are generally hard to be included in any tool (e.g., not quantifiable factors). Finally, we provide recommendations for finding good locations for mobility points based on our findings.

RECOMMENDATIONS FOR MOBILITY SERVICE PROVIDERS

› Use **data-based planning tools to make informed decisions** about your mobility offers.

› **Know your users and their needs**.

› Using **GIS-based methods can be a very effective tool** but setting threshold values, e.g., for area selection, should be **made thoughtfully**.

› If no historic data is available, e.g., for new development areas, **prognosis data can fill the gaps**.

Authors: Benjamin Biesinger, Stefan Arbeithuber, Bin Hu

MOBILITY POINT LOCATION OPTIMISATION

Mobility planners and mobility point operators often face the challenge to find the optimal locations to implement new mobility points within a city that generate interest in their target group and are accepted by their users. For answering the question which offers fit which surroundings first a look at the influencing factors on offer choice is made to identify potential for sharing offers. This knowledge is applied and included the developed mobility point configurator (MPC) tool which is a GIS-based expert tool for helping planners in their locations choice for placing mobility points.

INFLUENCING FACTORS ON OFFER CHOICE

Table 1 shows the most common influencing factors on mobility behaviour and in which context or relation these factors are influencing (context column). The table further provides examples for data and the specific data used in the test and application of the mobility point configurator. See also paper NEW OPPORTUNITIES FOR PROPERTY DEVELOPERS FOR COOPERATION WITH MOBILITY PROVIDERS, PUBLIC AUTHORITIES AND USERS for further discussion on such influencing factors.

EXPLOITING USER KNOWLEDGE FOR DEVELOPING PLANNING TOOLS

With the listed influencing factors, the question is how to utilise which data to build a planning tool. Following aspects are considered.

- Possibility of combining different factors
- Data quality and level of detail for the planning
- Intuitive visualisation with a decent information content
- Data comparability (level, year)
- Data accessibility

While this paper focuses on the planning tool, the evaluation requires the simulation module (see paper SIMULATING THE IMPACT OF MOBILITY MEASURES WITHIN AN AREA).

FACTORS TO BE CONSIDERED	CONTEXT	DATA SOURCES (EXAMPLES)	DATA CONSIDERED IN MPC APPLIED FOR VIENNA
SPATIAL SURROUNDING	Design of public spaces and circulation areas influences the mode choices	availability and quality of bike lanes, sidewalks, parks	-
ATTRACTORS IN THE NEIGHBOURHOOD	Distance to suppliers of groceries, pharmacies, schools		-
PUBLIC TRANSPORT QUALITY (PTQ)	The higher the public transport quality, the more independent of the private car	Public transport quality level (PTQ)	PT SQL-model Austria as GIS information (so called "ÖV Güteklassen") 2017
CONVENIENCE AND COSTS FOR CAR OWNERSHIP	Availability of parking	Number of public parkings, parking restrictions, zoning management	Parking zones Vienna as GIS
CONVENIENCE AND COSTS FOR CAR OWNERSHIP	Costs for parking The lower the degree of motorization, the more need for alternative means of transport	Free parking, short-term parking Degree of motorization	
AVAILABILITY OF ALTERNATIVE MOBILITY OFFERS	Availability of taxi, rental cars, carsharing, bikesharing, kickscooter sharing	Operating areas of free-floating shared-mobility operators, locations of station-based carsharing	Operating areas of freefloating carsharing (2019)
DENSITY OF HOUSING	The higher housing-density, the higher the user potential for the mobility services	Housing density as GIS-data on level of building blocks	Population density (2019) on level of building blocks
		Expected population development in specific areas	Population prognosis for Vienna in 2035 on district level
DISTANCE TO THE MOBILITY POINT SERVICES	Proximity to services increases the convenience and therefor the likelihood to use them	Walking distance to the mobility point	Consideration of 300m walking distances
PRICING OF THE MOBILITY SERVICES			Consideration of usage costs per hour
PERSONAL PREFERENCES	Personal mode preferences, interest in sharing services (due to habits, physical abilities, needs)	Indirect indicator: users of shared mobility tend to have higher education and higher levels of income	Share of tertial education (2016)

Relevant factors for mobility point configuration

MOBILITY POINT CONFIGURATOR

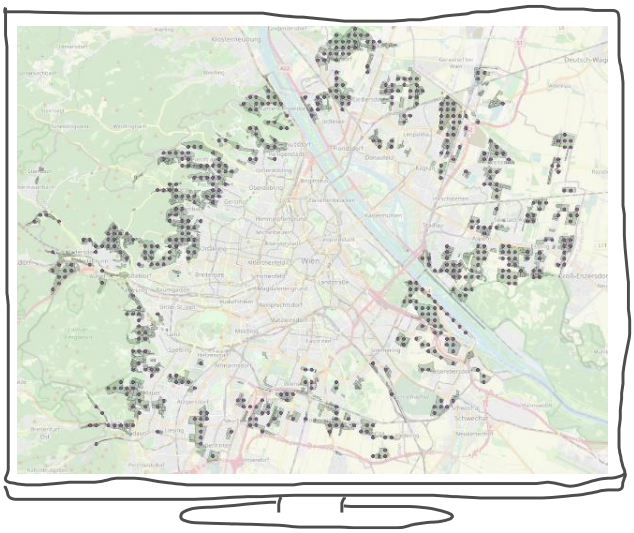
In the OptiMaaS project we developed the Mobility Point Configurator as a planning tool. In the following we show the different levels of detail for the planning and give an example of how we applied it on Vienna.

CITY LEVEL

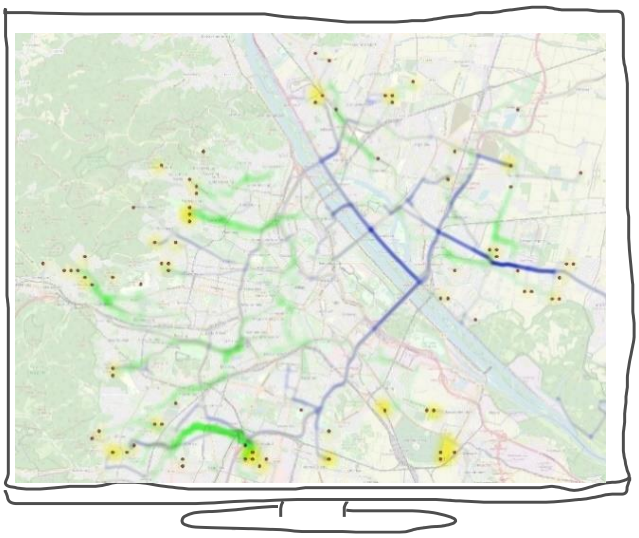
On the city layer, the objective is to identify areas that are suited for installing mobility points. In the spirit of the *OptiMaaS* project, we emphasise on the urban non-core areas where shared mobility has the potential to complement the public transport offers. The pre-selection is a filtering based on the following criteria:

VARIABLES	CRITERIA
POPULATION DENSITY	min. 277/ha
PT QUALITY	D – G

The following figure shows the results of this pre-selection process. The highlighted areas fulfil the selection criteria and potential locations are distributed on a grid of 300 meters. shows an example for an implementation of 83 mobility points in these areas. Road segments in green show the trips performed by shared bikes, while segments in blue show the trips performed by shared cars.



Potential locations for mobility points in the urban non-core area (AIT, MO.Point, 2021)



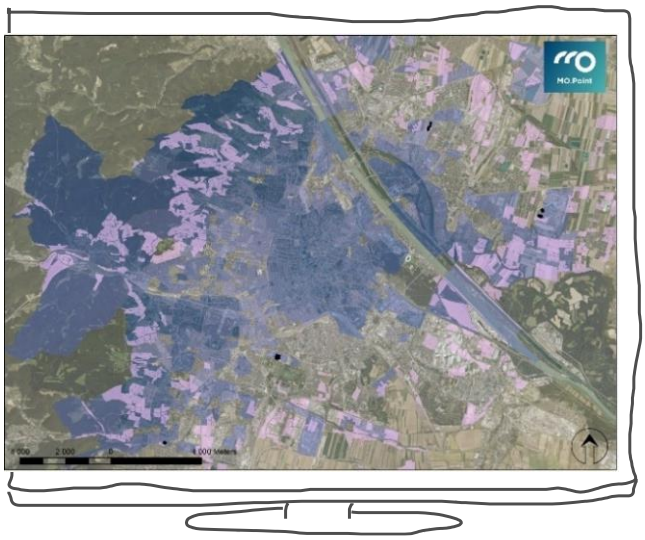
Potential impact of the mobility points and usage of shared mobility (AIT, MO.Point, 2021)

LOCAL LEVEL

On the local layer the objective is to identify city blocks more suited than others as to user potential for mobility points. Therefore, the following variables and thresholds were used to identify areas by filtering geographic information system- (GIS-) data:

VARIABLES	CRITERIA
POPULATION DENSITY	min. 277/ha
EDUCATION (TERTIARY)	min. 20%
PT QUALITY	D – G
CARSHARING (FREEFLOATING)	no

The map below shows the identified areas within non-core areas, based on the GIS-filter criteria. Due to the low population density in peripheral areas 8 areas could be identified for the city of Vienna. (s. Figure 4, black dots in the map)

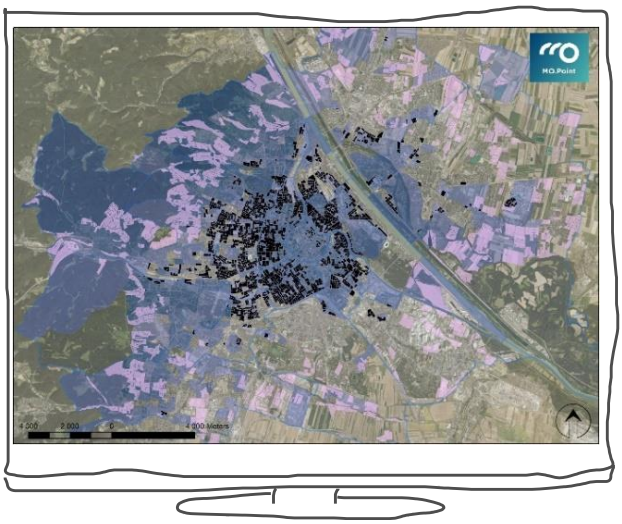


Result of MPC – GIS filter to identify areas suited for mobility points in areas with low PT quality (MO.Point, 2021)

To show the difference in results a **comparative assessment** has been done with focus on areas with the highest PT quality (Level A to C):

VARIABLES	CRITERIA
POPULATION DENSITY	min. 277/ha
EDUCATION (TERTIARY)	min. 20%
PT QUALITY	A – C
CARSHARING (FREEFLOATING)	no + yes

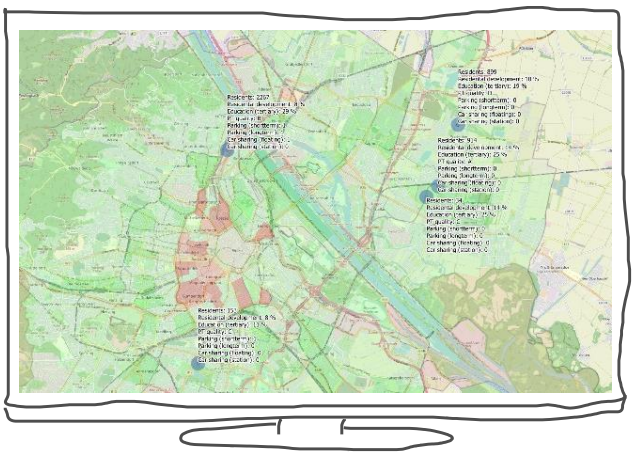
The numerous black city blocks on the map in the following figure indicate, why for mobility operators' core-areas are much more attractive due to higher user-potential. Further, a few areas could be identified in non-core areas as well including good to excellent PT-Quality.



Results of MPC - GIS filter in areas with good PT quality (MO.Point, 2021)

POINT LEVEL

On point-level the use of the MPC is to compare specific selected locations according to defined parameters. Figure 6 below shows the point request for the OptiMaaS target areas in Vienna. This application serves to select the locations most suited and can be applied also within a quarter or area.



MPC point request for OptiMaaS target areas in Vienna (MO.Point, 2021)

MOBILITY POINT CONFIGURATOR AS AN EXPERT TOOL

The *mobility point configurator* is a planning tool for experts which asses the applicability and impacts of (a network of) mobility point(s) and supports decision making. The tool is highly dependent on the available and quality of data, which is both given for Vienna. The MPC is an application that runs on the Softwareplatform QGis. Within this geo-information-software, the data-layers, mentioned in table 1, column 3 can be uploaded. Once configured, professional users can then configure the filters following the above-mentioned criteria to identify the area, location or city-block suited. Once, a location is chosen, the recommended number of vehicles for station-based sharing can be calculated, considering the user-potential in the surroundings.

On the city level, users obtain a close-pitch selection of target area(s) for implementing mobility points with respect to the chosen criteria. On the local level and point level, the tool provides a solid basis to compare and to identify those areas or locations more suited than others. Critical for the successful application is the careful selection of thresholds.

„MaaS is the future! Let's advance from an ownership-based mobility system towards a service-oriented system."

Bin Hu

Professional users can re-configure the underlying data, such as demographic data for building blocks on the local level in order to adapt to certain future developments. On the point level, the specifics of mobility points such as the exact location, the expected area of influence, the services provided, and the pricing can be configured. All these factors influence the overall performance of the mobility points.

A big challenge is the assessment of new development areas. While they are most interesting candidates for implementing mobility points, historic data in these areas do not reflect the future development where thousands of new housing units and working places are developed. For applying the tool in these areas successfully, the user has to manually update the data for the expected

housing development. Another challenge is the application of the tool to other cities. While certain GIS data might be available, the format, the comparability as to the level of detail and in particular the system of measurement may vary (e.g., the public transport quality rating).

POLICY RECOMMENDATIONS

› When **planning new mobility hubs** always look for **synergies with public transport** first.

› The **mobility point configurator (MPC)** is a powerful assessment **tool for experts** in urban and transport planning.

› The MPC works for new city development areas, but **prognosis data are necessary**, ideally per city block.

› Depending on the use case, **MPC can operate on different levels**, offering different views and levels of application (city, level, point).

› **When data is available** with a high enough quality, **planning tools are highly useful in the decision-making process**.

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HOW CAN ON DEMAND MOBILITY AFFECT USERS' CHOICE?

How can persons using motorised individual transport be directed towards public transport (PT) to strengthen the share of extended eco-mobility and the modal split of PT? On-demand as an additional mobility offer, especially in urban peripheral areas, can help reach this goal. For a successful implementation of on-demand mobility, user acceptance and usability, as well as data-based validation play a crucial part.

RECOMMENDATIONS FOR PT AND IT PROVIDERS

› The outcomes of the OptiMaaS project suggests that on-demand mobility should be implemented as an **additional offer in the existing public transport and MaaS system**.

› Before organisational decisions like pricing, pickup times, detours etc. are made and put into practice, they should be **validated by real customers** (e.g. through user questionnaires) **to increase acceptance**.

› The **target group should be researched** and depicted as detailed as possible, using the recommended approach of persona development to represent the target groups of an on-demand service.

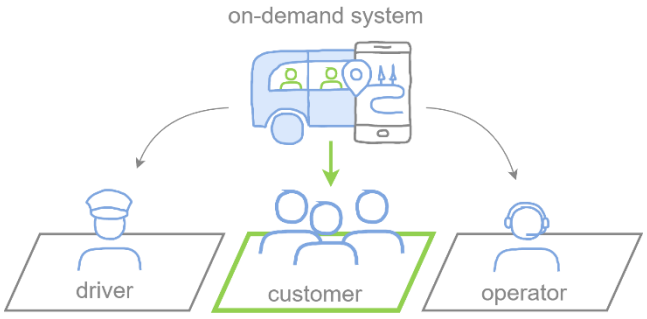
› User acceptance can be increased by using a **user-centred approach in the development of design, handling and functionalities** of a digital on-demand solution and **involving the user at several stages** of the process.

› Use cases and situations for using an on-demand service can be validated based on **target area evaluation and analysis**, hence by making use of data generated in already existing MaaS apps.

Authors: Bianca Humer, Angela Muth, Benjamin Biesinger, Vincent Neumayer

POSITIONING ON-DEMAND MOBILITY SERVICES WITHIN MAAS

The guiding question that is discussed in this recommendation paper is how persons using motorised individual transport can be directed towards public transport through on demand mobility services within Mobility as a Service (MaaS). We are focusing on the users' view, however, for the sake of completeness, we would like to point out that for the successful implementation of a digital on-demand mobility solution, it is also vital to consider the drivers' view, as well as to take into account the requirements and needs of the operator (e.g. public transport providers).



IT-users of an on-demand system (tbw research, 2021)

In order to achieve the overall goal of positioning on-demand within MaaS, several sub-ordinate targets have to be met: (1) the concept of shared mobility has to be made known to the users, as customers won't accept or make use of a service that they are not sufficiently familiar with. (2) a corresponding on-demand IT solution must be user-friendly and easy to use. (3) knowing the deciding factors for users to choose an on-demand service over their own car.

WHAT IS ON-DEMAND MOBILITY?

In the OptiMaaS research project, MaaS is defined as a bundle of mobility services accessible to the user, while on-demand represents one of the many MaaS services that exist. On-demand mobility, as the term indicates, is a demand-driven mobility service, which dynamically coordinates the time, pick-up location and route to bundle trips with similar routes. The concept of on-demand-based mobility services (including also classic services such as taxis) is supported by digital tools, like smartphone or web apps and IT-based scheduling hence such services are representing the transition from traditional (taxi, bus-service) to innovative demand-responsive services like ride-hailing, ride-pooling and MaaS. Other transport modes like car sharing and ride sharing have characteristics of both, traditional and modern demand-responsive transport systems (Koesling, 2018). As on-demand mobility providers, offers and systems are subject to constant change and continuous further development, a final and universal definition of on-demand mobility cannot be provided in this recommendation paper.

For our research activities, on-demand service was defined as an **affordable mobility option complementing existing public transport**, targeting especially areas located in the urban periphery. The service should allow passengers to request a vehicle by smartphone 24/7, which picks them up from their current location within 30 minutes and brings them to their desired destinations without having to change modes (ride-hailing). The mobility platform in the background matches multiple passengers heading in the same direction with a moving vehicle (ride-sharing) if wished. If shared, the ride gets cheaper and travel time can be prolonged by max 15 minutes. The whole on-demand service should represent a Mobility as a Service offer that allows almost the same flexibility as conventional taxis or private cars and makes a major contribution to the environmental balance through intelligent "pooling" that happens in the backend of the app (OptiMaaS Co-Creation Lab Kapfenberg, 2019).

ON-DEMAND - SERVICES BETWEEN PUBLIC TRANSPORT, (DIGITAL) MAAS AND PRIVATE CARS

Boundaries between public and private transport are continuously blurred, which has been triggered by the appearance of new types of transport providers. New mobility solutions and trends are more and more moving towards the disruption of traditional public and private mobility. Moreover, the increased use of digital devices, in particular smartphones and tablets, providing better access to internet technologies is a major enabler of and requirement for MaaS, with private mobility providers often in the role as early adopters (Jain, 2021). For a state-of-the-art, digital MaaS platform, it is crucial to implement services in a modular way, in order to enable scalability, expandability and connectivity of mobility services. Our research suggests that on-demand mobility should be either implemented as an additional offer in the existing public transport system and be treated as one amongst many other modules of a MaaS system or platform, or as a separate, independent application (on-demand User Questionnaire, 2021).

„MaaS platforms are indispensable as central point of control for mobility in the city, and ensure equal access to mobility for everyone."

Bianca Humer

An extensive survey on on-demand services was conducted within the OptiMaaS project. The majority of the participants in this survey (88%) prefers a **digital channel for booking an on-demand shuttle**. Among these, 41% think it worthwhile to integrate an on-demand mobility service in an already existing mobility app that they are using or are already registered for. For Vienna, this would for instance be the app "WienMobil". Other digital options like an individual app or a website for booking an on-demand service would also work well for the participants. This statement corresponds to the preferred registration for an on-demand service: 83 among 136 participants chose the integration in a mobility app already in use as

the most preferred way of registering (on-demand User Questionnaire, 2021). According to the experts participating in the OptiMaaS International Expert Panel in February 2021, embedding on-demand stronger in the MaaS context is highly recommended (OptiMaaS IEP, 2021).

USE CASES AND MOTIVATIONS FOR USING AND SHARING ON-DEMAND SHUTTLES

In order to direct the users' attention towards a new mobility service like on-demand, to explain the concept and to generate awareness, **multimodal journey planning can be a door opener**. This means that the on-demand service should be one of several modes of transport that can be combined according to the respective user's needs and requirements, like the combined route of on-demand and bike, or on-demand and public transport (OptiMaaS IEP, 2021). The use cases for using an on-demand shuttle instead of a private car are manifold, as are the main motivations. These use cases and motivations can be used as realistic "anchors" for communicating a new service like on-demand shuttles.

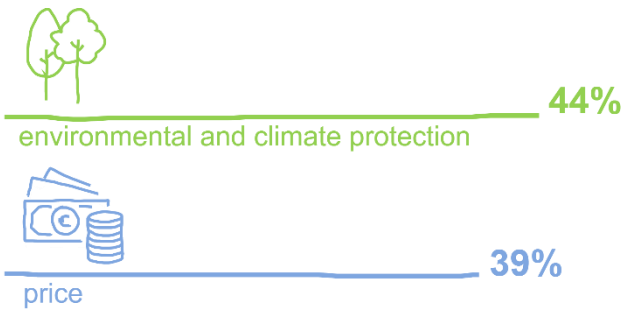
For example, 20% of persons asked do not even own a private car and would use an on-demand shuttle as an alternative. Another important factor is the price of the service and perceived lower costs compared to an own car, and the subjective feeling of getting a good price for the service (31%). This is followed by flexibility, availability and reliability (29%), which the participants explained mostly by the time factor (e.g. the rapid availability of an on-demand shuttle, short waiting times, a faster journey time compared to other modes of transport and the possibility of direct pickup e.g. at your home address). But environmental and climate protection was also often stated as a motivation (8%). Another important point stated by 13% of the participants is the search for parking spaces, which would be omitted when using an on-demand shuttle. Some participants also stated that usability is one of the major motivational reasons to use such a service (on-demand User Questionnaire, 2021).

Anchors for implementing and communicating a new on-demand shuttle service (OptiMaaS – user questionnaire 2020, graphic design: tbw research, 2021)

Several respondents stated that they would use an on-demand service for covering their "first and last mile" (e.g. from their home to the nearest or next higher-ranking public transport). Another major use case is transporting bulky or heavy objects like furniture, bigger shopping bags or pushchairs. Many participants also see an on-demand service as an alternative for a taxi. The most-stated time of day for using an on-demand service were off-peak hours and the night-time, mostly due to decreased public transport services. Airport transfer was also often mentioned (on-demand User Questionnaire, 2021).

CHOOSING ON-DEMAND MOBILITY STRENGTHENS EXTENDED ECO-MOBILITY

The most-stated main motivation for sharing an on-demand shuttle with others was environmental protection and CO2 reduction (44%), followed by price (39%).



Motivations for sharing an on-demand shuttle (OptiMaaS – user questionnaire 2020, graphic design: tbw research, 2021)

Only 7% of persons asked would not share an on-demand shuttle with other passengers. When it comes to the topic of price vs. service, most participants (64%) would choose the better (or cheaper) offer and share the on-demand shuttle with other passengers. An even higher number of participants (72%) stated that they think it is very important that the CO2 emission of their ride decreases with each additional passenger (on-demand User Questionnaire, 2021). Therefore, we estimate the potential of on-demand services to strengthen the share of extended eco-mobility (comprising public transport, biking, walking, shared mobility and on-demand services), from a user point of view, could lead to decreased overall energy consumption and emissions, and by increasing the modal split of public transport, also contribute to a reduction of motorised individual transport. The potential increase of eco-mobility, of course, also depends on the occupancy rate of the on-demand shuttles: the higher, the better. As this paper focuses primarily on the users' perspective, this is not dealt with in detail though.

When targeting the reduction of motorised individual transport through on-demand mobility, internal estimations, research and general market developments suggest that users perceive on-demand service as an intermediate step between "traditional" taxi services and private cars. Therefore, in order to reduce private car use and avoid cannibalisation of public transport, our suggestion for operators is to position an on-demand service between taxis and private cars, and not at the other end of the spectrum (which would be between public transport and taxi services) (OptiMaaS IEP, 2021).

To increase user awareness for on-demand mobility as an environmentally friendly mode of transport and the CO2 reduction potential that comes along with sharing a ride with others, we propose to work with CO2 comparisons or reference levels. In our usability lab tests, references that were close to the daily life of the participants worked best (e.g. "The CO2 emission for each passenger is 280g. An hour of watching TV would cause 150g of CO2.") (OptiMaaS Usability and Acceptance Lab, 2021).

All these efforts should lead to an approximation of on-demand mobility and private cars and for this to be achieved, the parameters behind car usage like the trip chains or entire journeys of private cars, destinations, activities etc. should be studied in detail. These topics, unfortunately, go beyond our research, which represents one of the limitations of the OptiMaaS project.

USABILITY AND USER ACCEPTANCE IS CRUCIAL

The user should always be at the centre of the development of new services. There are several ways of how user engagement and different participatory development approaches can be addressed when planning and implementing on-demand mobility services. This can be the focus of more general topics or improvement projects of mobility and MaaS. A few methods are described in the following paragraphs.

USER NEEDS AND REQUIREMENTS: CREATING PERSONAS AND SCENARIOS

Personas are fictional characters created to represent a target group or audience with its different user (arche)types, which are built around observed behaviour patterns among real people. Each persona is representative of a segment of the target group (Brunello 2018). The user's needs and requirements are to be considered especially when it comes to the design of an application or new service. Therefore, in OptiMaaS this methodology was used to describe and depict diverse user and target groups, from adolescents to senior citizens, and their specific and varying needs,

including behaviour and requested functionalities, as well as requirements for the frontend design (OptiMaaS D2.1 Report).

It is recommended to build the corresponding scenarios or use cases around the personas previously developed, as well as the respective or planned context. Combined, this approach serves as a good indicator and shows how the solution will be used rather than how developers or solution designers think it might be used, which has to be kept in mind for a design and development approach that puts the citizen (i.e. the user) in the centre. In order to ensure an optimal use of the personas and scenarios developed, they should be formulated precisely, as well as appropriately detailed but not too specific, and adequately reasoned for the use case you would like to describe (OptiMaaS Co-Creation Lab, 2020).

Persona example (OptiMaaS 2018, graphic design: tbw research, 2021)

USER-CENTRED DESIGN AND DEVELOPMENT APPROACH

Design of products and services, especially apps, often puts the consumer outside the value chain, where users are involved only for testing the apps or parts of them at certain stages in the development process, using the User Experience (UX) method, where users are benchmarking their user experiences with different apps in usability tests. If the whole design and development process should be user-centred though, using new methods and approaches is recommended (OptiMaaS Co-Creation Lab, 2019).

When implementing a user-centred design and development approach for IT solutions, it can be important and useful to **involve the users** representing your predefined target group **from the very beginning**. The innovative UX design approach of "Co-Creation", or the act of creating together, which is used for developing new business models, products and services with customers, clients or trading partners, was chosen as method. Based on user engagement that allows users to be their own designers, they work together with a set of different tools like developing a customer journey, organised in workshop formats.

In order to ensure diversity and to take into account various perspectives in the co-creation setting, it is important to choose appropriate personas and consistent scenarios, so that the participants can put themselves in the position of these personas easily and to lower possible, initial barriers to the co-creation exercises (see previous passage). It is also highly recommended to give the participants adequate information on the concept of the service, product or business model that they should work on, if possible, even prior to the workshops.

The inputs and ideas created by the participants should be collected, categorised, analysed and subsequently prioritised. Based on the combination of these inputs, the concept for features and designs for a user-centred on-demand mobility service can be drafted, which in turn serves as a practical basis for the technological development process (OptiMaaS Usability and Acceptance Lab, 2021).

REALITY CHECK FOR USER NEEDS AND ACCEPTANCE CRITERIA

User engagement does not end with the finalisation of the designs. Quite the contrary – the designs are subject to constant changes and adaptions based on user feedback as well. It is therefore vital not to skip the step of thorough usability and acceptance (UX) testing, where users can test the outcome in a realistic environment. For the creation of such a realistic environment, a so-called "Clickdummy" is useful. A Clickdummy is a partly interactive and "clickable" prototype of a website or application for testing key usability factors, hence enabling the test persons to navigate through a sequence of screens using clickable areas that are interconnected. Using a Clickdummy has been proven to be an efficient

way for testing designs, as changes can be implemented rapidly and easily, detached from possible technical constraints or development efforts (OptiMaaS Usability and Acceptance Lab, 2021).

If there is more than one way for navigating through the application, e.g. entering a destination for your on-demand ride either by typing the address or location on the smartphone keyboard or by setting a destination point on the map, this can be easily tested with a Clickdummy. In our case, the majority of test persons entered their destination by using the keyboard, allowing us to draw the conclusion that the other way is not needed or considered useful by the users, and hence won't be implemented in the "real" on-demand app later. Also, the **choice of wording** can be easily validated in the UX tests and changed accordingly, in case something is not clear or easily understandable by the test persons. Therefore, it is suggested to plan several user testing and feedback loops in order to be able to test and validate possible adaptions as well. We used the think aloud method for those testings. (OptiMaaS Usability and Acceptance Lab, 2021).

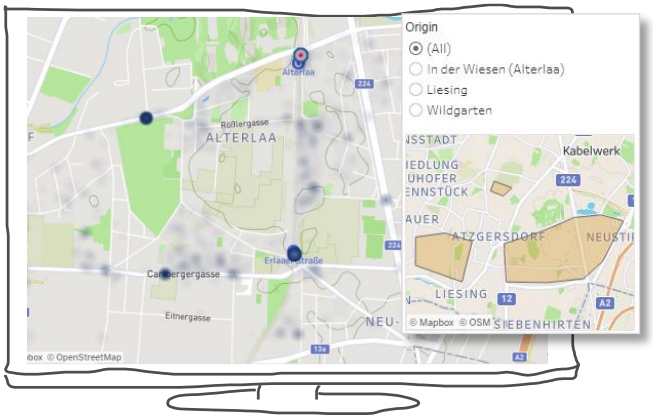
The most important findings from the UX tests can be validated by involving a broader opinion base, e.g. through online questionnaires. This is recommended particularly for topics concerning the service organisation itself, like the acceptable time span between booking the shuttle and pickup, where the majority of persons asked thinks 15 minutes are appropriate, or pricing schemes (see following chapter).

USER-CENTRED AND DATA-BASED MAAS PLATFORM

Using mobility data generated by MaaS platforms plays a vital part in urban planning and city management, as the visualisations and analyses that are based on this data source can be used as steering and planning instruments.

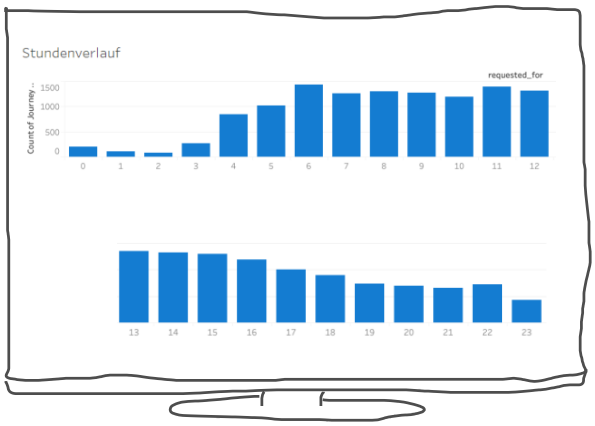
DATA-BASED VALIDATION OF TARGET AREAS USING DATA FROM EXISTING (AND FUTURE) APPS

The chosen approach for data-based validation of target areas in the OptiMaaS project was the analysis of the routing requests for predefined on-demand target areas from existing MaaS apps, using the app "WienMobil" as a data source. For each defined target area, the requested origin and destination routes can be used for analysing the demand for on-demand mobility services.



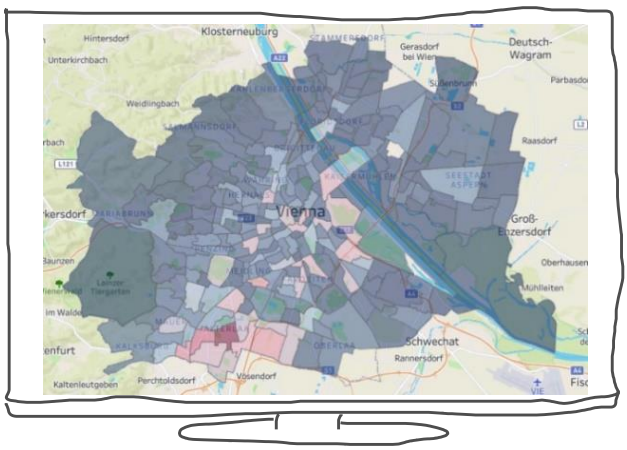
Mobility data-based validation of on-demand target areas (Upstream Mobility, 2021)

The detailed view of one of the defined target areas "In der Wiesen (Alterlaa)" shows the most important origin points. In our case, the darkest blue or red dots on the map are showing the most important starting locations, where people are getting on public transport, i.e. the next higher-ranked transportation hub like a metro station. These points can be analysed regarding walking distance from the origin (e.g. home location of the user) to the destination (here: PT stops), and if the implementation of an on-demand shuttle would make sense for covering the first and last mile in this area. Moreover, such an analysis can serve for the assessment of demand – as in when and where on-demand shuttles would be needed. For this task, the day and week chart can be useful (OptiMaaS Mobility Data Analysis, 2021).



Hourly schedule of journey counts (Upstream Mobility, 2021)

A heatmap analysis is recommended for analysing the destinations of routing requests from one registration district to another. It shows the points at which the predefined target areas are left. In our case, the graph shows that many, or even most of the routes requested, are directly in the immediate vicinity (the same or the directly connected registration district) or the catchment area, which in turn predicates that most ways are rather short. For these short routes, on-demand mobility services or other mobility services like car-sharing or micro-mobility could serve well to reduce motorised individual transport. Also, these short-distance routes are the ones with the highest potential for e-mobility. Particularly for urban development projects, urban peripheral areas, and the surrounding areas outside the city limits of Vienna, this heatmap analysis can help in planning new mobility offers (OptiMaaS Mobility Data Analysis, 2021).



Heatmap analysis of Vienna (Upstream Mobility, 2021)

For further substantiating the demand for on-demand mobility services, the number of daily active users and routing requests, as well as the average number of routing requests per user can be used. On the peak day of the evaluation period, a weekly average of 2.4 routing requests per daily active user was reached, confirming the high level of mobility requested concerning the predefined target areas. The average distance requested in the analysed routes can also be used for validating the implementation of an on-demand system. Our analysis shows an average distance between 8 and 10 kilometres for public transport routes. In order to make an in-depth analysis, a bell curve could be created that shows the distribution of the distances in PT. When short distances are requested for public transport, this can be an indicator of the demand for on-demand mobility or micro-mobility solutions. This in turn could benefit public transport planning, as increasing the frequency of PT lines is often not needed if shorter, but highly requested routes were served by an on-demand shuttle (OptiMaaS Mobility Data Analysis, 2021). This serves the quest for shorter intervals before higher number of transported passengers in one vehicle. (Oberzaucher, 2020)

THE IMPORTANCE OF PRICING AND TARIFF CONSIDERATIONS

According to the international experts taking part in our IEP discussion in February 2021, one of the keys to customers' acceptance of on-demand mobility services is a combination with existing public transport tariffs. Making prices more attractive compared to using a private car or taxi services should be the goal here. This can also be reached by reducing travel time and operating costs through efficient routing and bundling stops and/or passengers. This is handled in the background of the on-demand system, using intelligent backend algorithms (OptiMaaS IEP, 2021).

It is more than evident that the pricing of a possible, future on-demand offer is a crucial factor for potential users of such a mobility service. Price was ranked second (after flexibility) in the on-demand survey and was,

together with CO2 reduction, the most-named reasons for sharing an on-demand shuttle with other passengers. Of all persons asked, 64% would prefer the cheaper, shared ride to the more expensive and not-shared offer. Almost 50% of potential future users determined the appropriate price for a shared on-demand shuttle as a taxi fare, equally shared among the passengers (on-demand User Questionnaire, 2021).

WHAT'S IN THERE FOR US?

All points considered, the implementation of an on-demand mobility offer in the existing MaaS system in a city can lead to an increased share of extended eco-mobility, which comprises public transport, biking, walking, shared mobility and on-demand services. In German, this is called „erweiterter Umweltverbund". This also helps raise the modal split of public transport and decreasing motorised induvial transport at once. This in turn will lead to a reduction of energy consumption and CO2 emissions, which benefits the citizens indirectly (climate protection), but also directly (cheaper mobility). In order to achieve these high-set goals, a high occupancy rate is needed, as well as an approximation of on-demand mobility and private cars, image-wise, but also in terms of flexibility, reliability and pricing.

The user should always be at the centre of all efforts because if the customers do not accept new mobility offers, these goals cannot be reached either. This paper, therefore, showed several ways of how user engagement and participatory development approaches can be used for the planning and implementation of on-demand mobility services, but also more general topics or improvement projects of mobility and MaaS.

On-demand mobility is helping to provide better, more modern and contemporary transportation for our growing cities and, as a part of the MaaS ecosystem, is contributing to a decrease in own car usage, reacting to the overall trend of "everything on demand", and complementing public transport by mobility on-demand in general and demand-responsive transport shuttles in particular.

POLICY RECOMMENDATIONS

› **On-demand mobility** should be implemented as an **additional offer in an existing public transport and MaaS system** and preferably not as a standalone solution like a separate on-demand app.

› Implementing on-demand mobility leads to a **decrease of (second) car ownership** and use, as well as to the **improvement of the image of shared mobility services**.

› **Using data from existing sources** (e.g. apps already in operation) **supports the development** of additional and validation of planned services.

› New mobility services should be **developed as closely to the users** (i.e. citizens, customers) as possible. They should be integrated into this process from the beginning to increase acceptance and publicity of such services (and hence also the level of utilisation).

› The user acceptance can be increased by **considering the users' own, intrinsic motives and reasons for using an on-demand service** (and sharing it) for explaining and making such services known to the customers.

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MAAS AND SUSTAINABILITY

MaaS seeks to combine existing and emerging mobility offerings in a more effective and sustainable manner, while providing users with seamless access within a single platform. The configuration of any MaaS system should consider the societal costs associated with the modalities contained within. The negative externalities of private automobile use are currently ignored or poorly addressed in the design and operation of urban mobility systems. Future MaaS platforms should be implemented alongside policy mechanisms that ensure the integration of automobiles with other modes in ways that reduce these negative externalities.

"Simply put, without sustainable transport, there will be no lasting progress on climate action; without sustainable transport, there will be no lasting progress on the Sustainable Development Goals"

Wu Hongbo, UN Undersecretary General (United Nations, 2016)

Authors: Cyriac George, Thomas Vith

Climate action is just 1 of the 17 SDGs (UN, 2021)

SUSTAINABILITY AND PRIVATE CAR USE

Sustainability can be conceptualised as "(meeting) the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987). It is often delineated as having social, economic and environmental dimensions. The sustainability challenges associated with the prevailing urban mobility systems in the world often centre on the effects of private automobile use.

AUTOMOBILITY RISING

The prevalence of automobile use is evident, first and foremost, by its sheer scale. The number of private automobiles in the world has doubled from over 500 million in 2000 to 1 billion in 2015 (United Nations, 2018, p. 3). As low- and middle-income countries continue to grow economically, increase in global car ownership is expected to increase correspondingly. To make matters worse, an increasing share of these are fuel-guzzling sport utility vehicles (SUVs); as of 2018 they accounted for nearly 40% of global passenger vehicles sales (JATO, 2019). The overwhelming majority of these cars are not in use for the vast majority of the day – in fact, the average car is parked for about 95% of the time (Barter, 2013).

IDLE CAPACITY

New mobility solutions (e.g. MaaS, car sharing, on-demand mobility) that seek to exploit this idle capacity, can reduce the number of vehicles at a systemic level and contribute towards the transition to sustainable mobility insofar as they mitigate the negative externalities of private automobile use. These negative externalities include the following.

EXTERNALITIES OF AUTOMOBILITY

GLOBAL ENVIRONMENTAL COSTS

Transport accounts for 24% of global CO_2 emissions from fuel combustion with road transport accounting for nearly three-quarters of this (IEA, 2021). As compared with other sectors (e.g. agriculture and industrial production) "transport is the sector from which it has been hardest to cut emissions" (Marsden and Rye, 2010, p. 669).

Additional environmental costs include those associated with the extraction of petroleum for fuel production (Johnston et al., 2019) and, in the case of battery electric vehicles (BEVs), the

depletion of natural resources such as lithium and cobalt (Dehghani-Sanij et al., 2019; McManus, 2012).

LOCAL ENVIRONMENTAL (AIR, WATER AND SOIL) POLLUTION

The environmental costs of automobile use are not limited to GHG emissions - road transport, especially in urban areas, is a major contributor to high concentrations of dangerous substances such as suspended particulate matter (SPM), CO, NOx, SO_2 (von Schneidemesser et al., 2019). When dealing with SPM that is the result of friction between the tires and the road surface, vehicle electrification will not help.

CONGESTION

Urban mobility systems based on private automobile use are generators of traffic congestion – even attempts to alleviate congestion through capacity expansion merely leads to more driving and congestion, long term (Hymel, 2019). The economic costs of this extends to workforce productivity time loss as well as increased energy and operational costs (Jayasooriya and Bandara, 2017). This is in addition to the exacerbation of environmental effects as a result of congestion.

LAND USE

In urban areas, where space is among the most limited of resources, automobiles require comprehensive and geographically sprawling infrastructures including local roads, motorways, parking and refuelling facilities. This represents a significant opportunity cost for the myriad other functions that this land could otherwise serve, such as pedestrian areas, dedicated bus or bike lanes, housing, commerce, recreation, or agriculture (Gössling et al., 2019).

The geographic expansiveness of automobile infrastructure coupled with local air, water and soil pollution also reduces the level of biodiversity in areas outside of urban areas (van Essen et al., 2011)

COLLISIONS

Global fatalities resulting from automobile collisions have been over a million per year for decades now and have most recently reached 1.35 million; collisions "are currently the leading cause of death for children and young adults aged 5–29 years" (WHO, 2018, p. 3). In addition, there are millions of non-fatal casualties, property damage and time loss resulting from collisions.

"MaaS can free up urban space for living rather than parking"

Cyriac George

PUBLIC HEALTH

The links between built environments and public health have been the focus of scholarly attention since prior to the automobile age. More recently the health effects of transport systems based around the car, as opposed to active transport and public transit, have been linked with obesity and related health effects (King and Jacobson, 2017).

Automobiles are also key drivers of noise pollution, which has been shown to a contributing factor to physical and mental health problems, with effects ranging from sleeplessness, reduced efficiency, hearing loss, mental breakdown (Singh and Davar, 2004) as well as "tinnitus, mood changes, chronic sleep disturbance and lack of recovery from tiredness, nervousness, anxiety and phobia, cardiovascular diseases, and cognitive impairment of children"; additional costs include loss in property value in areas with high levels of noise pollution (Gössling et al., 2019).

TECHNOLOGY ALONE WILL NOT SAVE US

In recent years, the sale of BEVs has increased throughout the world. Norway is a leading country in terms of electric vehicle deployment and infrastructure development; In 2020 the market share for BEVs in Norway was over 54%, a figure that is expected to increase to 65% in 2021 (EV Norway, 2021). The rates of ownership are especially high in peripheral urban areas that have access to well-developed

infrastructure for both driving and re-charging. While such developments must be applauded, so many of the externalities mentioned above are exclusive of the tailpipe emissions. Policy makers must not enter a state of complacency whereby the reduction in fossil fuel use becomes the singular sustainable mobility goal. MaaS solutions offer an opportunity to reduce net private automobile use while bolstering other, more sustainable modes.

This is not to suggest that one should ignore the potential of new technologies. The OptiMaaS project has developed new digital tools to conduct virtual simulations of mobility behaviour and carry out mobility point configuration (i.e. makeup and scale of offerings at one site). Together with cleaner vehicles, such tools can be leveraged to promote the most sustainable technology and behaviour.

THE OSLO EXAMPLE

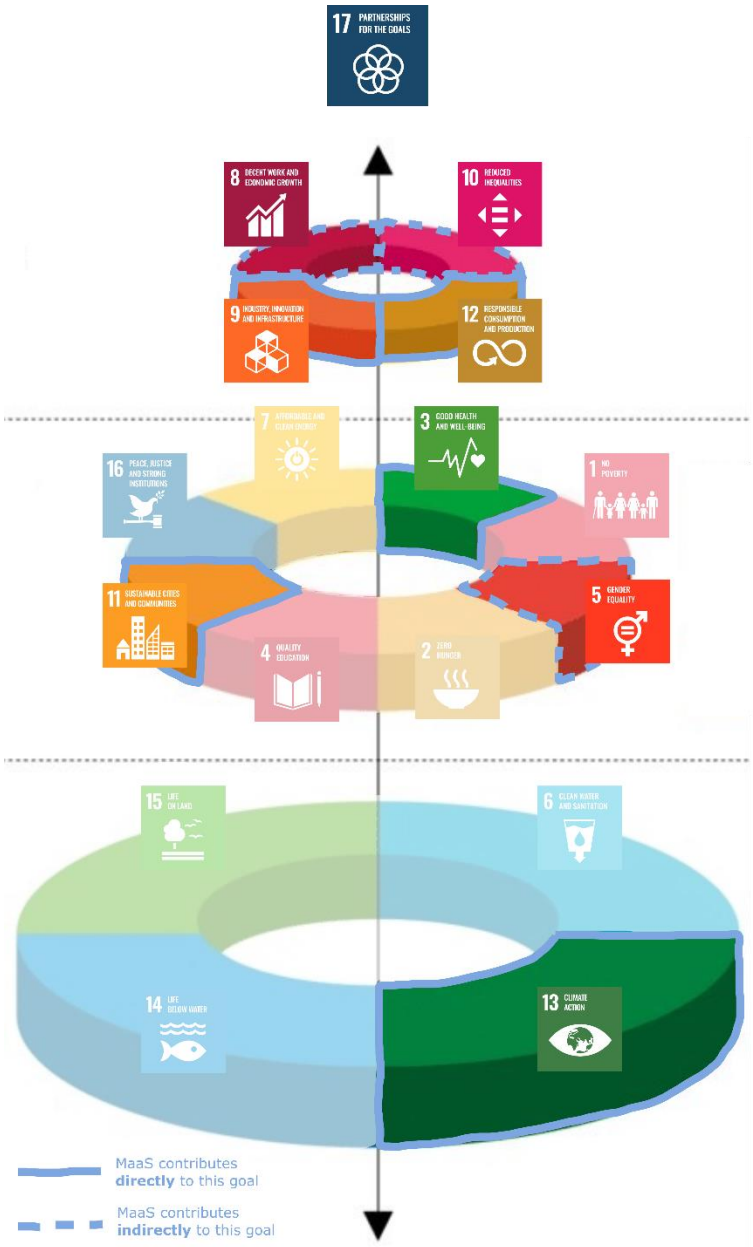
At the Vestre Billingstad site in Asker, just outside of Oslo, 1,640 new housing units are being developed over the course of nearly two decades. A precondition for the project was a binding target set by the municipality that the area would create no more than 4,600 daily trips by car. To meet this target, the four real estate developers jointly initiated a green mobility strategy, which resulted in a reduction in the number of parking spaces and the launch of an integrated mobility hub that offers residents shared cars and bicycles. Between Vestre Billingstad and the urban core of Oslo, toll roads with differentiated pricing based on rush hour and fuel type also limit automobile use. As the site takes shape, the mobility hub should be expanded and further integrated with existing transport offerings (e.g. local train station, bus lines, taxi) as well as new and emerging mobility services and technologies (e.g. ride hailing and electric scooter sharing) to provide the portfolio of mobility options that presents residents with a set of mobility options that are more attractive than owning a private car.

LAY FRAMEWORK CONDITIONS

MaaS seeks to integrate multiple modes of mobility in one interface. To be considered "sustainable" the offer of modal options must be configured such that private automobile use decreases. Integrated and on-demand solutions that do not address the externalities above should not be considered sustainable. I.e. public transit, walking, biking, and shared mobility need to be prioritised.

The technology exists but has yet to be configured/integrated effectively. If and when it is implemented, policy makers and providers must "set the ground rules" or framework conditions for achieving sustainability. Relevant components for such rules include measurements of total vehicle kilometres travelled (VKT), vehicle count, modal share, air quality assessments, public safety projects (e.g. Vision Zero), and integrated transport-land-use planning.

Not all the external costs are equal. Which costs should be prioritised? Which can be addressed more effectively (i.e. "low hanging fruit")? The answer to these will depend on context, i.e. there is no one MaaS solution that will fit all cities. Sustainable MaaS systems must be tailored to the needs and practices of their host environments – please refer to NEW OPPORTUNITIES FOR PROPERTY DEVELOPERS FOR COOPERATION WITH MOBILITY PROVIDERS, PUBLIC AUTHORITIES AND USERS. New tools such as simulation models can enable planners to evaluate MaaS measures in a virtual environment across multiple contexts – please refer to SIMULATING THE IMPACT OF MOBILITY MEASURES WITHIN AN AREA.



Maas contributes **directly to**:

- GOAL 3: Good Health and Well-being
- GOAL 9: Industry, Innovation and Infrastructure
- GOAL 11: Sustainable Cities and Communities
- GOAL 12: Responsible Consumption and Production
- GOAL 13: Climate Action
- GOAL 17: Partnerships to achieve the Goal

MaaS contributes **indirectly to**:

- GOAL 5: Gender Equality
- GOAL 8: Decent Work and Economic Growth
- GOAL 10: Reduced Inequality

MaaS' contribution to several of the 17 UN sustainable development goals (UN & tbw research, 2021)

POLICY RECOMMENDATIONS

› **Sustainable modes of mobility**, i.e. walking, bicycling, public transit and car sharing, should be **prioritised within MaaS systems**.

› **MaaS solutions must improve mobility and accessibility** while **increasing the modal share of walking, biking, public transit and shared mobility**.

› A comprehensive **assessment of the negative externalities of automobile use** must be a part of **future transport and land-use planning**.

› **Clear (and binding) targets** that cap or limit net kilometres driven within geographic units must be considered.

› The **social and economic aspects of sustainability** must not be overshadowed by the drive to reduce carbon emissions through electrification.

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ABOUT THE AUTHORS

Angela Muth is working on innovations in the field of MaaS and multi- and intermodal mobility at tbw research GesmbH. Her main approach is to include user perspectives and gender and diversity aspects both into research and project management. Another key qualification lies in her ability to connect and build trust with stakeholders and experts when developing process innovations and overcoming silo thinking. Angela Muth holds a master's degree (DI) in urban and regional planning.

Anna Wadström is project manager at the department radical innovations at public transport authority Ruter in the Oslo region, Norway. Her responsibility has been the planning, constructing, implementation and evaluation of mobility hubs in the greater Oslo area. In addition, she is leading a national network for mobility hub issues, connecting notable stakeholders such as municipalities, PTAs, operators, providers and end-users. Anna's academic background is from enterprise and business management, from Sweden, Minneapolis and San Francisco.

Benjamin Biesinger, born in 1987, graduated from the bachelor program "Computer Engineering" at the University of Applied Sciences in 2005 and from the master program "Computational Intelligence" in 2009. Subsequently was his focus during his PhD studies on the development of solution algorithms for difficult combinatorial optimisation problems in the field of location planning and transport logistics. During his studies Benjamin Biesinger was a project and university assistant at the Institute of Computer Graphics and Algorithms of the TU Wien. During this time he was able to publish several scientific papers in international renowned journals and to present his work at conferences. After finishing his dissertation in June 2016, Benjamin Biesinger joined the team "Dynamic Transportation Systems" of the AIT Austrian Institute of Technology and since focused on transport optimisation and logistics.

Bianca Humer graduated from the English Master's programme "European Studies & Management of EU Projects" at the University of Applied Sciences Burgenland, Austria, and completed two Bachelor's programmes ("Transcultural Communication" in German, English and French at the University of Vienna, Austria, and "European Business Management" at the University of Applied Sciences BFI Vienna and the Université des Hautes Études Commerciales EPHEC in Brussels, Belgium). She has several years of substantial professional experience in project and programme management, amongst others in the fields of automotive (as a digital project manager at Porsche Austria), e-health (as a project and programme manager for the Austrian Public Social Insurance) and mobility. In September 2019, she joined Upstream Mobility's R&D department. Her main responsibilities are grants and funding project management, trendscouting, innovation and sustainability, as well as digitalisation and accessibility.

Bin Hu, born in 1980, graduated in computer science (MSc in 2004, PhD in 2008) at the Vienna University of Technology, Institute of Computer Graphics and Algorithms. His research areas lie in combinatorial optimisation with topics such as network design, facility location, and transport optimisation. In 2015 he joined AIT Austrian Institute of Technology as a Scientist. Bin Hu is at the Center for Energy and part of the research field Integrated Transport Optimisation. He focuses on passenger and freight transport, facility location, transport and infrastructure network optimisation, with a long track record in project acquisition and project management of 10+ medium and large sized national and international research projects. He is actively involved as program committee member of several international scientific conferences in the field of combinatorial optimisation and an advisory board member of the open access journal European Transport Research Record.

Cyriac George is a researcher at the Norwegian Institute of Transport Economics. He has a background in political science and sustainability transitions and works with the adoption of new technologies with a focus on shared mobility and zero-emission vehicles.

Gerald Franz is an economist and has been working in the field of sustainable mobility for more than 10 years. At Urban Innovation Vienna, he works as a senior expert on mobility management in urban development areas. He studied environmental economics and systemic management. He started as a university assistant at the Vienna University of Economics and Business Administration, worked as a logistics consultant, built up the mobility department at the Lower Austrian Environmental Consulting Agency and was responsible for mobility issues at the Lower Austrian Energy and Environment Agency for several years. In this role, he was able to initiate projects such as bicycle rental systems, e-car sharing offers and campaigns on cycling and electromobility.

Thomas Vith works as a Mobility Expert at Urban Innovation Vienna, a municipal think-thank dedicated to supporting sustainable and inclusive urban development. His background in sociology and geography allows him to look at the close interlinkages between humans and the built environment in a systemic way.

Stefan Arbeithuber is managing partner and co-founder MO.Point Mobilitätsservices GmbH, focused on the planning and operation of mobility points. He has years of practical experience in mobility projects and in the configuration of digital mobility service. Stefan is a trained industrial designers background and holds an MBA in innovation management.

Vincent Neumayer holds both degrees in natural resource management and urban & regional planning. After having gained five years of experience in international consulting in spatial-, transport- and mobility planning at Vienna University of Technology and Urban Innovation Vienna (formerly known as TINA Vienna), since 2017 he is active as mobility planning expert and project manager for Vienna public utilities and in particular Wiener Linien (WL - Vienna Public Transport). There he develops and employs innovative, multimodal products and services f.i. mobility points in public space and in cooperation with real estate developers; is responsible for corporate mobility management; and works on strategies for WL towards becoming a MaaS-integrator.

GLOSSARY

BEV	battery electric vehicles
BUSINESS MOBILITY	traveling for business reasons – incl. mode of transport that is used
ECO-FRIENDLY/ SUSTAINABLE MOBILITY BEHAVIOUR	…usually refering to walking, biking, public transportation – but also relatively new shared mobility concepts. Generally, we want to reduce the overall mobility demand.
SHARED MOBILITY	Car- / bike- / scooter- / kick scooter-sharing is a type of mobility service that allows members to easily rent or use vehicles for short periods of time. In round-trip sharing users begin and end their trip at the same location, in station-based one-way sharing services, users can return the vehicle at another location; In free floating sharing systems users can start and end a trip at any place within a defined area
GAMIFICATION	the practice of making activities more like games in order to make them more interesting or enjoyable (dictionary.cambridge)
GHG EMISSION	Greenhouse Gas Emissions
HEATMAPS	A visualization method that shows the magnitude of usage on a transport element, e.g., number of car trips for each road segment.
ON-DEMAND MOBILITY	is a demand-driven mobility service, which dynamically coordinates the time, pick-up location and route to bundle trips with similar routes
ON-DEMAND SHUTTLE	Demand-responsive transport service, e.g. mini buses
MAAS	Mobility as a Service
(MUNICIPAL) MAAS PLATFORM	Mobility-as-a-service platform that crosslinks digital mobility services on one platform, wth public transport as a backbone and additional mobility services like taxi, car-sharing, bike-sharing, garages, etc.
MOBILITY DEMAND	consists of all the trips the population needs to perform each day
MODAL SPLIT	is the percentage of travellers using a particular type of transportation or number of trips using said type
MODE CHOICE	choice for a particular type of transportation e.g. bike, PT, car

MODE SHIFT	means a switching of type of transportation, such as when people switch from cars to, say, busses, trains and (shared) bicycles
MOBILITY POINT/HUB/STATION	The physical bundling of different mobility services in one location
MPC	Mobility point configurator – one OptiMaaS – IT-module (prototype) that supports the planning of mobility points
OPTIMAAS	Optimised mobility as a Service
PT	public transport
PTA	public transport authority
PTO	public transport operator
URBAN DEVELOPMENT CONTRACT	A contract made between a city authority and a developer with regards to a specific proposed development and the aim to secure certain standards for building and design that are not covered by the building code already. They can contain obligations for the co-financing of certain infrastructure (e.g. mobility-related).
URBAN NON-CORA AREA = URBAN PERIPHERY = URBAN PERIPHERAL AREA	There does not exist a clear definition of urban periphery. So, you have the same picture in mind, as we had: it is somewhat out of the city centre usually still within city boarders. The spatial structures of urban peripheral areas favour motorised private transport, offer and quality of public transport is often less extensive, and it is less densely populated. If you were a private car sharing operator you would probably not operate there.
SANKEY DIAGRAM	A flow diagram used for visualizing modal split changes. The width of the arrows is proportional to the flow rate.
SIMULATION	Computer model used to imitate / approximate the real-world transport system.
SUMP	*Sustainable Urban Mobility Plan*
SUSTAINABLE MODE CHOICES	…usually refer to walking, biking, public transportation – but also relatively new shared mobility concepts.
SUV	*Sports Utility Vehicle*
TSP	transport service provider, the organisation that operates mobility services
VKT	vehicle kilometres travelled
VISION ZERO	referring to the vision of zero killed persons in traffic (europa.eu)

GRAPHICS

OptiMaaS

Optimised Mobility as a Service

Holistic mobility solutions for the urban periphery

Recommendation Papers

OptiMaaS Consortium, 2021