



euMove

European Mobility Venture



Table of Contents

Introduction	4
Method	6
Report structure	7
Team Supervisors	9
City of Munich Factsheet	10
City of Munich	12
City SWOT ANALYSIS	17
City of Barcelona Factsheet	22
City Overview Barcelona	24
City SWOT ANALYSIS	29
Measures	30
Case Studiies	78
City of Tallinn Factsheet	108
City Overview Tallinn	110
City SWOT ANALYSIS	115
City of Helsinki Factsheet	116
City Overview Helsinki	118
City SWOT ANALYSIS	123
Choice of Cities	124
Measures	126
Case Studies	158
City of Stockholm Factsheet	178
City of Stockholm	180
City SWOT ANALYSIS	185
Measures	186
Case Studies	246
Overall Conclusion	274
References: Munich	280
References: Barcelona	282
References: Tallinn and Helsinki	290
References: Stockholm	300

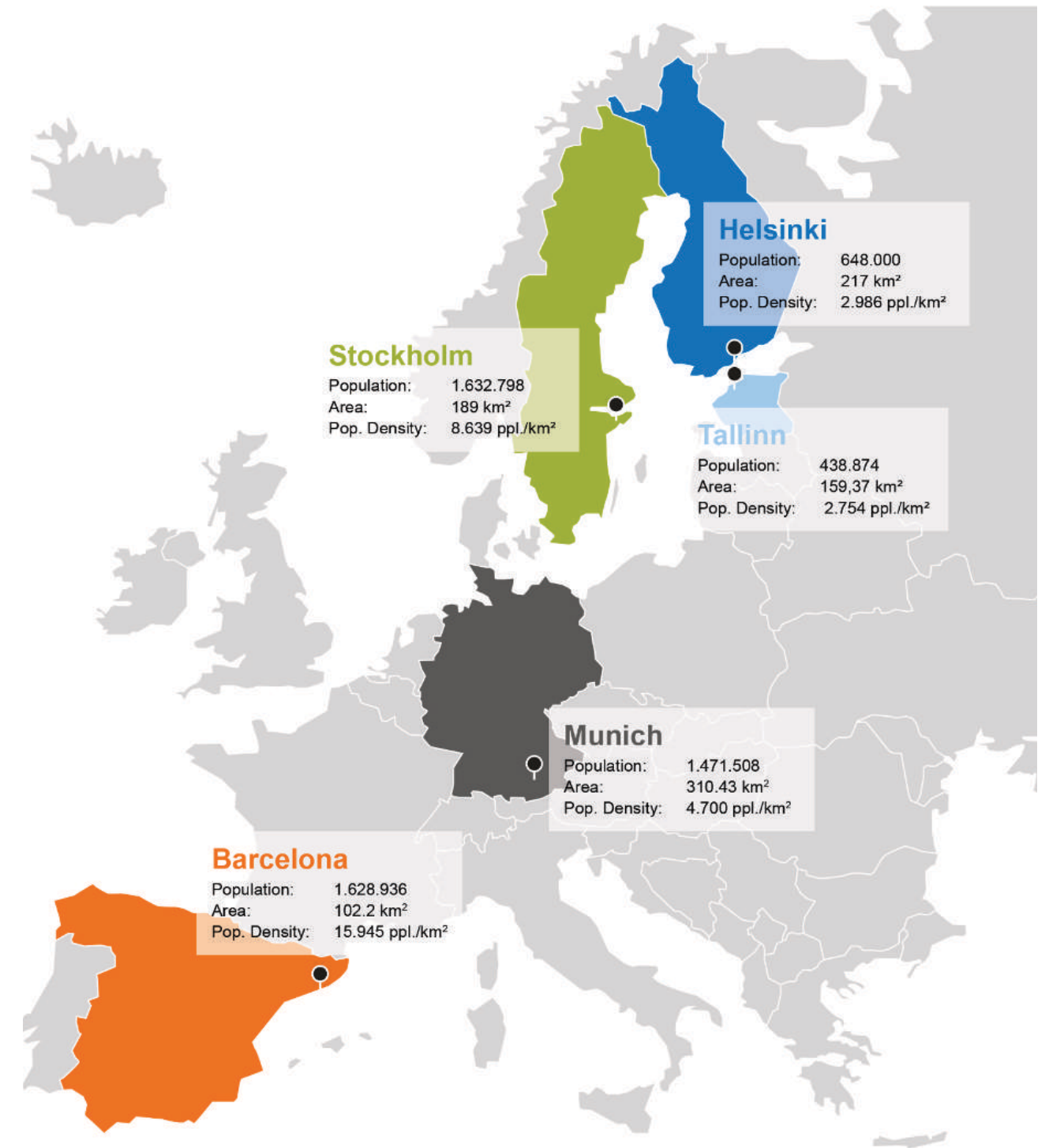
Introduction

Mobility is a megatrend – a growing number of people in urban areas commute and move around in a limited space. Cities all over the world are facing challenges like congestion, air pollution and traffic accidents. However, each city has found distinctive approaches to tackle these challenges. The euMOVE project provides an overview of these distinctions and presents a benchmark of particular urban mobility challenges and innovative solution approaches.

euMOVE – short for “European Mobility Venture” – is an interdisciplinary student project for the research of innovative and sustainable urban mobility in Europe. We are 12 students from different disciplines at the Technical University of Munich (TUM). The project is a cooperation of the Chair of Urban Structure and Transport Planning, the Chair of Automotive Technology, and the Munich Center for Technology in Society. The interdisciplinary approach allows us to address the topic from various angles: from an urban planning and environmental point of view, as well as from a technological and a socio-technical perspective. euMOVE is part of the M CUBE strategy project, which represents an interdisciplinary research approach that bundles competencies along three main clusters: (1) Electrification and automation of traffic systems, (2) development and integration of mobility options and (3) redesign and network of mobility spaces.

We explored these clusters in the metropolises of Barcelona, Tallinn & Helsinki and Stockholm which are all considered innovative vanguards of sustainable urban mobility. Barcelona hosts the head of the European Institute for Innovation and Technology of Urban Mobility (EIT) and is globally known for its radical approach to reshaping the use of streets. Helsinki provides a flourishing start-up scene with a leading role in Mobility-as-a-Service concepts. Its neighbouring city Tallinn, only 85 km away and linked through the Baltic Sea, is the first European capital to provide free public transport to its citizens and is famous for providing numerous digitized services. Since many projects are carried out in collaboration between Tallinn and Helsinki, we consider both cities as one metropolitan area. Stockholm’s ambitious innovation activities strive to become the smartest city on the globe by 2040 with many digital projects in the mobility sector (for more details, please refer to the respective city overview).

These cities do not only function as role models for ambitious cases distributed right across Europe, but they also shape sustainable urban mobility within their geographical, infrastructural, and social contexts. Taking into account that the simple ‘copy&paste’ of solutions hardly ever brings success, but that each city requires a tailored approach, we rather provide this variety of examples and experiences to facilitate a common learning process than to deliver concrete solutions. With our report, we hope to inspire and to encourage our readers to take responsibility for a sustainable mobility future – in Munich and beyond.



Map of Europe with the cities of the euMOVE project

Method

We have been working in three groups of four students, each group working closely with one or two mentors from the chairs. Every group chose a European city or a metropolitan region to visit and explore innovative mobility approaches and initiatives for two weeks in winter/spring 2020. During this empirical research phase, we conducted interviews with local authorities, mobility initiatives, start-up founders, transportation agencies, and citizens. We consider our daily movement through the traffic systems on-site as participant observations. In addition, our analysis included documents (plans, newspaper articles, policy documents, and videos) from and about the organizations and initiatives as well as literature reviews.

In order to give a comprehensive overview of mobility-related innovation in the chosen cities, we present the analysis of our findings in different formats. The variety of measures in the subsequent chapters includes successful projects, ground-breaking products, or progressive legislation – however, they all aim to improve urban mobility. A common analytical framework was developed to ensure that all relevant aspects are covered and to provide comparability. The measures are thematically grouped in the three clusters: (1) Electrification and automation of traffic systems, (2) development and integration of mobility options, and (3) redesign and network of mobility spaces.

A common rating system of three factors facilitates comparability between the 39 measures of mobility innovation. The assessment of desirable effects on a city encompasses the improvement of the quality of:

Air (local pollution, emission of global pollutants, noise, etc.)

Time (efficient, enjoyable, comfortable, healthy travels)

Space (equitable, just, safe, sustainable usage of space; political support for initiatives to improve the quality of space)

The impact of each measure is evaluated qualitatively and on a scale from one to three, higher numbers meaning better results.

Three to four case studies per city highlight mobility projects with an outstanding impact on the quality of the three dimensions. Through the open structure, the authors give in-depth insights into processes of implementation, interrelation of actors, and the embeddedness of actions into its socio-infrastructure context. Further, the case studies relate the knowledge gained during the empirical research to specific recommendations for Munich.

Report structure

The report is divided into four main chapters. The first one provides an overview of the current situation of urban mobility in Munich. Key facts and challenges implemented and ongoing projects, as well as a SWOT analysis map out the status of the city.

Subsequently, the results of the analysis of each city is presented in three similarly structured chapters. After an overview of the respective city, the most relevant measures are portrayed. The chapters end with comprehensive breakdowns of key topics in the case studies and a short conclusion summing up the authors' impressions.

Code*	Designation	Similar measures	Page
Cluster 1: Electrification and automation of traffic systems			
B.1.1	Motorbike Sharing		30
B.1.2	Electrification of public transport fleet	S.1.4	34
B.1.3	Electric mobility promotion	S.1.2	38
TH.1.1	Automated Delivery (Tallinn)	S.1.5	126
TH.1.2	Autonomous Shuttle (Tallinn & Helsinki)	S.1.1; S.1.3	129
TH.1.3	Traffic Management Systems (Tallinn & Helsinki)	S.1.7	132
S.1.1	Autonomous shuttle buses on public roads	S.1.3; TH.1.2	186
S.1.2	EV Charging Stations Infrastructure	B.1.3	190
S.1.3	ELIN – open autonomous driving testbed	TH.1.2	194
S.1.4	Fossil fuel free Public Transport	B.1.2	198
S.1.5	HUGO- Last mile delivery concept	TH.1.1	202
S.1.6	Night delivery with clean and silent vehicles		206
S.1.7	Smart Traffic Management. Prioritized Traffic Signals	TH.1.3	210
Cluster 2: Development and integration of mobility options			
B.2.1	Orthogonal Bus Network "Nova Xarxa"		42
B.2.2	Bicibox – safe bike parking	S.2.3	46
B.2.3	Bicing - Bike sharing		50
B.2.4	CARNET – Future Mobility Research Hub	TH.3.2	54
TH.2.1	Different ride-sharing operators in place (Tallinn)		134
TH.2.2	Smart parking in the Ülemiste Smart City (Tallinn)	S.2.1	136
TH.2.3	Park&Ride (Helsinki)		138
TH.2.4	MaaS/Modal Integration: Whim App (Helsinki)	S.2.2	141
TH.2.5	Open data as an enabler for mobility innovation (Helsinki)		144
TH.2.6	Smart Ticketing (Tallinn & Helsinki)		147
TH.2.7	Collaboration with other cities (Tallinn & Helsinki)		150
S.2.1	Digitalised Business Models for Parking Spaces	TH.2.2	214
S.2.2	UbiGo / MaaS	TH.2.4	218
S.2.3	Bike Parking	B.2.2	222
Cluster 3: Redesign and network of mobility spaces			
B.3.1	Urban Mobility Plan (UMP)		58
B.3.2	Increasing pedestrian-friendly space in Barcelona		62
B.3.3	Traffic calming		66
B.3.4	Making living spaces	S.3.3	70
B.3.5	Low Emission Zone		74
TH.3.1	Fare-free public transport (Tallinn)		153
TH.3.2	City Innovation Office / Think Tank (Helsinki)	B.2.4	155
S.3.1	Re-routing cyclists during construction work		226
S.3.2	Revision of parking regulations towards active mobility		230
S.3.3	Temporary pedestrian zones - summer streets	B.3.4	234
S.3.4	Tyck Till: Stockholm's Mobile Application and e-Service for the Citizens		238
S.3.5	Urban regeneration: Hammarby Sjöstad district		242

Code = CityCode.ClusterNumber.MeasureNumber; e.g. S.1.5 = Stockholm, Cluster 1, Measure 5

CityCode: B=Barcelona; TH = Tallinn/Helsinki; S=Stockholm

Team Supervisors

Barcelona:

Carolin Zimmer

Chair of Urban Structure and Transport Planning

Tallinn and Helsinki:

Carlos Cuevas Garcia

Munich Center for Technology in Society

Stockholm:

Lukas Merkle

Daniel Schröder

Institute of Automotive Technology



City of Munich Factsheet

Country	Germany
Size	310.43 km ²
Population (Germany)	83,149,300 (September 2019) [5]
Population (Munich)	1,471,508 (July 2019)
Population Density	4,700/km ² [4]

Modal Split

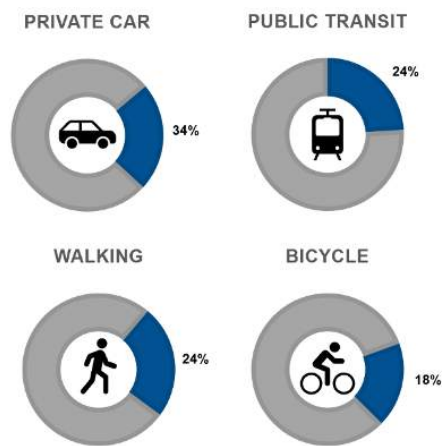


Figure 1.2: Modal Share (City of Munich) [16]

Key Analysis Area



Figure 1.1: Munich Region subdivisions [7]

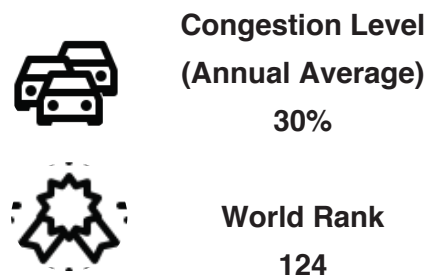


Figure 1.4. Munich public transport network map [23]

City of Munich

Munich is the capital of the land Bavaria and the third largest city in Germany, after Berlin and Hamburg. It is situated in the south-east of Germany. Compared to other German cities, Munich has the strongest economy [2] and the Munich Metropolitan Region is one of the most successful economic areas in Europe. This has a direct impact on the attractiveness of the city, especially for young professionals. Consequently, every 14th German citizen calls the Munich Metropolitan Region home [3].

Munich's population doubled about every 30 years

The vision of the city

“Only with a well-developed and, above all, smartly connected mobility will we be able to master the major challenges. [...] The backbone is, of course, the local public transport, which we do not only want to expand extensively, but also to create further tangential and ring connections in its network.” Dieter Reiter, Mayor of Munich [1].

Munich is divided into 25 boroughs or Stadtbezirke. Each of them is individually structured and represents different groups of citizens

The Region of Munich

Several smaller cities are today part of the Greater Munich Region, making up the Munich Metropolitan Region, which has a population of about 6 million people.

Demography

- Average age: 41.2
- Largest age group: 23-44 (358,055 people)
- Gender distribution: 51.3% females, 48.7% male [6]

Governance/ Political Authorities

Except for six years, SPD-majors have mostly governed Munich since 1948. This is a particularity for the city, since the rest of the federal state of Bavaria is mainly run by the CSU party, which tends to promote private vehicle policies. However, changing majorities in the city council complicate decisions on mobility changes.

Munich Metropolitan Area is generating more than 30 percent of Bavaria's total GDP [10]

Geography/ Structure of the city

Munich is a sunny city with 1.718 h of sunshine in the year of 2016, with an annual temperature average of 10,4 °C. These weather conditions contribute to high cycling and pedestrian shares. The park share is 13,3 % of the city's surface [8].

The city center is characterized by narrow and irregular streets due to the former needs of fortification. As characteristic axes, two boulevards built by the Bavarian kings in the 19th century enter the city center from the outside. The ring road that circumnavigates the city center and its configuration for bicycles is frequently in debate [9]. There are neither high mountains nor large lakes or big waters that limit the growth of the city in any direction. An outer highway circumnavigates the whole city from which several highways lead in all directions.

Economic Aspects

Inflation Rate in Germany: 1,4% (March 2020) [5]

Munich Metropolitan Area GDP: 78,810 EUR/ per capita (2017) [11]

Unemployment rate in Munich is 3.5% while it is 8.3% in Berlin and 6.3% in Hamburg. (2018) [10]

There are 90 711 companies in Munich, and 17 393 new businesses registered in 2019. The DAX-listed companies headquartered in Munich and surrounding account for approximately 300 bn Euros. While MVG is the public transport operator in Munich, there are other big mobility players in the city, such as BMW and MAN. In the area of mobility Munich start-ups are ranked among the best worldwide. Two out of ten biggest startups of Munich with the biggest rounds of financing in 2019 operate in the area of mobility: Flixbus (€507 million) and Cluno (€140 million). [12]

Taking a look at the current and future mobility investments in Munich (between 2019 and 2023), € 608 million are for the local public transport, and € 599 million for the road and bridge construction. [12]

Charging Stations: 1103 [21]

There are 131.006 university students in Munich.

City of Munich

Education and Research

The top three universities in Munich are: Ludwig-Maximilians-University (51.164 students), Technical University of Munich (40.632 students), Munich University of Applied Sciences (17.987students). [12]

The city attracts talents with its great start-up scene, several research institutes and universities with a variety of programs. Students from various backgrounds have a positive impact on the city's working landscape.

Mobility aspects

Public transport authorities: Münchner Verkehrsgesellschaft (MVG), Deutsche Bahn (DB)

Existing means of transport: Metro, Train, Tram, Bus

Passengers per year: 722 million boardings [13]: Tram (119 million), bus (193 million), metro (389 million), train/s-bahn (up to 306 million) [14]

Monthly public transport pass: differs according to the areas wanted to be travelled. Tickets for the inner zone (Zone M) are 3,30 EUR for a single journey and 55,20 EUR for monthly unlimited usage (monthly ticket). [15]

Commuting patterns/travel behaviour:

Even though the city of Munich has a developed public transportation system, 34 % of the residents prefer to travel from A to B by car. People living in the outskirts of the city have less access to public transport. While in the city 24% of people make use of public transport and 18% travel by bicycle, in the suburban areas of Munich Metropolitan region the numbers are 11% and 13% respectively. [16]

Network:

Munich has 4300 city bikes and 133 bike stations. [17]

Over 80% of the population owns at least 1 bicycle. [18]

Cycling routes: 1,200 km [19]

Car Ownership: 714 658 cars are registered (in use on the road). [12]

Electric cars: 4793 vehicles [20]

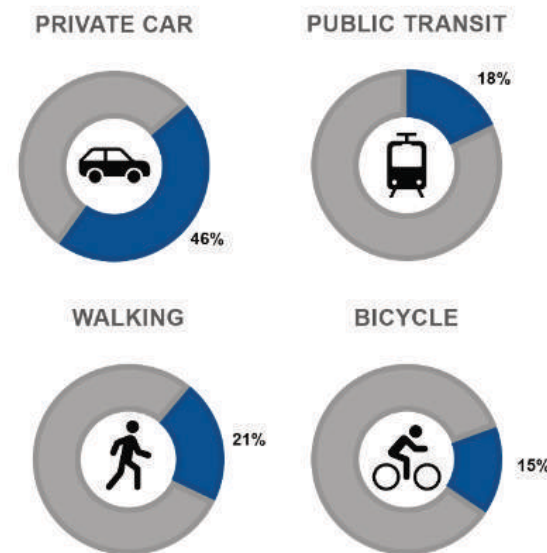


Figure 1.3: Modal Share (Munich Metropolitan Region) [16]

Parking spots: approximately 7400 [22]

Current challenges of the city

- **Continuous growth of the city & the metropolitan region:** the number of commuters increases, and the infrastructure has to compete [14].
- **City center urban freight distribution:** There exists space conflict for freight and parcel distribution in the dense city center, especially for

	Tram	Bus	Metro	Train S-bahn
Nr. of passengers/year (in million)	119	193	398	Up to 306
Nr. Of lines	17	85	8	8
Nr. Of stops	166	974	100	150
Network length (km)	79	482	95	434

Table 1.1: Public Transport Network in Munich [18]

- parking, which affects traffic flow and security, particularly cyclists and senior citizens [14].
- **Environmental pollution & noise:** the limits of NOx concentration are frequently exceeded [14]. Traffic causes a third of the CO2 emissions in Munich, which has to be reduced in order to fulfill Munich's goal to be climate neutral until 2050 [24].
- **Congestion:** the middle city ring is the most congested road in Germany [25].
- **Lack of road safety:** This is particularly relevant for vulnerable traffic participants [24].
- Reduce noise through a noise action plan [26] e.g., reduction of speed in some areas, noise barriers, etc.
- "Sauba sog i": reduce the traffic until 2025 by 80% through fostering emission-free vehicles, public transport, cyclists and pedestrians. [24]
- Vision Zero: make traffic safer in order to reduce the number of fatalities and seriously injured people to zero. [24]
- Improving the bicycle network with fast lanes: feasibility studies and public participation activities foster the discussions [27]
- Reducing car-traffic: restrictions for private vehicles in the old city center are being discussed [28]
- The overall concept for future mobility in Munich is presented [29]

Current approaches to tackle Mobility issues

- Creating and experimenting models for future mobility via EU funded projects, (e.g., Civitas Eccentric, SmarterTogether, EIT, etc., with the final goal to scale them up) or long-lasting think-thanks e.g., Inzell Initiative.
- The integration of different modes and micro-mobility solutions into the current public transport system is increasing and existing ones are continuously expanding.

Projects

European Funded projects

Projects financed by the European Commission, such as Civitas Eccentric or EIT are tackling Munich's mobility problems. The main purpose of these projects is to

City of Munich

examine to what extent new solutions and innovations can be applied to so that they could be scaled up.

Interreg Europe

This project supports regional and local governments across Europe in the development and delivery of better policy [30].

Inzell Initiative

“The Inzell Initiative, a cooperation between the State Capital of Munich and the BMW Group, brings together key players from government, industry, and science to implement forward-looking solutions for sustainable mobility in the city of Munich.” [31]

Model City 2030

A consortium of private, public, and research actors create a vision for urban mobility in 2030, including participatory formats for citizens. [32]

Civitas Eccentric

The European Model Project implements integrated and innovative measures that combine housing and mobility. For example, the Domagkpark, a development area in the north of Munich, serves as a living lab for citizen participation and electric and shared mobility. [33]

City2Share

The pilot project tests sustainable urban e-mobility, shared spaces and participation processes in an existing neighborhood. It includes public and private actors, as well as research institutions and universities [34].

City SWOT ANALYSIS

Strengths

- Innovative startup scene of Munich
- Strong economics
- Strong presence of automotive industry
- High capacity of research and innovations
- Geography and weather

Weakness

- High price of public transport tickets
- Reluctance to data sharing and open data
- Last overall plan for changing mobility is from 2006 – lack of concrete catalogue of measures that transform mobility on large scale

Opportunities

- Scale up the measurements which are successful in EU Projects
- Encouragement of the automotive field to get involved in finding solutions
- Financial possibilities
- M Cube project as an accelerator to bring different stakeholders

Threats

- Continuous growth of the city
- Urbanization and continuing car dependence
- Too strong industrial lobby, so that companies' interest sometimes prevail
- High congestion rate's effects on the city and people

Barcelona Table of Contents

About Us	21
City of Barcelona Factsheet	22
City Overview Barcelona	24
City SWOT ANALYSIS	29
Measures	30
Cluster 1: Electrification and automation of traffic systems	30
B.1.1 MotoSharing	30
B.1.2 Electrification of public transport fleet	34
B.1.3 Electric Mobility Promotion	38
Cluster 2: Developing and integration of mobility options	42
B.2.1 Orthogonal Bus Network “Nova Xarxa”	42
B.2.2 Bicibox – safe bike parking	46
B.2.3 Bicing (Bike-sharing system)	50
B.2.4 CARNET – Future Mobility Research Hub	54
Cluster 3: Redesign and network of mobility spaces	58
B.3.1 Urban Mobility Plan (UMP)	58
B.3.2 Increasing pedestrian-friendly space in Barcelona	62
B.3.3 Traffic Calming	66
B.3.4 Making Living Spaces	70
B.3.5 Low Emission Zone	74
Case Studies	78
Assessing sustainable mobility (via Indicators)	78
Superblocks	84
Air pollution mitigation measures by Barcelona	90
Shared mobility services in Barcelona	96
Conclusion: Reconfiguring Mobility via Regulation	102



About Us



DOMINIK GREIDERER
Master's Program
Environmental Engineering at
Technical University of Munich



MANUEL JUNG
Master's Program
Science and Technology
Studies at MCTS



ISHEEKA DASGUPTA
Master's Program
Power Engineering at
Technical University of Munich



HEDAYAT OMAR
Master's Program
Environmental Engineering at
Technical University of Munich

City of Barcelona Factsheet

Country	Spain
Size	102.2 km2
Population (Spain)	46,750,928
Population (Barcelona)	1,628,936 (July 2019)
Population Density	15,945 inhabitants/km2

Modal Split

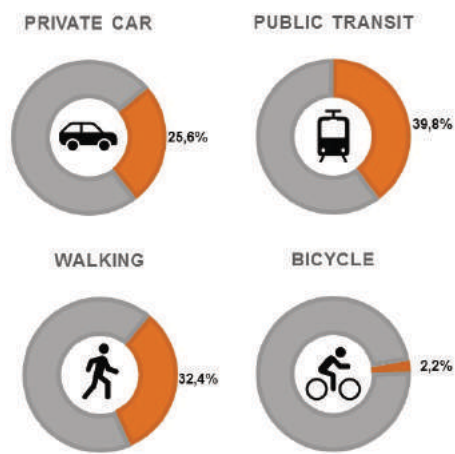


Figure 2.1: Modal Share (City of Barcelona)

Key Analysis Area



Figure 2.2: Barcelona Region subdivisions

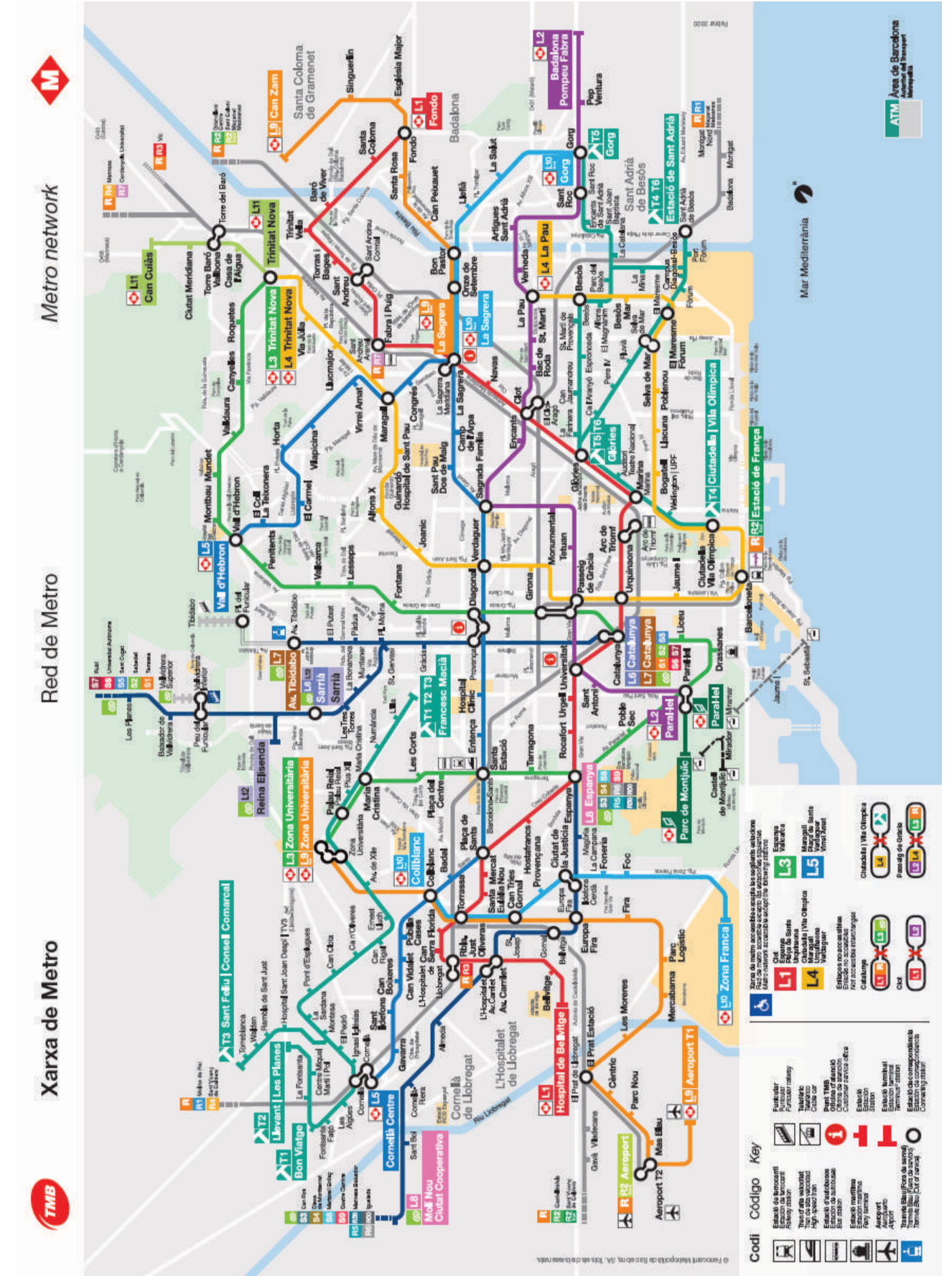
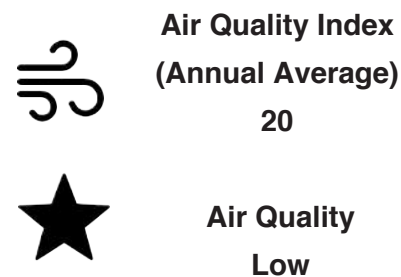
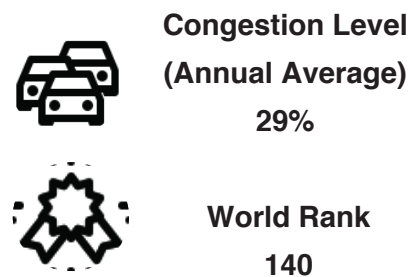


Figure 2.3: Public transport network in Barcelona (without buses) 2020 [19]

City Overview Barcelona

Barcelona is located in the northeast of Spain (~120km south of France) at the Mediterranean Sea and is the capital of Catalonia.

The old town of Barcelona “Ciutat Vella” is located directly at the sea. Here is also the center of the city with tourist attractions as La Rambla, Barri Gòtic, and the Picasso museum. Along the coast to the south lies the port, with a large industrial area and to the north are the cities’ beaches.

20% of the bike rides with the bike-sharing “Bicing”

Public transport 11,35 Euro for 10 rides

Walking share: 32,4%

The vision of the city

“We want a city with a more sustainable mobility model and a smaller carbon footprint, and for this change to bring with it a transformation of the public space where people are the protagonists.” Climate Emergency Declaration of the Municipality Barcelona [1]

“Barcelona is changing the mobility and transit paradigm towards healthier, more sustainable and safer mobility. The city has an extensive transport network that guarantees mobility to everyone in an equal, efficient and safe way, and in which public transport, cycling and traveling on foot are the preferred means of transport and the most used by the over five million people who travel around the city each day.” [138]

Demography

- Age structure [9]:
- 0-14: 12,6%
- 15-64: 65,9%
- 65+: 21,5%
- Gender distribution: 52,6% female, 47,4% male [137]

Geography and city structure

Barcelona is located in the east of Spain about 120 km from the French border. The Mediterranean city is embedded between mountains in the northwest and the sea in the southeast. The weather in Barcelona is warm and dry with 2718 h of sun per year and an annual average temperature of 16,3°C[6]. [7]. The old town of Barcelona “Ciutat Vella” is located directly at the sea. Here is also the centre of the city with tourist attractions as La Rambla, Barri Gòtic, and the Picasso museum.

Along the coast to the south lies the port, with a large industrial area and to the north are the cities’ beaches. In “Eixample”, today’s center of the urban area one encounters the characteristic linear city structure which was created by the extension of the old town in the second half of the 19th century [8]. Especially significant in the cityscape are the two major streets Avinguda Diagonal and Gran Via, which both extend straight-line through the whole city area and cross in the Plaça de Les Glòries Catalanes. The city is surrounded by highways, going along the sea and the mountains and from the borders of the city in all directions into the inland of Spain.

Subdivision

Barcelona consists of ten districts of which Eixample (265.910 inhabitants) and Sant Martí (238.315) are the most populated ones [137]. Most of the observations for this report were conducted in these districts.

Economic aspects

Barcelona is one of the wealthiest regions in Southern Europe, with a GDP per capita amounting to 43,700 Euros. Barcelona accounts for more than a quarter of Spain's GDP, with 69,420.3 million Euros in 2017. [9].

The city has a highly diversified economic structure. Barcelona has easy access to very dynamic large markets: the EU common market, which provides access to 510 million people. It also forms part of the axis of the Mediterranean corridor, a Trans-European Network for transporting goods. [9] As a port city, Barcelona has a long mercantile history. Textiles are of traditional importance, and one of the reasons the city is striving to become a major fashion center. The city has also relied on manufacturing as Spain's leading commercial and industrial center, but that industry has since been overtaken by the service sector with 88% percent of people being employed in tourist-based economy. [10] Apart from being a major tourist destination, Barcelona is also a significant site for conferences, exhibitions, and trade fairs.

The major companies headquartered in areas around Barcelona are Aena, SEAT, Nissan Motors, Caixabank. Barcelona also offers a vibrant and healthy startup landscape with up to 1,500 startups, of which 60 % are involved in 4.0 related technologies. [11]

369 million bus passengers/year

390 million metro passengers/year

City Overview Barcelona

Education

Barcelona has eight universities with almost 200.000 students in total:

University of Barcelona (UB), Autonomous University of Barcelona (UAB), Polytechnic University of Catalonia (UPC), Pompeu Fabra University, Ramon Llull University (URL, including ESADE), Open University of Catalonia (UOC), International University of Catalonia (UIC), Abat Oliba University (CEU UAO) [139].

Mobility Aspects

The Autoritat del Transport Metropolità (ATM) is the public transport authority of the mobility network of the metropolitan area Barcelona and functions as a consortium for the public transport services: The Transports Metropolitans de Barcelona (TMB) manages the metro, the buses and the funicular and cable car on Montjuïc; Ferrocarrils de la Generalitat de Catalunya (FGC) operates rail and other public transport in Catalonia; Renfe operates the Rodalies service (comparable to Munich S-Bahn); Tram operates the tramway. Nitbus is the operator of the night buses. The

public transport counted 985,1 million in 2017 [12]. The ticket price is 40 Euro for a monthly ticket and 11,35 Euro for ten travels (in Munich: 55,20 Euro for a monthly ticket in the standard area; 14 Euro for 5 regular rides [13]) [14].

The AMB (Àrea Metropolitana de Barcelona) is the metropolitan authority and is dedicated to transport and infrastructure planning in all municipalities of the region. One of their tasks is the promotion of sustainable public and private transport.

The municipality of Barcelona runs the bike-sharing service Bicing, which counted 13.275.267 rides in 2017 while Bicing accounts for 20% of the total bike rides in the city. Further, the public-private platform LIVE coordinates organizations engaged in sustainable mobility (electric and natural gas). The number of electric charging points for cars amounted 503 charging points in 2019 and the municipality is planning on further installations of especially underground chargers and fast chargers. [15, 16] [17] [18]

Current Challenges of the City

In 2020 safety concern has become the most prominent issue among people with 17.1 % of a yearly survey of 6000 citizens ranking it as their primary concern [20]. Offence rates are as on average 15 per 100 people in Barcelona [21] when compared to 6.7 per hundred people in Munich [22]. Nonviolent robberies are a common occurrence, which entails safety modifications in bike-sharing and bike usage.

Being the densest populated city in Europe, Barcelona faces significant space constraints with a high influx of tourists and employees who come to work from outside the city. The geographic features that limit the city's expansion put pressure on housing and accommodating a growing population, which continues to be a primary challenge in Barcelona [20].

Density is a huge advantage for public transport networks and a high fraction of walking in the modal split, but it also increases the number of vehicles on the street. As a result, 70 % of the population is exposed to poor air quality and a NOx concentration above WHO limits of 40 µg/m3. 98 % of the population is exposed to 20 to 40 µg/m3 of PM10 emissions [23]. Simultaneously, half of the population is exposed to noise beyond 65dB. Barcelona's dense structure has resulted in little space dedicated to green and public open space which causes high anthropogenic heat. For instance, the green space per capita in the large district Eixample amounts to 2,7m² while the WHO recommends 9m². [24] [25]

Being the 4th most popular destination in Europe, with 75% of tourists arriving via flight [26], also accounts for

the city's high level of noise and the amount of carbon dioxide emissions in the city. There have been organised a vast amount of public and private resources designed for tourists which positively affect sharing space and local resources. While in 2018 there have been documented 17.12 million tourist bed-nights in Barcelona, this years' number has increased to 19.29 million bed-nights in an area approximately one third of Munich. [27],

	Tram	Bus	Metro	Rodalies Renfe	FGC (trains)
Passengers/year (in million)	28	369	390.4	113.4	84.3
Lines	6	98	8	6	4
Stations	56	2541	156	122	80
Network length (km)	29.1	833.17	119	535	150

Table 2.1: Passenger and infrastructure data of public transport in Barcelona (2017) [18]

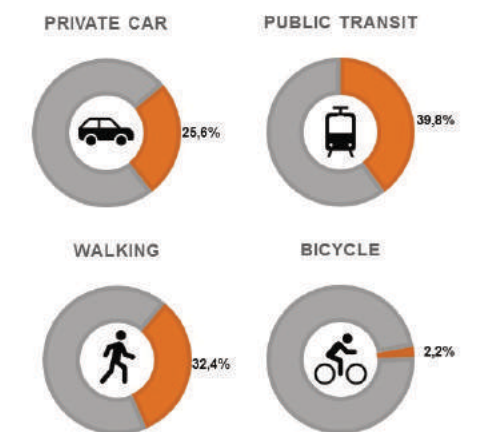


Figure 2.4: Modal Split of Barcelona based on data from 2017 [18]

City Overview Barcelona

Current projects approach the Challenges

Electric mobility

The Electric Vehicle Masterplan from 2016 and the Electric mobility strategy from 2018 push measures for the electrification of traffic. The public-private platform LIVE (Logistics for the implementation of Electric vehicle), for instance, brings actors of sustainable mobility together and promotes electric mobility (see B.1.2, B.1.3) [28] [29].

Urban Mobility Plan 2019-2024

Overarching guideline to transform infrastructure and urban spaces towards more sustainable mobility; based on an extensive participatory process (see B.3.1).

Climate Emergency Declaration

The municipality of Barcelona declared the Climate Emergency at the 15th of January 2020, which fosters the change of seven models of the status quo: urban model, mobility and infrastructure model, energy model, economic model, consumption and waste model, food model, cultural and educational model. The declaration claims the collaboration of governmental, public, and private actors and of the citizens. It accelerates measures towards a more sustainable city with 563,3 million euros (see B.3.3) [1].

Climate Plan 2018-2030 (see B.3.3)

Mobility Pact:

A consortium of different public and private actors, associations and organization (see B.3.1)

Online Participation Platform Decidim (see B.3.1)

Low emission zone (see B.3.5)

GrowSmarter

The Lighthouse Project of the European Innovation Partnership Smart Cities and Communities includes sustainable urban mobility measure like the distribution of e-cargo bike for freight [30]

Catalonia Living Lab

A comprehensive testbed for automated and connected driving in the region of Catalonia [31]

AMB

8 Metropolitan policies to promote cycling (see B.2.2, B.2.3)

EIT Urban Mobility

hosting the EIT Urban Mobility headquarter, Barcelona became the European capital for urban mobility [32]

Bicing widespread bike-sharing(see B.2.3)

CARNET: future mobility research hub (see B.2.4)

City SWOT ANALYSIS

Strengths

- Good weather conditions
- Density and compactness for public transport
- Transparency of the planning methods
- High walking modal share

Weakness

- High unemployment rate
- Limited space through geographical context
- Structure of mobility management organization
- Slope of city

Opportunities

- Very attractive city
- Political consensus on the need to reduce influence of private vehicles on city [33]
- EIT headquarter
- Large parts of the city were densely constructed before the spread of automobile

Threats

- Strong car manufacturer relation
- Masses of tourists
- Commuters in the metropolitan area
- Gentrification due to vaporization of public space

B.1.1 MotoSharing

The electric scooter rental for short periods is called motosharing in Barcelona. It is a service that can be used independently, within the coverage area of each company. Users can take and leave the motorcycle anywhere in the city so that other users can access the vehicle. It is a flexible urban transportation medium to manage short and medium distances in Barcelona. Currently, there are eight companies in Barcelona offering motorbike sharing services. All companies provide fully electric and emission-free vehicles.

Problem being solved

Motorbikes, defined as a means of transport with a small volume and high level of use, have advantages when moving in Barcelona with a natural upward slope. The flexibility of use, low consumption, and little space it takes up on the public highway, both when moving and when parked, are some of the advantages it presents. The companies which provide the motosharing services in Barcelona are all-electric motorbikes, which significantly reduces air pollution and promotes electric vehicles.

Stakeholders

The main stakeholders of motosharing services in Barcelona are the companies mentioned above. In order to provide the services, the city council is preparing regulation and legal policies. Although there is a large number of private motorbikes in Barcelona, many people are using the sharing services. As it is a dense city with lots of congestion, using motorbikes has been adapted very well and is being used for daily short and medium trips.

Expected result (vs real result)

Currently, Barcelona is not ready to take full advantage of these new systems but is rather generating prejudice (negative impacts from the use of public space). Therefore, a clear regulatory framework has been established on Feb 2020 to enable operators to manage systems safely and stable which allows the City Council to define the uses and spaces determined in the public space and minimize the negative impacts. [34]

Challenges of implementation:

The high density of the vehicles poses a problem, since they are not always parked in the authorized areas. Although parking is allowed on the pavement (only when indicated by a sign and when the width of the pavement is no less than 3 meters), the vehicles are not always parked correctly, which impedes pedestrians and people with reduced mobility or functional diversity. [34] Another negative aspect to be resolved is the accident rate which has become one of the most important municipal challenges regarding road safety.



Figure 2.5: Scooters from 3 different companies in the city (10)

The motosharing service started around 2015 in Barcelona, and they are increasing annually.

The legal framework which provides the license for almost 7000 users has been established recently. The licenses are valid for three years with the option to be extended for one more year. The city is expected to implement these licenses from Feb 2020. The city is planning to implement more licenses in the future.

Financial Aspects

As there are different companies offering motosharing services in Barcelona, the fees may vary, however, users are generally charged with a subscription fee or may register for free. The companies charge between 0.15 euro/min to 0.26 euro/min and there are some monthly rates that users can pay to use the services for one hundred minutes a week or a month.



Figure 2.6: Motosharing scooters Parking slot (own photograph)

Technical Aspects

All vehicles are designed with rechargeable batteries and two helmets. All motosharing vehicles are electric and connected, combining performance and design to allow the user to move at the pace of the city. They are practical, economical, non-polluting and fast

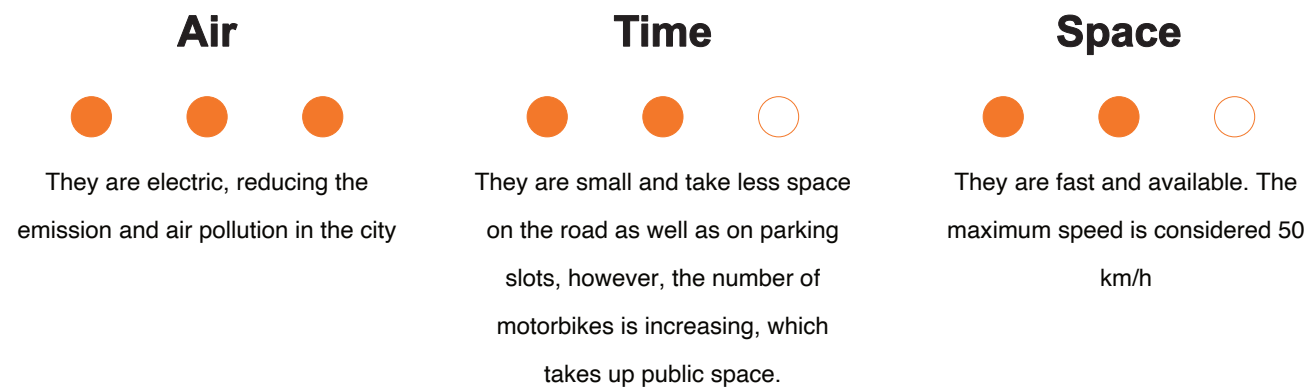


Figure2.7: Motosharing parking infrastructure on pavement [34]

Legal Aspects

The following provides an overview of the legal guidelines the city council has established for motosharing services. There have been published almost 7,000 licenses for the companies:

Respect the prohibition on the alienation, assignment, or transfer of licenses.

Provide the City Council with data regarding the geolocation of all vehicles in real-time during the 24h of

the day in an accessible format, in any case respecting the regulations on the protection of personal data.

Properly relocate those vehicles that are found to be in breach of their obligations parking in the public domain within 24 hours.

Guarantee the anchorage of bicycles in the parking lots installed by the City Council in the public space in an inverted "U" shape for this purpose.

Do not concentrate more than 50% of the fleet in the

central area for more than two hours consecutive times. [34]

Applicability to Munich

As Munich is a congested city like Barcelona, implementing the motosharing concept could be an excellent measure to get faster from one point to another. According to INRIX Traffic Scorecard 2018, there is a congestion of 140h per person/year in Munich and 147h per person/year in Barcelona. [35]

Motorbikes are small-sized and considered a clean vehicle since they are an electric and very flexible urban transportation medium to overcome short and medium distances. Since 2017, the motosharing company Emmy offers its services in Munich. Since then, the electric rental scooters of the Berlin start-up can be seen everywhere in the city center and the suburban areas. In Munich, Emmy works together with Green-City AG, which supplies the scooters with green electricity. In the meantime, the fleet has grown from 50 scooters to 400, with 15,000 registered users. [36]

B.1.2 Electrification of Public Transport Fleet

The Electric Vehicle Master Plan 2018-2024 of Barcelona [37] aims to pioneer electric mobility and is progressing by setting an example in the public fleet. The strategy specifically targets the buses of Transports Metropolitans de Barcelona (TMB), aiming to have 25 fully electric vehicles by 2020 and 100 by 2024. It is expected that by that time, electric bus technology and its testing will have evolved sufficiently to allow a commitment to purchasing only zero-emission buses from 2025 onwards to reach a 100% electric fleet of buses in 2040.

The metropolitan commitment to clean mobility is proposed to reduce the taxis and vehicles serving in metropolitan cities to less than 50% diesel-only vehicles by 2020. By 2025 diesel-only vehicles will not exceed 33%. As of 2019 no new taxi licenses are issued for diesel vehicles, whereas from 2024 onwards, only electric taxis can apply for a taxi license. Apart from this, the reduction of empty journeys, vehicle emissions, and the integration of private digital taxi platforms into one unique management system are Barcelona's future goals [38].

Problem being solved

The City Council of Barcelona pursues the goal to make electric vehicles the preferred mode of mobility for the motorized individual and collective, public and private. By 2024, 80% of the municipal fleet should be electric - as well as 100 buses and 800 taxis.

Stakeholders

The decision and targets for public buses are set at the metropolitan level by the AMB and TMB for fleet renewal and rate of procuring, testing and, maintaining new vehicles. The decisions regarding taxi regulations are undertaken by the AMB, Metropolitan Taxi Institute and Local Councils Agents and taxi companies.

Expected result (vs real result)

Currently, the following projects are being engaged by TMB for electric buses and their infrastructure: I-CVUE; ZeEUS; The elliptical; Electric minibus; EBSF-2; Assured and Network C40 Cities.

Currently, the TMB bus fleet has 9 electric buses and 309 hybrid buses out of 1067 operating buses. In 2020, 23 new electric articulated buses (whose delivery is expected at the beginning of 2021) were ordered which will be used to continue the transformation of the main city line H16 (Pg. Zona Franca – Fòrum / Campus Besòs) into the first TMB line entirely operated via zero emission vehicles.

Up to 26 taxi drivers have opted for an electric vehicle currently. From 2007 to 2018, the fleet of environmentally efficient vehicles (hybrids or gas) has increased from 1% to more than 43% as shown in Figure 2.9. In order to reduce the wasteful distances taxi drivers make to find customers, the number of taxi stops has increased from 180 to 300 throughout the city from 2012 to 2020 [40]. As of 2020, there exists only 2 fast chargers dedicated for taxi drivers.

Challenges of implementation

Apart from the extensive procedure to test electric bus technology, the challenges to renew the public bus fleet

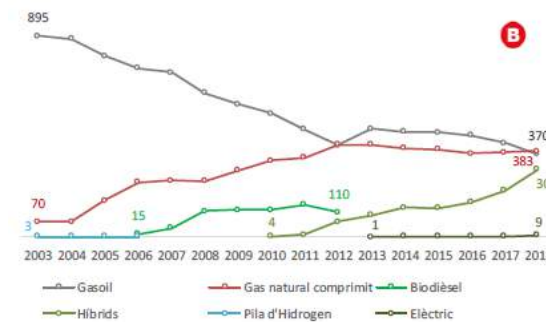


Figure 2.8: Barcelona public bus fleet evolution by fuel type [39]

are mainly economic. Another challenge poses the up gradation to new fast varying technologies with old labor force. Operational barriers were the most prominent challenges with technological standards insufficient to ensure interoperability. However, according to TMB representatives, adaptability and well-defined training programs along with real time technology-based triggers for improved driving behavior in electric buses helped promote a positive shift.

There were no particular challenges regarding battery safety when testing electric buses through ZeUs and Solaris projects and reduced maintenance was a welcomed change.

However, there is great resistance in converting taxi fleets to electric modes. The average age of the taxis is approximately 5 years and with competition from private groups like Cabify, the recharging model with shifts does not yet prove to be economically-

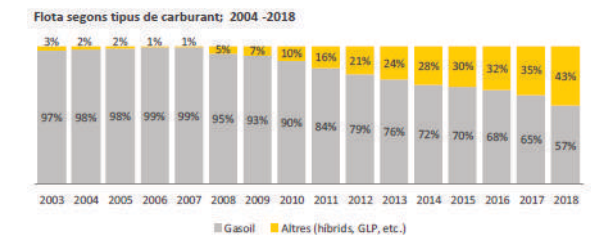


Figure 2.9: Barcelona Taxi fleet evolution by fuel type [39]

Financial Aspects

TMB's growing investment in its fleet was 30.6 million Euros in 2016, 38.2 million Euros in 2017 and 42.3 million Euros in 2018 of which a major part is financed by the European Investment Bank, ATM, AMB, and Barcelona City Council.

In 2019, TMB received a grant of 73.5 million Euros loan from EIB to cover the expenses for a bus fleet renewal with a total sum of 145.7 million Euros. The money will be used to buy 254 new buses. 116 of them will be electric buses. The new vehicles will be delivered according to a timeline that will be scheduled in 2021.

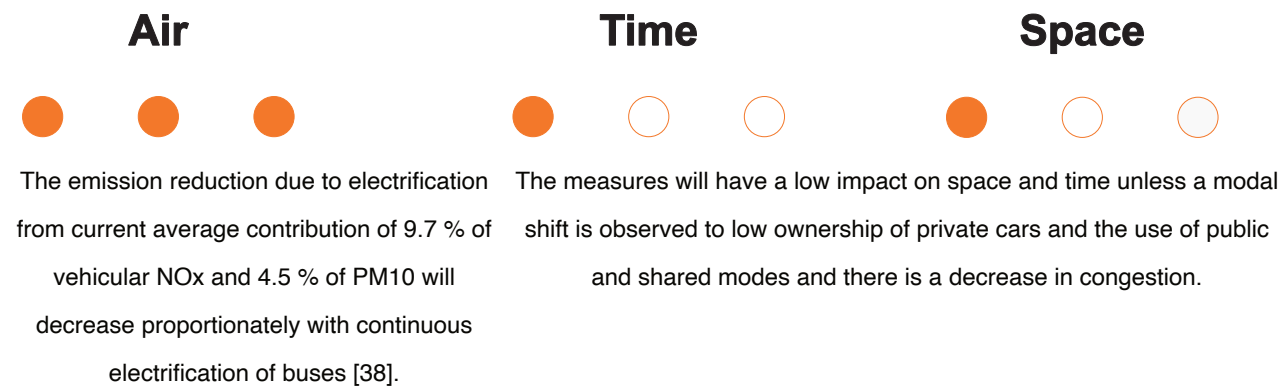


Figure 2.10: Electric bus with opportunity charging in Barcelona [41]

-competitive except when considering freelance drivers who have the option of overnight charging. [37]

Duration

The testing period for the first 2 electric buses started in 2014 to which 4 more Irizar ie buses and 2 Solaris buses were added in 2019. Both measures are an ongoing process which shall continue till new vehicles are being deployed and are in conjunction with the Barcelona Climatic Plan.

The plan to digitize the taxi fleet and create an app to harmonize taxi movements shall start in 2022.

Technical Aspects

After implementing particulate filtering systems and gradually adding more sustainable options to the fleet since 2012 (as shown in Figure 2.8), the trend is towards a completely electric fleet.

For that reason, numerous tests have been carried out under the European Union's ZeEUS project involving two different technologies: night charging and opportunity charging.

During the test period with 2 Irizar buses(352 kWh), it was found that the night charging model does not yet

meet the requirements for operating in a city like Barcelona especially during summers with the use of air conditioner , as the batteries do not last throughout the 16 hr service hours.

With regard to the opportunity of charging at bus terminals, tests with 2 Solaris (125 kWh) revealed that this model does not meet the operational needs of Barcelona's bus routes with an additional depot charge of 3 hours. It is done via a roof-mounted pantograph placed above the first axle with fast charging of up to 400 kW. This is the opted model for operation for electric the buses on the H16 route, which already has an electric charging point at the terminals. Comparisons between overnight and opportunity charging show that the infrastructure required for overnight systems is 40% cheaper than the one required for opportunity charging schemes.

Applicability to Munich

MVG is planning on having at least 500 electric buses by 2030. Around 70% of SWM buses are currently Euro 5, EEV, or Euro 6 vehicles. All city buses in Munich have soot filters, and all newer buses also have nitrogen oxide catalyts [42].The procurement and testing of electric buses in Munich are already underway and are comparable with the challenges and success of electric buses in Barcelona. Regarding the taxi sector, however, taxi meters and collaboration of all companies to a single platform could help reduce kilometers traveled. This data can also be used to indicate the customers sustainability choice and to make sustainability part of the competition.

B.1.3 Electric Mobility Promotion

LIVE (Logistics for the implementation of Electric vehicle) Platform is an open public-private platform operating since 2012 that promotes the use of electric vehicles in Catalonia and is one of the main measures to encourage e-mobility in the Electric Vehicle Master Plan [37] of Barcelona. A direct or indirect tangible result of which has been the following incentives:

- Free recharging on the 550 recharge points on the public network, free parking in green / blue area for electric vehicle users (depending on residential status or specific timings).
- An integrated app Smou to help digitize the process of reserving, parking and payment via QR code.
- 75% discount on Tax on Mechanical Traction Vehicles plus other State aids for purchasing zero-emission vehicles.

Problem being solved

According to the Electric vehicle master plan, Barcelona aims to increase the number of electric private cars and motorcycles both to a total of 24,000 in 2040 from 3760 in 2018 [37]. This amounts to 4% and 8% of the fleet of private cars and motorcycles, respectively.

Stakeholders

The LIVE platform is a regional platform promoted by the government of Spain, Catalonia, and has major managing partners like Barcelona City Council, AMB, along with private companies like Nissan, Seat, Volkswagen, Endesa and Siemens.

The most influential parties affecting the decisions are the Barcelona City Council, which is responsible for the strategic guidelines of the Electric vehicle master plan, AMB, Endolla (under the City council) for the charging infrastructure, and B:SM for the parking infrastructure.

Expected result (vs real result)

The LIVE Platform has managed to gather and coordinate the momentum of Barcelona with other public administrations and with important companies of the sector, achieving synergies that enhance the municipal efforts. LIVE has become an effective governance system to provide a centralized framework to develop electromobility. Its achievements include the following

1. Communication:
 - Web and Social Networks,
 - TV Campaign ,+1800 followers on Twitter ,
 - Quarterly Newsletters, Events and Publications
 - Brochure map of charging points
 - Expoelectric , Ecofleet 2018 Automobile Fair
2. Increasing the number of private fleets using electric vehicles: LIVE is involved in identification and support (TCO calculation, Vehicle tests, Mentorship) to both private vehicles and fleet owners.
3. Offering support and advice on all the strategic areas for the creation, management and growth of sustainable mobility companies.
4. Enabling cooperation in the progressive elec-

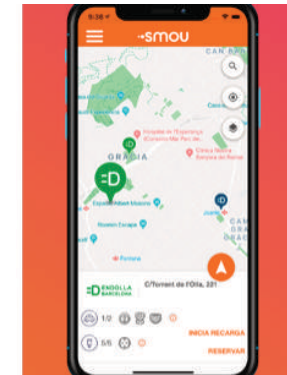


Figure 2.11: Smou app for accessing free charging Network of Barcelona [43]

trification of the H16 bus line.

5. Expanding charging network: Currently, the network is based on 504 slow chargers with 17 fast charging points which results in 95% of the citizens having a free fast charging point within 2 km and / or 6 minutes. [37]

6. Providing information on the steps to create, administer and amend planning processes, rules and regulations, including in zoning, parking, and permitting.

Challenges of implementation

Managing a balance between the confronted interests that some companies and municipalities has been an expected challenge

Charging infrastructure:

- According to AMB representatives, charging should be done overnight, however, despite helping the promotion of electric vehicles, free charging has also led to misuse and irresponsible usage.



Figure 2.12: Free parking site for electric vehicles in public charging network of Barcelona [44]

Duration

The LIVE platform was launched in 2011 and has been expanding since to greater areas of Catalonia and other alternative low emission vehicles. The process of providing infrastructure to manage the electric vehicle demand will remain an ongoing process.

The LIVE Platform engages 12 Director members who provide a significant amount of financial support, with a contribution of 20.000€ each year. Together with contributions of collaboration members, the platform reaches an approximate final budget of 260.000€ per year.

Air



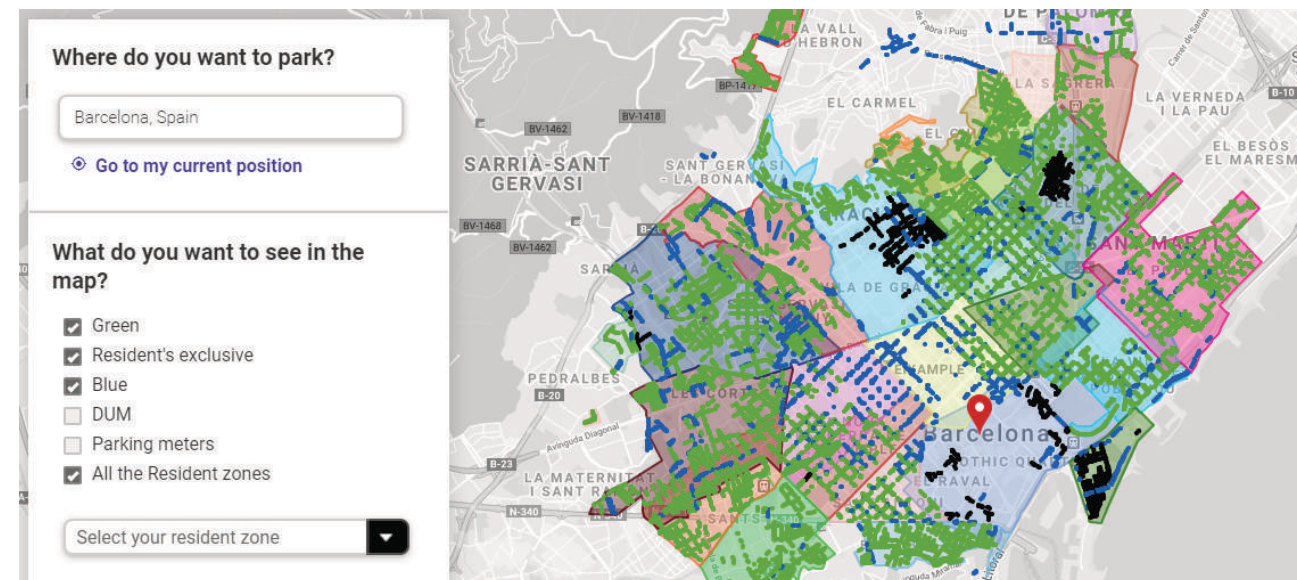
The emission reduction due to electrification from the current average contribution of 34 % of vehicular NOx and 39 % of PM10 will decrease proportionately with the progressive electrification of private cars [38].

Time



The measures will have a relatively lower impact on the space and time and current scenarios of congestion and traffic will continue to exist even if there is a complete replacement with electric vehicles. Hence the focus primarily lies on active modes of mobility. However, some reduction in the number of cars can be expected if parking spaces are indicated as taken and the user then prefers a different mode.

Space



- Due to the rapidly changing industry and the presence of different providers there have been complications with the spare parts and the up-gradation of software and hardware facilities of the recharging points
- The electricity of the Spanish mix is not yet green unlike Munich's and hence is a challenge for the overall sustainability of the electric vehicles.

The Total Cost of ownership is still higher for conventional vehicles than for new electric vehicles, which impedes the customers' buying capacity.[37]

Financial Aspects

The LIVE Platform engages 12 Director members who provide a significant amount of financial support, with a contribution of 20.000€ each year. Together with contributions of collaboration members, the platform reaches an approximate final budget of 260.000€ per year.

Technical Aspects

Users can charge their vehicles with more than 500 charging stations located on public roads and in B: SM car parks, checking their availability in real-time.

Charging infrastructure - The stations are mostly slow charging and have the most common electric vehicle connectors: Schuko, Mennekes, CHAdeMO and Combo 2. All the charging stations support Mennekes and Schuko plugs. Both types of sockets can give up to 16A (3.6 KW). Charging points are located and designed to be supplied by the railway power grid that have energy efficiency advantages compared to charging points supplied by the public distribution grid. Parking: Smou also allows all users automatic entry into the B: SM car parks with QR codes. The parking barrier is automatically opened through a license plate reader. Users pay for their stay via phone when leaving the car park. Recharging stations can be reserved 20 minutes in advance, selecting the recharging station on the map as shown in Figure 2.11, 2.12 and Figure 2.13. There has been great success with reservation of parking place.

Applicability to Munich

A common platform to create public awareness should be in place to identify and encourage all future vehicle owners to convert to electric vehicles. Given a similar car industry and economy relationship, better collaboration, project management and knowledge sharing to upcoming businesses can be possible in Munich as is in Barcelona

Munich has 535 charging stations provided by SWM with 22 kW at each station. Making the service free is a debatable proposition since they are fast chargers and responsible usage can be assured while providing fast charging and reliable service.

Positive discrimination for parking of electric vehicles can be transferred to Munich for furthering usage of electric vehicles.

Integrated apps like Smou can be used to support e-mobility and digitization. The reservation feature successfully reduces recharge anxiety and vehicle kilometers traveled looking for a charging point and can be considered for MVG more.

B.2.1 Orthogonal Bus Network “Nova Xarxa”

The goal of the project “Nova Xarxa de Bus de Barcelona” was to restructure the bus network of Barcelona from the historical grown one into an orthogonal network. The restructuring followed the simple principle of traversing Barcelona's urban area with (8) horizontal and (17) vertical high-performance bus lines, supplemented by (3) diagonal ones (see Figure 2.14) [46]. On the one hand, this scheme fits the urban structure of Barcelona, on the other hand it is consistent with the concept of Superblocks (see Figure 2.15) [47]. A great success was the increase in efficiency of the system and the number of customers, which is in line with the strategy of more sustainable transport. [48]

Problem being solved

The historical grown bus network of Barcelona was inefficient, since the lines were often overlapping, especially in the central places of the city. Thus, resources were instead of ensuring that public transport services are improved. [48] [47]

One way particularly bus service plays a major role [47]. Therefore, the bus network in Barcelona has therefore been transformed into a more transparent and efficient system.

Stakeholders

The project was part of Barcelona's Urban Mobility Plan from 2013 to 2018. As such, the main stakeholders were the City of Barcelona, the Agència d'Ecologia Urbana de Barcelona (a public consortium consisting of the City Council of Barcelona, the Municipal Council and Metropolitan Area of Barcelona and the Barcelona Provincial Council) and in this case especially TMB, the local public transport operator (for more details see Measure B.3.1 Urban Mobility Plan (UMP). [50] [51]

To inform and exchange ideas with the citizens the Barcelona City Council and TMB organized a broad information and participation process for the “Nova Xarxa”

project. They conducted several citizen initiatives (neighborhood mobility committees and citizens councils from each district, Mobility Pact, Senior Citizens' Council), and organized open information and consultation sessions as well as information events as school and bus garages, to create a common consensus. [48]

Expected result (vs real result)

The new orthogonal bus network consists of 28 new lines, so called “high performance routes” and covers a larger territory with the same resources as the old network. The savings in resources are used to generate . In addition, the distribution of bus lines and stations is now more homogeneous, which results in 95% of Barcelona's population enjoying a more efficient bus service less than 300 meters from their homes. [48]

Local planners of the network [52] point out, that the new structure of the bus network improves fair and equal accessibility of the public transport among citizens, regardless if they live in the inner city or at the outskirts.

Such a structure is unusual for public transport in cities since traffic planners have so far assumed that every

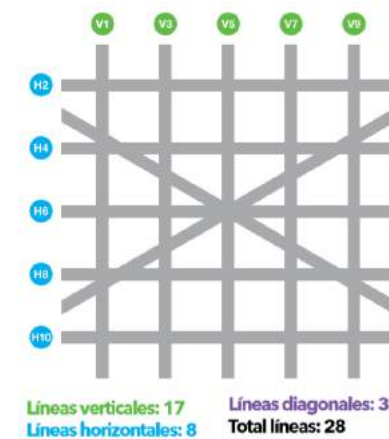


Figure 2.14: Scheme of the orthogonal



Figure 2.15: grid of major streets considering the super block concept [47]

change to reach the destination significantly reduces the attractiveness of the network for the users. However, a recent study from 2017 [53] has now shown that the used structure has increased the attractiveness of the bus network in Barcelona. The reasons for that are, among others, that there is an easier understanding of the network and that 90% of journeys can be done with only one change. [48]




Overall, these effects lead to an increased use of the bus network by citizens and to higher customer satisfaction [48] [53].

Challenges of implementation:

The challenge of this measure was that a significant part of the city's bus network had to be restructured. In order to make such a far-reaching measure possible, without completely suspending bus services for a long time, it was necessary to proceed carefully and gradually.

Technical Aspects

The project of restructuring the bus network was more a planning measure than a technological one. Nevertheless, the new structure helps to implement technical aspects, such as the prioritization of public transport, due to its straight routes [48] [52].

Air	Time	Space
		
<p>It is hoped that the increase in attraction of the public transport leads to a decrease of private vehicle use in the city. In this way the traffic volumes, congestion and parking can be reduced.</p>	<p>The required time is a main disadvantage of public transport in comparison to private one. With the new structure of the bus network fast accessibility of stations for all citizens is ensured.</p>	<p>The use of public transport, which is fostered by improving its attractiveness, is generally saving space because less vehicles and no parking lots are necessary for the same trips.</p>

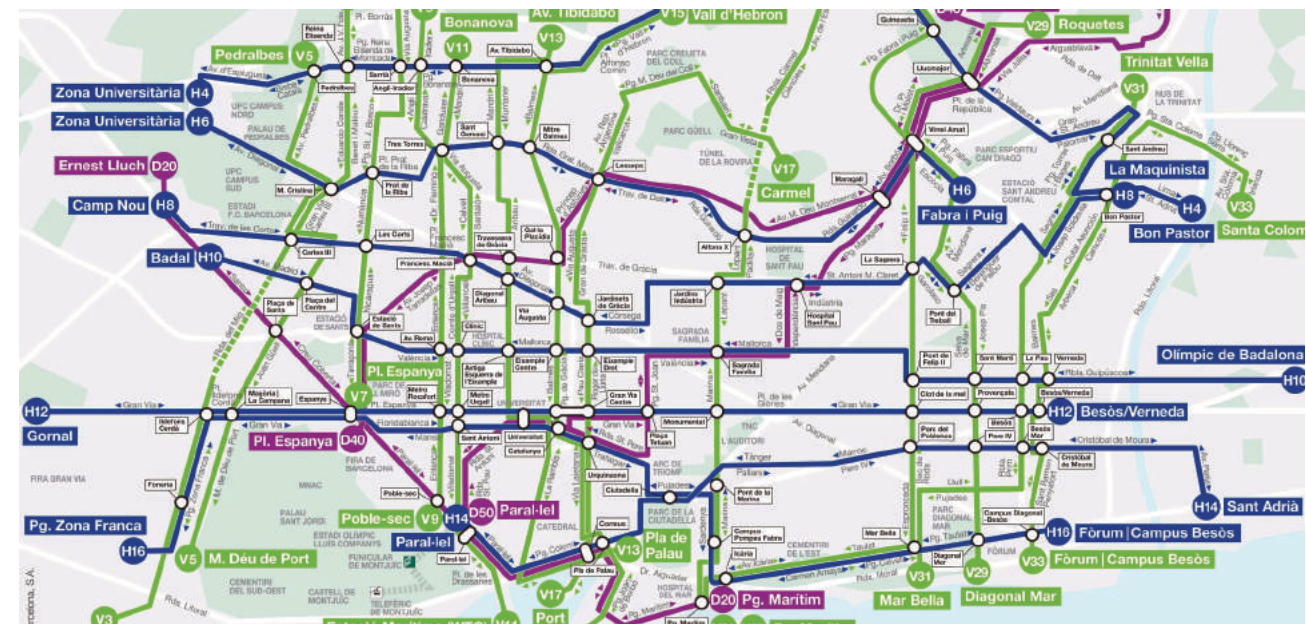


Figure 2.16: final network of the high-performance bus lines [54]

Duration

The transformation of the bus network took place gradually in several phases over six years. The first five lines were put into operation on the first of October 2012 and the network was completed with the last five lines in autumn 2018. [48]

Financial Aspects

To restructure the bus network, approximately €2

million have been allocated to each phase, and in total about €10 million were spent. [48]

Applicability to Munich

Since the city structure of Munich differs considerably from the structure of Barcelona, it seems questionable whether such an orthogonal structure makes sense.

In Barcelona, it is especially the city structure, which is affected by the sea (hindering the city to spread

radially), characterized by planned quarters with straight streets and the concept of Superblocks, which provide the framework for the bus network's structure to work properly. However, this measure provides interesting findings that can be used for Munich: a clear structure of the network has the effect of increasing its attractiveness, and in this context, transfers are not as great a barrier as previously assumed, at least if it is only once.

B.2.2 Bicibox – safe bike parking

The Bicibox is a service of the Area Metropolitana de Barcelona, providing safe parking places for bikes. The goal of this measure is to promote the sustainable mode cycling and multimodal trips with public transport for commuters. That is why the preferred location of this services is close to public transport stations. Currently 1.900 of such bike parking places are provided by 19 municipalities of the region in 165 locations. This concept, which was already developed in 2011, has become increasingly popular in recent years, and currently has 13.000 active users. [51]

Problem being solved

The overall goal of this measure is to promote the sustainable mode cycling in general, and especially for commuters. In this case, by providing secure parking for bicycles and thus protecting this transport mean from theft or vandalism. Furthermore, intermodal trips in combination with public transport is encouraged by the location next to train and metro stations. In this way a solution for the first and last mile of public transport trips is provided. [51] [57]

Stakeholders:

The transport authority of the Metropolitan Area of Barcelona (AMB) is providing this service.

Expected result (vs real result)

The service already started in 2011. While it was not well accepted at the beginning, it became increasingly successful in recent years, which reflects in the number of users [58]: Even though in the period from 2014 to 2018 the number of parking lots has increased only about 30 %, the number of users increased about 245 % and the number of parked bikes about 158 % [51].

Duration

The first Biciboxes were installed in 2011 and until today more and more facilities are implemented to enable safe bike parking.

Financial Aspects:

The costs highly depend on what kind of infrastructure is used for the Bicibox bike parking. Currently, it can be roughly divided into two types:

- creating a new facility in public space, which can be easily done by installing containers with seven or fourteen parking lots (see Figure 2.17) or by building special facilities like “bike garages” (see Figure 2.18), which are more expensive but have higher capacities and
- modifying space in existing buildings, by creating separate spaces for bike parking in train or metro stations or using the ground level of residential housings, where normally shops are located (see Figure 2.19)

The costs for the first implementation phase in 2011 where about 1,7 Mio € for 2.000 parking places. In addition, maintenance costs arise, which in this case amounted to €600,000 per year for the 2,000 parking spaces. [57] [58]



Figure 2.17: Bicibox container in public space [55]



Figure 2.18: Bicibox "garage" at a train station [56]

Legal Aspects

In case of theft the bikes of the Biciboxes are insured.

Technical Aspects

For the Biciboxes the user needs a special card in credit card format to lock and unlock the parking place. The same card can be used for all Biciboxes. Furthermore, the communication from a service center with the Biciboxes for cases of customer services must be possible. [51] [57]

Air



No direct improvements measurable, since Bicibox is a measure to promote biking, which in turn is a sustainable mode (without air pollution).

Time



The usage of a Bicibox takes more time to park for a cyclist, however, it is then safe against theft. Furthermore, going by bike or intermodal with public transport, user might save parking search time.

Space



The appearance of the safe parking with the Bicibox concept depends on the type of facility and its visual assessment might be a question of individual taste & the context.



Figure 2.19: Bicibox in the ground floor of a residential building in Sant Joan Despí [59]

Applicability to Munich

Bicycle parking is also a relevant topic in Munich and has become more important in recent years. The S-Bahn and U-Bahn stations are now largely equipped with appropriate parking spaces to enable intermodal trips. In contrast to the concept of the Bicibox from Barcelona, these parking spaces are open to everyone. Apparently, bicycle theft is not (yet) a major issue in Munich. In future projects, however, it should be

considered that a secure bicycle parking space is important if bicycle traffic is going to be encouraged, citizens spend more money on a bicycle and, above all, electric bicycles are significantly more expensive, and their battery is prone to theft. [60]

A similar measure dealing with bicycle parking can be found in Stockholm under S2.3.

B.2.3 Bicing (Bike-sharing System)

Bicing is allocated as a new form of public transport by bicycle in Barcelona. The owner of the service is Ajuntament de Barcelona (municipality). It is based around the ‘Smart Bike’ system, developed and managed by Clear Channel Outdoor. This public bicycle sharing system provides regular bicycles and electric bicycles for users. Initially, the service started on 22 March 2007, in Barcelona. [61] Currently, it has 6,300 mechanical and electric bicycles with 424 stations in Barcelona city. [62] The system is designed with the smart docking stations for bicycle parking, which provides flexibility, better performance and improve the safety of the system.

Problem being solved

Its purpose is to cover the small and medium daily trips within the city in a climate-friendly way, eliminating pollution, roadway noise and traffic congestion that motor vehicles create. Currently, a part of this pollution, noise, and congestion has been eliminated since launching this mode of transport in the city.

Stakeholders

The system is being managed and maintained in partnership by the city council of Barcelona together with the Clear Channel Communications Corporation until the last quarter of 2018. After that, the city council has assigned the service to Cespa, that started to manage it from 2019 on. [63]

Initially visitors of the city were able to use the scheme, however, this option has soon been removed to control expansion and the service is then limited to those who work/live in the city of Barcelona.

Expected result (vs real result)

There were (summer 2008) over 150,000 users subscribed to Bicing, which has been expanded to

6,000 bicycles. Each bike is used on average almost 8 times per day, which equates to over 1,162,930 journeys per month. [61]

However, effective promotion and a city culture and infrastructure ripe for bike-sharing prompted 30,000 users to sign up in the first two months, which is almost the forecasted number of users for the first year. It was a huge success, overshooting all forecasted usage rates and catalyzing an expansion of cycling culture and infrastructure in the city. By the end of its first year, the service had nearly six times more subscribers than expected, totaling 100,000 subscriptions and today it has 113,796 subscribers. [62]

Challenges of implementation:

Since Barcelona is downward sloping, people mainly want to use the service to move downwards, so that at a certain time of the day, most of the bicycles are parked in the lower part of the city, with very few people willing to use them to move upwards, with the consequence that there are not enough bikes available in the upper area of the city. Consequently, as the day goes by, many stations in the lower part of the city have no empty spots, which becomes also an important problem for the



Figure 2.20: Bicing station in city center
[Own photographs]

users, who must pay extra costs, both in money and time, due to this usual problem. As shown in figure 2.22 the Bicing operators are carrying the bicycles from the beach or city center to upward stations. Another cause for a bad redistribution of bikes can be something as simple as the weather. For instance, if in the morning there is good weather, many people will use the bikes to go to work, but if it starts raining, they will probably use public transport to go back home, leaving all the bikes concentrated in the most concurred places (where businesses usually are).

For solving the challenge of Bicycles redistribution, Bicing is producing more electric bicycles for the users so the users can easily ride upward. Yet, the problem remains for the mechanical bicycles.



Figure 2.21: Computerized pylon for the users
[Own photographs]

Technical Aspects

The service offers the possibility of making a reservation 5 minutes in advance. The service access system consists of 3 differentiated access methods (contactless smart card, smartphone with NFC technology or mobile application). The use of mobile application is really easy and useful and many Bicing users recommend it. By using this app, the user can check the nearest station to book a bike and find the shortest route and ride to their destination. If the user arrives at a full parking station, he or she is given 10 more minutes to find a slot. [62]

The mechanical bikes are designed with a GPS system, and the electric bikes are designed with rechargeable batteries as well.

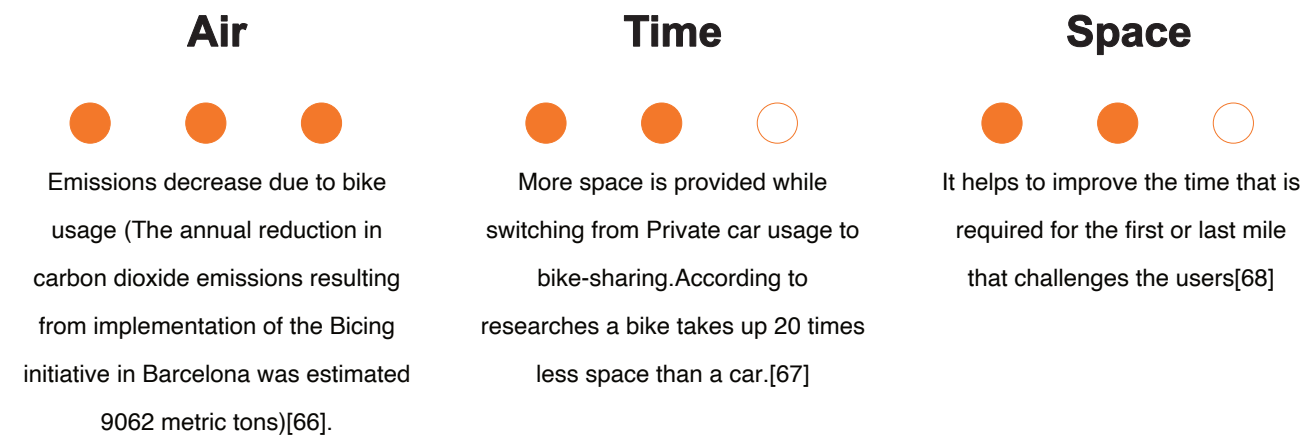


Figure 2.22: Redistributing the bikes from down parts to city upwards [own photograph]

For this purpose, Bicing has conducted a study with Univeritat Pompeu Fabra (UPF). The study is called; A logistic analysis of Bicing. After some analysis they suggested an incentive of € 0.05 per ascending trip but as it is not implemented yet in the system, they have to consider some scenarios and run some tests for the first year to examine the result. [63]

Duration

The installation of the system started in March 2007 and the original plan was to install a total of 100 parking stations with 1,500 bicycles available, by July 2007. There were (summer 2008) over 150,000 users subscribed to Bicing, which has been expanded to 6,000 bicycles, with more than 400 smart docking stations. Currently, there are 6,300 Bicing bikes in the city which 300 of them are electric and 424 docking stations. [64]

Financial Aspects

The system is mostly paid by local car drivers with an on-street parking control system, distributed throughout much of the densely populated inner city. This money, about €2.23 million annually, is paid to the system operator. The annual subscription to the service costs € 47.16 and it includes the first 30 minutes of each user for free, a reasonable time since the average usage time is between 13 and 14 minutes. Thereafter, the subsequent half-hour intervals are charged at € 0.74 up to a maximum of 2 hours. In the case of exceeding the 2 hours limit, a penalty is imposed and the user is charged with a fee for improper use of € 4.49 per hour. Finally, if a bicycle is not returned after 24 hours, a fine of €150 is imposed. Recently, the city made a sponsorship agreement with mobile operator Vodafone to feature the operator's logo on the system in exchange for €1.2 million a year. [64]

Legal Aspects

Like all vehicles, bicycles are subject to the general road regulations that ensure all road users to travel safely, namely the General Traffic regulation. In the city, Bicing users should cycle on the road and on specially designated areas. They must stick to road traffic rules since considered vehicle. Users can cycle on the road, preferably on the lane closest to the pavement and in the middle of it. A bike lane can only be used by bikes and bike riders have the right of way over other vehicles when they turn right or left across it. Pedestrians are only allowed to cross the bike lanes at the marked crossings, otherwise they are not allowed to use the

marked trails. On streets with 30kph speed limit bikes have the right to way over vehicles but not pedestrians. On these streets, bike riders must cycle in the direction indicated for the street if there is no bike lane which permits cycling in the opposite direction in a separate area. [65]

Applicability to Munich

Munich city is providing a bike-sharing system for Munich citizens by the name of MVG Rad. These services are for Munich residents, people from the district of Munich and guests who want to be on the go for sports. For those who commute to work daily and do not want to take their bike with them and/or want to save additional footpath.

This system started on Oct 9, 2015, with 600 bikes and 24 rental stations. 3,200 bikes are now available in 136 stations in Munich and 1,117 bikes within 162 stations in the area of Munich are provided for the users. Currently, there are 125,000 registered users with more than 100,000 trips per month. [69] The MVG Rad sharing system has launched MVG eRad and MVG eTrike for its users. The MVG Rad service is designed with smart dock stations and free-floating.

B.2.4 CARNET - Future Mobility Research Hub

CARNET is a knowledge hub for automotive science and technology focused on urban mobility. This Future Mobility Research HUB, initiated by SEAT, Volkswagen Group Research and the Universitat Politècnica de Catalunya (UPC), is an open hub for industrial and academic partners from the areas of automotive and mobility research & innovation. CARNET is located in Barcelona and works through project-based collaboration. It focuses on innovation and solutions that close the gap between academic research and industrial innovation in urban mobility.

Problem being solved

CARNET based its activity on four pillars: [70]

- Training & Education (Structuring and adapting to the industrial and societal needs for the education and training of automotive engineers and scientists).
- Cooperative Research (Promoting a highly applied research and innovation in automotive technology through close cooperation between industrial and academic research institutes).
- Networking (Participation in European / International networks and competitive calls, creating a high-class automotive research environment in Catalonia).
- Business Creation (Creation of Startups and supporting activities)

Stakeholders

City council is supporting Carnet and it is coordinated by UPC and the Center of Innovation and Technology (CIT). It's co-funded by the European Union and Government of Catalunya.

The founders of CARNET are SEAT, UPC and Volkswagen research group, currently, they are working with 12 partners like Altran, PTV Group, CIAC, RACC, Fer-

rovial, Kineo, autopistas, RUCKER LYPSA, ELISAVA, FICOSA, Tusgsal. [70]

Expected result (vs real result)

The creation of a successful knowledge hub such as CARNET requires building on an already existing and solid cooperation between partners, each of them bringing complementary capacities to the initiative. Mutual recognition and trust are key elements when embarking into a long-term initiative like this. A strong leadership from the industrial side is also required to shape a credible message and vision for the initiative. Top companies in the automotive and mobility arena support the CARNET initiative.

CARNET activities go well beyond networking, as in contrast to most groups and industrial associations. One of its main areas is cooperative research, where the strong network and knowledge base that is available within the participating organizations allows a quick setup of very relevant pilots on the field. An additional field of activity is the identification of talent through, for example, the organization of several hackathons with UPC students.

Challenges of implementation

CARNET's location is not arbitrary. The selection of Barcelona responds to the fact that it is widely recognized as one of the top smart cities worldwide, as it has implemented very competitive technological tools, such as streetlight sensors distributed all over the metropolitan area, which gather useful data about traffic patterns, parking areas, and air pollution. The support from local authorities is considered a key element in the successful implementation of the initiative.

Duration

It was initiated in 2015 by SEAT, Volkswagen Group Research and the UPC. Since then they are working on different projects in Barcelona and worldwide.

Financial Aspects

This project has received funding from the European Union's Horizon 2020 research and innovation program. The main funders are SEAT and Volkswagen, and it is co-funded by European Union and the Government of Catalunya.

Applicability to Munich

Inzell Initiative in Munich is created with the aim to bring together key players from governmental, industrial, and scientific field of competence to implement forward-looking solutions for sustainable mobility in the city of Munich. The Inzell Initiative is a cooperation between the State Capital of Munich and the BMW Group. [71]

It is a contribution to meet the City of Munich's sustainability goals, especially to deal with traffic planning challenges and to create quality livable urban space. The fundamentals of this issue are elaborated in

six different Inzell focus themes. These strategic fields of action are broad-based across-the-board measures, addressing up major challenges of modern mobility in Munich. The 6 focus topics are Electromobility, Delivery Traffic, Parking Space, Company Mobility, Multimodal Offers, Traffic Outside City Limits.

Technical Aspects

The initiative was formally launched in June 2016. As of today, it counts with 8 additional members and has successfully executed a high number of R&D/demonstration pilots in the city of Barcelona in the following areas: Vehicle concepts; Mobility software and apps; Urban mobility concepts; and Business design for urban mobility.

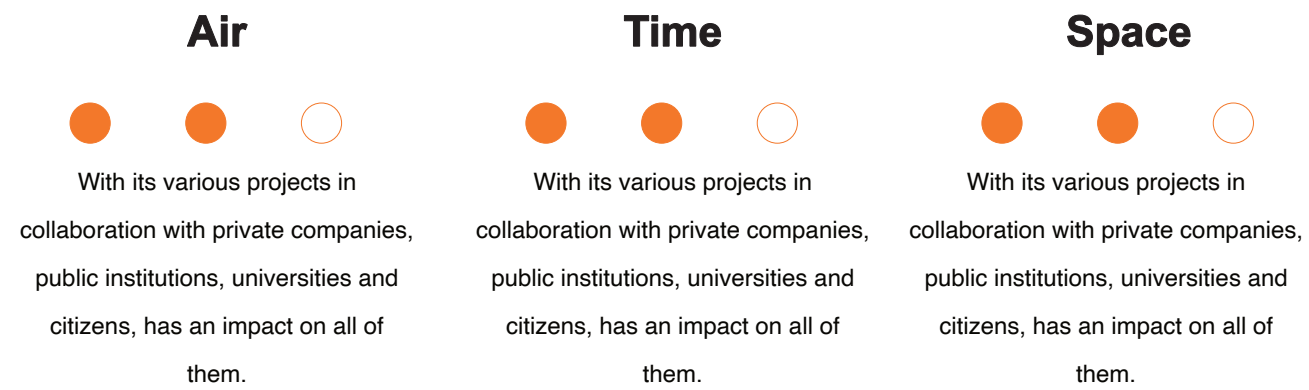


Figure 2.23: CARNET ideas for a dynamic city [70]

Recently, there has been established another initiative named M Cube. The M Cube strategy project brings together expertise from science, business and society in the Munich metropolitan region in order to develop innovations for sustainable mobility, implement concrete practical tests on site and make the solution approaches internationally visible.

To assess sustainable development, strategic quality goals are defined that focus on the economic, social

and ecological challenges of the metropolitan region. The project also significantly contributes to the development of a “model region” that enables well-founded technology assessment and process consulting for public actors and is of outstanding importance for the economic and scientific positioning of Bavaria as a location for innovation.

B.3.1 Urban Mobility Plan (UMP)

The Urban Mobility Plan (UMP) is a planning tool to guide the governing of sustainable urban mobility. The second version UMP 2013-2018 is based on the planning concept of the Superblock (see case study “Superblocks”). While evaluating actions from the former version, the UMP provides a diagnosis of all modes of transport with its advantages and weaknesses. The prognosis part anticipates the future mobility development and defines continued and new measures. The participatory process of the UMP deserves particular attention in this measure description. [16] [72] [73] [74]

Problem being solved

Barcelona suffers from the prevalence of private vehicles in the city along with inadmissible levels of noise, air pollution, green surface and accident numbers (see chapter “Current Challenges of the City”). The UMP tackles these issues in a coordinated way via a list of mobility measures together with a monitoring concept that is able to evaluate the success in terms of sustainability. The publicly available UMP provides transparency about the plans and about the evaluation of municipality interventions.

Stakeholders

The UMP draft is developed by the Mobility Pact – a participatory forum at the level of the city of Barcelona that holds several meetings for the UMP. Ten defined goals of sustainable mobility lay down the mission of the Mobility Pact, which consists of 124 members from different city districts (including entities from the metropolitan region) and sectors (e.g. associations, education, social services, public administration) [77]. After the approval from the General Management for Environmental Policies, Mobility and Security Commission, the document received criticism in a public information process. The

majority of comments led to changes in the final UMP, approved by the Barcelona City Council. The Councilor's Office for Mobility is in charge of the development, monitoring and evaluation of the UMP. [16] [72]

Thereby, the citizens and different stakeholder become part of the process of planning future mobility. The UMP explicitly aims at safer and more comfortable spaces for cyclists, pedestrians and at improving the bus network [73].

Expected result (vs real result)

The participation process should lead to more transparency and confidence from citizens. The municipality aims at sharing proposals and facilitate fluid communication. It fosters discussions and dialogues to work towards consensus and to minimize conflicts. Most importantly, participation is not the goal but seen as a process. All these contributions feed into the discussions with expert knowledge [72].

In this way, the UMP 2013-2018 defined 66 measures to be implemented along the four axes: Safe mobility, Sustainable mobility, Equitable mobility, and efficient mobility.

It is hard to tell whether public participation is success-



Figure 2.24 Participatory event for the UMP [75]

Figure 2.25: Decidim online-platform [76]

ful. However, the efforts to include publics in the development of goals and existence of an established panel for participation – the Mobility Pact – witness a certain degree of transparency and openness for the mobility futures of several actors.

Challenges of implementation

While a high share of the measures of the expired UMP could be implemented, some require continuous effort in the next plan.

Financial Aspects

The overall budget for the implementation of all measures for the period 2013-2018 was estimated at 260 million Euros [16].

Legal Aspects

The UMP bases on a number of legal regulations and environmental policy plans on different levels. The most important legal ground is the law of mobility of Catalan 9/2003 that obligates the municipality to review the UMP every 6 years. Others, like the National Guidelines of Mobility (Catalonia), Metropolitan Plan of Urban Mobility (Metropolitan Area) build a regulatory framework. The UMP aligns to other policies like the Strategic Bicycle Plan for Catalonia or the Road Safety Plan [16].

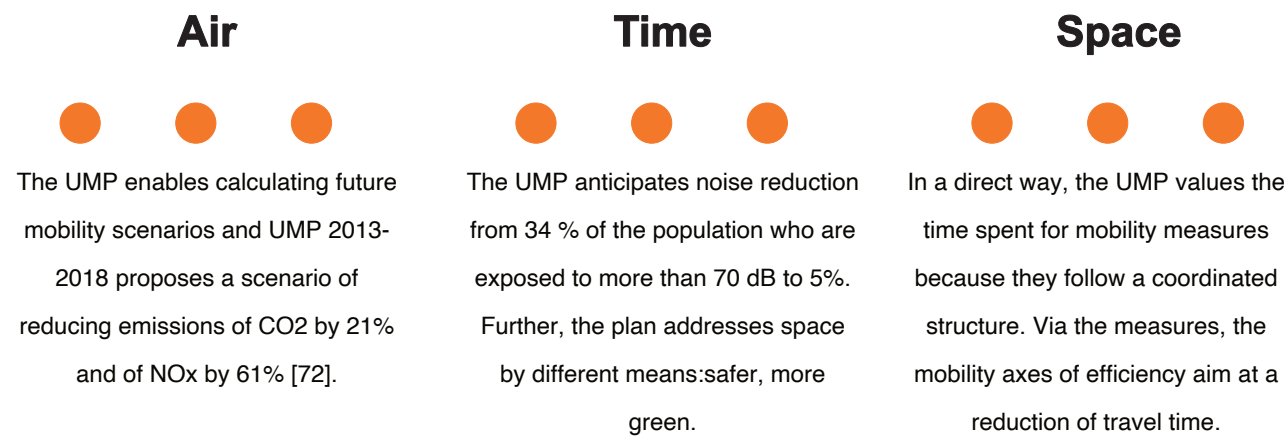


Figure 2.26: Measures of the UMP 2013-2018 of the dimensions of mobility by foot (blue), bicycle

Duration

The participation process for the new UMP was newly developed and lasted 17 months, from 12/2017 – 04/2019. It followed predefined steps: diagnosis, validation by the Mobility Pact, information period, debate, evaluation of debate, implement in report, publication, monitoring and evaluation afterwards. The aim is to implement the plan in the years 2019- 2024 (former UMP: 2013-2018).

Technical Aspects

In contrast to most of the measures presented, for the UMP, the innovative aspect is not a technology on the road but the technique of developing together the city's mobility future – a "technology of participation" [78].

For the upcoming plan 2019-2024, the participation process invites to sessions with thematic groups, like children, elderly people, gender in mobility. Further, an

open session for the general public discussed themes like technologies and services of mobility. The participatory approach used informative, awareness-raising and deliberative methods. Information and discussion were also held online via Twitter and the municipality's website. The platform Decidim provided online access to the discussions, not only for dissemination purposes but citizens could make proposals and evaluate and comment on other contributions, which are discussed in the meetings afterwards. The minutes are publicly available online [75]. The open-source platform is available for every city to implement democratic processes at decidim.org.

Applicability to Munich

Munich is lacking structured available information on mobility data, mobility measures and mobility plans. Barcelona's transparency towards all issues around mobility, the publicly available data and extensive documentation of the mobility plan and its participatory processes (inclusive meeting minutes!) is a convincing step towards a shared future of mobility for the citizens. The last comprehensive mobility development plan in Munich was outlined in 2006 [80]. Since the new overall mobility concept has just been introduced [81], this would be the chance to implement a regular process of monitoring, evaluating and co-developing the future of Munich's mobility with the public in short periods of 5-6 years. This measure is urgent, the chance to embed this in the new mobility concept should not be missed, especially since many EU funded projects already provide knowledge for sustainable mobility and transport in Munich.

B.3.2 Increasing pedestrian-friendly space in Barcelona

The goal of Barcelona is to increase walking journeys (within the timeframe of the last Urban mobility Plan: 2013-2018 about 10%) [47]. Therefore, the space of the city has to be redistributed and space of private vehicle use is “given to the citizens” in form of better walkable areas with high quality of staying. Part of the solution are the Superblocks, which are inside traffic-calmed and rededicated for the residents and serve as zone with priority to pedestrians. In addition, the concept of green corridors shall help to reach further improvement in the future. These are specially greened paths, intended to link parks and to run through the city like a green infrastructure [52]. Altogether these measures should increase the area for pedestrians by a factor of ten compared to 2011, when only 74,5 ha have been dedicated pedestrian area [47]. Currently, about 230 ha of the targeted 750 ha could be dedicated as pedestrian area [52].

Problem being solved

To reduce negative externalities of the traffic in Barcelona, one main goal is, to shift mobility towards more sustainable friendly transport modes. In detail it was the objective of the last Urban Mobility Plan (2013-2018) to Increase walking journeys by 10% (from 2011). That means an increase in walking from 31,9% to 35,1% of the modal split. According to recent mobility analysis this objective could not yet be achieved [6]. [47]

Stakeholders

The Urban Mobility Plan serves as a strategic plan for the development of the future transport system in Barcelona. Accordingly, all major stakeholders, such as the city of Barcelona the Agència d'Ecologia Urbana de Barcelona (a public consortium consisting of the City Council of Barcelona, the Municipal Council and Metropolitan Area of Barcelona and the Barcelona Provincial Council) were involved. Furthermore, the plan was drawn up with broad public participation. (for more de-

tail see Measure B.3.1 Urban Mobility Plan (UMP)). [47]

Expected result (vs real result)

As mentioned above the goal of increasing the modal share of walking could not be achieved to the targeted extend. Although the number of trips by foot increased by almost 10 %, due to similar increases in the use of other modes of transport, the modal share of walking has only increased to 32.5% [6]. The subgoal of increasing the pedestrian area is still in progress. According to experts [52], about 230 ha of the city are currently pedestrian zones.

Challenges of implementation

AOnly slow transformation from a street-like neighborhood to a traffic-calmed and pedestrian-friendly zone is possible, otherwise citizens are protesting. Especially car-affine residents are afraid that they are deprived of their freedom to use their car and shop owners are afraid that no more customers will come, if the possibili-



Figure 2.27: Space of pedestrian area in 2011 [47]



Figure 2.28: Aimed space of pedestrian area [47]

ties to arrive by car is somehow restricted. [4] [82]

Duration

The measure, which started with the last Urban Mobility Plan of Barcelona in 2013 is still in progress. According to current knowledge only about 30% of the planned 750ha of pedestrian area are realized.

Financial Aspects

The budget for all measures in the field of emphasizing the pedestrian mode for the time period of the Urban Mobility Plan 2013 - 2018 was 27.430.500€. This contains not only infrastructural measures as redesigning street space but also promotion of walking as sustainable and safe mobility in schools. [47]

Technical Aspects

Intersections with other modes and traffic lights are a barrier for pedestrians due to waiting times and safety issues. The removal of these barriers (in a 3x3 Superblock, see Figure 2.29) could improve the walking speed about 10%. [47]

Furthermore, the idea is to pacify motorized road traffic and thus make pedestrian traffic more attractive in terms of time, which is needed to reach a destination [52].

Air

● ● ●

The promotion of walking through creating more pedestrian space where people enjoy to stay, leads to a change in the citizens mobility behavior and obviously leads to a reduction of all emissions.

Time

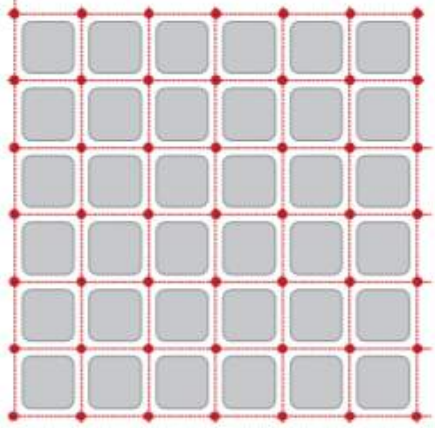
● ● ○



Walking is the slowest mode when it comes to top speed. Nevertheless, the quality of time can be very high. There is a reason why many people go to park for a walk.

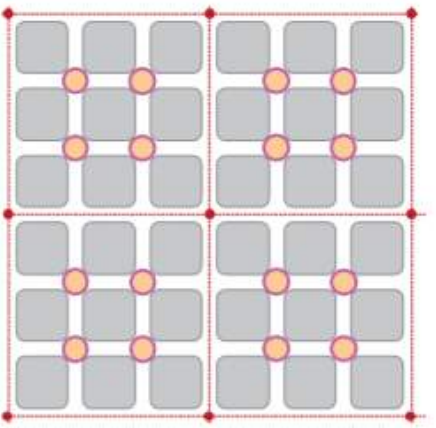
Space

● ● ●

Barcelona already offers good conditions for a high quality of stay in public spaces (weather, vegetation, culture), and by providing space and reducing conflicts by other transport modes.










Figure 2.29: Change of traffic ways and conflicts due to the Superblock concept [47]

Applicability to Munich

The extension of space for pedestrians is already underway in Munich (one recent example is the Sendlinger Straße and discussions about a car-free innercity). However, the widespread distribution in the form of entire networks through the city is not yet visible. Even though Munich differs considerably in its architectural structure, it should be examined whether the principle of Barcelona’s Superblocks, combining

several blocks to create pedestrian and recreational space inside, can also be transferred to Munich, since in this way a lot of space for these uses can be gained.



Figure 2.30: Illustration about the conflict of pedestrian space in urban areas by Karl Jilg



Figure 2.31: Illustration of an exemplary pedestrian area with high quality of stay [7] Superblock concept [47]

B.3.3 Traffic Calming

The effort to reduce the speed in the streets cut through several project frameworks: first, the Superblock concept (see case study “Superblock”) envisions the streets inside of 3x3 housing blocks to be pacified to a single-lane road with a speed limit at 10 km/h. Second, the challenge ‘30 city’ aims at transforming Barcelona into a city with the maximum speed of 30 km/h to become a safer place, especially for pedestrians and cyclists. Third, the project ‘Protect the Schools’ that strives for safer and more qualitative space around schools. This project and ‘30 City’ are part of the Climate Plan of Barcelona [83].

Problem being solved

Barcelona prioritizes the quality of mobility for pedestrians. Due to the high velocity and prevalence of automotive traffic, there are safety issues for vulnerable road users, especially pedestrians, cyclists, people on e-scooters and motorbikes. Further, the masses of vehicles cause health threatening air pollution (only 44% of population are exposed to NO_x values over 40 μm³; this is also the annual average limit for Munich, where it was fulfilled at 25% of the measuring points [87]) and noise exposure [25].

Stakeholders

The measures of traffic calming are implemented by the municipality. The interventions in the Superblocks rely on the Urban Mobility Plan (see B.3.1). ‘30 City’ and ‘Protect the Schools’ stem from the declaration of climate emergency, which was developed in working groups together with citizens from over 200 organizations plus discussions on the online Decidim participation platform, similarly to the Urban Mobility Plan.

Aside from the decision making, commuters and neighbors have a stake in the pacification of their streets. As the implementation of the first Superblock pilot projects

showed, it is a delicate balance of benefits and disadvantages for the neighbors. Even more different is the situation for local shops and businesses, which might rely on either costumers in cars or walk-in-costumers.

Expected result (vs real result)

The city follows the policy to shift attraction to the non-motorized modes of mobility – that is where pacification of vehicles directs to: higher modal share of so-called vulnerable road users. With lower speeds, the mortality rate of accidents of people being run over can decrease from 45% to 5% [88].

The result of the pacified streets in the Superblock is local but very visible. There are fewer vehicles inside (in Sant Antoni 82%) the area and more people walking and playing (in Sant Antoni 28%) [89].

Challenges of implementation

Some car-users still do not stick to the speed level in the Superblocks and pose a risk. Since the demarcation between traffic lane and pedestrian zone is blurry by design in order to provide a shared space. Additionally, some drivers use the way that is reserved for pedestrians directly next to the houses, which poses a high risk



Figure 2.32: The speed limit of 30 km/h will be valid for the largest part of Barcelona [84] [85]

for pedestrians and people who leave their house.

There might be a potential for higher traffic at the edges of the Superblocks. Hence, the traffic flow needs to be evaluated in an integrated model that goes beyond the calmed streets itself. Further, the change of speed regulation caused controversies and resistance from one local collective, while another collective defended the traffic calming (see case study “Superblocks”).

Duration

‘30 City’ strives for regulating the speed to 30 km/h for 212 km of streets within two years. As a first step, 112 km (67,7% of all streets) of secondary roads will be slowed down and a section of a main road. In the second step, another 100 km will reduce the speed to reach 75% of the city's road network. On the long

Figure 2.33: Safety for pedestrians and cyclists in Barcelona [86]

Technical Aspects

The pacification requires mainly infrastructural change. To control the speed limit, radar sensors, speed bumps, elevated pedestrian crossings and street signs will be installed. In the Superblocks, the interventions are more material. Many streets are changed by means of tactical urbanism: the new narrower single-lane road has painted edges and road signs raise attention to the speed limit. However, some streets were reconstructed with speed bumps, lawn and trees at the edges. These infrastructural changes are expensive. A pedagogical radar light was only used temporarily. Neighbors consider this too little control because of numerous violations of the speed limit in the Superblock. They would like more speed bumps [90].

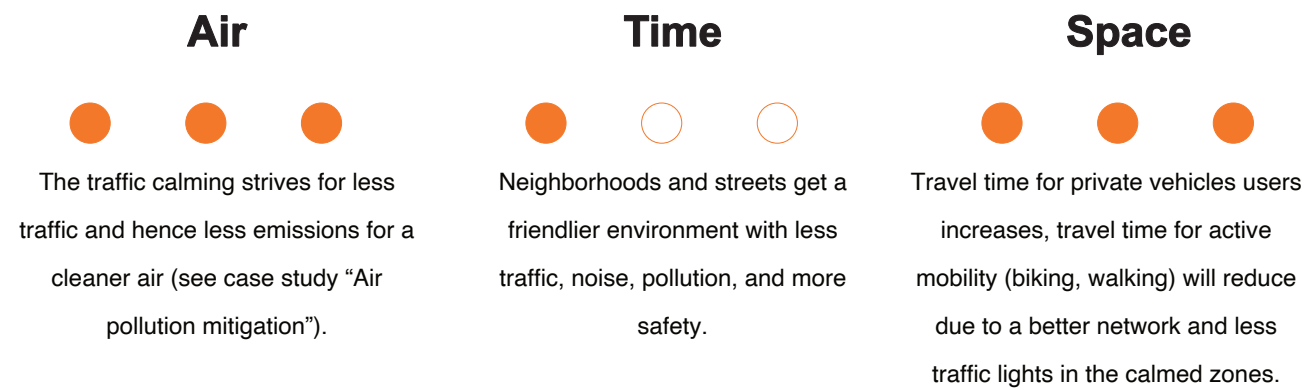


Figure 2.34: Model of structural intervention of the street design for traffic calming [92]

run, the speed limit should apply to the whole city [88].

The speed limits in the Superblocks are implemented after a participatory and design process of more than one year. The implementation of the ultimately planned number of 503 Superblocks is a long-lasting process of many more years. However, many parts of the city will have started processes of implementing Superblocks until the end of the legislation period in 2023 (for more details, see case study “Superblocks”).

Financial Aspects

The pacification can be implemented on different infrastructural levels. A tactical urbanism approach is rather cheap, appears temporally and easy to change. The structural intervention with more concrete edges and changes. (rough numbers: 200.000 vs. 2.000.000 Euro per street in one Superblock) [90].

Legal Aspects

Barcelona’s declaration climate emergency at the beginning of 2020 allocates 563,3 million Euro for sustainable development measures. This strong commitment of the Municipality is directed to speed up the measures that Barcelona planned in the climate plan from 2018 [91].

Applicability to Munich

Traffic calming appears interesting regarding Munich’s congested streets and high pollution values (Munich has the worst air in Bavaria [93]). Further, pacification is not only a means to slow down the vehicles but to reduce the use of cars on the long run. Hence, Munich needed to commit to this political agenda. This is an urgent task, which is already up to debate for the inner city [94]: to prioritize quality of mobility for vulnerable groups, who correlate with active mobility: pedestrians and cyclists.

B.3.4 Making Living Spaces

Barcelona's increase of pedestrian-friendly urban space (see B.3.2) is related to re-shaping neighborhoods towards user-centered spaces within the framework of the Superblocks (see case study "Superblock").

The 'Open Streets' project aims at drawing attention to the impacts of congestion and traffic on the space distribution in big cities. The initiative closes several broad streets for some hours one weekend a month to facilitate neighbors and other people to use the space for collective activities or sports and playing. Another approach to create living space in the streets can be found in Stockholm (see S.3.3).

Problem being solved

Barcelona has very little green space in the city (in the district of Eixample 2.7m² compared to recommended 9m² by WHO; in Munich the green space varies more from 2,3m² in Isarvorstadt, 6,3m² in West-Schwabing and 14,6m² in Sendling [95]. These permeable soil areas are an important factor for naturalization and green surfaces are necessary to reduce the heat radiation of in summer nights [25]. Further, the city envisions a sustainable mobility future with less vehicles and streets that provide space for playing, coming-together and activities.

Stakeholders

The municipality organizes 'Open Streets' and the Superblock interventions. The main stakeholders for more living space are the neighbors of these areas, the people who live there, shops and businesses. They are part of participatory processes and co-designing activities for the public space in the Superblocks. The 'Open Streets' affects also bus operators who have to re-configure their schedule for the particular weekends.

Expected result (vs real result)

The 'Open Streets' is directed to illustrate benefits of calmed streets for people, to raise awareness for the effects of motorized traffic for health and to promote the reduction of private motorized transport [88]. The Superblock concept should more than double the green area per inhabitant [96] and allow for more life in the streets. In the Superblock pilot projects, many small green areas are growing, and trees are installed (partly in pots) (see Figure 2.35, Figure 2.36, Figure 2.37).

Challenges of implementation

The interventions in the current traffic flow cause heavy political controversy. To create awareness, the activities on the streets should be a positive success that motivates people. After the first pilot of the Superblock, new participation processes had to be implemented. However, the municipality listened to the controversies and managed to overcome a crisis of the Superblock concept (find more in the case study "Superblocks").

Duration

The implementation of the Superblocks is an ongoing process over years. Since the pilot projects have been



Figure 2.35: A road intersection was transformed into a square that invites to stay in Sant Antoni [85]

Figure 2.36: Increasing green surface of the pacified streets in Sant Antoni [85]

subjects to debates, the public spaces were redesigned from time to time, which is also intended by the idea to provide space for the citizens to shape it. The preparation, participation process and implementation of a Superblock can take about two years. Until the end of the ongoing legislation period, the municipality will have started 17 Superblock(-like) areas (see case study "Superblocks").

Financial Aspects

The required budget depends on the particular material intervention. In Barcelona, the municipality dedicated 20 million for the improvement of space for pedestrians in the Urban Mobility Plan 2013-2018. This includes the design of public space, but also further improvement of pedestrian infrastructure [72].

Technical Aspects

The public spaces do not live from innovative technology but rather from material interventions that fits the neighbors' needs. Picnic tables turned out to be an attractive furniture. Children find playgrounds to spend their time. Paintings and poems are painted on the ground while the trees are often in pots, which provides a rather temporal gaze. Further, speed bumps, signage and lawn as demarcation facilitates the regulation of the traffic in the Superblock [97] [90].

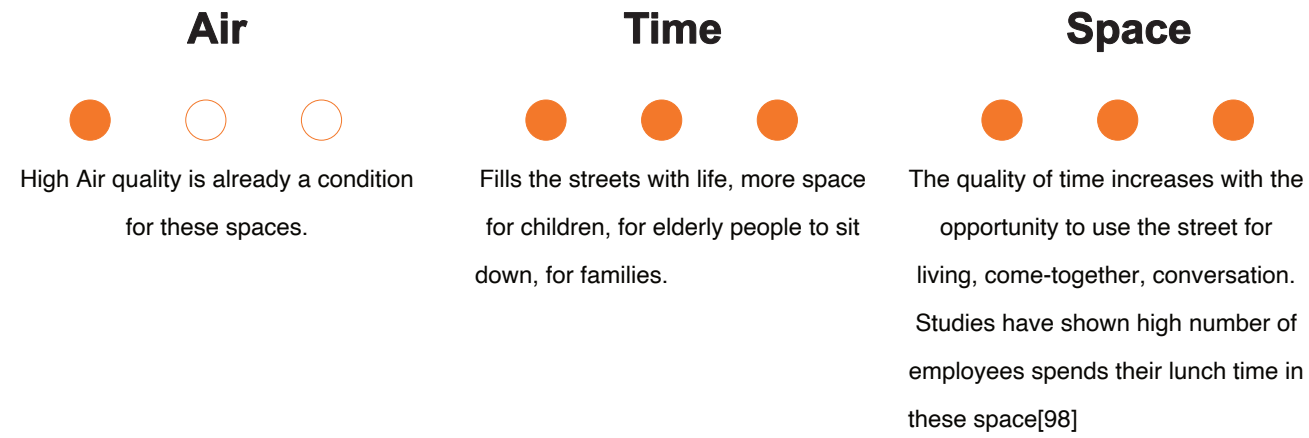


Figure 2.37: A road intersection was transformed into a playground an area to stay on the benches

Applicability to Munich

There are already similar project happening, like City2Share and CLEAR, which try to create public living space out of former car-occupied areas [100] [101]. The tendency is visible, even though political resistance complicates long-lasting interventions. Here, Munich can learn from Barcelona. The city gained a lot of experience with heavy controversies around the transformation from vehicles' space to pedestrian-

friendly areas. It adopted its models and listened to citizens and can now show some implemented Superblocks that are filled with life. Especially Munich as an economically well-situated city should not back off from engaging with the neighborhood to create local shared futures of mobility and urban space. Since the City2Share project is almost over, it is a good time to start further projects to co-create urban space.

B.3.5 Low Emission Zone

The Barcelona Low Emission Zone (ZBE Rondes BCN) is a 95 km² area (Figure 2.38, Figure 2.39) where entry of the most polluting vehicles is restricted. It has been implemented since January 1, 2020 (permanent, from Monday to Friday on working days from 7am to 8pm) and enforcement with fines beginning in April 2020. With 24.5 % circulating vehicles affected, an estimated 50,000 polluting vehicles will no longer enter the area from 2020.

Problem being solved

With an estimated 70 % population exposed to NO_x above WHO limits of 40 µg/m³ and 98 % population exposed between 20 to 40 µg/m³ of PM₁₀ emissions [23], Barcelona's air quality has been a major concern for both residents and government officials. The LEZ is enforced as a measure to reduce environmental pollution, and to preserve and improve air quality and people's health. It is part of the range of actions aimed at reducing air-pollutant emissions by 10% in 5 years and 30% in the next 15 years.

Stakeholders

The main actors in developing directives and implementing the LEZ are the Generalitat de Catalonia, the Area Metropolitana de Barcelona (AMB) and the Barcelona City Council along with local institutions. The AMB is responsible for the formulation and coordination of the measure. The General Directorate of Traffic (DGT) and Catalan Traffic service (SCT) are additional enabling bodies

Between June and September 2019, participatory processes took place for the drafting of the regulatory ordinance of the low-emission zone along with many technical representatives. In total, more than 230 people

participated, and 182 surveys were collected with citizen contributions to the ordinance. The major concerns were the disparity between real emissions, blanket Euro based labelling and also the lack of enough alternative public infrastructure to support the measure. However according to AMB officials, instead of focusing on real emissions of individual vehicle types, they are moving towards implementing zero emission zones in the future.

Expected result (vs real result)

By establishing the LEZ, AMB aims to achieve a reduction in NO_x and PM₁₀ emissions of up to 31% and 39%, respectively including a behavioral shift. The real results of the LEZ are not yet available. However, a more transparent and accessible air quality viewer is available for citizens to view the effects of the LEZ on a daily basis.

An assessment of different scenarios with respect to type of fleet cutoff, potential fleet renewal and vehicle kilometer reduction was carried out and an average reduction of 23% and 22.6% for NO_x and PM₁₀ was estimated for the year 2021 with respect to 2017 [103].

Since the availability of T-Verda card by TMB in 2017, an average of 284 new users (equal to scrapped polluting vehicles) have registered per month. According to



2.38: Area under the Low Emission Zone in 2020
AMB [102]

qualitative surveys, car ownership tendencies in the regions with emission zone in place have declined positively [104].

Challenges of implementation

Apart from the resistance from affected vehicle users, the trips banned by the emission zone had to be absorbed by public transport and given Barcelona's compact and dense environment, offering a seamless transition via public transport and P & R was a challenge. Along with this, renewal of fleet is difficult especially for poorer people and hence would cause inconvenience till conducive conditions for modal shift for it are in place.

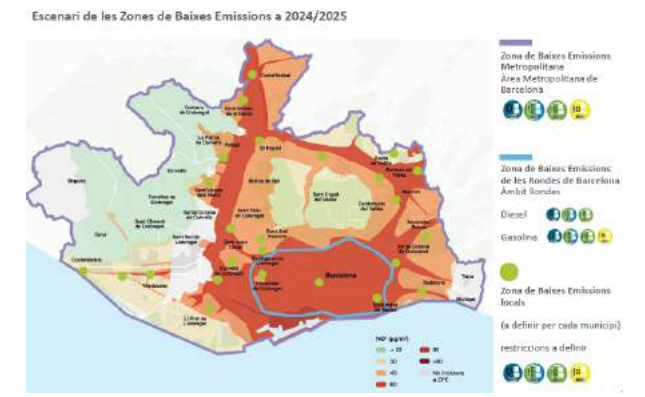


Figure 2.39: Expansion of Low Emission Zone in 2024/25 with stricter norms AMB [102]

Duration

The communication campaign began from 2016 to spread general awareness. Step by step transition was enabled from 2017 to 2020 wherein the zone was implemented only during episodes of high pollution to first cars and then motorcycles and also offering a free T-Verda public transport card to scrap old vehicles meanwhile. The public transport was strengthened in order to better receive the LEZ and planned to increase by 10 %. A new metro line section was completed, and the bus system was transformed and improved frequency was offered.

Air



The emission zones have been estimated to reduce NOx by 15 to 23% depending on the moratorium applied to heavy vehicles and 19-22% for PM in the area. [103].



Time



With lesser cars circulating, the quality of space and reduction of congestion might be a possible effect.



Space



With lesser cars circulating, the quality of space and reduction of congestion might be a possible effect.



Figure 2.40: Communication campaign for the LEZ. Source: AMB [102]

Technical Aspects

Characterization of the circulating vehicle fleet and study was initially carried out in 2017 and on the basis of the potential environmental benefits and feasibility the following vehicles were excluded from the LEZ-
Petrol cars registered before the Euro 3 standard (before 2000).

Diesel cars registered before the Euro 4 standard (before 2005 or 2006).

Motorcycles and mopeds registered prior to Euro 2 (before 2003).

From 2021, vans, lorries and buses without an environmental label will also be affected. An estimated 50,000 polluting vehicles will no longer enter the area.

Monitoring of the LEZ will be carried out automatically by using 100 cameras that behave as license plate readers and compare license plates to the corresponding DGT environmental label and the

Metropolitan Registry of Foreign and Other Authorized Vehicles.

The automatic control system, which uses over 100 cameras to read license plates at various locations in the Metropolitan Area, provides local authorities with data on the vehicles identified within their territory, in order to establish appropriate fines in the case of any offences. The cameras control several traffic lanes and verify all the license plates of the vehicles in circulation. The camera system is complemented by specific actions by the Barcelona police (Guardia Urbana) and will be helped to complement in areas of security and safety.

Financial Aspects

Initially it was estimated a contribution of the AMB of € 1,500,000 per year for the whole of the ZBE (action 1, 2 and 3). A major percentage of funds are being spent on the advertisement and communication campaign of the LEZ.

Applicability to Munich

A similar measure has been implemented in Munich since 2008. The measure despite being implemented in the 45 km² inner region of Munich since 2008 is less stringent and smaller than in Barcelona. The enforcement method is also human resource extensive compared to the camera-based licensing reading system that is implemented in Barcelona. However, the circulating fleet of Munich is newer in comparison and affected population density lower in areas of high

emission.

However economic justifications cannot be used to tolerate poor air quality and Munich can consider extending the exclusion to diesel passenger cars till Euro 5 like Barcelona plan in 2024.

Special incentives can be provided for scrapping pre-Euro 6 diesel vehicles and opting for electric vehicles if not free public transport

Assessing sustainable mobility (via Indicators)

An important element of urban planning is the evaluation if implemented plans and corresponding measures have led to the intended effects. For this purpose, it is necessary to specify objectives as precisely as possible in advance, at best, by quantifiable key figures. These key figures, also known as indicators, can serve on the one hand as tool for the final evaluation and on the other hand to monitor whether the project is on the right track. This evaluation approach is widely used by Barcelona’s strategic planning. The following case study briefly presents recent examples where goals with relation to mobility are set and evaluated in such a way. The Urban Mobility Plan (UMP) is the central strategic plan for urban mobility in Barcelona, but mobility also plays a role when it comes to sustainable development of the city. Weighted accordingly, corresponding plans from Barcelona are discussed below.

Urban Mobility Plan of Barcelona (UMP)

The UMP is a strategic plan of Barcelona’s government for the development of the local mobility system, which is valid for a period of five to six years before it is assessed and revised (see “Measure Urban Mobility Plan” for an overview of its function). It defines the strategic objectives, the planned measures and also the monitoring indicators for the corresponding period.

The strategic overarching objectives Safe, Sustainable, Equitable and Efficient Mobility remain the same across the different versions of the mobility plans. These objectives have further defined sub goals, varying according to the mobility plan version. Figure 2.41 shows the strategic objectives with its sub goals according the UMP 2006-2012. [47] [105]

The UMP does not only define the new objectives and indicators for the corresponding period, but also evaluates those from the previous plan. The most recent mobility plan at the moment (April 2020) is the UMP 2013-2018, which includes the evaluation of the UMP 2006-2012 (since no successor for the UMP 2013-

2018 is published, no evaluation of it is available until now). The evaluation of the measures of the UMP 2006-2012 was carried out in the UMP 2013-2018 in two steps [47]:

1. Assessment of the degree of implementation of the measures
2. Assessment of the achievement of the set goals using indicators

Assessment of the degree of implementation of the measures:

For assessing the progress of the measures, they were divided into one of five categories. [47]

- Information is required
- Not yet started
- With delay
- Slow pace
- Good pace

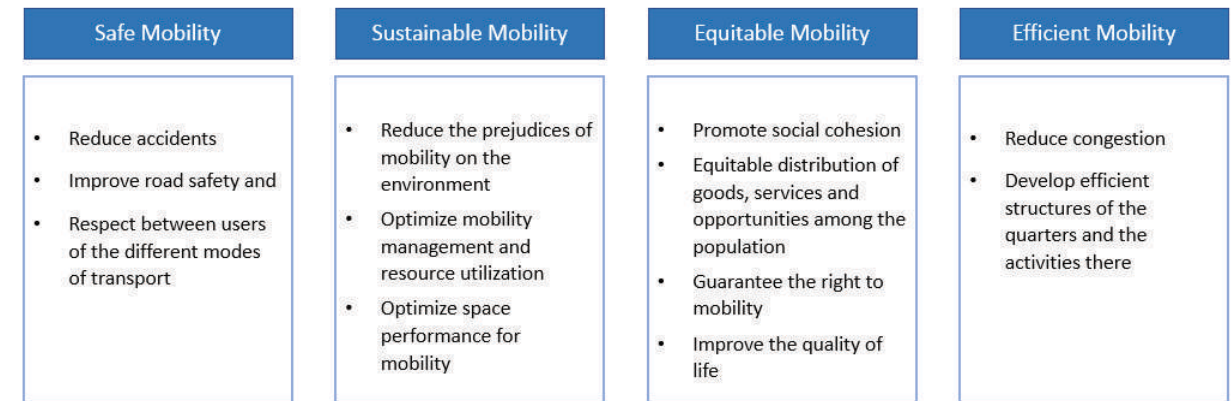


Figure 2.41: Strategic objectives with sub goals of the UMP 2006-2012 [own illustration based on UMP 2006-2012]

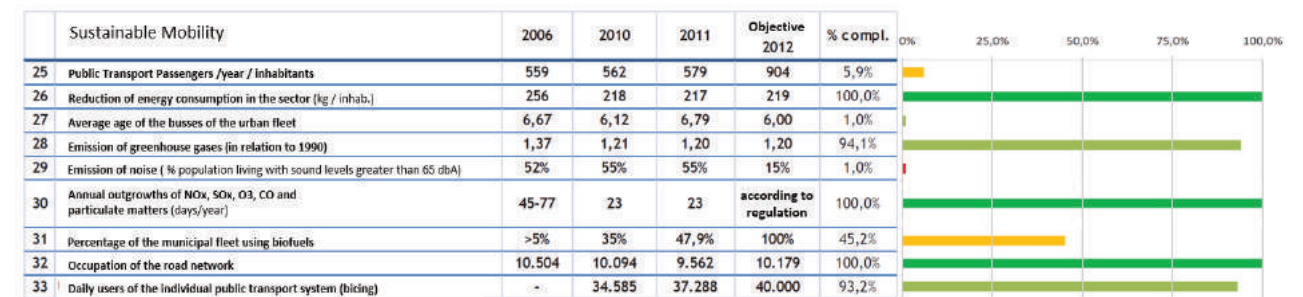


Figure 2.42: Assessment of the achievement of the objective Sustainable Mobility by individual indicators [illustration from UMP 2013-2018 modified by the author]

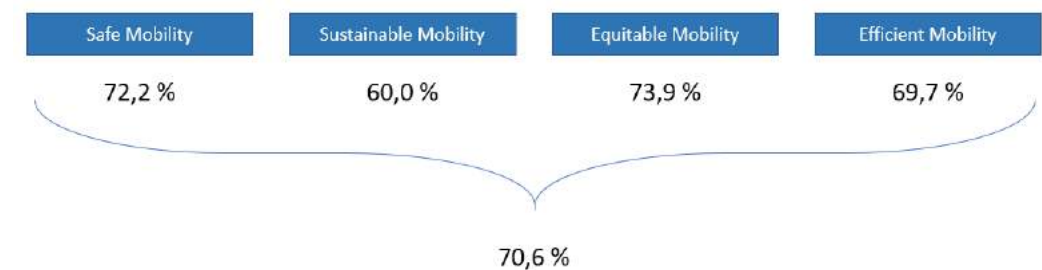


Figure 2.43: Degree of achievement of strategic objectives from UMP 2006-2012 [own illustration based on UMP 2013-2018]

Assessing sustainable mobility (via Indicators)

This results in four lists classifying the degree of implementation of the 67 measures of the UMP 2006-2012, clustered according to the four strategic objectives Safe, Sustainable, Equitable and Efficient Mobility. It can be seen that most (51) of the measures are rated as having a good pace, 9 having a slow pace and for the 7 measures left, this information is not available. [47]

Assessment of the achievement of the set goals using indicators:

In the next step, the indicators defined in the UMP 2006-2012 for each strategic objective were evaluated and the degree to which they were met was calculated. As 65 indicators were used in total to assess the fulfillment of the four strategic objectives, the evaluation will be presented only exemplary for the objective Sustainable Mobility. The strategic objective Sustainable Mobility is represented by nine indicators. (See Figure 2.42)

The target values, for the respective indicators, shown in Figure 2.42 under Objective 2012 were defined in the UMP 2006-2012 for the year 2012, which allows a quantification of the degree of completion ex post [105]. On the basis of the corresponding indicators, it can be concluded that the objectives of the UMP 2006-2012 were achieved in the field of Safe Mobility to 72,2 %, Sustainable Mobility to 60,0 %, Equitable Mobility to 73,9 % and Efficient Mobility to 69,7 %. This results in an overall value for the achievement of the objectives of the 2006-2012 UMP of 70,6 %. (see Figure 2.45) [47]

In addition, three further indicators were monitored: the level of self-restraint in everyday commuting of the

municipalities, the development of the GDP and the evolution of the fuel price. Although these indicators cannot be directly influenced by the UMP, they are important for contextualizing the obtained results. [47] In comparison with the UMP 2006-2012, the number of measures in the UMP 2013-2018 remains roughly the same (66), but the indicators to be monitored have been reduced to 39 in total.

As mentioned above the assessment of the UMP 2013-2018 is not yet published, therefore it cannot be presented at this point. Nevertheless, some findings from the UMP 2013-2018 regarding the use of certain indicators can be done. It is noticeable that in the UMP 2013-2018 CO₂, NO_x and noise play a decisive role in forecasting various scenarios and selecting respectively prioritizing measures [47].

An especially interesting subject of the UMP is the assessment of habitability of urban space, which is a widespread goal, but hardly measurable. The UMP presents a solution for this variable in form of a combined indicator: Nine indicators are measured, to determine one overall score for the quality of public space in a street (see Figure 2.44). [47]

The example from the pilot project of the Superblocks in the district Les Cortes shows how the habitability index of public space works and how it shall evolve by the corresponding measures (see Figure 2.45). [47]

Optimum	■	40 to 45 points
Good	■	35 to 39 points
Appropriate	■	30 to 34 points
Insufficient	■	25 to 29 points
Very insufficient	■	< 24 points

Indicator	Unit	Status quo	Future
Accessibility	Width of sidewalk	2,5-3,7m	≥ 3,7m
Space intended for pedestrians	% road width	46,7	100
Proportion of the street	h/d (height / dist. fasades)	0,33	0,33
Visual perception of public green	% green per way segment	34,2	40,0
Noise level	dB(A) day	56,3	52,7
Heat level	% hours of comfort per day	50 (7,5h)	80 (12h)
Air quality	µg/m ³ of NO ₂	32,5	26,4
Density of activities	activities /100m	3,44	6,0
Index of urban diversity	bits of information /100m	1,58	3,0
Index of Habitability in Public Space	Assessment of segment in points	30	40

Figure 2.44: Assessment of habitability of public space [illustration from UMP 2013-2018 modified by the author]

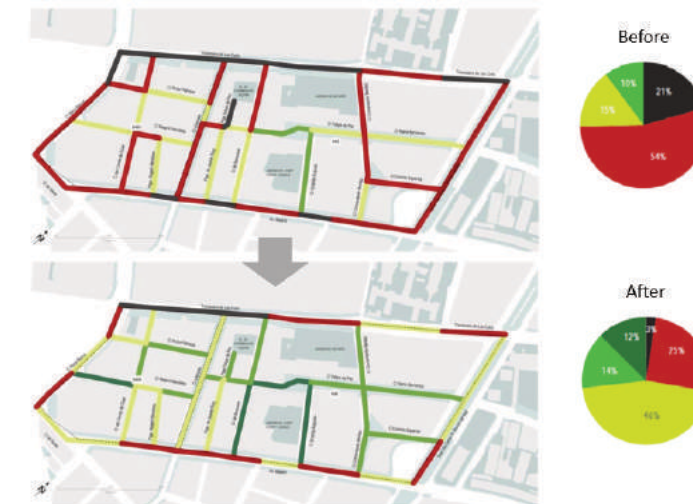


Figure 2.45: Example for the improvement of the habitability of public space by the habitability index [illustration from UMP 2013-2018 modified by the author]

Assessing sustainable mobility (via Indicators)

Further Assessments of Mobility in Strategic Planning

Beside the UMP, mobility is monitored and assessed also in other plans of Barcelona, as the Climate Plan and the Citizens Commitment for Sustainability.

Climate Plan of Barcelona

In the current Climate Plan of Barcelona mobility is a targeted sector to be improved in the sense of the UN sustainable development goals, Barcelona has committed itself towards [106]. The Climate Plan includes 18 lines of action, one of them is the promotion of more environmentally friendly mobility. The plan foresees that the 22 mobility measures will be monitored by the six indicators [107]:

- Kilometers of bike lanes installed
- Number of Superblocks installed
- NOx and PM10 emissions (micrograms / cubic meter)
- Number of electric-car charging points
- Energy consumption of the municipal vehicle fleet, by type of fuel
- Number of park & ride zones created

Citizens Commitment for Sustainability

The use of indicators as an evaluation element of strategic objectives is already a tradition in Barcelona. Since 2003, sustainability indicators have been collected annually for the Citizens Commitment for Sustainability to monitor whether the city is developing in accordance with the goals of Agenda 21 of Rio de Janeiro. In the latest update of 2018, the mobility behavior in the city is taken into account with two indicators. The first indicator is the modal share of ecofriendly modes, i.e. the share of trips with all vehicles except motorized individual transport. The second

indicator relates to the aspect of safety and reflects the number of accident victims (with traffic fatalities). Further indicators with a direct link to mobility are the emissions of NO₂, PM₁₀, PM_{2.5} and noise. The development compared to the previous year is considered on a three-level scale (good, neutral, bad). (see Figure 2.48) [6]

This study shows the crucial role of indicator assessment in the evaluation of strategic planning and that this approach is already widely used by Barcelona's authorities. Beside that fact, without exception, all local interview partners asked, confirmed that indicators are essential for planning and continuous improvement towards more sustainable mobility [82] [51] [108] [109] [110].



Figure 2.46: Climate Plan Barcelona (2018 - 2022)



Figure 2.47: Citizens Commitment for Sustainability (2012-2022)

Indicator	Result	In comparison to previous year
Public space and mobility:		
Ecomobility	74,9 % of total trips	positive
Road safety	257 victims (236 severe injuries and 21 deaths)	negative
Environmental quality and health:		
Air quality	Average concentration of NO ₂ : 37,9 µg/m ³ Average concentration of PM ₁₀ : 24,1 µg/m ³ Average concentration of PM _{2,5} : 15,6 µg/m ³	neutral
Noise	Population exposed to more than 65 dB (A) during the day: 22,8% Population exposed to more than 55 dB (A) overnight: 32,6%	(data from 2017 not available for 2018)

Figure 2.48: Indicators relating to mobility of the Citizens Commitment for Sustainable Mobility [own illustration based on the Indicadors de Sostonibilitat de Barcelona Informe 2018]

Superblocks

Urban planning in Barcelona is inseparably connected to the Superblocks model. The plan to transform the city is large scale, radical in tackling current urban problems and – most importantly – promises a more sustainable and more climate change resilient city. Urbanists and media channels around the world notice that the concept is worth getting attention [111]. The plan affects urban spaces as well as mobility itself.

The idea is to create one Superblock out of 3x3 housing blocks. The space inside of the Superblocks is a shared space. Benches, picnic tables, playgrounds, green areas and trees take the space and leave just a single-lane track for vehicles, which can enter the areas with a maximum speed of 10km/h but not allowed to cross the Superblock (see Figure 2.49). Pedestrians are prioritized for the road use (see measure B.3.2). The four intersections inside of the Superblock become public spaces with each 1.900km².

The impressive aspect of the Superblock model is its scale – the idea is to transform most of the city into 503 Superblocks. The planned effects are vast: the surface of the pedestrian network increases by 270%; increase of the green surface (e.g. in the Eixample by 135%); reduction of heat radiation on hot summer days by 35,9%; transformation of the bus network towards an orthogonal system; re-structuring and extension of the bicycle network; the length of the streets with priority to vehicles will reduce by 61%; almost half of the 60% of public space that is occupied by traffic will be given to shared usage with the priority on pedestrians. [25] (see B.2.1, B.3.1 to B.3.4). The value of the Superblock idea lies not only in its quantity of areas for buses, bicycles and pedestrians but also in the improvement of the quality of space: Salvador Rueda, the visionary of the Superblocks, emphasizes that the availability of public space does not only affect mobility but constitutes the citizens' right to use the city area according to their needs. The goal is to transform single-use spaces (mobility of vehicles) to multi-use spaces (different

modes of mobility plus cultural events, leisure, meeting, etc.) inside of the Superblock. This is not a ban for cars but a more balanced use of public space: according Urban Ecology Agency of Barcelona, a reduction of just 13% of the traffic would maintain the same infrastructure service for vehicles – and the goal of the Urban Mobility Plan is to reduce automotive traffic by 21% [25] [112]. The emergence of the Superblocks is tied to the history of City planning in Barcelona, most famously with Cerdà Plan, and its implementation is associated with challenges and hopes (for a story of the development of the Superblocks, we recommend David Roberts' five-part report [113]). Here, we limit ourselves to highlight four challenging elements that potentially boost the impact of the Superblocks for a sustainable future mobility. The key to success for these elements lies in the right understanding of the relation between mobility infrastructures and society.

Road hierarchy in the new Superblock model

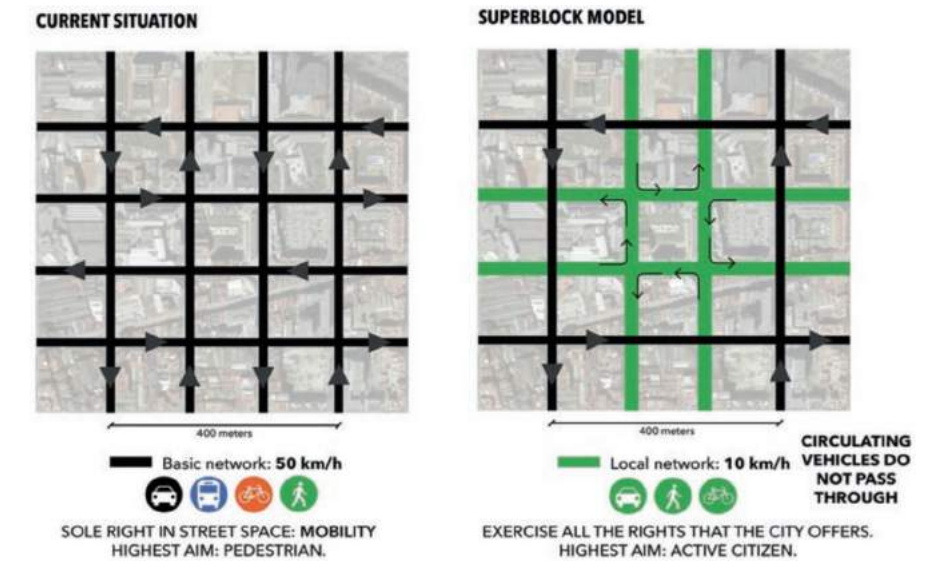


Figure 2.49: Transition of the traffic flow in a Superblock [25]

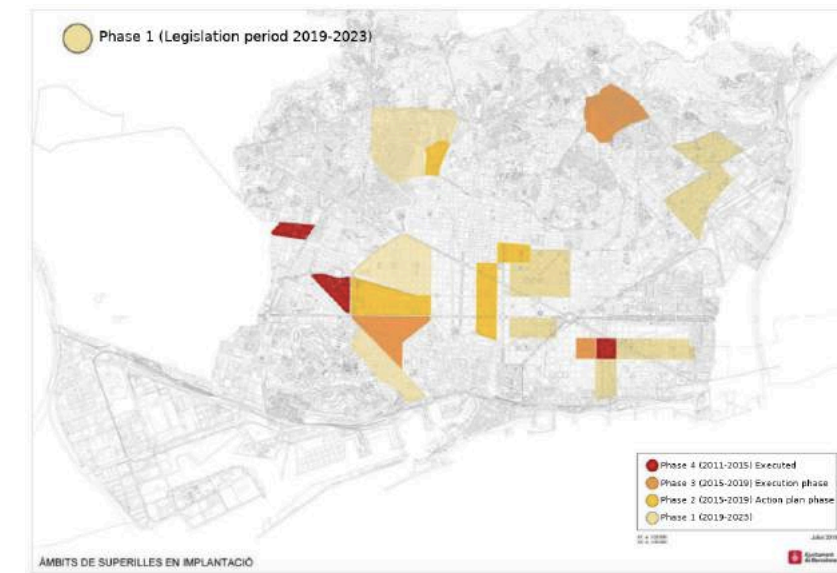


Figure 2.50: Step-by-Step plan of the Superblock implementation colored by legislation periods [114] (own translation)

Superblocks

Transforming the city by scaling up pilot projects step by step

The Superblock approach is deemed as a radical approach, not only because it questions the mere use of streets itself, but also because it envisions a step-by-step transformation of almost the whole city into more pedestrian friendly environment of 503 Superblocks. In the center for this transition are the first pilot projects.

The Superblock Poblenou was implemented in 2017. It is located in a relatively new, mixed area of businesses and housing, with a far lower population density than most of the inner districts. In the beginning, there were protests that lead into a crisis of the Superblock model. Immediately after the launch, the population of the Superblock divided into two groups: against and pro. Some neighbors who liked the idea felt overwhelmed because no consultation was done before. The temporal style of street furniture and trees appeared unattractive to many residents. The pilot project turned into an existential crisis for the concept. However, extensive efforts of the residents and collaboration between them and the municipality managed to overcome the crisis [90]. Eventually, the municipality included the lessons-learned into the implementation plan and approached the other pilot projects differently, first and foremost with an extensive participatory process, as in the following area of Sant Antoni [82]. This indicates that the local neighborhood in each Superblock should have the chance to participate and to co-create their streets to ensure that the mobility future is also a future of and with the citizens on site.

The municipality incorporates these learnings into their plans for future Superblocks and sticks to the extension

of the Superblock structure. The continuity of the concept even survived a political change from a center-right mayor to a leftist-activists mayor in 2015, who slightly changed some plans and added the slogan “Let’s fill the streets with life”, but the main strategy stayed the same [97]. Not every Superblock has the ideal shape of 3x3 blocks, but they are structured by the orthogonal bus grid that was co-developed with the Superblock plan. While three testbeds were started by the old city government, the new government of Ada Colau implemented another three pilot projects (among these Poblenou and Sant Antoni) and planned four more in the first legislation period until 2019. Now in the second period, seven more are in the pipeline [82].

The plan in the Figure 2.50 illustrates the scale and the seriousness of transforming the city. Even though changing city governments could still discard the plan, an urban architect states that the tipping point for transforming the city into a Superblock structure has already been reached [112]. The visualization also shows that the mobility changes do not limit to periphery quarters but tackle mobility issues in the central districts (the old city core follows an own transition plan [115]). The key for scaling up lies in how the specific characteristics and public of each Superblock is taken into account and how different stakeholder and actors learn from existing pilot projects.



Figure 2.51: Life in the Superblock of Poblenou on a regular afternoon [85]



Figure 2.52: Tactical Urbanism (left) and Structural Urbanism (right) in Superblocks in Barcelona [120]

Participatory Process

Materially embedded participation: addresses citizens, not pedestrians

The participatory process that was developed during the crisis of the Superblock concept and follows the directives [82]:

- maximum participation in diagnosis, propositions and execution
- integrate all the visions
- the program is not an isolated given fact but the start of a process of transition

The participants of the process are the citizens, the administration of the district, experts and the City Council Area for Ecology, Urban Planning, Infrastructures and Mobility.

The process encompasses four types of activities [82] [116]:

1. The driving group of each district supervises the participation process and is responsible for reporting. It consists of representative persons or associations from the Superblock area who dedicate themselves to the project from the beginning to the evaluation. They build the bridge between the technicians from the municipality to the neighborhood.
2. The municipality sets up thematic meetings with collectives who are especially affected by the Superblock and often do not participate in the open activities. These collectives are businesses, shops, companies, schools and others.
3. In open workshops for the neighbors, everyone can receive information and participate.
4. The municipality launches an online space for participation, in particular for those who do not attend personal meetings and to open the process up to all citizens beyond the district.

All the information on the process and the propositions are available at the website of the municipality. The step

to go online should guarantee transparency on the process. In the future, the platform Decidim (see B.3.1) should play an additional role to facilitate propositions, validation and commenting online.

This way participation processes can easily take 10 months. Therefore, the municipality is working on an acceleration of this process. At the same time, the participation faces difficulties like a polarization of the citizens, the feeling of disadvantage, effects beyond mobility, like economic ones. Beside the changes in the Superblock, the participatory process goes in line with Barcelona's democratic vision and its efforts for more direct participation [82] [116]. In practice, the challenge is to find a balance between collecting ideas of the public and pure information to be responsive to the visions of the citizens. This task is challenging and fosters controversies.

The arguments and controversies of Superblocks

The intervention of creating a Superblock interferes with many aspects of life – just like the arguments and controversies around it. This selection should be understood as learning about citizens' needs:

- The improvement of a healthy urban environment was mobilized as one argument for the Superblocks and received international attention with a study that announced that the implementation of the 503 Superblocks can prevent 667 premature deaths per year [117].

While some say that shops and businesses suffer because the accessibility by car gets worse, others argue that pedestrians and cyclists enter shops more often spontaneously than car drivers [118].

- The life in the streets itself is not unproblematic. While some complain about noise and people still sitting at the benches in the night, others embrace the opportunities to celebrate birthdays or free days outside together [90].

- The danger of gentrification is a concern of many neighbors who are generally in favor of the Superblocks. In the first pilot project in Poblenou, this was a minor issue because most buildings were public housing. The municipality argues that the improvement of public space should not be restricted, but gentrification must be addressed differently. On the long run, the idea is that most of the space is upgraded and the gentrification effects balance out [90].

- The shared space is contested. When bicycles, vehicles, transporters and pedestrians, including children and elderly people, share the street, everybody must pay high attention. Experiences show that many vehicles do not stick to the speed limit or the painted lines of the lane. The lane to demarcate the vehicles' space was also contested. Eventually, they had to paint it for safety reasons [90].

- The Superblock can be implemented by tactical or structural urbanism (Figure 2.51 and Figure 2.52). A tactical urbanism approach complicates to see the vision behind the project because all interventions appear temporal and not long-term. Structural urbanism interventions are far more expensive and harder to correct afterwards. A deputy mayor of Barcelona recommends a middle way to first wait for reactions and ideas of the residents in a tactical Superblock to transform it into structural version when the design goal is better established [97].

- Not to be neglected, the implementation is also a question of municipality politics. A study of the pilot project in Poblenou comes to the conclusion that besides the improvement of the quality of life, the struggle for political authority plays into the transition of the Superblocks [119].

Generally, the impression prevails that most people like the idea but when it materializes, proponents and protest raise their voices. Eventually in the Poblenou

pilot project, more and more people seem to enjoy the Superblock after the municipality implemented some changes inspired by the neighbors.

Lighthouse character getting global attention

Barcelona has a history of prominent city planning. Cerdà's plan from the 19th century is still compared to today's levels deemed a very progressive approach of urbanism [121]. Similarly, the Superblock concept raises global attention. It is not only the newspapers that tell about the concept in different places of the world, but several cities started to pick up on the idea for their own traffic issues, like Berlin and Seattle [122] [123]. The design of a Superblock won the BMW initiative award 2011 for their innovative approach [124]. The global attraction of the Superblocks underscores their potential to transform mobility towards more sustainable futures. Munich has some living labs that show similarities. The Domagkpark establishes neighborhood activities tied to sustainable mobility – however in a newly constructed environment [125]. The project City2Share imitates a Mediterranean square where people can use public space for their activities, while promoting sustainable mobility – however in a very temporal and spatially limited way [100]. The Superblocks inspire to reshape urban public space across existing districts in large sections of the city by long-term material interventions – together with the citizens!

Air pollution mitigation measures by Barcelona

Air pollution has significant implications for the health of citizens. While air quality is slowly improving due to technological reforms, the air pollution continues to be a great danger to environmental health. According to the latest report of the European Environment Agency [126], about 467,000 are directly responsible for air pollution premature deaths in the EU. In the case of NO_x, the legal limits of the EU and WHO state that they must not be exceeded, by annual average, 40 µg/m³. In the case of PM 10 the limits state that 40 µg/m³ should not be exceeded on an annual average which were reduced to 20 µg/m³ by WHO as of 2014. In both Barcelona and in Munich, a common occurrence in urban agglomerations, the measured concentrations of nitrogen oxides constantly exceed the legally acceptable values. Figure 2.53 and Figure 2.54 shows the range of modelled NO_x concentrations over the two cities (dispersion and emission not resolved enough for the case of Munich).

With approximately one third the population density and similar vehicle kilometers travelled via passenger vehicles with an older fleet, the average mortality due to NO_x exposure in Barcelona is expected to be higher than in Munich without the LEZ. However, Looking at NO_x concentrations measured at stations and the corresponding population density in the respective areas shown in Figure 2.55, and assuming that for concentrations above 20 µg/m³ there exists an increase in the risk of mortality by 5.5 % for a 10 µg/m³ increase in NO_x [126], one can estimate that the reduction of life expectancy is more severe in Munich in some polluted regions, despite lower population number affected.

The highest values in Munich are observed in regions around the Mittlerer Ring, which was assigned a regional traffic function in the 7th update of the air pollution control plan of Munich and a driving ban was not seen as a viable solution [127]. Similarly, the ring roads around Barcelona have not been included in the 2020 LEZ.

Pacifications and changing traffic structures are being

carried out in the remainder high pollution sites in Munich with less consideration to driving bans.

Vehicle related cause

The major cause of NO_x based air pollution in both cities is diesel related vehicular pollution. It accounts for 41.6 % of total NO_x related emission in Barcelona [10] and is as high as 68.9 % in the populated area of Gracia [130]. As for Munich, at Landshuter Allee, 67 % of the nitrogen dioxide pollution comes from private transport. Of this 67 percent nitrogen dioxide pollution, 91 percent comes from diesel vehicles (61 % from diesel cars and 30 from heavy vehicles) [128]. As can be seen from Figure 2.56, the majority of the fleet of Munich is higher in Euro class and hence is less polluting. This indicates a newer fleet in Munich and also perhaps a lesser tendency of fleet replacement with currently

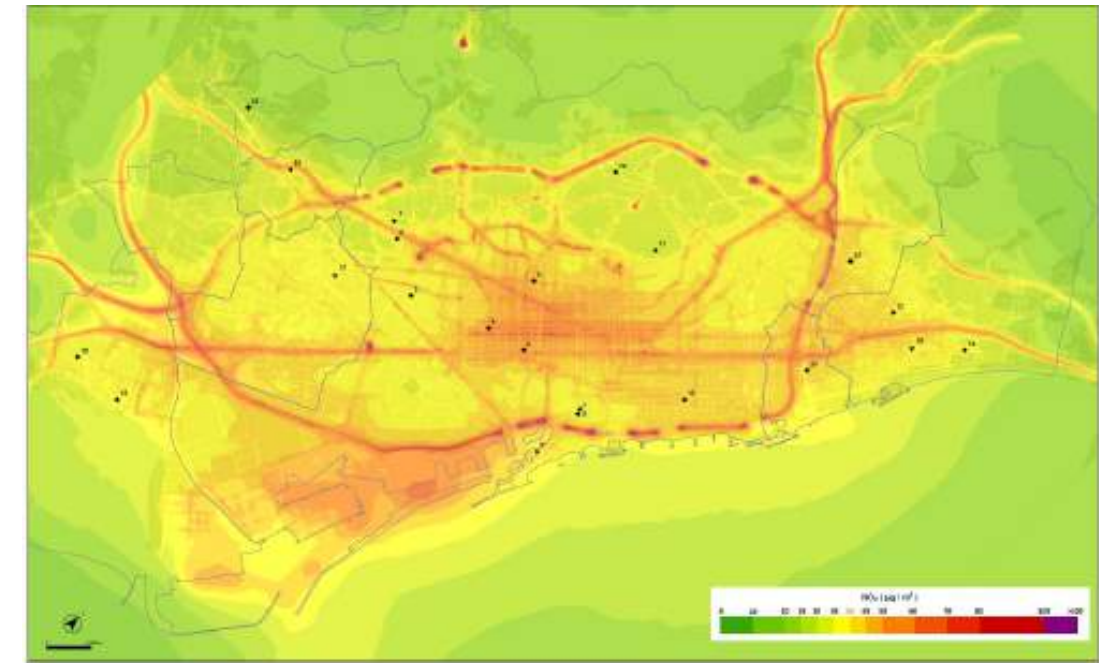


Figure 2.53: Modelled NO_x Immission over Barcelona in 2017 Source [102]



Figure 2.54: Modelled NO_x Immission over Munich in 2015 Source [128]

Air pollution mitigation measures by Barcelona

accessible Euro 6 vehicles. Despite having a lower number of car per 1000 inhabitants when compared to European cities, (350.4 cars/1000 inhabitants in Barcelona vs 454.7 cars/1000 inhabitants in Munich), the number of passenger cars per area is much higher for Barcelona at 5500 cars/km² vs 2200 cars/km² in Munich due to its density [131]. This combined with an older fleet composition is a direct indication of how urgently Barcelona requires measures to counter air pollution.

Main differentiating measures against it

Apart from measures that include promoting electromobility and modal shift towards active mobility, characteristic strategies of Barcelona’s fight against air pollution include-

- Low Emission Zone
- Superblocks

These are forms of traffic restriction methods for the most polluting vehicles within populated areas and also reduce vehicle kilometers travelled in these areas. The relative effects on reducing pollutant concentration levels are described as follows.

Low Emission Zone

While one can observe how late the LEZ has come into action in Barcelona in comparison to Munich (2020 in Barcelona vs 2008 in Munich), it encompasses a much larger area of initially 95 km² and eventually will expand to 656 km² in 2024. As shown in Figure 2.57, the estimated benefits with the scenarios in 2020 as compared to the emission in 2017 are modelled and estimated to reduce NOx concentration by 15 to 23%

depending on the moratorium applied to heavy vehicles and 19 - 22% for PM in the area [103]. With a greater environmental awareness, complimentary public transport system and more sustainable market options with well penetrated EV and hybrid vehicles, the LEZ in Barcelona will urge greater change.

As can be seen in Figure 2.56, the environmental label for permitted circulation will be more stringent from the year 2021 in the city primarily because passenger Diesel vehicles will be limited to only Euro 6 standards unlike current available plans for Munich. While assessing cost vs benefit analysis of limiting diesel vehicles to only Euro 6 in Munich, the focus should be on individual data points as shown in Figure 2.55 and not only on the city average.

As incentives to fleet renewal in Barcelona, residents of the metropolitan area who have deregistered and scrapped a vehicle without an environmental label can benefit from a free new travel pass, T-Verda that last for 3 years and extends to the entire metropolitan region. Since October 2017 to Nov 2019 approximately 5,700 T-Verda cards have been granted to Barcelona residents, with an average of 240 vehicles being taken to the scrapyard every month. Even though skepticism exists regarding replacing them with new vehicles, they are nevertheless less polluting. There are also financial aids and selective moratorium provided for people with an individual income below a predefined indicator. Expanding P&R infrastructure is also a key complimentary measure that is supporting the LEZ in the periphery areas of the city.

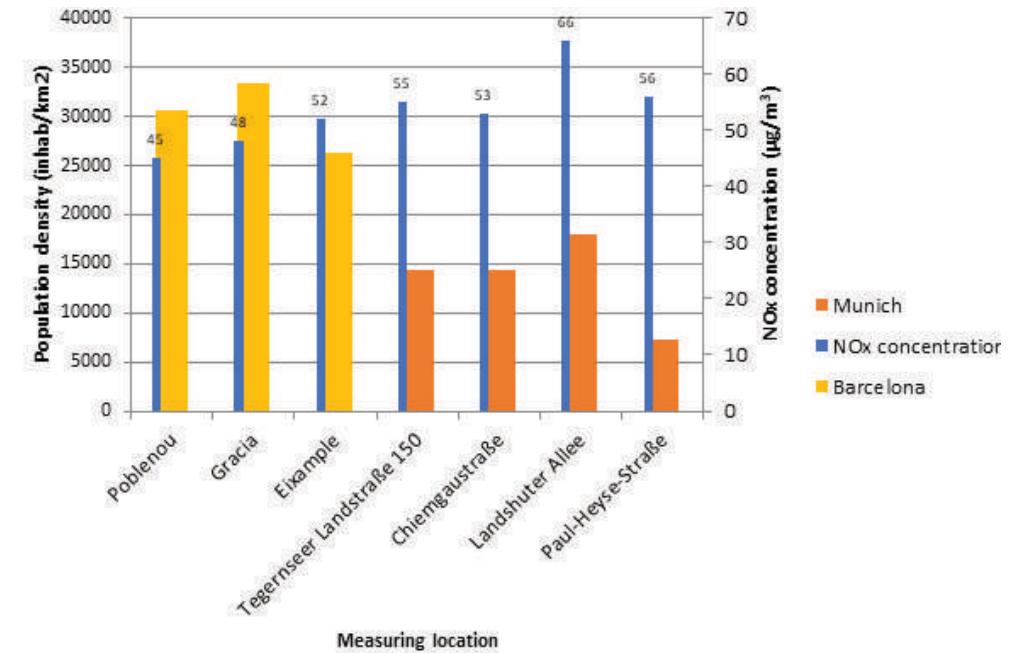


Figure 2.55: NOx measured at most polluting sites and their corresponding population

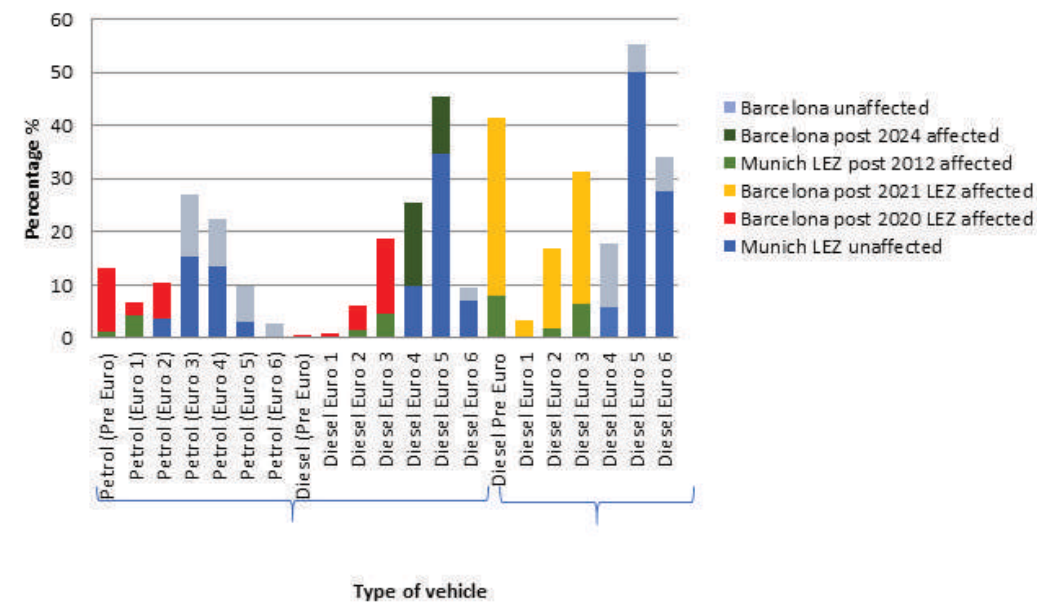


Figure 2.56: Distribution of vehicle Euro classes amongst Barcelona and Munich Data: ([38], [128]) Graph: Own

Air pollution mitigation measures by Barcelona

Superblocks pacification

In conjunction to the Low emission zone, the Barcelona Superblock model was developed with the aim of reclaiming public space for people and correcting the city's high levels of air pollution, noise and the lack of green spaces, as well as developing more urban green space. By reducing the secondary traffic to 20 kmph within the Superblocks and complimenting it with the orthogonal bus network to match the stopping frequency equal to the size of the average Superblock (400m), there would be a considerable reduction in the vehicle km travelled by private motorized vehicle by (estimated to be 19.25 % by [24]) and also congestion due to avoided turns into the Superblocks.

The increase in green space within the Superblock is also planned and estimated to be 12% which would greatly improve the local air quality.

By quantifying the results of the Superblocks as a health assessment, a recent study [24] found that the implementation of the original Superblock project could prevent an estimated 667 premature deaths per year , increase average life expectancy by nearly 200 days and have an annual economic impact of €1.7 billion with the Spanish value of statistical life as 2,510,000 EUR .The greatest health benefits of the Superblock model are associated with reductions in NOx pollution levels (291 preventable premature deaths per year.) Figure 2.58 shows the reduction in NOx concentration levels after the complete deployment of Superblocks and indicates how a majority of the population will be exposed to healthy air of NOx concentration below 40 µg/m3.

The complete implementation of Superblocks combined

with the low emission zone and orthogonal bus network would greatly impact the air quality and also improve social and health wellbeing of citizens in Barcelona.

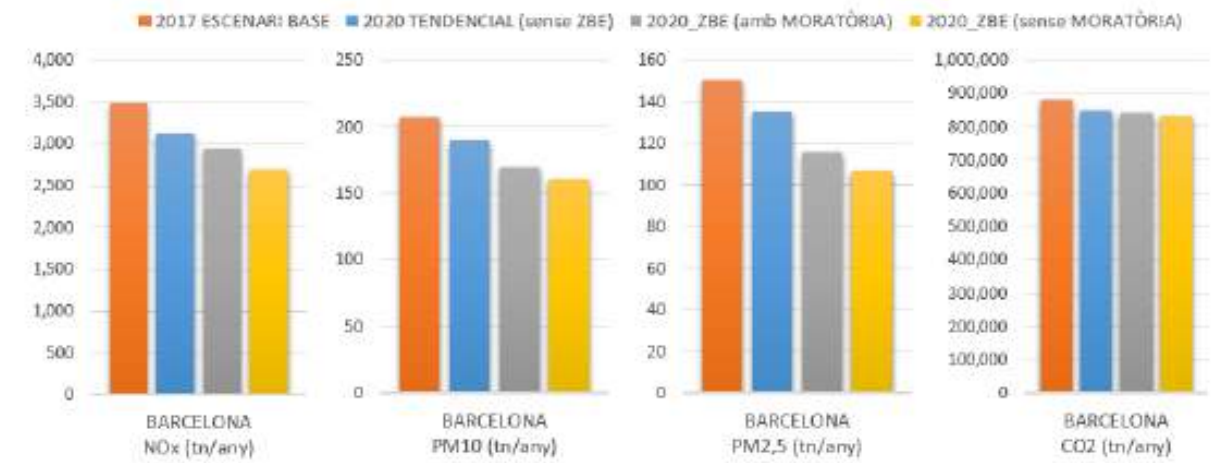


Figure 2.57: Modelled reduction in air pollution with implementation of Low emission zone Source [103]

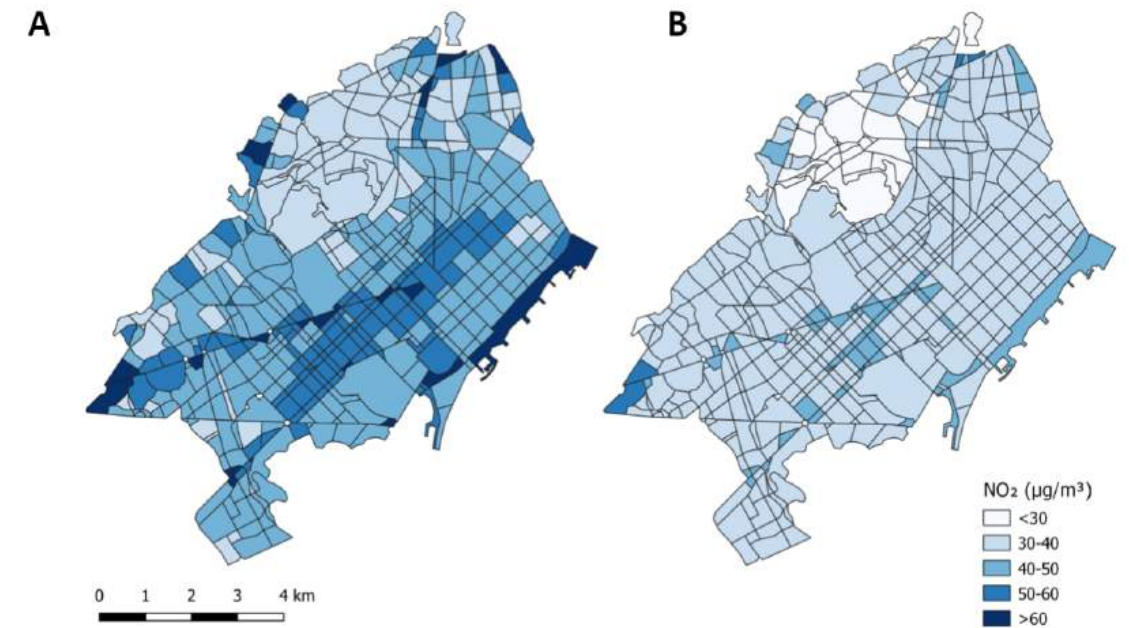


Figure 2.58: Modelled NOx concentration after complete implementation of Superblocks in B as compared to 2017 in A Source: [24]

Shared Mobility Services in Barcelona

Shared mobility services are increasing rapidly in European cities and it could be a good measure to solve the challenge of air pollution, noise, congestion, and the reduction of private transport. Each city is dealing with a different challenge while implementation of these services, so in this case study an analysis of the shared mobility services in Barcelona has been done. Shared mobility services are a good way of reducing and renewing the fleet of existing vehicles, reducing pollution, encouraging more sustainable mobility, managing to park and promoting vehicles with clean energy, such as electricity.

There are various private, public and cooperative shared vehicle companies (cars, motorbikes or bicycles) operating in Barcelona, working in different types of services: Free movement, with or without fixed stations, or circular movement.

People who use shared mobility services are not usually a habitual car or motorbike drivers. They generally have inter-modal transport habits and use alternative modes of transport to the car, such as bicycles, public transport or making journeys on foot. They use this type of shared vehicle service for regular journeys consciously: one 'car-sharing' or any other kind of shared vehicle can substitute up to five vehicles on the roads. [34] Therefore, it represents an important economic and environmental saving.

Shared mobility helps to mitigate pollution, encourage the use of bicycles and public transport, and boost electric vehicle use. Some of the stand-out advantages of shared vehicle services are:

- Saving on maintenance costs
- Better access to a vehicle
- The flexibility of a practically door-to-door service
- Best option to avoid the use of a private vehicle
- Reduction of vehicle possession and amortization costs.

The opportunities that shared mobility services can bring for Barcelona city as it's city council listed are as follows:

- Regulation of sharing in conjunction with different actions against pollution bonuses and incentives will allow to reduce and renew the current fleet of vehicles, for more vehicles efficient and fewer pollutants
- Optimal management of surface and underground parking (preferably in the underground and at a motorcycle in road and underground)
- Recovery of the public space of the city
- Promotion of electric vehicles

A very important impetus for the use of the bicycle and its standardization

Improved road safety (newer, safer vehicles with or without speed limits) lower speed.

Based on these opportunities and advantages Barcelona city started to make policies and strategies to regulate shared mobility services in the city. They started in 2017 to review and do case

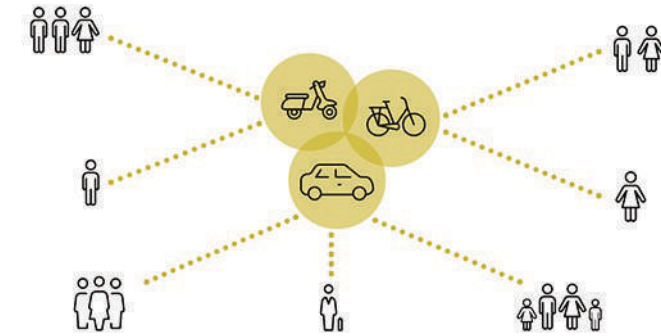


Figure 2.59: Shared Mobility services types in Barcelona [132]



Figure 2.60: SEAT Minimo carsharing model [134]



Figure 2.61: Respiro Carsharing in Madrid [135]



Figure 2.62: Motorbikes in Barcelona [34]

Shared Mobility Services in Barcelona

studies according to some other European cities like; Milan, Copenhagen, Madrid and Munich to provide a working framework for the businesses in this city. [132] Finally, in Feb 2020, they awarded several licenses for motorbike sharing and bike sharing for private companies to service legally in the city. [34] They are still working on regulation for carsharing services in Barcelona and as it's a dense city, they cannot permit carsharing companies to park cars on streets. Following a general explanation has been done about carsharing, motorbike sharing and bike-sharing in Barcelona.

Carsharing

Carsharing is a model of car rental where people rent cars for short periods, often by the hour. It differs from traditional car rental in that the owners of the cars are often private individuals themselves, and the carsharing facilitator is generally distinct from the car owner. Carsharing is part of a larger trend of shared mobility. Carsharing service in Barcelona is not permitted due to the parking problem. Shared cars are not allowed to park on the streets because of space lack. That's why SEAT is running a project with the cooperation of CARNET to analyze and provide underground parking for its carsharing services. [133] They will provide station-based carsharing services with many numbers of underground parking spot all-around their service area in Barcelona city. SEAT is running its car-sharing services by the name of Respiro in Madrid and like a pilot project in a municipality near to Barcelona by the name of L'Hospitalet de Llobregat. SEAT purchased Respiro and entered the carsharing sector for the first time in 2018. Launched nine years ago, Respiro is one

of Spain's carsharing platforms and has 15,000 users in Madrid. SEAT also recently announced it move into corporate carsharing to cover the needs of businesses and provide them with cars by the minute, hour and day in the city center, at the dealership and place of work as well.

One of the cars which SEAT designed to use for their carsharing services in Barcelona is SEAT MINIMO [133] which presented on February 25, 2019, at the Mobile World Congress for the first time.

Motosharing

As cities are facing a lot of congestion because of cars, so they are searching for good alternatives to replace the usage of cars in the cities. Barcelona is one of the leaders in this regard which is trying to shift more people from car usage to motorbikes which is taking less space, as they are electric almost zero emissions in the cities and it is a good example of smart mobility. Motorbikes account for 25% of journeys made by private vehicles in Barcelona and 7% of overall mobility in the city. [34]

Barcelona is one of the European cities with the most motorcycles and mopeds on its streets. There are more than 500,000 motorbikes in Barcelona as private and shared. [133] As a very flexible urban vehicle for use in the average short and medium distance journeys in Barcelona. The private motorbikes are both electric and consuming fuel.

Barcelona is a downward slope city, so people are

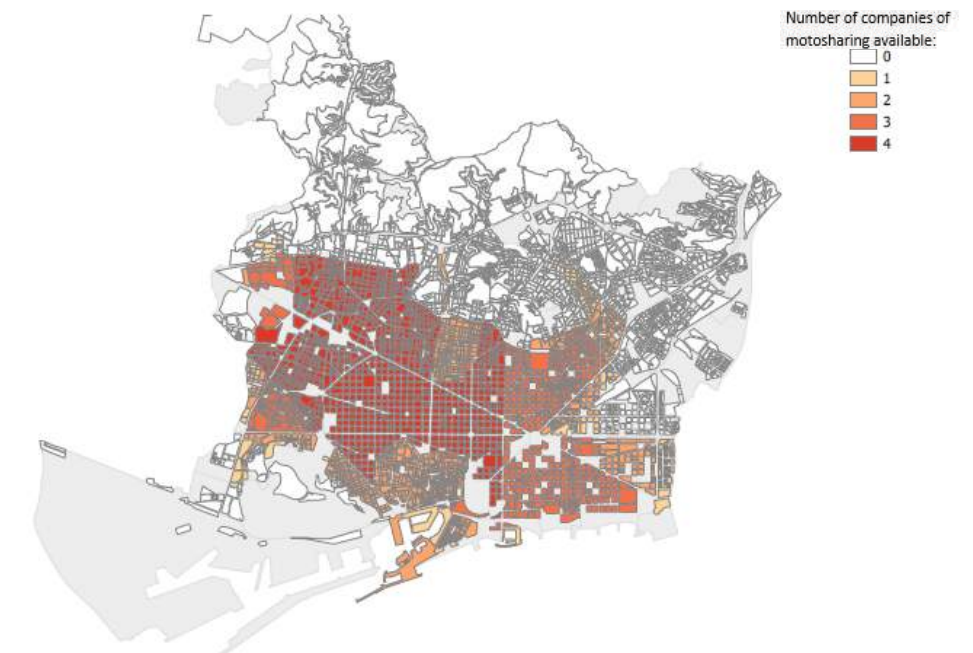


Figure 2.63: Motosharing coverage area in Barcelona [136]

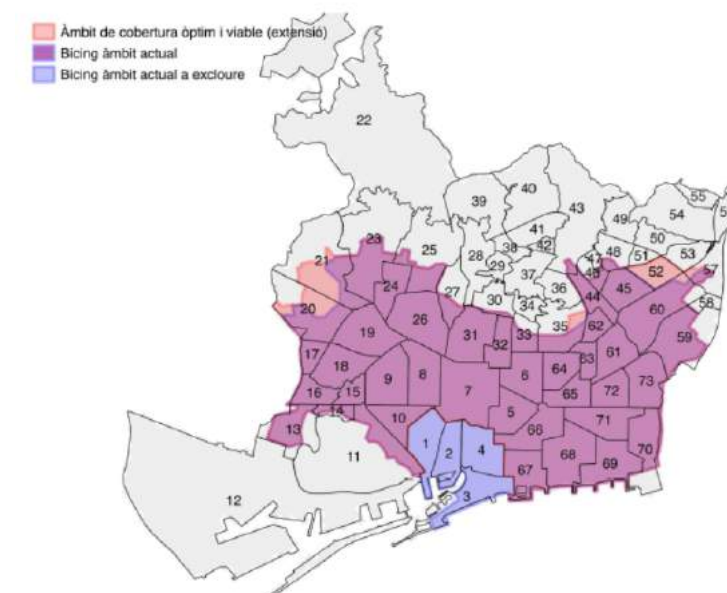


Figure 2.64: Current Viable coverage area of bike-sharing [132]

Shared Mobility Services in Barcelona

culturally adapted to the usage of a motorbike for their daily trips to go up or down in the city. This is one of the reasons there is a lot of private and shared motorbikes in the city, but the city council published safety regulation on Feb 2020 for private motorbike sharing companies and a framework.

This framework allows 21 companies to offer motorbike sharing services in Barcelona with a maximum of 300 vehicles in the city. Barcelona city is awarding 6,958 new licenses for motorbike sharing companies of which only the can award 2,319 to the same company. All vehicles should be electric. As the private once mostly consume fuel and it's polluting the city and the loud noise they generate while moving are the main reason that all shared vehicle designed to be electric. The electric vehicles are helping to minimize energy consumption and the ensuing emissions, as well as noise pollution.

Figure 2.63 shows the motosharing service area of 4 companies in 2017. The motosharing and bike sharing covering service area map which is proposed in 2018 by city council is about the same area in figure 2.63, which covers about 45.37% of the Barcelona area, and 83.34% of the population. [132]

Bike-sharing

Bike-sharing services are those which provide bicycles for the individuals as shared with a fee or free. These services can be station-based or free-floating. Usually, offered as public services by government or as businesses by private companies. In Barcelona, these services are like Bicing which is provided by the government and the other providers are the Donkey

Republic, Scoot which is currently providing bike-sharing in Barcelona.

As bike-sharing services were increasing and they were creating some problems in the city, the city council decided to limit the number of shared bikes in the city and regulate them by publishing a framework the same as motosharing and awarding several licenses for bike-sharing companies. This declaration establishes the total number of permits in the city and per company, which shall be allocated by the limits set out in the regulations and defines the procedure for awarding permits for shared-use bicycles in the city. It also sets out the terms and conditions of use of the permit and the duty to pay the charge for parking in the public space, approved by the Full Council Meeting.

The total number of permits for bicycles shall be allocated to companies that apply for them and meet the requirements. For the first year, the number of licenses for shared-use bicycles for economic exploitation is set at 3,975 for the entire city, of which a maximum of 1,325 can be awarded to a single company. 10 companies won the contract and the licenses awarded to them.

The users are renting bikes with the app in their smartphones, and the payment method is subscribing yearly or per ride. The bicycles are electric or mechanical. There are about 6,000 mechanical and 300 electric bikes which are provided by the Bicing public bike-sharing operator for the citizens. The Donkey Republic is providing about 800 mechanical bikes and Scoot is with 1,000 mechanical bikes servicing in the city right now.

Shared Mobility Impacts

Positive impacts of shared mobility on mobility and city are summarized as below:

Impacts on mobility:

- They influence the behavior of travelers as it increases the supply of means of transport, increasing intermodality and promoting the use of public transport and walking
- The shared mobility user gives up his car, increasing the more sustainable travel and rationalizing the use of the car and the motorcycle
- Reduction in the number of private vehicles and the total number of km traveled
- Bike-sharing is a good option for covering last-mile journeys

Impacts on the city:

- Decrease of the existing park of vehicles (1 carsharing = 5-20 cars)
- Renewal of the existing vehicle fleet, for more efficient and less polluting vehicles (reduction of the energy consumption and pollutant emissions)
- They encourage the management of the car park and reduce its demand
- Bike-sharing enhances the modal shift towards the bicycle and promotes its normalization in the city
- Free-travel systems (without fixed stations) increase accessibility when older capillarity and flexibility as a complement to public transport, as they balance the offer /demand between public transport and private vehicles at peak times

Negative impacts of shared mobility services are defined as below:

- - Strong

occupation of public space, which may lead to its privatization

- Problems of competition between companies (companies that operate under a local license) they do it without a license on the street)
- Free-travel models with or without fixed stations may increase the number of parking slots in some areas
- Some systems may harm road safety
- Bike-sharing generates overcrowding in the parking lot and hinders the rotation of bicycles
- Lack of civility in motorcycle and bicycle parking, which is difficult for businesses to control if these vehicles do not have geolocated vehicles or they do not have a strict internal control system.

Conclusion: Reconfiguring Mobility via Regulation

Cities are major hubs for resource, sharing and convenience act as development accelerators and will continue to expand and grow in density all throughout the world. Barcelona is a vanguard for an innovative and planned approach to tackle challenges of climate change and a traffic congested city. It combines economic development with providing sustainable and accessible means of mobility in a dense city. Barcelona's Urban Mobility Plan proves that density (in contrast to urbanization) is an opportunity for sustainable transport.

Barcelona has an overall city concept: organizing the city in urban cells, the Superblocks, where challenges can be met on a local scale and functioning solutions can be upscaled. This reduces mobility needs and increases active mobility within these cells which is the primary focus to convert transport progressively sustainable in the most effective manner. At the same time, the complimentary and efficient public transport grid interconnects the Superblocks in a sustainable mobility way. While the quadratic structure of large parts of the city facilitate this orthogonal bus network, the city manages to incorporate also more irregular structured districts. The hurdles during transition and eventual benefits of this approach will be a test of time.

Barcelona has a methodical and transparent mobility, energy and climate planning system and implements determined and targeted measures with extensive effects to transform the mobility in the city. Private mobility is of least priority and the city believes in spreading awareness through integrating sustainability in the municipality and set an example. The city does not shy away from rising controversies but tries to respond to them via extensive participation formats. It employs less high-technology based solutions with a sustainable perspective but rather focuses on restructuring and hard politics with quick transition and real consequences.

We expect Barcelona to transform its mobility landscape to a much more active mobility based scenario in the coming 10 years with a more uniform distribution of resources through Superblocks. Omnipresent in the mobility plans, the city embraces walking in its imaginaries of future mobility.

Through our research we can confirm that Barcelona is a global leader in terms of vision, strategy and in particular ambition for sustainable mobility (compare [2]).



Tallinn and Helsinki Table of Contents

About Us	107
City of Tallinn Factsheet	108
City Overview Tallinn	110
City SWOT ANALYSIS	115
City of Helsinki Factsheet	116
City Overview Helsinki	118
City SWOT ANALYSIS	123
Choice of Cities	124
Measures	126
Cluster 1: Electrification and automation of traffic system	126
TH.1.1 Automated Delivery (Tallinn)	126
TH.1..2 Autonomous Shuttle (Tallinn & Helsinki)	129
TH.1.3 Traffic Management Systems (Tallinn & Helsinki)	132
Cluster 2: Developing and integration of mobility options	134
TH.2.1. Different Ride-sharing operators (Tallinn)	134
TH.2.2 Smart Parking, Ülemiste Smart City(Tallinn)	136
TH:2.3 Park&Ride (Helsinki)	138
TH.2.4 Mobility-as-a-Service (MaaS, Helsinki)	141
TH.2.5 Open Data: Innovation Enabler (Helsinki)	144
TH.2.6 Smart Ticketing (Tallinn & Helsinki)	147
TH.2.7 City Collaboration (Tallinn & Helsinki)	150
Cluster 3: Redesign and network of mobility spaces	153
TH.3.1 Fare-Free public transport (Tallinn)	153
TH.3.2 City Innovation Office/Think Tank (Helsinki)	155
Case Studies	158
The Implementation of Autonomous Vehicles in Public Transport	158
Mobility as a Service (MaaS)	162
The Role of Smart Cities in Mobility	168
Conclusion	172

About Us



ABIOLA OLANIYI
Master's Program
Responsibility in Science,
Engineering and Technology
(RESET) at MCTS



BEYZANUR OZGUN
Master's Program
Management and Technology



CHRISTIAN FREIMOSER
Master's Program
Environmental Engineering at
BGU



FABIAN KUNTZ
Master's Program
Responsibility in Science,
Engineering, and Technology
(RESET) at MCTS



City of Tallinn Factsheet

Country	Estonia
Size	159,37 km2
Population (Estonia)	1.32 Mio.(2018)
Population (Tallinn)	438.874 inhabitants (2018)
Population Density	2.754 people per km2

Modal Split

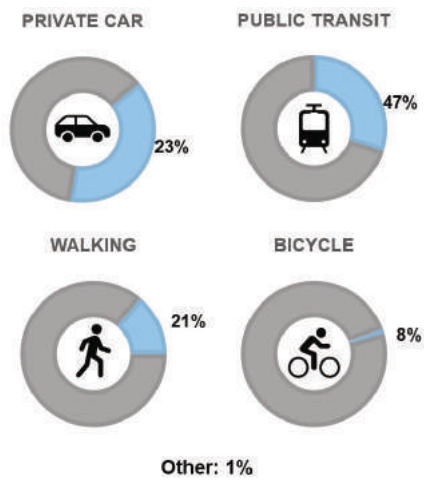


Figure 3.1 Tallinn Modal Split [8]

Key Analysis Area



Figure 3.2 Tallinn Area Map [3]



Congestion Level
(Annual Average)
31%



World Rank
111



Air Quality Index
(Annual Average)
22



Air Quality
Moderate

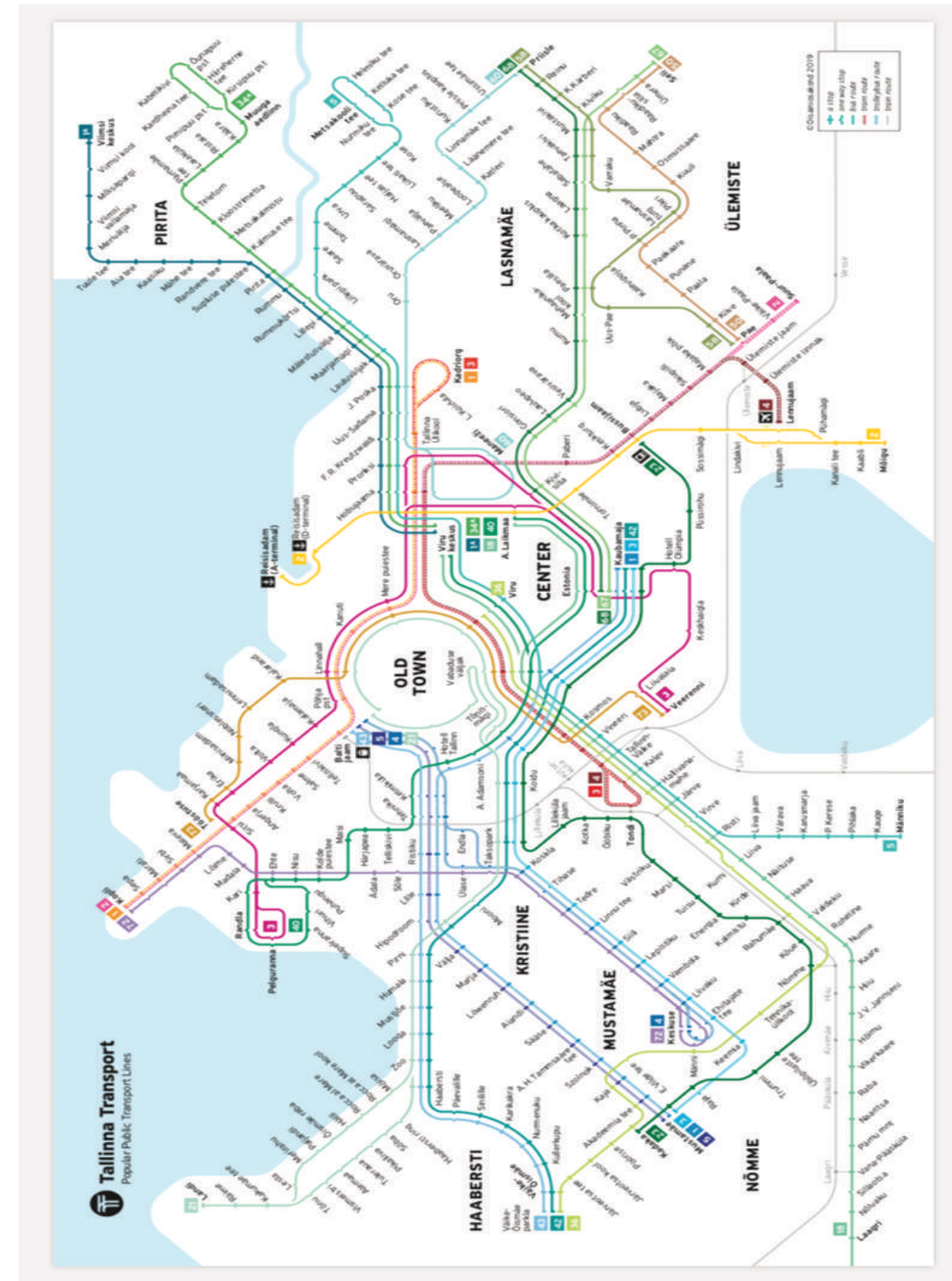


Figure 3.3: Popular Public Transport Lines Tallinn [7]

City Overview Tallinn

The Medieval Hanseatic city of Tallinn is Estonia's capital and the country's largest city. As well as being Estonia's centre of culture, finance and higher education, the historical part of the city is a UNESCO world heritage site and attracts tourists from all over the world every year.

Tallinn Region GDP:
32.890 EUR/per capita

Unemployment rate:
4,8%

Estonian Inflation Rate:
+3,4%

Vision of the city.

"In 2050, citizens in Tallinn enjoy an attractive, clean and quiet living environment that encourages sustainable behaviour. The cityscape is dense, so all services are within easy reach or are provided in the home. More public space is allocated to living, and less to motorised transport.

Smooth, seamless public transport connects all the city areas. Smart planning is used to respond dynamically to the changing demand for the transport of people and goods. The transport and ticketing systems around the Baltic Sea are integrated in a way that is simple, comfortable, affordable (free), clean and fast" [1].

Demography[2].

Average age: 39,7 for males, 46,4 for females

Largest age group: 30–34-year-old (39,958 of the total population)

Gender distribution: around 70% female, 30% male

Tallinn's subdivisions.

Eight city districts (City Centre, Kristiine, Northern Tallinn, Mustamäe, Nomme, Haabersti, Lasnamäe, Pirita)

Geography/City Structure[3].

Tallinn has a strategic location in the north-eastern part of the Baltic Sea region. A harbour city, just across the water from Helsinki, which is around 80km away. In the north of Tallinn is the Gulf of Finland, Russia in the east is around 150km away and Tartu, another big economic centre in Estonia, is located around 150km in the south-east of Tallinn.

Tallinn is between the Gulf of Finland and Lake Ülemiste, and the city is shaped like a bow tie, which causes traffic problems.

As already mentioned, Tallinn is a harbour city. This means, that the infrastructure and the city structure is highly developed in this area. The harbour area is only rarely elevated, whereas the old town is the highest point in the city center. The pavement in the old town is characterized by the historic cobblestones and different to the asphalt streets in the rest of the city.

Governance/ Political Authorities

Tallinn City Council is a representative body of Tallinn. It is a local government unit, elected by the voting people of the city and independent in deciding.

The City Government is the local government's executive body. The City Government fulfills the assignments given to it by legislative drafting, economic activity, control and the involvement of the residents. The Tallinn City Government consists of a total of seven members: the Mayor and six Deputy Mayors. The city districts are administrative agencies (8 agencies) whose statutes, structure, personnel, salary levels and conditions are approved by the City Council upon the proposal of the City Government[4].

Economic Aspects [2]

Almost half of Estonia's businesses have converged around the capital and its environs, and more than half of Estonia GDP is created in Tallinn. The distribution of Tallinn's larger investments are 34,5% for roads and streets, 0,7% for transport and 33,3% for education. In 2017, there were 14,772 companies with turnovers of more than €100 thousand, and 42 with turnovers of €100 million.

As of 1 January 2019, there were 24 companies per 100 residents in Tallinn, which means a total number of 105.000 registered businesses.

The largest enterprises in Tallinn (2014) are the following:

Free Monthly public transport pass for citizens and 30 EUR for others [7].

222 Mio. passengers per year [6]

City Overview Tallinn

	Name of Enterprise	Information
1	Ericsson Eesti AS	production of communications network equipment
2	AS Tallink Grupp	passenger and cargo transport on the Baltic Sea
3	Maxima Eesti OU	retailing
4	Selver AS	retailing
5	Neste Eesti AS	retailing

Table 3.1: Largest companies in Tallinn (by sales revenues) [5].

Furthermore, some innovative mobility companies are for example Bolt, Starship and Cleveron.

Education[2].

Compared to other OECD countries, more than twice as many students on average in Estonia study ICT (information and communications technology) subjects. Every year, one in ten students choose ICT (in Germany around 14 percent). There are 12 schools of higher education and around 10.000 students are graduating every year. Most students are studying Business, Management and Law, Technology, Manufacturing and Construction and Humanities and the Arts. Estonian students are furthermore according to the PISA result one of the best in the world.

Mobility Aspects.

Mobility Stakeholders includes the Transport Department of Tallinn City, Tallinna Transpordiamet, Ministry of Economic Affairs and Communications, Transportation and Traffic Division, Tallinna Linnatranspordi AS. Existing modes of transport are Buses, Trolley-Bus, Tram, Commuter train, Ferry, Bike and Scooter. The public transport fleet consists of four tram lines with 20 new CAF trams, 24 short trams, including 6 renovated retro-trams, and 12 low-bottom KT 6 trams; Four trolley-bus lines with 32 trolley-buses; 73 bus lines with a total of 414 buses, of which 44 are hybrid buses, and 17 are gas-powered buses; 88,3% of the buses, trams and trolley-buses have low bottoms (at least two low entrances), incl. 92.9% of the buses, 45.7% of the trams and 100% of the trolley-buses[2].

Commuting patterns/travel behaviour.

At present, Tallinn dominates in Estonia for its commuting volumes. 79,000 people travel to Tallinn and 41,000 leave the city every day for work, studies or other regular activities. The commuter trains are especially meant for the Harju County residents for a connection to Tallinn, but the routes are also used by city residents, especially of Nomme district. [8]

Tallinn Transport Network Statistics.

Roadways: 1.038km [2]

Sidewalks: 981km [2]

Cycling routes: 283km [2]

Tram routes: 20,0 Mio. trips (2014) [8]

Bus routes: 96,6 Mio. trips, 25,8 Mio trips (Trolleybus) (2014) [8]

Railway: 7,76 Mio. Passengers, 3,7 Mio. trips (2014) [8]

Car ownership: 145.000cars/440.000inhabitants (2016) = 330 cars / 1000 inhabitants[9].

Parking.

There are about 5,800 parking places in the paid parking lots: 650 in the Old Town, 500 in the heart of the city and 4,650 in the city centre. The number of parking places is constantly decreasing, but the number of cars is increasing. In public parking areas, the first 15 minutes of parking is free of charge[2].

Electric Mobility.

Tallinn plans to switch completely to electric mobility by 2035 (full bus fleet transition); In March 2011, Estonia established ELMO (Estonian electro-mobility programme), an innovative countrywide network of quick-chargers – the first of its kind in the world. The ELMO network was officially opened in February 2015 and consists of 167 CHAdeMO-standard quick chargers in whole Estonia. Charging points were distributed on all roads with dense traffic, in towns with over 5 000 people (27 in Tallinn) and next to frequently visited locations; pay for the charging facility, EV drivers can use the ELMO app on their mobile device or authorise payments using a radio-frequency identification (RFID) card. As a part of its national transport development plan, Estonia is committed to increasing the share of renewable energy in the transport sector to 10 per cent of overall consumption by 2020. [10]

Current challenges of the city [9].

- Car dependence & high levels of car use

- Lack of urban and transport planning
- Lack of multi-level governance collaboration related to urban planning
- Road Safety for pedestrians and cyclists
- Limited understanding of transport demand in and around Tallinn & lack of evidence-based policy-making
- Lack of taxes to discourage people from owning a car

Current approaches to tackle mobility issues[2].

- Public transport card: electronic, contact-less smart card (e-card), which proves your right to ride on public transportation; RFID-technology;
- Parking platform: mobile parking, shows permits, administration of penalties
- Park&Ride (P&R): the users are the drivers of vehicles who park their passenger cars or vans in P&R parking lots and travel to and from their destination by public transport; P&R ticket is an electronic ticket
- Real time information boards/Public transport prioritization: priority at traffic lights, less waiting time, fluent traffic

Projects.

Civitas MIMOSA (Making Innovation in Mobility and Sustainable Actions): CIVITAS MIMOSA is an innovative collaboration among five cities. In Tallinn, the goal was to improve the image of public transport by implementing priority systems and real time traffic management; funded by Horizon 2020; (2008-2012)[11].

City Overview Tallinn

POLIS: Polis is the network of European cities and regions working together to deploy innovative solutions for a more sustainable mobility. The aim is to improve local transport through integrated strategies that address the economic, social and environmental dimensions of transport; funded by Horizon 2020; 1989-now)[12].

CREATE (Congestion Reduction in Europe): Advancing Transport Efficiency; CREATE is an EU Horizon 2020 and Civitas project that aims to cut road congestion in cities by encouraging a switch from cars to sustainable modes of transport. Ten cities are participating in this project (2015-2018)[13].

E-ticketing project: Combination of ticket sales systems in Tallinn, Tartu and Helsinki, which would simplify people's ticket purchases and make traveling more convenient[2].

HUPMOBILE project: Organization of a study to prepare for a feasibility study of adaptive traffic light systems. In the course of the project, there are also plans to successfully test new services/solutions through mini-pilot projects; funded by Interreg Baltic Sea Region Programme; (2014-2020)[2].

FinEst Smart Mobility project: Creation of an interactive queuing system for heavy trucks in the Helsinki and Tallinn ports, in which directing the vehicles into the port takes place in real time based on the traffic situation and the ships' schedules; funded by Interreg Central Baltic Programme; (2016-2019)[2].

SOHJOA project: Promotion of the importance of the public transport chain for the city and for city transport, including the introduction of small automatic electrical minibuses, especially for traveling the first or last mile; funded by Interreg Central Baltic Programme; (2017-2020)[2].

SUMBA project: Organization of a feasibility study related to light rail transport around Tallinn and the modelling of public transport, along with the collection of the necessary input data; funded by Interreg Central Baltic Programme; (2017-2020)[2].

Conclusion

Tallinn was the first country to introduce free public transport for its citizens. Based on this, the city intends to continue to invest in the expansion of transport networks and thus improve the public transport experience, achieve its goals of environmental sustainability and better quality of life. The good economic environment and political guidelines promote innovation and make Tallinn one of the smartest cities in Europe. Prioritisation of pedestrians and public transport in the centre streets, expansion of pedestrian zones and reduction of on-street parking are the next steps towards an environmentally friendly mobility[14].

City SWOT ANALYSIS

Strengths

- Efficient eGovernance
- High simplicity of starting businesses
- Open for new technologies
- investor-friendly declaration
- Good infrastructure, especially in IT
- Innovative mobility companies, e.g. Bolt and Starship

Weakness

- strong dominance of the capital region
- small internal market
- limited resources

Opportunities

- eGovernance as an enabler of mobility innovations
- 5G standard already in use for new innovation possibilities
- One of the cities with the most start-ups per capita
- Development of new markets because of railway projects "rail baltic"
- Export of innovations in foreign countries

Threats

- Lack of specialists

City of Stockholm Factsheet

Country	Finland
Size	217 km ²
Population (Finland)	5,51 Mio (2018)
Population (Helsinki)	648.000 inhabitants; Helsinki Region: 1.49 Mio (increased by 0.7 % in 2018)
Population Density	2.986 people per km ²

Modal Split

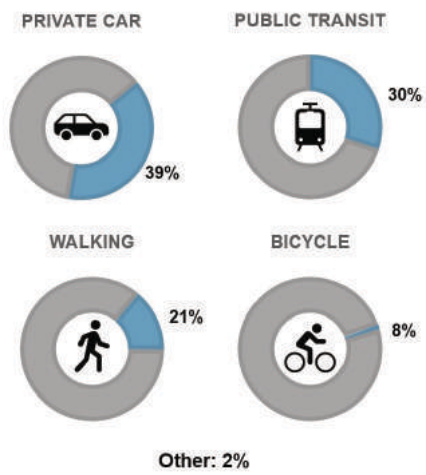


Figure 3.4 Helsinki Modal Split [25]

Key Analysis Area



Figure 3.5 Helsinki Area Map [16]

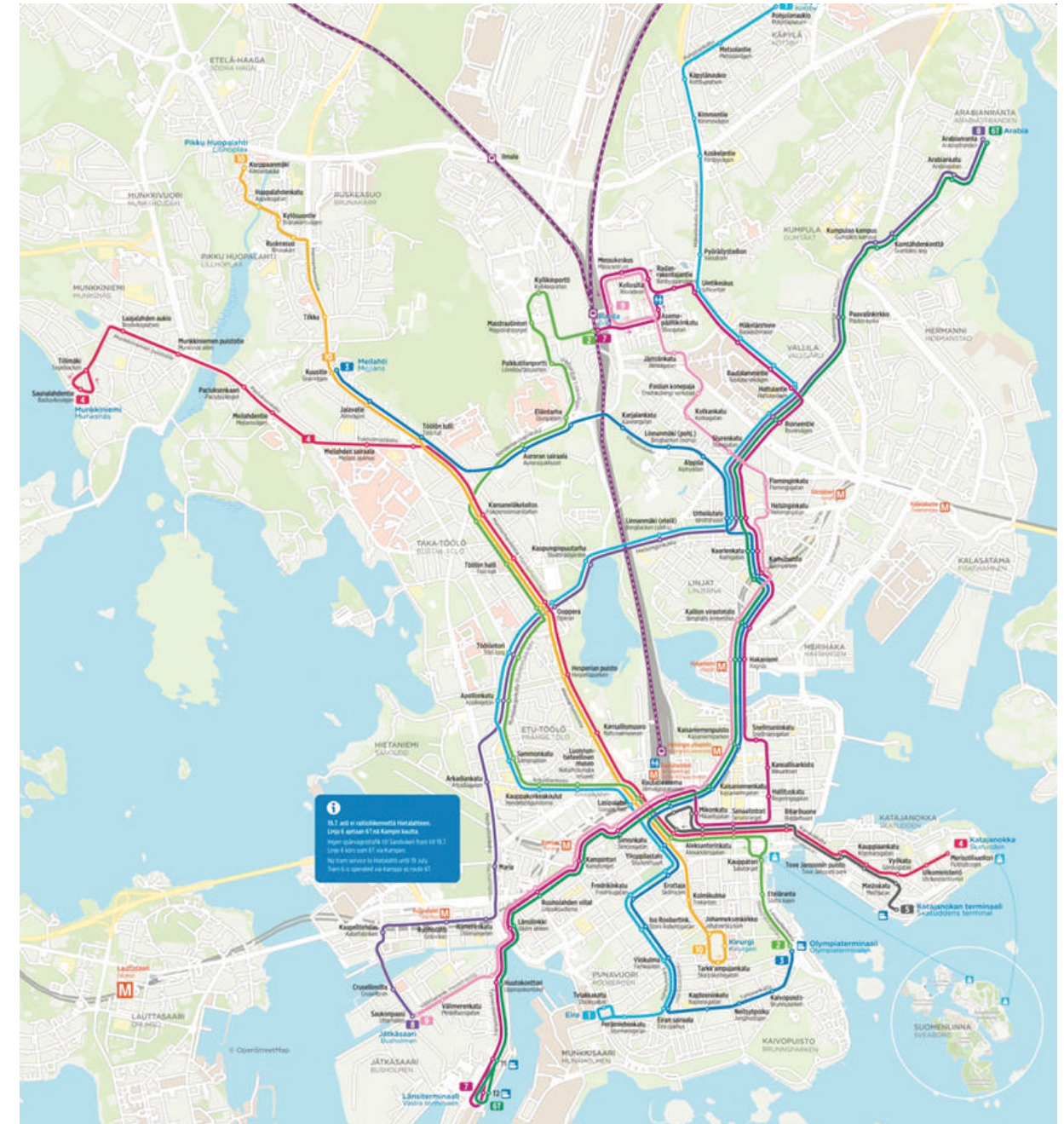
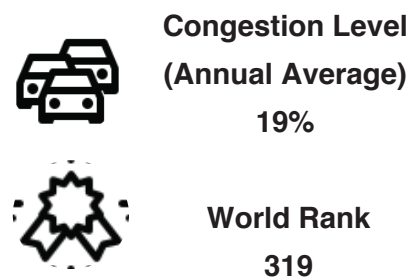


Figure 3.6: Tram Route Map Helsinki [31]



City Overview Helsinki

Helsinki is Finland's capital and its administrative, economic, scientific and cultural center. The metropolitan area covers 0.2 percent of the country's land area, with 19 percent of the entire population living there which generates 30 percent of the nation's total output[16][17].

Helsinki Region GDP:
54.444 EUR/per capita
[20]

Unemployment rate:
7,9% Helsinki; 7,1%
(Helsinki Region), 7,4%
Finland [16]

Finnish Inflation Rate:
+1,0% [19]

Vision of the city.

"In the future, Helsinki will be an urban, rapidly growing rail transport network city with expanding central areas coupled with other developing centers. Commuter trains and the metro will offer fast rail connections between the central areas and other parts of Helsinki. The light rail network will complement this traffic system, making it a highly efficient network. The city will be concentrated along the transverse traffic routes, the expanding centres and in what are currently highway-like areas. First and foremost, Helsinki is a city with a human scale. Urban spaces will be designed on terms that suit pedestrians, not vehicular traffic"[15].

Demography[16].

Average age: 40.7 years in Helsinki and 42.9 in Finland

Largest age group: 25–29-year-old (63,662 of the total population)

Gender distribution: 52,5% female and 47,5% male

Helsinki's subdivisions[16].

Helsinki Metropolitan Area (Helsinki, Espoo, Vantaa, Kauniainen) and Helsinki Region (additionally Kirkkonummi, Vihti, Nurmijärvi, Hyvinkää, Tuusula, Kerava, Järvenpää, Mäntsälä, Pornainen, Sipoo)

Geography/City Structure.

Helsinki is located in the very south of Finland at the Gulf of Finland and covers numerous islands, peninsulas and bays. Stockholm lies 400 km to the west, St Petersburg is situated approximately 400 km to the east and Tallinn 60 km to the south. Helsinki is a harbour city which means, that the infrastructure and the city structure is concentrated in this area. The pavement in the old town is

characterized by the historic cobblestones and is different from the asphalt streets in the rest of the city.

Governance/ Political Authorities[18].

The highest decision-making organ in Helsinki is the City Council. The Council elects the Mayor and four Deputy Mayors for the duration of the Council term. The Mayor serves as the chair of the City Board, and the Deputy Mayors chair the sector committees. The Mayor and Deputy Mayors are full-time elected officials. The Urban Environment Division consists of three segments, which are land use and city structure, buildings and public areas, and services and permits. The rescue function and the Helsinki City Transport (HKL) municipal enterprise are organizational units corresponding to segments.

Economic Aspects.

Helsinki is generating 30 percent of the nation's total output and is the strongest economic center of Finland [17]. There are 426.500 jobs in Helsinki and the gross domestic product is higher than in the rest of the country. The total turnover 2016 of all enterprises in Helsinki have been 79.8 billion EUR. [16]

	Name of Enterprise	Personel
1	Nordea Bank Finland Abp	3749
2	Posti Oy	3457
3	HOK-Elanto Liiketoiminta Oy	3076
4	ISS Palvelut Oy	2703
5	SOL Palvelut OY	2146

Table 3. 2: Largest Enterprises in Helsinki 2017 (by number of personnel) [16]

Furthermore, some interesting mobility companies and MaaS providers are for example MaaS Global, Kyyti and Perille,

Bus routes: 180
Mio.
passengers [21]

Rail transport:
approximately
200.000
passengers a
day, (72 Mio. a
year) [16]

City Overview Helsinki

Education[16].

Ninety-one per cent of 3-6-year-old children in Helsinki take part in early childhood education.

There are 41.245 students in universities of applied science and 41.240 enjoy university education:

- University of Helsinki: 31.331
- Aalto University: 17.346
- Hanken School of Economics: 2.545
- University of Arts: 1.968
- National Defence University: 963

The educational structure shows that 18 percent of the population has a Bachelor's degree or some equivalent level and 23 percent have a Master's degree. 21 percent enjoyed a vocational education.

Mobility Aspects.

Mobility Stakeholders: HSL, Helsinki Region Transport Authority, City of Helsinki, Transportation Department, Forum Virium as a Think Tank. The Public Transport is organised by the Helsinki Regional Transport Authority and operated by Helsinki City Transport.

Existing means of transport: Bus, Tram, Metro, Ferry, Commuter Train, Bike, Scooter

Vehicle fleet: 1.457 buses on 290 routes, 47 metros on 2 routes, 128 Tram Trains on 11 routes, 117 commuter trains on 14 routes and 5 Ferries on 2 routes. [21]

Passengers per year: 375 Million boardings (2 Mio. at Ferries, 60 Mio. at Trams, 65 Mio. at Commuter Trains, 68 Mio. at Metro and 180 Mio. at Buses) [21]

Monthly public transport pass: 53-124 EUR (depending on zones) [22]

Commuting patterns/travel behaviour.

Helsinki residents rely on public transportation. Seventy-one percent of all commuting to the city center during the morning peak hours is by the metro, trams (streetcars), commuter trains and buses. There is a heavy emphasis on rail in Helsinki's development plans. Trams are an integral part of Helsinki's new central districts, and the metro system is being expanded. [17]

Commuting is most popular around larger cities and growing hot spots, because the people are living outside the metropolitan areas and are working in the center.

Almost one-in-three of all employees commuted to their workplace outside of their residential municipality in 2015, around 5,5 percent covered a distance of more than 100 km. This development can especially be seen in the growing triangular hub of Tampere, Turku and Helsinki, which offers many employment possibilities. [23]

Furthermore, the biggest commuter group to Helsinki, Espoo and Tampere were software and applications developers and analysts, most shop sales persons commuted to Vantaa, and most nursing and midwifery associate professionals commuted to Turku. [24]

Network:

Helsinki has 3.450 public city bikes and 238 bike stations and 3.2 Mio. people are using this service [16]

Cycling routes: 1200km, 730km of them are paved

Tram routes: 45km, 60,2 Mio. passengers [21]

Metro routes: 35km, 67,5 Mio. passengers [21]

Commuter train: 64.8 Mio passengers [21]

Car ownership: one in three residents of Helsinki [26]

Car ownership: 213.000 cars/648.000 inhabitants

=329 cars/1000 Inhabitants [16]

Electric Mobility:

Electric cars currently constitute 1.3 percent of new cars. However, the Finnish government's new subsidy schemes for charging infrastructure can reduce "range-anxiety" issues and thus improve adoption. [27] Large-scale up-take of electric buses in Helsinki region will commence with the first 12 fully electric buses deployed to commercial operation in the pilot phase (2017-2018) and continue operation in a living lab environment. 10 % of the fleet will be fully electric in commercial operation by the end of 2021. [28] Currently there are around 4.700 electric vehicles and 25.000 plug-in hybrid cars in Finland [29]. In total, there are 76 charging stations in Helsinki [30].

Current challenges of the city

Congestion: Helsinki commuters lose eight working days a year sitting in traffic, which means around 17 minutes every day[32].

Air quality/pollution: Air quality is usually good in Helsinki compared with the large cities of Europe, but occasionally air pollution increases to hazardous levels in the city. Most frequently, the worsening of the city's air quality is caused by vehicular traffic, as its emissions are released at the street level and directly to air[33].

Increasing housing costs: Housing density in Helsinki is 34 m² of floor area per person, compared to 40.5 m² in all of Finland. Also the average monthly rent prices of a flat are around 40 per cent higher in Helsinki than in Finland[16].

- migration from the rural area, urbanization

Still high ridership of cars: making the public transport more attractive and providing affordable PT, without compromising city finances

Implementing smart parking with dynamic pricing: parking fees vary according to time and space; manage the parking situation and reduce parking pressure

Sustainability taking mobility solutions from test phase to deployment phase: bringing research or concept projects into real world environment, as e.g. autonomous buses

Current approaches to tackle mobility issues

Congestion fee: Congestion charges are the most effective way to steer mobility towards more sustainable forms of transport, that is, walking, cycling and public transport. Congestion charges would reduce hazards related to air quality, as well as noise, greenhouse gas emissions and congestion. Congestion charges would also help to mitigate climate change[34]. The congestion toll is not legal in Finland yet but it is in political discussion.

Projects.

MySmartLife: The project focuses on creating more environmentally friendly cities by reducing CO₂ emissions: Electric Buses in Operation, Electrification of Maintenance and Logistics, Autonomous electric buses; funded by Horizon 2020; (2016-2019) [28].

MUV (Mobility Urban Values): Encouragement of residents to change their mobility behaviour and make more sustainable mobility choices through illustration and gamification [35].

City Overview Helsinki

FABULOS (Future Automated Bus Urban Level Operation System): The FABULOS project focuses on how cities can use self-driving minibuses in a systematic way. The goal is to procure the operations of an automated bus line; funded by Horizon 2020; (2018-2020)[36].

Sohjoa: The SOHJOA Baltic project researches, promotes and pilots the use of driverless electronic autonomous minibuses as part of transportation services, especially in access traffic as a solution for the first or last mile; funded by Interreg Central Baltic Programme; (2017-2020)[37].

Interreg Europe: Interreg Europe helps regional and local governments across Europe to develop and deliver better policy, financed by European Regional Development Fund (ERDF); (2014-2020)[38].

FinEst Smart Mobility: The Helsinki-Tallinn smart mobility experiments constitute a Smart City living lab – a real-life environment in which users and developers cooperate in the development of new digital services; funded by Interreg Central Baltic Programme; (2016-2019)[39].

Central Baltic Project: The Central Baltic Programme 2014-2020 is a EU cross-border cooperation programme. The Programme supports projects in four priorities: Competitive economy, Sustainable use of common resources, Well-connected region and Skilled and socially inclusive region; funded by ERDF; (2014-2020)[40].

For further and more projects visit the Homepage of Forum Virium Helsinki[41].

Conclusion

Mobility in Helsinki is well-developed and the city's commitment to innovation is consistently driving further improvement to the system. The public transport system is highly reliable and accessible throughout the city. Cycling and walking are also popular, despite often-adverse climatic conditions.

Helsinki is also leading the way with Future of Mobility concepts such as MaaS and shared mobility. The successful launch of self-driving public buses could provide early lessons to cities looking to adopt similar technologies[27].

City SWOT ANALYSIS

Strengths

- Presence of apps based on MaaS
- High public transport adoption rates
- Deployment of autonomous buses in regular public transport services
- Fast adaptation of legislation/regulation/policies
- Commitment of providing open APIs
- Good IT infrastructure
- Transparent policy making

Weakness

- High tax burden
- Small and limited single market

Opportunities

- High development competence through a innovative start-up scene
- Export of innovations in foreign countries
- Development of new markets because of railway projects "Rail Baltic".

Threats

- Lack of skilled workers
- Urbanization causes negative development as congestion and concentration of social problems

Choice of Cities

Rail Baltic

The TEN-V 27 (Trans European Network) project „Rail Baltic“ will be completed until 2026 and will achieve a better connection of East Europe. This venture will create new economic corridors along the route and a very environmentally sustainable infrastructure. Furthermore, new inter modal transport solutions will be accomplished and Europe continues to grow together (Figure 3.7)[42].



Figure 3.7: Route of „Rail Baltic“ and cities of interest [43]

The section between Tallinn and Helsinki especially is part of our interest, the so called FinEst-Link.

FinEst-Link

The goal of this cooperation is to develop mobility between Helsinki and Tallinn and to improve transport links. The venture will also provide the framework for consolidating economic co-operation between both cities as well as investigating the economic impact of the planned underwater railway tunnel[44].



Figure 3.8: FinEst-Link between Tallinn and Helsinki [45]

The economic gap between both cities is large which causes an asymmetric mobility behavior. Workers are commuting from Estonia to Finland to benefit from higher wages, whereas people from Finland are travelling to Estonia mainly for tourism[46].

Already now nearly 10 million passengers are commuting from Helsinki to Tallinn and vice versa and the number is strongly increasing. With the new underwater tunnel, which reduces the travel time between both cities dramatically, the number will more than double by 2050 in contrast to only 40 per cent increase without the tunnel[45]. Furthermore, many mobility ventures and research projects are going on between both cities. For further details please have a look at the measures in Tallinn and Helsinki.

TH.1.1 Automated Delivery (Tallinn)

Autonomous delivery robots are operating in Kristiine, a district of Tallinn. They bring food and other supplies to customers in the area. The vehicles have a standardized size and can be filled with to-go food from restaurants or items from a supermarket. They operate autonomously by detecting obstacles like pedestrians, cars and crossroads. Their main routes go along pedestrian walkways. They cross streets either on calm byroads or at zebra crossings.

According to our observations, car drivers show a lot of patience when the delivery robots try to cross the street. Recharging works by replacing the battery in specific devices made for that purpose.

Problem being solved

Different solutions for food delivery currently compete with each other, e.g. delivery by bikes or by cars. All of them come with several disadvantages: bike deliveries have challenges in rainy weather conditions; car deliveries increase the already high car traffic. Automated delivery service hereby can reduce traffic. Also, it reduces the time that people need to spend if they pick up their foods or items personally.

Stakeholders

Starship Technologies is the company that developed the robots. They are now San Francisco based, but still have their engineering department in Tallinn[47]. An important stakeholder are the city administrations since they need to allow the robots to operate in cities or at least in parts of it. A third group are the customers who use the delivery services, either the restaurants or the users themselves: are they willing to pay the delivery fee of about 1,50 Euro? [48]

Expected result (vs. real result)

By allowing these automated delivery robots, Estonia and Tallinn hopes to become a forerunner for these kinds of services, which would attract companies like Starship Technologies to settle there. Since Estonian people are used to live in a very digitized country, no bad user behavior towards the robots was expected and in effect, did not occur.

Challenges of Implementation.

The speed of the robot vehicles is with 6 km/h [47] slow compared to deliveries by real car. In addition, the measures for a safe conquering of streets requires the robot to take long stops. The robots operate in Tallinn in an industrial area with big street and few pedestrians on the way. It might be more difficult to operate it in an area with a lot of pedestrians because the robot then needs to stop more often or make complicated sidesteps. In an early stage of the implantation, a car driver hit a robot while turning into a street. Following that minor accident, all robots now wear blinking lights. Another challenge came up when a wheelchair user reported that these robots block wheelchair ramps at traffic lights. This example shows how important it is to not weigh seemingly advantages against other mobility goals like a high accessibility. The developer of the robots

announced that they will investigate the issue and stopped the testing in regions where this problem occurred.

Legal Aspects

According to Estonian regulations, the robots must be smaller than one meter, longer than 1,2 meters, or weigh more than 50 kilograms. Also the look is regulated: The front and sides of the machine must be white, with red rear reflectors and lights for evening visibility [50].



Figure 3.9a Starship autonomous delivery robot (own photographs)

Technical Aspects

The delivery robots are designed in a way so that possible harming accidents risks are reduced to a minimum. For that, the robots are designed very light so that it could even harmlessly drive over someone's feet [49].

The batteries of the robots are replaceable. The robots are able to autonomously drive to battery changing stations and get their nearly empty battery changed with a loaded one. That allows the robots to operate without long stops.

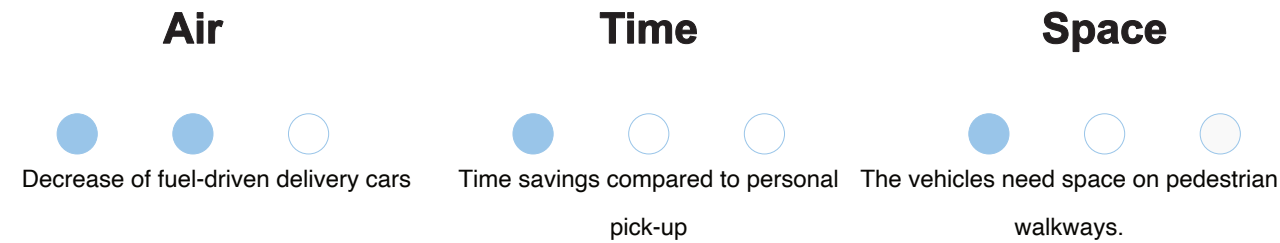


Figure 3.9b: Starship autonomous delivery robot (own photographs)

Applicability to Munich

Food delivery services are already part of Munich's traffic. A testing of delivery robots might make sense in industrial areas or in areas with big pedestrian walkways and easy-to-cross car traffic.

TH.1.2 Autonomous Shuttle (Tallinn & Helsinki)

Autonomous (self-driving) vehicles have been touted as vehicles of the future. They are vehicles that navigate autonomously at sub-50km/h speeds along predetermined, learned paths and provide an attractive, flexible solution to move people around industrial campuses, city centers, or suburban neighborhoods, connecting such areas with main mass transit systems, significantly improving public transportation [51].

These shuttles also known as the Robot bus in the City of Helsinki and Tallinn twin-city development strategy aims at providing smart & environmentally friendly public transport to reduce the need for private cars, or even eliminate it [52]. Pilots to be discussed include the SOHJOA BALTIC project and FABULOS bus project [53][54].

Problem being solved

Automated shuttle buses are commercially viable options for regional transportation first and last-mile services by taking riders from public transit station to stops near their homes & offices. Typically, these routes cannot be operated with conventional buses but could become feasible with driverless buses [57][58].

Stakeholders

Decisions to implement these shuttle buses are made by the European Union, Federal Government, City Transport authorities and City Administrators. Stakeholders for both projects have included top-high ranking universities in the respective cities (Metropolia University of Applied Sciences, Helsinki and Tallinn University of Technology, Tallinn [59]. City Administration offices and also innovation companies who design these buses (Navya Technologies, IseAuto, etc) [58][60][61].



Figure 3.10: Navya Autonomous Shuttle [55]

Expected result (vs real result)

Autonomous shuttle bus implementation in public transportation should provide a better service level and user experience for more extensive clientele. (Elderly, disabled people, accessibility). However, real results show that autonomous technology is not quite ripe enough to make a fleet of robot buses remotely controlled [61].

Challenges of Implementation

Autonomous vehicles would have already been implemented if existing infrastructure excluded humans

and their unpredictable behaviour. There is a need to redesign streets, transport plans and cities as using these shuttles on busy streets is currently problematic [49]. Issues that cropped up during the pilots include shuttles having problems identifying the road when it snowed, battery issues due to extremely cold or hot weather, mechanical faults etc [49]. Socially, many citizens do not understand why such vehicles will be used and if they are safe or not. Economically, the technology is not cheap or readily available, most of the available technology is in the innovative stage [62].

Duration

Autonomous shuttle buses were first piloted in Helsinki in 2015 and 2017 in Tallinn [52] [56]. To be implemented into the city's current public transport system, the pilot projects have to determine if the technology is ready [63].

Financial Aspects

The Sohjoa project budget is funded by the Interreg Baltic Sea Region programme of the European Union to the tune of MEUR 3.7. The project will run from October 2017 till September 2020 [54]. The FABULOS project also received MEUR5.8 from the European Union Horizon 2020 research and innovation programme and will run from 1 January 2018 until 31 December 2020 [62].

Legal Aspects

In Tallinn and Helsinki, legislation for autonomous vehicles have been modified to include "the presence of a natural person, not necessarily in the vehicle but also

a control room [60]. An AI task force has also been appointed in Estonia to regulate AV's, so there are no changes to traffic laws [64].

Impacts

Best results in terms of reducing emissions and congestion is achieved when private car trips are replaced with shared rides. Leaving private vehicles at home requires that there is a wide range of, and above all public, transport services available. For example, CO2 emissions from cars could fall by 34% in Helsinki with the introduction of autonomous shuttles, thus reducing congestion by 37% [65]. Unlike human drivers, autonomous shuttles could hypothetically run all day, pausing only to recharge its batteries. This allows for an efficient allocation of resources, savings of fuel and maintenance which would drive down transportation costs considerably.

Technical Aspect

In order to achieve the ambitious goal of safe, fully autonomous driving within urban areas, vehicles have been equipped with many sensors. These sensors essentially convert a normal car into a type of robot, adding new functionalities for control such as perception and Artificial Intelligence (AI) [51].

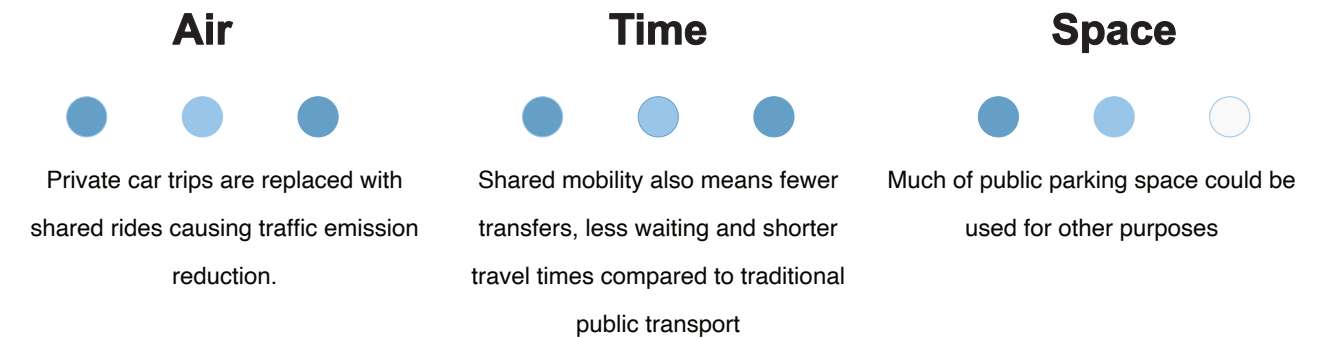


Figure 3.11: Easyride Autonomous Shuttle [66]

Applicability to Munich

Munich is becoming another hub of autonomous vehicle technology due the city's automotive manufacturers the topic and are already working on research and innovation [67][68][69]. To implement these shuttles, current laws need to be reanalyzed, as automated driving has significant implications for civil liability when a driver can no longer be held accountable for accidents. Currently, 50% of Germans will not pay extra for vehicles equipped with self-driving features as its safety is still the number one concern[70]. A more pilot testing, and a sensitization of

citizens is needed to understand how the technology works and to gather a better variety of results. However, there is already a project titled "Easyride", run by the City. Stakeholders include the BMW Group, Stadtwerke München, Technical University of Munich among others. The project is funded by the Federal Ministry of Transport and Digital Infrastructure with MEUR6.6 [18]. The pilot will take place at the Olympiapark till the end of 2020 and results will be evaluated and culminate in concrete recommendations. The implementation of these buses can help to solve emission and urbanization problems.

TH.1.3 Traffic Management Systems (Tallinn & Helsinki)

The services of the Traffic Management systems in Tallinn and Helsinki include the upkeep of an up-to-date situational picture of road traffic, traffic control, traffic information and incident management in cooperation with public authorities[72]. Traffic Management Systems in both in both cities include the Ports of Tallinn and Helsinki to control car and cargo traffic.

With 9 million passengers a year, these ports have become the busiest in the world [72]. There is a traffic light priority system in both cities to handle traffic pressure during rush hour and specific periods. There are also vehicle restricted zones in both cities (notably the city centres). This has cut off vehicle traffic, reduced the use of cars and increased the use of other means of transportation to get to the city centre [73][74][75]. There are open real-time traffic situation reports where citizens can also play a part as participatory observers. Citizens are actively involved in helping the government also to collate information on the current traffic situation [76].

Problem being solved

The focus is on safe and seamless traffic. These can be improved by up-to-date traffic communications and efficient management of incidents, which can be done using various traffic management systems on the roads such as traffic light systems, vehicle restriction zones etc [72].

Stakeholders

In Finland, the Traffic Management Finland is in charge. Departments include: Finrail Oy is responsible for the control and management of rail traffic; Intelligent Traffic

Management Finland Oy (ITM Finland) is responsible for the control and management of road traffic; Vessel Traffic Services Finland (VTS Finland) is responsible for maritime traffic management, and Air Navigation Services Finland (ANS Finland) is responsible for air navigation [72]. In Tallinn, the Transport Department oversees the Traffic Management Systems [77].

Expected result (vs real result)

To provide and developing services that ensure safe and fluent transportation [72].

Impacts

Better traffic management systems can cause reduced traffic emissions Smoother travel chains increase the share of public transport by reducing travel times and helping with the planning of journeys.

Technical Aspect

For traffic management systems to work, the use of Artificial Intelligence to control infrastructure like smart pedestrian lights, traffic lights, up to date control centre and open data

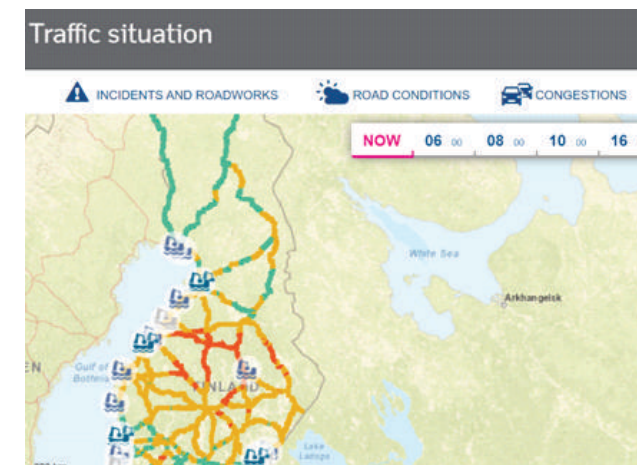
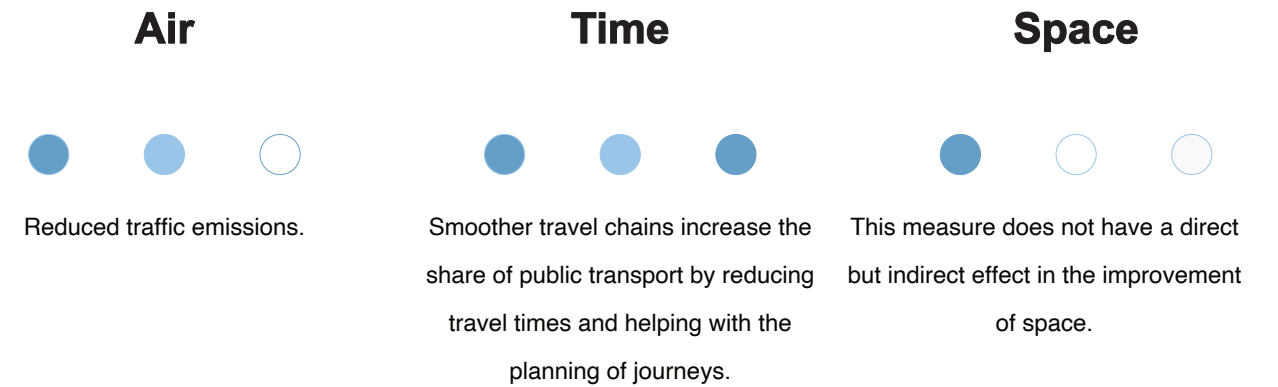


Figure 3.12: Traffic Management Finland real-time traffic situation report [76]



Figure 3.13: Smart City Pedestrian Crossing [154]

Applicability to Munich

Traffic management systems are already implemented in Munich. However, these systems can still be upgraded with automation to improve traffic safety and enable intelligent traffic control to help more people especially emergency vehicles. Intelligent traffic services increase competition, introduce new modes of transport on the markets and allow the choice of more affordable modes of transportation. There is a growing global demand for intelligent traffic services, as the same mega-trends influence development all over the world.

TH.2.1. Different Ride-sharing operators (Tallinn)

Ride-sharing operators that matches passengers with car drivers offer citizens a comfortable way to get from A to B. Citizens in Tallinn can choose between different service providers for ride-sharing: Either they use BOLT, the player with the highest market-share, followed by Uber, and local taxi companies.

Problem being solved

Ride-sharing operators address the need of people who don't have an own car. Even if people usually rely on public transport, there might be some routes where public transport connection is bad or not given at all. Also, travelling at specific times or at bad weather conditions, e.g. at night or at rainy days, might limit the public transport options. In addition, as a first mile solution to train stations or as a last-mile option from train stations to the final destination, ride-sharing operators might be a useful supplement to existing structures.

Stakeholders

Stakeholders are the ride-sharing companies who are asking for market access as well as the national regulators and the city regulators who are the ones to decide about operating licenses and conditions.

In Tallinn, these are:

1. Bolt (formerly: Taxify)
2. Uber
3. Local taxi operators
4. City of Tallinn

Expected result (vs. real result)

The ride-sharing-operators might lead to a decrease of car-ownership because people might not need an own car anymore if they use public transport in combination with these ride-sharing opportunities.

Challenges of Implementation

The operations rise questions about the background of the drivers (e.g. if they have a driving training for carrying other passengers), the maintenance of the cars (e.g. if all seat belts are working) and the labor conditions of the drivers. Also, the cars may be ordered to positions where it is difficult to stop to load new passengers, e.g. at main roads or other busy streets. In locations with many expected passengers, e.g. malls, it might be useful to determine specific spots for the loading and unloading of passengers, something that should be agreed on with city officials.

Financial Aspects

The investments are made by the ride-sharing companies themselves. For customers, different operators in place lead to a competition for low prices. Uber, who has high market shares in many countries, only has a small market share in Tallinn, because its competitor bolt offers lower prices.

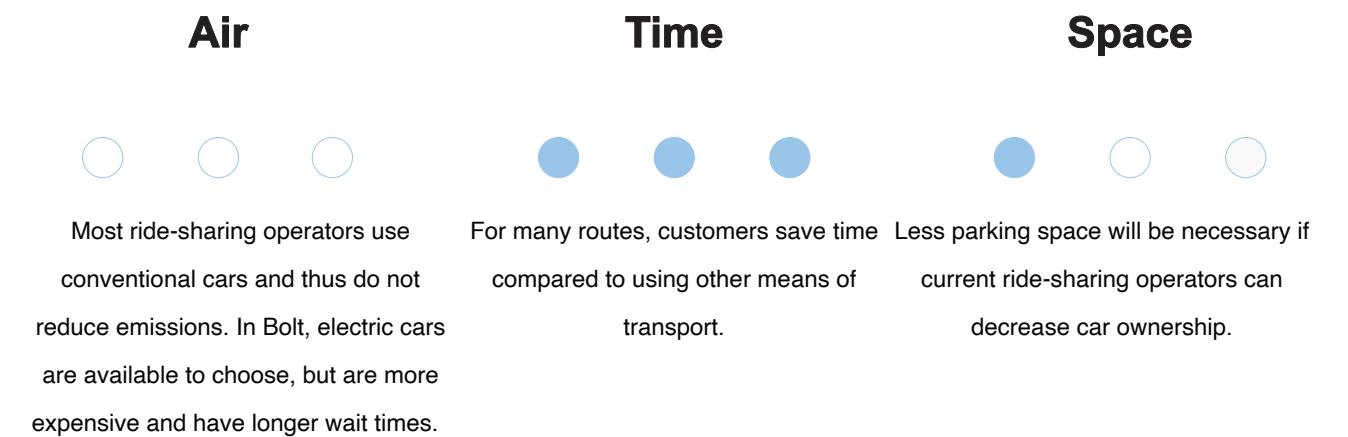


Figure 3.14: Bolt in Tallinn [78]

Technical Aspects

Both operators, Bolt and Uber, work with an app. Customers open the app which automatically detects the customer's location. He or she can then choose the size and propulsion of the car (e.g. a conventional car, or an electric car) and sees the estimated waiting time and the estimated price for the ride. After booking the ride, a driver will show up after some minutes, depending on the location and time of day.

Applicability to Munich

Ride-sharing operators like UBER and CleverShuttle are already operating in Munich.

TH.2.2 Smart Parking, Ülemiste Smart City (Tallinn)

Existing cameras are used to determine free parking spots in Ülemiste, a district of Tallinn. Ülemiste is currently the largest Smart City in the Baltic. There, citizens can find free parking spots through the Ülemiste website or through guiding on site.

Problem being solved

Finding a free parking spot usually takes a lot of time at the end of a ride, which also leads to higher emissions. That time to search for free parking spots is reduced if not eliminated with that measure.

Stakeholders

The main stakeholder in Tallinn is the operator of Ülemiste City. Sufficient parking spots were planned with from the beginning and existing surveillance cameras are used to detect free parking spots.

Expected result (vs. real result)

The time to find a parking spot for people who work or live in Ülemiste city, or visit it for business or shopping, will be reduced. Car drivers will be guided to free parking spots close by. Unnecessary driving will be reduced with this measure.

Challenges of Implementation

Any new implementation of surveillance cameras raises ethical questions because they interfere with people's privacy. This is also valid for adding another use case to surveillance cameras. It needs to be very specific and in according to data protection and privacy laws what data will be used and who has access to it, if

and where it is stored, for how long and in what format. Technical possibilities to increase anonymity should be used, e.g. a person recognition is not necessary to detect free parking spots and should therefore not be implemented.

Financial Aspects

The investments are made by the ride-sharing companies themselves. For customers, different operators in place lead to a competition for low prices. Uber, who has high market shares in many countries, only has a small market share in Tallinn, because its competitor Bolt offers lower fares.

Technical Aspects

On the website of Ülemiste city, visitors can see at any time where there are available parking spots. They can see the amount of free spaces, of total spaces and the price for short-term parking, daily parking or monthly parking as well as if parking is free for some time. The detection of free parking spots is done AI-based by using existing surveillance cameras. The software detects when cars depart and leave a free spot or when a free spot is going to be used[82]. With this method, no additional sensors are needed.

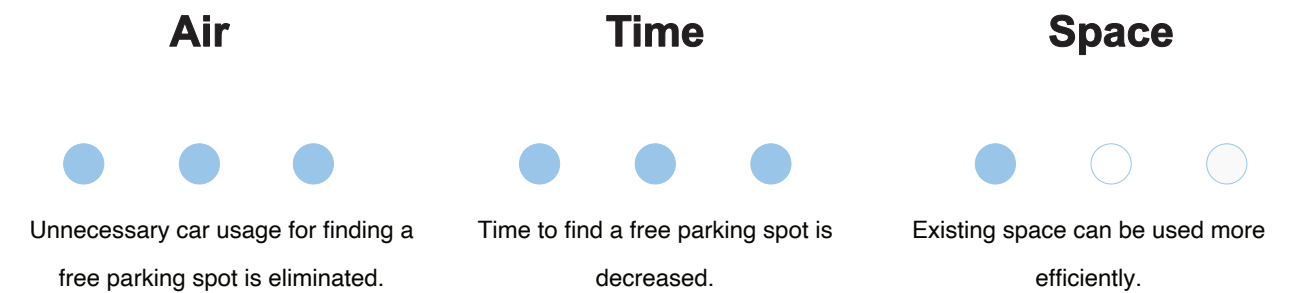


Figure 3.15: Picture of a shopping mall with a large parking spot in Ülemiste City [80]

Applicability to Munich

The problem of finding free parking spots is a common one in Munich, especially in the city center. Smart parking solutions can make sense here. With the Tallinn method, no additional sensors are necessary; the systems work with existing surveillance camera in combination with an AI-based software. However, we don't have information on how many parking spots would already be equipped with

such cameras. If new cameras were built, it is important to consider all applicable privacy laws and the additional privacy needs of citizens. A challenge is to decide who would operate the cameras and who would be in charge of giving maintenance to any new additions.

TH.2.3 Park&Ride (Helsinki)

Park and Ride is one of the solutions to tackle Helsinki regions growing population and traffic by encouraging citizens to leave their cars outside the most congested areas and continue their trip with public transportation. HSL Park and Ride application contains all the important information about parking facilities and their services near public transportation hubs. Public transport users can benefit from this solution free or paying less than others. Drivers are able to see the number of available parking spaces for cars and bicycles on the map.

Problem being solved

Most people prefer to live in the city. Others living outside of the city are likely to commute to the city for job, education and health purposes. This causes congestion, especially in the city centre. In Helsinki, the number of cars on the streets and traffic has doubled in two decades.

In the centre, parking is allowed only in specified places, and it is usually subject to a charge during the week between 9:00 and 21:00. This also applies in certain places during the weekend. Parking time is restricted[84]. There is not enough space and also not enough parking lots for all these cars. Therefore, it is worth considering travel via public transport while visiting the city. Park and Ride facilities might encourage the residents to leave their cars. Moreover, it is also a convenient way to avoid traffic jams, especially during rush hours.

Stakeholders

HSL/HRT (Helsinki Region Transport) offers these parking spaces for all the citizens. Car and bicycle owners are able to park their cars in these lots free or for few euros if they have the public transport card.

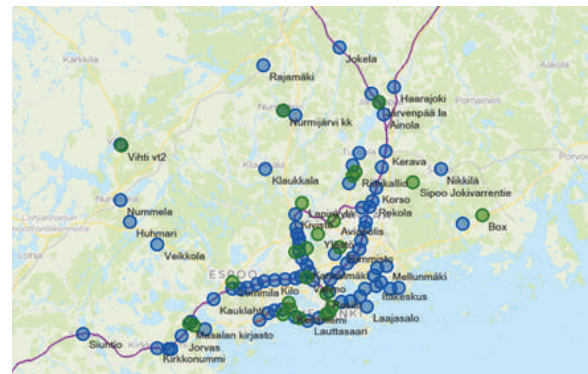


Figure 3.16a: Maps showing the available parking lots [83]

Expected result (vs. real result)

The expected result is for the residents to park their cars on the outskirts of the city and continue their journeys by public transport. However, it is also possible that these spaces are used as drop-off/pick-up locations or regular parking spots in case they are close other facilities.

Challenges of Implementation

Not everybody use these parking spots and commute to the city center with public transport. Due to time, comfort, availability and so on, they may still prefer driving to the city.

Financial Aspects

Regular parking places are divided into three payment

zones. Since there is limited space, parking in the centre is more expensive than other zones. Private parking facilities are also available in the city centre. However, Park & Ride facilities are usually free of charge for commuters. Commuters using their public transport card are able to use this service free of charge or paying small amounts. Others have to pay more to park their cars in these areas [84].

Impacts

The decrease of vehicle distance traveled lowers the emission in the city. Parking the car and commuting to the city via public transport is likely to decrease the time spent in the traffic and searching for a parking lot inside the city. This additional time may be used for work or leisure. Also, these facilities may decrease the street parking and the need for parking spaces within the city

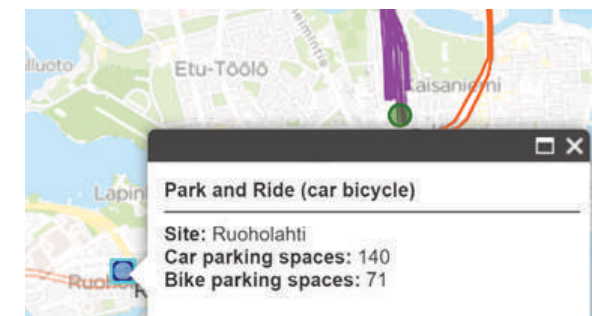


Figure 3.16b: Maps showing the available parking lots [83]

Technical Aspects

The HSL app that the drivers can get information about the locations and availability of these parking lots is developed as an open source project in GitHub [85]. HSL also provides its Park & Ride information system API which includes static and real time information. The data is maintained by municipalities and operators via a browser-based user interface. Anyone can include this information in their mobile applications.

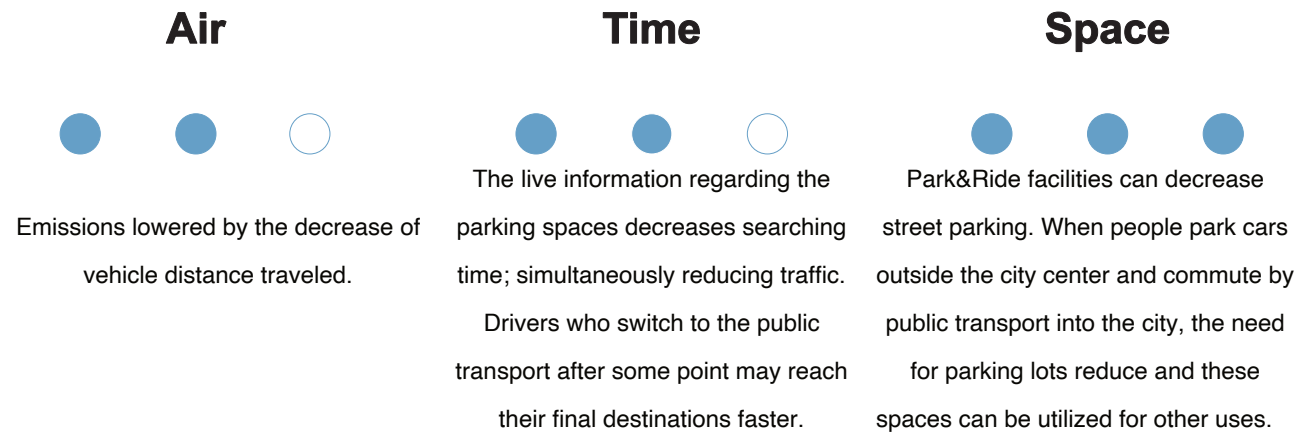


Figure 3.17: Bicycle parking spaces [83]

Applicability to Munich

Park & Ride facilities are also available in Munich. Even though they are not free for public transport users, they are quite cheap compared to the parking facilities in the city centre. Daily rate for most of these facilities are around € 1.00 - 1.50, which is quite affordable for car owners [86]. Non-public transport users can also use these parking lots when they are willing to pay more. Cars enter these facilities through gates, and no additional sensor systems

are needed to determine the number of available spaces in a parking lot. In order to make parking easier for drivers, sensors showing the available spots with numbers or lights could be used.

Since Munich is more populated and also car usage in the modal split is higher than Helsinki, there are more parking spaces needed in Munich. In order to decrease congestion and street parking in the city centre, Park & Ride facilities should be promoted heavily.

TH.2.4 Mobility-as-a-Service (MaaS, Helsinki)

According to MaaS Alliance, Mobility as a Service (MaaS) is the integration of various forms of transport services into a single mobility service accessible on demand [87]. This service is usually a mobile app including a journey planner, a booking and payment system and real time information. Therefore, all tickets can be purchased online. Depending on the service provider, different modes of transportation (public transport, car/bike sharing, taxi and on demand services, etc.) could be used as Pay-as-You-Go or via monthly subscriptions. [88]

Whim App: is the app which is developed by MaaS Global in Finland. It is the first all-in-one solution in the market which is commercially available and allowing users to travel with public transport, taxis, bicycles, cars and many other options. The app first launched in Helsinki in 2017. At the beginning of 2019, 3 million journeys using Whim app have been reached. They also operates now in Birmingham and Antwerp and still expanding their operations. [89]



Figure 3.18a: Whim App [89].

Problem being solved

Each mobility service provider (public or private) had its own app for people to use their services. It was almost impossible to plan a journey from A to B without using more than one mobile application. People had to sign in different applications as well to buy tickets or to pay for their journey. In an ideal world, people should have only one app for all kinds of mobility services independent from the operators to plan their journey, purchase their tickets, use various services in a fast, easy and seamless way.

Stakeholders

Government: In Finland, all transport providers are required to provide access via open APIs to information on timetables, routes, ticket prices, as well as real-time

location data. The legislation entered into force on 1 July 2018. This legislation has made it easy for third parties to use this information and built their own mobility apps. This act represents Finland's vision of MaaS and open data [90].

MaaS provider: In this ecosystem, MaaS Global is the layer between transport operators and end-users. Their main goal is not only to provide a great user experience, but they also have a societal goal: reducing car ownership. For this reason, they try to create an open ecosystem that all players and the users can benefit from it.

Public Transport Operator (HSL/HRT): HSL/HRT (Helsinki Region Transport) is the public transport operator in Helsinki. In addition to Whim, HSL/HRT also has its own app that enables users to plan their journey

with different public transport options and purchasing single, daily, or monthly tickets. In this section, city-specific players of the ecosystem are examined. However, more information regarding MaaS stakeholders could be found in the Mobility as a Service case study.

Expected result (vs real result)

Decrease in car ownership is one of the end goals of MaaS concept. As MaaS is a new concept, it is not easy to talk about its effects on car ownership at this moment. However, a research conducted by Ramboll using the first-year user data of Whim app and the results show that Whim users ride public transportation more than their Helsinki Metropolitan Area counterparts [91].

Challenges of Implementation

Nonetheless, accessing to open data is easier in Helsinki compared to Munich, not all the providers have the same format and quality of data.



Figure 3.18b: Whim App Interface [79]

Availability of e-ticket and e-payment systems are also an important factor. When dissatisfaction occurs, users will likely to see Whim as the responsible even though it would be from the service provider. Therefore, it is important to choose companies wisely not to damage its reputation.

Duration

The company was founded in 2015 but the app went live in 2017. At the beginning of 2019, 3 million journeys using Whim app have been reached. In 2018, Whim was launched first in Birmingham and then in Antwerp.

Financial Aspects

All the MaaS apps which are used in Helsinki are developed by private companies. They work together with all the providers, usually on a commission basis, to finance these apps

Legal Aspects

The legislation which requires all the mobility service providers to open their APIs is one of the biggest enablers of the MaaS concept. Transport operators allowing a third party to sell their service is a must have.

Impacts

The ultimate goal of the MaaS concept is reducing the car ownership. Even though more time needed to reach this goal, in the future it is likely to have an impact regarding reducing emission, utilizing the space in the city and time spent in the traffic. At this moment, the MaaS app helps people not only to find the fast and most convenient but also the greenest travel options.

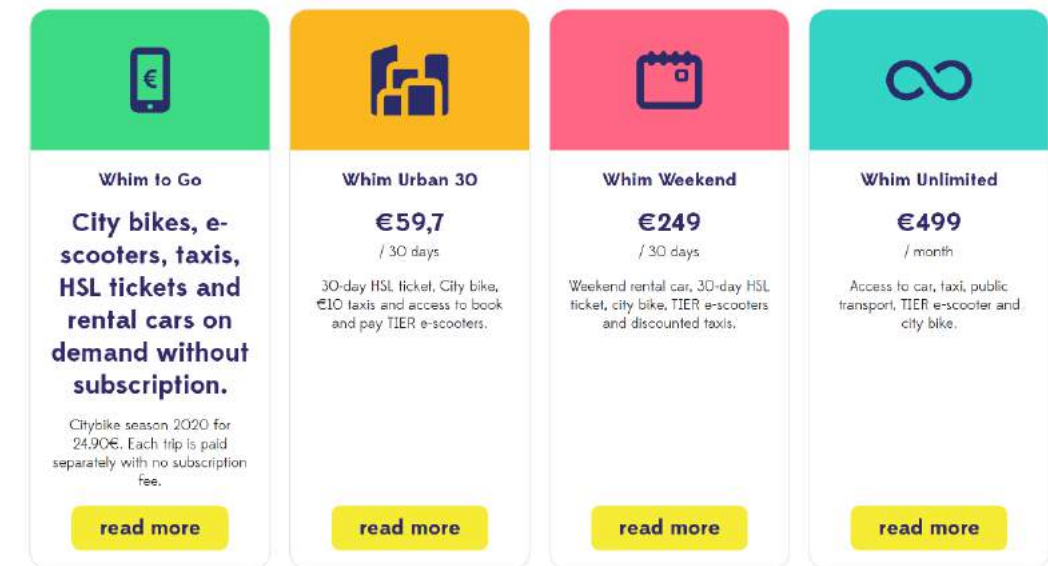
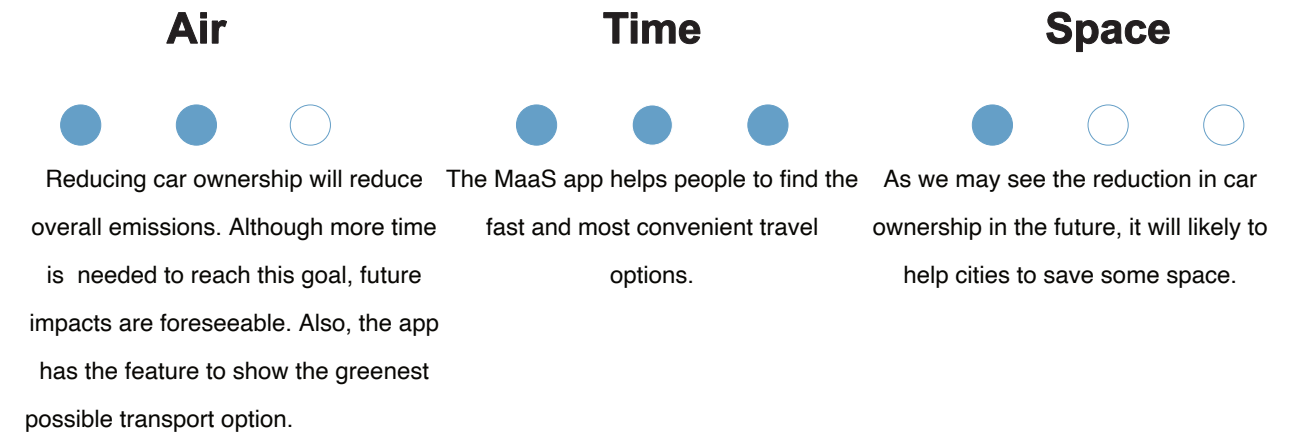


Figure 3.19 Subscription models. Source: Whim website [89]

Technical Aspects

Google maps infrastructure is used in the app. The timetables, capacity, ticketing etc. are available as open public data. Also, private APIs from mobility providers to integrate into the app.

Applicability to Munich

There are various mobility players in Munich. Even though there are some mobile applications with different

features, an all-in-one solution is needed for Munich. A strong collaboration between public and private mobility providers is required to make this real. A sovereign presence of automotive industry working on car-sharing projects in and around Munich is an opportunity for the city to carry out a MaaS app. Their years of experience in mobility may help the other players to understand the needs of Munich residents with a different point of view. However, their willingness to collaborate is an important factor.

TH.2.5 Open Data: Innovation Enabler (Helsinki)

Cities continuously collect and produce data which are used in the planning, production and decision-making processes. Since 2011 Helsinki metropolitan municipalities have been opening up these data. Over 1000 data sets have been created so far. Everybody can access this data via the HRI (Helsinki Region InfoShare). It is possible to see various data falling under different categories as housing, traffic, construction, maps and so on. Helsinki's public transportation authority opened all relevant transportation data for anyone to use.

This also includes ticketing which allows the third parties to sell public transport tickets. Moreover, a legislation including all transport providers entered into force on 1 July 2018. It required them to provide access to their timetables, routes, tickets and real-time location information via open application program interface (APIs)[90]. Consequently, not only the municipalities but also the other transport providers have to open their data.

Problem being solved

Open data increases citizens' knowledge and understanding of their living area, its history and future development. This increases the overall activity, participation and interaction of citizens. Open data can be seen as a facilitator for creating new services and business opportunities, as well as supporting research and development. The value of public data increases the more when it is used. Moreover, the legislation for all mobility providers to open their API's has made it easy for all parties to use this information. Anyone who



Figure 3.20a: HRI Logo [93]

Stakeholders

Opening up all the data for public use was the project of Forum Virium Helsinki, the City Innovation Office, which is wholly owned by the city. First, municipalities have opened up their data. Citizens, private and public companies, universities are able to use these data to develop solutions for the city. However, the obligation of open API for mobility providers is decision at a national level. Local and national governments are involved in this process. Citizens and companies are communicated in the decision afterwards.

Expected result (vs. real result)

The number of visitors on the HRI website has grown

steadily. At the moment, the monthly traffic amounts to approximately 9,000 visitors. There have been about one million page views and more than 67,000 downloaded open data sets [94].

Challenges of Implementation

There were mostly technological difficulties as not all the mobility providers have the same quality and amount of data to share.

Duration

The idea of opening up the municipality data came up first in 2009 and implemented in 2011. Also, the open data law came into force in 2011.

Financial Aspects

Over 1000 data sets created so far with public funds. They are free even for the commercial use. Start-ups and citizens have developed mobile apps using the open data that City provided. In 2013, HRI was awarded

a 100,000 Euro prize by the European Commission. This has helped the utilization of open data. Municipalities also benefit from this project due to the development of several useful apps that they would need to spend a lot of money.

Legal Aspects

The legislation made it obligatory to share their data for the mobility service providers.

Impacts

This measure does not have a direct impact on improving air, time and space. However, open data is a significant enabler of mobility innovation and the solutions which are developed using open data may create environmental impacts. They should be taken into consideration while looking at this measure.

Technical Aspects

Application Programming Interfaces (APIs) allow anyone to use open data with integration to their applications. This integration can be done by anyone who has the necessary know-how. Not all the data the city and other mobility providers own have the same level of quality. Thus, some improvements have to be made accordingly.

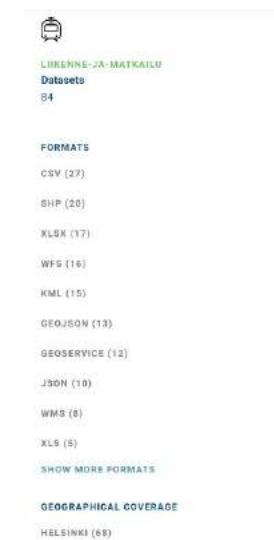


Figure 3.20b: HRI datasets [93]

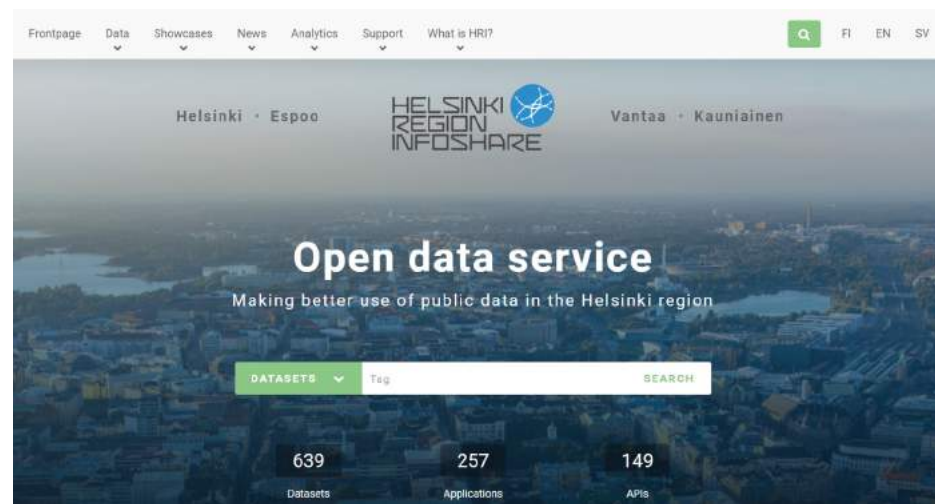
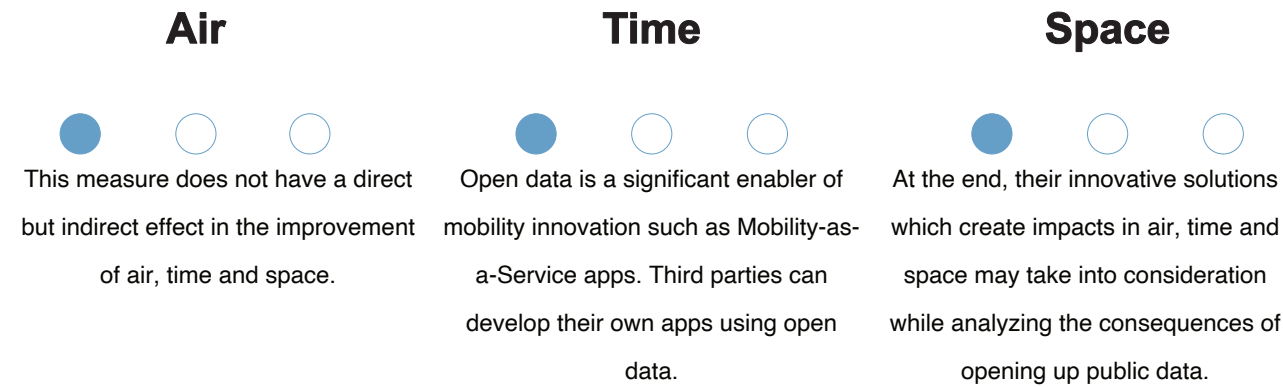


Figure 3.20c: HRI website [93]

Applicability to Munich

The opening of data is inevitably progressing all around the world. Despite the great potential benefits of open data as an enabler of innovation, there are some points of tensions to pay close attention to [95]: Power to grant access (who controls the access), data origins (how the data is produced and retained), the purpose of use and managing databases (data processing and governance). Cultural, historical and political differences between Munich and Helsinki should be taken into consideration before opening up the data for public use. For this measure to be applicable in Munich, some legislation might be changed and all specific challenges taken into consideration. Opening up public data needs a planning phase and the assurance of maintenance of such

data. We believe that the city has the necessary managerial and technical know-how and also high-quality data to be opened for public use. Thus, this measure can be applied as soon as the necessary bureaucratic steps are taken. If all the points above are clarified and the measures were implemented, there will be a significant public benefit. With its start-up scene, big universities and talented students from various backgrounds, many innovative solutions could be developed using public data in Munich. The longer Munich waits for this measure to be applied, the more opportunities will be missed. We recommend the city to implement this measure as soon as the crucial constitutional and technical steps are taken.

TH.2.6 Smart Ticketing (Tallinn & Helsinki)

Only separated by the Gulf of Finland, the Estonian and Finnish capitals see the integration of their urban mobility systems as a powerful means of improving the quality of life of their residents; as such, there is a plan to harmonize their public transport networks and create a common ticketing system for travellers who use both cities' public transport networks [96][97]. The digitalization of public transport tickets is opening opportunities for further integration.

Estonians and Finns will soon be able to use the same public transport apps to pay for public transport tickets in Helsinki, Tallinn and the Estonian city of Tartu. In a unique European project, Tallinn and Tartu local public transport apps will also expand to the Helsinki region, and the Helsinki Public Transport Agency's HSL travel app will also offer Tallinn public transport tickets [98][99].



Figure 3.21: City of Tallinn smart card validation [100]

Problem being solved

Due to the high volume of cross-border mobility traffic between these cities, harmonizing the city tickets would be the right thing to do. Expanding the apps will make life a lot easier, especially with the arrival of transport cards which can be used in both countries on public transport vehicles and being able to pay with contactless cards in the Helsinki area [102].

Stakeholders

When completed, the project would enable residents of each country to use the same electronic farecard to pay for rides or provide proof of the right to a free ride in Tallinn and Helsinki's public transport systems [98]. Stakeholders involved the city of Tallinn – lead partner, Helsinki Regional Transport (HSL – Helsingin Seudun Liikenne) and City of Tartu.

Expected result (vs real result)

There are plans for tickets to be sold for each city through Helsinki's and Tallinn's public transport app. However, due to validation machine issues and a legal case, the Helsinki Public Transport Authority decided to withdraw from the project [103] [99].

Challenges of Implementation

In Tallinn, customers can buy tickets on vehicles, including using contactless payment. But, in the Helsinki region, there are two options: find a ticket machine or download the HSL app from the Helsinki Public Transport Agency (HPTA) and connect it to a bank card. For casual travellers to Helsinki, this is relatively troublesome, and there is not always a ticket machine at every public transport stop [99]. It was also currently reported that the Finnish start-up company MaaS Glo-

bal had filed a complaint with the Finnish Competition Authority. Their business model is based on a multi-modal subscription service for service in cities which includes travelling by public transport, taxis and rental cars. When asked, the company did not give a clear answer as to why the Helsinki Public Transport Agency's decision to sell Tallinn tickets has affected them [103].

Duration

Due to these hiccups, the measure has unfortunately not been implemented. It is part of a long-planned combination travel service for use in Helsinki and Tallinn and will first be available as a mobile app.

Financial Aspects

The project is funded by Interreg Central Baltic to the tune of MEUR2.61and will run from 1 May 2018 – 30 April 2021 [104]

Legal Aspects

While, the current plan is to sell these city tickets at no added cost, there have been questions asked by the HPTA who stated that selling Helsinki transport tickets is a statutory obligation. There now is confusion about selling other company tickets. The HPTA argued that sale of other city tickets can pose an economic loss and vice versa. Thus, the transport authority failed to include Estonian tickets in its app [103].

Impacts

It is expected that the time spent on travelling can be reduced approximately by 5% [104].

Technical Aspect

The key technology behind this measure will be smart cards that use NFC tap and pay. There is a current need to consolidate smart card machines on both ends for the ticket harmonization to work. However, the city of Helsinki needs to replace its current validation machines to match those of Tallinn. This is because Helsinki's ticket validation machines are older fashioned than in Tallinn.

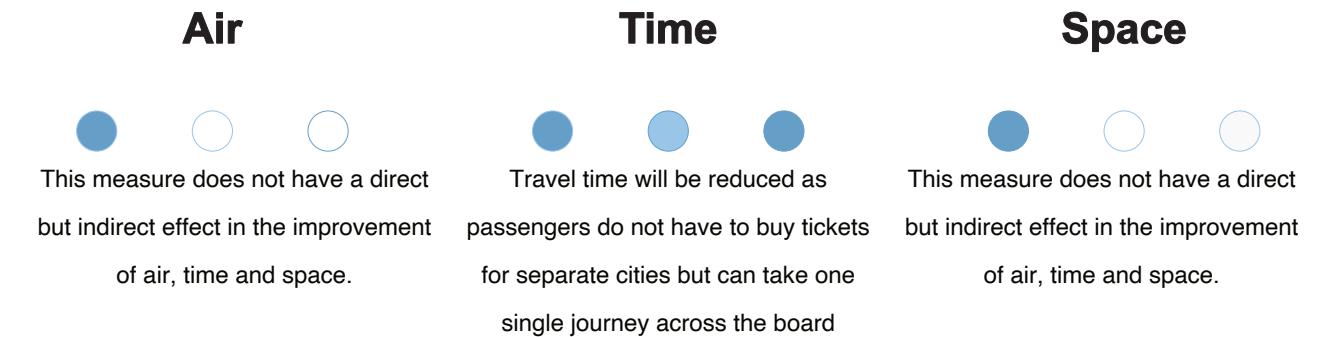


Figure 3.22: City of Helsinki smartcard validation [101]

Applicability to Munich

To implement this in Munich, transport operators would need to open up their API/data for other operators. There would also need to be a serious overhaul of current infrastructure, i.e. smartcards and newer validating machines are needed, mobile applications. Benefits would include less travel time as already pointed out This would be a good initiative if it can be carried out all over Germany, this way it is easier to implement a Europe wide transportation card if needed. Currently, there is currently no such implementation in Munich as impeded by the current infrastructure. This measure is essential; cities are

beginning to make transport ticket purchase easier, smoother and faster. Implementing smart ticketing is a secure way to do this. As there is already good and up to date research on this technology, such a measure can be implemented as soon as possible. This would enable the city to carry out testing, and purchase all necessary infrastructure [105]. There is no specific method for choosing cities to harmonize transport systems with. However, important criteria to consider includes distance, cities with substantial commuter traffic to Munich, current ticket validation systems and a pricing structure

TH.2.7 City Collaboration (Tallinn & Helsinki)

Sustainable, intelligent transport solutions and cooperative mobility planning to solve cross-border mobility dilemma have helped to mitigate border congestion & other negative externalities borne out of the large traffic volumes passing through cities [102]. Such a project is the FinEst smart mobility, it has enabled knowledge transfer on mobility solutions, innovation procurement and partnerships, and deepened the know-how on the role of digital innovation for the transport sector. A similar project is the Rail Baltica project.

Problem being solved

At the core of both projects are the Helsinki–Tallinn connections, but also the improvement of traffic connections between Finland and Estonia. The objective of the FinEst project is to reduce emissions, noise and other negative impacts of traffic in the ports and cities of Helsinki and Tallinn. It aims to tackle these challenges through intelligent traffic solutions [102]. It has been estimated that the Rail Baltica railway connection from Tallinn to Warsaw will be completed in 2025. Prior to that, it is important to make the traffic between Helsinki and Tallinn run as smoothly as possible, both in terms of freight traffic and passenger traffic [106] [107].

Stakeholders

Stakeholders include the city of Helsinki, city of Tallinn, Maanteeamet (Estonian Road Administration), Forum Virium Helsinki and ITL Digital Lab. Pilot companies include Fleetrange Ltd., GoSwift OÜ, Infotripla Oy and Kyyti Group, Helsinki Regional Transport Authority with support of Port of Helsinki and Port of Tallinn [102]. The citizens of both cities would benefit from the cross-border mobility as it will make commuting easier.



Figure 3.23: Finest Smart Mobility [102]

Expected result (vs real result)

Results include the access of traffic management systems to predictive and real-time traffic information that helps them to react to changes in traffic. Ferries can be integrated into regional journey planners as an integral part of passengers' travel chains [102]. There was valuable expertise in innovation procurement, and co-development of smart mobility solutions and open data helped to bridge gaps between country-specific infrastructures.

Challenges of Implementation

Sharing such confidential transport information and data with other cities may pose legal problems. This also presents ethical and social challenges as data security has become an important topic in the EU. Although in theory, open data is an adequate solution, it also prese-

ts risks. While, open data can stimulate economic growth and spur innovation, enhance policy-making and foster citizen participation in political and social life and increase the transparency of government, it can also be incomplete, falsified, used wrongly and bring about un-anonymization thus creating even worse consequences than solutions. Strategies that pose a potential risk to data usage need to be handled pragmatically and carefully.

Duration

The FinEst smart mobility project was implemented from 2016 – 2019. However, the Rail Baltica project is still ongoing, with an estimated completion in 2026. There has been a considerable amount of planning from both cities to bring these projects to fruition.



Figure 3.24: Rail Baltica [106]

Financial Aspects

The FinEst smart mobility had a budget of MEUR1.8 budget (cofounded by Interreg Central Baltic and European Union Regional Development fund) and the Rail Baltica which will cost BEUR5.8 is co-financed by the Connecting Europe Facility of the European Union [91] [95].

Impacts

The aim of these projects is to allow for lower levels of CO2 noise and pollution in the ports and surrounding residential areas [102]. There is also reduced transportation time for passengers and cargo. Improved sea-land multimodality and end-to-end experience [102]. These new affordable and agile solutions can also allow for the modification of physical infrastructure [102].

Technical Aspects

To carry out these projects, there was an implementation of better traffic management systems and traffic apps

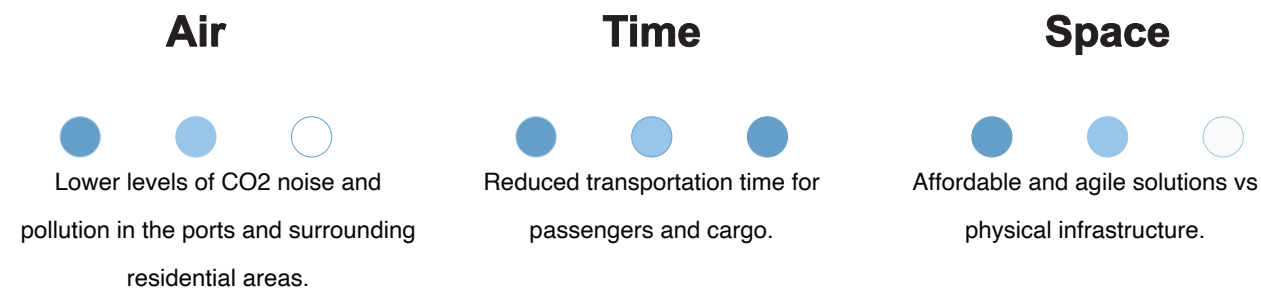


Figure 3.25: Finest Smart Mobility [108]

Applicability to Munich

This measure can be implemented in Munich. What would be needed is the willingness of a partner or a neighboring city. Challenges include the cities/country to collaborate with. Due to the position of Munich on the map, it might be hard to pick specific cities for collaboration. However, cities such as Augsburg, Nuremberg, Salzburg (Austria), Innsbruck (Austria) are great places to start. Collaboration benefits include the development of an economic growth corridor and a good way for the city to build more opportunities for its inhabitants across borders. Planning

and development of the measure can be accelerated as the city already has links to other cities in Europe and even in Germany.

TH.3.1 Fare-Free public transport (Tallinn)

Tallinn offers free public transport for its citizens since 2013. It was the first European capital to do so. Residents of the city can register for a green card which allows them to use the buses and trams for free.

Problem being solved

First, the measure solved the problem that people who lived in Tallinn didn't officially register there. Because the free public transport is only granted to Tallinn inhabitants, the number of inhabitants increased significantly after the measure was introduced. Second, this measure contributes to a reduction of noise, traffic and air pollution because more people use public transport – however it is unclear if this increase is derived from a general trend or from the measure itself. In the long run, a reduction of car ownership should be reached with this measure; however this cannot be observed yet in Tallinn.

Stakeholders

The stakeholders here is the city of Tallinn as well as the public transport operators who need to find a way to get financed. The residents of Tallinn are stakeholders here.

Expected result (vs. real result)

The measure to provide public transport free for residents may lead to an increase of public transport usage and in a decrease of car ownership. Since people financially benefit from free public transport, they might use public transport more frequently than their own car.

Challenges of Implementation and financial aspects

When the gains out of ticket sales diminish, the public

transport needs to be financed in other ways.

In this case, the city of Tallinn pays for public transport. The city itself gets more funding from the national level since the number of citizens with an official residence in Tallinn has increased with the measures' implementation.

Another challenge is to provide sufficient buses and trams while simultaneously keeping the service level high enough so that public transport doesn't lose attractiveness. In addition, the social meaning of private car ownership should not be underestimated. If private cars are connected to showing social status, it also needs a cultural change and not only a financial one to bring people switch to public transport.

Duration

The measure was implemented in 2013 in Tallinn. In 2015, other Estonian counties and cities followed, e.g. Tartu and Saare County.

Technical Aspects

Residents who are eligible for free public transport need to register for a so-called "Smartcard" which can be purchased at specific sales points. When entering a bus or tram, the passenger needs to show that card to a reading device and a green light indicates that the card is valid and entitles for a ride.

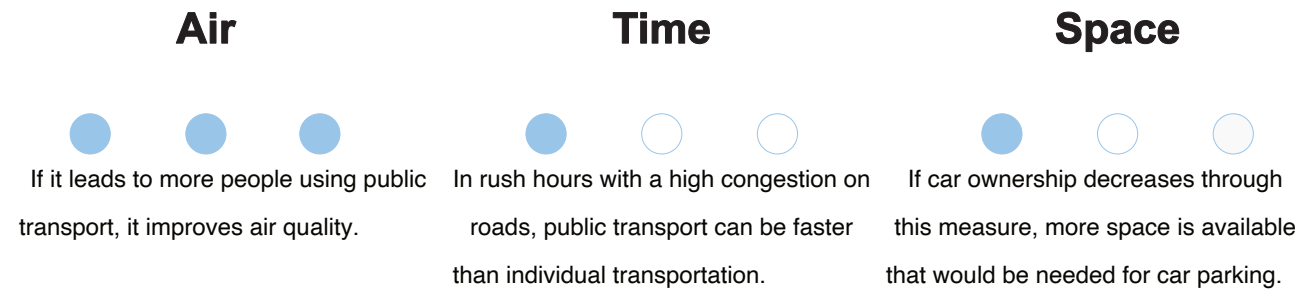


Figure 3.26: “Green card” to use public transport in Tallinn for free [109]

Impacts

There are no studies proving that this measure has led to an increase in passenger numbers. An increase in the number of passengers could have been expected for other reasons. However, since only Tallinn residents are eligible for free public transport, more people registered Tallinn as their official residence.

Applicability to Munich

The subway system in Munich is already very crowded during rush hours. Free public transport would not be feasible now. It might make sense if capacities increase rigorously.

TH.3.2 City Innovation Office/Think Tank (Helsinki)

Forum Virium Helsinki is the City of Helsinki innovation company. It co-creates urban futures with companies, universities, other public sector organizations and Helsinki residents. Forum Virium Helsinki’s mission is to make Helsinki the most functional smart city in the world.

Problem being solved

Communication and coordination problems between the local government, companies, universities and other public sector organizations. They build bridges between the public and private sector. Even though they solve the public sector problems, the solutions usually come from the private sector. Also, the residents support this process with their feedback. Moreover, the office speeds up the innovation in the city. Innovative solutions are being tested with the support of City Innovation Office. If it is likely to scale, it is communicated to local government.

Stakeholders

Municipalities: This office acts as an intermediary between the local government and other parties. At the end, the cities make the last decision and fund the projects.

Private companies: Mostly public problems are being solved but the solutions usually come from private companies.

Residents: Some pilots are tested in the smart city and the citizens could try them and give feedback, so the process let the citizens involve in decision taking.

Universities and other public institutions also act as stakeholders through their involvement of pilots and

implementation of the projects.

Even though there are many layers in these processes, the City Innovation Office allows innovators to try out their solutions faster. The office helps the companies and universities to test their ideas with City’s support and if it is feasible, the solution is scaled to use in the city. Therefore, everybody benefits from these innovations.

Expected result (vs. real result)

A smooth fast innovation process bringing not only public institutions with private companies together but also requires the involvement of residents in the developing and implementing innovative solutions for the cities.

Challenges of Implementation

Main challenges are having too many partners to collaborate and supporting the process of matching them up.

Duration

The office helps actualizing a variety of solutions coming from different parties. The duration of pilots or scaling of them depend on the project itself.

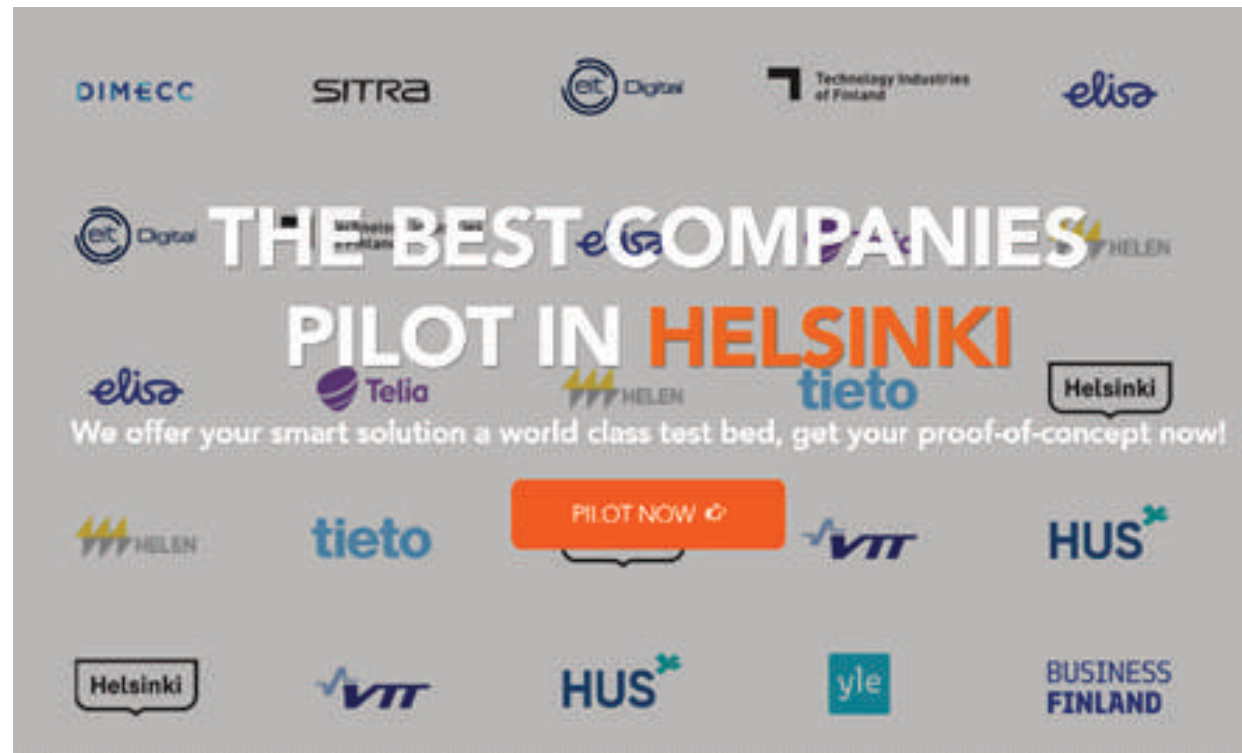


Figure 3.27: Forum Virium Helsinki website [94]

Financial Aspects

The pilots are funded by the office with small budgets. Later, the City supports them in case they are feasible to implement in a wider scale. As it is an additional layer to test the pilots, it may help to save money before full implementation.

Legal Aspects

Forum Virium (the City Innovation Office) is fully owned by the City of Helsinki.

Impacts

With its various projects in collaboration with private companies, public institutions, universities and citizens, Forum Virium, the City Innovation Company, has an impact on all of them.

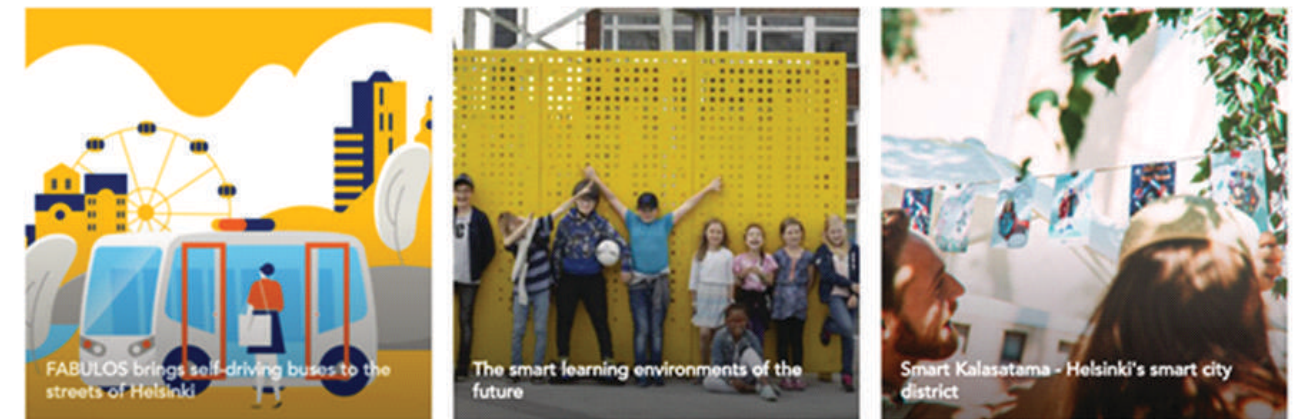
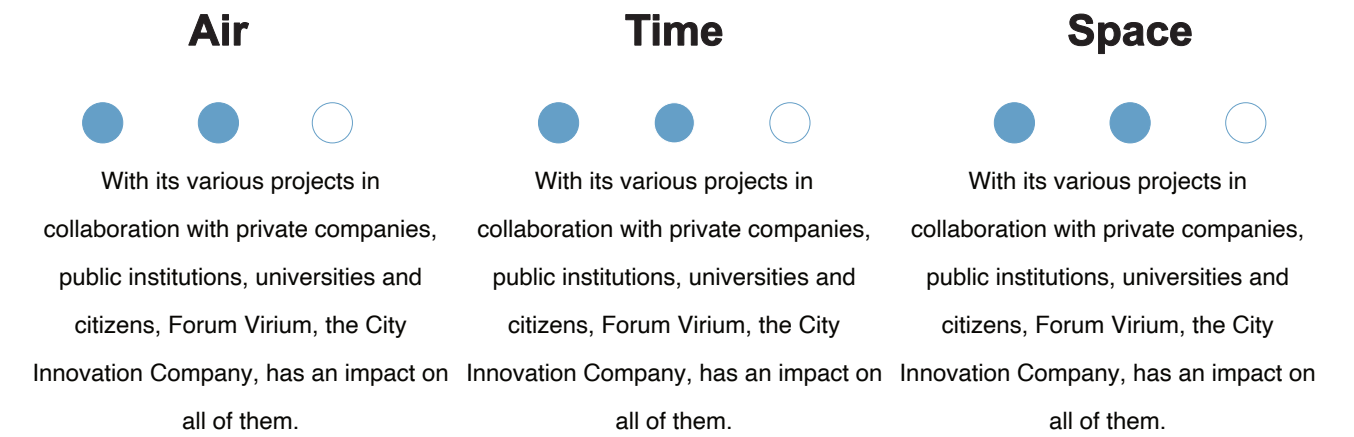


Figure 3.28: Exemplary projects of Forum Virium [94]

Applicability to Munich

In Munich, there are also organizations like UnternehmerTUM acting as Forum Virium Helsinki. Since UnternehmerTUM is located in Garching and collaborating with TUM students and employees of startups located there, there is a huge human source that the City of Munich is likely to benefit from it.

The Implementation of Autonomous Vehicles in Public Transport

Urban transportation in the next few decades will shift worldwide toward electrification and automation, with the final aim of increasing energy efficiency and safety for passengers. Such significant change requires strong collaboration and efforts among public administration, research and stakeholders in developing, testing and promoting these technologies in public transportation [111, p. 1].

It has been speculated that by the year 2050, two thirds of the world population will be living in urban areas [112]. This will increase the number of people living in urban areas, also considering the world population's growth. The sheer number of inhabitants, together with economic growth, will lead to an increasing need for effective modes of urban transport in terms of energy and costs [113].

As we move toward this urbanization and into worlds where cars are self-driving, cities are starting to see a variety of AV-based solutions on the horizon, from transit to taxis to freight. But the most common anticipated role for AVs is bridging existing gaps in public transit systems, a crucial link that planners call the “first-last mile.”

Autonomous shuttles thus represent an attractive first-last mile solution method that will reduce congestion. They could soon become a common sight on college campuses, city centers, shopping plazas, hospitals, airports etc. [113]. Autonomous shuttles are vehicles that navigate autonomously at sub-50km/h speeds along pre-determined, learned paths. These characteristics make the autonomous bus shuttle segment less regulated than the automotive market. Hence, trial deployments are anticipated to ramp up quickly [114]. Deploying these shuttles will reduce congestion and time wasted looking for parking thus opening up spaces for other purposes, in-

crease safety by eliminating human error, reduce car emissions and benefit people with limited mobility (elderly, disabled, immobile individuals etc.) [115] [116].

Current Projects.

Experiments have been conducted on automated driving systems (ADS) since at least the 1920s [117]. Cities in Europe are starting to conduct pilots to determine their readiness for such technology [118]. A major propeller of such trials includes finding ways to find ways to reduce transportation emissions. For example, the capital city of Finland, Helsinki, strives to be carbon neutral by 2035 [119].

• SOHJOA BALTIC PROJECT.

The Sohjoa Baltic project is funded by the Interreg Baltic Sea Region program of the European Union. The project budget is MEUR 3.8, of which Baltic Sea Region funding accounts for MEUR 2.8. This project researches, promotes and pilots automated driverless electric minibuses as part of the public transport chain, especially for the first /last mile connectivity.

The public transport chain especially for the first/last mile connectivity. The project brings knowledge and competence on organizing environmentally friendly and smart transport. It also provides guidelines on legal and organi-

zational setup needed for running such a service in an efficient way. There were already large-scale pilots in Tallinn and Helsinki in 2019 for 1 year respectively.

The Tallinn pilot was carried out with two EasyMile buses in 2017 and was initiated by the Government Office, Ministry of Economic Affairs and Communications in collaboration with the private sector (Milrem, EasyMile, DSV, Tallink). The pilot took place in Tallinn downtown close to the Old Town and Old Harbor. The main issues were related to procurement and operation.

For example, the buses failed to recognize traffic lights, and pedestrian crossings had to be taken over manually each time [111, p. 10]. In addition to self-driving vehicles, self-driving delivery robots were legalized in Tallinn, they will mainly be operating on sidewalks at similar speeds to pedestrians [120] [121].

On the other side of the Baltic Sea, Helsinki hit headlines in late 2016 with the SOHJOA “robot bus” pilot.



Figure 3.29: The Interior of An Autonomous Shuttle, Navya Bus Helsinki [124]

Featuring an Easymile EZ10 bus on the city's Hernesaari waterfront district, the pilot helped the city increase public awareness of AV technology [122] [123]. The city strategy 2017-2021 encourages a transition to a demand-driven traffic system and Helsinki aims to serve as a testing platform in the commercialization of new smart mobility solutions which are being enabled by current transport legislation and in the promotion of tomorrow's technologies. Solutions to traffic problems can come from automation and notably also from public transport.

The city believes that robot buses can have a positive impact on the attractiveness and use of public transport. By enabling a multitude of projects with autonomous shuttles, Helsinki prepares for a future where autonomous mobility will be the norm. In addition, the city wants to be a pioneer in overall functional smart traffic systems.

The SOHJOA project provided the cities with tools and know-how for planning the public transport solutions of the future, unique data (impact on traffic flow) and the opportunity to carry out user-based studies on autonomous shuttles [124]. Another objective was to learn how autonomous shuttles adapt to harsh winter conditions, but it became clear that the technology is not yet advanced enough.

Also, the pilots became a platform for Finnish companies to develop and test their products and services. The SOHJOA project provided a comprehensive understanding, what it is that these autonomous shuttles require to operate and function in mixed vehicle traffic on public streets [111, p. 10].

The Implementation of Autonomous Vehicles in Public Transport

• THE FABULOS PROJECT.

Another pilot that has taken place in both cities is the Fabulos project. The FABULOS (Future Automated Bus Urban Level Operation System) is a research and development project to establish and to deliver a systemic proof-of-concept on automated last mile public transport as part existing transport system of urban areas using self-driving minibuses. The FABULOS project has received funding from the European Union's Horizon 2020 research and innovation program and runs from 1 January 2018 until 31 December 2020.

The FABULOS project has partners in Estonia, Finland, Greece, the Netherlands, Norway and Portugal [125]. The final goal for FABULOS project is to produce the next generation robot bus service which solves a great deal of technological problems, from the automated shuttle to fleet control as well as the business models of the public transport integration. The FABULOS budget is M€5.8 Euros. The project has received funding from the European Union's Horizon 2020 research and innovation programme, and will run from 1 January 2018 until 31 December 2020 [126].

Stakeholders

Stakeholders include and are not limited to usually a funding body, in these projects funding bodies have been the European Union, Federal Governments and even state government. The SOHJOA BALTIC project has partners from Finland, Estonia, Sweden, Latvia, Germany, Poland, Norway and Denmark [127]. Partners from Tallinn and Helsinki are; Metropolia University of Applied Sciences, Forum Virium Helsinki, Finnish Trans-

port Safety Agency Trafi, Helsinki Region Transport Authority HSL, FLOU Solutions Ltd (FI), Tallinn University of Technology, Tallinn Transport Department (EE). The same can be said for the FABULOS project where stakeholders include Forum Virium Helsinki, Finland, the Ministry of Economic Affairs and Communications, Estonia and the Helsinki Metropolia University of Applied Sciences, Finland among others.

This project also includes a consortium of innovation companies tasked with producing the autonomous shuttles and piloting them [127]. Private companies are not left out as this is a way to gain more information and show innovation that has been taking place in the industry. Educational institutions serve as a research pool for the brightest minds and researches to be able to carry out needed research on new topics, technologies and innovations. The citizens are also a significant determinant of technology's acceptability.

Link to Munich

Way down south in Europe, Munich is just getting ready to carry out its first pilot on automated shuttles. Tallinn and Helsinki is already facing a great deal of congestion



Figure 3.30 :Some Stakeholders for the Navya Helsinki Project

due to urbanization and personal vehicle use. Implementin autonomous shuttles would encourage the using less cars. More people are moving to cities for work and study. In Munich, the project "Easyride - Automated and Connected Driving in an Urban Context", would analyze and test these new technologies. Partners in this project include, the Münchner Verkehrsgesellschaft (MVG), BMW Group, Stadtwerke München, Technical University of Munich among others.

The City of Munich, Department for Urban Planning and Building Regulations is responsible for project planning. The Federal Ministry of Transport and Digital Infrastructure is funding the project with 6.6 million euros, the total volume is 10.56 million euros [128].

In the second quarter of 2020, SWM / MVG, together with the vehicle manufacturer e. GO, will start the first of two pilot tests for autonomouse shuttles in Munich (Olympiapark). Passenger surveys are planned to evaluate the impressions and experiences of the passengers.

Conclusion/Thoughts

The number of autonomous shuttle pilots has increased rapidly over the last few years. These pilots have drawn interest in various cities, universities and private companies. In Europe, these pilots aim mostly to integrate themselves into the public transportation system [111, p. 8]. It is obvious that urbanization, population growth and safety constitute strong motivations to support electric autonomous vehicles. However, further research is needed to cope with technological issues like electrification and automation. Aside from the technology, the legal

framework requires clarifications and joint international work to harmonize legislation and fill gaps between driver-based transportation and future autonomous driving. Another challenge lies in the lack of experience of road administrations and safety institutes with these types of automated shuttles. Processes to test these new mobility systems in mixed traffic vary tremendously per country in content and duration. A simplified process resulting in temporary license plates solely for pilot purposes has worked well in Helsinki.

Current practices on citizen participation and engagement also need to be improved. When including citizens in such projects, there needs to be laid out action plans and timelines for collecting and integrating feedback from citizens. Creating such structures entails asking specific questions. Should citizens be involved in choosing pilot project sites? Is their feedback only needed when the pilot is already underway. Developing good mechanisms of participation by making sure that citizens are also treated as important stakeholders in such projects.

It is also very important to study, how cities will change and public transport will evolve with the implementation of AV's. Pilots should not only be carried out on the technology, but on how the society will be impacted by AV introduction. We cannot expect that cohabitation of humans and AVs will happen naturally and unproblematically. We need to be ready for such issues and concerns when they arise. It is obvious that more pilots, tests and studies need to be carried out before AV's can be implemented into the society.

Mobility as a Service (MaaS)

According to MaaS Alliance, Mobility as a Service (MaaS) is the integration of various forms of transport services into a single mobility service accessible on demand. [77] This service is usually a mobile app including a journey planner, a booking and payment system and real time information.

Therefore, all tickets can be purchased online. Depending on the service provider, different modes of transportation (public transport, car/bike sharing, taxi and on demand services, etc.) could be used as Pay-as-You-Go or via monthly subscriptions. [88]

Mobility-as-a-Service aims to tackle issues such as congestion, car ownership, traffic and capacity management, inefficient use of existing infrastructure and poor customer experience.

Trends supporting MaaS growth[130].

- Consumer Expectations: Experiences are increasingly expected to be provided “as a service” which is believed to bring more value to customers.

- Technology change: Open data is increasing and it is an enabler of MaaS. Internet of Things and autonomous driving will also bring more data in the market that enables MaaS innovations.
- Changes in mobility consumption: Young people are increasingly saying no to car ownership.

Future of Mobility as a Service

Even the most improved MaaS concepts available now are considered as level 3. With the integration of societal goals, they are able to move to the level 4 in the future. However, most solutions in the market do not even have the booking and payment integration for all the modes.

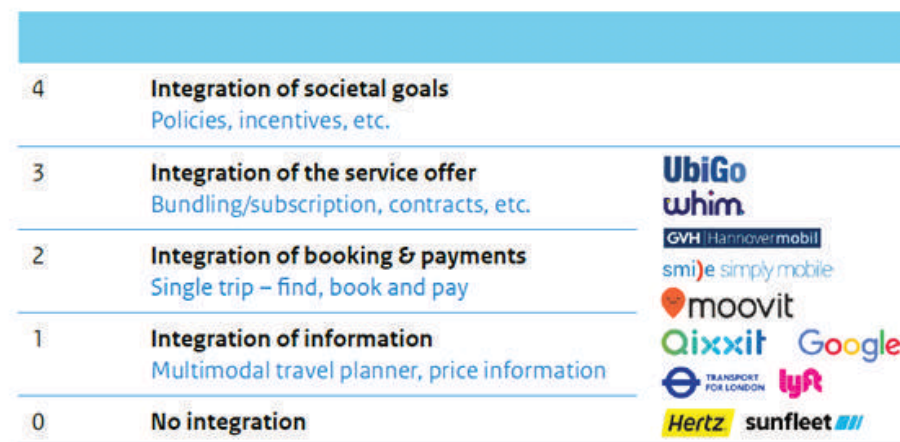


Figure 3.31: MaaS Levels and Examples [115]

Projects

After the secondary research conducted regarding MaaS concept and its examples, three companies which operate in this area are visited for interviews. In the table at the end of this section, their business models are compared and summarized. As seen in the table, they serve different solutions to particular user groups.

Whim (MaaS Global)

Whim is the product of MaaS Global which is considered as world’s first true MaaS operator. It is launched in Helsinki in 2017 [65]. Whim allows its users to plan, book and pay their journey in the same app. Helsinki residents are also able to choose the fastest or the greenest option from the list of integration of various transport modes. In order to use taxi or scooter services, they do not need to sign into different apps, either.

Ramboll conducted a study comparing the first-year data of Whim app and the data coming from the Helsinki municipality. The most important results are as follows [91]:

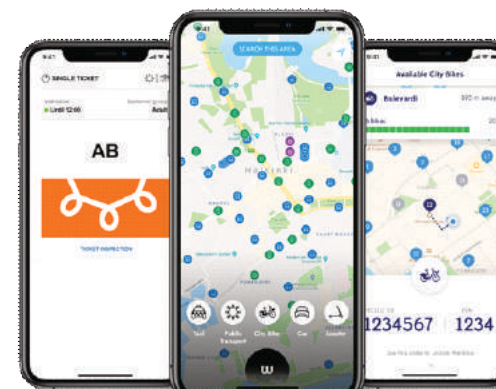


Figure 3.32: About Whim [79]

While public transport model share in Helsinki metropolitan area is 48%, it is 63% among the Whim users. Also, number of trips by car has remained the same. On the other hand, Whim users have traveled by taxi 2.1 times more often than the average residents. MaaS Global does not only aim to offer seamless multimodal journeys, but they also want to create an environmental impact via their solution. They try to educate the market and the people to reach their ultimate goal: reducing car ownership [131].

Kyyti

They do not position themselves as an end-user brand but instead they focus on providing the technology for other platforms [132]. MaaS implementation is not an easy process; including too many parties such as the different user groups, public authorities, mobility providers with each of them having particular needs and expectations, can be challenging.

Perille

Perille is positioned as a MaaS solution focusing on inter-city trips. Users are able to reach the offers via their website. With Perille, travelers can find different transportation options, plan their trips and buy tickets. Perille finds not only all long-distance transportation options in Finland but also local transportation in the Helsinki metropolitan area [134]. However, their focus is long distance travels. [135]

The table below compares these three MaaS solutions:

Mobility as a Service (MaaS)

	MaaS Global (Whim app)	Kyyti	Perille
Solution	MaaS app focusing on urban mobility	White-labeled apps developed for business customers	Website and app focusing on intercity and cross-country travels (secondary focus)
Business mode	The app is free for the end user. All the fees and pricings are based on the bilateral agreements between MaaS Global and transport service providers.	Selling customer branded apps	Small service delivery fee from the end user & Commissions from the transport operators
Customer focus	Urban residents & suburban residents commuting to the city	Businesses	Residents travelling to other cities

Table 3.3 Comparing MaaS Global, Kyyti and Perille

Stakeholders

Scaling a MaaS solution can be quite challenging. There are several steps and stakeholders to implement it. The most influential stakeholders are listed below:

Policy makers

They are one of the key players to enable MaaS with legislations and incentives. In Finland, all transport providers are required to provide access via open APIs to information on their timetables, routes, ticket prices as well as real-time location data. The legislation entered into force on 1 July 2018. This legislation has made it easy for the third parties to use this information and built their own mobility apps.

MaaS provider

Its role is to bring all parties together to establish the app realize. Even though the MaaS providers from Helsinki are private companies serving as a layer between the transport operators and the end user, this provider may also be one of the operators as MVG in Munich. For the MaaS provider, offering a good user interface is a significant part of the operation.

Public Transport Operator

Public transport is the backbone of the MaaS solution with its huge network and customer base. In order to have a comprehensive solution, public sector has to lead or support the third parties to take the lead.

This may also encourage private service providers to get involved. Certainly, some companies may not be truly interested in joining this all-in-one solution if they have a big customer base or they are not willing to compete with others.

It is important to create a win-win situation for all parties. In addition to the MaaS solutions operating in Helsinki, HSL/HRT (Helsinki Region Transport) has also its own app that enables users to plan their journey with different public transport options and purchasing single, daily or monthly tickets.

Other Transport Service Providers.

Some taxi companies, e-scooter and city bike providers are also a part of the MaaS solution. A close collaboration between the MaaS operator and service providers is important to sustain this solution. The more various modes and mobility providers are represented in the solution, the higher the benefit expected for the end user.

Residents.

A MaaS solution is aimed to provide a fast and seamless journey with a user friendly interface. Urban residents can find the most flexible and effective way of travelling via these mobile applications but they are not the only one who benefit from them. When the point is reached that all the residents find it more attractive to use the same app, most of the providers can then reach the users they could not target before. Nonetheless, the big players may also lose some of their customers as they will find out the new ways of travelling. At the end, the customers themselves decide which app and mobility

modes to use. There are also other stakeholders influencing the decision making and processes as investors, insurance companies, universities, unions etc. However, they are out of the scope of this report.

Link to Munich

Even though there is not an all-in-one solution in Munich Metropolitan Area yet, three widely used mobility apps, MVG Fahrinfo, MVG More and DB Navigator, have been chosen to analyze in this section. One of the main differences between Munich and Helsinki regarding MaaS solutions is that the ones in Munich are developed by public transport operators while it has been done by private companies in Helsinki.

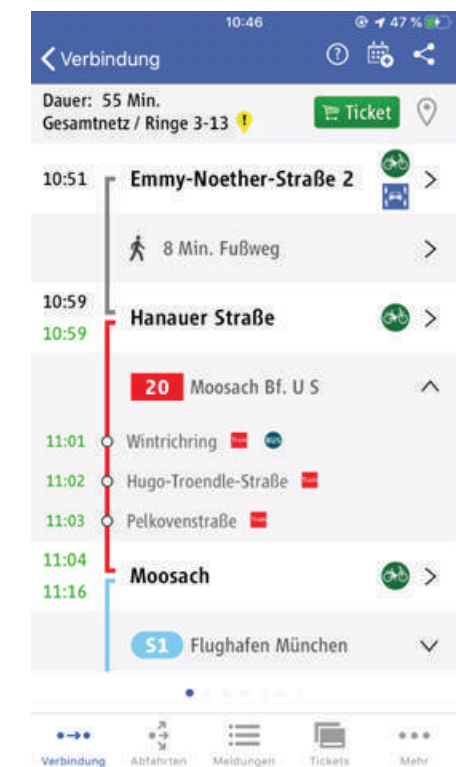


Figure 3.33: MVG Fahrinfo Journey Details [136]

Mobility as a Service (MaaS)

Criteria to evaluate the mobility apps are:

1) Ticket & Payment integration: when one smart card or ticket can be used to access all the modes taking part in the service and one account is charged for the use of those services;

2) Mobility package: when customers can pre-pay for a specific amount (in time or distance) of a combination of mobility services; 3) ICT integration: when there is a single application or online interface that can be used to access information about the modes. [88]

Moreover, there are new ventures working in building a new MaaS solutions for Munich. The first one is the Mobility Inside Initiative which is developing an app for the whole country and MVG is one of the partners. This app is still in the test phase. [137]. The second one is the partnership of MVG and Trafi for a MaaS app that it is announced with a press release in February 2020. [138]

The table below compares the features of chosen mobility apps in Munich according to the criteria above:

	MVG Fahrinfo	MVG More	DB Navigator
Modes of Transport	Public Transport Only	PT, city bikes, e-scooter, car sharing	PT and regional trains
Journey Planning function	Yes	Yes	Yes
Routing	Yes	No	Yes
Payment/Ticket Integration	Yes	Limited	Yes
Mobility Package Integration	No	No	No
Information	Limited	Limited	Yes
Sign-in	Single	Multiple	Single

Table 3.4: Comparing current Munich mobility app features

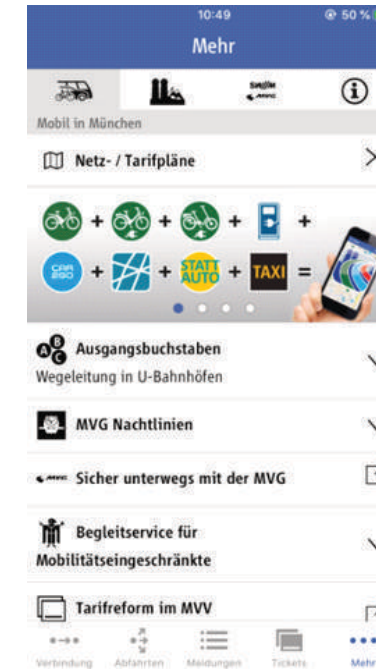


Figure 3.34: MVG Fahrinfo App [136]

Conclusion/Thoughts.

As the three apps chosen from Munich are mostly focus on the urban residents, we can compare them with Whim app operating in Helsinki. With the help of open data and ecosystem, Helsinki residents are able to use different modes of transport, plan their trips, and pay for the tickets or subscribe for monthly bundles via Whim app. Its user interface is quite clean, easy to understand and use. Also, tickets can be purchased quickly. As a result of agreements with different providers offering the same sort of service, users are free to choose between different providers.

Compared to Helsinki, Munich is behind Helsinki when it comes to open data availability.

This is a sensitive topic that specific challenges of the city and the points of tensions which are discussed in measures for open data should be considered to handle this sensitive topic. Not having open data is a big challenge for the third parties not only to develop an app but also improve their services in general.

There are various mobility players in Munich. Even though there are some mobile applications with different features, an all-in-one solution is needed for Munich. Integration of different modes are increasing in Munich and, there are also some new solutions in progress, however, there is still room for improvement. Even though the users are able to purchase public transport tickets via MVG and DB apps, they are not able to use car rental or taxi services without using other apps. A strong collaboration between public and private mobility providers is required to put it into practice.

The Role of Smart Cities in Mobility

Modern cities face many challenges, such as an increasing movement from rural to urban areas, an increasing aging population and an increase of mobility needs. Such challenges lead to a rethinking of existing city structures by city officials [139] and a partially introduction of smart city concepts.

Smart city concepts try to find solutions to some of the challenges by using technological means. They set a new paradigm of intelligent urban development and socio-economic growth [140]. This is for example done by obtaining data from different sources, e.g. sensors that are installed in a specific area. These data can then be used for planning and control of city structures, either citywide or limited to a specific smart city area. It is a “complex system in which a great volume of real-time information is processed and integrated across multiple processes, systems, organizations and value chains to optimize operations and inform authorities on incipient problems” [140].

They usually have a top-down structure, meaning that the underlying vision is started by city planners; they have a high involvement of stakeholders, that means a collaboration of citizens, companies, city administration; and they are focusing on technologies infrastructure [139]. This enables an ecosystem that consists of businesses, politics, scientific organizations, citizen organizations etc. and leads in an ideal case to an attraction of smart people, start-up, entrepreneurs; giving them an environment to flourish.

Overall aims of smart city projects are for example an increase of the productivity through automatic routine

processes an improvement of decision-making processes through better data.

How smart cities can improve mobility

According to the framework of Neirotti, smart cities can provide advantages in the following areas [140]:

- City logistics: “Improving logistics flows in cities by effectively integrating business needs with traffic conditions, geographical, and environmental issues” [134]
- Info-mobility: “Distributing and using selected dynamic and multi-modal information, both pre-trip and, more importantly, on-trip, with the aim of improving traffic and transport efficiency as well as assuring a high quality travel experience” [134]
- People mobility: “Innovative and sustainable ways to provide the transport of people in cities, such as the development of public transport modes and vehicles based on environmental-friendly fuels and propulsion systems, supported by advanced technologies and proactive citizens’ behaviours” [134]

Tallinn example: Ülemiste Smart City

Ülemiste is the name of an area in Tallinn that counts as their smarty city showcase projects. In their self-description, they write:

“Ülemiste City is the place where future happens. This is the largest Smart City in the Baltics and biggest privately owned business campus in Northern Europe. We offer the best environment for ambitious talents and scaling businesses. We’ve brought together all necessary daily services so you can focus on what you do best.” [141]

It was born out of a transformation from an industrial area into a modern urban center, including modern offices, apartments, a kindergarten, school, university facilities, parks, recreational areas, restaurants [142].

Its location is close to major highways, a tram station, a railway station and the airport. Public bus lines operate in that area. The area also has a modern street network and enough parking spots, most of them connected with smart parking concepts. Around 20,000 people live, work and study there daily [141].

The district is still under expansion. One of the future plans is the connection to the Rail Baltica High Speed Train terminal, which will be according to current planning the only station in Tallinn [142] and then gives access to other Baltic capitals with the possibility to connect to other countries in Central and Northern Europe.

Smart parking as an example of a smart city concept.

On the website of Ülemiste city, people can see in advance which parking areas are free. The data for that is aggregated by different sources, e.g. by already existing security cameras [143] and by sensors installed in the parking lots. This prevents unnecessary driving

around the area to find a free spot which also reduces emissions. It therefore improves air quality and simultaneously reduces the time people need to spend in their car.

An the end of 2018, they tested a new system where drives are guided to a free parking spot by a combination of signposts, LED displays, web interfaces and an AI video camera [82]. With that variant, there are no sensors at the parking spots necessary; the data provided by security cameras is sufficient.

Excursus: Parking spots for eScooters

Modern kinds of transport like eScooter need adapted parking spots. In Ülemiste Smart City, there is a parking area for eScooters only, situated directly next to an office building and much closer than car parking spots (Figure 3.35).



Figure 3.35: Parking spot for eScooters in Ülemiste Smart City

The Role of Smart Cities in Mobility

Other examples

- Smart Traffic Lights: Traffic lights see if pedestrians are approaching and then start a visual signal for car drivers so that they stop and let the pedestrians pass.
- Traffic Management Systems: E.g. traffic lanes are handled flexible, which means that during rush hours more lanes lead to the direction where most of the cars go, changing in the morning and evening so that the existing spaces is handled more efficiently. It can also be an intelligent way to handle traffic to the Tallinn ferries so that the boarding time of lorries can be kept efficient and short.

Munich Example Domagkpark

Domagkpark is a new designed city district in Munich. It was built on a former military area that is now in civil hands. The idea was to include citizens in all processes from the beginning.



Figure 3.36: Parking Spot Domagkpark (own photography)



Figure 3.37: Bike Station Domagkpark (own photography)

One central element is the “mobility station” there. In these mobility stations, all modes of transport that are needed the residents that live there shall be provided at that place. This included bikes, cars, public transport, freight bicycles etc.

Conclusion

Smart city projects are a showcase for future city innovations. The concept itself can mean a lot from a small technological gimmick to a holistic concept for whole city parts. In the projects of Tallinn and Munich, it is apparent that smart city concepts are implemented where newly built city districts are. That highlights that it is easier to implement measures when they can be thought through from scratch. It will be more difficult to add smart city components into an existing environment.

Conclusion

Estonia and Finland are two countries that do not come to mind first when it comes to innovative technological developments or forward-looking mobility concepts. In particular, the two urban areas which simultaneously are the capitals of the two countries, Tallinn and Helsinki, are in some cases leaders in Europe in the field of IT and smart technology. Estonia, for example, is one of the smallest countries in Europe with the third most start-ups per capita (550 in total) and has even produced a unicorn company in the field of mobility, called Bolt. This transport platform company offers various services ranging from micro-mobility to food delivery and is now represented in over 150 cities around the world. In the field of automated delivery of orders, the Estonian company Starship, which uses autonomous driving robots, is also well-known. [1]

Helsinki in turn is known as a country that invented the MaaS concept and was the first to test it. This technology is considered to be the key to success when it comes to solving current traffic problems.

Both countries work closely together due to their strong economic ties and also carry out various projects across borders. These have already been explained in more detail in the chapter on measures. However, it can be said that the constant exchange of knowledge and the removal of legal barriers between the two cities leads to a strong improvement in transport relations.

Transport is furthermore a support system that enables the preservation of settlement and the utilisation of space.

In particular, the low bureaucratic hurdles, widespread eGovernance and the obligation to make APIs publicly available are drivers of innovation and progress. The use of mobility cards on both sides of the Gulf of Finland is also worth mentioning, which makes commuting much easier and thus makes the use of public transport more attractive.

Although the economic resources of the two countries are different, both have set themselves the goal of promoting sustainable and environmentally friendly mobility.

The "Rail Baltic" rail project will bring the two cities even closer together in the near future and connect them more closely to the rest of Europe.

In addition, both countries or cities have concrete ideas about what mobility should look like in the future. These visions, as well as concrete measures that can be implemented, can be seen in the respective Sustainable Urban Mobility Plans (SUMP) and represent the strategy for developments in the field of transport and mobility.

The expansion of the public transport and cycle path network, the creation of new recreational areas for the population, the pedestrian-friendliness of neighbourhoods and the improvement of local transport mobility in the city districts are the main factors here. The three overriding goals of improving the air quality and reducing emissions, redesigning and more efficient use of space and squares, and faster, congestion-free travel are to be addressed.

However, one question remains: can all the measures that are being implemented and tested in the two cities now also be implemented in Munich? There is no easy answer to this question, as this varies from one measure to the other. More detailed information regarding the feasibility in Munich can always be found in compact form at the end of each measure.

All in all, however, it can be said that some suggestions have already been implemented in Munich in a similar way, e.g. test beds for autonomous driving.

The big problem or hurdle in Munich and Germany as a whole is that there is no obligation to make APIs publicly available. This means that different private and public institutions collect data, but do not share it with each other. As a result, data may be collected twice and be in different file formats. In Estonia, the philosophy is that it is not the data itself that is valuable, but what you make of it. This means that theoretically every private person or company can use this data and develop new business ideas. This offers incredible added value for everyone, as the hurdles to business development are much lower.

A good example of this is MaaS technology. Since almost all data from various transport companies is available online in Finland, it is sufficient to use just one (MaaS) app instead of many different applications for rail, public transport and cycling, as is the case in Germany.

In addition, the bureaucratic hurdles for setting up a company or approving new technologies such as autonomous driving are significantly lower than in

Germany, which is why fully automated buses already operate there in mixed traffic with other vehicles, whereas in Munich testing is only allowed on cordoned-off areas.

In addition, as in the case of Tallinn and Helsinki, it is advisable for Munich to continue to work closely with neighbouring municipalities and cities, as mobility knows no city limits and must also function well interregionally.

Therefore, we would recommend Munich to allow innovation, to provide active support to companies and especially start-ups in legal and bureaucratic matters, and to lobby at state and federal level for data to be publicly accessible, thus creating new opportunities for innovation.

Stockholm Table of Contents

About Us	177
City of Stockholm Factsheet	178
City Overview Stockholm	180
City SWOT ANALYSIS	185
Measures	186
Cluster 1: Electrification and automation of traffic system	186
S.1.1 Autonomous shuttle buses on public roads	186
S.1.2 EV Charging Stations Infrastructure	190
S.1.3 ELIN – open autonomous driving testbed	194
S.1.4 Fossil fuel free PT	198
S.1.5 HUGO – autonomous, electric last-mile delivery	202
S.1.6 Night delivery with clean and silent vehicles	206
S.1.7 Smart Traffic Management: Prioritized Traffic Signals	210
Cluster 2: Developing and integration of mobility options	214
S.2.1 Digitalized Business Models for Parking Spaces	214
S.2.2 UbiGo – Mobility as a Service	218
S.2.3 Bike Parking	222
Cluster 3: Redesign and network of mobility spaces	226
S.3.1 Re-routing cyclists during construction work	226
S.3.2 Revision of parking regulations towards active mobility	230
S.3.3 Temporary Pedestrian Zones - Summer Streets	234
S.3.4 Tyck Till: Stockholm's Mobile Application and e-Service for the Citizens	238
S.3.5 Urban regeneration project: Hammarby Sjöstad District	242
Case Studies	246
Mobility as a Services – Potential and Challenges	246
Levande Stockholm - Vibrant city through temporary installations	252
Road Safety in Stockholm	260
Congestion Tax	266
Conclusion	272



About Us



**ANDRA LAURA
CHALAPCO OANCEA**
Electrical Engineering &
Social Sciences



FELIX GOTZLER
Mechanical Engineering



LINUS MÜLLER
Environmental Engineering



SOPHIA RUIZ
Environmental Engineering

City of Stockholm Factsheet

Country	Sweden
Size	189 km ²
Population (Sweden)	10.100.000 (2020)
Population (Stockholm)	1.632.798 (2020)
Population Density	2.986 people per km ²

Modal Split

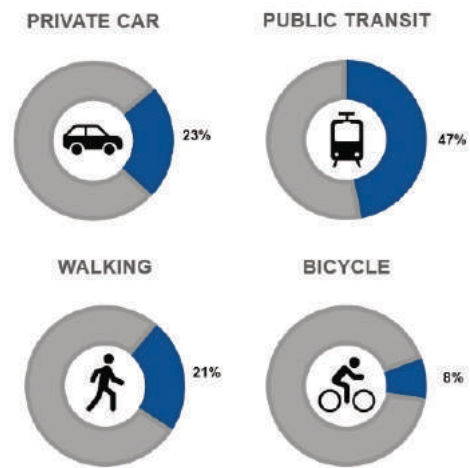


Figure 4.3. Modal share Stockholm [13]

Key Analysis Area



Figure 4.1. Administrative and political map of

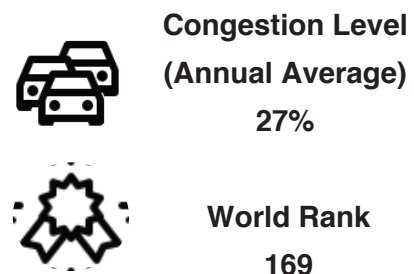


Figure 4.2. Rail transit network of Stockholm [11]

City of Stockholm

Stockholm is Sweden’s capital, economic and political center, and most populous urban region. It is one of the fastest-growing regions in Europe [3].

Stockholm represents 22 % of Sweden population. [5]

The population of Stockholm increased by 1.79 % since 2019 [4]

There is only one fare for the entire network.

The vision of the city:

The motto of the 2040 Stockholm’s vision is “The smartest city in the world”. This statement shows that digitalization is one of the city’s priorities while providing the best environment for business and targeting the highest quality of life. In addition, Stockholm’s vision focuses on four main qualities, which make the city stand out and become even more attractive. The four principles are: to stay united, to be eco-smart and to be financially and democratically sustainable.

[1] [2]

Climate:

Stockholm has a humid continental climate with warm, humid summers (highs around 22 °C; lows around 13 °C), cold winters (highs around –1 °C; lows around –5 °C), and 539 mm of precipitation annually [3]. Due to the low number of light hours in the cold season (about 6h), which can lead to depression, the government is particularly careful about the mental health of its citizens.

Demography:

The largest age group in Stockholm is the 25-64 years old.

Gender distribution: 50.3% female and 49.7% male [6]

Geography/ Structure of the city

Stockholm is situated on 14 islands by Sweden’s Baltic east coast that are connected by 57 bridges. It is divided into 14 district councils that are subdivided into 132 districts [3]. The district councils work within their respective geographic area and have the whole responsibility for their activities. The district councils manage the primary schools, social, leisure and cultural services.

Economic Aspects

Stockholm’s economy is responsible for a third of the total national domestic product (31.2 %). During the period of 2009 – 2017, the average gross domestic product (GDP) was 130,6 bn €. The GDP per capita in purchasing power standards (PPS) amounts 49.700 €, which is significantly higher than the national average of 36.300 €, as well as the average in the EU of 30.000 €. With 5,6 % in 2018, the level of unemployment reached its lowest value since 2009 and is lower than the average in the EU (6,9 %) [8]. The consumer price index (CPI) of Sweden is 334, the annual change is 1%. The largest companies in Stockholm by the number of employees are [9]:

	Name of the Enterprise	Employees
1.	Ericsson	8.510
2.	Södersjukhuset Aktiebolag	5.650
3.	Nordea Bank AB	4.720
4.	H & M Hennes & Mauritz Gbc AB	4.410
5.	Skanska Sverige AB	3.380

112 public charging stations in April 2020 [17].

Its cycle path network density is the third highest in the world with 4041km/1000km2

City of Stockholm

Mobility aspects

Stockholm possesses a very well-developed mobility system, as the second place in Arthur D Little's global Urban Mobility Index, which assessed the maturity, innovativeness and performance of Stockholm urban mobility solutions [10].

Responsible for the organization not only of the bus system but also for the whole public transportation in Stockholm is the Stockholm Regional Council (Region Stockholm) at a political level (planning, financial issues, subsidies, etc.) and Storstockholms Lokaltrafik (SL) for the operation and maintenance of the public transport systems with the cooperation of several private operators. There are tickets and travelcards (SL access card), for short and longer periods [11].

Passengers per year reported by SL in 2017: 2.8 million passengers every day.

The existing means of transport are [11]:

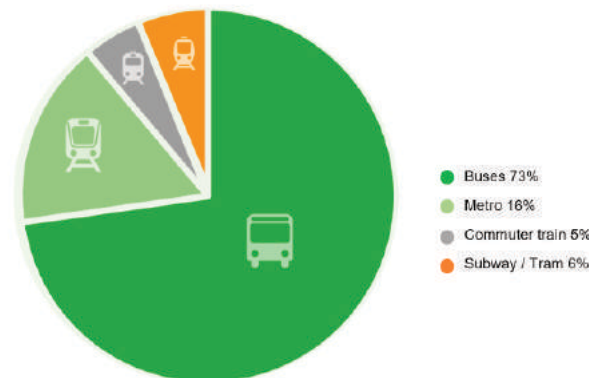
- 4 tramway lines
- 2 light rail lines
- 3 metro lines
- Commuter rail
- Several commuter train and bus lines that are organized in three different categories, namely inner-city blue bus lines: suburban blue bus lines and service green bus lines.
- Ferries
- As for February 2020, the monthly public transport pass costs 88 EUR. A single ticket costs 3,50 € for adults and 2,40 € with the discount fare which is for persons under the age of 20 or over the age of 65. The network is not divided by fare zones such as Munich rail network.

Commuting patterns/travel behaviour:

SL's and the city's traffic measurements show that 41% of all journeys in Stockholm county derive from the use of public transport [12], which is significantly higher than the Munich public transport ridership of 24%.

Data collected from the Stockholm City Survey of the Environment and environmental habits in Stockholm, carried out every three years, exhibit that half of Stockholmers who work or study state that they commute using public transport, just over a fifth travel by car, while just under a fifth ride bicycle [12].

Moreover, according to this survey, the proportion of men who choose a car is significantly greater than the



Distribution of number of wagons and buses in SL's public transport [12]:

proportion of women. In both groups, individual motorized traffic is greater on weekends than on weekdays. It was also shown that the main difference between the groups of 16-24 and 40-64-year-olds is that the latter uses the car to a greater extent. The younger travellers generally choose the public transport bus,

subway and other rail traffic much more often than any other age group [12].

Network:

PT:

○ Stockholm's subway is sometimes also referred to as the world's longest art gallery since most of the station stops are decorated with paintings, sculptures, and mosaics [11]. It consists of 110 km, with 100 stations (use of green electricity only) [14]

○ Regional Train: 4 km of line length, every 30 min from 5.00 to 24.00 (use of green electricity only) [14]

○ Commuter Train: 241 km of line length, every 5-30 min from 5.00 to 24.00 (use of green electricity only) [14]

○ Boats: 40 boat lines passing over 300 bridges, 4 million passengers/year, from 6.00-20.00. 2.7 million passengers travel by commuter ferry every year [14]

○ Buses: 2,100 all of them use only renewable fuel. [15]

□ Car network consisting of 3600 streets (city streets and smaller local streets) [12]

□ Car ownership 361/ 1000 inhabitants (2019) [12]

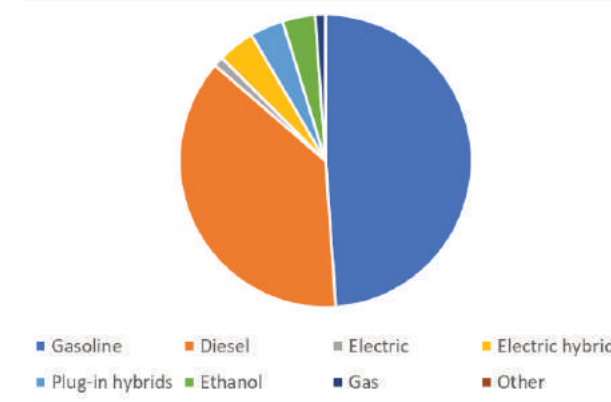


Figure 4.3. Official share of vehicles in Stockholm [18]

Electric mobility

Stockholm has the ambitious goal of becoming one of the world's leading clean vehicle cities by 2030. In order to reach this goal, it was decided to boost the city's electric vehicle (EV) charging infrastructure by expanding the existing charging infrastructure and build a fast-charging network. The project started in 2014 intending to install 10 new fast and 100 normal charging points – all intended for public use - and developing a plan for future network expansion. [16]

649 is the Statista Number of vehicle charging stations in selected municipalities in Sweden in 2017.

The share of electric cars can be seen in Figure 4.3.

Current challenges of the city

The major traffic-related challenges named by the city of Stockholm are

- Congestion
- Air pollution
- CO₂ emissions
- Spaces dominated by cars
- Accidents

Current approaches to tackle Mobility issues

Stockholm has a long term strategy for the development of the city. The "Stockholm City Plan" [19] contains the cities general challenges and objectives as well as concrete action plan covering all relevant topics. The mobility related strategic goals of Stockholm are:

1. Encouraging the use of high capacity transport modes (HCTM).
2. Decreasing journey times of HCTM while increasing journey time reliability.

City of Stockholm

3. Developing the road network into attractive urban spaces in order to promote active mobility.

4. Limiting the use of private cars to journeys where it constitutes the most effective mode of transport.

In order to achieve these goals, six action plans containing corresponding measures were developed to improve the following fields. Detailed information on the given examples can be found in the subsequent chapter.

1. Cycling (e.g. bicycle parking or rerouting of cyclist during construction work)

2. Freight (e.g. transition to clean and silent delivery vehicles)

3. Pedestrian (e.g. establishment of temporary pedestrian zones during summer)

4. Parking (e.g. revision of parking regulations)

5. Transit Network (e.g. implementation of a MaaS offer)

6. Road Safety

Whereas the implementation of these plans is still in progress, relevant improvements in cycling infrastructure, freight efficiency, traffic management and the general liveability of streets have been achieved.

Projects

European Funded projects

Projects financed by the European Commission, like GrowSmarter and Civitas Eccentric, are tackling Stockholm's problems in several fields: Low energy districts, Integrated infrastructures or Sustainable urban

mobility. These projects are thought to be pilot projects and their effectiveness is measured and assessed. The main purpose of these projects is to examine their extent of applicability.

Interreg Europe

This project supports regional and local governments across Europe developing and delivering better policy. [20]

UbiGo

The MaaS app was launched in the summer of 2019. UbiGo provides access to five modes of transport: public transport, bike sharing, car sharing, car rental and taxi.

RUFS 2050

RUFS 2050 is the regional development plan for Stockholm region. Its vision is to be Europe's most attractive metropolitan region. [21]

City SWOT ANALYSIS

Strengths

- Strong economy
- Multiple platforms for communication with citizens
- Long-term transport planning policies and decisions
- Inclusion of socioeconomic aims
- High tolerance among citizens

Weakness

- Spatial resources are sparse
- Congestion in bypasses
- Low temperatures and low amount of daylight in the cold season

Opportunities

- Financial possibilities
- Prioritization of active mobility
- Fossil-free road transport sector by 2040
- Investment in alternative transport modes
- Openness to data sharing and open data

Threats

- Rapid growth of population
- Urbanization and continuing car dependence
- Limited space

S.1.1 Autonomous shuttle buses on public roads

Over the course of six months, two autonomous shuttle buses (ASB) were tested in the area of Kista, which is especially known for its high density of tech-companies and is therefore informally called “Science City”. ASB are expected to work as an efficient extension of public transport, especially on the first and/or last mile of a trip. The ASB were operating on a course of 1,6 km with speeds of up to 15 km/h. They performed 41 trips per day on average, which results in 3.606 km during the testing period. In total, 21.165 passengers travelled in the ASB and no major incidents occurred [22].

Problem being solved

The city of Stockholm wants to decrease the usage of private cars within the city limits in order to increase the standard of living. Therefore, an attractive alternative way of travelling that can compete with the benefits of motorised individual transport (MIT) shall be established. The focus of this project is the public reception of AVs, however, further topics, such as business cases and collaboration with conventional vehicles are investigated.

Stakeholders

A brief overview of all involved Stakeholders is presented in Table 4.1. The project was started by Nobina Technology in 2016 with the aim of being Scandinavia’s first AV showcase on public roads. It is a subproject of DriveSweden’s contribution to autonomous driving called KRABAT [23].

Expected result (vs. real result)

The Kista project produced diverse results [24]. It paved the way for future showcases of AVs on public roads by

Financially contributing partners	Description
City of Stockholm	Administration of the city
Nobina Technology	Provider of PT technology
Ericsson	Communication technology provider
SJ	Regional PT provider
Klövern	Real estate company
DriveSweden	Governmental collaboration platform
Supporting Partners	
Urban ICT Area	ICT cluster for development and testing in Kista
KTH-ITRL	KTH’s integrated mobility research area

Table 4.1. Stakeholders of the ASB project in Kista



Figure 4.4. ASB in summer and winter use [22]

mapping out risks and challenges as well as processual shortcomings in Sweden’s legislature. The reception of AVs was thoroughly investigated within the subproject SARA1, which focused on the behavior of ASB users, especially their willingness to use (WTU) and willingness to pay (WTP) for autonomous bus services. The results show that both of these factors are highly dependent on user profile and, according to expectations and trust level towards AVs (e.g. regular PT users are less likely to use ASB and car owners show greater interest in premium on-demand-services). The main factors for WTU are travel fare and frequency of service. The WTP is influenced the most by the perceived safety of AVs and comfort (e.g., waiting and travel time or ride comfort). The project also showed that current ASB solutions on the market seem to be unable to fulfil the passengers’ needs, as the WTU decreased for participants trying the AVs in Kista. This can mainly be

explained with the low speeds that result in longer travel times compared to conventional buses.

Furthermore, a simulation based on the measured parameters revealed that ASB have the potential of reducing the total cost of bus traffic. The potential strongly depends on properties of specific routes like required frequency or capacity.

Further, it has been examined that traffic poses a great challenge to AVs. The software of the ASB turned out to be very cautious, which lead to frequent stops because of e.g. cyclists or cars not being parked according to traffic rules.

Challenges of Implementation

The initial plan was to start the trials in the fall of 2016. However, they started in January 2018 [22]. This delay resulted from complications in the legal framework. Receiving permission to drive AVs on public roads turned out to be very complicated as various stakeholders are involved. These include the Swedish Transport Agency and the city of Stockholm, which both had to give their consent in this case.

Financial Aspects

The hardware investments for this project amount to roughly 540.000 € [22]. On top of that, there were costs arising from training the security staff as well as rising awareness by spreading information and advertising. According to current law, a trained driver must supervise the operation of the vehicles and intervene in case of failure. This leads to high operational costs during the trials. Simulations within the projects have indicated cost saving potential on certain routes by the operation of autonomous vehicles. It is expected that these savings occur with the application of ASB in standard operations.

Duration

The first idea for the project came up in April 2016, so it took almost two years until the ASB could be used on the road. The permission for the project was granted in December 2017, roughly 1,5 years after the first initiative was launched. It took about another year to align all partners, train the security staff and prepare the roads and buses. The testing phase of six months started in January 2018 ended in June 2018.

technical specifications shown below from the French manufacturer EasyMile was chosen [25]. One of the specified vehicles costs about 250.000 €.

Besides the vehicles, the streets had to be modified according to the requirements of the AVs. Modifications to the infrastructure mainly mean the installation of suitable bus stops and some reflectors for the vehicle's sensors. The costs for the adjustments of infrastructure amount to roughly 40.000€.

Technical Aspects

ASB are available on the public market and therefore exceed according regulations. The model EZ10 with the

Nr. Of passenger	12	Payload	1.000 kg
Battery capacity	30,7 kWh (LiFePo ₄)	Length/Width	4.020/1.998 mm
Energy consumption	2,95 kWh/h	Sensors	Odometry, Lidar, GPS, Camera
V_{max}	40 km/h		
Weight	2.030 kg	Connectivity	4G

Table 4.2. Technical specifications EasyMile EZ10 [25]

Air



Electric vehicles cause no local air pollution.

Time



Last mile PT solutions increase the service level and facilitate better accessibility of locations distant to train/metro stations or regular bus stops.

Space



ASB are an effective way of moving small groups and can therefore decrease the traffic volume.



Figure 4.5. Route of the ASB [22]

Applicability to Munich

Automated driving is one of the major trends in urban mobility. While today's research is mostly conducted in closed lab environments, tests on public roads with real traffic must be conducted before finalised products, according to legislation and sustainable business opportunities can be rolled out. There are several decentral areas in Munich that could serve as a testbed for ASB, for example, the campus area in

Garching. The example in Kista shows that such projects are relatively inexpensive and the risks, especially in a technology-friendly environment like a campus, are comparably small. Munich has also started a similar trial and may benefit from preceding projects by studying their approaches, results, and mistakes.

S.1.2 EV Charging Stations Infrastructure

Stockholm aims to become a global leader in renewable mobility by 2030. [26] In order to achieve this goal, concrete steps have been taken: from the expansion of the city's electric vehicle (EV) charging infrastructure to building normal and fast networks and promoting the installation of charging facilities in multifamily houses.

Stakeholders

For building the normal (3.7kW, charging time from 6 to 25h) and fast infrastructure (50kW, charging time approximately 30 minutes), the main stakeholders are: the Environment and Health Administration, who also coordinates the work in collaboration with the Traffic Administration, Stockholm Parkering AB, a city-owned company responsible for Stockholm's parking infrastructure, and three municipal housing companies. Since 2015 the funding is provided by the state through the program Klimatklivet.

For promoting the installation of charging facilities in the multi-family houses, the main beneficiaries are the citizens and the housing associations. The city of Stockholm has prepared several workshops and information material: Stories from houses that have already installed chargers, details about the charging equipment around Stockholm county, but also information on how to install the facilities, how to apply for the government subsidy for local climate investments or how to handle the administrative work. All the know-how is also available online in Swedish [29]. To offer as much information as possible, ten suppliers of charging equipment were involved and 27 municipalities from the greater Stockholm region. The initiative has received funding from the European Commission via the project Civitas Eccentric. The Swedish Environmental Protection Authority also supported the initiative and it is

planned that similar information campaigns continue to be provided for the citizens also in other Swedish regions.



Figure 4.6.. (a) An EV charging station in Stockholm [27]

Expected result (vs. real result)

To promote the use of electric cars, 1,000 chargers were installed in 2015 at various Stockholm Parkering parking facilities. From 2016 to 2018, further 307 charging stations were installed. The picture 6(b) shows the progress that has been made: the number of EV raised approximately six times since 2015 and the numbers of EV charging stations seven times. Due to the development in infrastructure, the private and commercially electric car ownership has increased. During 2017, 15 on-street charging stations have been added, with eight fast ones and more than 100 normal charging stations built in total. 101 of these are on-street charging stations. Petrol stations, fast food restaurants, and large supermarkets have proven to be the main types of business choosing to install charging points. [30]

The usage of fast and normal charging infrastructure differs. Fast charging is comparable with refueling, in comparison with normal charging, which is similar to parking. That is the reason why even today, most of the fast -charging stations are located in the inner city. Most EVs are charged overnight. Until the end of 2020, 500 on-street charging stations are planned to be installed. [31]

In 2015, only three car dealers (Nissan, Volkswagen and Tesla) had installed public fast chargers on their own premises. In September 2019, 19 different OEMs (Original Equipment Manufacturer) were present in Stockholm (Nissan, Peugeot, Porsche, Renault, Smart, Subaru, Tesla, Toyota, VW, Volvo, Audi, BMW, Hyundai, Jaguar, Kia, LandRover, Mercedes, Mini, Mitsubishi). This shows that the incentive had success and Stockholm became an attractive market for almost all the global OEMs.

The workshops were attended with great interest: : in the first seven workshops, 800 people attended. A follow-up survey after the first six seminars revealed that six months later 200 respondents claimed to have started the process of installing over 1,000 charging units. It is estimated that each replacement, from non-

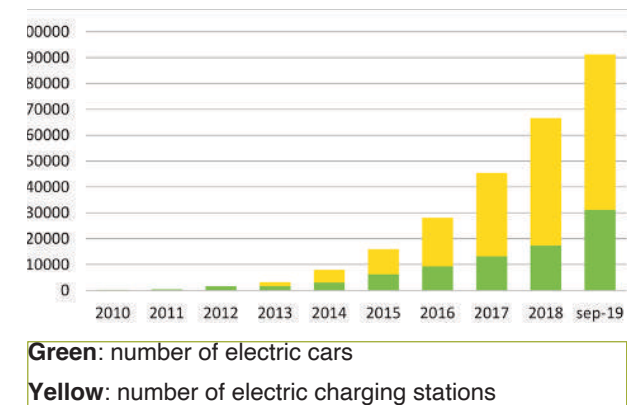


Figure 4.6. (b) Overview of the number of electric cars and electric charging stations from 2010 to sept 2019 [28]

electric passenger car to electric, causes a reduction of two tons of CO2 per year.

Challenges of Implementation

Deciding where to install the fast-charging stations was not an easy choice. Investigations showed that fast charging goes hand in hand with very frequent refilling, therefore used mostly by services like taxi. For this reason, most of the fast charging stations have been placed in the city center.

For the normal charging stations, it was sometimes

Problem being solved

Since 2015, there have been taken specific actions to achieve the goal of becoming a global leader in renewable mobility by 2030. When it comes to expanding the infrastructure for the EV charging, this means providing parking for normal charging and for fast charging. In September 2015, via Klimatklivet (Climate Step) program, Stockholm applied for state funding of investments to expand its EV charging infrastructure. The investment and funding are still ongoing. Businesses and municipalities can apply for grants for charging stations. However, until 2017, private individuals were not eligible to apply.

The private-owned infrastructure is also important when the increase of the electric vehicles is a priority. In terms of charging opportunities, overnight charging is the most common choice for private citizens. Applying for the installation of the facilities can be difficult when proper information is unavailable or hard to access. In 2017 a new measure was put in place, with the goal to disseminate the proper knowledge on how to organize, procure, and install EV overnight charging in privately-owned garages and parking areas in the residential areas.

difficult to select the “correct” power and current due to different technologies available on the market and cost, each one having advantages and disadvantages. Cars have different charging capabilities and require single-phase or three-phase power, and DC or AC, respectively. Also, there are different types of plugs available: the European standard socket from 2015 (type 2), the normal grounded socket and type 1 socket. The possibility of modifying the charging station at a reasonable cost was always considered. The final decision was that “smart” charging stations are the best solution, though very expensive due to the service it provides. They are equipped with options for statistics, alarm, communication with the charging station, remote control, etc.

Duration

The first Klimatklivet grant for expanding EVs’ infrastructure was awarded in 2015 and is ongoing. The workshops’ aim is to disseminate the know-how. They started in 2017 and are ongoing.

Financial Aspects

From the end of 2015 to 2018 approximately 55 million euros have been invested. In 2019 another 7,8 million were invested. [32]

The costs for the dissemination of the information in the first two years, 2017 and 2018, were 166.000 euros. [33]

Technical Aspects

For the normal charging Stockholm Parkering uses normal chargers as standard. These chargers have a charging power of up to 3.7 kW, which corresponds to a voltage of 230V and a current of 16 A.

For the fast charging stations, all four standards are available. CHAdeMO (the charging standard developed by Japanese car manufacturers), CCS (Combined Charging Standard, which has been developed jointly by German and North American car manufacturers), AC 43 (developed by French car manufacturers) and the one used by Tesla.

Air



It is estimated that each replacement, from non-electric passenger car to electric, causes a reduction of two tons of CO2 per year. [34]

Time



Depending on the type of charger chosen, a full charge could last from 30 minutes (for the fast chargers) to 6h (for the normal ones)

Space



Chargers require lots of street space. Consequently, this means less space for walking, biking, bus lanes, and moving cars.

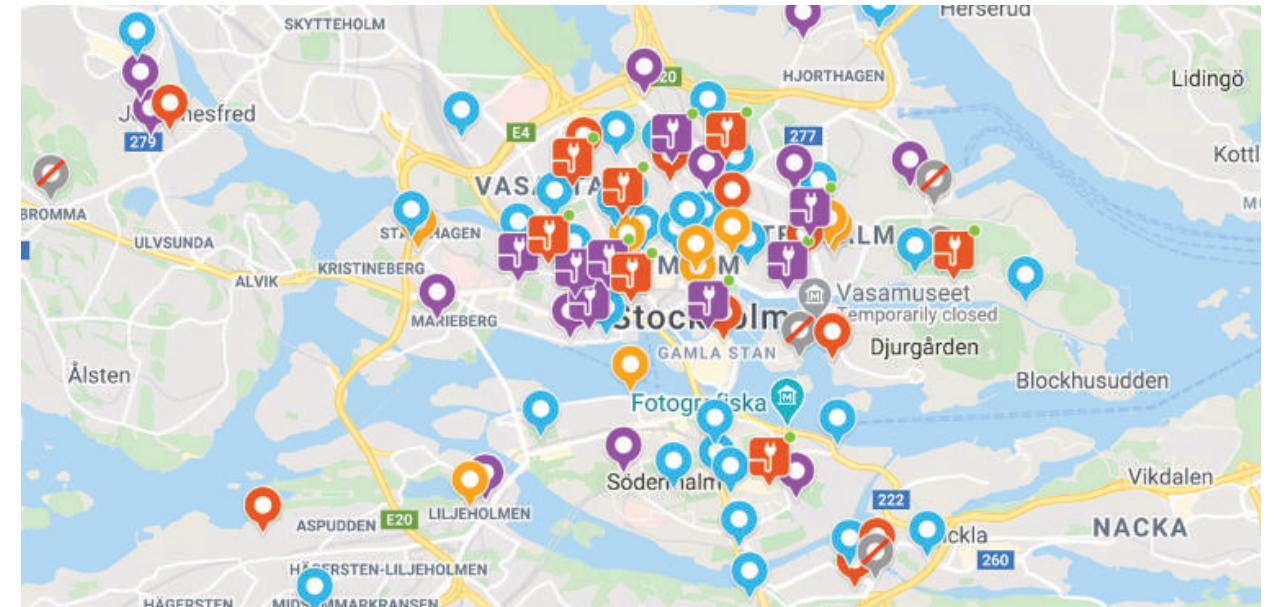


Figure 4.7. Map of the EV charging stations infrastructure in Stockholm [35]

Applicability to Munich

Applying for grants through Klimatklivet has resulted in more actors being interested in installing public charging stations. This led to a great development in the infrastructure of electric charging stations. The measure of disseminating the information to citizens and housing associations on how to apply for grants to have private EV charging stations pushes the development of the infrastructure also in the private

sector. In Munich, there are several projects to increase EVs’ infrastructure one of them being Me (Munich Electrified). In addition to a solid, tested strategy and a variation of technical solutions that can be embraced, the message must reach the citizens via strong advertisement. The citizens need to be nudged into applying to such grants, meaning that the legislation and the application process shall be provided in an accessible way.

S.1.3 ELIN – open autonomous driving testbed

Linköping University (LiU), which is located a two-hour train ride south-east of Stockholm, has set up a roughly two kilometers long test route for autonomous shuttle buses (ASB). Two ASB of different suppliers were acquired with the aim of gaining knowledge about the automation of traffic. What makes this testing ground special is that it hosts several projects. The infrastructure may be used for all projects that apply successfully. This enables especially smaller but innovative companies and benefits research groups that cannot fund the setup of a dedicated testing site. [36] [37] [38]

Problem being solved

Being a platform for various projects, ELIN's goals are manifold. The general motivation can be summed up as understanding the challenges of autonomous driving, building knowledge about intelligent and sustainable cities and their traffic and beginning the process of developing a framework for AVs. All these insights and the data collected are meant to enable future innovation without having a direct output themselves.

Stakeholders

The project was initialized and is hosted by LiU. It is supported by the Swedish government through Vinnova's (Sweden's Innovation Agency) initiative DriveSweden. There is a number of parties currently involved, as shown in Table 4.3. All of them benefit from the knowledge obtained in the testing area.

Partner	Description
Vti	Swedish National Road and Transport Research Institute
LiU	Linköping University
RISE	Research Institute of Sweden
Ostgötatrafiken	PT agency of the Linköping region
Linköpings kommun	Municipality of Linköping
Transdev	Private PT operator
Akademiska Hus	Governmental real estate enterprise for educational housing
Combitech	Private cyber security company
Tekniken Verken	Energy operator of Linköping
Ericsson	Communication technology company
Scania	Truck company

Table 4.3: Stakeholders of ELIN

Expected result (vs. real result)

Since the testbed is open and hosts a variety of projects, the areas in which data, knowledge and experience is built are diverse. One of the technical sides the topics include cyber security of autonomous vehicles, human-machine-interface studies, safety and security of AVs in real life conditions and optimization of routes driven by AVs. Socio scientific research focusses on acceptance and expectation of citizens, environmental impacts from a system perspective, socio-economic consequences and the effects of AVs on community development and building. From an economic point of view, lessons on costs and revenue of ASB or pricing and business models can be learned.

Duration

The initial planning and first ideas about ELIN came up in 2016. It took about three years until the first projects were finally launched.



Figure 4.8. (a) One of the vehicles [38]

Financial Aspects

The budget amounts to roughly 1.2 Mio. € [37] and mainly comes from the Swedish Government. Each vehicle costs about 250.000 €. Even though there is no direct return on this investment, the projects are necessary to promote autonomous driving and gain insights in diverse dimensions.

Challenges of Implementation

Since AVs are not common yet, a lot of challenges arise from their operation on public streets. One major issue is the permission process that must be completed. Due to the novelty of the issue, no standardised approach is present yet. Finding a suitable testing environment poses another demanding task. University campuses are very well suited as the surrounding is mostly open for experiments and future technology. Once the testing site was chosen, it needs to be prepared for autonomous traffic. That means for example mounting of special traffic signs, cutting trees or building garages to work on and store the vehicles.

In the case of ELIN, some incidents caused minor delays. Since collecting as much data during the operations as possible is one of the main goals of the projects, accessing the vehicle's sensors is required. For that to happen, it was planned on using an API delivered by the bus's manufacturers, however, they could not manage to deliver the interface in time. In order to maximize the amount of information, LiU intends to mount additional sensors to the vehicles. The suppliers agreed to this first but want to be asked for permission before modifying their vehicles. As they are very cautious, this process takes longer than planned and no sensors could be mounted yet. Furthermore, the process of installing the needed infrastructure (e.g. signs, bus stops etc.) was more complicated than anticipated due to the manufacturer's extensive requirements.

Technical Aspects

The key technology applied in ELIN are autonomous vehicles, and the IT infrastructure connected to them. In order to be able to control the vehicle in special situations, the AV cannot handle itself, it is necessary for a human being to take over. Teleoperating the AVs in such situations is saving costs since there is no driver in the vehicle while posing a possible cybersecurity risk. Amongst others, understanding these risks regarding cybersecurity of AVs is one of the main goals.

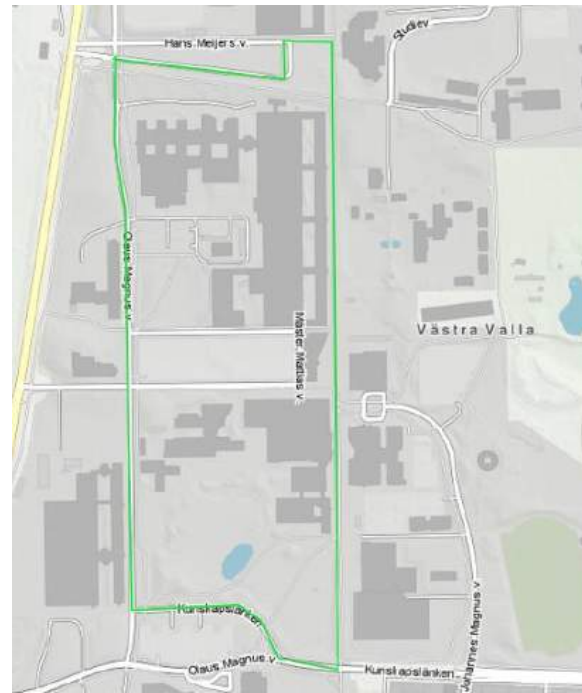


Figure 4.8. (b) The testing route [38]

Air



Electric vehicles cause no local air pollution and less noise.

Time



Last mile PT solutions increase the service level and facilitate better accessibility of locations distant to train/metro stations or regular bus stops.

Space



ASB are an effective way of moving small groups and can therefore decrease the traffic volume.

Applicability to Munich

Due to its complexity in multiple domains, e.g., legislation or technical aspects, being being a leading development service in autonomous driving takes collaboration of all involved stakeholders. This includes, amongst others, legislation, cities/ municipalities, car manufacturers, technology suppliers, and also the citizens, who provide space to develop and test vehicles in real traffic conditions. The

metropolitan area of Munich, accommodating global leaders like BMW or Infineon, could benefit heavily from a testbed that allows shaping the future together. However, doubts and concerns, as well as business rivalry, might inhibit such initiatives. Therefore, the city of Munich should provide a mutual communication platform and strive to initiate a project that gathers relevant stakeholders in order to develop future innovation together.

S.1.4 Fossil fuel free PT

Stockholm Public Transport (SL) claims to be on its way to becoming the most sustainable public transport company in the world. Achieving low environmental impact has been a priority for a long time. Today, SL's public transport system on land is powered 100% by fossil-free fuels and energy from renewable sources.

Problem being solved

Transportation and car travel are responsible for one-third of Sweden's greenhouse gas emissions [40]. Therefore, SL is focusing on buses powered with renewable fuels to achieve low emissions of CO₂, nitrogen oxides (NO_x), carbon monoxide (CO), hydrocarbon (HC), and particulate matter (PM) simultaneously [41]. In the search for smarter and more effective ways to drive public transport sustainably, SL has raised interest in modern electric-powered buses. The aim of the transition to electric buses is to contribute to better air quality, reduced noise, increased energy efficiency, and an attractive and climate-neutral Stockholm region.

Stakeholders

The politicians have defined aims, and the Stockholm Public Transport Administration is implementing the transition with the help of requirements on renewable energy in the procurement of traffic. As all traffic in Stockholm is procured, the financing of the conversion to fossil-free energy is included in the transport companies' price on traffic. [15]

Challenges of Implementation

The work of building and financing new infrastructure for renewable fuels has been the biggest challenge, especially for biogas and ethanol. Since the project was

planned back in the 90s, today's challenges are different. Nowadays, these include in particular, the charging of electric buses. New investments in infrastructure will be primarily allocated to depots and terminals where the electric buses will charge their batteries. [42]

In addition to the challenges, there are potential risks today, which can be problematic for this measure. The availability of renewable fuels, which is also linked to the price, can be a potential risk, as well as not getting enough electricity to charge the electric buses due to transmission capacity in the electricity grid. [15]



Figure 4.9. (a) Fossil-fuel free powered bus in STO [39]

Duration

From the time the project started with the first ethanol bus, it has taken about 30 years to arrive at the current result. On that journey, the most important step has been that the political parties during these 30 years have

established a common ground and now agree on the goals of renewable energy in public transport. Thus, the Stockholm Public Transport Administration has been able to work on the issue in a sustainable matter.

Financial Aspects

Excluding extra costs for infrastructure, the change to fossil-free energy has almost been cost-neutral. [15]

Technical Aspects

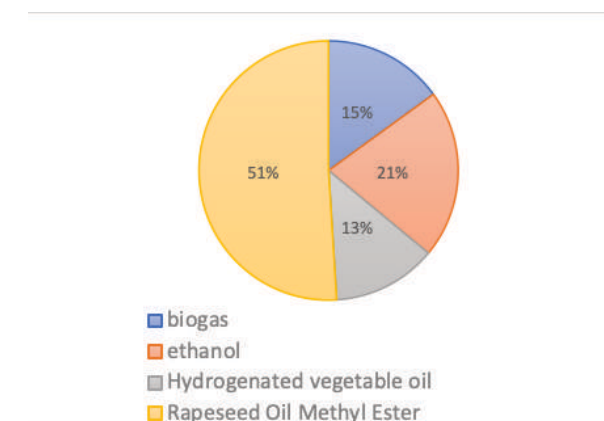


Figure 4.9. (b) The division between environmentally classified fuels in Stockholm with a total of 2100 buses (2018):

SL relies on biofuels as a key technology. Biofuels are produced from raw materials such as rapeseed oil, sunflower oil, sugar cane or tall oil, and from biological waste such as fat, slaughterhouse waste, or old food waste. SL uses 15% biogas, 21% ethanol, 51% rapeseed methyl ester, and 13% hydrogenated vegetable oil in its buses. [40] All biofuels used in SL transport must comply with the EU Sustainability Directive. This means that they must be produced in an environmentally and socially sustainable manner.

Expected result (vs. real result)

The original target for the city of Stockholm was that all public transport by land would be operated with 100% fossil-free fuel in 2025. Since, September 2018, all rail traffic has been running on 100% renewable electricity and all 2100 buses on renewable fuels (biodiesel, biogas and ethanol). Maritime traffic (70 ships) runs on 20% renewable fuels. Between 2011 (base year for targets) and 2019, the Public Transport Sector has reduced CO₂ emissions by 65% in bus traffic and 31% in maritime traffic. During the same period, NO_x was reduced by 57% for buses and 36% for ships and PM 50% for buses and 39% for ships. [15]

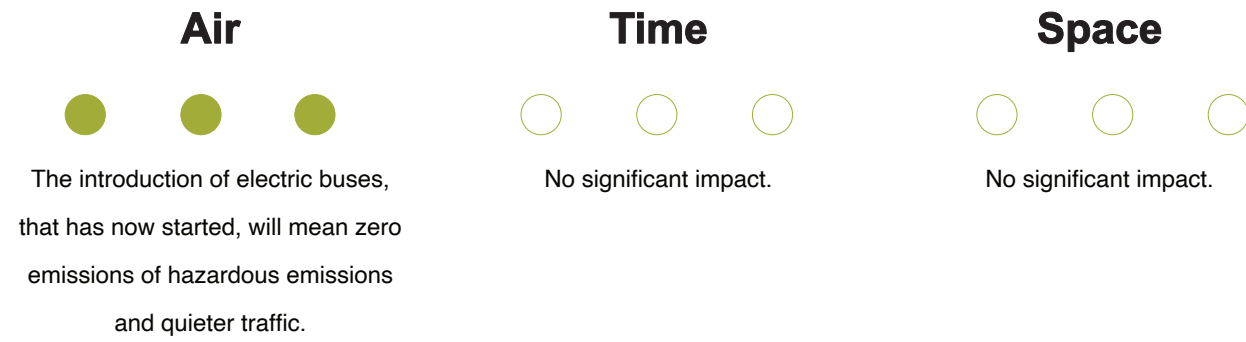


Figure 4.10. PT Stockholm [43]

Applicability to Munich

The Münchner Verkehrsgesellschaft (MVG) is currently working on 100% electrification of the urban public transport system in Munich. Subway and tram are running on 100% green electricity, and therefore, the MVG is currently running about 80% on electrified

lines. Although Stockholm is in the first stages of electrifying its bus fleet, they state that they manage already without fossil fuels. In contrast, Munich has only electrified 0.6% of its buses and is still largely dependent on fossil fuels. [44]

S.1.5 HUGO – autonomous, electric last-mile delivery

HUGO is a ground-based automatic last-mile delivery system. Small autonomous and electric vehicles deliver packages to end customers. In order to provide maximum flexibility, the chassis is modular, and the top case, which is mounted to a platform obtaining all hardware needed to drive, can be changed and/or modified to specific use-cases. The user/end-customer interacts with the robots via an app and can, for example, choose a preferred delivery time and is notified about the arrival of his parcels. [45]

Problem being solved

As a result of e-commerce becoming more and more popular, delivery traffic increases continuously. It is expected to increase up to 130% in the next decades. Especially in densely populated areas, this traffic leads to various problems: air pollution (global and local), noise pollution, congestion, scarcity of (parking) space and safety of other road users. In addition, last-mile delivery is expensive, takes a lot of time and can cause delays for both sender and recipient.

Stakeholders

The project was initialized and funded to a large extent by Berge Consulting. It is supported through DriveSweden and/or Vinnova. Additional partners are Boras Textile School, Ericsson, Something Borrowed, and Sportlala. The most recent project involves Chalmers and Gothenburg Universities, Johanneberg Science Park, Akademiska Hus, Ernst Rosén, HSB Gothenburg and Gothenburg's Traffic Office. Future questions regarding the permission to test and use autonomous last-mile vehicles will rely heavily on the cooperation of cities being responsible for road safety. The citizens should also be involved, as their acceptance will finally decide about HUGO's success.

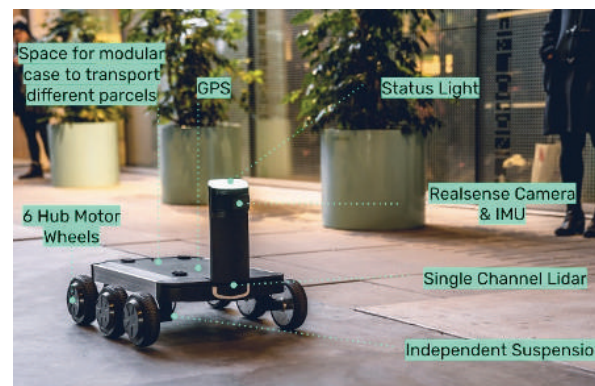


Figure 4.11. (a) The vehicle and specifications. [46]

Expected result (vs. real result)

The introduction of automated vehicles aims to decrease urban freight traffic. This is especially necessary considering the expected increase in total freight traffic, mostly related to e-commerce. HUGO aims to gain insights into the new landscape of delivery to be prepared for predicted changes. Besides technical feasibility, findings on user expectations and experience are emphasized. The emissions and energy consumption associated with last-mile deliveries are expected to be decreased significantly as well as the operational costs [46].

Challenges of Implementation

Even though last-mile delivery already poses a challenge in most urban environments, the transition to new solutions is just about to start. HUGO cannot rely on established knowledge but has to act open-minded and



Figure 4.11. (b) The corresponding smartphone app. [46]

needs to think outside the box. Lack of knowledge about legal frameworks might be a challenge causing delays once the robots are supposed to drive on public areas. Furthermore, the citizens' reception will decide about the success of autonomous delivery vehicles like HUGO, so including them early and exploring their needs, fears, and expectations is crucial. Overall, regulatory tools follow a specific decision-making path within local governments, which can be difficult to align with the particular conditions of research and demonstration projects.

Duration

The company HUGO was founded in 2018. The first prototypes were ready after four months and were subsequently tested internally and adjusted to the new findings. The first working prototypes were publicly presented in January 2019 and various research projects in different regions are being executed and/or planned in 2020.

Financial Aspects

Berge Consulting mainly funds HUGO, but specific research projects are co-financed by the involved partners, e.g., real estate companies. The development

budget is not publicly available. Testing and/or demonstration sites are to be set up relatively uncomplicated and connected with low cost as no infrastructure besides the equipment of the manufacturer (HUGO) is needed. This new form of delivery has the potential to decrease delivery costs significantly due to a big degree of automation.

Technical Aspects

The HUGO vehicle consists of two parts. The chassis carries six sprung hub motor wheels, comparable to the ones used in scooters, a computational unit (Intel NUC functioning with code written in ROS), as well as a variety of sensors: GPS, camera, inertial measurement unit (IMU) and Lidar. The modular transport case can be connected and locked to the chassis. It also contains the battery, so when the robot returns to a station to pick up a new delivery, it also receives new energy. HUGO plans to adjust the transport case specifically to each customer's needs and therefore be able to reduce costs by using the same chassis in all applications.

Air



Small electric vehicles produce no local and fewer global emissions.

Time



Quick delivery can be realized efficiently and cheaply. Fewer trucks mean less traffic and better conditions for cyclists and pedestrians.

Space



Even though smaller cars take less space than full-size trucks, the number of autonomous delivery vehicles should be limited in order not to interfere with cyclists and pedestrians.



Figure 4.12. HUGO in use [45]

Applicability to Munich

Last-mile delivery is a pressing topic in Munich. HUGO is a promising approach that has the potential to solve this problem. Because AV development and the connected regulation is still at an early stage, conducting research and tests early on will pay off later. There are multiple mobility labs in Munich that could

work as a testing area for HUGO. If the manufacturer provides the necessary equipment, trials could be realized with comparably little financial effort and deliver valuable results towards new forms of last-mile delivery.

S.1.6 Night delivery with clean and silent vehicles

Even cities with heavy traffic congestion during peak periods have available road capacity at night, in the evening and early morning. A policy that shifts urban freight deliveries from peak to off-peak hours has the potential to increase the efficiency of freight distribution and reduce negative external effects like noise or pollution. Between 2014 and 2016, the City of Stockholm conducted a pilot project that enabled heavy trucks within the city by to use clean and silent engines with the tool of geofencing to deliver their goods at night.

Problem being solved

The growing urban population, economic growth, and structural change in the economy have increased the demand of companies and residents for goods deliveries. Traffic congestion is a major problem in urban areas around the world and can cause high costs for travelers and business operations. Congestion leads to delays and unreliable delivery services for the freight industry. Simultaneously, freight transport itself has significant negative external effects on accessibility, the environment and quality of life. Frequently identified externalities involve traffic congestion, air pollution, and greenhouse gas emissions, as well as accidents, visual intrusion, barrier effects, disruption and noise [49].

Stakeholders

Commercial freight transport is usually a regional matter. However, local traffic regulations and restrictions can be applied by the Stockholm City Council, which has control over areas or individual roads through the use of low emission zones. The main parties involved were the EU initiative CIVITAS ECCENTRIC, the Traffic Administration of the City of Stockholm, KTH, Scania as the provider of the trucks and McDonald's stores as the recipient.



Figure 4.13 (a) Plugin hybrid electric vehicle from Scania [47]

Expected result (vs. real result)

The expected effects of implementing this measure for night-time deliveries include more effective transport and transfer of goods, an improved working environment and effective noise reduction - allowing night-time deliveries without disturbing residents and others. In addition, due to the calm traffic, deliveries are on time, which results in the satisfaction of residents, goods recipients, road users and, above all, the truck drivers themselves. For trips with waste to the processing sites, night-time operations fluctuated on average by +/-15% of typical travel times, while the fluctuation for daytime operations between 07:00 and 12:00 was +/- 22%. The results also show that

night-time operations consumed less fuel and produced fewer emissions. Night operations consumed about 2.7-3.6 liters/100 km less fuel than morning operations. This was equivalent to about 8-11% less emissions. Furthermore, travel times for trucks at night-time were around 25-30% shorter. [50]



Figure 4.13 (b) Geofencing map example [48]

Challenges of Implementation

Due to the strict noise protection regulations of the City of Stockholm, it was a challenge to implement the measure. Despite the quiet engines, some residents complained to the Environment Department. In order to receive the complaints, the trucks first had a telephone number printed on them and later a website for residents to get information. One delivery point had to be completely cancelled because the neighborhood was so traffic-calmed that loading and unloading exceeded Stockholm's noise regulations. [51]

Duration

The first off-peak delivery project was carried out between 2014-2016. The second operation of the night delivery scheme started start in October 2018, and data collection on performance indicators such as delivery

efficiency and noise were performed during one year of service. [52]

Financial Aspects

This measure was financed by the EU initiative CIVITAS ECCENTRIC with 340,000 €. [50]

Technical Aspects

The term geofencing is all about the relationship between the position of a mobile device and a predetermined location. If this object leaves or enters the area previously defined by a receiver, an action is triggered. The position is determined, for example, by GPS, RFID systems, or mobile phone and WLAN networks. In combination with PHEV, the trucks switch to electric mode when they enter an environmental zone, and in a pedestrian zone, the speed can be reduced. Besides the vehicles, unloading is also a source of noise. In this project, several possibilities to minimize the noise were explored. First, the road surface was given a special asphalt to reduce the noise. Secondly, low-noise roller cages were used. Thirdly, a special tool, the Silence Advisor, was developed and tested. It consists of a microphone and a display with diodes, which should be placed in the user's line of sight. The microphone records sound and when pre-set thresholds are exceeded; the diodes light up to give feedback to the user. [53]

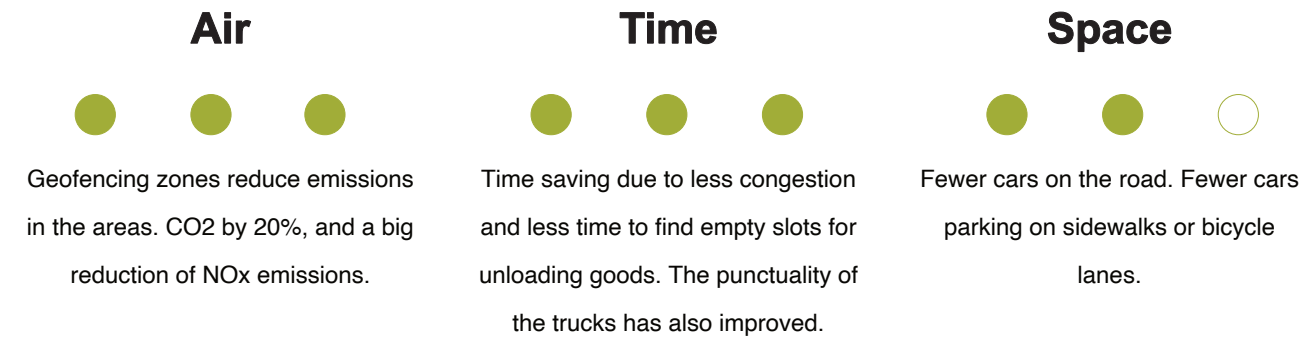


Figure 4.14. Night delivery [52]

Applicability to Munich

Night deliveries in themselves are a well-applicable measure for Munich. This would require the establishment of geofencing zones and a fleet of PHEV electric or plug-in hybrid trucks, which were supplied by the truck manufacturer Scania a role that MAN could take up in Munich. Since trucks are currently allowed to

deliver from 22:45-10:15 [54] most places in Munich, the majority of them accumulate in the morning during rush hour. In order to relieve car drivers, buses, other road users and, above all, the truck drivers themselves night deliveries with clean and quiet trucks would be a good measure to implement soon.

S.1.7 Smart Traffic Management: Prioritized Traffic Signals

This measure represents an incentive to boost the usage of alternative fuels in HDV (Heavy-Duty Vehicles) and to diminish the number of starts and stops. It is made possible by offering signal priority to HDVs which are using alternative fuels at key intersections.

Problem being solved

The measure was applied in order to promote the transition towards cleaner vehicles and fossil-free fuels. In the past, the city of Stockholm has taken comprehensive steps to solve the problem: for example, fossil-free vehicles were excluded from the congestion tax.

Stakeholders

The Stockholm-based firm Carrier incorporated HVO (Hydrotreated Vegetable Oil), fuelled heavy vehicles into their fleet. [56]. The City Traffic Department was also involved together with the company Swarco, the operator of the signal system.

Expected result (vs. real result)

Two impacts are concluded: safety and CO2 saving, generated using HVO as an alternative to fossil fuels for the propulsion of heavy vehicles. The environmental impact was reduced by prioritizing the vehicles at the intersection, therefore the number of starts and stops was reduced. Safety was also improved due to much better traffic flow. [57]

Challenges of Implementation

The biggest challenge of the implementation was the collection of the data from the field and the synchronisation of the work of all stakeholders. The City

of Stockholm had to program the traffic lights so that it enables the test. The traffic lights network operator activated and deactivated the system on alternate weeks throughout the year, so that a comparison of operations with and without the prioritization would be possible. Moreover, the company Carrier worked together with the



Figure 4.15. Technic device which was used to achieve the signal priority [55]

software provider to ensure that the interface between traffic lights and mobile phones works properly.

A concern was that larger negative impacts would be generated for the other users who are not prioritized. To cope with this possible risk, it was decided not to overlook the importance of walking. Therefore, pedestrians were not deprioritized by the system if they choose to cross the street.

Duration

This measure was tested for a period of 18 months. Though, not continuously, since adjustments from the technical side needed to be done during the project.

Financial Aspects

The total budget for this measure was approximately €11 per annum. [58]

Technical Aspects

There are two main technical parts: the integration of the prioritizing system into a dynamic one and choosing the area where to run the system. The selection of the tested area should be done at the very beginning and should not be changed later during testing since it might have a negative impact on other road users. The testing area was chosen to be a major hub for entering the city center from the south: close to Gullmarsplan and the bridge to Södermalm. Furthermore, the area is a frequent route for freight transport and contains several traffic lights.


Air

CO₂ savings generated by the use
of HVO



Time

Time is directly impacted due to
better traffic flow.



Space

No significant impacts



Applicability to Munich

This measure is reproducible to any city. The main part is to choose the correct route-type in order to avoid the negative impact on other users of the road. It is crucial for the measure to work that all stakeholders

synchronize their work and communicate, since adjustments are needed during the implementation. The measure might be particularly interesting for the private business in the freight sector. [59]

S.2.1 Digitalized Business Models for Parking Spaces

The Stockholm Parkering, which is a local company owned by the City of Stockholm, which builds, owns, maintains, and operates 65.800 parking spaces situated in underground garages, parking decks and parking lots. Their business system was modernized to enhance business operations. [60]. Moreover, to facilitate parking searching and payment, the City of Stockholm developed the digital payment application called Betala P and approved digital services run by private operators that buy parking time from the city and sell it in their applications [61].

Problem being solved

By modernizing and optimizing the system of Stockholm Parkering, the system is now considered a user-friendly and browser-enabled web portal solution. It supports extensive case management processes providing care to the clients [64]. The available apps share the vision of building smarter and more liveable cities by developing parking solutions. The apps allow a balance between the parking supply and driver, not due to additional parking spots and fewer cars, but thanks to predictive technology that connects drivers to available spots in an easy way. It is a way of promoting parking on the outskirts of the city, preventing traffic congestion when looking for a place to park. Besides, it also offers drivers a broader choice regarding price when looking for a parking space [63].

Stakeholders

The modernization of the Stockholm Parkering was made with the company Softronic which is a leading Microsoft Dynamics consulting firm offering CRM (customer relationship management systems) and ERP (enterprise resource planning) consulting services [64].

The City of Stockholm promotes the use of the Betala P application service also at Stockholm Parking's

facilities. Many of the privately developed apps operate in different countries [60].

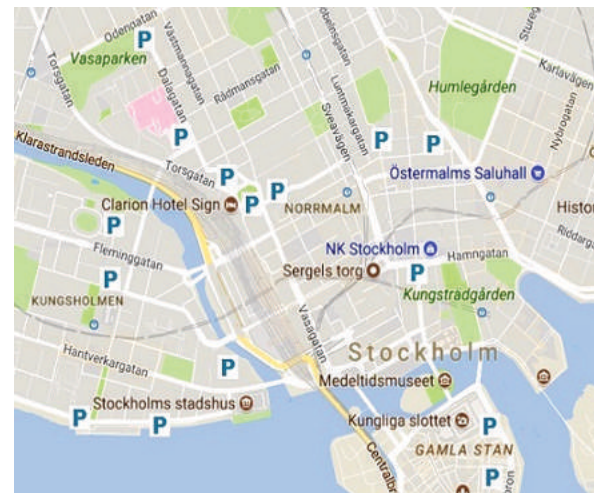


Figure 4.16. (a) Stockholm Parkering parking areas in inner-city [62]

Challenges of Implementation

According to [64], Stockholm City Parkering modernization faced the following business challenges:

- Replace an outdated proprietary system that was very high risk and expensive
- Meet customer demand with quick responses to problems/cases in a multi-channel environment that includes voice, web, e-mail, and mobile

- Manage daily operations with a modern-state-of-the-art business system
- Foresee future integration to parking equipment (e.g. IOT) and parking facilities

Duration

In 2015, the first facilities of Stockholm Parkering were built. The Betala P app started the collaboration with Easypark in 2011-2012 and the app was released in 2013.



Figure 4.16. (b) SMS Park app. [63]

Financial Aspects

In 2019, the Stockholm Parkering net profit was approximately 143 million euros. The positive result derives from the leased facilities and the revenues by the high number of visitors. The investment amounted to 208 million euros, where most of the budget went to the Parking house Hagastaden aimed to be constructed by 2022 [60].

Technical Aspects

For the Stockholm City Parkering, Axonom partner, Softronic, replaced the outdated homegrown business system with Microsoft Dynamics CRM and Powertrak

Portal to extend service and support using mobile devices. Some technical benefits are [64]:

- Case intake and creation through Powertrak Portal = 4.000 cases/month
- Enhanced support for customers, partners, and suppliers
- Self-billing invoices to suppliers
- Workflow for supplier invoices including authorization
- Customer service support with troubleshooting guides and distribution of service orders
- Rental management of thousands of parking lots

Expected result (vs. real result)

The modernization of the Stockholm Parkering focuses on developing and digitizing services that increased the customer benefit and lead to the company streamlining its processes and finding new technical solutions [60]. The system to support business decisions promotes users to create dashboards and views to display outcomes and key performance indicators and also generates reports on profitability per park facility [64]. It also allowed the expansion of the parking facilities and the incorporation of new elements, such as charging stations for electric vehicles, bicycle parking and carpool spaces. As for the app usage, over 70 percent of the customers of Stockholm Parkeing choose to use a mobile app. Of the total revenue from visitor parking, the proportion is somewhat lower, about 55 percent of payments are made via mobile app [60].

On the other hand, the multiple features of the parking apps allow the user to spot the most proximate parking spaces on a map. Once the user has selected a parking space all the required information becomes visible: parking times, hourly rates, parking time limits

and zone codes. In the app, the payment can be made as well as the extension for the parking if necessary. Figure 4.17 depicts the EasyPark app route of parking digitalization [63].

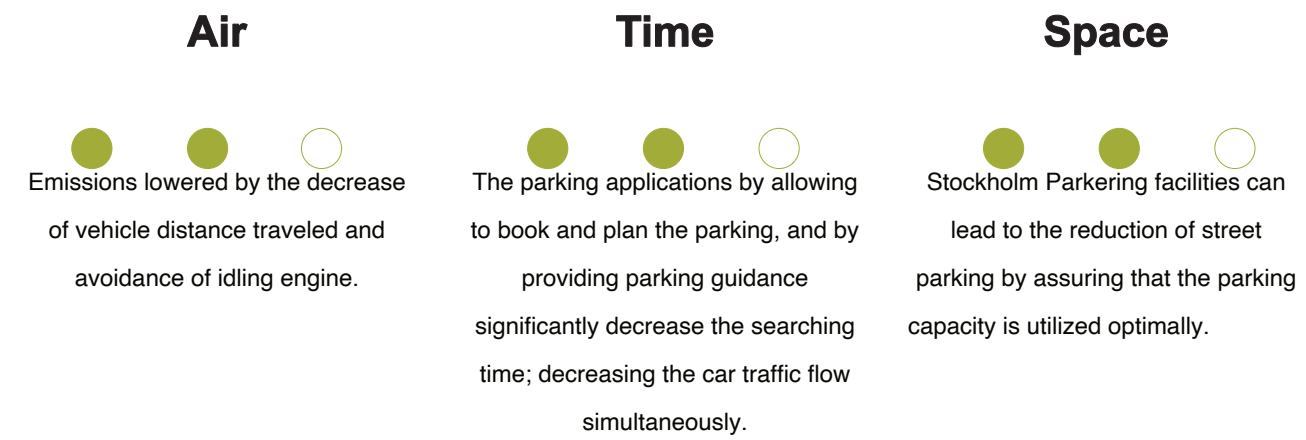


Figure 4.17. EasyPark app route of parking digitalisation [63]

Applicability to Munich

Parking in Munich's inner city can be hard. Thus, digital parking platforms and a consolidated and central system such as the Stockholm Parkering system that manages all off-street parking and provides information for the users can mitigate parking problems and provide new solutions that focus on

maximizing the parking capacity and lowering vehicle traffic simultaneously. It is important to consider data privacy and data protection in every phase. Also, it can orientate newcomers about the city's parking regulations and restrictions.

S.2.2 UbiGo – Mobility as a Service

With the goal of promoting viable alternatives to owning a private car, the MaaS application UbiGo was launched in the summer of 2019. UbiGo provides access to five modes of transport: public transport, bike sharing, car sharing, car rental and taxi. The app enables its users to plan trips by providing information on travel times, fares and departures. UbiGo boasts a subscription model. Users can choose from predefined as well as personalised plans. Each plan includes a certain amount of ‘mobility units’, for example, hours of rental car usage or days of PT access [37].

Problem being solved

For some car owners, public transport on its own cannot satisfy all mobility needs like leisure trips or the transport of large objects, which makes it hard for them to abandon their car. But since the car has a very high share of fixed costs, it only makes sense to use it frequently once purchased. To achieve the goal of reducing the ownership and usage of private cars, viable alternatives, especially for citizens relying on their car for certain occasions, must be provided. This can be achieved by developing an integrated offer containing various modes and deploying shared or rented cars as a solution for special instances.

Stakeholders

The project was initialized and is led by the company UbiGo. UbiGo, as well as the city of Stockholm, collaborate with various transport providers. The project is supported by the European Union through Civitas Eccentric. The supplementary transport modes are provided by GoMore (car rental) and Snappcar (peer-to-peer car rental) [66].

Expected result (vs. real result)

After a lot of research on MaaS, especially in Sweden, the scientific findings shall finally be applied to the present challenges. After the execution of pilot projects, one of the first real world MaaS applications was launched as UbiGo. The main target is to develop viable business models and map out challenges. Taking this knowledge to other cities, MaaS can help solving many problems in today’s urban mobility.

Duration

UbiGo is the successor of different pilot projects that were executed since 2012. One of the main goals is to transfer the findings from these pilots and develop a working business model. UbiGo was officially launched summer 2019, and strongly benefits from the previously conducted studies.

Financial Aspects

The project was supported with 752.000 € from the European Union through Civitas Eccentric [66]. The city of Stockholm does not provide financial support but contributes by advising in regard to legal and regulatory aspects as well as providing a communication platform

for the various stakeholders. Besides the amount from the EU UbiGo does not receive external funding, however, it aims to prove that MaaS business models can be sustainable.

Technical Aspects

UbiGo provides a smartphone application that enables users to plan, book, and pay for their trips. Therefore, it is necessary to obtain information on travel times, fares etc. from all involved TSPs. If this exchange of information happens using the TSP’s APIs, the technical challenge of the MaaS is relatively small.



Figure 4.19. The UbiGo application in use [67]

Challenges of Implementation

The collaboration between all involved transport service providers poses the greatest challenge. Especially for PT, becoming part of a MaaS agreement can be a demanding task since there normally is a bureaucratically complex procurement procedure in place for cooperations with third party contractors. Since a MaaS product is highly dependent on every travelling mode included, a trustworthy relationship between all actors is essential. If one of the TSP steps back or does not fulfil its duties, this could negatively affect all other parties. Therefore, besides a well-planned legal framework, awareness for the collective goals must be raised.

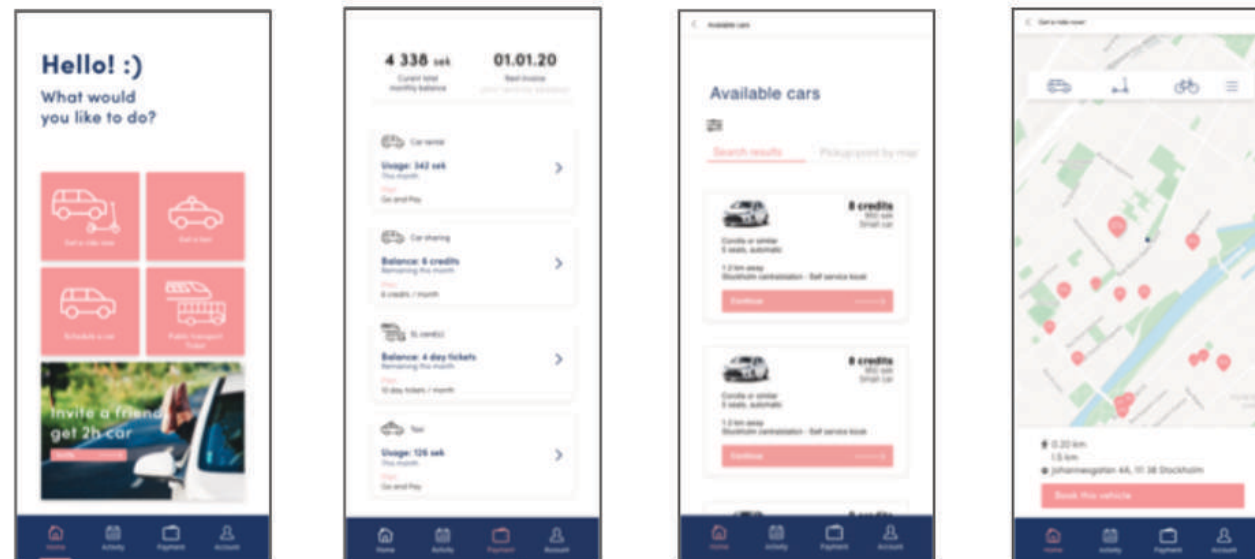


Figure 4.18. User interface of the UbiGo mobile app [65]

Applicability to Munich

MaaS is a universal and flexible concept that can be modified to the requirements and circumstances of specific cities. In many trials it has proven great potential in solving various traffic-related problems by shifting modal shares towards public transport. Munich provides all technical requirements of a MaaS solution, however, it did not yet succeed in establishing one. The biggest challenges of MaaS might be finding a structural model that is beneficial to all transport

providers, as well as the willingness to share customers and their data. The MVG, which is in charge of the complete PT system, is the most critical party involved. Without PT, MaaS cannot fulfil its potential. Therefore, MVG must find a way of collaborating with other transport providers and become open to other stakeholders. The city of Munich should contribute by legislation as well as facilitating a productive discussion.

S.2.3 Bike Parking

The Stockholm city recognizes that bike parking should be more accessible. Therefore, new parking spaces for cyclists are being built every year, according to [68], a total of 30.000 bicycle parking spaces are all around the city. Just between 2017-2018 approximately 2.000 new bike parking spaces were built. These are strategically built next to transport hubs, arenas, shopping malls, parks, and public spaces. There is a variety of parking spaces and a Sweden's first fully automatic bicycle garage as shown in Figure 4.20 was built by Stockholm Parkering.

Problem being solved

With the increasing number of bicycles, the need for bicycle parking increases. An important aspect of a good cycling infrastructure is having enough coverage and choice for safe bicycle parking. The different types of bike parking are selected according to the local situation, for example, two-story stands are used at public transport hubs where there usually is a great need, but the areas are limited. The simpler infrastructure can be found in almost all neighbourhoods. Moreover, parking spaces are differentiated from the pedestrians' space, to prevent traffic and pedestrians' obstructions caused by badly parked bikes. Inappropriate parked bikes can also pose a danger to, for example, people with visual impairment [69]. Additionally, the city moves parked bicycles that are parking at the same place for more than 24 consecutive hours in order to facilitate cleaning and maintenance, and to increase accessibility and free up bicycle parking spaces the city [69]. Furthermore, it facilitates multimodality since the parking spaces are located near public transport stations or by allowing the customers who have an existing car rental to park their bikes in 25 selected facilities managed by Stockholm Parkering, free of charge.



Figure 4.20. (a) "Cykelsnurrar" automated parking. [60]

Stakeholders

Apart from the bikers themselves the two most involved players in bike parking are the City of Stockholm and Stockholm Parkering.

Challenges of Implementation

Some of the challenges to ensure the availability of bicycle parking for all users were the selection of locations and types of bicycle parking, as well as the search for appropriate infrastructure and maintenance plans for bicycle parking.

Duration

The first part of the bicycle parking plan covered the period 2015-2018 and as there still was a great need for bicycle parking, a new orientation decision was made in 2018 regarding investments in bicycle parking between 2019 and 2022. It has been decided to further expand the stock with approximately 1.000 bicycle parking spaces per year [68].



Figure 4.20. (b) Multi level bike parking. [own]

Financial Aspects

The costs of bike racks are expressed in Table 4.4.

Technical Aspects

There are different types of bike parking and racks: double deck rack, two-story racks (see Figure 4.20 (b)), bicycle rack with marked and shielding ends, bollard -

with room for one or two bikes, bicycle rack with front wheel holder. Many of the bike stations include air pump stations to refill on air, free of charge. All frames are designed for locking in the frame. The standard distance between the bollards is 90 cm, however, it is not suitable for cargo bikes [69]. Additionally, the company Stockholm Parkering manages multiple bike-sized lockers, the exclusive bicycle parking garage called Odenplan and "Cykelsnurrar" (see Figure 4.20 (a)) - Sweden's first fully automatic bicycle garage. Odenplan's bicycle garage has over 300 bicycle spaces and 30 boxes (see Figure 4.21). Each box is equipped with a charging option for an electric bicycle. There are

Expected result (vs. real result)

The bicycle plan envisions an expansion rate of approximately 500 bicycle parking spaces per year. However, there is such a great request that the pace of development has been more ambitious: there have been installed almost 3,000 bicycle parking spaces per year between 2015 and 2018 and 2,000 planned bicycle parking spaces per year between 2019 and 2020 [69]. Besides, vehicle parking spaces have been occupied by a type of bike parking space called "Stockholmshagen" that has room for about ten bicycles. A total of about 130 "Stockholmshagen" have been placed in 70 locations with a total space for around 1300 bicycles. Two-story stands have been placed in five places creating parking space for over 400 bikes [69].

Type of bike rack	Cost per bike rack (Euro)
Two-story rack with weather protection	730 approx.
Bollards of different models	460 approx.
"Stockholmshagen"	640 approx.

Table 4.4. Cost of seats per bike rack.

also 3 places for cargo bikes [60].

The automated bicycle parking “Cykelsnurren” has 24 leased spaces, the regular price is 18 euros per month. It is 1.8 m height and has a diameter of 5.5 m. An electronic key opens the lock of the storage and it spins forward to place the bike right in the groove or to take out the desired bike. The door then closes automatically. According to [60] the requirements for

bicycles are:

- Max length: 1.9 m
- Max guide width: 65 cm
- The bicycle must not have a basket on the front
- No loose material may be hung on a bicycle
- Adult bicycle with wheels of at least 26 inches.

Applicability to Munich

On December 31, 2019, there were around 38,700 municipal bicycle parking spaces in the Munich city area. This shows that Munich is already doing a lot in the field of bicycle parking. However, the Stockholms approach of using different parking methods could

ensure that a device is set up in more places, as well as, innovative solutions such as automated bike parking can be an attractive way to promote cycling. Furthermore, set targets could help to increase the number of bicycle parking spaces.

Air



The attractiveness for using a bike increases and so that fewer cars will be used lowering emissions

Time



Less time is spent searching for a bicycle parking space

Space



Through organized bicycle parking space can be used more efficiently



Figure 4.21. Bike parking boxes. [61]

S.3.1 Re-routing cyclists during construction work

To keep cyclists and pedestrians safe at all time, the City of Stockholm aims to increase road safety wherever it is necessary. By using innovative re-routing methods and materials during construction work, the Traffic Office improves security and safety for cyclists, pedestrians, and construction workers.

Problem being solved

As Stockholm is growing rapidly, the number of construction works is increasing. These construction sites are often located near or on the road and do not provide pedestrians and cyclists with the necessary safe space between the construction site and the road. The usual approach of leading cyclists across the road and onto the cycle paths on the opposite side has created significant safety problems and more conflicts with cyclists going in the opposite direction, pedestrians and cars, as some cyclists did not use the detour system. [71]

Stakeholders

The Stockholm Public Transport Authority in cooperation with the Swedish Association for Safer Road Sites initiated the project and invited companies to present new and innovative solutions for barriers and other materials used to encircle construction sites. [71]

Challenges of Implementation

The biggest problem in implementing this measure was the limited space available between the construction site and the road to divert the bicycle and pedestrian path. Additionally, there were delays due to the coordination of many parties involved, from the traffic administration

to the construction workers and the owners of the driveways. [72]



Figure 4.22 (a) Rerouting facility [70] .

Duration

The first measurement, which was carried out before construction began, was placed for 14 days, in May 2019. The second measurement was performed in September 2019. [70]

Financial Aspects

The measure receives 250,000€ as funding from the EU initiative CIVITAS ECCENTRIC. [71] And the weekly material as fences, barriers or signs costs amount to 2500€. [73]

Technical Aspects

In this measure, the City of Stockholm tried to focus on new materials, signage and detours to ensure safety on construction sites. To measure the flow of cyclists on the test plots before, during and after the test pneumatic street hoses were used. And for detouring a fenced by-pass road with a width of 2.5 m was used. [72]



Figure 4.23. Rerouting system in Munich [74]

Expected result (vs. real result)

Due to better information and new safety measures, cycling by road construction sites is expected to become more attractive. The goal by Stockholm municipality is that the proportion of cyclists should not decrease by more than 5% in temporary road work areas. During the time of the temporary road work that was used as a test bed, the amount of cyclist decreased by 5,2%. According to the traffic office, it can get up to 30% caused by a construction site. After interviewing the cyclists, it was clear that this method has a high level of acceptance among them. 78% felt safe or very safe in relation to road works and 90% felt safe or very safe regarding other traffic. [70] In addition, the construction workers were very pleased with this method because they felt safer because of the diversion and conflicts with cyclists were avoided.

Air



This measure will make cycling safer and therefore more attractive, with benefits for air quality, noise pollution and public health

Time



Due to a direct diversion, there is no need to change lanes and thus time can be saved.

Space



Space is not necessarily saved, but the space for redirection is used more effectively to ensure safety.

Applicability to Munich

In Munich, cyclists are often rerouted at construction sites by merging the bicycle lane and the pedestrian lane or by redirecting cyclists onto the road, as seen in Figure 4.23. Both the redirection with the help of fences and blocks for the spatial separation to the road

and the construction site, as well as the signage and markings, are a more expensive, however, a much safer method for all persons involved. Therefore, this type of rerouting would be a well-applicable method for Munich bicycle paths, with the precondition that there is enough space.

S.3.2 Revision of parking regulations towards active mobility

In 2016, a new Parking Strategy was implemented. It mainly consisted of incrementing the parking fees, incremental of the inner-city boundaries to twice the size, delimiting the residential parking areas (see Figure 4.24 (a)) and the removal of parking lots for the creation of new bike lanes or their width expansion [75]. One of the main objectives of the strategy is to maintain a limited parking capacity, measured by maintaining 50% of the parking lots constantly unoccupied.

Problem being solved

The parking restrictions and regulations had reduced the volume of circulating traffic on the streets and simultaneously is constantly helping to improve the city environment [75].

The substitution of parking spaces into biking lanes has promoted and facilitated cycling. Many interventions have been made to meet the city's bicycle plan, however, many of them were made in strategic places to connect neighbourhoods or to enable the connections of future new housing developments. Besides, it aimed to make the road safer for cyclists (especially in identified busy cycle routes). Additionally, the interventions allowed the installation or improvement of the lighting infrastructure, the replacement of the ground to remove problems with water accumulation and drainage, and the creation of new intersections or connections to points of interest. Simultaneously accessibility has been improved.

Stakeholders

The Traffic Department Office leads the logistic behind the parking strategy and implementations. Together with the City Planning Department, the decisions are made, however, the execution is done merely by the Traffic Department Office [75].

Challenges of Implementation

According to the Traffic Office [75], one of the biggest challenges expected in the removal of parking spaces and the imposed parking regulation were citizens' complaints. They stated they had received multiple complaints through their communication platforms, nevertheless, the adaptation happened quicker than expected. One of the reasons for this was the quick construction of bike lanes right after the removal of parking spaces, which allowed the citizens to see the solution against the problem.

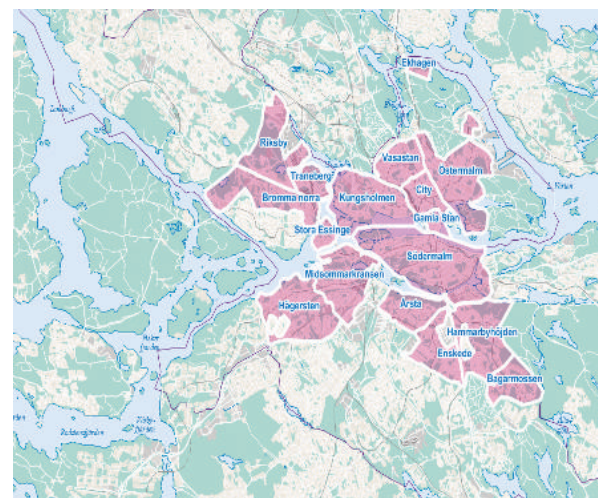


Figure 4.24. (a) Stockholm residential parking areas [75]

Duration

There is no exact data on the duration or steps the parking regulations were done. In the case of parking removals, the duration varies from project to project. In the case of the construction work on North Mälstrand it began in September 2015 and was completed in May 2017 [69].



Figure 4.24. (b) Parking signs [own]

Financial Aspects On the same project (North Mälstrand) the Traffic Office granted an investment of 3,08 million euros and the final investment was 2,79 million euros. The project received government co-financing of 0,88 million euros and compensation of about 140.000 euros for work carried out for Ellevio and Stokab [69].

Technical Aspects

The coordination with different participants for the removal of the parking spaces, to adapt traffic during the construction time and for the construction of the new bike path infrastructure represented the mayor

technicalities. Furthermore, there are different on-street and off-street parking regulations around the city that allowed a strategic reduction of traffic, some of which are:

- The maximum stay in city centre boundaries is of one hour and the paid parking is set every hour of the day: €2,28- €4,57 (pending on streets), from Monday-Friday 09.00-21.00 hours, on Saturday,

Expected result & real result)

According to the Traffic Office [75], the parking spaces in the inner city were lowered from 35.000 to 17.800 spots in total. Many of the newly available spaces were transformed into bike lanes or renewed into public spaces that promote the city's liability. In this way, the municipality improved accessibility, quality of life and safety in the city centre. Besides, due to the parking regulation's car ownership lowered, and there has been a noticeable growth in active mobility [75]. Moreover, the newly constructed bike lanes had enabled the connection of neighborhoods, increased safety for cyclists, and had a positive impact on accessibility as is the case of the bike path on North Mälstrand (see Figure 4.25) where the high flow bike path was widened to 4.5 m and provided with better lighting, passages and pedestrian connections, the traffic analyzes done do not show any negative impact on motor vehicle traffic attributed to this intervention [49]. Overall, the intervention done in North Mälstrand required the removal of 60 longitudinally parking lots, the bicycle flows totalled approximately 8.000 cyclists per day in 2018. On the City Hall bridge east along the street, the number of bicycle passes has increased from a maximum of 10.000 per day in 2016 to 11.500 per day in 2019 [69].

Sunday and public holidays 09.00-19.00 hours.

The parking rate for other hours is €1,37

- In districts such as Vasastaden, Östermalm, Södermalm and Kungsholmen unlimited parking was set on Monday-Friday 09.00-19.00 hours (€1,37/hour) and Saturday 11.00-17.00 hours (€0,91/hour). In the rest of Stockholm, unlimited parking was set on Monday-Friday from 07.00-19.00 hours, with a rate of €0,46/hour. For residential parking areas, the residents can apply for a housing parking permit

- Free parking is only allowed in the suburbs Liljeholmen and Solna. Today there are no reduced parking fees for clean vehicles (biogas, ethanol and electric hybrid vehicles), mainly because there is not a settled common national definition on "clean vehicle". The city council is most likely to introduce free parking only for vehicles registered in the municipality of Stockholm and for commercial vehicles with a special parking permit.

Air



There are fewer cars and therefore more cyclists and pedestrians on the roads, which results in fewer direct emissions

Time



Cycling routes are faster due to the newly created routes that increment district connectivity. As well, the paths by having the exclusivity for cycling allows a higher travel speed.

Space



The measure creates newly available space that can be transformed for the benefit of the inhabitants.



Figure 4.25. North Mälärstrand bike lane. [76]

Applicability to Munich

The cycling network of Munich is extensive. Nevertheless, many cycling routes are narrow, not segregated from pedestrian paths or are shared with motor vehicles (bike streets with a limit of 30 km/h) making them dangerous to all road users. Therefore, restrictions for parking, and prioritizing and incrementing exclusive cycling paths over motorized

vehicle infrastructure could bring similar benefits as the ones seen in Stockholm. Jammed parking spaces can be lowered in Munich city center, which can be a way of ensuring safety for cyclists and pedestrians, increasing the connectivity between neighborhoods, and could bring opportunities to commute in a faster way.

S.3.3 Temporary Pedestrian Zones - Summer Streets

In 2015, Stockholm city decided to convert the street Swedenborgsgatan (see Figure 4.26) into a pedestrian street during summer months. This increased liveability, promoted active mobility and supported businesses in the neighbourhood area. It became the starting point for the project Living Stockholm [77] (see case study 2). Due to its big success, the city decided to expand the project on different streets. Nowadays multiple streets such as, Götgatan, and become vibrant pedestrian streets each summer. Rörstrandsgatan, Götgatan, and Skånegatan become vibrant pedestrian streets each summer [75].

Problem being solved

The city of Stockholm recognizes that the concept of open summer streets alone cannot solve pollution and traffic problems, however, they are a powerful way of modelling a car-free future. Therefore, they promote open streets to show people not just what human-scale public space looks like but also re-introduce neighbourhoods to residents as places to travel actively: foot, bike or scooter [77].

Stakeholders

The Traffic Office of Stockholm in collaboration with the district councils oversee the implementation of the summer streets. The coordination of closing the streets and logistics behind the possible detours for private transportation and bus routes is mainly done by the Traffic Office. The estimated risk of increasing the congestion on parallel streets is taken into consideration and therefore action plans must be developed accordingly. Nevertheless, so far, the congestion outcomes have been low, and no major problems have occurred [75].

The local amenities such as shops, cafes, restaurants, and hotels also play a big role in the summer streets'

success. They allocate and provide the necessary infrastructure in order to expand their services and facilities on the streets.

Challenges of Implementation

One of the biggest challenges faced was the potential incremental of congestion in parallel streets and the

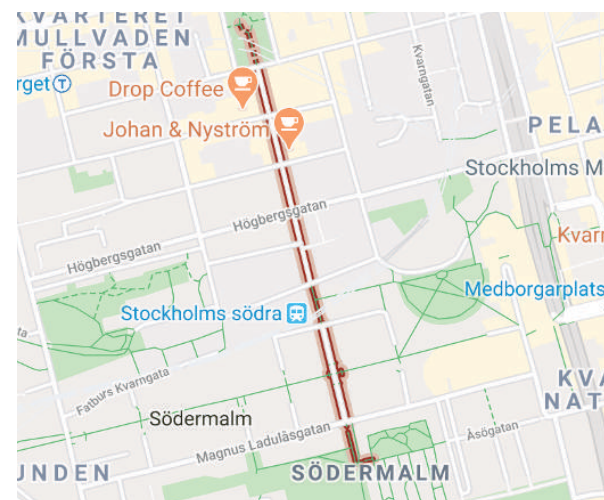


Figure 4.26. (a) Geo-location Swedenborgsgatan street [78]

relocation or removal of parking spaces. Nevertheless, the Traffic Office of Stockholm states they had not experienced congestion problems, mainly because the redirection of routes has been tested and implemented already in early stages. Moreover, there has been a big acceptance and low resistance making the implementation easier [75]. One key point for success is that the complaints received were taken into consideration, for example, the regulation Motor traffic prohibited was replaced with pedestrian street with run-in possibilities from specific directions to enable residents to reach their properties around the clock [77].

Another challenging aspect were the characteristics and price of the needed infrastructure (benches, signage posts, bollards, greenery, etc). The infrastructure for the summer streets specifically shall be easy to remove but secure to use and should be reusable and easy-recyclable [77].

Duration

The summer Swedenborgsgatan street was planned one year before its implementation. The decision of incrementing the number of summer streets has been made systemically during the years. Overall, the duration of the road closure started in 2015 from June to August, and has been expanded from mid-May to mid-September [75].

Financial Aspects

The cost has increased from the beginning of the project and has risen from 68.825 € in 2015 to 749.813€ in 2017. The biggest investment costs are the pipe decoration, speed reduction objects and the use of consulting support [77].



Figure 4.26. (b) Swedenborgsgatan street visited in summer. [9]

Expected result & real result)

The chosen mode of transportation for visiting the summer streets is inclined to active mobility. Since the summer streets are located nearby a metro station, aiming to attract visitors from different neighbourhoods and simultaneously intend to decrease car usage, there has been a noticeable increase in public transportation ridership. Because of this and the success measured by the number of visitors, the Traffic Office of Stockholm is planning on incrementing the number of closed streets during summertime [77].

Altogether, these summer streets had exponentially increased the sales of near localities since the number of visitors duplicates in comparison with previous seasons. Additionally, the restaurants and cafes located along with the pedestrian street benefit from the extra space expanding their outdoor seating onto the streets [77].

Technical Aspects

Pedestrian traffic and bike flow are being analysed each year in order to assess the implemented design and the reception of the project. A more specific in

motion pattern analysis was implemented by the Viscando Traffic Systems in Norrtullsgatan summer street in 2018 [77].

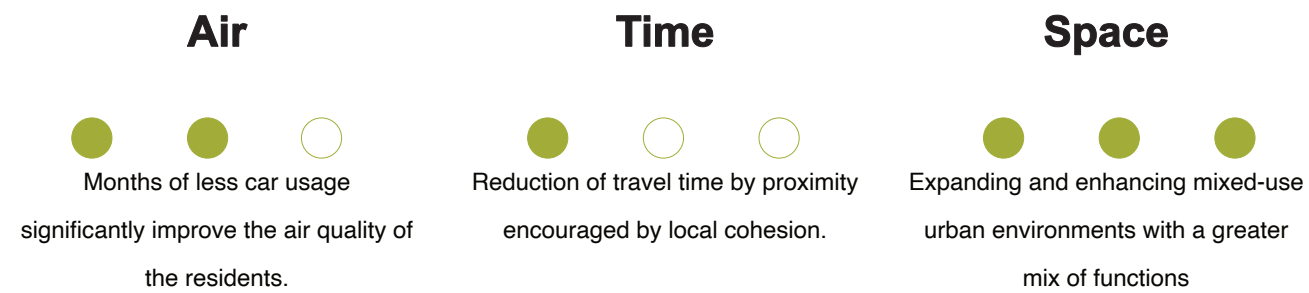


Figure 4.27. Active Mobility in Skaegatan summer street. [79]

Applicability to Munich

Few transition experiments have been made in Munich. In summer 2019, two small squares in Alpenplatz and eight parking spots in Schwanthaler Höhe were transformed into a small pedestrian zone and parklets respectively. Thus, implementing an urban intervention of a bigger scale, for example, such as a summer street in a strategic and central location aiming to attract all kinds of visitors could bring long-term impacts such as the ones seen in Stockholm.

Even though they are being implemented only temporarily, summer streets can permanently bring change, as it is the case of some summer streets in Stockholm that still remain pedestrian exclusive. They can also provide proper insights to assess and support the co-creation, trialling evaluation, and dispersal of a range of sustainable mobility solutions. It is a way of understanding public space as a vital resource for a systemic transition to sustainable mobility.

S.3.4 Tyck Till: Stockholm's Mobile Application and e-Service for the Citizens

Tyck Till (english: Leave a comment) is the dedicated mobile application and an e-service provided by the City of Stockholm to actively engage its citizens in the city live. The app provides different services: from submitting an idea, question or praise to asking about the schedule of a certain department. Using the phone's GPS function makes it easy to specify a location. Pictures can also be attached. Another interesting fact is that a user can choose between providing personal data and remaining anonymous.

Stakeholders

The key stakeholders are the citizens, who are the users of the app, The City of Stockholm, the Traffic Office, and the Swedish company Norconsult Astando. The company was in charge of conceptualizing and developing the app back in 2014 and is since then also in charge of managing it.

Expected result (vs. real result)

In 2016, approximately 10.000 were actively using the app. The following years, the number of the users has increased. [82]

The app intends to engage the citizens in the city's live, to empower them and to keep the communication open and constant in an easy and enjoyable way. Since the app can also gather opinions and runs surveys, it enables the municipality to keep track of the opinion of its citizens about specific topics like mobility, the set-up of the summer streets, etc.

Challenges of Implementation

No major challenges have occurred while developing Tyck Till, yet there remains one challenge in the process of administration: the response time. For comments, the maximum response time is three days. For comments that need to be investigated, the response time is ten

days, while complex cases may require longer response time. Regardless of the comment's complexity, the user will receive a response within three days. Comments which show immediate risk or accidents are rectified as soon as possible.

Duration



Figure 4.28 (a) Tyck Till advertisement on a construction site in Stockholm [own]

The mobile application was launched in February 2014, and has been constantly updated since. For example, a service to allow citizens to access already reported bugs was added in 2016 so that users are able to subscribe to information about what is happening in a specific case. [83]

Financial Aspects

This measure has a significant positive effect on the efficiency of the city employee's work. Especially for park and street engineers, who after the introduction of the Tyck Till service can concentrate more on their work, rather than answering phone calls about problems that might be happening in the city.

Technical Aspects

The development platform used for this app is Xamarin.Forms. The application and e-service are available on both Android and iOS operating systems. Moreover, if the Stockholmers do not want to install the app on their smart phone, a web version is also available.

From the point of view of the user experience map, the flow contains five main actions: (1) Download the Tyck Till app, (2) Choose the type of point of view, (3) Select the topic and the location, (4) Describe with your own words and attach pictures and (5) Submit your point of view. Each category is linked to the right group of administrators at the Traffic Office. The process of distribution is highly automated and does not require the operation of an employee.

For the use-case (2) Choose the type of point of view, several actions are possible:

- Error report: Choose a fault report if something



Figure 4.28 (b) On-line Tyck Till advertisement [80]

does not fulfill its function, is broken, or requires urgent maintenance due to damage. For example, one can report a broken lamp, holes in the street, debris, fault parking, slipping or damage.

- Complaint: Choose a complaint if you are dissatisfied with the operation or think it is a lack of quality in function, workmanship or aesthetics. For example, one can file a complaint about the performance of the snow removal, sand removal or cleaning.
- Question: Choose a question if you are wondering something about the city's traffic and outdoor environment. One question could be how to apply for a parking permit or an outdoor restaurant.
- Idea: Choose an idea if you want to share a proposal, for example about how school roads can be safer.
- Praise: Choose praise if you want to tell the municipality something you appreciate or think works well. For example, one can be satisfied with the city's summer streets or flower arrangements

Problem being solved

With an estimated population of 1,6 million in 2020 and with an approximately yearly growth of 1.8 % [81] from one year to another, it is hard to keep in touch and know the opinion of every citizen of the City of Stockholm. Moreover, with a surface of 189 square kilometres, it is hard for the municipality to know in real time what is happening on each and every street. That is why this application and e-service was created: to engage citizens in city's life, in order to keep better care of it.

For the use-case (3) Select the topic and the location, the following actions are possible:

- There is a list of preselected topics: the user must choose what best fits for each case.
- Indicating the location is mandatory to specify. The location can be introduced:
 1. Based on the GPS of the mobile phone
 2. By adding the exact address
 3. By positioning a red marker on the map

Existing error reports appear as red needles on the map. If users press the red needle, details are shown. One can also enter the email address or phone number if an update of the status is wanted by the user. It is not necessary to file a new entry report if someone else has already done one for the same case.

For the use-case (4) Describe with your own words and attach pictures, a very detailed and clear description is required. The attachment of a picture is not mandatory, but helpful.

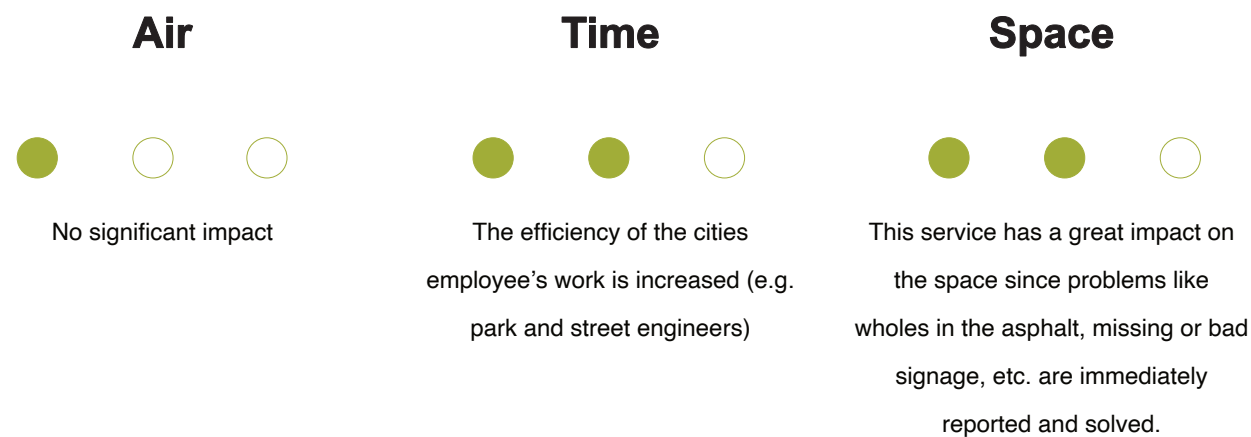
For the last use-case (5) Submit your point of view, the user should choose whether the submission is with or without feedback. If feedback is wanted, the user's e-mail or phone number is needed.

Legal Aspects

Sometimes, depending on the user's action/request, personal data is requested. On the official website of the Stockholm Stadt it is stated that "all the written communication with us become public documents and may be archived or disclosed to others in accordance with the principle of publicity". [84]



Figure 4.29. Shall we help you? In the Tyck Till app you can submit your views and ideas on traffic and the outdoor environment in Stockholm. [85]



Applicability to Munich

The concept behind Tyck Till application can only bring added value for any city. When advertised properly and with a support team, which can be as responsively as the team in Stockholm, it can only bring success. It represents an excellent way of keeping the communication between the city administration and

citizens open, and it engages the citizens in a fun a pleasant way to participate actively in the city's life. The app has multiple functionalities: from reporting something broken, indicating garbage on the street to safety issues like damage to the asphalt, wrong signage, etc.

S.3.5 Urban regeneration project: Hammarby Sjöstad District

The Hammarby Sjöstad is an eco-district environmental project build on a former industrial and polluted site. It was planned with an eco-governance approach, and sustainability is the crowning value when maintaining and managing the place. Therefore, synergies between elements from traffic, transport, water supply, sanitation, urban functions, energy, landscape planning, architecture, ICT, and waste management [86] are created. Personal transport accounts for the biggest reduction in the environmental impact. This is a consequence of the mobility and the communication infrastructure being integrated from the very beginning, leading to changes in residents' behavior. [87].

Problem being solved

The transition to integrated mobility was facilitated by the design approach that embraced multiple synergies and developed accordingly. Moreover, different trends and technologies influencing urban mobility were contemplated and the benefits of this were maximized in line with local priorities for improving residents' quality of life.

The whole neighbourhood developed in the place of a formal industrial site. The city of Stockholm determined that the site was too polluted, and during the cleaning process started, overall, 120 tons of oil and grease were removed from the site together of 180 tons of heavy metals.

Stakeholders

The city of Stockholm was the main decision entity when the eco governance approach was decided. These decisions were taken so that the quality of the citizens is high. For the implementation of the project, several construction companies and different investors were involved: Skanska, NCC, SKB, Boratt, ByggVesta, Envac, Wallenstam, etc. together with several consultants.



Figure 4.30 (a) Hammarby Sjöstad geographical composition [86]

Expected result (vs. real result)

According to [86], there has been a car use decrease of 40%. One of the most relevant factors for the modal share of the district is the "Tvärbanan" light rail link and the ferry services that combined connect the different parts of the district and gives easy and fast access to the city centre. The frequency of both modes of transport is every 10 min for the tram and every 25 min for the ferry.

The tram-line was built as the main commuting traffic mode and it was the first tram-line that outline as a cross-connection in the southern part of Stockholm [87]. In 2008 the CO₂ emissions from personal transport by car in the district were compared to a scenario without ferry & "Tvärbanan", results can be seen in Table 4.5 Besides, the creation of an attractive pedestrian and bicycle networks increased the district accessibility and promote active mobility (see Figure 4.31). By having a long promenade that connects dead-ends of different streets the connectivity of the district increased. Additionally, there are exclusive mobility services for the residents such as a carpool platform offered by the companies Sunfleet and Bilpolem.nu [86]. Further, heavy transportation has been lowered by waste



Figure 4.30 (b) Waste management system. [own]

management through a stationary vacuum system for solid waste (see Figure 4.30) managed by the company Envac and that consists of a system of underground pipes that conducts solid waste to a common facility [86]. When the container is full, it is picked up by a regular container truck that transports it for processing/recycling. This is the only sequence of the collection that is handled by car, which means that collection with a vacuum cleaner reduces carbon dioxide emissions (from garbage trucks) in a residential area by up to 90% [88]. As well, there are consolidation centres in each building complex for the recycling material, facilitating

Technical Aspects

The underground infrastructure needed for the automated waste collection system is extensive. The collection spots are no more 30 meters from the door of each dwelling, many are also located in parks and plazas. When the input is full (level sensors) or at pre-programmed times - the powerful fans located in the collection station, at the terminal, are activated. A negative airflow is created which sucks the waste bags from each box into a separate container - one for each type of waste. The transport in the underground pipeline takes place at about 70 km/h and the distance between the inlet and terminal can be up to 2 km [88].

Transport type	Scenario without ferry & "Tvärbanan"	Current situation in Hammarby Sjöstad
Car	35%	21%
"Tvärbanan" light rail link	0%	34%
Bus	50%	18%
Bicycle	7%	9%
Walking	8%	18%

Table 4.5. Breakdown of residents' everyday journeys (2008) [87]

the recollection and lowering the traffic around the district [86].

The combustible waste is incinerated, and the energy produced is used for the district heating, hot tap water, and electricity. The produced biogas is used in the residents' kitchen but also for all the buses that run along the district [86].

Challenges of Implementation

One of the biggest challenges was to achieve the set goal in the planning phase. There were set clear environmental goals for the neighbourhood: from land usage, transportation, construction materials, energy consumption to water, sewage, and waste. The general goal stated that the district's environmental impact should be 50% lower than that produced using the technology level current in early 1990 [87]. Although the percentage achieved reduction was 30-40% the environmental impacts are exceptionally low. Creating a dense, compact district with high

accessibility to all kinds of needs was a challenge to overcome since the early stages. Thus, the involvement and coordination of the multiple stakeholders needed to be managed in a way that they could communicate with each other at each stage of the project and therefore having a holistic and clear approach to the incorporation of each measure [86].

Duration

The project started with the planning phase in 1997 and is estimated to be fully finished by 2020 [86].

Financial Aspects

The roughly net figures spent on the project are 4.5 billion euros. The net investment from the City is about € 0,2 billion, the rest being paired by the investors. According to [86], the innovative implementations of the project had an extra cost of 2-4% to the total budget.

Air

● ● ●
Air quality improved by the reduction of circulation motorized traffic

Time

● ● ○
Travel time reduction to commuting to the city centre and point of interest attributed to the tram covered area, the ferry frequency, and the active mobility infrastructure

Space

● ● ●
Optimization and prioritization of the public space over traffic infrastructure



Figure 4.31. Residents of Hammarby Sjöstad,[own]

Applicability to Munich

The experience of Hammarby Sjöstad district can be a model to follow when planning the developments of new neighborhoods in Munich. This experience has been applied in another project in Stockholm (the Stockholm Royal Sea Port), which proves that the project's principles are transferable. As well, an eco-governance approach can be seen as a tool to create synergies that facilitate a transition to sustainable mobility.

Measures such as the use of biogas from the combusted waste, attractive pedestrian, and bicycle networks and exclusive to carpool platforms for neighbourhoods can directly be applied in Munich's neighbourhoods. Apart from that, Munich's neighborhoods could benefit from having a centralized system for garbage collection, reducing the traffic of heavyweight. Yet, some methods can be applied only if they are designed and integrated into the neighbourhood's system from the beginning, e.g. the

Mobility as a Services – Potential and Challenges

Mobility as a Service is often presented as a solution to various problems induced by an increasing demand for mobility that is present in most cities around the world. These include congestion, noise, emissions or overloaded infrastructure [89]. The expansion of physical infrastructure and emergence of digital offers combined with a shift in user's preferences and attitudes allow the development of new forms of urban mobility. The term MaaS is often used to describe these new approaches without providing a clear definition. Due to this unclear specification, discussions about MaaS often stay very vague and do not lead to tangible results.

Roles and properties

Since several MaaS projects including corresponding research has been conducted in Sweden, a topology that provides clarification has been established.

Considering the fact that MaaS is still at an early stage of development, a textbook definition can and should not be provided yet in order to allow the concept to be adjusted to recent developments. However, three crucial elements forming MaaS can be identified [90]:

1. Offering a service with customer/user/traveller transport needs as the main focus
2. Offering mobility rather than transport
3. Offering integration of transport services, information, payment and ticketing

Before describing MaaS scenarios in depth, the roles and designations of the involved stakeholders must be clarified. When a MaaS system is put in place, the value chain known from transport service providers (TSP) who work detached from each other transforms as follows according to [91]. While in traditional systems the public transport provider and the other TSPs like taxi, car- or bike-sharing companies directly interact with the customer, in the case of integrated MaaS two new roles are formed. The MaaS integrator assemble the services of several TSPs. That includes technical integration, contract management and reimbursement. The MaaS operator designs and delivers the final service to the customer as one product, for example by a smartphone application.

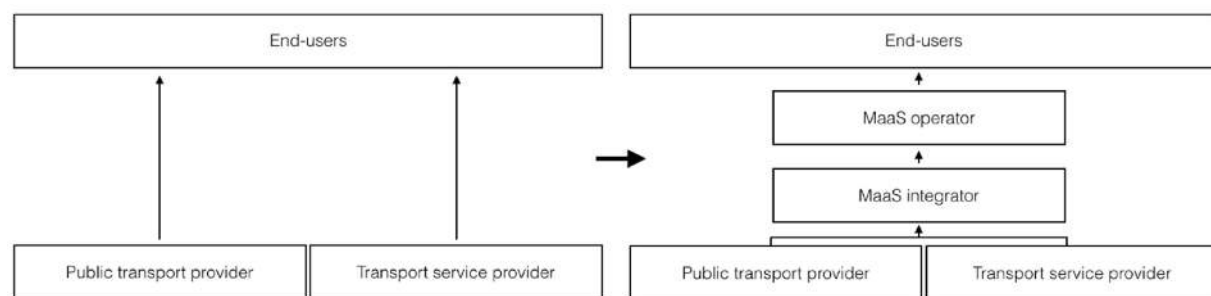


Figure 4.32: Transition of the core roles in detached and integrated MaaS value chains [91]

MaaS in Four Levels

The fundamental properties and emerging roles provide a rough idea of MaaS but still leave a lot of room for interpretation. Especially the element of integration comprises many domains. Therefore, a refined topology building on these three basic modules has been proposed by Sochor et al [90] and is depicted in Figure 4.33

Defining Level 0 as the current state of transportation in most cities, all transport services operating independently and without any connection, Level 1 means the integration of information. This information can amongst others be provided in form of multimodal travel planning, pricing quotes or availabilities and enables the user to choose between travelling options. This kind of services can already be found free of charge in numerous applications, the most prominent amongst these being GoogleMaps. Therefore, no willingness to pay is to be expected from the users. While revenues for the operator can be made by advertising, there are no sustainable business models for Level 1 MaaS Operators. In order to realise a Level 1 MaaS offer, the involved transport providers must deliver the relevant data. They can potentially benefit when new customers explore previously unknown possibilities.

Level 2 builds on the information provided in the previous level and additionally enables the user to book and pay for the trip he has chosen based on the information provided. From both a technical and business point of view, Level 2 becomes significantly more complicated. A constant exchange of information must be put in place in order to enable the MaaS operator to provide valid tickets. A major challenge is often posed by the integration of public transport (PT) tickets. As PT is often publicly funded, reselling tickets or combining business models with private companies

might be complicated, requires legal examination and can cause delays. Due to the risen responsibilities, the level 2 operator (e.g. Uber) must find a viable business model to compensate for his efforts.

The subsequent level 3 (e.g. UbiGo) includes a bundled, possibly subscription-based service offer for the customer. They obtain uncomplicated access to different modes of transport via one contract with the MaaS operator. The MaaS operator has agreements with diverse transport service providers and fixed conditions towards the providers as well as the customers. The pricing is non-transparent though, as the operator is free to resell the transport providers services at another price once he has e.g. added value by combining multiple modes. The TP's benefit is the activation of potential new customer groups that could not be targeted with a single service but might use the service occasionally (or increasingly frequent in the best case) once it is conveniently accessible to them.

Level 4 aims to realise societal goals mentioned in the introduction, like the reduction of car ownership and therefore reducing emission, noise, making cities more liveable and so on. User behaviour can be influenced by setting incentives that promote more sustainable ways of travelling. These incentives can for example be set by local governments.

Desirable Effects

As mentioned in the introduction, MaaS is claimed to solve several problems of urban mobility. Though it will not be able to do so on its own, MaaS certainly has the potential of contributing towards a more sustainable way of travelling. These are mostly related to a reduction of private car ownership, as Hans Arby explains [92]. Citizens who own a car are very likely to use it frequently even though it might only be the optimal form of transportation in very few cases, because the majority

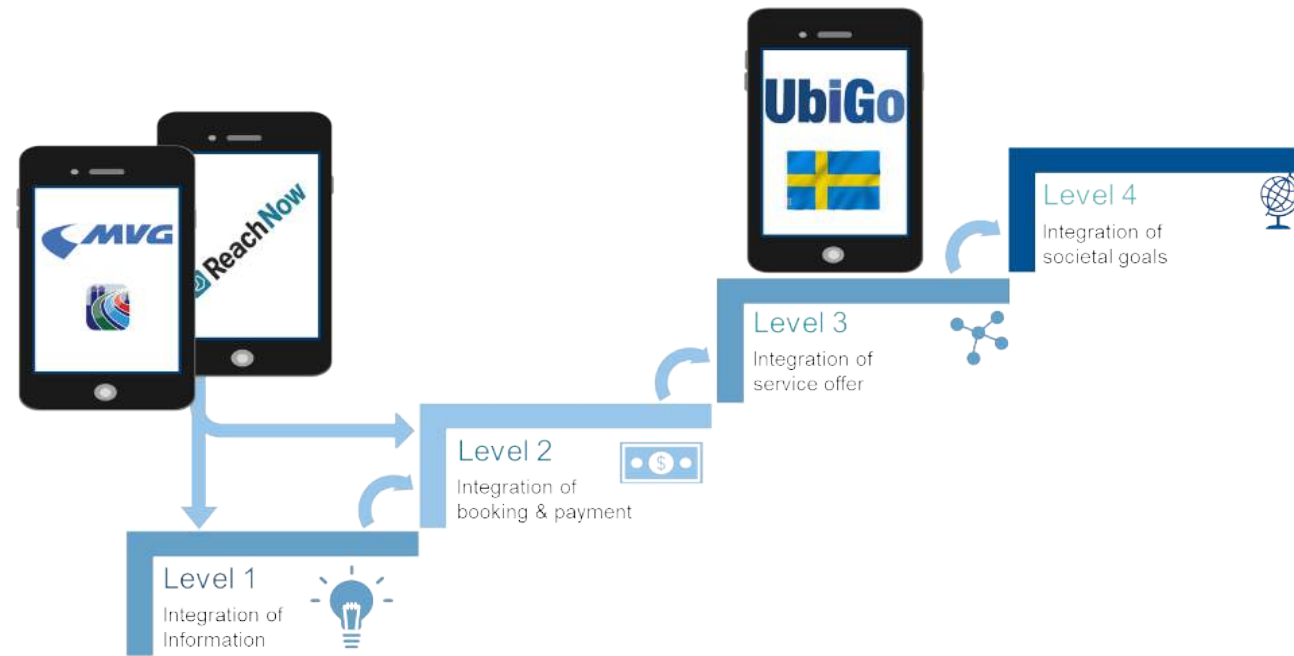


Figure 4.33: MaaS defined in four levels (based on [90])

of costs connected to owning a car is fixed like insurance, tax or loss in value. People who acquire a car in order to utilise it occasionally, for example, for leisure trips or to visit relatives, will very likely also use it in their daily life because the cost of additional trips is relatively low. Therefore, it is very unlikely for these citizens to buy a PT subscription, as they rely on their private car for certain rare occasions and a subscription of a single mode of transport can't serve as a substitute. But once a MaaS product integrates PT and car sharing, the private car can be replaced. The user will shift his travel behaviour towards PT in most occasions and only use shared cars when they are the optimal mode of transport. This approach also enables PT providers to target a new group of customers they are not able to reach without cooperation. Figure 4.34 also explains why cars (e.g. in the form of sharing or rental) and PT are the most important modes of transport in MaaS.

Another effect often mentioned by critics is also shown schematically in Figure 4.34. As service quality of MaaS increases, PT becomes more attractive and accessible

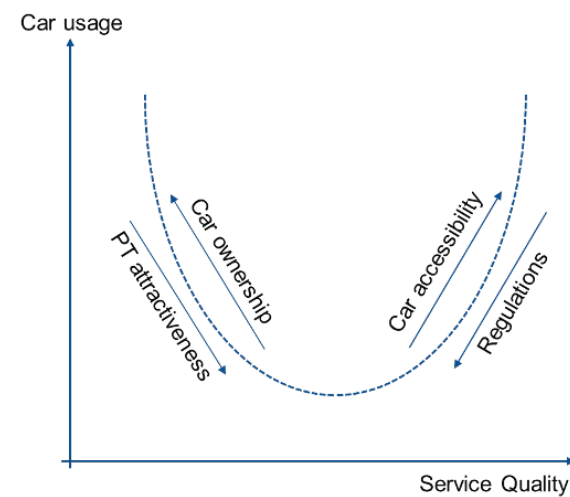


Figure 4.34: Car usage as a result of Service Quality (based on [92])

and therefore gets used more frequently, which leads to a reduction of car usage. Increasing service quality also eases the usage of cars and can increase the usage of cars as a result, which would undermine the initial goal of reducing private car ownership and usage. Similar effects could be observed when ride hailing services like uber and Lyft were introduced, and mobility behaviour shifted away from PT towards these convenient travelling options [93]. The most effective way of restricting this unwanted effect are rules, regulations and incentives by the (local) government, e.g. limited monthly amounts of kilometres or hours per user or a limit on the number of cars per 100 customers.

Challenges

Despite its great potential there are also some challenges that come with MaaS. One lies within the

collaborative innovation that must happen as a joint effort between public and private actors [94]. Because of resales of PT tickets through private companies the legal aspects might become a challenge. Furthermore, big public agencies might be perceived as averse of innovation by smaller private business partners. Another risk connected to MaaS are the expectations that were raised by promises made to the public [95]. By promoting MaaS as a comprehensive solution for various problems, the barrier of implementing such a system was raised tremendously as well as the pressure on the operator.

Possibly the biggest challenge regarding MaaS is the governance [96]. There are several mandatory questions regarding e.g. equity and inclusion, data security and transparency or taxation that must be taken care of specifically in each country and city. There's no

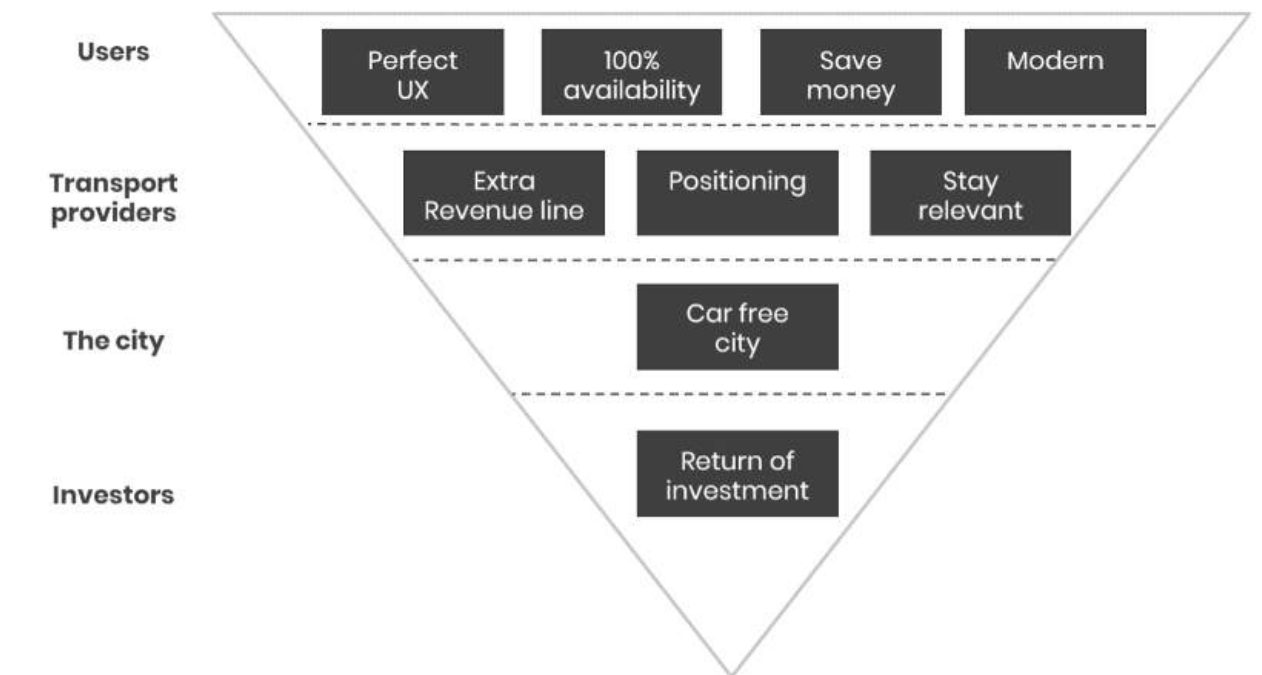


Figure 4.35: Expectation of MaaS stakeholders [65]

universal framework yet but pilot projects and first real-world applications like UbiGo are being conducted with the goal of mapping out key factors.

Conclusion & recommendations

MaaS has the potential to change the way we travel and thereby make it more sustainable, as multiple research projects and real-world applications like Whim in Helsinki or UbiGo in Stockholm have proven. Figure 4.35 shows potential gains for all stakeholders that were identified on the market by UbiGo. Even though the challenges described previously occurred during the realisation, UbiGo managed to attract 200 subscribers performing more than 2.000 bookings per month.

With a well-developed PT system and different local car-sharing and -rental companies, Munich fulfils all requirements needed to implement a MaaS concept. Current developments show that economically strong private actors like ReachNow or Uber have a strong interest in leading the MaaS market [97] [98]. If these private companies don't succeed in integrating PT in their offer, there's a high chance of missing the societal goal of reducing the share of private cars as a mode of transport. In order to be economically sustainable, they must attract as many customers as possible and maximize the number of trips taken, which will draw traffic from PT to other less desirable means of urban transport [99].

Meanwhile, Munich's PT agency MVG is working on its own multimodal travelling offer, providing bikesharing, carsharing, scooter and even ride hailing on top of traditional PT to its customers. Even this approach seems to be promising, experts doubt that a public transport agency is suitable as a MaaS operator due to an assumed lack of innovative capacity [100] and little experience with other modes of transport [92].

Furthermore, sourcing out the technical complexity as well as the expenditures necessary to provide comprehensive customer service (e.g. in case of accidents) is advisable [92].

For the reasons stated above, the most effective way of realising a MaaS system is collaboration. Independent operators and integrators that guarantee fair contracts between all stakeholders should be put in place between TP and customers. Pilot projects are necessary to map out city-specific challenges and potentials and will help creating realistic expectations. This way, MaaS has the potential of changing Munich's urban mobility substantially.

Levande Stockholm - Vibrant city through temporary installations

As the city grows, more people use the city's public space, and therefore the demand increases. Since the available space is limited, an appropriate redesign is required. Thus, to achieve high-quality urban spaces, redesigns must aim to have a socially cohesive city with a vibrant, accessible and safe urban environment that adapts to the diverse needs of people.

As well, a redesign that focuses on increasing the accessibility and good public environments in between the local areas can bring those areas closer to each other. This also promotes a transition towards sustainable mobility, since proximity encourages an active lifestyle. Many people walking or cycling to destinations in their neighbourhood, has positive effects on the health, environment, and the overall traffic flow [101].

The city of Stockholm is developing and implementing new methods of redesigning and revitalizing urban spaces. Through the project Levande Stockholm (which translates into Living Stockholm) more than twenty interventions have been done throughout the city. The project focuses on creating a more vibrant city through temporary installations [102]. The overall aim is to have high-quality outdoor areas, where activities take place, inviting people to stop, sit, eat, play and meet. The timeline of the project can be seen in Figure 4.36. The interventions involve designs according to citizens' needs and therefore emphasis has been put on citizens' participation throughout the entire process: from the generation of ideas, through design to implementation [103].

Evaluation of the project has shown that the interventions not only had contributed to improving the

quality of life of citizens but had also contributed to long-term changes and are considered major tools of transition management [103].

Duration and selection process

The selection of streets is mainly done by the Traffic Office and considers different perspectives. There are basic prerequisites for the selections, such as having grounds for enough walking, existing crossings and having amenities (restaurants and shops) on both sides of the street. In Figure 4.41 different criteria can be seen; this is used for evaluating the suitability of a street. Additionally, suggestions from political objectives and the citizens are taken into consideration in the selection process [75]. The location of summer squares and pop up parks is also arranged by the Traffic Office. The projects are modified annually, and new projects are added each year. Some summer pedestrian streets have been permanently established on Swedenborgsgatan, Rörstrandsgatan, Skånegatan, and other streets [102]. The duration of the interventions varies from year to year, on average the summer installations last from May to August. The winter projects last from November to February [103].

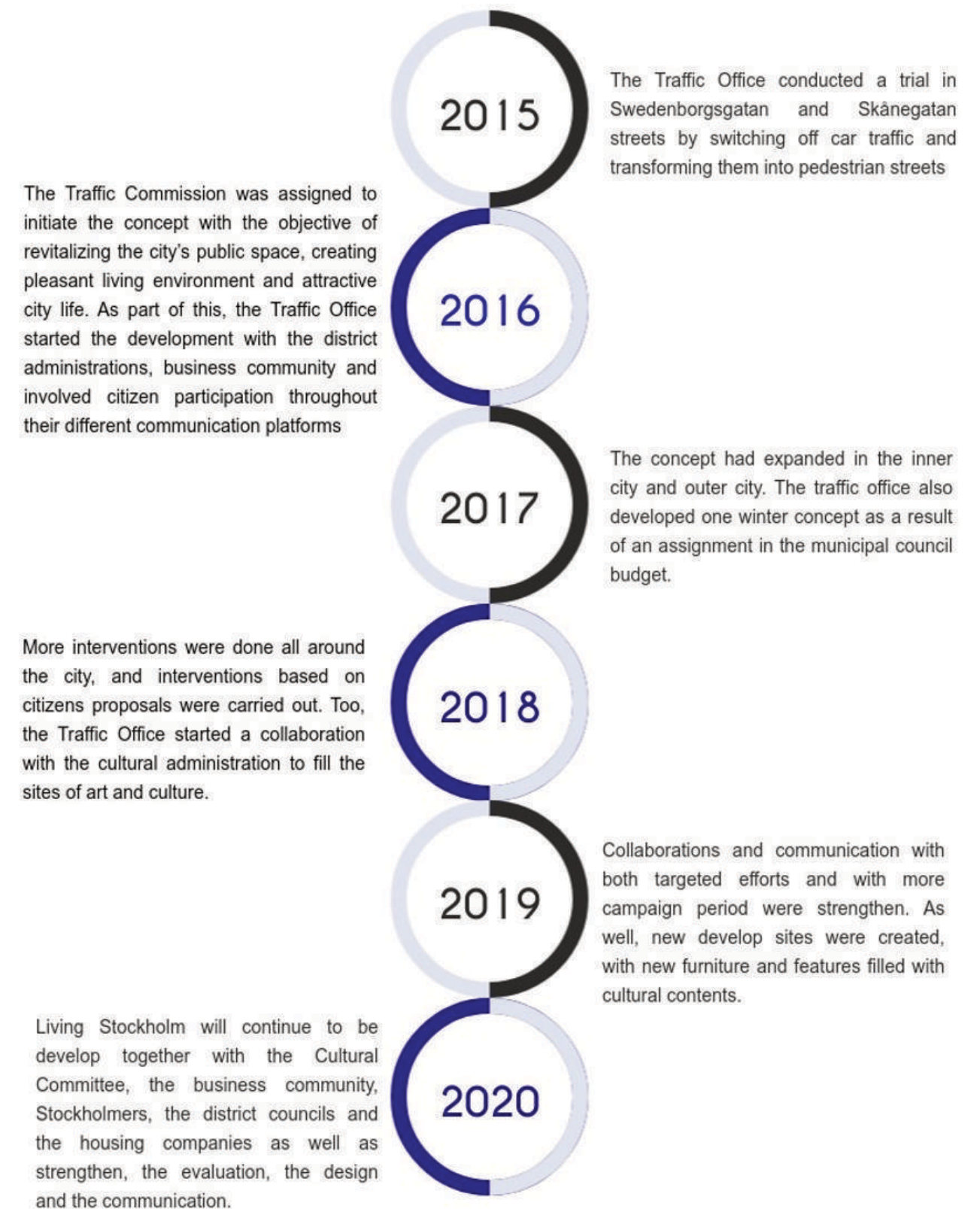


Figure 4.36. Levande Stockholm timeline [103].

The interventions are established through three main concepts [9].

Summer pedestrian streets refer to streets or part of a street that are converted into pedestrian streets during summertime to contribute to more vibrant city life and to prioritize pedestrians (see measure S.3.4).



Figure 4.37. Summer Street Rörstrandsgatan [9]

Summer squares are installations in local squares outside of the city center decorated and furnished with plants and flowers. They are also spaces for cultural activities with temporary art installations and performances.



Figure 4.38. Summer square [9]

Pop-up parks are temporary parks with seating and plant boxes that are installed on part of a street or in parking spaces to create a natural meeting place. They serve a dual purpose since they are meant to create a space for people and raise questions on what could be done with the streets if they were set up differently.



Figure 4.39. Pop-up parks [9]

Winter projects are installations (benches, lighting, etc.) set up in the streets to promote walking during winter



Figure 4.40. Winter interventions [9]

Design

Spaces and streets are designed based on future flows, where the surrounding built environment is expected to contain functions that encourage an urban space full of experiences, with plenty of activity on the ground floor [101]. The spaces are tested with a robust and flexible design so that they can have multiple functions and be used in different ways over the day and change over time. This creates a sustainable design that can develop and simultaneously tested as society changes [102]. In general, the places are designed in a way that the prioritization for pedestrians is evident. All parking spaces except the places for people with disabilities are removed. The freed-up space is utilized as serving places for the local restaurants as outdoor seating areas [75].

Car traffic is banned or is limited from 6:00 am to 11:00 am for residents in most of the summer streets. The following constraints apply for interventions [103]:

- Pedestrians have priority in the streets
 - Vehicles must not be driven at a higher speed than walking.
 - Vehicles must not be parked in any place other than specially arranged parking spaces.
 - In a pedestrian street, motor vehicles must not be driven except to cross it.
 - Deliveries to or from stores or nearby amenities are allowed.
 - Transports of guests to or from a hotel are allowed.
 - Transport of sick or disabled persons is permitted
- The incorporated elements (infrastructure e.g.) in the projects vary in each space and vary yearly in a way that different designs can be tested. The elements are accommodated and planned to achieve a good balance between functions [103]. Citizens' suggestion are also considered in the design phase of each intervention, this data is acquired via surveys conducted yearly after the interventions or through the different communication

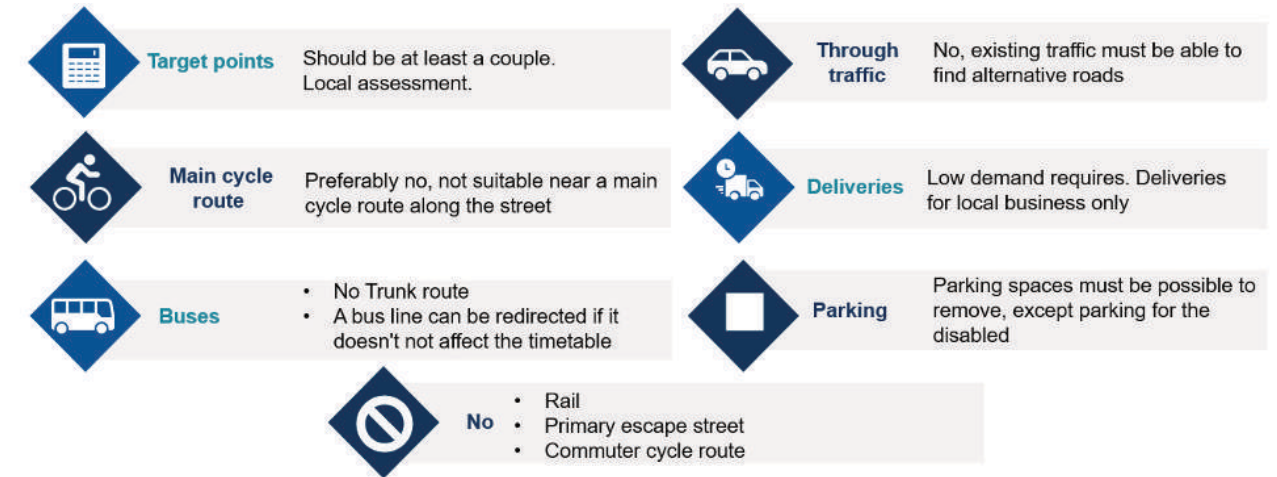


Figure 4.41. Criteria for selection of places. (Based on [9])

platforms the city provides [102]. As well, citizens' input provides information to investigate how well the design works in terms of acceptance and performance.

Traffic measurements

By understanding and assessing how the space is used, meaning, how people move, the design can be optimised [9]. Consequently, each year the pedestrian flow is observed and analysed. According to [103], the measurements are done both during and after the interventions to evaluate how the temporary regulations affected movement patterns on the streets. This data is used in the design process and modifications of future interventions.

A more extensive analysis was made, in Norrtullsgatan summer street, since plans were in place to permanently maintain the pedestrian and bicycle area [103]. The analysis made by Viscando Traffic Systems in 2018, based on 3D and Artificial Intelligence (AI), consisted of mapping all the patterns of movements through the area for five days. This provided a comprehensive visual picture of the movement, flows, speeds and the variation of directions around the time of the different road users as seen in Figure 4.42 [104]. Here it can be observed

the most recurrent pattern of movement (highlighted in the yellow circles) used by pedestrians and bikers and can be observed that the vehicle transit was contained outside the street.

These measurements provided the information needed to fully evaluate the test design and subsequently to propose the final a permanent configuration design. During 2019 the street has been permanently rebuilt into a pedestrian street [103].

Cooperation and communication

In 2016, the name Living Stockholm began to be used and the communication took place under the concept "Do you see the opportunities?" which is usually used for communication efforts linked to the Accessibility Strategy. The sun heart is the symbol of Living Stockholm used in everything from campaign posters to print sunbeds. This is to easily keep communication together [103].

The general communication throughout the years have been done in multiple ways [103]:

- Postal dispatch to residents and businesses around the areas

- Organized meetings with the relevant businesses and police
- Advertising in the local press before and after the end of the trial
- Press inaugurations
- Web pages (stockholm.se/levandestockholm) and social media platforms
- Information signs and digital information city boards
- Monitoring of incoming comments and press coverage

Moreover, the cooperation with traders has generally worked well throughout the years, early communication being the key for it [75]. The communication platforms incentives the traders to seek police permits in the early stage for providing their services in the streets or to locals for expanding their restaurants or cafes into the streets and also is a way to establish and clarify all the rules to follow.

Overall, local businesses have expressed a good response from customers [103].

Conclusions

Public spaces are vital in developing urban living throughout the city. Opportunities to arrange temporary events in the urban space are being promoted by the Levande Stockholm program. It has been proved that the built environment offers many potential meeting places that can enable social contact between residents and contribute to mobility within the city.

The multiple interventions have made Stockholm more pleasant, greener and has contributed to the creation of a more vibrant city with more outdoor seating and city life. More people get to use the space when the streets are filled with people, restaurants, and vegetation instead of cars alone. As well, the local business community benefits from a rich urban life boosting the local economy.

A key principle of Living Stockholm has been the strengthening of opportunities for the cultural council, the business community, Stockholmers, the district councils and the housing companies to take a seat in the public room. The project has many points of contact

with different departments and therefore it is a good platform to test new innovative solutions and develop working methods.

The temporary interventions have invited the Stockholmers to not only travel along but also staying on the streets. It shows the citizens that streets are not only places for (motorized) traffic but are also public space. It can be said that neighbourhoods are being re-introduced as places to travel. Further, the evaluations carried out, showed that the summer pedestrian streets had a positive impact on traffic by the drivers slowing down the speed on the street and by having more people walking, cycling and staying on the streets. Besides, the evaluations exhibited satisfaction, commitment and increase awareness of citizens, being this the reason why the number of interventions has been gradually increasing from year to year. Overall, the experiments have given the possibility to test, evaluate and implement. The city of Munich can follow this path of transition promoted by the upscaling of interventions. Systemic changes can be supported by temporary interventions that guide the design.

Nevertheless, it is of great importance to consider Munich's local context in every phase.

Although good analysis is necessary to avoid the challenges, various streets and spaces in Munich have great potential of becoming successful lively spaces during summer months. Streets near Gärtnerplatz such as Reichenbachstrasse and Klenzestrasse are dense, have low traffic, and are surrounded by restaurants, thus, potentially can be transformed into summer pedestrian streets. Or else, streets near popular spots such as Türkenstrasse near English Garden or Rotkreuzplatz near Nymphenburg Palace can incorporate pop up parks or spaces nearby could be transformed into summer squares.

However, it is important to consider that the achieved outcomes of the Levande Stockholm projects involved strong support from the local authorities. For the Stockholm City, it was not enough to consider the interventions as a tool for urban planning thus a clear strategic path embedded in the city's vision and supported by different stakeholders was established. Therefore, is key for its success that the City of Munich takes a similar approach.

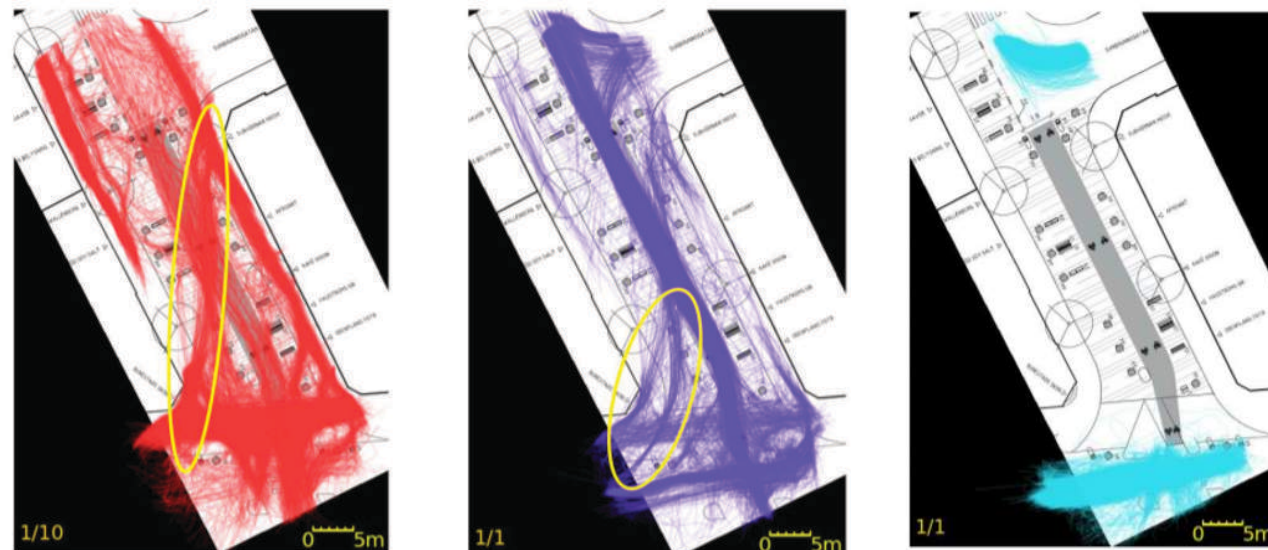


Figure 4.42. Patterns of movement for pedestrian, bikes, and vehicles [104]

Road Safety in Stockholm

In Stockholm, traffic accidents are one of the biggest public health problems. For Stockholm to be an attractive city, residents, businesses and visitors must feel that the transport system is reliable, safe and secure. Traffic accidents not only cause personal suffering for the individual but also high costs for the city and society. [105] According to police reports there are about 3 705 traffic accidents in Stockholm every year. About 3.858 people are injured in these accidents. [106] In comparison, with a similar population Munich has 6,518 traffic accidents in which 7.791 people were injured. [107] It should be noted that there is a large estimated number of unknown cases for both cities and that this figure is larger for pedestrians and cyclists. For this reason, the City of Stockholm has established a road safety program that addresses Stockholm's road safety problems. This program based on Vision Zero, a road safety concept developed by Sweden in the 1990s.

Vision Zero:

When the Vision Zero concept was introduced in 1995, it turned the traditional view of road safety work on its head. Starting from a focus on accident prevention, the current direction is that no one should die or be seriously injured in traffic.

Vision Zero believes that the main problem is not that accidents happen - it's whether the accidents result in death or lifelong injuries. Vision Zero emphasises the fact that the road transport system is a single entity in which different elements such as roads, vehicles and road users must interact to ensure safety. In order to avoid serious consequences of accidents, human-centered design of roads and vehicles is essential. [108] Vision zero's safety philosophy is based on three main principals:

- Road traffic accidents should not lead to serious health loss
- Consideration must be paid to capabilities and limitations

- A safe system assumes shared responsibility

The Vision Zero Academy was founded by the Swedish Transport Administration in 2019. It is a global knowledge hub with the overall goal of spreading knowledge about Vision Zero and supporting and cooperating with various stakeholders around the world in their quest for safe road transport systems. Figure 4.43 provides information on the origins and progress of Vision Zero. [109]

In over 20 years of Vision Zero being part of the systematic road safety efforts in Sweden, the concept shows examples of measures that have had an impact on road safety and how the number of fatalities and road accidents has been reduced. This illustrates the impact of strong leadership and focus on road safety. [110]

Goals:

The Road Safety Program for the City of Stockholm 2010-2020 (Trafikkontoret, 2010) was arranged in November 2010. The program describes road safety

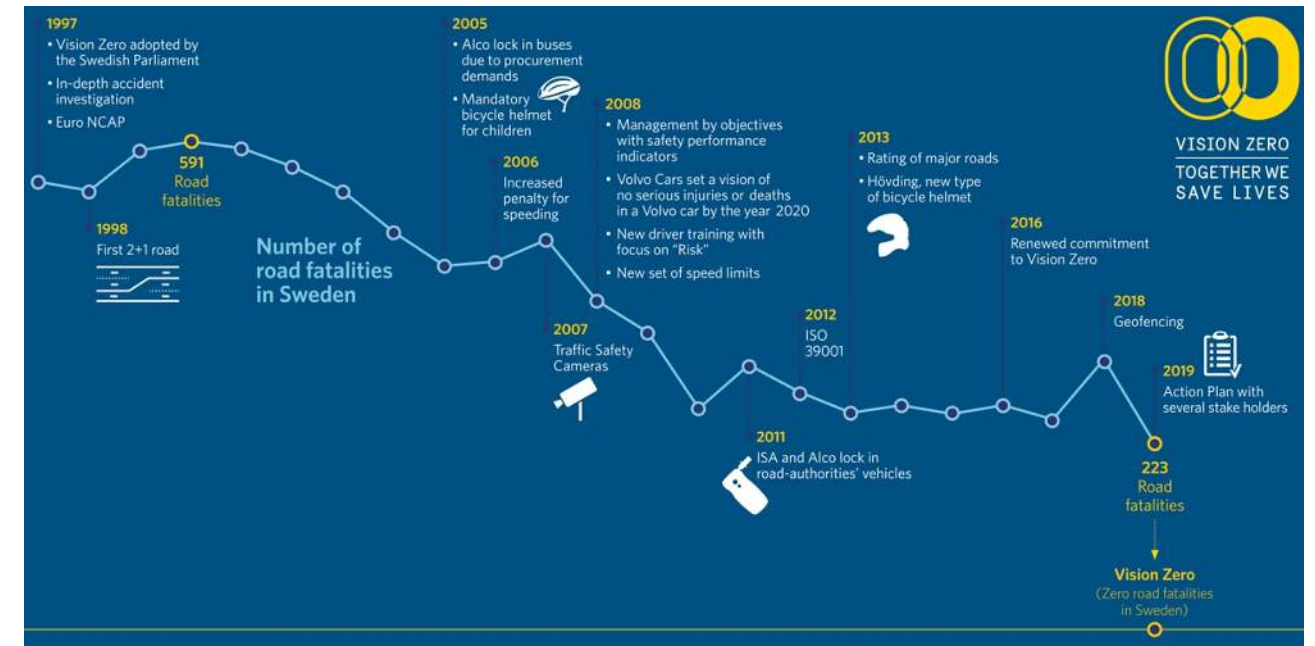


Figure 4.43 Progress of Vision Zero [108]

efforts and targets to be achieved by 2020. To provide a long-term perspective, the Stockholm Road Safety Program is divided into two parts. The first part maps out the most relevant road safety problems and aims to create a common platform for all who live and work in the city. This part can thus serve as a long-term basis for road safety work. The second part deals with the priorities, objectives and measures to solve the major problems. As the problems are given, the main layout of the work is already defined. It is then a matter of setting priorities and ambitions. By selecting measures in annual action plans, it is possible to change the ambitions and priorities without having to create a new road safety program. The main objective is to reduce the number of people killed or seriously injured (KSI) by 40% from an average of 278 in 2006-2009. [111]

Indicators:

The program defines nine indicators for a number of factors that influence the number of KSI in Stockholm.

These are classified according to the priority given to them, based on the relationship between the indicator and the number of KSI and the degree to which the municipality can influence the indicator. Three priority levels are defined:

Level 1: Considerable effort and resources are required: indicators that have a strong relationship with the number of KSI and that can be influenced by the city administration

Level 2: A limited amount of effort and resources is required: indicators that are weakly proportional to the number of KSI or that can only be influenced by the city administration to a very limited extent

Level 3: Little effort and resources are required: indicators with a weak relationship to the number of KSI and limited possibilities for the municipality to influence the indicator

A target group is defined for each indicator. The target groups comprise all those KSI that are assumed (or intended) to be affected by the indicator. For each

	Description	Target group
Level 1 indicators		
1. Speed	Proportion of all vehicles driving at or below the speed limit.	All KSI involved in crashes with at least one motor vehicle
2. Safe main roads	Proportions of safe junctions and pedestrian / bicycle crossings	KSI Pedestrians and cyclists in crashes involving motor vehicles at junctions or crosswalks on main roads KSI motor vehicle occupants in all type of crashes at at-grade junctions on main roads
3. Increased knowledge	No indicator defined	All KSI
Level 2 indicators		
4. Management & maintenance (M&M)	Standard of M&M on roads, and winter maintenance on pedestrian and bicycle tracks	KSI pedestrians and cyclists in single accidents (falls) KSI motor vehicle occupants in single crashes
5. Heavy vehicles	Creating a strategy for heavy vehicles	KSI involved in collisions with heavy vehicles
6. Safe local roads	Proportions of safe pedestrian / bicycle crossings	KSI pedestrians and cyclists at junctions or crosswalks on local roads
Level 3 indicators		
7. Seat belt use	Proportion of front seat occupants in passenger cars that are using the seat belt	KSI adult front seat passengers in passenger cars
8. Bicycle helmets use	Proportion of all cyclists wearing a helmet	All KSI cyclists
9. Driving under the influence of alcohol (DUI)	Proportion of sober drivers (BAC < .20)	All KSI Involved in crashes with a drunk driver

Table 4.7 Definition and target groups for indicators [111]

indicator, Table 4.7 summarises the definition of the indicator and the target group. [111]

Measures:

In order for the vision to become reality the contribution of all road users is required. In order to increase road safety, measures are being taken to reduce speed and to ensure that roads and pavements are in good

condition. Stockholm invests a lot in measures around schools, because it is important that the children feel safe and secure in traffic.

Measures for speed reduction:

Speeding is one of the biggest problems in Stockholm is the main factor that determines how serious the injuries will be in an accident. Therefore, various speed

reduction measures are implemented, and speed limits are adjusted. Between 2016 and 2026 new speed restrictions will gradually be introduced in the city. Speeds of 30, 40 and 60 kilometres per hour will eventually replace the current 30, 50 and 70. In addition, more speed bumps will be built, elevated crossings and pedestrian crossings will be implemented, roundabouts will be created and traffic surveillance cameras will be installed. The right speed, based on road standards, reduces the number of road accidents and is crucial for road safety.

Prevention of traffic accidents:

In order to prevent accidents, the City of Stockholm finds out what is causing them and ensure that the roads are properly constructed and in good condition. Factors that increase the risk of accidents are, for example:

- excessive speed
- lack of protection and visibility
- risky behaviour
- badly constructed roads
- no road maintenance



Figure 4.44 Sweep and Salt vehicle [114]

One of the infrastructural measures was mentioned in the above chapter Rerouting of cyclists during construction work and another one is Sweep and Salt. Sweep and Salt's aim is to increase the rate of cycling in winter by improving the maintenance of cycle paths and making the existing infrastructure easier, safer and more comfortable to use. [112]

The Sweep and Salt method means that a sweeping brush removes / brushes the snow from the cycle path, which is then prepared with saline solution or moistened salt, NaCl (sodium chloride). Salting can be done both for preventive purposes and before precipitation, so that the cycle path can withstand lower temperatures and precipitation before freezing, or during a snowfall. An important factor is to prevent the snow from sticking to the coating and making it difficult to brush off. [113]

Safe school roads:

It is important that children feel safe and secure in traffic. For this reason, extra effort is invested in creating safe and secure environments around schools. Here, children are involved in the development of the measures. These measures are designed to create awareness and influence the behaviour of drivers.

Examples of measures are

- Safe intersections where children cross roads
- Secure drop-off points in the immediate vicinity of the school
- Better networks of walking and cycling paths around schools
- Better parking of bicycles
- Limited possibilities for stops, parking and transit
- 30 zones with signs "Children playing" or 30 directions on the road
- Better lighting [105]



Figure 4.45. His Majesty the King of Sweden Carl XVI Gustaf. Foto: Mikael Ullén

Administration:

The City Council has overall responsibility for road safety. The City Council clarifies the division of responsibilities among the city's various committees and decides on objectives and strategies for the city's road safety work. [105]

As the issue of road safety is becoming increasingly prominent and Sweden is a pioneer in this field, the 3rd Global Ministerial Conference on Road Safety was held in Stockholm where 1700 delegates from 140 countries met to discuss the future strategic direction of global road safety until 2030 and beyond.

His Majesty King Carl XVI Gustaf opened the conference by saying that it is an honour for Sweden to host the conference, and just as transport crosses national borders, so do the challenges of road safety. 'It is important that we come together and can share knowledge, examples and ideas from around the world to improve road safety'. [115]

Congestion Tax

The congestion tax is an incentive to reduce the traffic demand and to improve accessibility. In June 2007, after a period of 7 months of trial period and a referendum, a congestion tax was implemented in Stockholm's city center. Today, the congestion charge zone consists of 26 toll stations, many of them having several hundred years of history as tolled entry points to enter goods into the city.

The population growth of 2 % each year in the last decades, led to an increased demand for travel and transport and therefore to an increased congestion in the Stockholm's city center, especially during morning and afternoon peak hours. Along came the environmental issues and the pollution associated with the high traffic: high CO₂, nitrogen oxides and volatile organic compounds. The main goal of the introduction of the congestion tax is to reduce the travel time, respectively travel time uncertainty. Another goal stated by the Government of Sweden is improving the environment and general health of the people in Stockholm's city centre.

A Political Gamble

Looking back to 2006, before the congestion tax was about to be introduced, the stakeholders' network looked very entangled: starting from the Government at all its levels (national, regional and local), the political parties who had to discuss, compromise and negotiate, the citizens who voted in a public referendum, media who wrote about the whole situation and the technical teams who implemented it.

At that time, the Mayor of the city, Annika Billström from the Social Democrats, promised in her campaign that during her mandate no congestion charge will be implemented. But at the national level, the Social

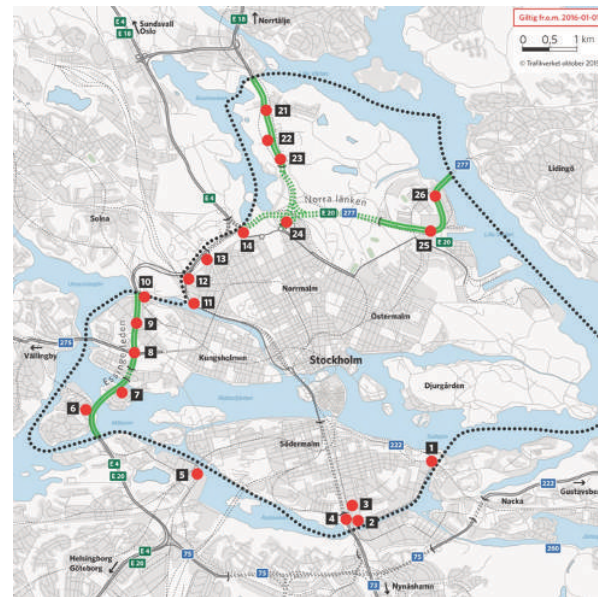


Figure 4.46. Current congestion charge zone, with its charging tolls [81]

Democrats were the largest party in the parliament and eager to maintain power by forming coalitions and this required the active support of the Greens. Their support was conditioned by the testing of a full-scale congestion charging scheme. In the end, the Social Democrats from the national level leaned on Billström to compromise, fearing that the coalition with the Greens might fail and she announced the seven months trial and the referendum. She also mentioned that, since the congestion tax is set to be implemented in Stockholm's

city center, only the results held in the municipality of Stockholm will count and although the referendum was formally only advisory, the city would respect the decision of the electorate. Stockholmers were asked to vote and 51.3 % said "yes" to the congestion charge. [116]

A big part of the success was also due to the integration of the charges into the national investment planning process, thereby giving local and regional politicians substantial influence over the use of the revenues. Therefore, it is planned that the funds collected from the tax to be spent on the expansion of the new subway. The Stockholm County Council will build nine new subway stations and rail infrastructure in Stockholm, Järfälla, Nacka and Solna during 2018 to 2025. [116] Currently, the money collected is managed by the Swedish Transport Administration.

Expected vs. Real Results

The congestion tax implementation had important improvements for the whole well-being of the city in more than one way. The initial objective during the Stockholm trial were: (1) A reduction in traffic by 10 – 15% during rush hours, (2) Improvements in traffic

flows, (3) Reductions in the emissions of carbon dioxide, nitrogen oxides and particles, (4) That the residents should perceive an improvement in the urban environment. [118]

All of the measurements have been done during the months trial period, when congestion tax was still under close scrutiny from both citizens but also government, to measure as accurate as possible its effects. [117]

• Effects on traffic:

Fig. 4.47 shows the different types of effects, according to the type of road. All the results were beyond expectation. The reduction in total number of vehicle passages across the charge cordon over 24h was 22%, meaning that approximately 100.000 fewer passages to/from the inner city. The reduction is lower during the morning peak period (16%) and higher during the afternoon/evening peak (24%). For inner city streets the reduction in the number of vehicles was around 8% and for roads approaching the city around 5%.

• Effects on emissions and air quality:

The reduction in traffic during the Stockholm trial

The Inner-City	Tons/ year	%
Particles, PM10	21	-13
Nitrogen Oxides, NOx	45	-8.5
Volatile organic compounds, VOC	110	-14
The Greater City*		
Particles, PM10	30	-1.5
Nitrogen Oxides, NOx	55	-81.3
Volatile organic compounds, VOC	130	-2.9

Table 4.7 Definition and target groups for indicators [111]

has led to a fall in emissions from road traffic by 8% to 14% in the inner-city. For greater Stockholm, which represents the area of 35x35km across central Stockholm, the reduction was between 1% and 3%. Other improvements were also proved: the

greenhouse gas carbon dioxide has fallen by 40% in the inner-city and by 2-3% in Stockholm County, the emissions of carbon dioxide and nitrogen oxides dropped and eutrophication in the soil, lakes and sea, have also decreased. The following table

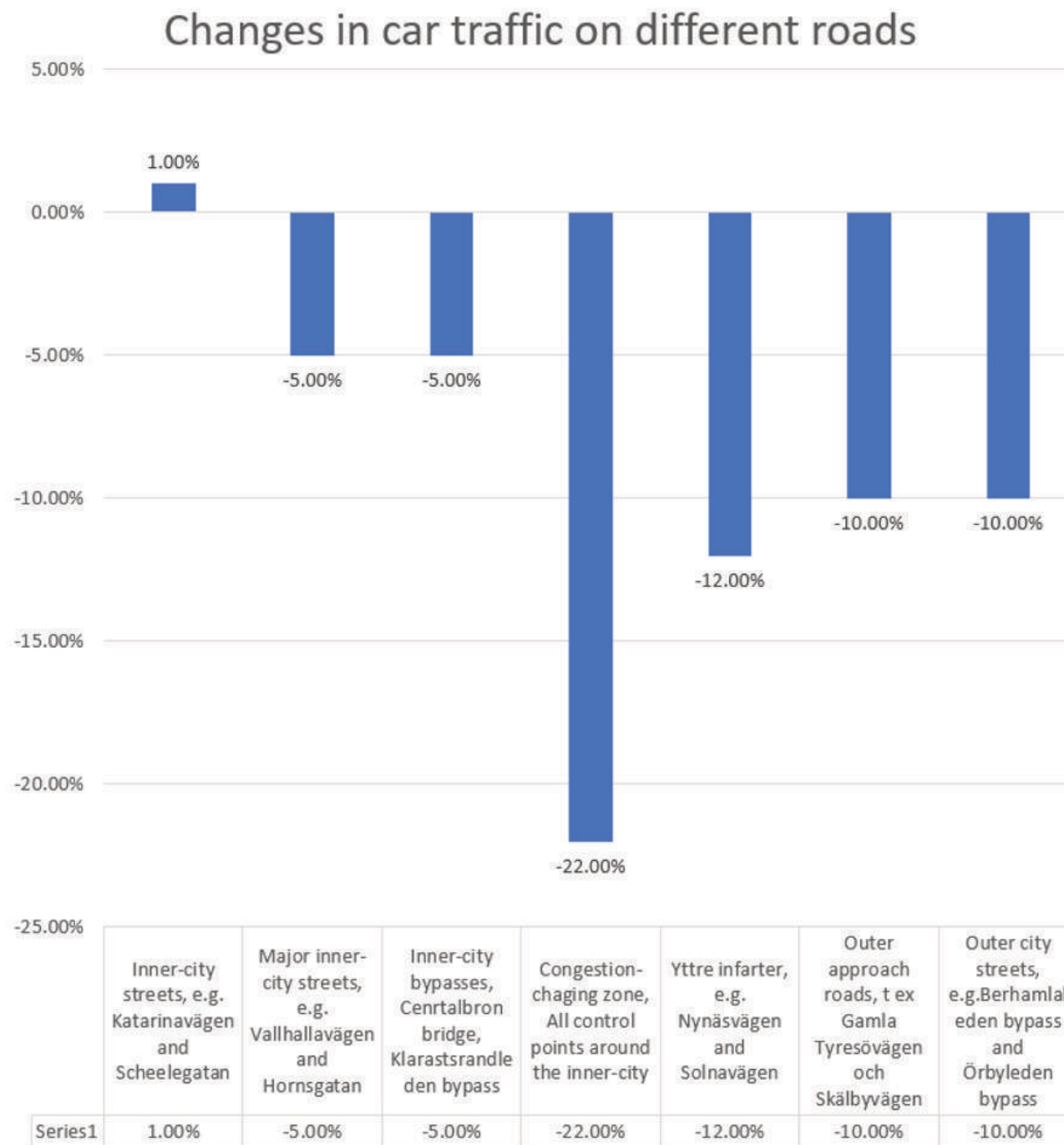


Figure 4.47. Changes in car traffic on different roads [117]

shows the emissions from road traffic in Stockholm are estimated to fall on an annual basis, compared with a situation before the trail.

- Effects on the citizens' traveling behaviour:**
 In the spring of 2006 (when the trail happened), approximately 40.000 more people used more the public transport system, compared to a year before. [119]
- Effects on traffic Safety**
 In the inner-city was measured a reduction by 5 to 10 % in the number of accidents involving personal injuries. This corresponds to a reduction of between 40 and 70 personal accident injuries per year.

Challenges and Settlement

The biggest challenge for implementing the congestion charge was the political agreement, challenge which merged with the initial concern that the tax will not be accepted by the Stockholmers. The news that there will be a congestion trail was welcomed with great resistance and the numbers showed that right before the trail, the support for it had fallen to 36 %. [120] The media image also changed once charges were in place, from intensely critical to very positive. On 22nd of August 2005 the full-scale trial in Stockholm began and ended on 31st of July 2006. The congestion tax applied for seven months, between 3 January and 31 July 2006. Once the trail started, the public also embraced the measure, culminating with a 51.3% voting for "yes" at the referendum.

Financial

The cost of the Stockholm Trail was approximately 236 million euros. The congestion tax levied is estimated to

be 69 mil. euros in one year and the running costs euro 1,64M. In 2017, by using part of the money gathered through the congestion tax, 36M euros were used for the co-financing of costs for the Metro extension in the Stockholm region. [119] Currently, the congestion tax is levied between 6.00 a.m. and 6.29 p.m. The tax per passage varies from 0,9 euros to 4,1 euros, depending on the time of day. The highest amount charged is during rush hours between 7.00 and 8.29 a.m. and 4 and 5.29 p.m. [121] The maximum amount per day per vehicle is 12.3 euros. During off-peak season (period between 1st of March and the day before Midsummer Eve, and between 15th of August and 30th of November), the maximum amount is 9.5 euros.

Technical Infrastructures

The congestion tax system consists of four principal components:

- road equipment to collect vehicle information
- pre-processors, to process the information from the control points and generate tax decisions
- business process platform, to book tax decisions, handle payments, reminders, reports
- a web portal – with both a public website and an Intranet for the benefit of Customer Services and the National Tax Board

Traceability of the needed information had to be assured, therefore several systems needed to be integrated: The Swedish Traffic Registry, National Tax Board, Enforcement Service, Swedish Postal Services, Pressbyrå kiosks and 7-Eleven shops (Reitan Servicehandel Sverige AB), Bank and payment services.



Figure 4.48. One of the charging points in Stockholm [122]

Conclusions

Congestion is a big problem for any big city and Munich makes no exception. In fact, the nick-name of “the traffic-jam capital” is there for a reason and authorities should act fast in finding quick and sustainable solutions to fix this problem. Once the politicians would agree on this solution and the citizens would embrace the idea of having a congestion tax in the Bavarian capital, the benefits will be easily visible. These two factors represent a key point if this solution would also be applicable to Munich.

Furthermore, attractiveness is an important point for future development and durability continuity for any city. Congestion in general creates serious problems and

makes it difficult for businesses to operate, which reduces any city’s attractiveness. In many larger cities around the world, congestion and environmental influences hinder continued sustainable city development. City’s reputation is of great importance when seeking skilled personnel, who in turn attract companies and create further growth. Seen in this perspective, the Stockholm trial and the permanent congestion-tax boosts Stockholm’s overall attractiveness and this kind of effect might be visible on any other city where a congestion tax is successfully implemented, including Munich.

Conclusion

Stockholm's commitment to innovation is consistent and drives continuous improvements of mobility. The measures strongly enhance the city's value the citizen's live standard, including health and safety.

Yet the question remains: can all the measures that are presented in this report also be transferred to Munich? This is not an easy question and it depends on the context of each city. Detailed information regarding the feasibility in Munich can always be found in a compact form at the end of each measure.

Nevertheless, there are some measures that stand out like ELIN the Linköping University's project for the test route for autonomous shuttle buses. The measure is specially applaudable since it allows smaller but innovative companies as well as research that cannot fund the setup of a dedicated testing site to enter the project and use the data for further research and innovation. The big problem in Munich and Germany is that data is being collected, but rarely among researchers. Such behaviour certainly impedes innovation, i and Munich could learn from Stockholm.

Another interesting measure which Stockholm applies and could serve as inspiration for Munich is the open and prompt communication with its citizens. The example of the TyckTill app is relevant. The actual goal is to empower and engage citizens in the city's life and to make them feel that "the city", and its wellbeing, is something that we are all responsible for. Summer streets is another interesting measure successfully integrated into the city life of Stockholm and could also serve as an inspiration for Munich. Implementing an urban intervention on a bigger scale in a strategic and central location has the goal to attract all kinds of visitors and could bring important long-term impacts such as: pedestrian exclusive or can give the proper insights to assess and support the co-creation, trialling evaluation, and dispersal of a range of sustainable mobility solutions.

Stockholm regularly ranks very high in mobility rankings. This success cannot be explained in an easy recipe that could be applied to every European city, however, there is one thing the examples above underline: in order to achieve equal, sustainable and efficient mobility solutions, the whole city must collaborate and share. This means citizens and politicians as well as the economy and includes sharing of all resources: space for housing and traffic and living in the city, responsible handling of negative impacts like emission, or intangible goods like data or customers. Taking this approach into consideration, we are sure Munich can benefit, learn or just get inspired by Stockholm's success.

Overall Conclusion

The overall conclusion chapter summarizes the nine measures that impressed us the most – either because of their impact on the city’s mobility, their applicability, or their uniqueness in the cities we visited for this research. In the individual conclusion chapters, we already summarized the most compelling characteristics of the mobility efforts of each city. Here, we provide a compact final overview of measures to inspire future collaborative efforts on the improvement of the quality of air, space, and time.

Cluster 1: Electrification and Automation of Traffic Systems

Electric mobility promotion

Barcelona has an Electric Vehicle Master Plan 2018-2024 that includes as main measure the promotion of e-mobility via the collaborative platform LIVE (Logistics for the implementation of Electric vehicle). Since 2012, the open initiative of private and public actors in the mobility sector has enabled the charging infrastructure to develop 550 free charging stations combined with free parking in green painted spaces. Further, the integrated app Smou provides digitally facilities reservations, parking and payment. Most interestingly, the platform became an effective governance system through communication, support for sustainable mobility companies, enabling cooperation for the electrification of the public transport fleet, expanding the charging network and providing information for regulation and planning.

Since Munich is already underway towards improving their e-mobility services, the city could increase the momentum by implementing a collaborative platform for communication and knowledge sharing between public and private stakeholders.

Air

Time

Space



Autonomous Shuttles

Autonomous shuttles are tested both in Tallinn and Helsinki. Most of the projects collaborate with their respective universities and their city transportation offices. They are a viable option for regional transportation and last-mile services by taking riders from a public transit station to stops near their homes and offices. With that, such last-mile routes could become commercially feasible with driverless buses and could be an excellent alternative to conventional buses where hiring drivers might be overly expensive. The target audience is mainly elderly and disabled people.

The current challenges are that the shuttles still require a person in control (either in the vehicle or remote) and that they can only drive on predetermined routes. For the application in Munich, planners need to take into consideration different laws regarding the technology as well as their different perceptions across countries.

Air

Time

Space



Night delivery with clean and silent vehicles

Delivering goods at night relieves a city’s road network, especially during peak traffic hours. On the downside, noise, pollution due to combustion and driving heavy vehicles is unreasonable for residents. The City of Stockholm conducted a pilot project that enabled inner-city heavy delivery trucks to use clean and silent hybrid engines. By geofencing, usage of the electric drivetrain and therefore low noise emissions can be reduced.

This measure is well applicable to Munich. Appropriate trucks can be supplied by the local company MAN, the matching software for geofencing e.g. by one of Munich’s universities. Contested traffic networks as well as rising opposition towards urban freight traffic present two major challenges in Munich that might be solved by a similar project.

Air

Time

Space



Overall Conclusion

Cluster 2: Development and Integration of Mobility Options

CARNET – Future Mobility Research Hub

CARNET, initiated by SEAT, Volkswagen Group Research and the Universitat Politècnica de Catalunya (UPC), is an open hub for industrial and academic partners from the areas of automotive and mobility research & innovation. The municipality supports the organization that is committed to training of engineers and scientists, cooperative research, networking, and business creation. Most notably, the strong relations between the members facilitate the quick development of pilot projects for future mobility.

The existing Inzell Initiative in Munich strives for similar goals. Hence, mutual learning of these research hubs appears promising. Simultaneously, another project with actors from the scientific sector, economy, and social sector is being created: The M Cube project will bundle forces for a more sustainable future mobility.

Munich possesses all the physical infrastructure needed for a MaaS app. The biggest challenge of launching a similar project here will be the willingness to provide and share open data and accepting that customers are not tied to one single supplier but may be choosing between different providers.



Open data as enabler for mobility innovation

Since 2011, municipalities in the Helsinki metropolitan area make data that has been conducted for planning and decision-making purposes, e.g. data concerning congestion or accident hotspots publicly available. In addition, transport providers are obliged to make their timetables, routes, tickets, and real-time location information accessible via open APIs. Open data is considered a significant enabler of mobility innovation and allows further development of a flourishing mobility start-up environment in Helsinki.



MaaS/UbiGo

UbiGo is a MaaS application that provides access to five modes of transport: public transport, bike sharing, car sharing, car rental, and taxi. It enables its users to plan and pay for trips by providing information on travel times, fares and departures. The app boasts a subscription model which enables the users to buy mobility units independent from a specific mode of transport.

Overall Conclusion

Cluster 3: Redesign and Network of Mobility Options

Free Public Transport

Tallinn has been offering free public transport for its citizens since 2013 and is the first European city to do so. Tallinn residents can register for a green card which allows them to use the buses and trams for free. This measure contributes to a reduction of noise, traffic and air pollution since more people are using public transport. However, it remains unclear if this increase derived from a general trend or from the measure itself. Currently, it is disputable to introduce free public transport to Munich since especially the subway system is already very crowded during rush hours. First, the capacity of the public transport system must be increased. The level of service should not be decreased by the consequences of free public transport



Urban Mobility Plan (UMP)

The UMP is a planning tool that governs and evaluates activities for sustainable mobility every six years. The UMP 2013-2018 coordinates the implementation of Superblocks – a redistribution of urban space for active mobility (on foot and bike) and citizens' activities, while the multi-use spaces are structured by the grid of the effective orthogonal bus network. The regular development of the plan is based on the elaborations from the Mobility Pact (a forum of diverse societal actors), the citizen participation process (in meetings and through the online-platform Decidim), and the evaluation of the previous plan's measures based on a set of indicators. Catalonia established a legal framework for the UMP. The plan is a particularly valuable tool to foster transparency on mobility plans. Munich's overall mobility plan is underway. Barcelona's UMP can serve as an example for an intensive participatory process and a transparent presentation of measures along with predefined sustainability indicators.



Summer Streets – Temporary Pedestrian Zones

With their project Living Stockholm, the city transforms regular streets into pedestrian streets during summer. The trials were highly successful and proved to increase liveability, promote active mobility and foster local businesses like restaurants or shops. Most importantly, summer streets give an idea on what a less car-orientated and more human-centred urban environment might look like.

Projects with similar ideas but a much smaller scale have already been conducted in Munich, proving that creating a more liveable, vibrant urban environment is one of the city's goals. The concept of summer streets has high potential to bring permanent change as it can be seen in Stockholm where some streets remain pedestrian exclusive. Summer streets can also provide the necessary insights to assess and support the co-creation, trialling evaluation, and dispersal of a range of sustainable mobility solutions. It is a way of understanding public space as a vital resource for a systemic transition to sustainable mobility.



References: Munich

- [1] muenchen.de, „Konzept vorgestellt: Münchens Mobilität der Zukunft,“ [Online]. Available: <https://www.muenchen.de/aktuell/2020-01/konzept-vorgestellt-muenchens-mobilitaet-der-zukunft.html>. [Zugriff am 01 02 2020].
- [2] Messe München GmbH, „icm-muenchen.de - Facts and figures,“ [Online]. Available: https://web.archive.org/web/20120619061243/http://www.icm-muenchen.de/en/Home/cn/kongressstadt/daten_fakten. [Zugriff am 07 04 2020].
- [3] Metropolregion München, „The region "Munich Metropolitan Region",“ [Online]. Available: <https://www.metropolregion-muenchen.eu/en/the-munich-metropolitan-region/members/>. [Zugriff am 07 04 2020].
- [4] Bayerisches Landesamt für Statistik, „Bayern in Zahlen,“ Bayern in Zahlen Fachzeitschrift für Statistik, Bd. 4, 2020.
- [5] Statistisches Bundesamt, „Destatis,“ March 2020. [Online]. Available: https://www.destatis.de/DE/Presse/Pressemitteilungen/2020/03/PD20_113_611.html?sessionId=2324520808C74E5866B3C5F4A8A90B F7.internet8711. [Zugriff am April 2020].
- [6] Statistisches Amt München, „Das Durchschnittsalter der Münchner Bevölkerung 2000 und 2018 nach Stadtbezirken,“ 2018. [Online]. Available: https://www.muenchen.de/rathaus/dam/jcr:9d609bf8-437a-46e8-856d-c04a716f0d1e/Altersdurchschnitt_Tabelle.pdf. [Zugriff am 07 04 2020].
- [7] T. Gensler, „Altstadt-Lehel,“ 2004. [Online]. Available: https://commons.wikimedia.org/wiki/File:Stadtbezirke_Lage_in_M%C3%BCnchen.png. [Zugriff am 07 04 2020].
- [8] muenchen.de, „München in Zahlen,“ [Online]. Available: <https://www.muenchen.de/sehenswuerdigkeiten/muenchen-in-zahlen.html>. [Zugriff am 07 04 2020].
- [9] P. Peters, Planning Without Overview. On how Munichs Planners Plan for Cycling, Complexity and the Baroque, München,

- 2019.
- [10] City of Munich - Department of Labor and Economic Development, „Munich Annual Economic Report,“ Munich, 2019.
- [11] City of Munich, „muenchen.de - Das offizielle Stadtportal,“ 2017. [Online]. Available: <https://www.muenchen.de/rathaus/dam/jcr:883f8b0f-8bee-44b5-af14-7996c1749350/jt190501.pdf>.
- [12] City of Munich - Department of Labor and Economic Development, „Munich as a Business Location: Facts and Figures,“ 2020. [Online]. Available: www.wirtschaft-muenchen.de/publikationen/pdfs/en_factsandfigures_2020.pdf. [Zugriff am April 2020].
- [13] MVV, „MVV-Muenchen,“ 2018. [Online]. Available: <https://www.mvv-muenchen.de/mvv-und-service/der-verbund/mvv-in-zahlen/index.html>. [Zugriff am April 2020].
- [14] Civitas, „Civitas Eccentric Munich,“ [Online]. Available: <https://civitas.eu/eccentric/munich>. [Zugriff am 07 04 2020].
- [15] „MVV Muenchen,“ [Online]. Available: <https://www.mvv-muenchen.de/tickets/tickets-tageskarten/index.html>. [Zugriff am March 2020].
- [16] „muenchen.de,“ [Online]. Available: <https://www.muenchen.de/rathaus/Stadtverwaltung/Referat-fuer-Stadtplanung-und-Bauordnung/Verkehrsplanung/Verkehrsmodell-VisMuc.html>. [Zugriff am April 2020].
- [17] „muenchen.de,“ June 2019. [Online]. Available: <https://www.muenchen.de/aktuell/2019-06/2000-neue-mvg-raeder-fuer-muenchen.html>. [Zugriff am April 2020].
- [18] Civitas Initiative, „Civitas,“ [Online]. Available: <https://civitas.eu/eccentric/munich>. [Zugriff am March 2020].
- [19] „muenchen.de,“ [Online]. Available: <https://www.muenchen.de/rathaus/Stadtverwaltung/baureferat/freizeit-sport-natur/radnetz.html>. [Zugriff am April 2020].
- [20] M. Ferstl, „Sueddeutsche Zeitung,“ 9 September 2019. [Online]. Available: <https://www.sueddeutsche.de/muenchen/muenchen-verkehr-elektromobilitaet-foerderung-1.4593535>. [Zugriff am April 2020].

- [21] Bundesverband der Energie- und Wasserwirtschaft e.V. , „bdew,“ 10 January 2020. [Online]. Available: <https://www.bdew.de/presse/presseinformationen/muenchen-wird-neue-hauptstadt-der-ladepunkte>. [Zugriff am April 2020].
- [22] „muenchen.de,“ [Online]. Available: <https://www.muenchen.de/verkehr/parkhaeuser.html>. [Zugriff am April 2020].
- [23] „MVG,“ [Online]. Available: <https://www.mvg.de/dienste/plaene.html>. [Zugriff am March 2020].
- [24] Landeshauptstadt München, „Verkehrsplanung,“ [Online]. Available: <https://www.muenchen.de/rathaus/Stadtverwaltung/Referat-fuer-Stadtplanung-und-Bauordnung/Verkehrsplanung.html>. [Zugriff am 05 01 2020].
- [25] INRIX, „INRIX Reveals Congestion At Germany's Worst Traffic Hotspots To Cost Drivers €48 Billion Over The Next Decade,“ 30 11 2016. [Online]. Available: <https://inrix.com/press-releases/inrix-reveals-congestion-at-germanys-worst-traffic-hotspots-to-cost-drivers-e48-billion-over-the-next-decade/>. [Zugriff am 07 04 2020].
- [26] Landeshauptstadt München, „Lärmaktionsplan für München,“ München, 2013.
- [27] Planungsverband äußerer Wirtschaftsraum München, „Planungsverband München: Potenzialanalyse Radschnellwege in Der Region München,“ 2015. [Online]. Available: <https://www.pv-muenchen.de/leistungen/ortsplanung/verkehrskonzepte/radschnellwege/potenzialanalyse-radschnellwege-in-der-region-muenchen/>. [Zugriff am 22 4 2020].
- [28] Landeshauptstadt München Redaktion, „Autofreie Altstadt,“ [Online]. Available: <https://www.muenchen.de/rathaus/Stadtverwaltung/Referat-fuer-Stadtplanung-und-Bauordnung/Verkehrsplanung/Autofreie-Altstadt.html>. [Zugriff am 22 4 2020].
- [29] Landeshauptstadt München, „Gesamtkonzept für Münchens Mobilität der Zukunft,“ 31 1 2020. [Online]. Available: <https://ru.muenchen.de/2020/21/Gesamtkonzept-fuer-Muenchens-Mobilitaet-der-Zukunft-89546>. [Zugriff am 22 4 2020].
- [30] Interreg, „Welcome,“ [Online]. Available: https://www.interreg.de/INTERREG2014/EN/Home/home_node.html?sessionId=AAB66A280EAA123A5126036BC61D0B37.live11292. [Zugriff am 07 04 2020].

- [31] Inell Initiative, „Inzell Initiative,“ [Online]. Available: <https://www.inzellinitiative.de/inzell-initiative-en.html>. [Zugriff am 07 04 2020].
- [32] Landeshauptstadt München, „Modellstadt München 2030,“ [Online]. Available: <https://www.muenchen.de/rathaus/Stadtverwaltung/Referat-fuer-Stadtplanung-und-Bauordnung/Verkehrsplanung/Modellstadt2030.html>. [Zugriff am 22 4 2020].
- [33] Landeshauptstadt München, „Projektvorstellung: Ein europäisches Modellprojekt für München,“ [Online]. Available: <https://www.muenchen.de/rathaus/Stadtverwaltung/Kreisverwaltungsreferat/Verkehr/Mobilitaetsberatung/Civitas-Eccentric/Das-Projekt.html>. [Zugriff am 22 4 2020].
- [34] City2Share, „City2Share,“ [Online]. Available: <http://city2share.de/>. [Zugriff am 07 04 2020].
- Marienplatz U-Bahn Station Photo by Dominik Martin on Unsplash
- Munich Central Train Station Photo by Kolar.io on Unsplash
- Star icon icon by Icons8
- Air icon icon by Icons8
- Traffic Jam icon icon by Icons8
- Quality icon icon by Icons8
- Pictures for front page : Adobe Stock and MGv.de

References: Barcelona

- [1] Ajuntament de Barcelona, This Is Not a Drill - Climate Emergency Declaration, Barcelona, 2020.
- [2] I. H. P. D. M. B. J. Dixon S., "www2.deloitte.com," Deloitte, 7 January 2019. [Online]. Available: <https://www2.deloitte.com/us/en/insights/focus/future-of-mobility/deloitte-urban-mobility-index-for-cities.html>. [Accessed 10 April 2020].
- [3] Innovation Cities™, "Europe Cities Ranking 2019 by 2thinknow Innovation Cities™ Index," 11 11 2019. [Online]. Available: <https://www.innovation-cities.com/europe-cities-ranking-2019-innovation-cities/18839/>. [Accessed 22 4 2020].
- [4] A. Rae, "Overstretched cities - Europe's most densely populated square kilometres – mapped," The Guardian, 22 March 2018. [Online]. Available: <https://www.theguardian.com/cities/gallery/2018/mar/22/most-densely-populated-square-kilometres-europe-mapped>. [Accessed 10 April 2020].
- [5] muenchen.de, "muenchen.de - Das offizielle Stadtportal," Landeshauptstadt München, Referat für Stadtplanung und Bauordnung, Abt. 4 Räumliche Entwicklungsplanung, Flächennutzungsplanung, N.N.. [Online]. Available: <https://www.muenchen.de/rathaus/Stadtverwaltung/Referat-fuer-Stadtplanung-und-Bauordnung/Projekte/Langfristige-Siedlungsentwicklung/Projekt/Verdichtung.html>. [Accessed 10 April 2020].
- [6] N. Martí, "Indicadors de Sostenibilitat de Barcelona - Informe 2018," Ajuntament de Barcelona, Barcelona, 2020.
- [7] Ajuntament de Barcelona, "Barcelona green infrastructure and bisodiversity plan 2020," Barcelona, 2013.
- [8] M. Bausells, "www.theguardian.com," 1 April 2016. [Online]. Available: <https://www.theguardian.com/cities/2016/apr/01/story-cities-13-example-barcelona-ildefons-cerda-planner-urbanisation>. [Accessed 10 April 2020].
- [9] AMB, "Barcelona data sheet 2018 - Main Economic Indicators," 2018. [Online]. Available: https://www.barcelona.cat/internationalwelcome/sites/default/files/DataSheet2018Web_eng_0.pdf. [Accessed 2020].
- [10] Ajuntament de Barcelona, "PECQ 2011-2020," Barcelona, 2010.
- [11] Generalitat de Catalunya, "www.catalonia.com," 2019. [Online]. Available: <http://catalonia.com/startups-in-catalonia/known-them-all-the-barcelona-catalonia-startup-directory/barcelona-1500-startups-new-record.jsp>. [Accessed 2020].
- [12] Ajuntament de Barcelona, Dades Bàsiques de Mobilitat. Informe 2017, Barcelona, 2018.
- [13] MVG, "Tickets & Tarife," [Online]. Available: <https://www.mvg.de/tickets-tarife.html>. [Accessed 22 4 2020].
- [14] TMB, "Single Tickets," [Online]. Available: <https://www.tmb.cat/en/barcelona-fares-metro-bus/single-and-integrated>. [Accessed 22 4 2020].
- [15] Ajuntament de Barcelona, "Endolla Barcelona, a New Municipal Charging-Point Service for Electric Vehicles," 8 8 2019. [Online]. Available: https://www.barcelona.cat/infobarcelona/en/tema/mobility-and-transport/endolla-barcelona-a-new-municipal-charging-point-service-for-electric-vehicles_845742.html. [Accessed 22 4 2020].
- [16] Ajuntament de Barcelona and BCNecologia, Pla de Mobilitat Urbana de Barcelona - PMU 2013-2018. Introducció i Diagnosi, Barcelona, 2015.
- [17] Ajuntament de Barcelona, "Collaborating Entities and Operators," [Online]. Available: <https://www.barcelona.cat/mobilitat/en/about-us/organisations-and-operators>. [Accessed 22 4 2020].
- [18] Ajuntament de Barcelona, Dades Bàsiques de Mobilitat. Informe 2017, Barcelona, 2018.
- [19] TMB, 2020 Barcelona Metro Map, 2020.
- [20] Ajuntament de Barcelona, "Enquesta de Serveis Municipal 2019," Barcelona, 2019.
- [21] Barcelona Field Studies Centre, "www.geographyfieldwork.com," 2016. [Online]. Available: <https://www.geographyfieldwork.com/EIRavalCrime2016.htm>. [Accessed 2020].

- [22] Federal Republic of Germany, "Police Crime Statistics," 2018. [Online]. Available: https://www.bmi.bund.de/SharedDocs/downloads/EN/publikationen/2019/pks-2018-flyer.pdf?__blob=publicationFile&v=4. [Accessed 2020].
- [23] Ambiental Salut, "Avaluació de la qualitat de l'aire la ciutat de Barcelona," Barcelona, 2017.
- [24] M. Natalie and D. Rojas, "Changing the urban design of cities for health: The superblock model," Environment International, vol. 134, January 2020.
- [25] S. Rueda, "Superblocks for the Design of New Cities and Renovation of Existing Ones: Barcelona's Case," in Integrating Human Health into Urban and Transport Planning, M. Nieuwenhuisen and H. Khreis, Eds., Cham, Springer International Publishing, 2019, p. 135–153.
- [26] Stay Grounded, "Barcelona: a city exploited by tourism and air traffic," 2016. [Online]. Available: <https://stay-grounded.org/barcelona-una-ciudad-explotada-por-la-turistificacion-y-el-traffic-aereo/>. [Accessed 2020].
- [27] www.statista.com, "Leading European city tourism destinations in 2018, by number of bednights," 2019. [Online]. Available: <https://www.statista.com/statistics/314340/leading-european-city-tourism-destinations-by-number-of-bednights/>. [Accessed 2020].
- [28] Ajuntament de Barcelona, "Electric Vehicle," [Online]. Available: <https://www.barcelona.cat/mobilitat/en/means-of-transport/electric-vehicle>.
- [29] LIVE, "www.livebarcelona.cat," [Online]. Available: <https://livebarcelona.cat/es/la-aplicacion-smou-incorpora-la-red-de-recarga-electrica-endolla-barcelona-y-sigue-creciendo-en-servicios/>. [Accessed 22 4 2020].
- [30] GrowSmarter, "Lighthouse City: Barcelona," [Online]. Available: <https://grow-smarter.eu/lighthouse-cities/barcelona/>. [Accessed 22 4 2020].
- [31] Catalonia Living Lab, "Catalonia Living Lab," [Online]. Available: <http://catalonialivinglab.com/>. [Accessed 22 4 2020].
- [32] CARNET, "Barcelona will be the European capital of urban mobility, with CARNET as a key technological partner," [Online]. Available: <http://www.carnetbarcelona.com/index.php/2019/02/04/>

- barcelona-will-be-the-european-capital-of-urban-mobility-with-the-up-as-one-of-the-key-technological-partners/. [Accessed 22 04 2020].
- [33] D. Roberts, "Could Barcelona's Plan to Push out Cars and Build Superblocks Work in the US?," 12 4 2019. [Online]. Available: <https://www.vox.com/energy-and-environment/2019/4/12/18273897/barcelona-urban-planning-portland-oregon-superblocks>. [Accessed 22 4 2020].
- [34] B. C. Council, "Mobility and transport," Barcelona City Council, 04 February 2020. [Online]. Available: <https://www.barcelona.cat/mobilitat/en/means-of-transport/shared-vehicle>. [Accessed 15 March 2020].
- [35] INRIX, "Global Traffic Scorecard," INRIX RESEARCH, Washington, 2019.
- [36] A. Schubert, "ADAC kritisiert Roller-Sharing von Emmy," Süddeutsche.de, 10 August 2018. [Online]. Available: <https://www.sueddeutsche.de/muenchen/mietroller-emmy-adac-unzulaessige-geschaeftsbedingungen-1.4088957>. [Accessed 16 March 2020].
- [37] Ajuntament de Barcelona, "Estratègia de Mobilitat Electritat," Barcelona, 2018.
- [38] AMB, "PLA METROPOLITÀ DE MOBILITAT URBANA," Barcelona, 2019.
- [39] IERMB, "Dades socioeconòmiques i de mobilitat de l'area metropolitana de Barcelona," 2019.
- [40] A. d. Barcelona, "Programa de Mesures contra la contaminació atmosfèrica: Resum d'actuacions," 2019.
- [41] ENDESA S.A, "www.endesa.com," [Online]. Available: <https://www.endesa.com/en/projects/all-projects/energy-transition/electric-mobility/ultrabfast-charging-bus-barcelona>. [Accessed 2020].
- [42] MVG, "www.mvg.de," 2020. [Online]. Available: <https://www.mvg.de/ueber/mvg-projekte/bus/elektromobilitaet.html#intro>. [Accessed 2020].
- [43] LIVE, "www.livebarcelona.cat," [Online]. Available: <https://livebarcelona.cat/es/la-aplicacion-smou-incorpora-la-red-de-recarga-electrica-endolla-barcelona-y-sigue-creciendo-en-servicios/>. [Accessed 2019].
- [44] Smou, "app.apple.com," [Online]. Available: <https://apps.apple.com/cr/app/smou/id1439898721>. [Accessed 2020].

References: Barcelona

[45] Ajuntament de Barcelona, "https://www.areaverda.cat," [Online]. Available: <https://www.areaverda.cat/en/map>. [Accessed 2020].

[46] G. M. Coma, "Barcelona's New Bus Network - Committed to safe and efficient sustainable mobility," Barcelona City Council and TMB, Barcelona, 2019.

[47] Ajuntament de Barcelona, "Pla de Mobilitat Urbana de Barcelona (Urban Mobility Plan)," Barcelona, 2015.

[48] Barcelona City Council and TMB, "https://www.tmb.cat," September 2019. [Online]. Available: https://www.tmb.cat/documents/20182/111197/Nova+xarxa+bus_EN/aeafe1a9-67f8-49c2-9108-a0164c778f65. [Accessed 7 April 2020].

[49] Agència d'Ecologia Urbana de Barcelona, "www.bcnecologia.net," October 2012. [Online]. Available: http://bcnecologia.net/sites/default/files/proyectos/2012_10_dossier_prensa_bus_ortogonal_barcelona_red_web.pdf. [Accessed 7 April 2020].

[50] Area Metropolitana de Barcelona, "www.amb.cat," Area Metropolitana de Barcelona, n.n.. [Online]. Available: <http://www.amb.cat/en/web/mobilitat/gestio-i-organitzacio/empreses-operadores>. [Accessed 10 April 2020].

[51] L. E. A. o. M. A. B. AMB, Interviewee, Head of cycling projects and sustainable mobility services. [Interview]. 5 March 2020.

[52] L. E. A. d. Barcelona, Interviewee, Lively Streets. [Interview]. 10 March 2020.

[53] A.-C. J. D. C. F. Badia H., "How network structure can boost and shape the demand for bus transit," Elsevier, 29 May 2017.

[54] Ajuntament de Barcelona, "www.barcelona.cat," Ajuntament de Barcelona, 30 May 2018. [Online]. Available: https://www.barcelona.cat/infobarcelona/en/three-new-bus-routes-to-help-make-public-transport-more-efficient_669024.html. [Accessed 10 April 2020].

[55] Area Metropolitana Barcelona, "www.bicibox.cat," AMB Mobilitata, N.N.. [Online]. Available: <https://www.bicibox.cat/ca-es/>.

[Accessed 10 April 2020].

[56] elBaix.cat, "www.elbaix.cat," elBaix.cat, 5 June 2019. [Online]. Available: www.elbaix.cat/2019/06/05/gava-acull-el-primer-bicibox-de-gran-capacitat-de-larea-metropolitana-de-barcelona/. [Accessed 10 April 2020].

[57] Area Metropolitana de Barcelona Entitat de Transport, "Plec de prescripcions tècniques servei d'aparcaments segurs de bicicletes (Bicibox)," Area Metropolitana de Barcelona, 2010.

[58] R. M. Bravo, "El Bicibox no roda," El Punt Avui, Castelldefels, 2012.

[59] Redaccion K-Press, "www.komunica.press/," Komunica Press, 2 August 2019. [Online]. Available: <https://www.komunica.press/lamb-posa-en-marxa-a-sant-joan-despi-el-primer-local-comercial-per-aparcar-bicicletes-particulars-vinculat-al-bicibox/>. [Accessed 10 April 2020].

[60] MVV GmbH, "Mobilitätsangebote - Radfahrer," MVV GmbH, 2020. [Online]. Available: <https://www.mvv-muenchen.de/service/weitere-mobilitaetsangebote/radfahrer/index.html>. [Accessed 10 April 2020].

[61] B. Barcelona, "Bicing Barcelona, Clear Channel," www.bicing.com, Barcelona, 2018.

[62] "Bicing," Nou Bicing | Bicing, [Online]. Available: <https://www.bicing.barcelona/>. [Accessed 07 03 2020].

[63] H. R. Lourenço, "A logistics analysis of Bicing," November, Barcelona, 2018.

[64] "En.wikipedia.org," Wikipedia, [Online]. Available: <https://en.wikipedia.org/wiki/Bicing>. [Accessed 07 March 2020].

[65] Barcelona City Council, "Information About Using Bicycles," Barcelona City Council, Barcelona.

[66] A. d. N. M. T. M. J. N. David Rojas-Rueda, "The health risks and benefits of cycling in urban," BMJ Journals, pp. 343-351, 2011.

[67] S. B. B. A new approach to public transport in Barcelona, "Eco-Business," [Online]. Available: <https://www.eco-business.com/>

press-releases/a-new-approach-to-public-transport-in-barcelona-spain-bicing-bicycles/. [Accessed 20 April 2020].

[68] P. UPC, Interviewee, PhD. [Interview]. 09 March 2020.

[69] R. Schawohl, "Contribution to a smart mobility in Munich," Munich Transport Corporation, Munich, 2019.

[70] CARNET, "CARNET – FUTURE MOBILITY RESEARCH HUB," Carnetbarcelona.com, [Online]. Available: <http://www.carnetbarcelona.com/>. [Accessed 23 March 2020].

[71] I. Initiative, "Inzellinitiative.de," November 2019. [Online]. Available: <https://www.inzellinitiative.de/inzell-initiative-en.html>. [Accessed March 2020].

[72] Ajuntament de Barcelona and BCNecologia, Pla de Mobilitat Urbana de Barcelona - PMU 2013-2018. Proposta, Barcelona, 2015.

[73] Ajuntament de Barcelona, "Urban Mobility Plan," [Online]. Available: <https://www.barcelona.cat/mobilitat/en/about-us/urban-mobility-plan>. [Accessed 22 4 2020].

[74] BCNecologia, "Sustainable Urban Mobility Plan of Barcelona (2013-2018)," [Online]. Available: <http://www.bcnecologia.net/en/projects/sustainable-urban-mobility-plan-barcelona-2013-2018>. [Accessed 22 4 2020].

[75] Ajuntament de Barcelona and El globus vermell, Informe de Resultats Del Procés Participatiu Del Pla de Mobilitat Urbana (PMU) 2019-2024, Barcelona, 2019.

[76] Decidim.org and Ajuntament de Barcelona, Decidim. Free Open-Source Participatory Democracy for Cities and Organizations.

[77] Ajuntament de Barcelona, "Mobility Pact," [Online]. Available: <https://www.barcelona.cat/mobilitat/en/about-us/participatory-bodies/mobility-pact>. [Accessed 22 4 2020].

[78] J.-P. Voß, "Reflexively Engaging with Technologies of Participation," in Remaking Participation, J. Chilvers and M. Kearnes, Eds., London, Routledge, 2016, p. 239–260.

[79] Ajuntament de Barcelona, Pla de Mobilitat Urbana de Barcelona - PMU 2019-2024. Procés Participatiu, Barcelona, 2019.

[80] Landeshauptstadt München, Referat für Stadtplanung und Bauordnung, Verkehrsentwicklungsplan, München, 2006.

[81] Landeshauptstadt München, "Gesamtkonzept für Münchens Mobilität der Zukunft," 31 1 2020. [Online]. Available: <https://>

[ru.muenchen.de/2020/21/Gesamtkonzept-fuer-Muenchens-Mobilitaet-der-Zukunft-89546](https://www.muenchen.de/2020/21/Gesamtkonzept-fuer-Muenchens-Mobilitaet-der-Zukunft-89546). [Accessed 22 4 2020].

[82] E. Municipality, Interviewee, Barcelona Mobility Innovations and Superblocks. [Interview]. 3 March 2020.

[83] Ajuntament de Barcelona, "A City at 30 Km/h," 24 2 2020. [Online]. Available: https://www.barcelona.cat/mobilitat/en/ws-and-documents/news/a-city-at-30-km-h_921411. [Accessed 22 4 2020].

[84] Ajuntament de Barcelona, "L'eix Del Carrer de La Creu Coberta-Carrer de Sants Passa a Ser de Velocitat 30 Km/h : Servei de Premsa," 24 2 2020. [Online]. Available: <https://ajuntament.barcelona.cat/premsa/2020/02/24/leix-del-carrer-de-la-creu-coberta-carrer-de-sants-passa-a-ser-de-velocitat-30-km-h/>. [Accessed 22 4 2020].

[85] M. Jung, Barcelona, 2020.

[86] D. Passmore, 2013. [Online]. Available: <https://www.flickr.com/photos/dylanpassmore/10577918293/in/photostream/>. [Accessed 22 4 2020].

[87] Landeshauptstadt München, "Stickstoffdioxidmessungen," 11 2 2020. [Online]. Available: https://www.muenchen.de/rathaus/Stadtverwaltung/Referat-fuer-Gesundheit-und-Umwelt/Luft_und_Strahlung/Stickstoffdioxidmessungen.html. [Accessed 22 4 2020].

[88] Ajuntament de Barcelona, "A Greener City, Better Suited to Walking and Playing," 25 1 2020. [Online]. Available: https://www.barcelona.cat/infobarcelona/en/tema/mobility-and-transport/a-greener-city-better-suited-to-walking-and-playing_907529.html. [Accessed 22 4 2020].

[89] Ajuntament de Barcelona, "La Supermanzana de Sant Antoni Disminuye En Un 82 % El Paso de Vehículos," 16 12 2019. [Online]. Available: <https://ajuntament.barcelona.cat/superilles/es/noticia/la-supermanzana-de-sant-antoni-disminuye-en-un-82-el-paso-de-vehiculos>. [Accessed 22 4 2020].

[90] Resident_Superblock, Interviewee, [Interview]. 4 March 2020.

[91] Ajuntament de Barcelona, "Climate Emergency Declared in Barcelona," 15 1 2020. [Online]. Available: <https://www.barcelona.cat/infobarcelona/en/tema/climate-emergency/climate-emergency-declared->

References: Barcelona

in-barcelona_902739.html. [Accessed 22 4 2020].

[92] Ajuntament de Barcelona, Presentació d'inici d'obres Consensuada Amb Grup Impulsor, Superilla de l'àmbit de Sant Antoni, Barcelona, 2018.

[93] D. Hutter, "München hat die schlechteste Luft in ganz Bayern," 10 1 2020. [Online]. Available: <https://www.sueddeutsche.de/muenchen/muenchen-luftverschmutzung-ranking-bayern-1.4751688>. [Accessed 22 4 2020].

[94] Landeshauptstadt München Redaktion, "Autofreie Altstadt," [Online]. Available: <https://www.muenchen.de/rathaus/Stadtverwaltung/Referat-fuer-Stadtplanung-und-Bauordnung/Verkehrsplanung/Autofreie-Altstadt.html>. [Accessed 20 4 2020].

[95] P. Geisser and S. Lenk, "Grau, Grün Und Blau – Die Bodennutzung in München," Münchner Statistik, 2017.

[96] S. Rueda, La Supermanzana, Nueve Célula Urbana Para La Construcción de Un Funcional y Urbanístico de Barcelona, Barcelona, 2016, p. 43.

[97] D. Roberts, "Barcelona Wants to Build 500 Superblocks. Here's What It Learned from the First Ones.," 9 4 2019. [Online]. Available: <https://www.vox.com/energy-and-environment/2019/4/9/18273894/barcelona-urban-planning-superblocks-poblenou>. [Accessed 22 4 2020].

[98] D. I. Akaltin, J. H. Chen, W. Cho, C. De Haan Boch, I. Flock, S. Grondin, I. A. Guzmán, S. King, A. Kinman, S. McCausland, E. Oscilowicz, H. Rachelson, J. Roe, J. Soler Cruz, Y. K. Kang, J. Zhu, Z. Muxi and J. Honey-Rosés, Life in Poblenou: Observing Spaces in Transition, 2019.

[99] Col.lectiu Superilla, "Tallers Oberts Poblenou," [Online]. Available: <https://tallersobertspoblenou.org/ca/collectiu-superilla>. [Accessed 22 4 2020].

[100] City2Share, "City2Share," [Online]. Available: <http://city2share.de/>. [Accessed 22 4 2020].

[101] TUM, "CLEAR - Professur Für Siedlungsstruktur Und

Verkehrsplanung," [Online]. Available: <https://www.bgu.tum.de/sv/forschung-und-beratung/projekte/projekte/clear/>. [Accessed 22 4 2020].

[102] AMB, "Implantació de la Zona de Baixes Emissions de les Rondes de Barcelona (ZBE Rondes)," 2017.

[103] Barcelona Regional Agencia Desenvolupament Urbana, "Informe dels Resultats Del Balanc D'Emissions de l'aire de la ZBE," Barcelona, 2017.

[104] Creafutur, "BAROMETER: CITIZENS AND MOBILITY IN BARCELONA," 2019. [Online]. Available: <https://static1.squarespace.com/static/5970906d4c0dbf748f1594a5/t/5e99a80bee90300a4966042c/1587128368271/Mobility+Barometer+-+Executive+Summary.pdf>. [Accessed 2020].

[105] G. R. J. L. C. N. M. M. Lopez Rodriguez A., "Pla de Mobilitat Urbana de Barcelona 2006-2012," BCN Mobilitat, Barcelona, 2008.

[106] Ajutament de Barcelona, "www.barcelona.cat," Ajutament de Barcelona, 25 July 2019. [Online]. Available: https://ajutament.barcelona.cat/relacionsinternacionalsicooperacio/en/noticia/barcelona-is-committed-to-the-united-nations-2030-agenda_844785. [Accessed 10 April 2020].

[107] Area of Urban Ecology. Barcelona City Council., "BCN Climate Plan 2018-2030," own publication, Barcelona, 2018.

[108] P. T. M. a. U. i. Barcelona, Interviewee, Mobility landscape in Barcelona. [Interview]. 4 March 2020.

[109] L. E. T. (. p. t. operator), Interviewee, Mobility landscape in Barcelona. [Interview]. 6 March 2020.

[110] P. f. U. P. a. U. i. Barcelona, Interviewee, Mobility landscape in Barcelona. [Interview]. 9 March 2020.

[111] BCNecologia, "Collection of Published News about Barcelona's Superblocks 2016-2017," 2017.

[112] D. Roberts, "Barcelona's Superblocks Are a New Model for 'Post-Car' Urban Living," 11 4 2019. [Online]. Available: [REFERENCES](https://www.vox.com/energy-and-environment/2019/4/11/18273896/barcelona-</p>
</div>
<div data-bbox=)

spain-politics-superblocks. [Accessed 22 4 2020].

[113] D. Roberts, "Barcelona's Radical Plan to Take Back Streets from Cars," 9 4 2019. [Online]. Available: <https://www.vox.com/energy-and-environment/2019/4/9/18300797/barcelona-spain-superblocks-urban-plan>. [Accessed 22 4 2020].

[114] X. F. de Castro, "Barcelona explora 10 noves superilles," 26 4 2019. [Online]. Available: https://www.totbarcelona.cat/societat/barcelona-explora-10-noves-superilles_1929387102.html. [Accessed 22 4 2020].

[115] Ajuntament de Barcelona, Mesura de Govern: Pla de Mobilitat Del Districte de Ciutat Vella 2018-2023, Barcelona, 2018.

[116] Ajuntament de Barcelona, Presentació Del Consell de Barri "Finalització i Seguiment Actuacions", Superilla Sant Antoni, Barcelona, 2019.

[117] N. Mueller, D. Rojas-Rueda, H. Khreis, M. Cirach, D. Andrés, J. Ballester, X. Bartoll, C. Daher, A. Deluca, C. Echave, C. Milà, S. Márquez, J. Palou, K. Pérez, C. Tonne, M. Stevenson, S. Rueda and M. Nieuwenhuijsen, "Changing the Urban Design of Cities for Health: The Superblock Model," Environment International, vol. 134, p. 105132, 2020.

[118] K. Mess, "Barcelona Verbannt Autos Mit Einem Genialen Konzept Aus Der Innenstadt - Das Ist Auch in Deutschland Möglich, Sagt Ein Experte," 6 1 2020. [Online]. Available: <https://www.businessinsider.de/wirtschaft/barcelona-verbannt-autos-mit-einem-genialen-konzept-aus-der-innenstadt-das-ist-auch-in-deutschland-moeglich-sagt-ein-experte/>. [Accessed 22 4 2020].

[119] C. Zografos, K. A. Klause, J. J. T. Connolly and I. Anguelovski, "The Everyday Politics of Urban Transformational Adaptation: Struggles for Authority and the Barcelona Superblock Project," Cities, vol. 99, p. 102613, 2020.

[120] Ajuntament de Barcelona, Presentació Final Actuacions i Seguiment Superilla, Barcelona, 2019.

[121] D. Roberts, "Barcelona's Remarkable History of Rebirth and Transformation," 8 4 2019. [Online]. Available: <https://www.vox.com/energy-and-environment/2019/4/8/18266760/barcelona-spain-urban-planning-history>. [Accessed 22 4 2020].

[122] Changing Cities, "Bergmannkiez wird erster „Superblock“

Berlins," 31 10 2019. [Online]. Available: <https://changing-cities.org/aktuelles/bergmannkiez-wird-erster-superblock-berlins/>. [Accessed 22 4 2020].

[123] A. Schmitt, "Seattle May Try to Replicate Barcelona's 'Superblocks'," 6 9 2019. [Online]. Available: <https://usa.streetsblog.org/2019/09/06/seattle-may-try-to-replicate-barcelonas-superblocks/>. [Accessed 22 4 2020].

[124] BCNecologia, "The Superblocks of Gràcia (Barcelona), Designed by BCNecologia, Win the BMW Initiative Award 2011," 8 11 2011. [Online]. Available: <http://www.bcnecologia.net/en/press/superblocks-gracia-barcelona-designed-bcnecologia-win-bmw-initiative-award-2011>. [Accessed 22 4 2020].

[125] DomagkPark, "Home - DomagkPark," [Online]. Available: <https://www.domagkpark.de/>. [Accessed 22 4 2020].

[126] European Environment Agency, "Air quality in Europe – 2019 report," 2019.

[127] City of Munich, SWM, "www.muenchen.de," 2019. [Online]. Available: https://www.muenchen.de/rathaus/Stadtverwaltung/Referat-fuer-Gesundheit-und-Umwelt/Luft_und_Strahlung/FAQ_Luftreinhaltung.html. [Accessed 2020].

[128] Gerstenberger and L. M. Gerhard, "Masterplan zur Luftreinhaltung für die Landeshaupt in München," Munich, 2018.

[129] Statistisches Amt München, "Die Immissionsmessergebnisse nach Monaten 2018," Munich, 2018.

[130] Ajuntament de Barcelona, "Programa de mesures contra la contaminació de l'aire," 2017.

[131] CreaFutur, "CITIZENS AND MOBILITY IN BARCELONA," 2017. [Online]. Available: <https://www.creafutur.com/estudios-blog/2017/6/14/ciudadanos-movilidad-barcelona>. [Accessed 2020].

[132] B. C. Council, "Sharing: regulation proposal," Barcelona City Council, Barcelona, 2018.

[133] CARNET, Interviewee, Project Manager. [Interview]. 10 March 2020.

[134] SEAT, "Mobile World Congress," SEAT, 25 Feb 2019. [Online]. Available: <https://www.seat.com/company/news/cars/seat-minimo-mwc.html>. [Accessed 05 April 2020].

[135] SEAT, "Respiro," SEAT, 16 July 2019. [Online]. Available:

References: Barcelona

<https://www.seat-mediacycenter.com/newspage/allnews/company/2019/>

SEAT-will-roll-out-a-corporate-carsharing-service-and-presents-its-vision-for-urban-mobility-in-Madrid.html. [Accessed 05 April 2020].

[136] B. C. Council, "study of the shared vehicle in Barcelona: analysis," Urbaning , Barcelona, 2017.

[137] Ajuntament de Barcelona, "Departament d'Estadística i Difusió de Dades," [Online]. Available: <https://www.bcn.cat/estadistica/castella/index.htm>. [Accessed 22 04 2020].

[138] Ajuntament de Barcelona, "Councillor's Office for Mobility," [Online]. Available: <https://www.barcelona.cat/mobilitat/en/about-us/organisation>. [Accessed 22 04 2020].

[139] Ajuntament de Barcelona, "Barcelona Universities," [Online]. Available: <https://meet.barcelona.cat/en/study-and-research/studying-barcelona/barcelona-universities>. [Accessed 22 04 2020].

List of Figures:

Figure 2.1: Modal Share (City of Barcelona)

Figure 2.2: Barcelona Region subdivisions

Figure 2.3: Public transport network in Barcelona (without buses) 2020 [19]

Figure 2.4: Modal Split of Barcelona based on data from 2017 [18]

Figure 2.5: Scooters from 3 different companies in Duration the city [10]

Figure 2.6: Motosharing scooters Parking slot (own photograph)

Figure 2.7: Motosharing parking infrastructure on pavement [34]

Figure 2.8: Barcelona public bus fleet evolution by fuel type [39]

Figure 2.9: Barcelona Taxi fleet evolution by fuel type [39]

Figure 2.10: Electric bus with opportunity charging in Barcelona [41]

Figure 2.11: Smou app for accessing free charging Network of Barcelona [43]

Figure 2.12: Free parking site for electric vehicles in public charging network of Barcelona [44]

Figure 2.13: Free parking zone in Barcelona for electric vehicles [45]

Figure 2.14: Scheme of the orthogonal

Figure 2.15: grid of major streets considering the super block concept [47]

Figure 2.16: final network of the high-performance bus lines [54]

Figure 2.17: Bicibox container in public space [55]

Figure 2.18: Bicibox "garage" at a train station [56]

Figure 2.19: Bicibox in the ground floor of a residential building in Sant Joan Despí [59]

Figure 2.20: Bicing station in city center [Own photographs]

Figure 2.21: Computerized pylon for the users [Own photographs]

Figure 2.22: Redistributing the bikes from down parts to city upwards [own photograph]

Figure 2.23: CARNET ideas for a dynamic city [70]

Figure 2.24 Participatory event for the UMP [75]

Figure 2.25: Decidim online-platform [76]

Figure 2.26: Measures of the UMP 2013-2018 of the dimensions of mobility by foot (blue), bicycle

Figure 2.27: Space of pedestrian area in 2011 [47]

Figure 2.28: Aimed space of pedestrian area [47]

Figure 2.29: Change of traffic ways and conflicts due to the Superblock concept [47]

Figure 2.30: Illustration about the conflict of pedestrian space in urban areas by Karl Jilg

Figure 2.31: Illustration of an exemplary pedestrian area with high quality of stay [7] Superblock concept [47]

Figure 2.32: The speed limit of 30 km/h will be valid for the largest part of Barcelona [84] [85]

Figure 2.33: Safety for pedestrians and cyclists in Barcelona [86]

Figure 2.34: Model of structural intervention of the street design for traffic calming [92]

Figure 2.35: A road intersection was transformed into a square that invites to stay in Sant Antoni [85]

Figure 2.36: Increasing green surface of the pacified streets in Sant Antoni [85]

Figure 2.37: A road intersection was transformed into a playground an area to stay on the benches

Figure: 2.38: Area under the Low Emmission Zone in 2020 AMB [102]

Figure 2.39: Expansion of Low Emmission Zone in 2024/25 with stricter norms AMB [102]

Figure 2.40: Communication campaign for the LEZ. Source: AMB [102]

Figure 2.41: Strategic objectives with sub goals of the UMP 2006-2012 [own illustration based on UMP 2006-2012]

Figure 2.42: Assessment of the achievement of the objective Sustainable Mobility by individual indicators [illustration from UMP 2013-2018 modified by the author]

Figure 2.43: Degree of achievement of strategic objectives from UMP 2006-2012 [own illustration based on UMP 2013-2018]

Figure 2.44: Assessment of habitability of public space [illustration from UMP 2013-2018 modified by the author]

Figure 2.45: Example for the improvement of the habitability of public space by the habitability index [illustration from UMP 2013-2018 modified by the author]

Figure 2.46: Climate Plan Barcelona (2018 - 2022)

Figure 2.48: Indicators relating to mobility of the Citizens Commitment for Sustainable Mobility [own illustration based on the Indicadors de Sostonibilitat de Barcelona Informe 2018]

Figure 2.47: Citizens Commitment for Sustainability (2012-2022)

Figure 2.49: Transition of the traffic flow in a Superblock [25]

Figure 2.50 :Step-by-Step plan of the Superblock implementation colored by legislation periods [114] (own translation)

Figure 2.51: Life in the Superblock of Poblenou on a regular afternoon [85]

Figure 2.52: Tactical Urbanism (left) and Structural Urbanism (right) in Superblocks in Barcelona [120]

Figure 2.53: Modelled NOx Immission over Barcelona in 2017 Source [102]

Figure 2.54: Modelled NOx Immission over Munich in 2015 Source [128]

Figure 2.55: NOx measured at most polluting sites and their corresponding population

Figure 2.56: Distribution of vehicle Euro classes amongst Barcelona and Munich Data: ([38], [128]) Graph: Own

Figure 2.57: Modelled reduction in air pollution with implementation of Low emmission zone Source [103]

Figure 2.58: Modelled NOx concentration after complete implementation of Superblocks in B as compared to 2017 in A Source: [24]

Figure 2.59: Shared Mobility services types in Barcelona [132]

Figure 2.60: SEAT Minimo carsharing model [134]

Figure 2.61: Respiro Carsharing in Madrid [135]

Figure 2.62: Motorbikes in Barcelona [34]

Figure 2.63: Motosharing coverage area in Barcelona [136]

Figure 2.64: Current Viable coverage area of bike-sharing [132]

List of Abbreviations:

UMP – Urban Mobility Plan

List of Tables:

Table 2.1: Passenger and infrastructure data of public transport in Barcelona (2017) [18]

References: Tallinn and Helsinki

- [1] J. Ainsula, E. Den Ouden and R. Valkenburg, “AMBITION, VISION & ROADMAP SMART MOBILITY TALLINN,” 12.09.2017. [Online]. Available: http://roadmapsforenergy.eu/wp-content/uploads/2017/final_city_reports/20170912_D6.4_Final_City_Report_Smart_Mobility_Tallinn.pdf. [Accessed 14. 04. 2020].
- [2] T. C. E. Department, “Facts about Tallinn 2019,” 19. 09. 2019. [Online]. Available: <https://www.tallinn.ee/eng/clustersinestonia/Uudis-Facts-about-Tallinn-2019>. [Accessed 23.03.2020].
- [3] T. T. I. Centre, “Map of Tallinn,” 2020. [Online]. Available: https://mediabank.visittallinn.ee/static/files/045/kaart_a3_2019.pdf. [Accessed 13.02.2020].
- [4] C. o. Tallinn, “About Tallinn city administration,” 21. 11. 2019. [Online]. Available: <https://www.tallinn.ee/About-Tallinn-city-administration>. [Accessed 14.04.2020].
- [5] T. E. DEPARTMENT, “FACTS ABOUT TALLINN 2018,” 05. 09. 2019. [Online]. Available: <https://www.tallinn.ee/eng/Uudis-Facts-about-Tallinn-2018-2>. [Accessed 03.03.2020].
- [6] S. Estonia, “Passenger transport by road and rail increased over the year,” 09.03. 2020. [Online]. Available: <https://www.stat.ee/news-release-2020-027>. [Accessed 23.03.2020].
- [7] T. T. I. Centre, “Public transport in Tallinn,” 2020. [Online]. Available: https://www.visittallinn.ee/static/files/098/tallinn_transport_2019_eng.pdf. [Accessed 03.03.2020].
- [8] C. o. Tallinn, “Local Transport - Tallinn,” 2013. [Online]. Available: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwirvfy97DoAhWEyqQKHdViDdQQFjAAegQIBRAB&url=https%3A%2F%2Fwww.tallinn.ee%2Fest%2FIndicator-2_Transport_Tallinn&usq=AOvVaw0VzrKMIQRc-PrHE2MaF5-W. [Accessed 06.03.2020].
- [9] C. Cavoli, “CREATE - City Report Tallinn, Estonia; Past, Present and Future mobility challenges and opportunities in Tallinn,” UCL Centre for

Transport Studies, Tallinn, 2017.

- [10] J.-W. Van Der Pas and J. Tuisk, “ELMO: Estonia’s innovative national quick-charging EV network,” 31. 08. 2015. [Online]. Available: <https://www.eltis.org/discover/case-studies/elmo-estonia-innovative-national-quick-charging-ev-network>. [Accessed 08. 04. 2020].
- [11] H. Mullarkey and E. O’Connell, “CIVITAS MIMOSA,” [Online]. Available: <https://civitas.eu/sites/default/files/civitasmimosacitybrochure.pdf>. [Accessed 12. 03. 2020].
- [12] K. Vancluysen, “POLIS - CITIES AND REGIONS FOR TRANSPORT INNOVATION,” 10.10.2019. [Online]. Available: https://www.polisnetwork.eu/wp-content/uploads/2019/10/POLIS_Brochure2019-web-30y.pdf. [Accessed 03. 03. 2020].
- [13] P. Jones, “Urban Mobility: Preparing for the Future, Learning from the Past,” 2018. [Online]. Available: <http://nws.eurocities.eu/MediaShell/media/CREATE-ProjectSummaryRecommendations.pdf>. [Accessed 23. 03. 2020].
- [14] A. Leisner, “Innovative cities - Before and after CIVITAS,” 2013. [Online]. Available: <https://civitas.eu/sites/default/files/civitasmimosacitybrochure.pdf>. [Accessed 05. 04. 2020].
- [15] C. P. D. o. Helsinki, “Urban plan - the new Helsinki city plan Vision 2050,” 2013. [Online]. Available: https://www.hel.fi/hel2/ksv/julkaisut/yos_2013-23_en.pdf. [Accessed 14. 04. 2020].
- [16] A. Jaakola, T. Vass, S. Saarto and L. Haglung, Helsinki facts and figures 2019, Helsinki: Helsinki City Executive Office, Urban Research and Statistics, 2019.
- [17] A. C. City of Helsinki, “City of Helsinki,” [Online]. Available: https://www.hel.fi/hel2/kanslia/guggenheim/helsinki_an_overview.pdf. [Accessed 21 03 2020].
- [18] C. o. Helsinki, “Helsinki City Organization,” 06. 12. 2019. [Online]. Available: <https://www.hel.fi/helsinki/en/administration/administration/organization>. [Accessed 14. 04. 2020].
- [19] O. S. o. F. (. C. p. i. [e-publication]., “Helsinki: Statistics Finland,” ISSN=1799-0254. [Online]. Available: <https://www.stat.fi/til/khi/>

index_en.html. [Accessed 21 03 2020].

- [20] T. Henriksson, “Helsinki Region Statistics,” 12 02 2020. [Online]. Available: <https://www.helsinki.fi/hs/en/city-information/>. [Accessed 21 03 2020].
- [21] R. Rautava and e. al., “HSL Helsinki Region Transport,” Annual Report 2017. [Online]. Available: <https://annualreport.hsl.fi>. [Accessed 21 03 2020].
- [22] H. H. r. Transport, “HSL HRT Season Ticket,” 2020. [Online]. Available: <https://www.hsl.fi/en/tickets/season-tickets?zoneSelectorValue=abcd&zones=abcd>. [Accessed 21 03 2020].
- [23] y. broadcasting, “Commuting 100-plus km for work part of daily life for thousands in Finland,” 28 03 2018. [Online]. Available: https://yle.fi/uutiset/osasto/news/commuting_100-plus_km_for_work_part_of_daily_life_for_thousands_in_finland/10137093. [Accessed 12 03 2020].
- [24] E. Mikkela and J. Keva, “Commuting is common in professional occupations,” 01 11 2019. [Online]. Available: http://www.stat.fi/til/tyokay/2017/04/tyokay_2017_04_2019-11-01_tie_001_en.html. [Accessed 02 02 2020].
- [25] S. Dixon, “Deloitte City Mobility Index,” 2019. [Online]. Available: <https://www2.deloitte.com/us/en/insights/focus/future-of-mobility/deloitte-urban-mobility-index-for-cities.html>. [Accessed 13 03 2020].
- [26] b. yle, “Number of cars growing more rapidly than population,” 07 07 2019. [Online]. Available: https://yle.fi/uutiset/osasto/news/number_of_cars_growing_more_rapidly_than_population/10866214. [Accessed 14 03 2020].
- [27] S. Dixon, H. Irshad and J. Vähäkylä, “Deloitte City Mobility Index - Helsinki,” 2019. [Online]. Available: https://www2.deloitte.com/content/dam/insights/us/articles/4331_Deloitte-City-Mobility-Index/city-mobility-index_HELSINKI_FINAL.pdf. [Accessed 05 04. 2020].
- [28] M. Viitanen, “mySMARTLife activities in Helsinki,” mySMARTLife Helsinki Lighthouse Lead <https://mysmartlife.eu/cities/>. [Online]. Available: <https://mysmartlife.eu/cities/helsinki/>. [Accessed 11 03 2020].
- [29] F. T. a. C. Agency, “Electric passenger cars in traffic use,” 21. 01. 2020. [Online]. Available: http://www.aut.fi/en/statistics/long-term_statistics/number_of_electric_vehicles. [Accessed 08. 04. 2020].

- [30] Chargemap, “Charging stations in Helsinki,” 2020. [Online]. Available: <https://chargemap.com/cities/helsinki-fi>. [Accessed 04. 04. 2020].
- [31] H. R. T. HSL, “Timetables and routes,” 2020. [Online]. Available: <https://www.hsl.fi/en/timetables-and-routes/routemaps>. [Accessed 27 02 2020].
- [32] b. yle, “Survey: Helsinki commuters lose eight working days a year sitting in traffic,” 31. 03. 2015. [Online]. Available: https://yle.fi/uutiset/osasto/news/survey_helsinki_commuters_lose_eight_working_days_a_year_sitting_in_traffic/7900522. [Accessed 03. 03. 2020].
- [33] C. o. Helsinki, “Factors affecting air quality,” 06. 12. 2019. [Online]. Available: <https://www.hel.fi/helsinki/en/housing/environmental/air-noise/factors-air/>. [Accessed 03. 03. 2020].
- [34] C. o. Helsinki, “Congestion charges are the best way to improve air quality in Helsinki,” 16. 01. 2017. [Online]. Available: <https://hel.fi/uutiset/en/helsinki/congestion-charges>. [Accessed 03. 03. 2020].
- [35] S. Sahala, “MOBILITY URBAN VALUES – MUV,” 10 2018. [Online]. Available: <https://forumvirium.fi/en/the-mobility-urban-values-muv/>; <https://www.muv2020.eu>. [Accessed 22 03 2020].
- [36] R. Martijnse-Hartikka, “FABULOS BRINGS SELF-DRIVING BUSES TO THE STREETS OF EUROPE,” 27 03 2018. [Online]. Available: <https://forumvirium.fi/en/fabulos-brings-self-driving-buses-to-the-streets-of-europe-2/>; <https://fabulos.eu>. [Accessed 23 02 2020].
- [37] J. Honkonen, “SOHJOA BALTIC – ROBOT BUSES TO AID SMART PUBLIC TRANSPORT,” 26. 06. 2018. [Online]. Available: <https://forumvirium.fi/en/sohjoa-baltic-robot-buses-to-aid-smart-public-transport/>. [Accessed 04. 02. 2020].
- [38] P. Haapalainen and A. Mäkinen, “Interreg Europe - Finland,” 2020. [Online]. Available: <https://www.interregeurope.eu/in-my-country/finland/>. [Accessed 22. 03. 2020].
- [39] R. Ritvos, “FINEST SMART MOBILITY – SMART MOBILITY IN TWO COUNTRIES,” 16. 02. 2017. [Online]. Available: <https://forumvirium.fi/en/finest-smart-mobility/>. [Accessed 03. 03. 2020].
- [40] R. C. o. S. Finland, “Interreg Central Baltic,” 2020. [Online]. Available: <https://centralbaltic.eu>. [Accessed 03. 03. 2020].
- [41] F. V. Helsinki, “PROJECTS,” 2020. [Online]. Available: <https://forumvirium.fi/en/projects/>. [Accessed 03. 03. 2020].

References: Tallinn and Helsinki

- [42] R. R. AS, "Rail Baltic - Future direct," 2017. [Online]. Available: http://www.railbaltica.org/wp-content/uploads/2017/04/R_B_buklets_21x21.pdf. [Accessed 22. 02. 2020].
- [43] Mitnija, "Connecting Europe: building for Rail Baltica in Lithuania," 2020. [Online]. Available: <https://mitnija.lt/en/project/connecting-europe-building-for-rail-baltica-in-lithuania/>. [Accessed 24. 03. 2020].
- [44] U. Tapaninen and K.-M. Halla, "FinEst-Link project," 2020. [Online]. Available: <http://www.finestlink.fi/en/>. [Accessed 04. 03. 2020].
- [45] M. Vikman-Kanerva, "FinEst Link Feasibility Study – Final report," 07. 02. 2018. [Online]. Available: <http://www.finestlink.fi/wp-content/uploads/2018/02/FinEst-link-REPORT-FINAL-7.2.2018.pdf>. [Accessed 24. 03. 2020].
- [46] C. Nauwelaers, K. Maguire and G. Ajmone Marsan, "The Case of Helsinki-Tallinn (Finland-Estonia) – Regions and Innovation: Collaborating Across Borders," 2013. [Online]. Available: <http://dx.doi.org/10.1787/5k3xv0lr1r6-en>. [Accessed 03. 03. 2020].
- [47] [Online]. Available: https://en.wikipedia.org/wiki/Starship_Technologies. [Accessed 5 April 2020].
- [48] [Online]. Available: <https://news.postimees.ee/6468671/robots-to-deliver-food-in-mustamae>.
- [49] Estonia.ee, "Estonian delivery robots are transforming the world," [Online]. Available: <https://estonia.ee/delivery-robots-created-by-estonian-engineers-are-transforming-the-world/>.
- [50] engadget, "Estonia is first in the EU to let cute delivery bots on sidewalks," [Online]. Available: <https://www.engadget.com/2017-06-15-estonia-welcomes-delivery-robots-to-sidewalks.html>.
- [51] LedderTech, "Autonomous Shuttles," [Online]. Available: <https://leddartech.com/market/autonomous-shuttles/>. [Accessed 2 4 2020].
- [52] Forum Virium Helsinki, "Ride a robot bus to the beach in Helsinki, one of the world's most active test cities for robot buses," 2019. [Online]. Available: <https://forumvirium.fi/en/robotbus2019/>. [Accessed 2 4 2020].
- [53] Forum Virium Helsinki, "FABULOS brings self-driving buses to the streets of Europe - Forum Virium Helsinki," 2018. [Online]. Available:

- <https://forumvirium.fi/en/fabulos-brings-self-driving-buses-to-the-streets-of-europe/>. [Accessed 3 4 2020].
- [54] Interreg Baltic Sea Region: Sohjoa Baltic Project, "Sohjoa Baltic - Eco-friendly public transport in Baltic Sea Region," [Online]. Available: <https://www.sohjoabaltic.eu/>. [Accessed 2 4 2020].
- [55] NAVYA : Autonom Shuttle, "Autonomous shuttle," [Online]. Available: <https://navya.tech/en/autonom-shuttle/>. [Accessed 2 4 2020].
- [56] Iseauto, Interviewee, Autonomous Shuttle Buses. [Interview]. 14 February 2020.
- [57] Forum Virium Helsinki, "A wider service area for mass transit with the help of autonomous buses," 2019. [Online]. Available: <https://forumvirium.fi/en/a-wider-service-area-for-mass-transit-with-the-help-of-autonomous-buses/>. [Accessed 2 4 2020].
- [58] City of Helsinki, "Self-driving bus on Helsinki RobobusLine goes to scheduled service," [Online]. Available: <https://www.hel.fi/uutiset/en/helsinki/robobus-line-goes-to-scheduled-service>. [Accessed 3 4 2020].
- [59] Metropolia University of Applied Sciences, "Smart Mobility," [Online]. Available: <https://www.metropolia.fi/en/rdi/innovation-hubs/smart-mobility>. [Accessed 2 4 2020].
- [60] City of Helsinki Innovation Office, Interviewee, Forum Virium Helsinki. [Interview]. 21 February 2020.
- [61] Metropolia University of Applied Sciences, Interviewee, Autonomous Shuttle Bus Projects in Helsinki. [Interview]. 24 February 2020.
- [62] City of Helsinki: Jätkäsaari Mobility Lab, Interviewee, Jätkäsaari Mobility Lab. [Interview]. 21 February 2020.
- [63] Tallinn University of Technology, Interviewee, Sohjoa Baltic Project. [Interview]. 14 February 2020.
- [64] Ministry of Economic Affairs and Communications, Transportation and Traffic Division, Interviewee, Mobility in Tallinn. [Interview]. 12 February 2020.
- [65] Internationales Verkehrswesen, "ITF Study: Shared Mobility Simulations for Helsinki," 2017. [Online]. Available: <https://www.internationales-verkehrswesen.de/shared-mobility-simulations-helsinki/>. [Accessed 3 4 2020].

- [helsinki/](https://commons.wikimedia.org/wiki/File:Bolt_TAKSO_-_Opel_Zafira.JPG). [Accessed 3 4 2020].
- [66] Münchner Verkehrsgesellschaft mbH, "EASYRIDE Zukunft erfahren," [Online]. Available: <https://www.mvg.de/ueber/mvg-projekte/bus/hochautomatisiertes-fahren.html>. [Accessed 3 4 2020].
- [67] Autonomous Intelligent Driving, "AID," [Online]. Available: <https://aid-driving.eu/>. [Accessed 3 4 2020].
- [68] BMW Group, "Autonomous Driving Campus," [Online]. Available: <https://www.bmwgroup.com/en/innovation/technologies-and-mobility/autonomes-fahren/campus.html>. [Accessed 3 4 2020].
- [69] Siemens Mobility GmbH, "Siemens campus in Munich-Perlach to field-test autonomous driving," [Online]. Available: <https://press.siemens.com/global/en/pressrelease/siemens-campus-munich-perlach-field-test-autonomous-driving>. [Accessed 3 4 2020].
- [70] Chelsie May, "All Roads Lead to...Germany? Meet the New Autonomous Driving Hub," 2019. [Online]. Available: <https://medium.com/hackernoon/all-roads-lead-to-germany-meet-the-new-autonomous-driving-hub-ce59ed5d34d9>. [Accessed 3 4 2020].
- [71] Deloitte Analytics Institute, "Autonomous driving in Germany- how to convince customers," 2017.
- [72] Traffic Management Finland, Interviewee, Traffic Management Systems. [Interview]. 24 February 2020.
- [73] Eltis, "Public transport priority system in Tallinn/Estonia," [Online]. Available: <https://www.eltis.org/discover/case-studies/public-transport-priority-system-tallinnestonia>. [Accessed 3 4 2020].
- [74] Traffic Management Finland, "Intelligent Traffic Management Finland - Safe and Fluent Traffic," [Online]. Available: <https://tmfg.fi/en/itm>. [Accessed 3 4 2020].
- [75] ERR, ERR News | ERR, "Tallinn implements new traffic light management system, disruption expected," 2020. [Online]. Available: <https://news.err.ee/1029432/tallinn-implements-new-traffic-light-management-system-disruption-expected>. [Accessed 2 4 2020].
- [76] Traffic Management Finland, "Traffic Situation," [Online]. Available: <https://liikennetilanne.tmf.fi/>. [Accessed 3 4 2020].
- [77] Transport Department of Tallinn City, Tallinna Transpordiamet, Interviewee, Mobility in Tallinn. [Interview]. 20 February 2020.
- [78] P. Domain, "Bolt TAKSO - Opel Zafira," 26. 08. 2019. [Online]. Available: https://commons.wikimedia.org/wiki/File:Bolt_TAKSO_-_Opel_Zafira.JPG. [Accessed 04. 06. 2020].

- [79] D. G. Artist, Taxi in Tallinn, Estonia. [Art]. 2016.
- [80] B. Hunter, "Ülemiste Centre (CC BY-SA 3.0)," September 2019. [Online]. Available: https://en.m.wikipedia.org/wiki/Ülemiste_Centre#/media/File:3AÜlemiste_center.jpg. [Accessed 04. 06. 2020].
- [81] L. Moroz, Artist, Vaade Ülemiste keskuse parklast Peterburi tee poole. [Art]. 2019.
- [82] M. Ülemiste, "A unique artificial intelligence system now directs Ülemiste City drivers to available parking spots," [Online]. Available: <https://www.mainorulemiste.ee/news/a-unique-artificial-intelligence-system-now-directs-ulemiste-city-drivers-to-available-parking-spots>. [Accessed 3 April 2020].
- [83] "HSL Website," [Online]. Available: <http://www.hsl.fi>.
- [84] City of Helsinki Public Works Department, "Parking in Helsinki," [Online]. Available: https://www.hel.fi/static/hkr/julkaisut/sujuvaa_pysakointia_en_web.pdf. [Accessed April 2020].
- [85] "HSL Park & Ride API," [Online]. Available: <https://github.com/HSLdevcom/parkandrideAPI>.
- [86] "Car Parking Europe," [Online]. Available: <https://www.car-parking.eu/germany/munich/pr>. [Accessed April 2020].
- [87] MaaS Alliance, "Guidelines and Recommendations to Create the Foundations for a Thriving MaaS Ecosystem," 04 September 2017. [Online]. Available: https://maas-alliance.eu/wp-content/uploads/sites/7/2017/09/MaaS-WhitePaper_final_040917-2.pdf. [Accessed April 2020].
- [88] W. L. M. M. Maria Kamargianni, "A Comprehensive Review of "Mobility as a Service" Systems," in 6th Transport Research Arena (TRA2016), Warsaw, 2016.
- [89] MaaS Global, "Whim Website," [Online]. Available: <https://whimapp.com/>.
- [90] "Finland Open Data Law," [Online]. Available: <https://travelspirit.foundation/resources/cities-for-open-mobility-helsinki-the-open-data-law/>.
- [91] J.-P. P. Ari Hartikainen, "Whim: Insights from the world's first Mobility-as-a-Service (MaaS) system," Ramboll, Copenhagen, 2019.

References: Tallinn and Helsinki

[92] Valdani Vicari & Associati, "MaaS Alliance," June 2019. [Online].

Available: [https://maas-alliance.eu/wp-content/uploads/sites/7/2019/07/](https://maas-alliance.eu/wp-content/uploads/sites/7/2019/07/Market-access-and-competition-issues-related-to-MaaS_final_040719.pdf)

Market-access-and-competition-issues-related-to-

MaaS_final_040719.pdf. [Accessed April 2020].

[93] "Helsinki Region Infoshare Website," [Online]. Available: [http://](http://www.hri.fi)

www.hri.fi.

[94] "Forum Virium Website," [Online]. Available: [http://](http://www.forumvirium.fi)

www.forumvirium.fi.

[95] V. Aula, "Institutions, infrastructures, and data friction - Reforming

secondary use of health data in Finland," *Big Data & Society*, pp. 1-13,

2019.

[96] EU projects database: Interreg Projects, "Creation of the

interoperability between the electronic ticketing systems in Estonia and

Finland," [Online]. Available: [https://www.keep.eu/project/19924/](https://www.keep.eu/project/19924/creation-of-the-interoperability-between-the-electronic-ticketing-systems-in-estonia-and-finland)

creation-of-the-interoperability-between-the-electronic-ticketing-

systems-in-estonia-and-finland. [Accessed 3 4 2020].

[97] Eltis: Francesco Ripa, "Tallinn and Helsinki to harmonise their

public transport networks," 2019. [Online]. Available: [https://](https://www.eltis.org/in-brief/news/tallinn-and-helsinki-harmonise-their-public-transport-networks)

www.eltis.org/in-brief/news/tallinn-and-helsinki-harmonise-their-public-

transport-networks. [Accessed 3 4 2020].

[98] Central Baltic Programme, Interviewee, Helsinki&Tallinn e-ticketing

project. [Interview]. 17 February 2020.

[99] Err, Err I., "Tallinn, Tartu transport apps can be used in Helsinki

from spring," 2019. [Online]. Available: [https://news.err.ee/992339/](https://news.err.ee/992339/tallinn-tartu-transport-apps-can-be-used-in-helsinki-from-spring)

tallinn-tartu-transport-apps-can-be-used-in-helsinki-from-spring.

[Accessed 3 4 2020].

[100] E. A. o. S. Sciences, "Public Transportation in Tallinn," [Online].

Available: <https://www.sisekaitse.ee/en/transportation>. [Accessed 3 April

2020].

[101] S. video, "Shutterstock," [Online]. Available: [https://](https://www.shutterstock.com/video/clip-1035198257-helsinki-finland---july-28-2019-man)

www.shutterstock.com/video/clip-1035198257-helsinki-finland---july-28-

2019-man. [Accessed 03 April 2020].

[102] City of Helsinki: Finest Smart Mobility, Interviewee, Finest Smart

Mobility. [Interview]. 20 February 2020.

[103] Err, Err I., "Cooperation deal fails between Tallinn, Helsinki

transport ticket project," 2020. [Online]. Available: [https://news.err.ee/](https://news.err.ee/1031622/cooperation-deal-fails-between-tallinn-helsinki-transport-ticket-project)

1031622/cooperation-deal-fails-between-tallinn-helsinki-transport-ticket-

project. [Accessed 3 4 2020].

[104] Central Baltic Project Database, "Creation of the interoperability

between the electronic ticketing systems in Estonia and Finland,"

[Online]. Available: <http://database.centralbaltic.eu/project/91>.

[Accessed 2 4 2020].

[105] Climate Action Tracker, "Germany," [Online]. Available: [https://](https://climateactiontracker.org/countries/germany/)

climateactiontracker.org/countries/germany/. [Accessed 3 4 2020]

[106] Rail Baltica, "Project of the Century," [Online]. Available: [http://](http://www.railbaltica.org/about-rail-baltica/)

www.railbaltica.org/about-rail-baltica/. [Accessed 3 4 2020].

[107] Wikipedia, "Helsinki–Tallinn Tunnel," [Online]. Available: [https://](https://en.wikipedia.org/wiki/Helsinki%E2%80%93Tallinn_Tunnel)

en.wikipedia.org/wiki/Helsinki%E2%80%93Tallinn_Tunnel. [Accessed 3

4 2020].

[108] Finest Smart Mobility, "FinEst Smart Mobility," [Online]. Available:

https://twitter.com/finest_smart/status/1116290492742946817.

[Accessed 3 4 2020].

[109] P. Domain, "Ticket for public transport in Tallinn," 04. 12. 2012.

[Online]. Available: [https://commons.wikimedia.org/wiki/](https://commons.wikimedia.org/wiki/File:Ticket_for_public_transport_in_Tallinn.JPG)

File:Ticket_for_public_transport_in_Tallinn.JPG.[Accessed 06.04. 2020].

[110] -j.-. (. B.-S. 3.0), Artist, Bus no 18 at bus stop, Tallinn, Estonia

Scania CL94UA bus, year built 2006. TAK Tallinn company.. [Art]. 2006.

[111] J. Ainsalu, V. Arffman, M. Bellone, M. Ellner, T.

Haapamäki, N. Haavisto, E. Josefson, A. Ismailogullari,

B. Lee, O. Madland, R. Madžulis, J. Müür, S. Mäkinen, V.

Nousiainen, E. Pilli-Sihvola, E. Rutanen, S. Sahala, B. Schönfeldt, P. M.

Smolnicki, R.-M. Soe, J. Sääski, M. Szymańska, I. Vaskinn and M.

Åman, "Sustainability 2018 Review: State of the Art of Automated

Buses," no. 10, 2018.

[112] United Nations: Department of Economic and Social Affairs, "68%

of the world population projected to live in urban areas by 2050, says

UN," 2018. [Online]. Available: [https://www.un.org/development/desa/en/](https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html)

news/population/2018-revision-of-world-urbanization-prospects.html.

[Accessed 31 3 2020].

[113] R. Knight, "Autonomous Shuttles: Rolling Toward Efficiency," 2020.

[Online]. Available: [https://insideunmannedsystems.com/autonomous-](https://insideunmannedsystems.com/autonomous-shuttles-rolling-toward-efficiency/)

shuttles-rolling-toward-efficiency/. [Accessed 31 3 2020].

[114] LedderTech, "Autonomous Shuttles," LedderTech, [Online].

Available:<https://leddartech.com/market/autonomous-shuttles/>.

[Accessed 31 3 2020].

[115] EU Commission, "A European Strategy for Low-Emission Mobility;

Technical Report," 2016.

[116] M. B. News, "What is an autonomous vehicle? Definition and

meaning," [Online]. Available: [https://marketbusinessnews.com/financial-](https://marketbusinessnews.com/financial-glossary/autonomous-vehicle/)

glossary/autonomous-vehicle/. [Accessed 31 3 2020].

[117] Wikipedia, "Self-driving car," [Online]. Available: [https://](https://en.wikipedia.org/wiki/Self-driving_car)

en.wikipedia.org/wiki/Self-driving_car. [Accessed 31 3 2020].

[118] Bloomberg Philanthropies, The Aspen Institute, "Initiative on Cities

and Autonomous Vehicles," [Online]. Available: [https://](https://avscities.bloomberg.org/)

avscities.bloomberg.org/. [Accessed 31 3 2020].

[119] Carbon Neutral Cities Alliance, "Helsinki – Finland," [Online].

Available: <https://carbonneutralcities.org/cities/helsinki/>. [Accessed 31 3

2020].

[120] C. Velazco, "Estonia is first in the EU to let cute delivery bots on

sidewalks," 2020. [Online]. Available: [https://www.engadget.com/2017-](https://www.engadget.com/2017-06-15-estonia-welcomes-delivery-robots-to-sidewalks.html?guccounter=1)

06-15-estonia-welcomes-delivery-robots-to-

sidewalks.html?guccounter=1. [Accessed 31 3 2020].

[121] S. Technologies, "Starship," [Online]. Available: [http://](http://www.starship.xyz)

www.starship.xyz. [Accessed 31 March 2020].

[122] S. Baltic, "Sohjoa Baltic Project," [Online]. Available: [https://](https://projects.interreg-baltic.eu/projects/sohjoa-baltic-111.html)

projects.interreg-baltic.eu/projects/sohjoa-baltic-111.html. [Accessed 31

3 2020].

[123] Mauro Bellone, "How to bring self-driving buses to the streets of

Europe? The Sohjoa Baltic Project".

[124] A. Salonen and N. Haavisto, "Towards Autonomous Transportation.

Passengers' Experiences, Perceptions and Feelings in a Driverless

Shuttle Bus in Finland," *Sustainability*, vol. 11, no. 3, p. 588, 2019.

[125] Forum Virium Helsinki, "FABULOS brings self-driving buses to the

streets of Europe," 2018. [Online]. Available: [https://forumvirium.fi/en/](https://forumvirium.fi/en/fabulos-brings-self-driving-buses-to-the-streets-of-europe/)

fabulos-brings-self-driving-buses-to-the-streets-of-europe/. [Accessed 31

3 2020].

[126] F. A. B. U. L. O. S. FABULOS, "FABULOS," [Online]. Available:

<http://fabulos.eu>. [Accessed 3rd April 2020].

[127] S. Baltic, "Sohjoa Baltic - Eco-friendly public transport in Baltic Sea

Region," [Online]. Available: <https://www.sohjoabaltic.eu/>. [Accessed 31

3 2020].

[128] R. mvg.de, "EASYSRIDE Zukunft erfahren | Münchner

Verkehrsgesellschaft mbH," [Online]. Available: [https://www.mvg.de/](https://www.mvg.de/ueber/mvg-projekte/bus/hochautomatisiertes-fahren.html)

ueber/mvg-projekte/bus/hochautomatisiertes-fahren.html. [Accessed 31

3 2020].

[129] Metropolia university of applied sciences, "Smart Mobility," [Online].

Available:[https://www.metropolia.fi/en/rdi/innovation-hubs/smart-](https://www.metropolia.fi/en/rdi/innovation-hubs/smart-mobility)

mobility. [Accessed 2 4 2020].

[130] Catapult Transport Systems, "Mobility as a Service: Exploration the

Opportunity for Mobility as a Service in the UK," Catapult Transport

Systems, Milton Keynes, 2016.

[131] Anonymous, Interviewee, MaaS Global. [Interview]. 18 February

2020.

[132] Anonymous, Interviewee, Kyyti. [Interview]. 19 February 2020.

[133] Kyyti Group Ltd., "Kyyti Website," [Online]. Available: [https://](https://www.kyyti.com/)

www.kyyti.com/.

[134] "Perille Website," [Online]. Available: <http://www.perille.fi>.

[135] Anonymous, Interviewee, Perille. [Interview]. 20 February 2020.

[136] "MVG," [Online]. Available: [https://www.mvg.de/services/mobile-](https://www.mvg.de/services/mobile-services/fahrinfo.html)

services/fahrinfo.html. [Accessed February 2020].

[137] "Mobility Inside Website," [Online]. Available: [https://](https://www.mobilityinside.de/)

www.mobilityinside.de/.

[138] MVG Münchner Verkehrsgesellschaft mbH, "Neue Plattform für

geteilte Mobilität: MVG macht München zur Sharing-Metropole," [Online].

Available: [https://www.mvg.de/ueber/presse-print/pressemeldungen/](https://www.mvg.de/ueber/presse-print/pressemeldungen/2020/februar/2020-02-13-MVG-Share-Trafi.html)

2020/februar/2020-02-13-MVG-Share-Trafi.html.

References: Tallinn and Helsinki

[139] M. Jaekel, Smart City wird Realität, Springer Fachmedien, 2015.

[140] P. Neirotti, A. De Marco, A. Cagliano, G. Mangano and F. Scorrano, “Current trends in Smart City initiatives: Some stylised facts,” Cities, pp. 25-36, Juni 2014.

[141] “Ülemiste City,” [Online]. Available: <https://ulemistecity.ee/en/>. [Accessed 3 April 2020].

[142] S. Huston, A. Jadevicus, S. Şahin, W. Manley, S. Price, R. Baines, N. Minaei, K. Velibeyoglu, O. Mengi, R. Rahimzad, A. Parsa, M. Kozłowski, Y. MY, P. Lee, A. Kashyap, J. Berry and Sp, Smart urban regeneration: visions, institutions and mechanisms for real estate, Routledge Taylor and Francis, 2017.

[143] “Estonia is leading the way in smart city solutions,” invest in estonia, [Online]. Available: <https://investinestonia.com/estonia-is-leading-the-way-in-smart-city-solutions/>. [Accessed 3 April 2020]. [144]

Vision Mobility, “Autonomous driving: Munich tests e.GO Movers,” [Online].

[145] C. A. Tracker, “Germany | Climate Action Tracker,” [Online]. Available: <https://climateactiontracker.org/countries/germany/>. [Accessed 3 4 2020].

[146] T. Tehnikaülikool, “Iseauto starts passenger transport in Ülemiste City and at the airport,” [Online]. Available: <https://www.ttu.ee/iseauto-starts-passenger-transport-in-ulemiste-city-and-at-the-airport>. [Accessed 31 3 2020].

[147] R. Sell, A. Rassõlkin, R. Wang and T. Otto, “Integration of autonomous vehicles and Industry 4.0,” 2019. [Online].

[148] NAVYA, “Autonomous mobility solutions | NAVYA : autonomous & electric shuttles,” NAVYA : autonomous & electric shuttles, [Online]. Available: <https://navya.tech/en/>. [Accessed 31 3 2020].

[149] Forum Virium Helsinki, “Helsinki residents feel positive about robot buses,” 2019. [Online]. Available: <https://forumvirium.fi/en/voosaari-robotbus-2-2/>. [Accessed 2 4 2020].

[150] Future Automated Bus Urban Level Operation Systems, “FABULOS project,” [Online]. Available: <https://fabulos.eu/fabulos-project/>. [Accessed 2 4 2020].

[151] FEV Consulting, “Mobility as a Service: Framework and Whim Case Example,” Munich, 2020.

[152] L. H. S. H.-L. T. Z. Anne Durand, “Mobility-as-a-Service and Changes in Travel Preferences and Travel Behaviour: A Literature Review,” Ministry of Infrastructure and Water Management, The Hague, 2018.

[153] E. Wolfe, “Pitt pauses testing of Starship robots due to safety concerns,” The Pitt News, 21 October 2019. [Online]. Available: <https://pittnews.com/article/151679/news/pitt-pauses-testing-of-starship-robots-due-to-safety-concerns/>. [Accessed 12 April 2020].

List of Abbreviations

ADS - automated driving systems

AI - Artificial Intelligence

ANS Finland - Air Navigation Services Finland

API - application programming interface

BMW - Bayerische Motoren Werke

CHAdEMO standard - Charge de Move standard

Civitas MIMOSA - Civitas Making Innovation in Mobility and

Sustainable Actions

CREATE - Congestion Reduction in Europe: Advancing Transport

Efficiency

DB - Deutsche Bahn

ELMO - Estonian electro mobility programme

EU - European Union

EV - electric vehicle

FABULOS - Future Automated Bus Urban Level Operation System

FinEst - Finland Estonia

Forum Virium - City Innovation Office

GDP - Gross Domestic Product

GDPR - General Data Protection Regulation

HKL- Helsinki City Transport

HPTA - Helsinki Public Transport Agency

HSL - Helsingin Seudun Liikenne (Helsinki Public Transport Agency)

HRI - Helsinki Region InfoShare

HRT - Helsinki Region Transport

ICT - Information and communications technology

ITM - Intelligent Traffic Management

LED - Light emitting diode

MaaS - Mobility as a Service

MAN - Maschinenfabrik Augsburg Nürnberg

MUV - Mobility Urban Values

MVG -Münchner Verkehrsgesellschaft

OECD -Organisation for Economic Cooperation and Development

Oy - Osakeyhtiö (stock company)

P&R - Park&Ride

RFID - Radio frequency identification

SUMP - Sustainable Urban Mobility Plans

TEN - Trans European Network

TUM - Technical University of Munich

VTS Finland - Vessel Traffic Services Finland

List of Figures

Figure 3.1: Tallinn Model Split [8]

Figure 3.2: Map of Tallinn area [3]

Figure 3.3: Popular Public Transport Lines Tallinn [7]

Figure 3.4: Helsinki Model Split

Figure 3.5: Map of Helsinki Metropolitan area [16]

Figure 3.6: Tram Route Map Helsinki [31]

Figure 3.7: Route of „Rail Baltic“ and cities of interest [43]

Figure 3.8: FinEst-Link between Tallinn and Helsinki [45]

Figure 3.9a: Starship autonomous delivery robot (own photographs)

Figure 3.9b: Starship autonomous delivery robot (own photographs)

Figure 3.10: Navya Autonomous Shuttle [55]

Figure 3.11: Easyride Autonomous Shuttle [66]

Figure 3.12: Traffic Management Finland real-time traffic situation report [76]

Figure 3.13: Smart City Pedestrian Crossing [154]

Figure 3.14: Bolt in Tallinn [78]

Figure 3.15: Picture of a shopping mall with a large parking spot in Ülemiste City [80]

Figure 3.16a: Maps showing the available parking lots [83]

Figure 3.16b: Maps showing the available parking lots [83]

Figure 3.17: Bicycle parking spaces [83]

Figure 3.18a Whim App. [89]

Figure 3.18b Whim App. [89]

Figure 3.19. Subscription models. Source: Whim website [89]

Figure 3.20a. HRI website [93]

Figure 3.20b. HRI datasets [93]

Figure 3.20c. HRI website [93]

Figure 3.21: City of Tallinn smartcard validation [100]

Figure 3.22: City of Helsinki smartcard validation [101]

Figure 3.23: Finest Smart Mobility [102]

Figure 3.24: Rail Baltica [106]

Figure 3.25: Finest Smart Mobility [108]

Figure 3.26: “Green card” to use public transport in Tallinn for free [109]

Figure 3.27. Forum Virium Helsinki website [94]

Figure 3.28: Exemplary projects of Forum Virium [94] – can be placed somewhere else

Figure 3.29: The Interior of An Autonomous Shuttle, Navya Bus Helsinki [129]

Figure 3.30: Easyride Robot bus to be tested by the City of Munich [128]

Figure 3.31: MaaS Levels and Examples [115]

Figure 3.32: About Whim [89]

Figure 3.33: MVG Fahrinfo Journey Details [136]

Figure 3.34: MVG Fahrinfo App [136]

Figure 3.35: Parking spot for eScooters in Ülemiste Smart City

Figure 3.36: Parking Spot Domagkpark (own photography)

Figure 3.37: Bike Station Domagkpark (own photography)

References: Tallinn and Helsinki

List of Tables

Table 3.1: Largest companies in Tallinn (by sales revenues) [5].

Table 3.2: Largest Enterprises in Helsinki 2017 (by number of personnel) [16]

Table 3.3 Comparing MaaS Global, Kytti and Perille

Table 3.4: Comparing current Munich mobility app features

Helsinki Tram Picture

Photo by Tapio Haaja on Unsplash

Star icon icon by Icons8

Air icon icon by Icons8

Traffic Jam icon icon by Icons8

Quality icon icon by Icons8

References: Stockholm

- [1] [Online]. Available: <https://its-sweden.se/wp-content/uploads/2017/05/Stockholm---The-smartest-city-in-the-world-2040.pdf>. [Accessed 11 04 2020].
- [2] [Online]. Available: https://international.stockholm.se/globalassets/vision-2040_eng.pdf. [Accessed 13 04 2020].
- [3] L. Boecker, P. Priya Uteng, L. Chengxi and D. Martin, "Weather and daily mobility in international perspective: A cross-comparison of Dutch, Norwegian and Swedish city regions," Transportation Research Part D: Transport and Environment, vol. 77, pp. 491–505, 2019.
- [4] [Online]. Available: <https://worldpopulationreview.com/world-cities/stockholm-population/>. [Accessed 11 04 2020].
- [5] [Online]. Available: <https://www.scb.se/en/finding-statistics/statistics-by-subject-area/population/population-composition/population-statistics/>. [Accessed 11 04 2020].
- [6] [Online]. Available: <https://start.stockholm/globalassets/start/om-stockholms-stad/utredningar-statistik-och-fakta/statistik/omradesfakta/hela-staden-2018.pdf>. [Accessed 11 04 2020].
- [7] "Administrative and Political Map Stockholm Vector," [Online]. Available: <https://www.vectorstock.com/royalty-free-vector/administrative-and-political-map-stockholm-vector-25570010>. [Accessed 01 03 2020].
- [8] E. Comission. [Online]. Available: <https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/base-profile/stockholm>. [Accessed 03 04 2020].
- [9] C. o. S. T. D. Expert, Interviewee, Presentation Levande Stockholm. [Interview]. 02 March 2020.
- [10] Arthur D. Litte, "The Future of Mobility 3.0," [Online]. Available: https://www.adlittle.com/futuremobilitylab/assets/file/180330_Arthur_D.Little_&_UITP_Future_of_Mobility_3_study.pdf. [Accessed 04 2020].
- [11] Storstockholms Lokaltrafik (SL), "Getting around Stockholm," 2019. [Online]. Available: <https://sl.se/>. [Accessed 28 March 2020].
- [12] AB Storstockholms Local Traffic, "SL and the County 2018," Stockholm, 2018.
- [13] Deloitte Corporation, "City Mobility Index: Stockholm," 2017. [Online]. Available: https://www2.deloitte.com/content/dam/insights/us/articles/4331_Deloitte-City-Mobility-Index/Stockholm_GlobalCityMobility_WEB.pdf. [Accessed 01 03 2020].
- [14] CIVITAS ECCENTRIC, "Stockholm City Description," 2016. [Online]. Available: <https://civitas.eu/eccentric/stockholm>. [Accessed 01 03 2020].
- [15] J. Böhlím, Interviewee, Strategist for fuel and energy for the Region of Stockholm. [Interview].
- [16] E. t. u. m. observatory. [Online]. Available: <https://www.eltis.org/discover/case-studies/stockholm-implementing-public-electric-vehicle-charging-network-sweden>.
- [17] ChargeMap, [Online]. Available: <https://chargemap.com/cities/stockholm-SE>. [Accessed 07 04 2020].
- [18] O. S. o. Sweden, "Vehicles in counties and municipalities".
- [19] City of Stockholm, "Stockholm City Plan," [Online]. Available: https://vaxer.stockholm/globalassets/tema/oversiktplan-ny_light/english_stockholm_city_plan.pdf. [Accessed 03 04 2020].
- [20] [Online]. Available: <https://www.interregeurope.eu/higher/news/news-article/2697/the-sustainable-urban-development-of-stockholm/>. [Accessed 11 04 2020].
- [21] [Online]. Available: <http://www.rufs.se/in-english>. [Accessed 11 04 2020].

- [22] P. Hafmar, V. Selin, M. Jansson, L. Polgren and R. Engström, "Slutrapport – Autopiloten i Kista," Stockholm, 2018.
- [23] DriveSweden, "KRABAT," [Online]. Available: <https://www.drivesweden.net/en/projects-5/krabat>. [Accessed 3 4 2020].
- [24] A. Pernestål, R. Darwish, Y. Susilo, E. Chee Pei Nen, E. Jenelius, J. Hatzebühler and P. Hafmar, "Shared Automated Vehicles – Research & Assessment in a 1st pilot," Stockholm, 2018.
- [25] EasyMile, "EasyMile Press Kit," [Online]. Available: <https://easymile.com/wp-content/uploads/2019/03/EasyMile-Press-Kit.pdf>. [Accessed 02 04 2020].
- [26] [Online]. Available: <https://frevue.eu/wp-content/uploads/2017/04/Final-report-Experinces-from-establishing-public-charing-etc-Feb-2016.pdf>. [Accessed 12 04 2020].
- [27] [Online]. Available: https://civitas.eu/sites/default/files/sto_6.6_master_plan_for_developing_electric_vehicle_charging_in_stockholm.pdf. [Accessed 11 04 2020].
- [28] [Online]. Available: https://energiradgivningen.se/system/tdf/fixa_laddplats_presentation_brf_nov_2019.pdf?file=1&type=node&id=5722&force=1. [Accessed 12 04 2020].
- [29] [Online]. Available: <https://energiradgivningen.se/projekt/fixa-laddplats-till-flerbostadshus>. [Accessed 13 04 2020].
- [30] [Online]. Available: <https://www.eltis.org/discover/case-studies/stockholm-implementing-public-electric-vehicle-charging-network-sweden>. [Accessed 11 04 2020].
- [31] [Online]. Available: <https://www.eltis.org/discover/case-studies/stockholm-implementing-public-electric-vehicle-charging-network-sweden>. [Accessed 12 04 2020].
- [32] [Online]. Available: <https://www.svt.se/nyheter/lokalt/stockholm/85-miljoner-kronor-i-stod-for-klimatsatsningar-i-stockholm>. [Accessed 12 04 2020].
- [33] [Online]. Available: https://civitas.eu/sites/default/files/sto_6.7_promote_the_installation_of_electric_vehicle_charging_in_multifamily_housing.pdf. [Accessed 12 04 2020].
- [34] [Online]. Available: https://civitas.eu/sites/default/files/sto_6.7_promote_the_installation_of_electric_vehicle_charging_in_multifamily_housing.pdf. [Accessed 12 04 2020].
- [35] [Online]. Available: <https://chargemap.com/cities/stockholm-SE>. [Accessed 12 04 2020].
- [36] DriveSweden, "Security for autonomous vehicles from a societal and safety perspective," [Online]. Available: <https://www.drivesweden.net/en/projects-5/security-autonomous-vehicles-societal-and-safety-perspective>. [Accessed 03 04 2020].
- [37] M. Asplund, Interviewee, Professor. [Interview]. 14 02 2020.
- [38] A. Anund, "ELIN – Ride the future," Linköping, 2020.
- [39] biofuel-express, [Online]. Available: <https://www.biofuel-express.com/en/stockholm-is-the-worlds-first-capital-with-100-fossil-free-bus-services/>. .
- [40] SL, [Online]. Available: <https://sl.se/sv/info/om-sl/hallbarhet/miljo/>.
- [41] Eltis, [Online]. Available: <https://www.eltis.org/discover/case-studies/more-400-ethanol-buses-stockholm-sweden>.
- [42] County Stockholm public transport administration, "Transition to electric buses in Stockholm".
- [43] SL, Writer, Renewable fuels in Stockholm Public Transport.. [Performance].
- [44] MVG, [Online]. Available: <https://www.mvg.de/ueber/mvg-projekte/bus/elektromobilitaet.html#intro>.
- [45] HUGO Delivery AB, [Online]. Available: <https://www.hugodelivery.com/>. [Accessed 01 04 2020].
- [46] D. Borjesson, "HUGO," [Online]. Available: <http://www.davidborjesson.com/hugo>. [Accessed 03 04 2020].
- [47] C. V. Magazine. [Online].
- [48] L. Smart. [Online]. Available: <https://www.locationsmart.com/platform/geofencing>.

References: Stockholm

- [49] KTH Royal Institute of Technology, "Transport Efficiency of Off-peak Urban Goods Deliveries".
- [50] Ramboll, "Night goods transport in Stockholm".
- [51] R. Billsjö, Interviewee, Urban Freight Strategist City of Stockholm Transport Department. [Interview].
- [52] CIVITAS ECCENTRIC, "Night-time deliveries using clean and silent vehicles".
- [53] KTH, "Off-peak city logistics—a case study in Stockholm".
- [54] Die Stadt München, "muenchen.de," [Online]. Available: <https://www.muenchen.de/rathaus/Stadtverwaltung/Kreisverwaltungsreferat/Verkehr/Verkehrsordnung/Fussgaengerzonen.html>.
- [55] [Online]. Available: https://grow-smarter.eu/fileadmin/editor-upload/Smart/Factsheet_36_Synchronisation_traff_signals__Stockholm.pdf. [Accessed 11 04 2020].
- [56] [Online]. Available: https://grow-smarter.eu/fileadmin/editor-upload/Reports/recommendations_for_Policy_makers_and_practitioners.pdf. [Accessed 13 04 2020].
- [57] [Online]. Available: https://grow-smarter.eu/fileadmin/editor-upload/Reports/recommendations_for_Policy_makers_and_practitioners.pdf. [Accessed 11 04 2020].
- [58] C. C. J. E. R. J. P. M. R. P. F. Albert Tapia. [Online]. Available: https://grow-smarter.eu/fileadmin/editor-upload/Reports/Smart_City_Market_Introduction.pdf. [Accessed 11 04 2020].
- [59] [Online]. Available: https://grow-smarter.eu/fileadmin/editor-upload/Smart/Factsheet_36_-_Synchronisation_traff_signals__Stockholm.pdf. [Accessed 11 04 2020].

- [60] Stockholm Parkering, "For Sustainable Mobility: The year that has passed 2019– The year to come 2020," 2019. [Online]. Available: https://www.stockholmparkering.se/SiteAssets/%c3%85rsber%c3%a4ttelse_2019.pdf. [Accessed 10 March 2020].
- [61] Stockholm Parkering, "Bike Parking," [Online]. Available: <https://www.stockholmparkering.se/Pages/Cykelparkering.aspx>. [Accessed 11 March 2020].
- [62] "Parking in Stockholm," [Online]. Available: car-parking.eu/. [Accessed 01 03 2020].
- [63] EasyPark, "Who it works?," 2019. [Online]. Available: <https://easypark.se/howItWorks/en>. [Accessed 11 March 2020].
- [64] Axonom Inc, "Stockholm Parkering leverages Microsoft Dynamics CRM and Powertrak," 2015. [Online]. Available: https://www.axonom.com/Data/Sites/1/media/casestudies/stockholmparkering_casestudy.pdf. [Accessed 10 March 2020].
- [65] H. Larhimi, "The Future of Urban Mobility," UbiGo, Stockholm, 2020.
- [66] H. Carlsson and Civitas Eccentric, "Develop a smart choice of mobility services," Stockholm, 2019.
- [67] J. von Porat and UbiGo, Stockholm, 2019.
- [68] Stockholm Stad, "Cycle Parking," 04 10 2019. [Online]. Available: <https://cykla.stockholm/cykelparkeringar/>. [Accessed 15 March 2020].
- [69] Traffic Office of Stockholm City, "Stockholm Cycle Billion 2012–2018: Final Report and Compilation of Measures," Stockholm, November 2019.
- [70] S. Risberg, "Skills enhancement EU project Eccentric".
- [71] CIVITAS ECCENTRIC, "Report Policy for rerouting cyclists during construction work".
- [72] S. Risberg, Interviewee, Senior Traffic Engineer City of Stockholm Transport Department. [Interview].

- [73] Steffan Risberg, "Policy for re-routing cyclists during construction work," Stockholm, 2020.
- [74] Sueddeutsche Zeitung, "Süddeutsche Zeitung," [Online]. Available: <https://www.sueddeutsche.de/muenchen/muenchen-radwege-fraunhoferstrasse-csu-1.4546190>.
- [75] Traffic Office, Interviewee, Projects and Generalities of the Traffic Office Parking Department. [Interview]. 13 February 2020.
- [76] "BICYCLING Blog," [Online]. Available: bicycling.se/blogs/kristerisaksson/bygg-sa-kommer-de-del-2.htm. [Accessed 01 03 2020].
- [77] Traffic Office (Urban Enviroment), "Evaluation Report: Living Stockholm 2019," Stockholm, 2019.
- [78] Google Maps, "Geo Location Stockholm Streets," [Online]. Available: <https://www.google.com/maps/place/Swedenborgsgatan,+Stockholm,+Sweden/data=!4m2!3m1!1s0x465f77ef87741235:0x218ce80321374486?sa=X&ved=2ahUKEwjWUjB1hdroAhWPYqQKHdgrBs4Q8gEwAHOE>. [Accessed 01 03 2020].
- [79] K. Philipson, "Pocket Park & Pallis," 2015. [Online]. Available: <https://whitearkitekter.com/project/pocket-park-pallis/>. [Accessed 02 03 2020].
- [80] [Online]. Available: <https://video.stockholm.se/video/36249756/5-tyck-till-film>. [Accessed 11 04 2020].
- [81] [Online]. Available: <https://www.transportstyrelsen.se/globalassets/global/vag/trangselskatt/congestion-tax-a4.pdf>. [Accessed 11 04 2020].
- [82] [Online]. Available: <https://smartstad.stockholm/2017/11/22/nytt-besokarrekor-for-tyck-till-appen-nu-nominerad-till-digitaliseringspriset/>. [Accessed 11 04 2020].
- [83] [Online]. Available: <https://www.norconsultastando.se/nyheter/2017/tyck-till/>. [Accessed 11 04 2020].
- [84] [Online]. Available: <https://trafik.stockholm/tyck-till/tyck-till-med-mobilen/>. [Accessed 11 04 2020].
- [85] [Online]. Available: https://www.google.de/imgres?imgurl=https://i.ytimg.com/vi/1NlJuTSeVX0/maxresdefault.jpg&imgrefurl=https://www.youtube.com/watch?v=3D1NlJuTSeVX0&tbnid=ztoibYmTVnsyXM&vet=1&docid=C_jOxEnCIFAzrM&w=1280&h=720&itg=1&q=tyck+till+english+add&hl=en-de&source=sh/. [Accessed 11 04 2020].
- [86] E. Freundenthal, Interviewee, Study visit to Hammarby Sjöstad. [Interview]. 20 02 2020.
- [87] Grontmij AB, "Report summary – Follow up of environmental impact in Hammarby Sjöstad: Uppföljning av miljöbelastning i Hammarby Sjöstad," Stockholm, 2008.
- [88] Envac, "This is how the vacuum cleaner works," [Online]. Available: <https://www.envac.se/sa-fungerar-sopsuganlaggningen/>. [Accessed 17 March 2020].
- [89] Karlsson, Mukhtar-Landgren, Smith, Koglin, Kronsell, Lund, Sarasini and Sochor, "Development and implementation of Mobility-as-a-Service – A qualitative study of barriers and enabling factors," 2020.
- [90] Sochor, Arby, Karlsson and Sarasini, "A topological approach to Mobility as a Service: A proposed tool for understanding requirements and effects, and for aiding the integration of societal goals," 2018.
- [91] Smith, Sochor and Karlsson, "Mobility as a Service: Development scenarios and implications for public transport," 2018.
- [92] H. Arby, Interviewee, [Interview]. 21 February 2020.
- [93] N. Sadowsky and E. Nelson, "The Impact of Ride-Hailing Services on Public Transportation Use: A Discontinuity Regression Analysis," 2017.
- [94] Smith, Sochor and Karlsson, "Public-private innovation: barriers in the case of mobility as a service in West Sweden," 2019.
- [95] Pangbourne, Mladenovic, Stead and Milakis, "Questioning mobility as a service: Unanticipated implications for society and governance," 2020.
- [96] Docherty, Marsden and Anable, "The governance of smart mobility".
- [97] ReachNow. [Online]. Available: <https://www.your-now.com/de/our-solutions/reach-now>. [Accessed 03 04 2020].

References: Stockholm

- [98] Uber, [Online]. Available: <https://www.uber.com/us/en/transit/agency/>. [Accessed 03 04 2020].
- [99] L. Bliss, "citylab.com," [Online]. Available: <https://www.citylab.com/environment/2020/02/uber-lyft-pollution-data-carbon-emissions-ride-hailing-study/607063/>. [Accessed 03 04 2020].
- [100] Karlsson, Mukhtar–Landgren, Smith, Koglin, Kronsell, Lund, Sarasini and Sochor, "Development and implementation of Mobility-as-a-Service – A qualitative study of barriers and enabling factors," 2020.
- [101] Stockholm City, "Stockholm Pedestrian Plan," Stockholm, 2016.
- [102] Traffic Office: Hans–Olov Blom, "Official Statement: Living Stockholm 2019. Proposal for decision (in Swedish)," Stockholm, 2019.
- [103] Traffic Office: Hans–Olov Blom, "Official Statement: Live Stockholm 2020. Suggested places and continued development (in Swedish)," Stockholm, 2019.
- [104] Viscando Traffic Systems, "Stockholm Norrtullsgatan: Movement patterns and traffic flow," Stockholm, 2018.
- [105] A.–S. Welander, "Road safety program for the city of Stockholm (in Swedish)".
- [106] City of Stockholm, "Trafikolyckor (in Swedish)," 2018.
- [107] Polizeipräsidium München, "Verkehrsbericht 2018".
- [108] Trafverket swedisch traffic administration, [Online]. Available: [https://www.trafikverket.se/en/startpage/operations/Operations-road/vision-zero-academy/](https://www.trafikverket.se/en/startpage/operations/Operations-road/vision-zero-academy/This-is-Vision-Zero/).
- [109] Trafverket swedisch traffic administration, "https://www.trafikverket.se/en/startpage/operations/Operations-road/vision-zero-academy/," [Online].
- [110] "Roadsafetysweden.com," [Online]. Available: <https://www.roadsafetysweden.com/about-the-conference/news-on-road-safety-conference/2020/vision-zero-at-the-global-conference/>.
- [111] TØI Institute of transport economics, "Road safety program for Stockholm 2010–2020: Review and evaluation of goals, indicators and measures".
- [112] CIVITAS ECCENTRIC, "Easy, safe and comfortable cycling and walking around the year".
- [113] G. B. I. J. Anna Niska, "VTI– Utvärdering av sopsaltning på cykelstråk i Stockholm vintern 2016/17 – (in Swedish)".
- [114] [Online]. Available: <http://anlaggningsvarlden.se/mer-sopsaltning-stockholm>.
- [115] "roadsafetysweden.com," [Online]. Available: <https://www.roadsafetysweden.com/about-the-conference/news-on-road-safety-conference/2020/summary-of-the-first-day-of-the-conference-including-a-film-collage/>.
- [116] D. E. D. Amy Rader Olsson, "Expanding the Scope of Sustainability Planning: Lessons from Stockholm's Congestion Charging Policy," COGITATIO, vol. 2, pp. 81–92, 2017.
- [117] L. B. ., B. F. Christer Johansson, "The effects of congestions tax on air quality and health," Elsevier, 2008.
- [118] [Online]. Available: <http://www.stockholmsforsoket.se/templates/page.aspx?id=2431>. [Accessed 11 04 2020].
- [119] [Online]. Available: http://www.stockholmsforsoket.se/upload/Hushall_eng.pdf. [Accessed 11 04 2020].
- [120] J. E. M. H. K. B.–F. Maria Börjesson, "The Stockholm congestion charges – five years on. Effects,," CTS Working Paper, vol. 20, p. 1.12, 2013.
- [121] "Hours-and-amounts-in-stockholm," [Online]. Available: [https://www.transportstyrelsen.se/en/road/Congestion-taxes-in-Stockholm-and-Goteborg/congestion-tax-](https://www.transportstyrelsen.se/en/road/Congestion-taxes-in-Stockholm-and-Goteborg/congestion-tax-in-stockholm/hours-and-amounts-in-stockholm/)

- in-stockholm/hours-and-amounts-in-stockholm/. [Accessed 11 04 2020].
- [122] [Online]. Available: https://www.researchgate.net/figure/The-Stockholm-congestion-tax-gantries-Courtesy-Swedish-Transport-Agency-Photographer_fig4_261385684. [Accessed 11 04 2020].
- [123] "World Population Review," [Online]. Available: <https://worldpopulationreview.com/world-cities/stockholm-population/>.
- [124] "https://worldpopulationreview.com/world-cities/stockholm-population/," 2020. [Online]. Available: <https://worldpopulationreview.com/world-cities/stockholm-population/>. [Accessed 04 2020].
- [125] "https://its-sweden.se/wp-content/uploads/2017/05/Stockholm---The-smartest-city-in-the-world-2040.pdf," Stockholm Stadt, [Online]. Available: <https://its-sweden.se/wp-content/uploads/2017/05/Stockholm---The-smartest-city-in-the-world-2040.pdf>. [Accessed 11.04.2020 April 2020].
- [126] [Online]. Available: <https://www.miljofordon.se/tanka/laddkarta>. [Accessed 13 04 2020].
- [127] [Online]. Available: <https://international.stockholm.se/governance/city-governance/>. [Accessed 11 04 2020].
- [128]
- [129]
- [130] K. R. I. o. Technology, "Transport Efficiency of Off-peak Urban Goods Deliveries".
- [131] S. Risberg, Interviewee, Senior Traffic Engineer for the City of Stockholm Transport Department. [Interview].
- [132] S. Risberg, "Kompetensförstärkning EU-projekt Eccentric Trafikutredning".
- [133] S. Risberg, Writer, CIVITAS ECCENTRIC Workshop on road safety. [Performance]. 2020.
- [134] Ramboll, "Night goods transport in Stockholm".
- [135] B. Express, "Biofuel-express.com," [Online]. Available: <https://www.biofuel-express.com/en/stockholm-is-the-worlds-first-capital-with-100-fossil-free-bus-services/>.
- [136] B. Express, "biofuel-express.com," [Online]. Available: <https://www.biofuel-express.com/en/stockholm-is-the-worlds-first-capital-with-100-fossil-free-bus-services/>.
- [137] C. ECCENTRIC. [Online]. Available: <https://civitas.eu/eccentric/stockholm>.
- [138] J. Böhlén, Interviewee, Strategist for fuel and energy for the region of Stockholm. [Interview].
- [139] R. Billsjö, Interviewee, Urban Freight Strategist City of Stockholm Transport Department. [Interview].
- [140] KTH Royal Institute of Technology, "Transport Efficiency of Off-peak Urban Goods Deliveries".
- [141] CIVITAS ECCENTRIC, "Policy for rerouting cyclists during construction work".
- [142] KTH Royal Institute of Technology, "Off-peak city logistics—a case study in Stockholm".
- [143] CIVITAS ECCENTRIC, "Night-time deliveries using clean and silent vehicles".
- [144] Ramboll, "Night goods transport in Stockholm".
- [145] Stadt München, [Online]. Available: <https://www.muenchen.de/rathaus/Stadtverwaltung/Kreisverwaltungsreferat/Verkehr/Verkehrsplanung/Fussgaengerzonen.html>.
- [146] SL, [Online]. Available: <https://sl.se/sv/info/om-sl/hallbarhet/miljo/>.
- [147] MVG, [Online]. Available: <https://www.mvg.de/ueber/mvg-projekte/bus/elektromobilitaet.html#intro>.
- [148] CIVITAS, "Living Lab– Stockholm," [Online]. Available: <https://civitas.eu/eccentric/stockholm>. [Accessed 31 March 2020].
- List of Abbreviation**
- API Application programming interface
- AV Automated vehicle
- ASB Automated shuttle buses

References: Stockholm

CRM	Customer relationship management	Figure 4.11. (a) The vehicle and specifications. (b) The corresponding smartphone app [46]
ERP	Enterprise resource planning	Figure 4.12. HUGO in use [45].....
HDV	Heavy-duty vehicles	Figure 4.13 (a) Plugin hybrid electric vehicle from Scania [47]. (b) Geofencing map example [48]
HVO	Hydrotreated vegetable oil	Figure 4.14. Night delivery [52]
IMU	Inertial measurement unit	Figure 4.15. Technic device which was used to achieve the signal priority [55].....
IOT	Internet of things	Figure 4.16. (a) Stockholm Parkering parking areas in inner-city (b) SMS Park app. Sources: [62] & [63]
KSI	Number of people killed or seriously injured	Figure 4.17. EasyPark app route of parking digitalization Source: [63].....
MaaS	Mobility as a service	Figure 4.18. User interface of the UbiGo mobile app [65]
MIT	Motorised individual transport	Figure 4.19. The UbiGo application in use [67]
OEM	Original equipment manufacturer	Figure 4.20. (a) “Cykelsnurran” automated parking. (b) Multilevel bike parking [60].....
PHEV	Plugin hybrid electric vehicle	Figure 4.21. Bike parking boxes [61].....
PT	Public transport	Figure 4.22 (a) Rerouting facility [70]
WTP	Willingness to pay	Figure 4.23.Rerouting system in Munich [74].....
WTU	Willingness to use	Figure 4.24. (a) Stockholm residential parking areas (b) Parking signs [75]
TSP	Transport service provider	Figure 4.25. North Mälärstrand bike lane. Source: [76].....

List of Figures

Figure 4.1. Administrative and political map of the city of Stockholm [7]	Figure 4.26. (a) Geo-location Swedenborgsgatan street (b) Swedenborgsgatan street visited in summer [78], [9]
Figure 4.2. Rail transit network of Stockholm [11].....	Figure 4.27. Active Mobility in Skaegatan summer street. Source: [79]....
Figure 4.3. Official share of vehicles in Stockholm [18].....	Figure 4.28 (a) Tyck Till advertisement on a construction site in Stockholm (b) On-line Tyck Till advertisement [80].....
Figure 4.4. ASB in summer and winter use [22].....	Figure 4.29. Shall we help you? In the Tyck Till app you can submit your views and ideas on traffic and the outdoor environment in Stockholm. Source: [85]
Figure 4.5. Route of the ASB [22]	Figure 4.30 (a) Hammarby Sjöstad geographical composition [86] (b) Waste management system.....
Figure 4.6. (a) An EV charging station in Stockholm (b) Overview of the number of electric cars and electric charging stations from 2010 to sept 2019 Sources: [27], [28]	Figure 4.31. Residents of Hammarby Sjöstad, own source
Figure 4.7. Map of the EV charging stations infrastructure in Stockholm [35]	Figure 4.32: Transition of the core roles in detached and integrated
Figure 4.8. (a) One of the vehicles [38] (b) The testing route [38].....	
Figure 4.9. (a) Fossil-fuel free powered bus in STO [39] (b) The division between environmentally classified fuels in Stockholm with a total of 2100 buses (2018)	
Figure 4.10. PT Stockholm [43].....	

MaaS value chains [91]
Figure 4.33: MaaS defined in four levels (based on [90]).....
Figure 4.34: Car usage as a result of Service Quality (based on [92]).....
Figure 4.35: Expectation of MaaS stakeholders [65].....
Figure 4.36: Levande Stockholm timeline [103].
Figure 4.37. Summer Street Rörstrandsgatan [9]
Figure 4.38. Summer square [9].....
Figure 4.39. Pop-up parks [9].....
Figure 4.40. Winter interventions [9]
Figure 4.41. Criteria for selection of places. Source: design based on [9]
Figure 4.42. Patterns of movement for pedestrian, bikes, and vehicles [104].
Figure 4.43: Progress of Vision Zero [108].....
Figure 4.44 Sweep and Salt vehicle [114].....
Figure 4.45. His Majesty the King of Sweden Carl XVI Gustaf. Foto: Mikael Ullén
Figure 4.46: Current congestion charge zone, with its charging tolls [81].
Figure 4.47. Changes in car traffic on different roads [117]
Figure 4.48. One of the charging points in Stockholm [122]

TECHNICAL UNIVERSITY OF MUNICH

EU MOVE

CITY OF MUNICH

CITY OF BARCELONA

CITY OF TALLINN

CITY OF HELSINKI

CITY OF STOCKHOLM

ORGANIZED BY:

• CHAIR OF URBAN STRUCTURE AND TRANSPORT PLANNING

TECHNICAL UNIVERSITY OF MUNICH

(DEPARTMENT OF CIVIL, GEO AND ENVIRONMENTAL ENGINEERING, PROF. DR.-ING. GEBHARD WULFHORST)

• CHAIR OF AUTOMOTIVE TECHNOLOGY

TECHNICAL UNIVERSITY OF MUNICH

(DEPARTMENT OF MECHANICAL ENGINEERING, PROF. DR.-ING. MARKUS LIENKAMP)

• MUNICH CENTER FOR TECHNOLOGY IN SOCIETY

TECHNICAL UNIVERSITY OF MUNICH

(TUM INTEGRATIVE RESEARCH CENTER, PROF. DR. SEBASTIAN PFOTENHAUER)

ALL ENQUIRIES SHOULD BE FORWARDED TO: EUMOVE@FTM.MW.TUM.DE