SUSTAINABLE URBAN MOBILITY AND COMMUNTING IN BALTIC CITIES

GOOD PRACTICE EXAMPLES

SOLUTIONS TO IMPROVE THE URBAN TRANSPORT SYSTEM TOWARDS SUSTAINABLE URBAN MOBILITY

SUMBA

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1. INTRODUCTION

Commuter traffic accounts for a high proportion of the traffic volume and is therefore the focus of attention in the transformation of traffic towards a more environmentally friendly transport system. Many cities struggle with different challenges in terms of transport and commuting in general and with a high proportion of car use among commuters in particular. In order to meet these challenges, numerous solutions have already been developed and implemented, many of them being transferable to other cities.

Within the project SUMBA, the partner municipalities will address their challenges by finding and defining possible solutions. For this purpose there has been an intensive knowledge exchange of good practice solutions within the consortium. Some of the findings are summarised in this compendium of problems and challenges in commuting countered by good practice solutions. With the aim of contributing to the existing knowledge of stakeholder groups, these solutions are presented here in the form of case studies. As such, they are not intended to be universally applicable, but rather to serve as inspiration for cities to develop their own context-specific solutions.

The larger issues that this compendium seeks to address are those created/compounded by large-scale car dependent commuting activities common in cities in the Baltic Sea Region (and elsewhere). These issues include climate change, congestion, air pollution, road safety, poor health, obesity, shortage of urban space for non-driving activities. Reducing commuting or redirecting it from private cars to more sustainable transport modes would help alleviate all of these important issues. As such, the good practice examples in this document point towards ways for addressing various challenges that are common when attempting to make current commuting patterns more sustainable.

Five main topics were identified which are common to the cities in the Baltic Sea Region, as they emerged from the discussions between the partner cities and from the results of the SWOT analysis carried out in each city. The topics are

- Transport and urban planning,
- Analysing the transport system,
- Infrastructure
- Integrated ticketing and tariff system,
- Services

Each of them represents one chapter of the document. The topics are described in more detail, their relevance for the topic of commuting is worked out and possible solutions and indicators of success are presented. Each chapter concludes with a detailed description of good practice solutions that have addressed the outlined challenges well.

2. TRANSPORT AND URBAN PLANNING

2.1 Relevant common challenges and problems

One of the main issues regarding mobility and urban planning processes in today's cities is their fragmentation along administrative as well as departmental borders. Being composed of a city and its commuting zone, a functional urban area (FUA) encompass the economic and functional extent of a city based on daily people's movements. Administratively, a FUA is usually made up of a number of municipalities and/or other administrative units. This complicates planning a well-functioning transport system within the functional urban area as cooperating with other administrative units can be quite a challenge. When cross-border cooperation is not working well enough, the result is a fragmented transport system where various services and bits of infrastructure are not connected into coherent routes and journeys between relevant destinations throughout the urban area. This is especially true for public transport (PT) and active modes of transport (e.g. walking, cycling) as the infrastructure and organisational solutions for these modes are still being developed in most cities, whereas car infrastructure is already connected and usually relatively well developed. In addition, the status of active modes as modes of transport relevant to commuting (as opposed to a recreational activity) is very recent and, at times, still contested. As such, the political will and administrative capacity to develop these modes (across municipal borders or as means of access to public transport) is often lacking when compared to motorised transport. Thus, poor cooperation between neighbouring municipalities within the same functional urban area is a significant issue for developing a well-functioning transport system for PT and active modes of transport.

Organisationally, land use planning and mobility planning are often carried out by separate departments without much coordination. This is an issue for planning a well-functioning transport system because land use and transport systems have profound influences on each other. Land use dictates the distribution and overall quantity of demand for mobility, which directs the development of transport systems and travel behaviour, at least in the long term. At the same time, the existence of transport systems is a necessary prerequisite for enabling new development. Additionally, changes in existing transport systems are often necessary to support changes in land use patterns in existing neighbourhoods. Due to paying too little attention to this relationship between these two fields, single use neighbourhoods far from the existing PT lines are allowed to emerge in many cities. As a result, commuting distances and car dependency are increasing. Thus, insufficient coordination between land use planning and mobility planning is currently a widespread barrier for developing a sustainable and well-functioning transport network.

2.2 Relevance for commuting and intermodality

Fragmentation of mobility and land use planning has obvious adverse effects on commuting and intermodality as the resulting mono-functional developments, poor service level of public transport service, fragmented active travel networks make it difficult to use these modes for commuting or essential daily errands, especially when one's journey crosses administrative borders. This reduces the opportunities for performing multi-modal journeys and increases car dependency.

2.3 Possible solutions

One way to address both challenges outlined above is to adopt a specific regional planning concept for increasing accessibility as well as mobility by PT and active modes of transport, that incorporates specific land use and transport system configurations into a unified strategy. Drawing on this concept, a strategy and action plan should be developed for the whole functional urban area. Of course, this requires extensive cooperation and coordination on the part of relevant administrative units and departments. However, it is easier to cooperate if a common direction is set out first.

A good example of a regional planning concept is the concept of decentralised spatial concentration (*Dezentrale räumliche Konzentration*). The general principle for the development of the concept of decentralised spatial concentration is that it consists of a polycentric net. In order to disburden the core centre, it is surrounded by other (smaller) high performance centres. Additional tangential transport connections complete the radial transport structures to strengthen not only the connection between the smaller centres but also to enable the core centre to develop itself. Such a concept provides specific directions for land use as well as mobility planning. In both areas, it aims to increase accessibility by PT and active modes of transport. In terms of land use, a pattern is introduced where there are more jobs and services close to residential areas. At the same time, people's mobility is improved by the fast PT connections between centres.

Administratively, to set up and carry out a regional planning concept, a regional body needs to be established that brings together all the relevant departments from relevant administrative units (and other relevant actors if necessary). The level of integration depends on the specific type of body chosen. On the less integrated end of the spectrum is a regularly convened council where joint decisions are made, actions planned and responsibilities allocated by independent members. On the more integrated end is a regional land use and mobility planning organisation with the capacity to plan and carry out activities on its own. Both ends of the spectrum can work if they fit well with the local context. However, it is important to make sure that cooperation between relevant agents is regular and consistent.

2.4 Indicators for success

The following indicators should be measured to gauge the city region's performance in solving the problem of fragmented mobility and land use planning:

- Plan: existence of a regional plan directing mobility and land use planning
- Sustainability: inclusion of sustainability principles in land use as well as mobility planning within the regional plan.
- Integration: organisational integration between land use and mobility planning. Can be assessed by reviewing the organisational structure of the city administration for managing mobility and land use planning (is it done in one department or separately) and by verifying the existence and extent of institutionalised procedures for coordinating the activities of the two departments/areas
- Cooperation: consistent cooperation between municipalities (e.g. how often parties meet to coordinate their activities)
- Compliance: compliance of municipalities' activities with the regional plan. Can be assessed by reviewing the activities carried out by municipalities and comparing them to the activities prescribed in the plan or by measuring progress towards the goals set in the regional plan, e.g. by measuring changes in modal share and accessibility measures for PT and active modes of transport.

2.5 Good practice examples

The intention of this (sub-)chapter is to give insight into transport and urban planning structures relevant for commuting and intermodality. It was not the attempt to compare the two regions presented here: Utrecht and Hanover. Both regions face similar challenges nowadays and in future times. Moreover, both regions:

- have a relatively high number of small and medium sized municipalities,
- have a higher amount of commuter activities due to an economic increase in workforce,
- are central and important "traffic pivots" because of geographical position for all me-

ans of transport,

- develop/developed “mobility (climate) action plans” for different modes of transport,
- use a similar approach to transport and urban planning.

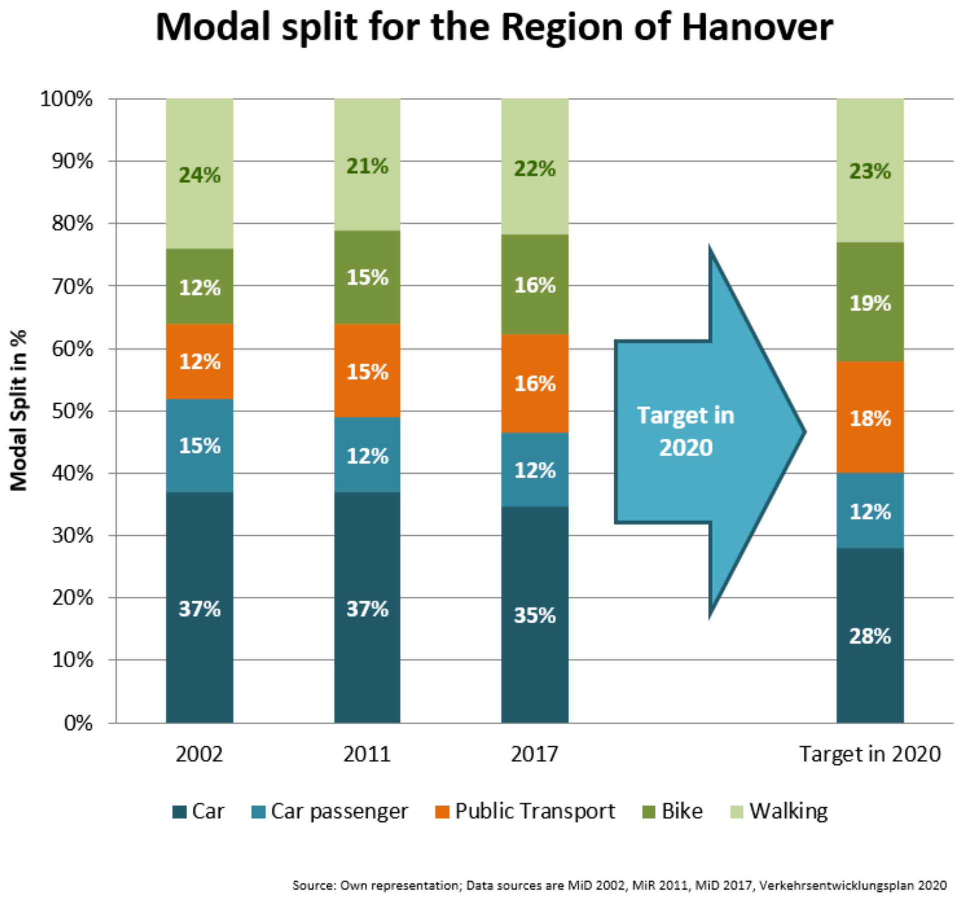

Figure 1. Modal split for the Region of Hanover

2.5.1 Region of Hanover

2.5.1.1 Administrative structures for cross-border and cross-operator coordination

The “Region of Hanover” consists of 21 municipalities with the main public administrative centre being situated in the City of Hanover. The city of Hanover itself is the capital of the federal state of Niedersachsen (Lower Saxony). The “Region Hanover” is a relatively young form of a regional authority (“*Gebietskörperschaft*”) founded in 2001. In the 21 municipalities there are a total of 1.1 million inhabitants.

The City of Hanover plays an important role as an economic centre, with attractive workplaces in various fields, such as science, trade and industry. This not only for the 21 municipalities, but also for the whole northern part of Germany. The city of Hanover is also a central axis in the northern part of Germany for train, car, public transport, other transport (people and goods) in all four main directions as well as Europe (The Netherlands/Poland). Hence daily commuter activities are booming and transport of goods around the main traffic axes is increasing. As an example of this, the central railway station in Hannover experienced an increase of 68 % in passenger volume between 1999 and 2011.

One of the main tasks of the regional authority is transport planning. Specifically, the Region of Hanover is responsible for managing regional public transport and carrying out interventions to support sustainable commuting. These activities are supported by municipalities which are responsible for restrictive actions/sanctions i.e. management of parking facilities like P+R places, removal of street lanes or formation of low emission zones to reduce individual motorised transport.

The sustainable transport strategies are outlined in the SUMP created in 2011 by the Region of Hanover. The SUMP is called “VEP - pro Klima” (VEP-*Verkehrsentwicklungsplan*) and it includes the following five main (administrative) pillars:

- tightly coordinating new land developments and development of regional cycling conditions in order to increase sustainability of the regional transport system,
- developing regional public transport,
- fostering traffic management, street infrastructure and parking,
- developing a mobility management strategy,
- additional concept for developing freight traffic due to an increase in economic activity in that area (+25 %).

In terms of specific policies, public transport options for daily commuting in the Region of Hanover are provided by a radial railway network between municipalities complemented by feeder buses (responsibility of the regional authority). Additionally, bicycle highways are in the planning stage to connect residential areas with the city centre. An important regional goal is to provide access from any point in the region to the city centre using ‘S-Bahn’ (suburban railway) within a maximum of 45 minutes. This goal is aimed to be achieved by providing additional first and last mile transport options, such as Park + Ride and Bike + Ride facilities (responsibility of the municipalities). Every five years a revision of the sustainable mobility network in the whole region is carried out and the SUMP is updated accordingly to include the consideration of current developments in land use planning.

Socio-economic and geographical aspects Region of Hannover

<table>
<tr><td>Population:</td><td>1.1 million</td><td rowspan="4">• Strong regional cooperation between Region of Hanover and City of Hanover
• Status: regional administration
• Regional „supply and development“ urban/ peri-urban concept
• Bicycle highways in planning
• Transport development plan “Pro Klima” and “Masterplan 100 % for climate protection” to promote e-mobility
• Urban logistic concept - main goal: CO2- free (city) logistic till 2030</td></tr>
<tr><td>Surface:</td><td>2.291 km^2</td></tr>
<tr><td>Municipalities:</td><td>21</td></tr>
<tr><td>Geography:</td><td>Mostly flat; some “hilly” parts</td></tr>
</table>

Table 1: Overview socio-economic and geographical indicators Region of Hanover (own source)

2.5.1.2 Integrated regional transport, spatial planning and housing policies

The Region of Hanover is responsible for both transport and spatial planning. Such an administrative configuration supports integrated mobility and spatial planning.

Since 2000 Region of Hanover has worked towards establishing sustainable spatial settlement patterns. This has included a twofold approach: a) enforcement of administrative cooperation between municipalities to realise the overall concept of regional planning (see above) and b) development of the overall concept: Stadt der kurzen Wege (“City of short Ways”) (Beckmann et al. 2011). This concept is complemented by “Leben an Schienenachsen” (Living next to tracks). These two concepts aim, respectively, to reduce commuting distances by encouraging mixed land use patterns and to improve residents’ mobility by PT. To work towards the latter aim, the administration has built “S-Bahn” (urban-suburban commuter railway system) lines that cater to the high amount of daily commuting into the city (centre) of Hannover. These two concepts contribute towards realising the broader urban planning vision/concept of decentralised regional spatial planning (see above).

Figure 2. Region of Hanover and its 21 municipalities (Source: https://en.wikipedia.org/wiki/Hanover_Region)

Indicators of success (Hanover)

Indicator:	Result:
Plan	SUMP: VEP - Prom Klima; regional concept: decentralised spatial concentration
Sustainability	PT, cycling and pedestrian accessibility and mobility are prioritised through mobility as well as land use planning
Integration	Land use policies present in SUMP; same organisation for mobility and land use planning
Cooperation	Areas of responsibility are allocated between the regional body and municipalities; every 5 years the SUMP is renewed together
Compliance	n/a

2.5.2 Region of Utrecht - The Netherlands

2.5.2.1 Administrative structures for cross-border and cross-operator coordination

The “Region of Utrecht” is part of the “Randstad” area. This western area in NL has a population of 8,2 million. The “city circle” covers the cities of Amsterdam, Rotterdam, Delft, Gouda, Leiden, The Hague, Dordrecht, Hilversum, Almere, Haarlem and city of Utrecht. As a result, the region is confronted with daily commuting activities which lead to 57 million travellers per year through the main train station of the city of Utrecht. The region of Utrecht is the fastest growing regional economy in the Netherlands. The city itself will face a population growth of up to 400,000 inhabitants between 2025 and 2030, which is an increase of 17 % (compared to 2017).

The Region of Utrecht is an administrative organisation like the Region of Hannover. Hence, they cooperate with different entities and partners like the state or municipalities in that area. The regional authority unites 26 municipalities with the aim to plan an effective transport network throughout the entire urban functional area. Each municipality in the region can apply for subsidies. The Region of Utrecht is the central pivot for the municipalities and their development. Democratic structures like “eerste kamer and tweede kamer” (first and second chamber) confirm and justify various measures for the development of sustainable mobility options and detailed “mobility plans” so that the Region of Utrecht can actively implement them.

In terms of specific policies, the Region of Utrecht has put a lot of emphasis on developing multimodal transport options. By doing this, they have achieved a high number of intermodal trips within the region. For example, 40 % of all train trips start with a bike ride. One of the most important policies for encouraging multimodal trips is the national "OV chipkaart" (public transport electronic chip card). This electronic card allows commuters to use various modes of public transport in the Netherlands. The main advantage of this card is that customers are not confronted with different tariff systems in different regions or companies nor direct paying processes. The card can be used to access the public bike sharing system at stations as well as all public transport modes like buses, trams, and commuter trains for (short and long distances). The electronic "OV chipkaart" provides not only good conditions for intermodal trips but also an easy and quick access to public transport in general.

In order to continue to encourage intermodal trips, the region plans to use more direct bus lines with fewer stops in villages. In the remaining stops, bike parking facilities will be improved. By 2030 to 2035 a redistribution of train services in the region is planned to lighten the load on Utrecht central station.

In addition to intermodality, improving cycling conditions is an area of focus. In 2016, the region established the "Realisatieplan Fiets 2016-2020" (Realisation of Cycling Plan 2016-2020) with a budget of €30.75 million for this period. In this plan, the central aspects are safe routing for cyclists to support connections between residential areas and main destinations (e.g. train and bus stations, schools and working places). This was complemented by investments into cycling infrastructure for similar purposes made under „Mobiliteitsplan" (Mobility plan 2014-2028). Examples of these infrastructure investments include improving existing cycling paths by adding smart lighting, building cycling tunnels to guarantee a constant traffic flow for cyclists and widening cycle paths.

Socio-economic and geographical aspects Region of Utrecht

<table>
<tr><td>Population:</td><td>1.285 million</td><td rowspan="4">"Region of Utrecht" and City of Utrecht developed during the last decades a strategy to manage a) mobility and traffic in terms of active mobility towards sustainable modes of transport (biking, public transport, walking etc.) and b) regional - urban and peri-urban planning in general.
Mobility Masterplan 2014-2028
Several research programmes on public transport, cycling, (city-)logistics
"Cycling Plan 2016-2020" plus additional projects and programs (i.e. safety, cycling highways, connection with public transport etc.)</td></tr>
<tr><td>Surface:</td><td>1.378 km²</td></tr>
<tr><td>Municipalities:</td><td>26</td></tr>
<tr><td>Geography:</td><td>Flat</td></tr>
</table>

Table 2: Overview socio-economic and geographical indicators Region of Utrecht (own source)

2.5.2.2 Integrated regional transport, spatial planning and housing policies

Under the Region of Utrecht, spatial and transport planning are, similarly to the Region of Hannover, integrated as both are carried out by the same regional body. In cooperation with the state and municipalities, a common urbanisation strategy is carried out.

Specifically, the Region of Utrecht is making an effort to connect residential and popular destination areas into the transport network. Good examples are improved connectivity of cycling infrastructure carried out under the Realisatieplan Fiets 2016-2020 (see above) and a new tramline that will connect Utrecht's central train station and Utrecht Science Park, which is currently not accessible via train. Such measures improve the mobility of Utrecht's residents.

In order to guide the development of new land so that accessibility and mobility are offered at a high level, the City of Utrecht encourages development of dense mixed use neighbourhoods within the inner city that are well serviced by PT and cycling infrastructure. Such neighbourhoods are designed in tight cooperation with private developers to ensure the holistic functionality of these neighbourhoods. Within new developments sustainable transport hubs are planned. These hubs bring together various sustainable transport options to facilitate sustainable individual transport. Cars must be parked at the edge of the development, usually underground, while cyclists, pedestrians, PT users and car-share users can access the very centre of the neighbourhood at the transport hub. Such hubs improve residents' opportunities for multimodal trips and enhance overall mobility.

All these specific policies are set in the historical context of broader land use regulations under the Dutch 'ABC' land use policy. This nationwide policy has had a profound effect on the land use pattern in the Utrecht region. Essentially, the 'ABC location policy' sorts urban areas into various zones (A, B and C) with descending levels of pedestrian, cyclist and PT user comfort and ascending levels of car user comfort. The most ambitious tier, A, is mostly dedicated for central areas where businesses with many employees and visitors are required to be located. Zones designated as B are usually located slightly further out and require good PT connections but also good access by private car. Zone C is mostly reserved for areas on the perimeter of the city where car-dependent industrial activities are encouraged, e.g. hauliers, couriers.

The 'ABC' policy has directed most workplaces to be located in the inner city, thus reducing the commuting distances. In addition, the policy has made sure that most of such areas are very convenient to access using sustainable modes of transport and inconvenient to access using a private car. In these two ways, this land use policy has actively directed people's mobility patterns.

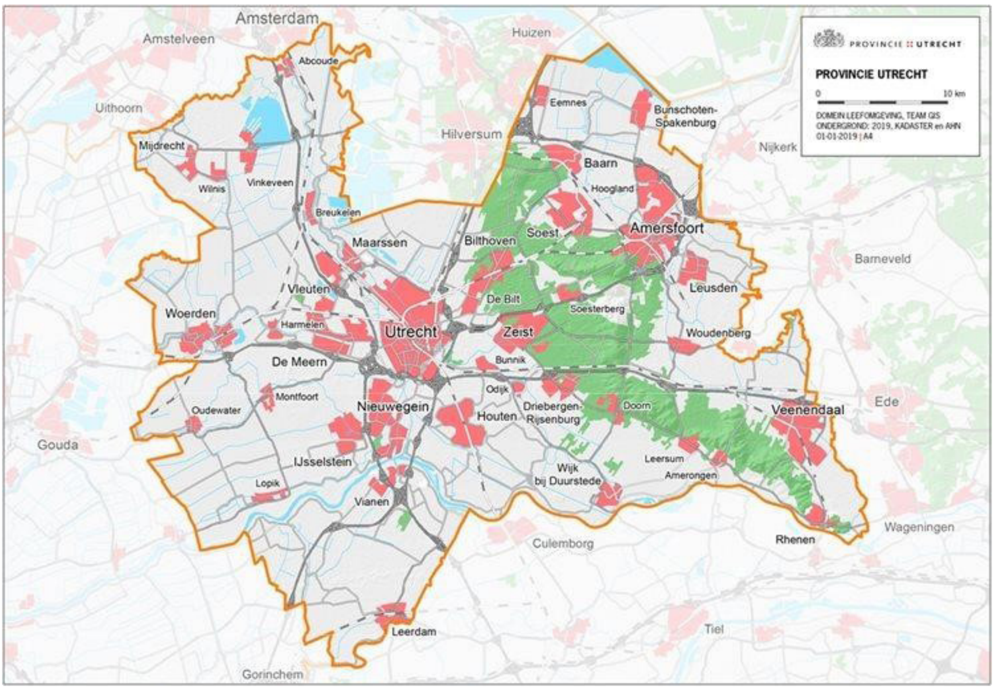

Figure 3. The Region of Utrecht and its 26 municipalities (https://www.provincie-utrecht.nl/algemene-onderdelen/serviceblok/english/province-utrecht/)

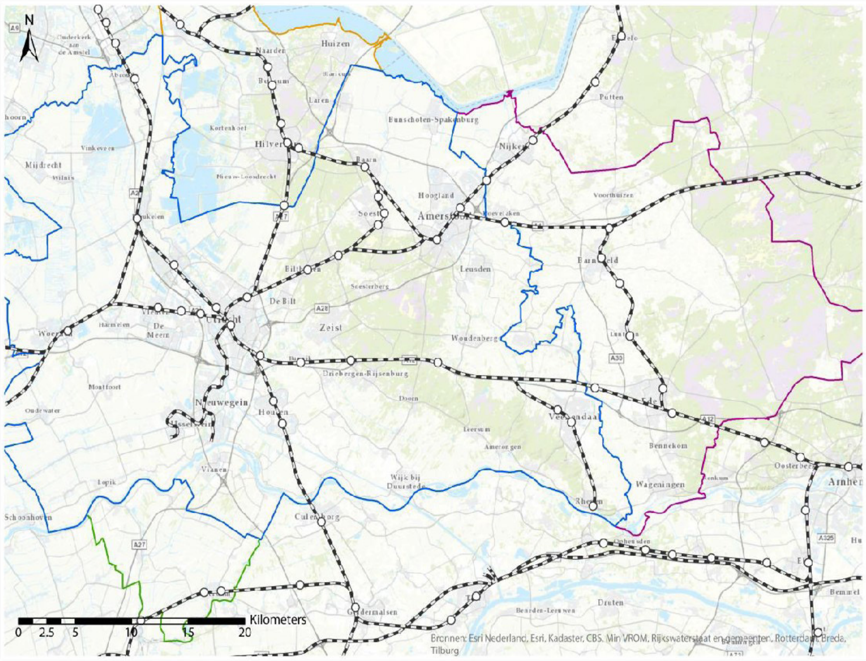

Figure 4. The Train-Network of the region of Utrecht

Indicators of success (Utrecht)

Indicator:	Result:
Plan	Mobility Masterplan 2014-2028
Sustainability	Cycling, PT and pedestrian movement prioritised; land use development in the inner city
Integration	Same regional organisation responsible for land use and mobility planning
Cooperation	Municipalities apply for funds through the regional body
Compliance	n/a

3. ANALYSING THE TRANSPORT SYSTEM

3.1 Relevant common challenges and problems

3.1.1 Data collection and sharing in multi-governance structure.

One of the main challenges in contemporary cities and towns is obtaining sufficient data on people's movements and transport habits for evidence-based transport planning. Without relevant data, it is difficult to strategically and consistently direct a city's transport system towards the goals and targets set (or indeed even set these targets). This issue is highlighted in the context of the increasing need to transition to sustainable transport systems. Considering the urgency of the issue and the availability of various new technologies that make data collection a lot easier than it has been previously, there is really no good excuse for failure to gather relevant and sufficient transport data. While many cities do have data collection systems in place, these systems are often very car centric as it is easier to measure and monitor vehicular traffic, while pedestrian, cyclist and public transport (PT) user patterns are more complex. This is an issue because it prevents evidence-based planning of sustainable modes of transport while developing further the already prioritised conditions for driving. Thus, perhaps even more important than setting up ambitious and innovative data collection systems, is making sure that these systems do not support the further prioritisation of vehicular traffic over PT and active modes of transport (walking, cycling and other micromobility).

Regional transport models. The data collected on people's transport needs and behaviour must be analysed to provide guidance to transport planners. Perhaps the best way to do this is by using transport models. Models enable analysing the current state of transport systems as well as predicting future developments in various scenarios. The latter use is especially important as it allows planners to estimate the effects of various potential interventions and choose/prioritise the most effective and/or cost-effective ones. Transport models have been in use for a while, but their accuracy and utility has been fairly limited when it comes to modelling public transport demand, active modes of transport and multimodal trips. While today there exist some models that are very good in that respect, their use in practice is still not nearly as widespread as that of motorised transport models. This has greatly contributed to the prioritisation of vehicular traffic in cities and towns as models have provided great insights and some measure of certainty in the case of motorised private modes, while leaving transport planners in the dark when it comes to planning systems for sustainable transport modes.

3.2 Relevance for commuting and intermodality

Data collection and modelling provide information about current mobility patterns and potential interventions. This enables planning and creating a more convenient and fit for purpose transport system in the whole functional urban area, which is essential for sustainable commuting. For intermodality, data collection and modelling are especially important because intermodal journeys are more complex than journeys using only one mode. Data and modelling help planners to understand the specific needs and problems of intermodal commutes.

3.3 Possible solutions

3.3.1 Data collection and sharing in multi-governance structure.

The type and amount of data that needs to be collected for effective transport planning depends to a large extent on the specific (types of) models chosen. As such, data gathering activities should be closely coordinated with transport and land use modelling activities. The easiest way to make sure enough relevant data on PT and active modes of transport is gathered, is to first choose models that enable high quality modelling of PT and active modes (see next paragraph) and then plan data gathering activities according to the requirements of these models.

For macromodels including many modes of transport, the main types of data needed include, among others, distribution of population, jobs, schools and other main functions, origin-destination and modal split trips, routes used, topography (for active modes) and journey times. There are various sources from which these data can be collected (see the 'SUMBA Guidance for modelling and data collection' document) and often it is beneficial to gather the same data from multiple sources for validation. An increasingly popular method is using mobile positioning data because it offers a lot of useful information about people's movement. However, even mobile positioning data is usually complemented by more traditional data sources like travel surveys.

When planning transport modelling and data collection activities, it is important that this be done in close cooperation between the municipalities making up the functional urban area to ensure that data on the whole area is included and concistently used. Otherwise, modelling will be of limited use as it will not be able to accurately predict transport patterns without all the relevant data. Similarly, the results of modelling and the activities based on these, should be shared and coordinated between the municipalities to ensure the effectiveness of transport planning in the functional urban area (see chapter 2.1 for more).

For a more detailed overview on the types of data necessary for specific types of transport and land use models, please refer to the document 'Guidance for modelling and data collection' compiled under the SUMBA project.

3.3.2 Regional transport models

There are many different types of models that are used for analysing different scales/aspects of transport systems. A set of models should be chosen that cover the relevant scales and fit well with each other. However, the main priority when choosing these models should be their ability to model PT, active modes of transport and multimodal journeys at a high level. While it is necessary to also model motorised transport, this capacity is present in most any general traffic modelling tool anyway. Focusing on PT and active modes of transport is essential for being able to plan a healthy, sustainable and well-functioning transport system in an urban functional area.

For an overview of the different types of models as well as descriptions of specific modelling tools, please refer to the document 'Guidance for modelling and data collection' compiled under the SUMBA project.

3.3.3 Measuring accessibility

One method that has been recognised as crucial for developing a sustainable transport system is modelling accessibility. Accessibility is often defined as the property of a location that shows the number of relevant places/activities that can be accessed from this location in a given time period by a given mode of transport. For example, measuring accessibility by PT for commuting shows how many workplaces can be reached from a certain point in, say, 30 minutes using PT. Accessibility is perhaps the most important criterion (although certainly not the only one) for assessing the performance of a mode of transport or the overall transport system because it measures the opportunities people have access to, which is arguably the main goal of transport planning. As such, accessibility for various uses and modes of transport should be modelled. However, measuring (and improving) accessibility by PT, active modes of transport and multimodal solutions should be prioritised as these modes can be used by more groups of people (e.g. children, elderly, the less wealthy) when compared to driving due to low costs and lower physical/mental capacity requirements. These modes of transport are also much cheaper to develop and much less disruptive for other activities and modes of transport (when compared to driving).

Specific modelling tools for computing accessibility include

- ArcGIS Network Analyst by ESRI,

- Sugar Access by Citilabs,
- UrMoAC by German Aerospace Centre.

As accessibility is affected by both land use patterns and available mobility, it is also a necessary piece of data for most Land Use Transport Interaction (LUTI) models. For more information about specific accessibility and LUTI models, please refer to the document 'Guidance for modelling and data collection' compiled under the SUMBA project.

3.4 Indicators for success

In order to measure progress on addressing the above mentioned challenges, these indicators should be measured:

- Data: historically consistent (comparable) basic transport data collection on PT and active modes. Can be measured by the period for which basic data are available.
- Modelling: use of models in planning for PT and active modes. Can be measured by how many different types/scales of models are used in planning.
- Accessibility: modelling accessibility scores for PT and active modes.

3.5 Good practice examples

3.5.1 Data collection and sharing in multi-governance structure: scooter-share data management in Chicago

In June 2019 the City of Chicago launched an e-scooter sharing pilot programme. The programme was restricted to only a part of the city and included a total of 2500 scooters from 10 different private operators (250 each). All scooters were required to have an attached GPS device so that their movement could be monitored. However, the multitude of operators made it difficult to manage the overall system as there were various levels of compliance with data-sharing requirements as well as a large number of complex data streams that had to be monitored and analysed. In order to overcome this challenge, the public administration decided to use a shared mobility management platform offered by a company called Populus.

Populus worked with the operators to achieve the required levels of data-sharing and consolidated the various data streams onto a single platform that enables the city administration to conveniently monitor the availability and movement of all scooters in real time as well as historically. This data allows the city administration to manage the daily operations of scooters, e.g. limit the overall number of scooters and their movement to within the selected pilot area.

An important aspect that can be monitored is the equitable distribution of scooters throughout the pilot area. In U.S. cities in general, wealth and service provision inequalities between different city districts is an important issue. Thus, one of the priorities when launching shared mobility services, is to make sure that these services do not contribute further to this inequality. In Chicago the equitable distribution of scooters is sought by requiring all operators to deploy at least half of their fleet in two areas identified as historically underserved. The mobility platform provided by Populus has a special feature that enables the city administration to monitor operators' compliance with this regulation.

In addition to helping to manage the scooter system, the unified platform provides data that can be used in future infrastructure decisions. Visualisation of the trips taken highlights the most popular routes where multimodal hubs could be planned and road safety conditions improved. It also points to potential issues on the lesser used routes that need to be addressed. These data can also be used in broader mobility models to enhance overall conditions for micromobility.

All in all, this platform provides the city administration data that can be used to manage the often chaotic scooter-sharing schemes, thus improving the user experience, as well as to support further improvements in the (infrastructure) conditions of micromobility.

Indicator:	Result:
Data	Well-organised data collection of the scooter-share scheme from the very beginning
Modelling	Not yet present for the scooter-share
Accessibility	Not yet present for the scooter-share

3.5.2 Regional transport models: Data-driven solutions for public transport system development (Tartu, Estonia)

In the summer of 2019, a new public transport network was implemented in Tartu, Estonia that was put together through modelling (the previous network was not). The model was not a comprehensive traffic model which would include other modes of transport and be responsive to changes in modal share as a result of changes in PT network. Rather, it was a network model that used current PT demand as fixed to model optimal (in terms of travel time) bus lines. Such an approach is fine as long as its limitations are acknowledged and possibly addressed in future modellings. These limitations include (probably) underestimating actual demand for PT, inability to estimate potential route modifications' effect on modal share and inability to estimate the modal share effects of potential changes in driving conditions (e.g. reduction of parking spaces in the city centre).

The main piece of data used for modelling was mobile positioning data, which provided the information on people's movements in space and time. This was complemented by land use data, verification data from electronic bus cards, the demographic profile of urban districts and many other types of data. All this data was compiled into an origin-destination matrix that was an important input for modelling a PT network that would minimise travel time. Other major inputs included the road network and the location of bus stops. The limits in terms of public spending were set by Tartu city government.

After modelling, feedback was gathered from the public on the new proposed PT network. As a result some changes were made to cater to students, night shift/early-morning workers and the elderly. This was an important step of public involvement that brought to the fore some necessary aspects of a PT network that were missed during modelling. The result was a time (and money) efficient PT network that caters well to the needs of various user groups.

The main changes in the new network were replacing circular lines with pendulum routes, increasing the frequency of buses (10 to 20 minutes between buses at peak times) and better connections between lines. As a result of public feedback, one circular line and night buses were added to the modelled network.

As of this writing, the effects of the new PT network have not yet been analysed extensively, but early results indicate that the number of passengers has increased by around 10 %. Overall, modelling new bus network allowed the city government to increase the time competitiveness and thus attractiveness of PT while maintaining similar levels of expenditure.

Indicator:	Result:
Data	Data on bus use collected using mobile positioning technology as well as data from validation of electronic bus cards. The former was collected as a one-time thing but electronic bus card data is available since its launch in 2015.
Modelling	A high quality PT network model used. Has some limitations that need to be addressed with future modelling.
Accessibility	Not present.

3.5.3 Measuring Accessibility: Riga Public Transport System accessibility assessment

Riga Public Transport System accessibility assessment carried out in 2017 was based on travel time measurements. More specifically, the travel time of using public transport was compared to that of driving. While it is more common to single out specific (types of) destinations, in this study the destination was simply the city centre. This simplification was made because some of the necessary data for conducting the study was missing and the city centre is the area of the city where jobs and services have clustered the most. The assessment was based on the EMME transport model that enabled considering car traffic's effects on public transport (speed). A total of 180 locations (potential mobility hubs) were picked within the functional urban area for which the travel time to the city centre was modelled by both PT and car. The assessment of accessibility was based on tiers of time where '0-8 minutes' was the best and 'over 48 minutes' the worst tier (see Figures 4 and 5).

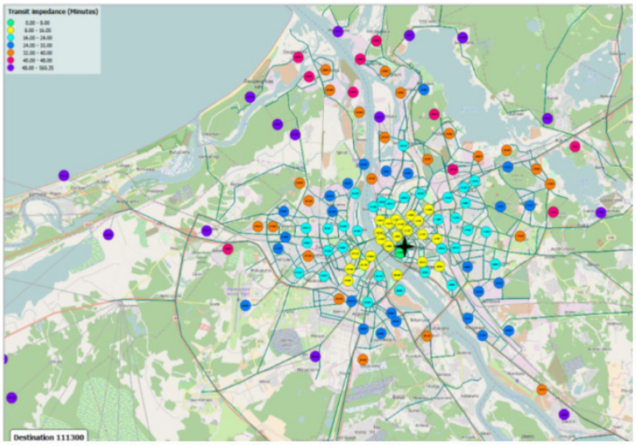

Figure 5. Map showing Riga PT impedance created by EMME in minutes (Source: EMME software):(green: 0–8, yellow: 8–16, light blue: 16–24, blue: 24–32, orange: 32–40, red: 40–48, purple: >48).

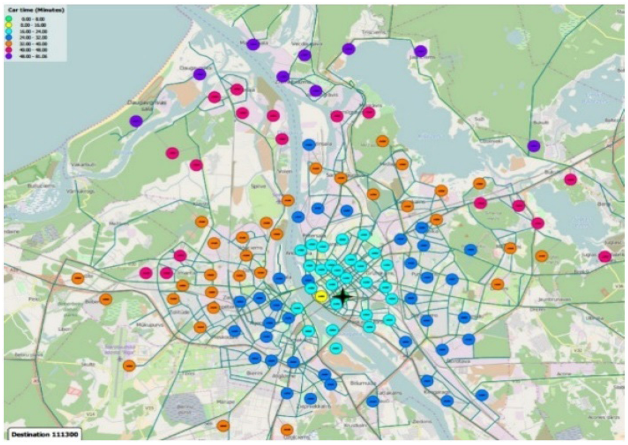

Figure 6. Map showing Riga car impedance created by EMME in minutes (Source: EMME software); green: 0–8, yellow: 8–16, light blue: 16–24, blue: 24–32, orange: 32–40, red: 40–48, purple:> 48).

As can be seen from the figures above accessibility measurements for PT were generally worse when compared to driving (especially for longer distances). Perhaps most strikingly, 23 % of the locations had the worst accessibility score for PT while only 7 % had such a score for driving. These results provide an effective way for measuring the quality and functionality of PT in Riga area. In the context of ambitious EU-wide climate commitments, the comparison to driving is especially useful since it provides a definitive accessibility goal that needs to be reached in order to effectively curb driving in Riga.

Indicator:	Result:
Data	Data from Riga Traffic Model (O-D matrices, bus routes, road network)
Modelling	Accessibility modelling using EMME software
Accessibility	Present and fairly well done for PT

4. INFRASTRUCTURE

4.1 Relevant common challenges and problems

A well-developed infrastructure that takes all modes of transport into account plays a key role in the design and transformation towards a sustainable transport system and in promoting sustainable transport behaviour. In this context, the infrastructure for each individual mode of transport has to be considered as well as interchange points with respect to intermodal routes combining different modes of transport.

In many cities, however, a one-sided focus is often placed on the expansion and continuous improvement of car infrastructure. As a result the conditions for the use of sustainable modes of transport are in great need of improvement and are not competitive compared to car use. More specifically, there is a need for convenient and reliable public transport connections as well as good infrastructure for non-motorised traffic, such as footpaths and cycle paths. At present, for example, the cycling infrastructure in many cities is severely underdeveloped and does not form a coherent, extensive network, and, particularly relevant for commuting, there is often a lack of safe and comfortable connections between the city centre and the suburbs.

As mentioned above, in addition to the network infrastructure, public transport stops play a particularly important role, as they serve as the „entry gates“ to the public transport network. Moreover, in addition to the infrastructures for the individual modes of transport, the interlinking of means of transport plays an important role with the aim of promoting intermodal transport behaviour. Intermodality in this context refers to the combination of different means of transport on one route and allows the individual advantages of the means of transport to be used with the aim of optimising the overall route. However, the change of means of transport is associated with inconveniences, especially in comparison to car use, which usually allows a door-to-door journey. Accordingly, the design and equipment of interchanges also plays an important role. Broadly speaking, two types of relevant amenities can be distinguished: those needed for continuing one's journey and those needed to make the stopping/waiting period more comfortable. The first sort includes, for example, sheltered bicycle parking, hubs where many transport modes meet, availability of bike and car share systems. The second sort includes seating, shelter from weather in the waiting area and facilities offering food and drink. However, the current design of public transport stops in many cities does not meet user expectations. In many cases the listed amenities are missing, as well as an informational and also architectural connection between the various means of transport.

4.2 Relevance for commuting and intermodality

Commuter traffic accounts for a high proportion of the daily traffic volume; the dimensions of the road infrastructure are usually planned and built for the period of maximum demand, which often represents the morning peak. Accordingly, the capacity of the infrastructure is only utilised for a short period of time. In order to satisfy the mobility needs in a cost and space efficient way, it is therefore in the interest of the cities to motivate commuters to use environmentally friendly means of transport as much as possible. This requires well developed infrastructures (network, stops, interchanges, and vehicles) for public transport and active modes to achieve a sustainable modal shift towards sustainable transport systems.

Well-designed interchanges and intermodal nodes play an essential role in intermodal travel chains. As changing is inconvenient both within public transport and between different modes of transport, the aim must be to make transfers as smooth, seamless and stress-free as possible.

4.3 Possible solutions

The spectrum of possible solutions ranges from the creation of coordinated planning tools, the definition and enforcement of uniform design and equipment specifications for stops, interchanges and intermodal hubs, innovative vehicle and network approaches to reduce the number of transfers, and the improvement of network infrastructures for each mode of transport.

To improve interchanges between various modes of transport, it is essential that all transport networks for all modes in the region are planned together so that the intersections of these networks could be created and located where they are needed most for commuting journeys. This requires extensive cooperation between relevant departments and probably some form of unified body for transport planning in the region.

For improved waiting amenities in interchanges and multimodal hubs, it is useful to devise and enact quality standards. Such standards should include adequate shelter, seating, food places, possible recreational facilities and other amenities deemed necessary for creating convenient multimodal hubs. By implementing these standards, an evenly good level of comfort can be guaranteed in interchanges and multimodal hubs. A complementary approach would be to reduce the need for interchanges altogether by using public transport that can transition from regional line to an urban one. This would be suitable for interchanges where the main interchange is between regional and urban modes of PT, e.g. regional train and urban tram.

To enable the use of active, non-motorised modes, suitable infrastructure networks need to be developed. A good solution is bicycle highways that connect suburbs directly to the city centre. The idea behind such highways is to provide direct and interrupted connections ideal for high speeds and long distances. Combined with the growing use of e-bikes, such highways provide a very real alternative to car-based commuting.

4.4 Indicators for success

- *Hubs:* Number of good quality intermodal hubs
- *Standards:* Existence of quality standards for transport interchanges and intermodal hubs
- *Connections:* Availability of commuting opportunities using active modes. Can be measured by share of suburban areas well connected to the city centre for active travel (e.g. with bicycle highways)
- *Changes:* How many mode changes people need to make when commuting. Can be measured by the average number of necessary changes of transport mode during a commute for suburban residents.

4.5 Good practice examples

In the following sub-chapters good practice solutions for individual infrastructure aspects are presented.

4.5.1 Quality standards for interchanges

Interchanges play an essential role in the transport system as they are both, the gateways to the public transport network as well as purpose-built facilities where interchange between different transport modes takes place. Therefore the overall aim for interchanges should be to fundamentally improve the interchange experience and make transfers as smooth, seamless and convenient as possible.

There are different types of interchanges regarding their size and function, ranging from PT stops with shelters till the central interchange in a very large city. According to their size and function within the PT network, there are different aspects to be considered regarding quality standards. Such aspects range from embeddedness and connectivity of the stop in the built environment, to the quality of stay and the provision of information, to additional offers such as retail and service. In order to cover the wide range of aspects, instead of presenting individual good practice solutions, reference is made below to knowledge, tools and guidance already compiled in other (European) projects. These have dealt in detail with the tasks, actors and quality standards of PT stops and interchanges.

The European collaborative research project NODES (New Tools for Design and Operation of Urban Transport Interchanges), co-funded by the Seventh Framework Programme, focused on the development and testing of a toolbox to help European cities to assess and benchmark new or upgraded urban transport nodes with the aim of improving performance and customer satisfaction. The NODES Toolbox contains a catalogue of integrated planning, design and management tools along the five key areas identified (1) strategies for integrated land use planning with urban passenger infrastructure planning, (2) innovative approaches relating to the design of new or upgraded efficient transport interchanges, (3) intermodal operations and information provision, (4) management and business models: the interchange as business case for the local economy and in itself, and (5) energy efficient and environmental friendly interchanges. The toolbox is available online at https://nodes-toolbox.eu/.

In addition, reference can also be made to already publish guidelines for the design of interchanges. In order to provide advice and guidance for improving the quality and efficiency of interchanges, Transport for London has designed the Interchange Best Practice Guidelines. Although they focus on the interchanges in Greater London, they give a very good overview of the aspects to be considered and suggest possible solutions. The guidelines consist of a design and evaluation framework covering the four main design themes of (1) efficiency, (2) usability, (3) understanding, and (4) quality and the principles and criteria supporting them. Each principle comprises one or more criteria, presented in the form of a series of questions. Furthermore, a list of important needs and aspirations of relevant stakeholders such as passengers, local residents, station manager and service providers is presented.

In summary, the guidance is a very good opportunity to inform about relevant aspects as well as to evaluate existing or planned interchanges and identify areas for possible improvements. More information and the Interchange best practice guidance are available online at www.tfl.gov.uk/interchange.

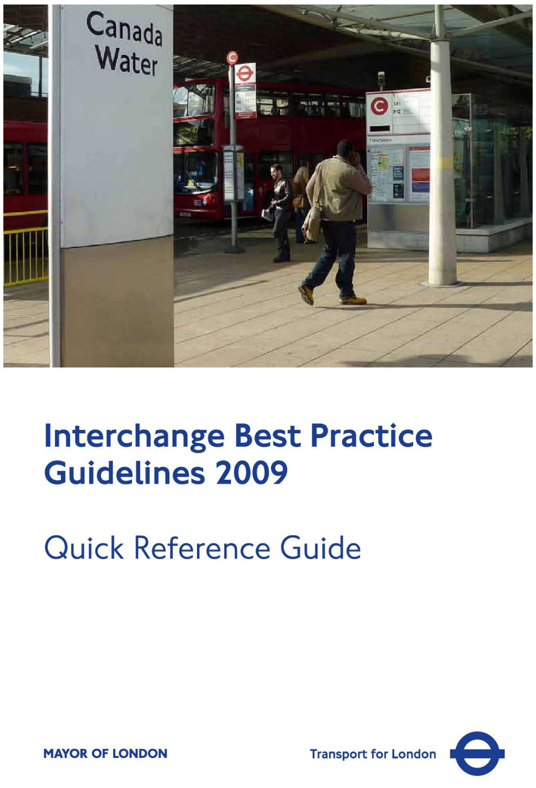

Figure 7. Interchange Best Practice Guidelines (source: Transport for London. 2009)

4.5.2 Intermodal / Mobility hubs

In recent years, a variety of new transport services and providers have emerged, especially in cities, such as station-based and free-floating bicycle rental systems, e-scooters, car sharing etc. These form the basis for a mobility of the future consisting of intelligently interconnected systems. More and more often, journeys are not made with one‘s own car from start to finish; instead, different mobility offers are combined depending on the situation and needs: By car to the train station, from there by train to the city centre and then by bus or shared bicycle or e-scooter to the destination. On the one hand, this enables users to use the most suitable means of transport for their chosen route. With regard to intermodality, it also enables users to choose the appropriate means of transport for each part of an intermodal route chain.

Especially on the feeder routes of rapid transit systems, the so-called first/last mile, such transport offers can greatly increasing the number of destinations reachable by public transport and generate a modal shift away from the car. Concerning commuter traffic, dedicated areas for parking cars (Park&Ride) or bicycles (Bike&Ride) are often already available in the periphery of a city and enable the use of one‘s own vehicle as a feeder to the rapid transit system. The new transport services in city centres mentioned above now also offer corresponding alternatives at the other end of the travel chain.

In order to increase the visibility of these mobility offers, to raise public awareness of inter- and multimodality and to strengthen and promote the use of such mobility services and a consequent change in mobility behaviour, cities try to bundle and organise the different offers spatially in a mobility hub. The principle idea of such mobility hubs (other used terms are mobility stations or intermodal hubs) is to create a recognisable place with different and connected transport modes. Moreover, they provide enhanced facilities and information and should be designed and spatially organised in an optimal way to facilitate access to and transport between modes. Facilities include but are not limited to appropriate PT stops, waiting areas with real-time arrival information, bicycle and car sharing stations and facilities, taxi waiting/call areas, bicycle parking, repair facilities, retail, and open spaces. By providing a wide range of options at mobility hubs, a variety of different needs can be accommodated and therefore increasing the number of destinations that can be reached by public transport.

Figure 8. Mobility Hubs Guidance (source: CoMoUK. 2019. Mobility Hubs Guidance)

A very comprehensive overview of the topic, advantages of mobility hubs and their different design depending on location and context accompanied by further case studies can be found in the Mobility Hubs Guidance developed within the Interreg project SHARE-North, available online at https://como.org.uk/wp-content/uploads/2019/10/Mobility-Hub-Guide-241019-final.pdf.

In the following, the example of mobility stations in the German city of Munich is presented which briefly illuminate the basic principle and the aspects to be taken into consideration.

Within the projects „Smarter Together“ and “City2Share”, mobility stations will be set up in the city of Munich in different urban areas with the aim of testing and evaluating new mobility services in a living lab. The aim is to provide smart mobility solutions for the residents and local economy in the neighborhood. Therefore, together with the citizens, offers will be further developed according to their needs. At the sites of the mobility stations, local public transport and other mobility services will be bundled at one point. The mobility services include, for example, e-car sharing, a bicycle rental system with both conventional and electric bicycles, cargo bikes, and charging stations for e-mobility. In addition, distribution stations with refrigerated and non-refrigerated compartments have also been set up at the mobility stations, enabling parcel and delivery services to deposit their shipments for customers.

Digital information steles on site and the Munich SmartCity App serve as information and central access to bookings.

Figure 9. Mobility station in Munich

Figure 10. Mobility station in Munich

4.5.3 Reducing interchanges by creating regional-urban lines

Another way of improving commuter relations, especially between the hinterland of a city and its centre, is to create continuous rail links using existing infrastructure. The aim is to create new connections and eliminate previously necessary transfers as described in the following example of tram train systems.

4.5.3.1 Tram-train systems with the example of Chemnitz

Tram-train systems as we know them today have their origin in the German city of Karlsruhe in the early 1990s. These systems are a combination of classical inner-city tramway or light rail systems with suburban railways. A typical tram-train line operates as a tram vehicle inside the city and continues its journey on electrified railway lines (or sometimes even on non-electrified tracks) outside the city. Vehicles for tram-train systems are usually dual- or multi system vehicles that can operate with different voltages and are able to run at higher speeds on suburban railway tracks. The advantage of such system is that it reduces the need of changes from one mode of transport to another: instead of taking the regional train to the central station (or any other) and then switching to tram, commuters can travel directly to the centre of the city. The slower speed of the tram in comparison to the train within the city borders and more frequent stops are in most cases outweighed by the time saved due to the reduced number of changes. This is especially true if the main railway station is not close to the centre of the city, as it is e.g. in Karlsruhe.

The investments into such a system include dual system vehicles, the connecting infrastructure between railway and light rail (rails, switches, catenaries, signals) and adjustments to the signalling systems, platform hights etc. In addition, vehicles for tram-train systems must be designed so that they comply with regulations for both light and heavy rail systems. Furthermore, on the administrative level, ticketing systems and fare schemes should be harmonized so that seamless travel within the tram-train network is ensured.

The city of Chemnitz in Germany is one of the prominent cases where a tram-train system has been installed and is still being expanded. Chemnitz is located in eastern, Central Germany in the federal state of Saxony and has about 245.000 inhabitants. The city is a regional administrational and industrial centre and a railway hub. The city had a tramway system which goes back to the 1890s and was never abandoned as in many other cities during the 1960s and 1970s. In the early 1990s the idea was proposed to develop a tram-train system similar to the one in Karlsruhe for the region of Chemnitz. A feasibility study was tendered in 1994 by the Saxonian ministry of economy and labour resulting in a recommendation for a North-South axis and an East-West axis. In December 2002 the first former suburban railway line between Chemnitz and Stollberg was opened to the tram-train service after it had undergone substantial refurbishment and upgrading (electrification, change of platform heights, additional crossing points along the route, four new stops). The trams serve the suburban route from

Stollberg up to the southern part of the city, where a new connection to the tramway system was built, and then continue their journey on tramway tracks up to the city centre and central station. As these two different sections operate with different voltage - 750 V outside the city and 600 V inside the city - the trains switch between these two power supply systems at this newly built connection. For the operation of the line to Stollberg, dual system, low-floor trams were purchased. The overall infrastructure investment amounted to 31 million EUR.

The route is served half-hourly, on Sunday in an hourly interval. Between Stollberg and Chemnitz the passenger numbers increased significantly from 0,16 million in 1998 before the conversion to 1,42 million in 2013, surpassing the prognosed number of daily passengers.

In a next step, the Central Station of Chemnitz was rebuilt, so that trams and tram-trains could enter the main station hall. Some of the old platforms for main line trains were dismantled and the tram and tram-train system received two new platforms instead. New tramway tracks were built to connect the new platforms to the tramway system and a connection to the heavy rail system was built, so that trams can switch to the heavy rail system after leaving the stop inside the central station. The conversion was found to be highly efficient, with a cost-benefit factor of 3.8, meaning that the investment will lead to an almost fourfold return. The whole reconstruction took 5 years from 2009 to 2014, costing 32.5 million EUR.

In 2016, three railway branches north of Chemnitz were included into the tram-train system. Currently, these lines run up to the Central Station then continuing their journey on a newly built inner-city tramway section to the university. For operating these lines, new vehicles were tendered. These vehicles can handle the two types of voltage (600 and 750 V) but can also run on diesel on the three outer railway branches. These new vehicles can run up to 100 km/h on conventional railway lines, and up to 60 km/h inside the tramway network.

The expansion of the tram-train system is ongoing. Currently, another railway line from Chemnitz to Thalheim and further to Aue, 45 km south of Chemnitz, is being converted to tram-train standard and will be served by the dual trains from 2021. Additional lines are in the planning stage.

Figure 11. Tram train at the diesel section to Burgstädt (source: Falk2, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=61435202)

Figure 12. Tram train of the first stage in the upgraded section to Stollberg (source: Aagnverglaser, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=47692088).

Figure 13. New tramway stop inside the Central Station (source: Clic, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=75119393).

4.5.4 Built infrastructure for non-motorized transport modes

Active modes such as walking and cycling play an important role in promoting mobility without the use of a car, as many journeys are rather short and are therefore suitable to be made with active modes. Moreover, these modes also have a feeder function to public transport in intermodal transport chains. In order to strengthen these modes, an appropriate infrastructure is important. The topic of infrastructure covers aspects like a dense network with straightforward routes, low detour factors, well equipped transfer points and parking facilities. Exemplary for a multitude of aspects to be considered and consequently good practice solutions available, the parking possibilities for bicycles at railway stations and cycle highways will be presented here.

4.5.4.1 Parking of bicycles at train stations

In many countries with a large proportion of cyclists and public transport users, experience has been gained over the past decades on how best to manage the safe and comfortable parking of bicycles at PT stops. Most of the experience with parking bicycles has been gathered in the Netherlands, where there are examples of solutions for stations of different sizes.

At almost all railroad stations, unguarded bicycle racks are available, which are often installed by the municipalities in cooperation with the station operator. These are often sheltered and close to the station to provide short transfer routes and can be used free of charge.

The trend towards higher-quality bicycles and electric bicycles, which are more expensive than normal bicycles, can lead to a greater need for safety by users. If there are no guarded bicycle storage facilities available, many smaller stations offer the possibility to rent bicycle lockers. In these lockers the bicycle can be stored safely as only the user has access.

If larger capacities are required for parking bicycles, dedicated bicycle parking buildings will be built. These often offer direct access for cyclists and short distances to other means of transport. Currently parking guidance systems are being tested at some of these stations to make it easier and faster for cyclists to find free spaces. To satisfy all customers, special parking facilities for larger bicycles (tandems, cargo bikes) and bicycles with child trailers can also be offered. Additional services can also be available, such as bicycle repairs, air pumps or the opportunity to purchase food.

Figure 14. Bicycle parking facilities at Antwerp Central Station

Another good practice example is the Biketower. This innovative fully automated storage system for bicycles has already been implemented in 16 cities in the Czech Republic, many of them in the immediate vicinity of railroad stations. It offers cyclists the opportunity to park their bicycles in a weatherproof and theft-proof location. It also offers cities the opportunity to promote the use of bicycles very prominently.

Bicycles are stored and retrieved in an input module equipped with a payment terminal and an information screen that gives detailed step-by-step instructions on how to use the system. However, the user is obliged to pay, but an agreement has been reached with the Czech railway company to provide discounts for discount cardholders and thus promote the use of the bicycle on intermodal routes. Further information can be found on the website https://www.biketower.cz/en/biketower.

Figure 15. Biketower at the train station of Prerov, Czech Republic (source: https://www.biketower.cz/en/biketower)

4.5.4.2 Cycle highways

The main objective of cycle highways is to provide a safe, quiet ride with fewer stops and increased safety in order to provide an alternative to the car for distances over 5 kilometres. The cycle highway is defined both by its location and by its physical characteristics. They connect work, study and residential areas, and the needs of commuters are given the highest priority. In addition, cycle highways are planned to run close to train stations to facilitate commuting by public transport. Moreover, the aim is to achieve the most direct route possible including as few stops as possible. This can be achieved both structurally by creating intersection-free routes by using bridges or tunnels, and by creating a green wave where the traffic lights are coordinated towards cyclists and allow an average speed of 20 km/h. Clear signage is also required. In addition to the aspects of accessibility and directness, comfort plays an important role as well and includes aspects that ensure a good cycling experience such as smooth surface, high level of maintenance, and additional services such as the provision of air pumps. The safety aspect addresses the physical safety by upgrading infrastructure in a way to reduce the risk of accidents.

More information on the background, planning, design and evaluation of cycle highways and supporting tools can be found in the manual at https://cyclehighways.eu/. In the following, the basic principle of cycle highways is presented using the example of Copenhagen, where this form of infrastructure was first designed and implemented.

Figure 16. The Dafe Schippers Bridge in Utrecht as an example for bicycle infrastructure

Cycle Superhighways in Copenhagen

Denmark and especially Copenhagen are known for cycling, especially in the larger cities the number of cyclist continues to increase. In 2016, for example, bicycle traffic in the centre of Copenhagen exceeded car traffic. In contrast, however, the number of cyclists in rural and suburban areas is declining. When it comes to crossing the city limits, bicycle traffic decrease and car traffic increase. The idea and assumption was therefore to encourage more people to cycle longer distances by creating regional cycle highways. Therefore, 27 municipalities and the Capital Region of Denmark have joined forces to create a network of cycle highways - a cycling infrastructure that makes it easy, flexible and safe to cycle to and from work. Some of the expected benefits include a reduction in congestion, traffic-induced noise and air pollution, and improved health.

Started in 2012 with a first cycle superhighway of 17 km in length, the network is already 167 km long by 2019 with the aim of extending it to 680 km by 2030 and 746 km by 2045. In general, the routes will use existing infrastructure and will be upgraded to meet the criteria and standards of cycle superhighways as mentioned above. Only where there are missing links will new routes be built. In addition, a new sign was introduced with the aim of making it as well known as the signs for the metro or the suburban railway. As a result, 65 % of the users and 91 % of the commuters know the sign (Office for Cycle Superhighways. 2019 (a)).

First results show an average increase of 23 % of cyclists (and up to 68 % on a certain route) compared to the situation before the introduction of cycle superhighways, 14 % of new cyclists used the car before. The average length of the route is 11 km with an average speed of 19 km/h. - A socio-economic analysis carried out in 2018 showed that cycle superhighways are one of the most profitable infrastructure investments in Denmark (Office for Cycle Superhighways. 2019 (b)).

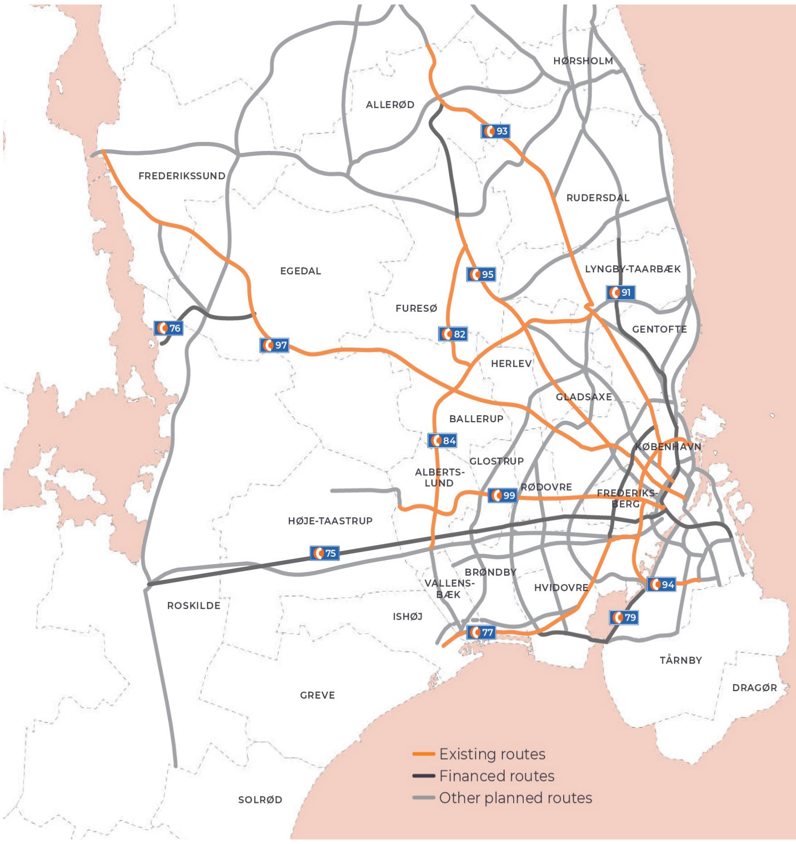

Figure 17. The Copenhagen network of Cycle Superhighways (source: Office for Cycle Superhighways. 2019)

5. INTEGRATED TICKETING AND TARIFF SYSTEMS

5.1 Relevant common challenges and problems

A major challenge for integrated ticket and tariff systems in public transport is often the large number of companies, actors and institutional and administrative structures involved in a functional urban area. At the level of administrative structures, fragmentation along administrative boundaries within the functional urban are is often an additional complicating factor. Having different PT modes and PT operators, ownership, tendering cycles and funding schemes often result in several ticketing and management systems which may result in less attractive, slower and more costly PT service for cross-border and intermodal trips in the region. For the customer this leads to unattractive ticket systems due to the possibly necessary purchase of several tickets when crossing administrative borders or when using different means of transport within the public transport system.

To overcome this situation, new agreements between the municipalities concerned and the actors in the region are needed, involving negotiations, changes in legislation and the creation of new institutions, management and financing procedures.

5.2 Relevance for commuting and intermodality

Lack of common and integrated ticketing may cause several problems in regional mobility:

- the PT service is attractive or affordable only when using 1 operator's service
- cross-border services do not have monthly passes, higher costs for users
- lack of motivation for interchanges for optimal PT connections, because of the need to buy a new ticket - cost is higher, service is slower or not covering the needs of customers
- customers sticking to only one operator leads to inefficient line network and duplication of services, higher costs of operation
- slower connection speeds due to ticket sales
- different payment and ticketing systems make the system unattractive and unreadable, confusing, not customer friendly, too much hassle
- driving becomes more attractive

5.3 Possible solutions

There are different levels of integration of ticketing and zoning

- common ticketing and tariffs for all PT services in the municipality
- common payment system (one card, but different tickets)
- common zoning and ticketing for regional PT service, regarding administrative borders (the zones are defined with administrative borders)
- common ticketing and zoning across all modes of regional and local PT with distance-based zoning
- nation-wide common ticketing (Switzerland).

5.4 Indicators for success

- *Cross border trips*: estimating the popularity of PT for trips crossing municipal borders. Can be estimated by measuring the percentage share of cross border PT trips of all cross border trips in the functional zone.
- *Systems*: counting the number of different ticketing systems in the region - single fares as well as period fares.

- *Integration*: measuring the share of PT services integrated into common ticket system
- *Trip cost*: cost of single trip when combining 2-3 different PT lines
- *Monthly cost*: cost of monthly pass within e.g one hour commuting trip in the region
- *Modal share*: measuring PT modal share trend in the region
- *Revenue*: measuring ticket revenue in the region

5.5 Good practice example

5.5.1 Regional ticketing and payment systems for better public transport integration (Helsinki region)

Regional ticketing and zoning is considered a success in Helsinki for a variety of reasons. It has led to cost-effective services, through use of economies of scale, reducing duplication of services, and increased management efficiency.

Before 1984, Helsinki's public transport was run by each municipality, with national roads and the regional railways run by national organisations. This worked until the municipalities grew to become one region. Since 1984 Helsinki region public transport management has gone through several stages of development - growing from Helsinki and 3 bordering municipalities into a region of 9 municipalities (2010) with a common planning and public transport region where all regional and local bus, tram, metro and commuter train services are covered by common zone based ticket system which allows cross-use of all PT modes either with a single ticket (valid for 80 minutes in the region) or period tickets.

Currently, Helsinki Region Transport (HSL) is a joint regional agency whose member municipalities are Helsinki, Espoo, Vantaa, Kauniainen, Kerava, Kirkkonummi, Sipoo, Siuntio and Tuusula. HSL began its operations in 2010. Some 370 million journeys are made on HSL's transport services annually. HSL's annual operating income is over €640 million, of which ticket revenue accounts for around €330 million (about 46 % in 2016). HSL has 373 employees. The organizational map can be found here: https://www.hsl.fi/sites/default/files/uploads/organisaatiokaavio2_en.pdf

From spring 2019 Helsinki Region is switching from administrative border based zoning system to more distance based integrated zoning that allows even more flexible travel across different zones. The Helsinki region will be divided into four zone circles with a diameter of about 10 kilometers, radiating from the centre of Helsinki. The zones have been designated by letters A through D from the inner to the outer zone. The capital region, i.e. Helsinki, Espoo, Kauniainen and Vantaa, is located in zones A, B and C, Kerava, Sipoo, Tuusula, Kirkkonummi and Siuntio are in zone D. However, Maantiekylä in Tuusula and Ruotsinkylä are in zone C. Zone E can be introduced later as the HSL area expands. Zone B covers parts of Helsinki, Espoo and Vantaa, see figure 18.

50 % of PT costs are covered by ticket revenues, with annual income of ticket sales totalling 365 m €. More than 80 % of PT passengers are using monthly or annual pass.

Figure 18. More information: https://annualreport.hsl.fi/

Indicator:	Result:
Cross border trips	n/a
Systems	One unified ticketing system in the region
Integration	All PT providers within the region are under the same ticketing system
Trip cost	Single fare ticket (2.80 euros for zones A and B) is valid for 80 minutes
Monthly cost	For an adult an AB zone (roughly a maximum of one hour from the centre) monthly pass is between 53 and 59 euros, depending on the length of the pass bought.
Modal share	Has fluctuated around the same level for the last 5 to 10 years.
Revenue	€365 million

6. SERVICES

6.1 Relevant common challenges and problems

Easy access to public transport increases the probability of using it. Access includes both the accessibility of the boarding station and access to relevant information in connection with the use of means of transport other than the own car. Access, especially to rapid transit stops, may be too long to be reached on foot. This problem of the so-called first/last mile requires either the use of other means of public transport such as buses or trams or the use of other modes of transport such as bicycle or car. Depending on the area, different offers are necessary; in urban areas, for example, offers for micromobility or bikesharing are created, while in suburban areas and the further hinterland, offers such as bicycle parking garages or Park&Ride facilities are provided. However, such services often involve additional costs or are less suitable for smaller towns and rural areas with low population density. If several mobility actors are active in a city or region, the variety of options as well as connection search and routing within a journey can be challenging and often requires the use of several different digital platforms for booking and payment. However, relevant for the user is only the possibility of obtaining a connection according to his preferences (time, cost and available means of transport) and preferably booking and paying for it via a single platform.

6.2 Relevance for commuting and intermodality

In order to succeed in competition with private car use, reliable and easily usable structures must be established using public transport, especially for commuters. Commuters try to optimise their individual routes, as there is a high need for optimisation (time, costs, and comfort) due to the almost daily journeys. With regard to intermodal travel chains, it should also be noted that an intermodal journey is only as effective as the means of transport available, the interconnectivity and reliability of these means of transport and the availability of relevant information for commuters and travellers.

6.3 Possible solutions

In order to provide solutions for the first/last mile, sharing systems for various forms of micromobility (bicycle, e-scooter, e-moped, etc.) are already on the rise in many cities. Both station-based systems and freefloating systems exist, which offer more flexibility to the user with lower infrastructure costs for the operator and the city. However, new challenges are associated with parking, the commercial use of already scarce public space (e.g. sidewalks), the misuse of transport infrastructure by other user groups (e.g. e-scooters on footpaths) and vandalism. Often the political and legal framework conditions have not yet been adapted accordingly.

Demand-responsive transport (DRT) can be a suitable complement to existing public transport and can address both people with special needs (elderly, disabled) and commuters in both rural and urban areas with otherwise low demand and/or poor access to rapid transit. Important here is the integration into existing timetable information and booking systems. Other booking methods such as telephone booking, SMS, web- or app-based booking can also be used temporarily. Timetable information systems are available as web-based and mobile applications that provide convenient access to traffic information such as timetables, ticket information and even real-time locations of vehicles (e.g. buses). However, these applications can be operator and/or region-specific and often do not provide information about intermodal travel options or their booking. Accordingly, a cross-provider information and booking platform is a suitable solution to enable intermodal travel chains.

6.4 Indicators for success

Services that improve access to mobility in both urban and rural areas can be in the form of new or updated modes of transportation and digital tools, such as mobile applications, that inform on how these modes are connected. Indicators of success for such services can include:

- Awareness: knowledge that a service exists. Can be tracked by survey information and number of application downloads for example.
- Number of available mobility solutions or providers: increase of mobility options improves access to mobility and the flexibility and connections of an intermodal journey.
- Usage statistics: can be in the form of trip numbers and/or ticket purchases (via app, when available): indicates that the service is useful for planning and ticketing
- Improved access to mobility: including rural areas, people with special needs ex: old-age, families with children and disabled and can be measured by GIS analysis, survey data and deployment data.
- Geographical region: as this expands, intermodal journeys become easier over longer distances.
- Reduced car use / dependence: measured by survey data

6.5 Best practice examples

6.5.1 First and last mile with e-scooters: Portland, OR (USA)

PORTLAND	
Population:	647 805
Geographical size:	376 km2
Transit operators:	Trimet (bus, light rail, commuter rail); Biketown (bike share);

Different forms of micro-mobility can play a role in filling those gaps between fixed-route public transit service points and journey start and destination points. As a last-mile solution in urban centers, bicycle hire systems are available in many large cities. E-scooters began showing up in many American and European cities – as early as 2017 in Santa Monica California, and in less than a year later, scooters were in operation in 65 American cities. The rate of implementation, the number of new operators, and sources of investment (ex. ride sharing companies like Uber and Lyft, Ford motor company) show early signs of a quickly expanding market, albeit one with growing pains.

The flexible nature of the e-scooters allows users to locate them via a mobile application and leave the scooter where they wish, within the rules defined by the system in coordination with city policy and regulations. The technology, however, was introduced to many cities at a fast rate by several operators, in some cases before appropriate regulations and policies were put in place. Companies such as Bird and Lime were already operating in 43 US cities prior to permit or consent. This caused problems with parking, discarded scooters, vandalism and uncertainties regarding how users use the city's infrastructure and resources. While many cities responded with cease and desist orders, fines or both, Portland took a different approach. Portland implemented a four-month pilot started in June 2018 with an open call for applications for e-scooter operators. Five applied and three accepted, with a start of 100 scooters per company and by August 643 per company were permitted. Considerations for parking, discounts for low-income users, distribution, including service to areas with otherwise poor transit access, were included in the detailed application guidelines.

The pilot involved a permit framework that aligned e-scooter company business practices with four City of Portland objectives:

- Reduce traffic congestion by shifting trips away from private motor vehicle use
- Prevent fatalities and serious injuries on Portland streets
- Expand access to opportunities for underserved Portlanders
- Reduce air pollution, including climate pollution

Figure 19. E-scooters in Portland

E-Scooter pilot in numbers	
Test period:	120 days (July – November 2018)
Service area:	Portland city boundaries (145 sq. mi) including East Portland
Total trips:	700 396
Total miles:	801 877
Average trips per day:	5 885
Average length:	1.15 miles
Average East Portland trip length:	1.6 miles

Portland is an example of a city council that has taken a systematic approach to introducing e-scooters to its city via a pilot project aimed to assess whether – and how – e-scooters could help meet Portland's transportation needs. This was done in a well-documented and transparent way. The city used public participation including surveys, reference groups from citizens, including users, to gain feedback on how the systems function. Three focus groups were formed including those from the Black community, East Portland (a lower income area) and people with disabilities. In general, the view of scooters in their city was positive however some barriers to using the system were identified including cost to borrow, knowledge of rules and access to discounts for low-income earners, and concerns over racial profiling and harassment. Dialogue and survey information (from 4500 people surveyed) showed decreased comfort for pedestrians on sidewalks, in particular for people with disabilities. Observational analysis of scooter user behaviour showed a preference for bikeways and other separated infrastructure. In their absence sidewalk riding increased. On roads with a speed of 30 mph (45 km/h) or higher, most users rode illegally on sidewalks. GPS tracking data from the four-month period was supplied by the participating companies to the city for the city to better understand use and travel habits.

According to survey data, because of the pilot, 34 percent of users reported they would have either driven a personal car (19 %) or hailed a taxi, Uber or Lyft (15 %), with a reduction of approximately 301 856 vehicle miles. Six percent of users had gotten rid of their personal car while 16 percent considered doing so. E-scooter use, however, also impacted active transportation with 42 percent of users reported they would have walked (37 %) or ridden a personal bicycle (5 %) had e-scooters not been available. In addition, the operation of e-scooters added motor vehicle trips needed for the operation and maintenance of the system. With regards to access to mobility, on average, nearly 250 e-scooters were deployed in East Portland, an area that has historically been underserved by public transit. 44 155 trips originated in East Portland during the pilot period and while there is potential for increased access via increased capacity, barriers exist related to perceived safety and lack of infrastructure for smaller vehicles (ex. bikes, e-scooters). E-scooter-related emergency room visits increased during the test period, from under one visit per week prior to the test to 10 per week during the test period with a peak in late August and early September. The majority of visits were due to non-collision (83 %) such as a fall while collisions with cars accounted for 12.5 %, 3 % involving pedestrians or other scooter users. To share information about the pilot and rules for e-scooter use, the city produced education materials including print (5 000 copies distributed) and website (viewed 50 000 times). Further engagement ensued via community events, test rides, flyers, warning signage and an online complaint and feedback form that gathered 2 860 comments.

Indicator:	Result:
Awareness	50 000 views of city’s e-scooter pilot information webpage
Available mobility options	Addition of e-scooters (2 043 permitted) deployed by four operators.
Usage	5 885 trips per day
Improved access	As required by city permits, operators deployed 10 % of their fleet to East Portland, an area with lower access to transit.
Geographical regions	Portland, East Portland
Geographical regions	Portland, East Portland
Reduced car use	301 856 vehicle miles

6.5.2 Route choice applications and information: Minrejseplan in Nordjylland (Northern Denmark region)

NORTHERN DENMARK REGION	
Population:	578 839
Area:	7 933 km2
Capital city:	Aalborg (123 921)
Transit operator:	Nordjyllands Trafikselskab

Minrejseplan in Denmark is a multimodal application based on the existing, nationwide journey planner Resjplan, which today is the fifth most downloaded application in Denmark. Launched in May 2018 as a pilot project in the North Denmark Region, Minreseplan integrates both public and private transport as a means to improve mobility in the region. Transit modes include public transit (bus, train, metro), taxi, ferries, carpooling, city cars and bike share. Also included is ride sharing services and on-demand services ‘Plustur’ and Flextur. Plustur is a service that connects rural passengers with the main public transit network via minibuses and taxis but at the price of traditional public transit. The goal of Plustur is to improve mobility in rural areas. Since its introduction, ridership of Plustur has been lower than expected, in part due to low awareness and dependence on digital booking that can be a challenge for older citizens, and dependence on an effective main transit system in the region, which is under development. Since integration in Minreseplan and with increased awareness (particularly of younger users), Plustur ridership has continued to increase, with over 500 person-trips per month.

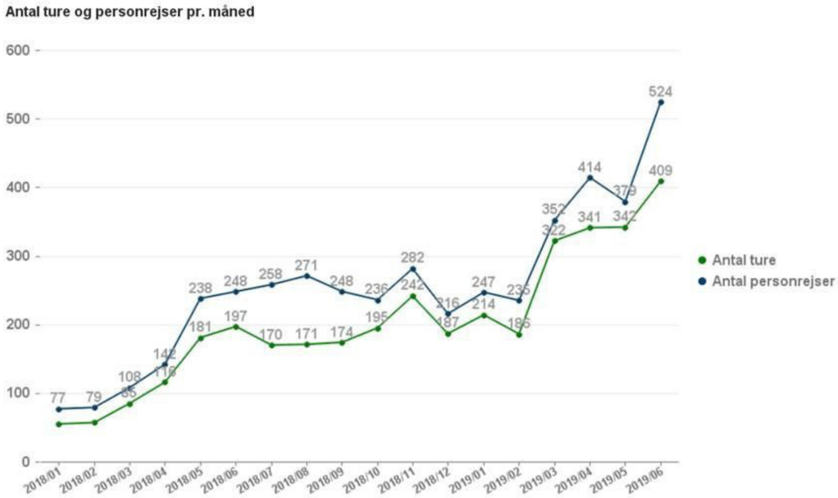

*Figure 20. Plustur: trips and person-trips per month, *1: introduction of Minreseplan, May 2018*

Flextur is a public mobility service for elderly residents that was launched in 2003 and can also be used by any residents in Norther Jutland for any chosen route from A to B. Since its implementation, the application was expanded to also include Copenhagen and Aarhus.

The project was part-financed by The Danish Transport, Construction and Housing Authority, an authority under the Danish Ministry of Transport, Building, and Housing. The goal is that the application should be integrated with the existing planner Resjplan and be available nationwide. A special version of Minrejseplan was introduced during the ITS World Congress in Copenhagen where all participants had access to the app. This version also includes a digital ticketing function and payment solution that is valid for public transport in Copenhagen and is seen as a step towards MaaS. Development of a common payment system for all travel modes has been a barrier for the app, due to lack of interest among different transport providers concerned with competition. Legal aspects including taxation and payment from public transit authority to private operators, is also being investigated. Costs involved with developing a full MaaS system are high and integration with other regions is necessary to help distribute these costs. The Minrejseplan pilot application is early in its development stage and is too early to make conclusions of indicators such as impact on car use.

Figure 21. MinRejseplan application

Indicator:	Result:
Awareness:	Uncertain; early in pilot period
Available mobility options:	11 (public and private, Northern Denmark Region), up from 4 public
Usage:	Plustur as benchmark: 409 trips per month; 526 person-trips per month in June 2019 (120 % increase from Minrejseplans introduction)
Improved access:	Resulting single application that combines several modes of transportation and possibilities for linking them in intermodal trips.
Geographical regions:	Northern Denmark Region, Copenhagen, Aarhus
Reduced car use:	Uncertain; early in pilot period

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ABOUT SUMBA

WHY DO WE NEED SUMBA?

More and more people chose to live in suburbs while they continue to work in cities, resulting in high number of daily commuters. Commuter traffic is still dominated by private cars, resulting in problems such as

- congestion
- air pollution
- high demand of parking spaces
- higher costs of public transport.

SUMBA will address commuter transport and help to mitigate these problems!

OUR ACTIVITIES

The urban transport system can be reshaped to an intermodal network that off ers a combination of various transport modes, including bike and car-sharing. This helps cities to achieve a more attractive and environmentally friendly commuting system. SUMBA will develop and test tools that help urban and transport planners to assess, plan, and integrate intermodal mobility solutions into transport plans and policies of their cities and municipalities.

OUR PARTNERS CITIES

Hamburg (Germany)
Tallinn city, Union of Harju municipalities (Estonia)
Tartu (Estonia)
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Associated cites Gdynia, Warsaw suburban region, Słupsk municipality (Poland), and Helsinki (Finland)

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