Vartiainen, Matti A.; Surakka, Teemu; Haahtela, Tero

Smart and Mobile Work in Growth Regions

Published: 12/12/2018

Document Version
Publisher's PDF, also known as Version of record

Please cite the original version:
Vartiainen, M. A., Surakka, T., & Haahtela, T. (2018). Smart and Mobile Work in Growth Regions. (pp. 1-79). (Aalto University publication series SCIENCE + TECHNOLOGY; No. 6). Helsinki: Aalto University.

M. Vartiainen, T. Surakka and T. Haahtela (Eds.) Smart and Mobile Work in Growth Regions Aalto University

2018

Department of Industrial Engineering and Management

Smart and Mobile Work in Growth Regions

M. Vartiainen, T. Surakka and T. Haahtela (Eds.)

Aalto University

SCIENCE + TECHNOLOGY

COMPILATION

Aalto University publication series
SCIENCE + TECHNOLOGY 6/2018

Smart and Mobile Work in Growth Regions

M. Vartiainen, T. Surakka and T. Haahtela (Eds.)

Aalto University
School of Science
Department of Industrial Engineering and Management
Virtual and Mobile Work Research Unit

Aalto University publication series
SCIENCE + TECHNOLOGY 6/2018

ISBN 978-952-60-8349-0 (printed)
ISBN 978-952-60-8350-6 (pdf)
ISSN 1799-4896 (printed)
ISSN 1799-490X (pdf)

https://smartcommuting.eu/publications/

Unigrafia Oy
Helsinki 2018

Finland

Business Finland, project 4670/31/2015

NORDIC ECOLABEL
441 697
Printed matter

Aalto University

Abstract

Aalto University, P.O. Box 11000, FI-00076 Aalto www.aalto.fi

Author
M. Vartiainen, T. Surakka and T. Haahtela (Eds.)

Name of the publication
Smart and Mobile Work in Growth Regions

Publisher School of Science

Unit Department of Industrial Engineering and Management

Series Aalto University publication series SCIENCE + TECHNOLOGY 6/2018

Field of research Industrial Engineering and Management

Language English

Abstract
Smart Commuting project explored new ways of combining work and life with new intelligent transport system services and developed new concepts to support sustainable CO2-free commuting and mobile, multi-locational work. The mobility of the workforce is increasing due to technology development, commuting and the nature of work, which has many consequences as long commuting may decrease the productivity of work and leave less time for relaxation, resulting in lowered wellbeing. Cities also have to address commuting when planning technical solutions, developing services and calculating their finance schemes. Therefore, the first objective of this project was to identify the changing needs of mobile workers for transport. The second objective was to support the implementation of sustainable and intelligent transport services that meet these needs.

The project was done as the collaboration of researchers and company partners from Austria, Finland, and Switzerland. Aalto University acted as the coordinator, and AIT Austrian Institute of Technology, tbw research GesmbH, and ZHAW Zürich University of Applied Sciences were research partners. The company and regional partners were: Virta Ltd. (Liikennevirta Oy), AC2SG Software Oy, Kyyti Group Ltd. (Tuup Oy), ISTmobil GmbH, Growth Corridor Finland (GCF), and the Office of Mobility in the Canton of Basel-Stadt. Smart Commuting - Smart and Mobile Work in Growth Regions project (2016-2018, www.smartcommuting.eu) is one of the projects in joint programme JPI Urban Europe (www.jpi urbaneurope.eu). The programme was created in 2010 to address the global urban challenges of today. In Finland, the project was funded by Business Finland.

The consortium collected data through surveys, interviews, collecting documents, making observations and having workshops in Austria, Finland and Switzerland to evaluate how new transport services meet the evolving needs of mobile workers. In addition, simulations were used to provide decision support for stakeholders to address urban planning and governance structures' challenges. Implementations in large commuting areas were pivotal aspects of this project as they helped scale up our partners' operations, get experiences about the needs of users and also discover some common grounds for governance and city planning policies.

Keywords Mobility, MaaS, Transport, New Ways of Working

ISBN (printed) 978-952-60-8349-0 **ISBN (pdf)** 978-952-60-8350-6

ISSN (printed) 1799-4896 **ISSN (pdf)** 1799-490X

Location of publisher Helsinki **Location of printing** Helsinki **Year** 2018

Pages 84

Aalto-yliopisto

Aalto-yliopisto, PL 11000, 00076 Aalto www.aalto.fi

Tiivistelmä

Tekijä
M. Vartiainen, T. Surakka and T. Haahtela (Eds.)

Julkaisun nimi
Smart and Mobile Work in Growth Regions

Julkaisija Perustieteiden korkeakoulu

Yksikkö Tuotantotalouden laitos

Sarja Aalto University publication series SCIENCE + TECHNOLOGY 6/2018

Tutkimusala Tuotantotalous

Kieli Englanti

Tiivistelmä
Smart Commuting -projektissa tutkittiin uusia tapoja yhdistää työ ja vapaa-aika älykkäiden liikennejärjestelmien ja -palveluiden avulla. Lisäksi kehitettiin käsitteellistä perustaa hiilivapaan liikkumisen ja mobiilin, monipaikkaisen työn tueksi. Työntekijöiden liikkuvuus on lisääntynyt teknologisen kehityksen, lisääntyneen mobiilisuuden ja töiden organisoinnissa tapahtuneiden muutosten ansiosta.Tällä on ollut monia vaikutuksia, sillä pitkät matkustusajat saattavat vähentää työn tuottavuutta ja ihmisten hyvinvointia, sillä aikaa on aiempaa vähemmän työstä palautumiseen. Myös kaupunkien on otettava liikkuminen huomioon asuinympäristöjä ja teknisiä ratkaisuja suunniteltaessa ja käyttöönotettaessa sekä laskettaessa niiden kustannuksia. Siksi tämän hankkeen ensimmäisenä tavoitteena oli tunnistaa liikkuvien työntekijöiden muuttuvia tarpeita liikkumisen osalta. Toisena tavoitteena oli tukea kestävien ja älykkäisen liikennepalveluiden kokeilua ja käyttöönottoa työntekijöiden tarpeiden näkökulmasta.

Tämä tutkimushanke toteutettiin tutkijoiden ja yritysten yhteistyönä. Tutkijaosapuolet tulivat Itävallasta, Sveitsistä ja Suomesta Aalto-yliopiston toimiessa hankkeen koordinaattorina.Tutkijapartnereita olivat: AIT Austrian Institute of Technology, tbw research GesmbH, ja ZHAW Zürich University of Applied Sciences. Yrityspartnereita puolestaan olivat: Virta Ltd. (Liikennevirta Oy), AC2SG Software Oy, Kyyti Group Ltd. (Tuup Oy) ja ISTmobil GmbH (Itävalta). Julkisen puolen partnerit olivat: Growth Corridor Finland (GCF) ja the Office of Mobility in the Canton of Basel-Stadt (Sveitsi). Hanke toteutettiin eurooppalaisen JPI Urban Europe (www.jpi-urbaneurope.eu) -ohjelman puitteissa. Ohjelma käynnistettiin vuonna 2010 vastaamaan globaaleihin urbaanin elämän haasteisiin. Suomessa hankkeen rahoitti Business Finland.

Hankkeessa kerättiin tutkimusaineistoa kyselyillä, haastatteluilla, keräämällä dokumentteja, havainnoimalla ja järjestämällä työpajoja Itävallassa, Sveitsissä ja Suomessa. Niitä käytettiin arvioitaessa, miten tarjolla olevat uudet liikennepalvelut kohtaavat mobiilien työntekijöiden tarpeita. Lisäksi kehitettiin ja käytettiin simulaatioita eri osapuolten päätöksenteon tukena, kun ne kehittivät kaupunkisuunniittelua ja sen hallintaa. Palvelujen kokeilu oli olennainen osa hanketta. Niiden avulla yrityspartnerit kykenivät paremmin kehittämään palvelujaan loppukäyttäjien tarpeita palvellen. Tutkimustulokset myös auttoivat julkisia toimijoita kehittämään politiikkaansa tutkijoiden esittämien suositusten avulla.

Avainsanat Mobiilisuus, MaaS, Liikenne, Uudet työnteon tavat

ISBN (painettu) 978-952-60-8349-0 **ISBN (pdf)** 978-952-60-8350-6

ISSN (painettu) 1799-4896 **ISSN (pdf)** 1799-490X

Julkaisupaikka Helsinki **Painopaikka** Helsinki **Vuosi** 2018

Sivumäärä 84

Smart and Mobile Work in Growth Regions

Edited by M. Vartiainen, T. Surakka and T. Haahtela

Contents

1. Introduction

1.1 Smart Commuting project and its aims

Smart Commuting project[1] explored new ways of combining work and life with new intelligent transport system services and new concepts to support sustainable CO2-free commuting and mobile, multi-locational work. The mobility of the workforce is increasing due to technology development, commuting and the nature of work, which has many consequences as long commuting may decrease the productivity of work and leave less time for relaxation, resulting in lowered wellbeing. Cities also have to address commuting when planning technical solutions, developing services and calculating their finance schemes. Therefore, the first objective of this project was to identify the changing needs of mobile workers for transport. The second objective was to support the implementation of sustainable and intelligent transport services that meet these needs.

The project was done as a collaboration of researchers and company partners from Austria, Finland, and Switzerland. Aalto University acted as the coordinator, and AIT Austrian Institute of Technology, tbw research GesmbH, and ZHAW Zürich University of Applied Sciences were research partners. The company and regional partners were: Virta Ltd. (Liikennevirta Oy), AC2SG Software Oy, Kyyti Group Ltd. (Tuup Oy), ISTmobil GmbH, Growth Corridor Finland (GCF), and the Office of Mobility in the Canton of Basel-Stadt.

The consortium collected data through surveys, interviews, collecting documents, making observations and having workshops in Austria, Finland and Switzerland to evaluate how new transport services meet the evolving needs of mobile workers. In addition, simulations were used to provide decision support for stakeholders to address urban planning and governance structures' challenges. Implementations in large commuting areas were pivotal aspects of this project as they help scale up our partners' operations, get experiences about the needs of users and also discover some common grounds for governance and city planning policies.

1.2 Conceptual backgrounds

This project focused on the new ways of combining work and life with the help of new intelligent transport system services and new concepts for supporting sustainable commuting. Globalisation, technology development and environmental issues have increased the use of new types of work arrangements, such as dispersed and flexible mobile work, increasing also

[1] Smart Commuting - Smart and Mobile Work in Growth Regions project (2016-2018, www.smartcommuting.eu) is one of the projects in joint programme JPI Urban Europe (www.jpi-urbaneurope.eu). The programme was created in 2010 to address the global urban challenges of today.

the number of locations from which knowledge-intensive work can be performed (Andriessen & Vartiainen, 2006; Eurofound 2015). A significant portion of work takes place in mobile settings; i.e., it is often not restricted to any one location (Vartiainen et al., 2007). This means that local infrastructures and services need to be considered from the viewpoint of dispersed and flexible mobile work (Huning et al., 2012). Also, the mobility of workers brings along the increase in CO2 emissions, if low emission transport services are not available.

The mobility of the workforce is continually increasing. Eurofound study (2012) showed that a quarter of the European workers are e-nomads – people who do not work all the time at their employers' or their own business premises and habitually use computers, the internet or email for professional purposes. The incidence of e-nomads varies considerably among countries, ranging from just above 5% in Albania, Bulgaria, Romania and Turkey to more than 40% in the Netherlands, Denmark and Sweden, and 45% in Finland. Similarly, Eurofound and the International Labour Office (2017) in their study on telework/ICT-mobile work (T/ICTM)[2] report that the incidence of T/ICTM varies substantially, from 2% to 40% of employees, depending on the country, occupation, industry and the frequency with which employees engage in this type of work. Across the EU28, an average of about 17% of employees are engaged in T/ICTM. In most countries, larger proportions of workers carry out T/ICTM occasionally rather than on a regular basis. T/ICTM is more common among professionals and managers but is also significant among clerical support and sales workers. In relation to gender, in general, men are more likely to perform T/ICTM than women. However, women carry out more regular home-based telework than men. This suggests that country-specific gender roles and models of work and family life play a role in shaping T/ICTM.

The trends in mobility has several consequences. Studies have found that prolonged commuting times decrease the productivity of work (e.g., Ommeren & Gutierrez Puigarnau, 2011). The duration of commute is influenced by a large number of factors, such as the income of the residents of the central city (Shen, 2000) and the quality and the cost of living. However, the journey to work plays only a limited role in residential location choices (Giuliano & Small, 1993). In addition to commuting, the nature of work may require extensive travelling. One study (Koroma et al., 2014) shows that the change of physical locations results in continuous searching for a place to work and remaining socially as an outsider in all work communities including the main office. Limited connections in the locations used for work seem to be the main challenges of increased mobility despite the recent developments in communication technology.

The quality of travel time, especially in commuting, is also changing and might do more so in the near future. Telecommunications technologies and services provide options to work on the go, which leads to different perception and acceptance of commuting times. This increases the demand for equipment and also the importance of qualitative aspects of transport services. In return, a greater supply of supporting (and entertaining) equipment during travel will have an impact on behaviour.

This project explored this increased mobility and its relationship with sustainable and intelligent transport system services. Due to the above-described trends, the value and the use of travel time will change, which in turn will affect mobility, travel, and working behaviour. These trends need to be taken into account when designing new solutions and services for mobile workers.

[2] T/ICTM is defined as the use of ICT – such as smartphones, tablets, laptops and desktop computers – for the purposes of work outside the employer's premises.

There is an increasing number of operators and companies offering Mobility as a Service (MaaS). Although these companies with networked business models have already established themselves, the appropriateness and applicability of these new services and business models in enhancing mobile work still need to be evaluated. Thus in addition to helping design new solutions, the objective of this project was to identify the needs of mobile workers, how they are changing due to above-mentioned trends, and envision evaluation methods for matching the changing needs of mobile workers with the value propositions of different mobility concepts.

1.3 Content and structure of the report

This report contains the main results of the project. In chapter 2, we will discuss the current and future needs of mobile workers. Chapter 3 describes the socio-technical regimes in our case countries and regions. This information is essential when applying the results and formulating policy recommendation for different stakeholders. Chapter 4 shows, who the stakeholders are and whose agency and power make them more critical in this transition. Chapter 5 shows six case examples of MaaS offerings and implementations and some experiences gained from them. Chapter 6.1 discusses MaaS at the conceptual level. Reviewing the state-of-the-art of MaaS research, it concludes that MaaS has all the attributes of a 'hyped' socio-technical phenomenon: it seems to be a loosely connected patchwork of optimistic political dogma, activists' enthusiasm, anecdotal evidence of successful services and a firm belief of investors in transport network companies such as Uber. Chapter 6.2 focuses on the assessment of micro transport services that operate a fleet of vehicles. Such services can be used for example in settings where the goal is to bridge the gap between public transport in rural and urban areas. Chapter 6.3 shows some results of the optimization analysis that help in constructing suitable optimization models and solutions when designing transport services. In Chapter 6.4, we compare an Austrian MaaS-related concept, ISTmobil[3] service with three other similar on-demand transport service concepts: the Finnish Kutsuplus and Kyyti[4] and the multinational UberPOOL. In chapter 7, policy recommendations for commuter regions, especially for administrations and legislators are listed and structured thematically. And finally, in Chapter 8 ten general recommendations are offered for decision-makers.

References

Andriessen, J. H. & Vartiainen, M. (eds.) (2006). Mobile virtual work. A new paradigm? Berlin: Springer.

Eurofound (2012). Fifth European Working Conditions Survey, Publications Office of the European Union, Luxembourg.

Eurofound (2015). New forms of employment, Publications Office of the European Union, Luxembourg.

[3] See: www.istmobil.at

[4] See: www.kyyti.com/english.html

Eurofound and the International Labour Office (2017). Working anytime, anywhere: The effects on the world of work. Publications Office of the European Union, Luxembourg, and the International Labour Office, Geneva.

Giuliano, G. & Small, K. A. (1993). Is the journey to work explained by urban structure? Urban Studies, 30(9), 1485-1500.

Huning, S., Bens, O., & Hüttl, R. F. (2012). Demographic change beyond the urban-rural divide: Reframing spatial differentiation in the context of migration flows and social networks. DIE ERDE–Journal of the Geographical Society of Berlin, 143(1-2), 153-172.

IDC (2011). Worldwide Mobile Worker Population 2011-2015 Forecast. International Data Corporation.

Koroma, J., Hyrkkänen, U. & Vartiainen, M. (2014). Looking for people, places and connections: Hindrances when working in multiple locations - a review. New Technology, Work and Employment, 29(2), 139-159.

Ommeren, J.N. van & Gutierrez Puigarnau, E. (2011). Are workers with a long commute less productive? An empirical analysis of absenteeism. Regional Science and Urban Economics, 41(1), 1-8.

Shen, Q. (2000). Spatial and social dimensions of commuting. Journal of the American Planning Association, 66(1), 68-82.

Vartiainen, M., Hakonen, M., Koivisto, S., Mannonen, P., Nieminen, M.P., Ruohomäki, V. & Vartola, A. (2007). Distributed and mobile work – Places, people and technology. Tampere: Otatieto.

2. Current and future needs of mobile workers

J. Asamer, M. Doiber, T. Haahtela, R. Hackl, M. Hakonen, M. Hoppe, F. Härri, M. Reinthaler, T. Surakka, E. Viitamo & M. Vartiainen

Mobile workers' current and future needs were studied by utilising both qualitative and quantitative data to identify the changing needs and the possibilities of new intelligent traffic system services in meeting these needs. The qualitative part of the study provides background information on the relevant topics and questions for the quantitative portion of this study, i.e., the survey. The survey was conducted with equal sample sizes (around 500 respondents) in each of our case region/country. The survey explored the suitability of the existing and future mobility solutions for the commuters' present and future mobility needs. Moreover, the purpose of the survey was to identify specific traveller profiles across and within the regions in question.

A qualitative approach, consisting of users' self-produced mobility maps and semi-structured interviews, was used to find out potential benefits and challenges of new and upcoming mobility solutions. Interviews also provided an excellent opportunity to gather panels that test and evaluate some of these new services.

2.1 Features and user profiles of mobile workers

This chapter summarises the key findings of the mobile workers' needs survey. The current and future needs of mobile workers deliverable[5] presents the basic statistics of the survey and the first round analysis on the travellers' profiles in more detail. The deliverable builds on the previous analysis of the mobile workers' needs survey[6].

The mobile workers' need survey was conducted in Austria, Finland (the Growth Corridor Finland, GCF) and Switzerland (Basel Region). The first set of findings describes the characteristics of mobile workers as well as their commuting environment. We then present the key findings on the mobility behaviour and the overall satisfaction with the present transport choices of the commuters. In addition, aspects that could potentially change the present mobility modes to more sustainable ones are discussed. The second set of findings are based on a cluster analysis, where the aim was to identify commuting profiles and user groups in each of the case regions.

[5] Deliverable 1.3 The current and future needs of mobile worker
[6] Deliverable 1.2 Survey results of the mobile workers' needs

2.1.1 Characteristics of mobile workers in three regions

The questions in the survey were related to the following themes (N = number of questions): respondents' background (N=18), commuting environment (N = 5), present modes of commuting (N = 13), satisfaction and motivations (N = 5), and future modes of commuting (N = 3). The questionnaire was issued in October 2016 – February 2017, and the data was collected in December 2016 – May 2017. Hence, there are three identical (region-adjusted) commuting surveys in Austria (N = 531) focusing the whole country, Finland (N = 523) focusing on the Finnish Growth Corridor and Switzerland (N = 549) focusing on Basel Region. The three focus regions are characteristically different as the purpose of the survey was to examine and compare different national contexts in commuting, mobility and the related services.

Despite the different geographic and cultural contexts and geographic foci of the three surveys, the samples show high similarity across the regions and the distributions with respect to the background factors. A typical number of cars in a household is one car in each region/country with an average of 45 % of the respondents. The overall accessibility to a car is, however, much higher as 91 % of the households in Austria, 80 % in GCF and 70 % in Basel Region owns at least one car. As to the household monthly net income, the Swiss respondents outperform the Finns and Austrians. The monthly net income among the Swiss/Basel commuters is about double higher than in the other regions/countries.

As with the background factors, the regions show high similarity and the distributions of the categories featuring the commuting environments. Of the different types of public transport stations, bus stop is dominantly within the walking distance of the traveller in all regions/countries (90 % of the respondents on average). The dominant place of work among the respondents in all regions/countries is the primary office varying between 78 % (Austria) and 89 % (Basel Region). Surprisingly, given the marked differences in the geographic sizes of the countries, the regions are relatively similar in the commuting distances and the distribution of lengths in each percentile. Half of the respondents have a commuting distance of less than 10 km.

On average, 60 % of the respondents have an "access to private car" while less than 10 % of the respondents have access to a company car. For the most important means of transport used for commuting, GCF and Austria show similar patterns. In Austria and Finland, "car-driver" is the dominant mode (over 50%), whereas "walking" is next important with around 20 %. In Basel Region instead, "bike", "train", and "tram" are equally important with 30 % among the respondents.

Specific patterns between the regions characterise the utilisation of digital services related to commuting. Basel Region is the most advanced in the "use of Internet for commuting info seeking" whereas in Finland and Austria show similar patterns (the relative shares of high use/moderate/low use). The high share of public transport in commuting in Basel Region also shows up in the scope and intensity of the various "activities during commuting", in which Basel Region ranks the first.

Regarding satisfaction and motivations related to the present modes of commuting, i.e., what is appreciated and what is not, there are distinct commonalities across the regions but also region-specific differences. Overall, GFC commuters are the most satisfied and the Austrian commuters the least satisfied with their present modes of commuting. On aggregate, we found that commuters are satisfied with their present mode of mobility: more than 80 % are satisfied or very satisfied. Based on the ANOVA tests, there are no interdependencies between the levels of satisfaction and the modes of mobility. Dissatisfaction is not associated with specific modes of mobility either. The most significant drivers to encourage commuters to use more public transport are: 1) more frequent service, 2) decreased travel time, 3) cheaper tickets, 4) better connecting services, 5) tickets provided by employer and 6) improved reliability of public transport.

It is very common to combine other activities to commuting. Shopping is by far the most common: nearly 80 % of the respondents combine shopping with commuting often or sometimes. Also, social activities, leisure or sports or using public services are combined with commuting trips at least sometimes. Education (17 %) and picking-up someone (15 %) are less common activities.

Of the two most prominent reasons for using a private car, the commuters have a shared view across the three regions. The highest valued advantages of using a private vehicle are flexibility and speed of travelling. On the other hand, the lowest ranking reasons are environmental concern, transport of other people, and avoidance of traffic jams. As expected, the rationales for using public transport are very different from those of using private cars. In general, environmental concern is the most often mentioned motivation among the commuters to use public transport. The second most important rationale is price, implying low costs of commuting. The survey results indicate that the most important enablers to increase public transport are more or less the same across the three regions. Ticket prices, better connecting services, decreased waiting time and frequent services are all pragmatic enablers related to the higher efficiency and service intensity of public transport and the travel chains. There are, however, regional variances, which may indicate impacts of different tariff policies and the efficiency of public transport.

The respondents in all regions and countries were quite suspicious of the new modes of commuting (ride sharing, car sharing, shared on-demand services, bike etc.). This result is consistent with commuters' relatively high satisfaction with their current transport means. Another potential explanation is that many commuters - or people more generally – are not fully aware of the emerging commuting modes and therefore they cannot yet consider them as viable alternatives.

2.1.2 Profiles of commuting groups

Another goal of the study was to identify typical user groups (households) in the regional samples sharing specific characteristics pertaining to the modal choice and its most relevant factors. As a multivariate method for multidimensional data, statistical two-step cluster analysis with SPSS was used to identify groups and relevant criteria of modal choice segmentation in the transport systems and respective demographic, socio-economic and spatial contexts. Two-step cluster analysis also automatically selects the number of homogeneous clusters. The two-step clustering method was applied separately to the data sets containing only valid, complete and plausible cases (responses) from Austria (N=240), Finnish Growth Corridor (N=456), and Basel Region (N=166). The main research questions addressed with cluster analysis were:

- Are there, and what kinds of, distinguishable user (commuter) groups?
- What are the most prominent determinants of modal choice in commuting? For example, to what extent does the disposable income influence commuting behaviour?
- How do the interdependencies and dynamics compare across the three case areas in Austria, Finland, and Switzerland?

Variables for the cluster analysis were household size, residential location, the number of children, dominant modal choice and workplace location. Household income and single parent family as a household structure turned out to be less of importance as a predictor. Based on these seven variables, the clustering algorithm produced five internally homogenous clusters of approximately same size both in Austria and Switzerland, while Finland had seven different clusters. As an example, the variables and their relative importance for cluster formation in Austria are shown in Figure 1.

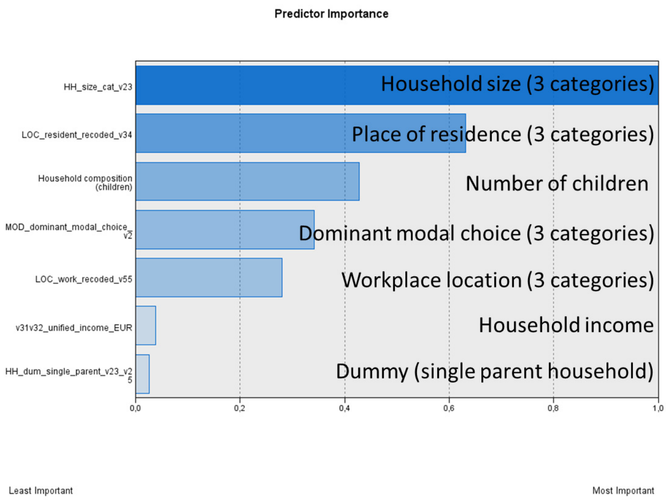

Figure 1. Variables' importance for cluster formation in Austria.

Profile 1 consists of urban single person households predominantly using public transport and to a lesser extent active modes (walking and cycling). Their workplace is located in the urban area, and they have relatively low total household income.
Profile 2 consists of couples or small family households (2-3 persons) living in a semi-urban environment and working in the city centre. They are typically car-reliant, but occasionally engaging in active modes. They share a relatively low household total income.
Profile 3 consists of large-family households located in a rural environment and heavily relying on a car. They have urban workplaces and average total income.
Profile 4 consists of well-off urban couples or small family households. They work and reside in urban areas or city centres and have high total income. They are a) heavily reliant on a car and b) the least active (walking/cycling) compared to other profiles.
Profile 5 consists of urban couples or small family households with a very high affinity towards public transport and active modes. They have an average income.

In general, the Swiss clusters of commuting profiles are highly similar, the main differences being in the commuting modes – higher car reliance in Austria and higher shares of active modes in Basel Region. As this difference owes largely to the spatial differences of these regions, it is concluded that these regions share some cultural characteristics, which may be linked to their geographic proximity.

The composition of user groups in Finland differs from Austria and Switzerland by a greater degree of heterogeneity within the sample, which explains the higher number of clusters – seven – but also by a different factor importance for cluster formulation in the clustering process. The dominant modal choice plays much higher importance, which means that it is more a cause than just a consequence, which is a clear contrast with the other regions. The fact that private cars are used by singles and small families in commuting to urban working locations indicate that the choice of a private car is justified by other than rational grounds only. In other words, the data supports the conclusion that more than in the other surveyed countries, a private car is associated with specific cultural values in Finland, e.g., private car as a status symbol. While the user profiles in Finland shows some distinctiveness in comparison to the other regions, the homogeneity within the user groups in Finland highlight the explanatory power of the chosen background variables.

Based on the cluster analysis, the existence of relative homogenous user groups among commuters suggests that specific needs concerning transport exist within each group. Accordingly, while the enablers for increasing the use of public transport or emerging services consist of lower ticket prices, more frequent services, reduced waiting times, etc. at a general level, they will have substantially different impacts on the user groups. This means that the likelihood of modal shift subject to the introduction of new services will be different for each group: while some groups may be quick to take up new commuting services, others may totally ignore them.

It is logical to assume that also the future modal choices are influenced by the cluster factors used in our study. Knowing about the cause and effect patterns behind modal choice will significantly support the development of new services and help improve their market potential. When designing new services to commuters, transport service providers are well advised to 'know' their potential customers well regarding the socioeconomic and demographic characteristics as well as the operational area of the services. On this basis, new services are customized to fit the respective commuters' needs, and market potentials can be assessed more realistically.

2.2 User needs and MaaS potential

In the beginning of the project, we realised that there is abundant statistical data available on commuting behaviour and its determinants. However, the existing data on the potential of MaaS in commuting is still limited. To fill this gap, we collected new kind of commuting data using a focus group method along with the survey on commuting behaviour in Finland. In addition, we wanted to know what kinds of information and conclusions are obtained from these two complementary data collection methods. The results are discussed in more detail in ICoMaaS 2017 conference paper.[7]

[7] Haahtela, T. & Viitamo, E. (2017). Searching for the potential of MaaS in commuting – comparison of survey and focus group methods and results

2.2.1 Focus groups data

Focus group is a form of qualitative data collection method consisting of interviews and discussion in an interactive group setting. Usually from 6 to 10 people are asked about their opinions, beliefs, and attitudes towards a selection of topics. We arranged six focus groups in Autumn 2016: two in October in Hyvinkää in the Growth Corridor Finland (a region between the capital area and Tampere region) and four in Turku in November in the southern growth corridor (region along the southern coast from Turku to capital area and Hamina city). In all of these six focus groups, the participants had a higher education level than the population on average. Participants also had more children and larger family sizes than average Finnish population or those answering the survey discussed before.

Each focus group session was divided into two sections. In the first section, we gathered information about the present daily commuting habits of participants. Participants were asked to illustrate and draw a simplified picture of his/her typical daily commuting behaviour. The reason for using a drawing was to make people feel more relaxed when describing their commuting. It was also easier to discuss and share own contributions with others when the picture could be used as a framework for explanation. To support the participants in this task, a simple illustrative model picture was shown to the participants. The participants' pictures were supposed to show 1) the modes of transport, 2) the distance, 3) time taken by the commuting mode, and also to illustrate 4) what other activities (e.g., shopping, dropping kids to school, social activities) were combined with commuting. After completing the picture, participants presented their daily commuting patterns to others and told why they had chosen the transport alternatives they were using.

The second section started with a short video that explained the Mobility-as-a-Service (MaaS) concept to the participants. After the video, participants drew and wrote in their pictures the possible changes that MaaS could have in their commuting patterns. The participants were encouraged to discuss different alternatives. During the second section, we also applied a threshold method (Figure 2). We asked what kind of services participants would like to have in the future that could change their mobility patterns. To stimulate their thinking, we suggested several different new services and ideas, e.g., car sharing services, ride sharing, grocery home delivery and using electric bikes. The purpose was to find out what kinds of services would be the 'threshold services' that would make them change their commuting patterns. Of special interest were the kinds of solutions that would be needed to make the change from using private cars in commuting to for more sustainable alternatives.

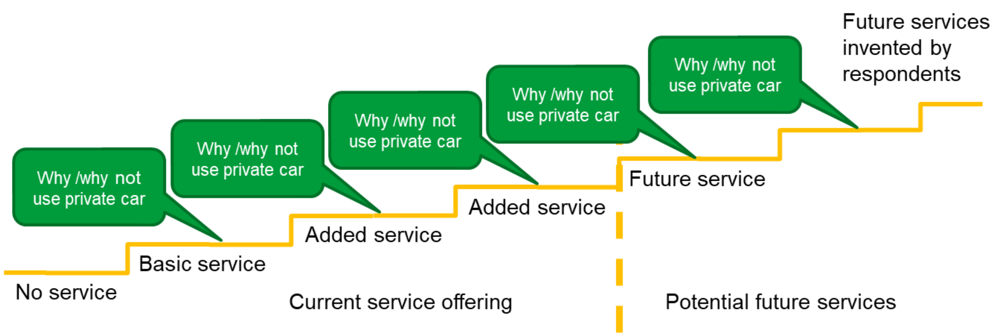

Figure 2. Threshold method used for inquiring what would change a commuter's mobility patterns.

We recorded each focus group session and collected the participants' drawings. In the last stage, we analysed and summarised the findings, and found out that the recorded explanations revealed especially the motivational aspects affecting individuals' choice of transport mode in commuting.

2.2.2 'Threshold services' able to change commuting patterns

Commuters seem to choose either walking or biking for their daily commuting if the travelling distance is at most 3 - 4 kilometres. However, in Finland half of the trips longer than 2 kilometres are already made by car. If the commuting distance was longer than 3 - 4 km, commuters in the focus groups used public transport or private car. Typically, private car users told that they save significantly time, half an hour or more, when using their own car instead of public transport. Focus group participants' children also saved time when the parents either took them to school or picked them up by car. If families had not used cars in these situations, their children would not have had enough time to come home, eat something, do the homework and go to their leisure activities. Also in the outskirts of the city, the participants considered headway between the buses too long.

The participants noticed that there are significant annual fixed costs related to owning a car, but the variable costs of driving additional kilometres are low. Once the car is bought, it is also used for those trips that could be made by other transport modes. Using a private car in Finland is in some cases even less expensive than public transport, if someone needs to buy two or more different tickets from local public transport operators. The participants also raised different work-related topics that required the use of a private car and a common reason for commuting with a car was that participants needed it in their work – for example to access different external meetings and sites. Sometimes a private car was considered the only mode of commuting that allows work-related phone discussions or joining in teleconferences. Some participants also said they like driving a car and, therefore, would anyway prefer it as a way of commuting.

Another finding from the focus groups was that commuters having children often combined other activities with their commuting. The two most common tasks were bringing kids to a kindergarten or to a school and doing groceries. The third most common combined activity was sports. Without these 'side-tracks' some of these participants would have used public transport as their main mode of transport.

When discussing their daily commuting and the choice of transport mode, it became clear that choosing the place of living and the transport mode used in commuting are related to each other. Some families rather live outside the city area in a larger house and use cars for daily commuting and other activities. There are families who live in smaller apartments closer to the city centre and use public transport for daily commuting. Both of these commuter groups justified their choices with their values: some prefer more space and freedom while others want to live closer to the services and support green values.

The satisfaction with the chosen mode of transport was on average good. For longer distances, train was considered a good alternative as the time spent on trains was often used either for working or used as spare time. The most significant challenge for long-distance commuters in the growth corridors was the last mile problem and matching the timetables of different transport modes. The latter is a challenge partly because train and bus stations are often not in the same location as many of the buses leave the passengers to the bus stops of the highway instead of driving to the city centre. Therefore, travelling between two cities in these corridors with public transport is difficult unless at least another end of the trip is close to the bus stop or railway station.

2.2.3 Needs for future commuting and MaaS

When thinking about future commuting possibilities and MaaS, participants of the focus groups mostly had very limited viewpoints on how their mobility patterns would change. Most of the expressed ideas were related to the improvement of some present modes of transport, for example, having smaller headways in public transport. Also, many of the ideas presented were already implemented by some public transport authorities.

The most common expressed need was to have a mobile application that would integrate all the different modes of transport, show different vehicles in real time and allow buying a ticket for the whole trip. In addition, the possibility for re-routing in case of delays was high in the list. Typical suggestions were:

- Real-time information on the location of public transport vehicles (buses, trams, trains etc.). The information when next buses are expected to arrive could be shown in the bus stops.
- Enhanced travel chain optimiser application that would dynamically suggest alternative travel chains, if the original one is not feasible anymore, e.g., due to delays. The same application could also announce when it is time to leave the vehicle.
- A service that would tell different travel chain alternatives between the destination and the current location based on price, travel time, CO_2 emissions etc. In addition, the ability to buy the ticket for the whole travel chain from a mobile application would ease the use of public transport.

Focus group commuters hoped that buses would stay on schedule and that the headways were shorter. Railway commuters suggested 1) silent cars for sleeping or working purposes, 2) better internet connections and charging possibilities for mobile devices, 3) possibility to have a cup of coffee and a snack in trains and stations (at least a vending machine) and 4) having a gym or exercise bikes in the train. Commuters using bicycles were mostly satisfied with the present situation. They recommended 1) better cycling opportunities and roads, 2) more and better bicycle parking facilities next to the public transport stations, 3) possibility to take a bicycle into the train for a reasonable fee and 4) using different gritting sand in the winter to lower the risks of tire punctures.

A new national level ticket pricing system in Finland was also considered a necessity. The price should be based on the distance travelled instead of the somewhat artificial travel zones currently used (or there should be more smaller zones). The present monthly ticket pricing should be changed so that those commuting only three times a week would also get discounted prices. This would encourage commuters to use public transport instead of a private car.

Commuters of the focus groups were not eager about ride sharing. Some argued that they would feel uncomfortable in a car with a stranger and that their schedule would be more dependent on others' travelling times. Ride-sharing was seen as a viable alternative only if there are many people offering rides via some applications. On the other hand, different car sharing models (floating or fixed station based, peer-to-peer systems or shared company cars) were seen as viable options, if the prices are competitive.

Finally, there is a distinct lack of MaaS-related services, especially for the last mile transport needs. To improve the present situation, the participants using buses for longer distances suggested a service, continuous shuttle buses to city centre, or some other alternative. Thus even in the cities, new mobility solutions are needed outside the rush hour, especially in the outskirts.

2.2.4 Discussion and conclusions

Both research methods show that commuters are highly satisfied with their present modes of mobility. Regardless of the mode, commuters prefer the same dimensions of satisfaction: flexibility, speed, reliability and the ease of use. What mostly seems to determine the mode of transport is the travel time difference between transport modes. This became quite evident especially in the focus groups. Furthermore, if there are children in the family, and therefore more mobility needs, it is more likely that the family uses a private car to save time.

According to the survey and focus group results, the commuter cannot yet identify the usability and the benefit of the new emerging modes and services like MaaS. However, the focus group method revealed latent needs of the participants that can be solved with MaaS and related concepts. Moreover, both methods showed that the most relevant unit of analysis is not an individual commuter but the family and household, which determines the prerequisites for the family members' travel.

According to our survey, 51% of the commuters still use a car as the primary mode of transport. While owning and driving a car may have a lower status than earlier, our focus groups revealed that car driving in commuting is motivated by enjoyment, particularly among middle-aged and older men. Furthermore, commuters would be willing to change to shared cars if the prices and service level were right for their needs. The propensity to increase the use of public transport is higher among car drivers in comparison with the whole sample. Public transport has a specific advantage of allowing other activities to be done during trips: reading, working or enjoying digital entertainment during the trip – however, contrary to our expectations, working during commuting is relatively uncommon activity.

Originally, we aimed to use focus groups as a tool for the design of survey questions, which is also the standard handbook recommendation. The findings of the focus groups showed that the relevant topics were tackled with highly detailed questions in the survey. This would have made the questionnaire too extensive and burdensome for the respondents, which necessitated some compromising with the research questions. Moreover, we concluded that it might be more practical to use both methods in parallel to investigate different but complementary issues of commuting.

According to our survey, only 15-25% of commuters could imagine of using the 'new modes' of commuting, i.e., car sharing, on-demand transport services, or bike sharing. In contrast, when the same questions were asked in the focus groups, most of the participants were favourable towards them. This highlights the fundamental differences of the two methods. When the questionnaire deals with unfamiliar and novel concepts, the respondents tend to skip the question or answer negatively rather than stop to think about the question thoroughly. The context is different in the focus group sessions; participants have more time and they can be guided to think the topic from their own perspective. In our focus groups, for instance, the participants first thought of their commuting patterns with a picture and text. This enabled them to imagine how the new concepts could be used in their own contexts. Moreover, if some service concepts were unclear, it was possible to have a clarification and further information from the moderator.

We conclude that survey and focus group methods complement each other. Both methods reveal that there is a demand for MaaS and new innovative Maas-related services among the users. Furthermore, the methods show that the reasons why private cars are used in commuting are highly rational. In particular, commuting modes and the places of living are interdependent value-laden issues decided jointly within families. This interdependency also explains the high levels of satisfaction with their present modes of commuting.

The survey does not provide sufficiently in-depth knowledge that would help to understand user-specific mobility needs on individual and household levels. Focus group method is more appropriate in this sense. Such knowledge on user needs and motivations are of high importance for decision makers, e.g., municipal authorities, city planners, traffic planners, transport authorities and MaaS-related service providers, when planning the sustainable future mobility with MaaS and MaaS-related services. Implications of the results of these two approaches are discussed in more detail in Chapter 7.1.

2.3 Behavioural change triggers

The sustainability of urban transport is becoming one of the biggest concerns in the field of mobility. Transport behaviour of urban citizens is highly car-dependent. New mobility solutions such as car-sharing services are seen as a potential innovative way to improve the environmental challenges in cities. Despite the availability of mobility solutions in the market, there seem to be hindrances why people would adopt this type of services and change their behaviour towards more sustainable urban living. To address this challenge, it is important to identify the factors influencing an individual's decisions to adopt mobility innovations and change his or her behaviour. However, there is no coherent framework to study innovation adoption in transport.

The master thesis study by Chuzhanova[8] provides a fresh perspective on an innovation adoption and a behaviour change in modern urban transport with the focus on new mobility solutions. The thesis includes a synthesis of three theories and introduces a framework including factors, which should be taken into account when developing interventions in the transport sector. To gain a comprehensive understanding of the problem area, particular attention was paid to theoretical concepts related to alternative mobility service factors. Especially, factors that assist in the behaviour change process when mobility services are introduced. These factors of the proposed framework were tested and validated by doing a multiple case study by interviewing transport experts (N=8) in Finland.

The findings of this thesis demonstrate the importance of understanding critical elements in an ecosystem that affect innovation adoption. These elements include the involvement of every stakeholder in addressing individual behaviour change, particularly peers that individuals trust and the government policies. As a part of Chuzhanova's study, the innovation characteristics are especially highlighted as factors having an important role when deciding innovation adaptations in transport. For instance, minimum complexity, an opportunity to try an innovation before making the adoption decision, competitive pricing, and the compatibility to prior

[8] Tatyana Chuzhanova (2016) Behavior Change through Innovation Adoption: A Case Study of Alternative Mobility Solutions. Master's thesis in the International Design Business Management master's programme in Aalto University. http://urn.fi/URN:NBN:fi:aalto-201604201835

experiences were listed as the most influential characteristics. The results of her study serve as a basis for the research on the design and development of interventions in the transport sector with a particular focus on new mobility solutions.

3. Current socio-technical regime in the chosen regions

T. Haahtela, T. Surakka, E. Viitamo, J. Asamer, M. Doiber & F. Härri

This chapter describes the socio-technical regimes in the participating countries and regions. This information is essential when analysing the empirical results about the user needs in these countries, when estimating the impacts and success factors of different business models, and how these models could be improved and transferred to other regions and countries. This information, gathered from the regions and their cases, is also essential when applying the results and formulating policy recommendation for different stakeholders.

3.1 Country comparison

All the countries are welfare countries with a subsidised, high-quality public transport. Additionally, each country tries to support sustainability, reduce emissions and support multimodality in commuting. From an infrastructure perspective, Austria and Switzerland have a long history of using trains and therefore they have a dense railway network. In each country, most people live in growing cities while the population in the countryside remains constant (in Austria and Switzerland) or is even declining (Finland).

Geographically these countries differ from each other. While they all have some less populated areas, on average the population density is higher in Austria and Switzerland than in Finland. Moreover, people in central Europe live in the villages while in Finland the distance between the houses is larger, and single farms are surrounded by fields and forests. All the major cities have high-quality public transport systems including on-demand modes of mobility, e.g., city bikes, car sharing, and new transport services and concepts are piloted frequently. Most significant differences are related to mobility in rural areas. While Austria and Finland have reduced the public transport in rural areas, it is still of high quality in Switzerland. However, all countries are investigating and piloting new ways to improve the efficiency of the rural area public transport.

3.2 Policy and Governance concerning mobility

Austria has three levels of legislation and policies: the federal government level, the Bundesland (state) level, and the municipality level. While Austria is officially a federal republic by the constitution, the legislative power is in practice in the hands of the government. However, while the legislation is the same, different states have different means to fulfil the requirement of the law in acquiring and providing public services. As a matter of convention, national laws that are not constitutional in nature take no priority over regional laws.[9]

The main mode of public transport all over Austria is railways, supported by buses. Austrian public transport, especially in urban regions, is known for its high quality. It is clean, safe and ticket prices are sufficiently low due to the high subsidisation. Intra- and inter-regional associations, e.g., Verkehrsverbund Ost-Region (VOR), are responsible for the planning, financing, and coordination of all public transport services. Multimodality in transport is one of their main strategies.

Switzerland differs from most other western countries by its true three-tier legal structure and direct democracy. The country is a confederation with the federal government. The next level consists of 26 cantons with their own parliaments. The third tier is the city and municipality level with their decision-making authorities.

Finland currently has two-level administration: national and municipality. The development guidelines and legislation in transport come top-down from the government, while the largest cities also have their mobility development programs. The major players in national level are the Ministry of Transports and Communications, the Finnish Transport Agency and the Finnish Transport and Safety Agency. The Ministry of Transport and Communications is in charge of implementing an intelligent transport strategy, and it is responsible for allocating sufficient resources to it within the transport administration sector.

3.3 Three differing regions

The three chosen regions of the Smart Commuting project are large travel-to-work areas with the need for new services and concepts developed by the project partners. Despite the differences in the characteristics of these areas, the development of intelligent transport systems is at the same stage in these countries. These similarities make it possible to implement new mobility services, get experiences about the needs of users and discover some common ground for governance and city planning policies.

The district of Korneuburg in Austria, just North of Vienna, was chosen as an example of an area where people mostly commute by car despite an existing, well-working public transport offer. This is also the area, where ISTmobil started its operations providing on-demand based rides that are a part of the public transport.

The Growth Corridor Finland (GCF) is a cooperation network and a transition platform consisting of 20 municipalities and cities. As a geographical area, GCF stretches from Helsinki to Tampere as a string of cities, but also the city of Seinäjoki (connected by railroad to the GCF) is represented in this collaboration network. It forms the forefront basis of national competitiveness; more than 50 % of Finland's GDP is produced in this area. In addition, GCF is the biggest pool of workforce in Finland with more than 350 000 daily commuters.

The metropolitan area of Basel, one of the five largest city areas in Switzerland, spans geographically to three different countries and has approximately 830,000 inhabitants, with 60% in Switzerland, 30% in Germany and 10% in France. Around 100 000 commuters come from surrounding areas to work in Basel city and of those 36 000 are cross-border commuters. Many of these commuters use bicycles or public transport. The experience of Basel is considered to be a testament of the ability of the multinational actors to overcome the inherent territorial

[9] http://www.nyulawglobal.org/globalex/Austria.html#_2.2_Legislation_/

complexity of cross-border cooperation - which in Basel brings together three countries, including four Swiss cantons, with significant legal and regulatory differences, and even EU border as an additional complexity. One part of the experience is the good cooperation on a higher political level but also activities in developing joint public services for the whole area. One example of these is a tri-national cross-border public transport running since 1997.

3.4 Technology

The whole mobility sector is affected by several parallel technological changes that are currently emerging, e.g., electrification, digitalisation, and sharing systems. Electrifying the means of transport is an ongoing global process. It includes passenger cars, but also bicycles and other new light vehicles. This trend is expected not only to reduce CO_2 emissions but also to improve air quality in the cities. Electrification in different countries is supported by car taxation, installing charging points and changing city buses to hybrids and full-electric vehicles. Also, autonomous vehicles, with differing level of autonomy, are gradually arriving. Various parallel technology developments support this latter trend: increasing computational power, improved sensors, new software and data algorithms, and connected vehicles. However, there are still some issues in technology, standards and legislation that are not yet ready. User attitudes towards autonomous vehicles are also still quite suspicious.

A significant change will also happen as a result of digitalisation and open data in mobility. Innovations based on these trends will allow better multimodality, capacity management and development of new alternative services for the last mile. The purpose is to make the whole mobility user experience as smooth as possible so that people will shift their habit into using more sustainable transport instead of their private cars. For example, mobile payments as a part of the MaaS applications provide more flexibility and allow buying tickets or one ticket for the whole journey at best. Inside navigation, in turn, will ease the use of public transport and the multimodality by simplifying the exchanges between different modes of transport.

Another significant change will be the introduction of 5G networks for teleworking and autonomous connected vehicles. Faster transfer speeds enable teleworking everywhere, also during travelling. The lower latency also supports the development of autonomous vehicles and gives an opportunity to monitor and steer vehicles from a control room if needed.

3.5 Resulting mobility service development in regions

In Austria, cities and governments (also on the state level) support the development of new services together with private partners. Some of these projects and pilots have been implemented and are running successfully so that they continue existing after the end of the test projects. Some pilots and funded projects have even led to services in public spaces and in residential buildings, where different modes of transport are offered at so-called “mobility-points”, usually combining public transport, car-sharing, bike-sharing and other local last-mile concepts with the help of convenient mobile app. On the other hand, Austria has also supported the development of MaaS in rural areas. ISTmobil concept (see chapter 5.1) that started in Korneuburg district is an example of how shared on-demand rides can complement or even be a part of the conventional public transport.

Two distinct features of Switzerland explain the mobility development in general: the confederation of cantons with differing laws, and the strong position of the two large public companies, Swiss Railways and Postbus. The Swiss rail network functions as the core of the public transport system: other public transport connections and their timetables are scheduled according to the trains, and the whole system is prompt as a Swiss clock. Differences in the legislation between the cantons, in theory, provides flexibility for service designers as it is easier to get small changes to the legislation and permission for a local pilot. However, in practice, this is too burdensome for small firms as they would need to have quite many negotiations with multiple parties. In addition, as the subsidised public transport service level is already high and well integrated, there is not that much demand for newcomers. The Swiss railways and Postbus are both countrywide high-quality operators with a significant portfolio of mobility services. They also cooperate with other modes of transport and partly own some new mobility service providers. As a result, most new mobility services in Switzerland are related either to the Swiss Railways or Postbus. While this does not support developing new mobility innovations, the system integration supporting multimodality is on a high level.

In Finland, the current trend is supporting multimodality with smart mobility services, open data, cooperation, and especially the Mobility-as-a-Service concept. The idea is that by digitalisation and enabling legislation smooth multimodality between different modes of transport is supported. Also, new services are eagerly piloted to find new ways to support MaaS and especially solve the last mile problem. The new transport code and other legislation, e.g., related to taxis, have become in act to deregulate and allow new mobility services in the sector that was earlier very restricted by law. As a concrete sign of this, the Finnish government has funded new MaaS concept pilots and given financial support to MaaS operator firms and companies developing MaaS-related mobility services. These MaaS-related services include, e.g., new car sharing models and shared on-demand rides. Cities, in turn, have implemented bike-sharing systems as a part of the public transport. However, despite good intentions, the realisation of MaaS in Finland has been slow and the main reason for this is the decentralized organisation of public transport. Thus, quite in the same way as it is in Switzerland, different service providers have to negotiate with many parties, and public procurement is always a slow process. This makes the market quite small for each firm, and many solutions have been pilots without a clear continuum plan once the pilot is over. Some large public service providers have also not been willing to open their application programming interfaces (API) for buying tickets. However, this has not stopped some Finnish companies from selling their technology to other countries.

Despite rapid development in mobility services, the use of a private car in commuting and everyday mobility has not yet decreased as expected. Partly this is because people are used to their way of commuting, but we are convinced that further improvement of MaaS solutions will give the chance to reach a level where these solutions match or outdo the convenience of private cars - even if they will never convince every commuter to change his or her own habits. Further cooperation between the public and private sector is clearly needed to achieve the sustainability goals in mobility.

4. Stakeholders' needs, motivation and network structure

T. Michl, F. Härri, M. Hoppe & T. Surakka

While previous chapters focused on the needs and behaviours of individuals and groups, and therefore give a general view of ongoing and future trends in commuting, this chapter considers the fact that there are actors, whose agency and power make them more critical compared to mobility users. The analysis of those stakeholders, their importance, interrelations, and opinions and their role in a potential transformation of commuting schemes is done on a theoretical informed basis. This analysis is mainly based on the case comparison between the Canton of Basel-Stadt in Switzerland and the Growth Corridor Finland. The goal of this study was to provide a comprehensive approach for characterising stakeholder interactions in the area of commuting and to gain knowledge about their attitudes to new mobility solutions such as Mobility-as-a-Service (MaaS). Based on the case study in Basel, a stakeholder network was created which provided helpful insights for understanding the stakeholder roles and the network structure within the decision processes in commuting (Chapter 4.2). This network and the expert workshops organised in the project guided the development of the survey looking into the stakeholder viewpoints regarding different transport innovations (Chapter 4.3). More information about the survey can be found in the conference paper presented at the 1st International Conference on Mobility-as-a-Service (ICoMaaS).[10]

4.1 Background

The starting point for this analysis was that both the notion of the need to own a car and the role of public transport in daily mobility are undergoing a transition. Especially the development of open data and mobile information platforms are changing consumer perceptions of public transport services (ITF, 2015). For example, the rising popularity of car-sharing (Shaheen & Cohen, 2016) in Europe has added real options for customers in supplementing mass transit services. These new mobility solutions are enabled and powered by a variety of societal, economic, technological, and consumer-related trends, such as urbanisation, congestion in large cities, and environmental issues of traffic (e.g., Tinnilä & Kallio, 2015).

From the viewpoint of a single transport operator, these new mobility solutions can be seen as competing offerings, but many of the regional transport authorities are already considering the sustainability of the entire public transport system. In addition, the role of regional

[10] Surakka, T., Härri, F., Haahtela, T., Horila, A. & Michl, T. (2017). Regulation and Governance Supporting Systemic MaaS Innovations – Towards Innovation Platforms. Conference paper presented at the 1st International Conference on Mobility as a Service (ICoMaaS), Tampere on 28-29 November 2017. Available at: http://www.tut.fi/verne/aineisto/ICoMaaS_Proceedings_S5.pdf

authorities in organizing this transport is viewed differently in this transition. Some regions and countries in Europe emphasise the policy objectives of public transport authorities such as the economic growth, the space optimisation, aesthetic impacts, the congestion, the social inclusion, and the citizen well-being (e.g., Polis Network, 2017). Others see private mobility service operators as a vital part of accessibility and connectivity (e.g., MaaS Alliance, 2017), for example, in the regions facing a rapid economic change. Both viewpoints call for the transparency and the broad stakeholder participation in the development of the transport system.

While the role of cities and regional transport authorities is under debate, the consensus is that new innovative services are needed to supplement traditional mass transport services in this technological and behavioural transition (Polzin, 2016). Mobility-as-a-Service (MaaS) is one example of these emerging services. Private MaaS operators are currently starting their operations in urban areas with larger customer bases, but the demand-responsive transport is also seen as one of the key options to meet public transport challenges in rural areas (ITF, 2015; Hazan et al., 2016). Regions and countries with strong natural transport monopolies have witnessed a similar increase in mobility services, but they are often a part of the service offering of these natural monopolies. Regardless of the organisation of these new services, MaaS in this chapter is used to describe the change from the mobility as a self-service and from the independent development of different transport modes to a genuinely integrated mobility made possible by new digital services. In the long term, MaaS may influence the city planning, the land use, the role of public organisations, and the welfare of citizens. Therefore, this new concept has gained growing interest among all the stakeholders.

There is empirical evidence of the importance of stakeholder participation when implementing systemic innovations in different contexts. For instance, Schaffers and Turkama (2012) explored the transferability of systemic innovations in home care and independent living, energy efficiency, manufacturing networks and citizen participation. According to their findings, a living lab approach (see e.g. Leminen, 2015) can be used for cases that call for the user-behaviour transformation or business-model innovations. Living labs are by nature local, addressing the needs of specific demographics and developing suitable solutions to these needs. While different MaaS offerings have so far been local, or at most connecting separated islands of urban mobility (cities) to the same offering, Kulmala and Tuominen (2015) point out that an efficient and productive transport system is an essential part of regional competitiveness, the overall economy and people's quality of life. This viewpoint enlarges both the context and stakeholder network of sustainable mobility services beyond the scope of traditional living labs.

The collaboration networks looked into in our project (the Trinationaler Eurodistrict Basel and the Growth Corridor Finland) share the principles of openness and inclusivity, meaning that they are open to all transport actors and inclusive for all kind of users. These networks have a history in the spatial planning, the transport system development and ensuring the economic vitality of the region, but now there are indications that supporting innovations in these thematic areas are also becoming an essential task of these networks.

4.2 Stakeholder network analysis in the city of Basel

Thanks to the stakeholder network analysis, estimations regarding the power and influence of certain stakeholder groups were made. For each stakeholder group, five different centrality analyses, i.e., degree centrality, closeness centrality, betweenness centrality and eigenvector centrality, were performed. In all these analyses, the group 'Administration' shows the highest degree of centrality. According to Hannemann and Riddle (2005), this strongly indicates that stakeholders belonging to this group are the most influential. In addition, the groups 'Transport company' and 'Planning & research' show a quite high degree of centrality, especially when looking specifically at the 'betweenness centrality'. This measurement of power relations refers to a stakeholder's position within the network. A stakeholder's belonging to one of these three most important groups of 'Administration', 'Transport company' and 'Planning & research' can, therefore, be seen as an indicator of pivotal stakeholders. As many connections between other stakeholders run through them, their role is considered as especially important for the existence of the network.

Somewhat different is the interpretation regarding the stakeholders of the group 'Associations & NGO'. While they show a high significance in the 'degree centrality', i.e., number of ties, and 'eigenvector centrality', i.e., how many connections there are to the central stakeholders, their results in the 'betweenness centrality', i.e., how many indirect connections run through them, is quite low. Hence, these stakeholders have contacts to many other stakeholders but are overall not deeply involved in the stakeholder network. Therefore, it is expected that they have a less influential role for the function of the network. The two remaining stakeholder groups 'Industry' and 'Political party' are the stakeholders with the least influence and importance within the stakeholder network. This may be due to the fact that these stakeholders mostly appear as providers of input and as cooperation partners in certain processes.

Participatory stakeholder research can be helpful to classify stakeholders according to their power in order to develop targeted approaches and strategies and to involve the actors in the most efficient way. In addition, it needs to be considered to whom the addressed development has the highest importance. Prell et al. (2009) point out that top-ranked stakeholders are often prioritised in participatory projects, which may lead to partially neglecting weaker stakeholders. The empowerment of those weaker stakeholders, however, can account for substantial improvements as well, depending on their position in the network. Of course, a stakeholder could be pivotal from the network structure perspective, though not too relevant from the traditional participatory stakeholder analysis perspective.

The performed stakeholder network analysis also helped to test a hypothesis. As expected, the official institutions such as the Office of Mobility of the Canton Basel-Stadt are very much at the centre of the network and therefore possess a quite high influence within processes related to commuting. As discussed above, the stakeholder network can be described in its overall qualitative characteristics revealing the possible influence of stakeholders (-categories) according to their centrality and stakeholder clusters. This may answer the questions where respective measures need to be set in order to make commuting more sustainable. However, it does not reveal the views, opinions and experiences of the individual stakeholders and, therefore, does not answer to the question, how these measures should be designed. This issue was addressed in the online stakeholder survey where stakeholders were surveyed regarding their view on trends, innovations, supporting factors or barriers and their experiences within stakeholder processes. The survey was issued in all three of the Smart Commuting case study areas, which made it possible to compare these areas and verify the universality of the obtained results.

4.3 Stakeholders' attitudes towards changes and innovations

The results of the online survey showed that stakeholders see the surveyed socio-economic and cultural developments as generally quite influential regarding their work and strategies. This shows a high level of general awareness in all three case study areas towards changing frame conditions. This awareness may help to sensitise stakeholders and decision makers to improve and change commuting by promoting new mobility solutions and strategies. In Switzerland and Austria, stakeholders are mainly concerned with spatial and socio-economic trends of population and the employment growth around larger cities and the resulting increase in the commuting distance. In Finland, travel behaviour trends, e.g., multi-modality, and technical innovations are seen as more relevant. Additionally, Finnish stakeholders often rate technical innovations very positively. Finnish stakeholders also quite much favour new mobility systems in commuting. Innovations, however, whose sustainability effects are controversial, e.g., privately owned autonomous cars, are seen less positively by stakeholders within the three case studies. One interesting finding regarding the implementation of new sustainability measures that became apparent is that the stakeholder group 'Administration' often shows somewhat above-average disapproval towards innovations.

The consolidated analysis concerning supporting factors and barriers for inducing a change in commuting showed that in particular the factor 'state of technology development' is an essential part in the implementation of new technologies. The factor considered the least supportive one is 'economic viability'. Therefore, it may be that stakeholders could consider investing in new technologies, even if their return on investment is not yet fully known. However, in the context of the expressed lack of willingness to invest or finance MaaS implementation cases by the Swiss stakeholders, this could also indicate that stakeholders do not even consider to financially invest in mobility innovations.

Regarding persisting challenges, the factor 'policy and legislation' is considered to be the main obstruction to the introduction of new mobility innovations. Stakeholders also noted that working and communicating with other stakeholders are not significantly difficult, but the picture is not so clear when looking at the open-ended responses regarding a stakeholder's positive and negative experiences in collaboration activities. On the positive side, the stakeholders of all three countries highlight very good examples of successful collaboration. Often mentioned aspects are the increasing openness for change and innovation in commuting among some stakeholder groups. Brought up examples are the Swiss Federal Railways in Switzerland, traditional private companies in Austria or public administration in Finland. Still many partners are seen more difficult in cooperation: In Finland, the national railway company VR is mentioned, in Switzerland the Car-Lobby, and in Austria, there exists a persisting dissension between taxi companies and car rental companies. Therefore, it seems that many challenges in this area persists, but the stakeholders observe a paradigm change nonetheless, as it is repeatedly mentioned in the answers to open-ended questions within the stakeholder survey.

4.4 Implications for managerial practices

From the perspective of new transport services, the Swiss approach to organising public transport (see Chapter 3) is a double-edged sword. It is quite easy to do different short-term demonstrations as most of the 26 cantons have resources and willingness to try various new services. The downside is that any countrywide solution requires a lot of resources, especially for small start-ups, when they need to analyse all the different rules and negotiate contracts with each of the cantons. Changes in the legislation in one single canton can also endanger the countrywide service promise. However, the single most significant challenge for new transport service providers to establish themselves in Switzerland is the subsidised and an already existing high-quality public transport. Cooperation with different stakeholders is challenging, as the federal and local natural monopolies have the opportunity to restrict the use of their resources, e.g., infrastructure, timetables, booking systems, and IT. As a result, a pragmatic way to establish a new transport service in Switzerland is to a) sell the concept to some of the large cities (for city-related services) or b) to cooperate with either the Swiss Federal Railways or PostBus, and hope that these companies incorporate the service as a part of their countrywide service portfolio.

On the other hand, Finland has chosen to deregulate the industry and utilise the emerging new businesses and business models fully to make transport provision more efficient with increased flexibility and competition. Finnish ministries and regional authorities are making valiant efforts in providing equal opportunities for all the actors and ensuring compatibility of the mobility offers. However, the fast-paced development in Finland has resulted in a very fragmented situation with many of the companies doing overlapping work when trying to serve the mobility needs of the few genuinely urban areas in Finland. With so many different public authorities tendering or organising local public transport, the result has been that transport operators and companies in Finland mainly have incompatible IT systems in use. Currently, the Finnish Transport Agency has opened all the data it produces, and the new transport code includes measures for supporting the use of open data and IT system interoperability. These steps include making the IT system interoperability through application programming interfaces an important selection criterion in public procurements. However, before all these legislative changes are in effect, organising public transport especially in rural areas remains to be a challenge with continuously diminishing population and passenger numbers, and challenges in combining the legally mandatory transport services into one offering more sustainably.

The regional collaboration platforms, such as the Growth Corridor Finland network, are aiming at enhancing the vitality of the whole region – not just the urban areas. For example, Growth Corridor Finland is actively supporting the electrification of the transport system, emphasising the connections of rural areas to efficient (and sustainable) transport corridors in spatial planning and creating possibilities for innovative mobility solutions to provide cost-efficient mobility solutions for people, goods, and services throughout the region. For these tasks, a Growth Agreement between the Finnish Government and Growth Corridor Finland was signed. This agreement resulted in, for example, extra funding for innovative experiments for the period of 2016-2018. The effects of this Finnish approach remains to be seen on the national level, but interestingly there are already first signs of global scaling of the MaaS business models developed in Finland (e.g. MaaS Global, 2017).

The engagement of citizens and stakeholders is one of the critical elements in any regional strategy work. This fundamental duty of local authorities should be enhanced by identifying all the relevant stakeholders and start appropriate, target-group specific processes to engage them. The importance of this process and the introduction of border-spanning, e.g., crossing regional, administrative, cultural, and country borders, innovation platforms is emphasised when dealing with institutional and systemic innovations such as MaaS.

References

Hanneman, R. A. & Riddle, M. (2005). Introduction to social network methods. Riverside, CA: University of California, Riverside. Online textbook. Available at: http://faculty.ucr.edu/~hanneman/nettext/ (Accessed: 14.9.2018)

Hazan, J., Lang, N., Ulrich, P., Chua, J., Doubara, X. & Steffens, T. (2016). Will autonomous vehicles derail trains? The Boston Consulting Group. September 30, 2016. Available at: https://www.bcg.com/publications/2016/transportation-travel-tourism-automotive-will-autonomous-vehicles-derail-trains.aspx (Accessed: 15.3.2018)

ITF. (2015). International experiences on public transport provision in rural areas. International Transport Forum Policy Papers, No. 14, OECD Publishing, Paris. Available at: http://dx.doi.org/10.1787/5jlwvz97dbbs-en (Accessed: 15.3.2018)

Kulmala, R. & Tuominen, A. (2015). Digitalisation in transport – Mobility as a Service. Background document for GB MaaS Workshop 8 May 2015.

Leminen, S. (2015). Living Labs as open innovation networks - Networks, roles and innovation outcome. Aalto University publication series DOCTORAL DISSERTATIONS 132/2015. Espoo. http://urn.fi/URN:ISBN:978-952-60-6375-1

MaaS Alliance. (2017). Guidelines & recommendations to create the foundations for a thriving MaaS Ecosystem. MaaS Alliance white paper. Available at: https://maas-alliance.eu/wp-content/uploads/sites/7/2017/09/MaaS-WhitePaper_final_040917-2.pdf (Accessed: 15.3.2018)

MaaS Global. (2017). Finnish company MaaS Global completes funding round, raising €14.2 million. Press release 2.8.2017. Available at: https://maas.global/finnish-company-maas-global-completes-funding-round-raising-e14-2-million/ (Accessed 26.3.2018)

Polis. (2017). Mobility as a Service: Implications for urban and regional transport. Polis network discussion paper. Available at: http://www.polisnetwork.eu/uploads/Modules/PublicDocuments/polis-maas-discussion-paper-2017---final_.pdf (Accessed: 15.3.2018)

Polzin, S. (2016). Implications to public transportation of emerging technologies. National Center for Transit Research White paper. Available at: https://www.nctr.usf.edu/wp-content/uploads/2016/11/Implications-for-Public-Transit-of-Emerging-Technologies-11-1-16.pdf (accessed 26.3.2018)

Prell, C., Hubacek, K., & Reed, M. (2009). Stakeholder analysis and social network analysis in natural resource management. Society and Natural Resources, 22(6), 501-518.

Schaffers, H. & Turkama, P. (2012). Living Labs for cross-border systemic innovation. Technology Innovation Management Review, 2(9), 25-30. Available at: http://timreview.ca/article/605 (Accessed: 15.3.2018)

Shaheen, S, & Cohen, A. (2016). Innovative mobility carsharing outlook. Carsharing market overview, analysis, and trends. Winter 2016. Transportation Sustainability Research Center. University of California, Berkeley. Available at: http://innovativemobility.org/wp-content/uploads/2016/02/Innovative-Mobility-Industry-Outlook_World-2016-Final.pdf (Accessed: 15.3.2018)

Tinnilä, M., & Kallio, J. (2015). Impact of future trends on personal mobility services. International Journal of Automotive Technology and Management, 15(4), 401-417. https://doi.org/10.1504/IJATM.2015.072876

5. Experiences of implementing new mobility services

This chapter includes six case examples of MaaS offerings and implementations and some experiences gained from them. The cases are the ISTmobil mobility service from Austria (Chapter 5.1), and five cases from Finland (chapter 5.2): AC2SG Software Oy, Liikennevirta Oy, Tuup Oy (currently Kyyti Group Ltd) and Samocat. In addition, pilot experiments of the Growth Corridor Finland, our co-operation partner, are presented.

5.1 Success factors for the implementation of new mobility services

M. Reinthaler, J. Asamer & B. Hu

5.1.1 Introduction

The implementation of new mobility services is prepared in several steps. The concept phase as well as the stakeholder and user involvement are crucial factors for successful implementations. The objective of the optimisation in the process is to incorporate mobility trends and data, identify transport modes and potential mobility hubs, and simulate and evaluate MaaS and sharing concepts such as e-car sharing, car-pooling and bike sharing. This will generate a decision support for regional and urban infrastructure planning and mobility service providers for the efficient use and disposition of resources in the field of mobility.

This case example is about the first steps to identify success factors based on data acquisition, availability and mobility trends, and on the detailed case analysis of ISTmobil mobility service. The consideration of success factors in the design of an optimised MaaS gives a possibility to obtain a guideline and to avoid repeating mistakes. This helps to efficiently implement concepts for MaaS and also transfer them into new regions.

5.1.2 Case ISTmobil

The case example was focused on a region in the north of Vienna, District Korneuburg (Figure 3). As the service of the mobility provider (ISTmobil) has operated in the case area for some years now, different statistics about mobility behaviour were available and the recorded data could be analysed. All the collected statistics were generated by a register-based census and they contain only working commuters (‘Erwerbspendler’), i.e., students are not included.

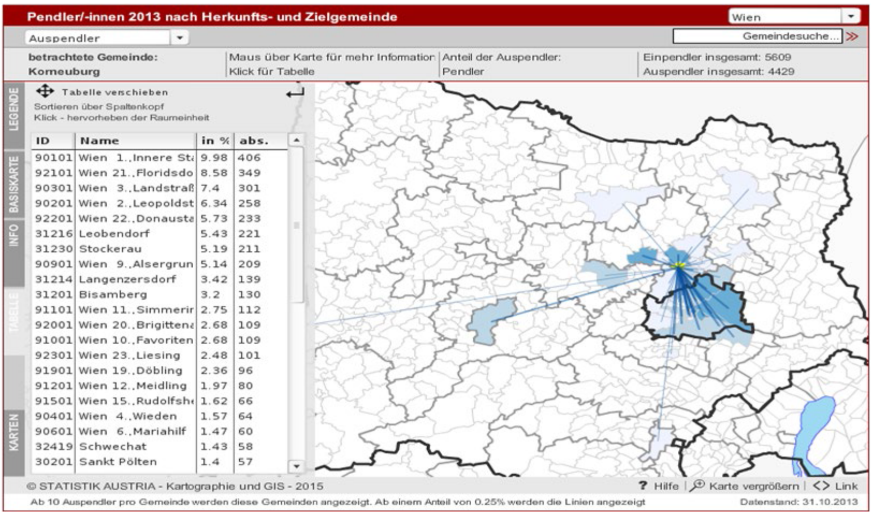

Figure 3. Out-commuter Korneuburg 2013, Source: Statistics Austria.

ISTmobil develops and operates a shared taxi system in Austria. The system is flexible in terms of the pick-up location and time. Moreover, trips are ordered up to one week in advance by telephone or web service. All vehicles of the system are equipped with a positioning system, which enables the tracking of taxis in real time. We used this tracking data to estimate the potential of sharing taxi trips when easing current constraints such as pick-up or delivery time. In Figures 4 and 5, all the points of departures and destinations of customer trips in the sample are visualized.

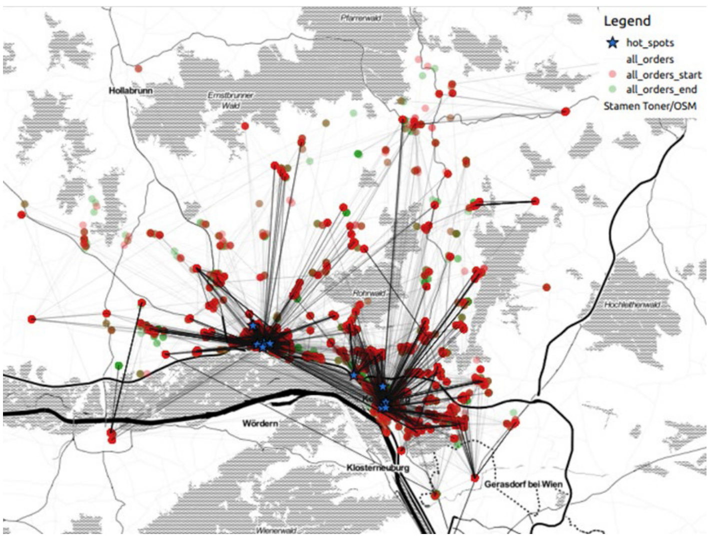

Figure 4. Points of departures and destinations of customer trips. Please note that many destinations (green dots) are concealed by the points of departure (red dots). Blue stars are the ten most frequent points of departures or destinations of trips.

Figure 5. Heatmap for points of departures (left) and destinations (right) of trips. Red indicates a higher number of trips in the corresponding region. Green lines indicate railroads.

The two most frequent locations for both points of departure and destinations are the railway stations of the two largest cities in the district. Therefore, the assumption is that the ISTmobil service is very often used in combination with other transport modes, especially for commuting. The lengths of the customer trips using the ISTmobil service are in 95% of the cases below 15 km and take less than 20 minutes (Figure 6). Half of the trips are even below 5 km and take less than 10 minutes. From this, we conclude that the service is mostly used for short distances.

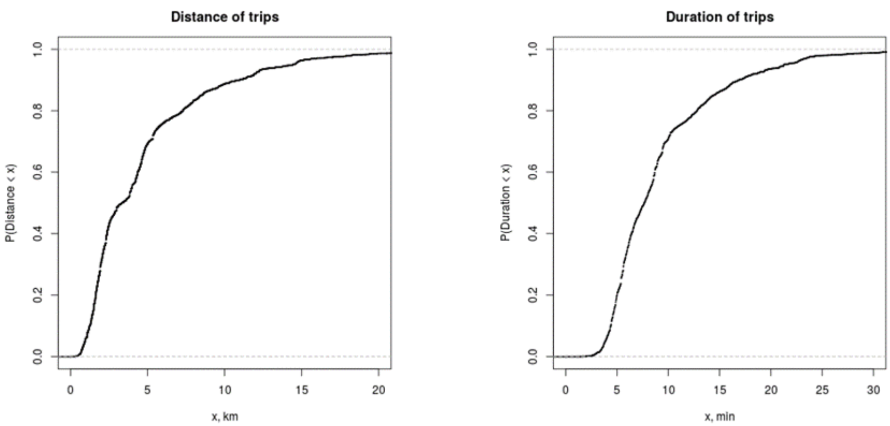

Figure 6. Empirical cumulative distribution of trip distance (left) and duration (right).

5.1.3 Findings

Mobility Trends. When talking about mobility trends, a crucial aspect is the role of private cars. This role varies in different regions, user groups and time periods. While motorisation in the last century was seen as an indicator and a factor of the economic growth, this (public) opinion has changed during the last decades. Because of the negative environmental and social impacts (see e.g. Knoflacher, 2013), the role of the car in our society has been critically scrutinised and is an ongoing topic for research activities.

Steg (2005) pointed out that private car is much more than just a mean of transport. The car usage is driven by instrumental, social (or symbolic) and affective motives. Instrumental motives are more or less objective consequences of the car usage such as travel time, flexibility and costs. Social motives refer to the fact that people want to express themselves and their social position. The affective motives refer to emotions that are evoked by the car, i.e., driving a car will change people's mood and generate positive feelings. Sometimes social and affective motives are merged into social-emotional factors, which are in contrast to rational factors or instrumental motives. Dittmar (1992) argues that in general material possessions, such as motor cars, represent instrumental values as well as symbolic values to us. From this we can conclude that both rational and social-emotional factors are relevant for all kinds of transport modes including the possession of a vehicle, e.g., bicycle, motorbike, scooter, etc. For instance, Goletz and colleagues (2016) identified social-emotional factors to be the most relevant reasons for the increase in the use of bicycles in Santiago, Chile. Two types of cyclists were described: One is a relatively low-income group that has traditionally used bicycle because it is the most cost-effective transport mode. The newer higher-income group consists of young professionals living in relatively central areas of Santiago (Goletz et al., 2016). The authors claim that the latter group uses cycling as a method to express their status of income and education. The negative effects of these social-emotional factors of car ownership are visible in Singapore, where owning a car is very expensive. However, these high costs make car ownership even more desirable as it is considered to be symbol of success. Therefore, people tend to spend a large share of their earnings to a private car.

In general, an increase of the car ownership and vehicle miles travelled per capita has been visible for most countries in the world since 1990. Between 1990 and 2005 people tended to drive more miles per capita year after year. However, since 2005 a shift in this trend is visible at least for urban regions. Millard-Ball and Schipper (2011) investigated this trend for cities in eight different countries (Australia, Canada, France, Germany, Sweden, UK, U.S. and Japan). Based on their analysis, they conclude that travel activity has reached a plateau in all eight countries. Newmann & Kenworthy (2011) lists possible reasons for the saturation of a private car usage:

- Constant travel time budget: People are willing to travel further but not longer. This means if the travel speed has reached an upper limit, e.g., due to safety or environmental reasons, the vehicle miles travelled remains constant.
- The growth of public transport: Due to environmental reasons, the development of public transport is an important topic for every city. As a consequence, public transport is becoming a competitive alternative to motorised individual traffic.
- The ageing of citizens: The average age of people living in cities is rising, and older people tend to drive less. So, the amount of vehicle miles per capita decreases.
- The increasing urbanisation: Urbanisation is constantly increasing and approximately half of the people live in urban regions currently. Because private car usage is more difficult (cost, space) and less necessary (public transport, walking/cycling distances) in urban regions, urbanisation leads to fewer vehicle miles travelled.
- Rise in fuel prices: Although the elasticity associated with fuel price is high, it has reached a level where higher prices lead to a decrease in private car use.

Urbanisation. A trend of the human settlement is visible in the continuous growth of urban regions. According to an UN-Report, the share of people who live in cities has increased in each continent between 1995 and 2015 (UN Habitat, 2016). In Europe and North America, the urbanisation is already on a high level (more than 60% live in urban areas) and therefore this growth is slower compared with Asia.

Urbanisation has impact on the mobility for different reasons. The scarceness of a private and public space influences car usage and promotes the spread of public transports, meaning denser transport network and shorter walking distances to nearby stations. Costs for driving and parking (congestion and parking fees) are higher in many cities compared to rural regions. Therefore, people tend to avoid car ownership and use other modes of transport in urban settings. Moreover, urban citizens can better protect themselves from adverse weather in urban regions and can more easily combine their trips with other activities (shopping, leisure) compared to rural areas.

Work Environment. In western countries, a shift from the secondary sector economy (manufacturing, industry), to the tertiary sector (services) is visible. Moreover, the primary sector (agriculture, livestock farming) plays only a subordinate role. As a consequence, the work environment is influenced by this change. While an isochronal and physical presence of workers is necessary for most secondary sector industries, this is not the case to the same extent for companies active in the tertiary sector. Especially ICT supports employees in this tertiary sector to be less independent of the place and time for working, making flexible working times and teleworking widely prevalent and affecting mobility. The impacts are less commuting trips, less peak hour traffic and a trend to use travel time for working.

E-Commerce and ICT. E-commerce influences mobility patterns of customers as well as transport demands of companies. Over a longer time period, overall travel distances are not observed to decrease (Weltevreden & Rotem-Mindali, 2009). One explanation for this could be that savings in commuting travel times and costs to some extent convert into other or longer trips for non-work activities (Mokhtarian, 2002) Residential and employment location choices may change, which in turn affect travel demand, especially for commuters on a long-term (Niles, 1994). For example, a combination of online shopping with teleworking may offer opportunities to choose a residential location in a more remote area. Living near a work or shopping location becomes less important. Car ownership is another decision that is affected by e-commerce. E-commerce may solve the problem to get purchased goods to home and support the idea to live without a private car, which also affects the modal choice in commuting. However, if e-commerce affects the spatial distribution of conventional shops, the average distance to the nearest store increases for households, and it becomes more difficult to shop near the home. Hence, e-commerce may indirectly reduce opportunities for shopping with active transport modes (walking, cycling) and for living without a car.

Car Sharing. Occasional need for a vehicle and financial savings are typical motivations for participating or providing an own car for car sharing. Car sharing affects car ownership as well as mobility behaviour. Katzev found that in the U.S. 26% of car sharing user sold their personal vehicles and 53% were able to avoid an intended purchase (Katzev, 2003). Also, Nijland et al. (2015) claim in their study, conducted in the Netherlands, a decrease in the car ownership caused by car sharing. In addition, they found that car sharers, on average, drove around 9,100 km per year before and 7,500 km per year after registering for the car sharing service. This decrease is mostly because some owners sold their privately owned car and began to drive far less, as some users also started to use shared cars for trips that before were either not made at all or done with other modes of transport. Although car sharing has the potential to decrease car ownership and mileage, the question is whether it affects travel behaviours of commuters, as car sharing is mostly used for occasional trips and is not so suitable for daily commuting. On the other hand, decreased car ownership fosters the usage of public transport, which in turn is used for commuting.

Electric Mobility. The intention in many countries worldwide is the electrification of mobility. This intention is driven by different objectives such as reducing emissions in densely populated regions, decrease the dependency from oil or increase the energy efficiency of transport (Weiss et al., 2015). The adaption to electric mobility progresses at different paces in different countries (China, Norway, Austria, Germany, USA and India) and is affected by the following factors:

- **Policy Support.** Policy support is an essential measure to foster or even enable the widespread introduction of battery electric vehicles, and it is, as witnessed in Norway (c.f. Figenbaum & Kolbenstvedt, 2016), a very effective measure. Policy support can be divided into incentives and limitations:
    - Incentives include monetary incentives, e.g., subsidies for buying an electric vehicle and tax exemptions or regulations regarding the usage of electric vehicles, e.g., usage of high occupancy lanes and parking areas. An important success factor for incentives is to inform adequately buyers of electric vehicles about them.
    - Limitations are less popular, but may help to foster electric mobility. To create advantages for the battery electric vehicle, limitations pertain to internal combustion engine vehicles. These limitations may be focused on different vehicle types, e.g., diesel vehicle, specific city zones or time periods. A drastic measure to spread electric mobility is to ban completely petrol-powered vehicles, as it is planned in Norway (Staufenberg, 2016).
- **Status of electric mobility.** Most buyers of a vehicle are already very familiar with a combustion engine since this was/is the predominant engine technology for passenger cars. The situation is different in countries where the penetration rate of passenger cars is still growing like in China and India. In these countries, most buyers of a vehicle are 'first-time buyers' and are not used to travel by car, e.g., their parents had no car. For this reason, buyers show less prejudice and are more open-minded for electric vehicles, which benefits the proliferation of electric mobility.
- **Attitude.** There is an increasing awareness of environmental aspects related to transport. For instance, trips and transport modes are evaluated regarding their carbon emission. Moreover, public and active modes of transport are not only chosen because of economic reasons, but also because of consciously choosing an environmentally friendly and sustainable mode of transport.

Autonomous Driving. The trend of autonomous driving is clearly visible in the fact that nearly every car manufacturer is currently working on prototypes for autonomous vehicles and plans to introduce market-ready solutions within the next few years (Glotz-Richter et al., 2015). Based on the level of autonomy, vehicles are categorized into low, medium and high autonomy. Low autonomy means that those vehicles are travelling on predefined routes only in logistical areas and in public transport routes. Medium autonomy means that although the area for travelling is defined, vehicles are able to change their route within this area. Finally, fully autonomous vehicles are equipped with highly intelligent sensor systems and instruments, and they are able to use the whole transport network and may deal with all kind of traffic situations and incidents.

In general, autonomous vehicles may have the following impacts:

- Decrease the number of road accidents
- Harmonize traffic flow and increase traffic density
- Reduce car ownership causing less congestion and more relaxed parking space situation
- Enables mobility for all citizens (children, elderly and physically challenged people) in regions with poor public transport.

Despite of all the advantages of autonomous vehicles, they may also increase the transport volumes as it might become much more convenient to travel by (automated) car.

General Aspects. For policymakers, it is relevant to know, how a specific measure will influence the different motives to use each transport mode. Impacts on mobility trends can be considered from different perspectives:

- Psychology of traffic. Since people in traffic are humans, the psychological aspects are strongly related to traffic. For example, the choice of a specific transport mode is affected by rational and individual social-emotional factors. These factors should be considered in transport mode choice modelling.
- An aspect of health: active (walking, cycling) vs passive transport modes (costs, status, health, convenience, rational and socio-emotional factors).
- Requirements on mobility. Apart from the psychological aspects of the traffic, a transport system has to satisfy objective and subjective user needs. Because of changes in society, settlement structures, working conditions etc., these objectives are shifting as well.

Since the number and complexity of user trips are constantly growing, a transport system has to enable a **more intertwined mobility behaviour**. For instance, the pricing of the public transport has to be designed in a way to enable a large diversity of trips for users, e.g., different destinations. To keep pace with this development, the transport association for Eastern-Austria (VOR – Verkehrsverbund) changed its pricing from fixed zones to user-specific transport fees. Moreover, seasonal tickets in the region are used for a personalized subnet of the public transport system.

References

Dittmar, H. (1992). The social psychology of material possessions: To have is to be. New York: Harvester Wheatsheaf and St. Martin's Press.

Figenbaum, E. & Kolbenstvedt, M. (2016). Learning from Norwegian battery electric and plug-in hybrid vehicle users: Results from a survey of vehicle owners. TØI report, (1492/2016).

Glotz-Richter, M., Karbaumer, R. & Koch, H. (2015). Autonomous vehicles – impacts on mobility of the future, Project report of CARE-North plus - Carbon responsible transport strategies for the North

Goletz, M., Feige, I. & Heinrichs, D. (2016). What drives mobility trends: results from case studies in Paris, Santiago de Chile, Singapore and Vienna. Transportation Research Procedia, 13(13), 49-60.

Katzev, R. (2003). Car sharing: A new approach to urban transportation problems. Analyses of Social Issues and Public Policy, 3(1), 65-86.

Knoflacher, H. (2013). Virus Auto: die Geschichte einer Zerstörung. Carl Ueberreuter Verlag GmbH. (in German)

Millard-Ball, A. & Schipper, L. (2011). Are we reaching peak travel? Trends in passenger transport in eight industrialized countries. Transport Reviews, 31(3), 357-378.

Mokhtarian, P. L. (2002). Telecommunications and travel: The case for complementarity. Journal of Industrial Ecology, 6(2), 43-57.

Newman, P. & Kenworthy, J. (2011). 'Peak car use': understanding the demise of automobile dependence. World Transport Policy & Practice, 17(2), 31-42.

Nijland, H., Van Meerkerk, J. & Hoen, A. (2015). Impact of car sharing on mobility and CO2 emissions. PBL Netherlands Environmental Assessment Agency. PBL Publication, 1842.

Niles, J. S. (1994). Beyond telecommuting: a new paradigm for the effect of telecommunications on travel (No. DOE/ER-0626). USDOE Office of Energy Research, Washington, DC (United States).

Reutter, O. & Reutter, U. (1996). Autofreies Leben in der Stadt: Autofreie Stadtquartiere im Bestand. Dortmunder Vertrieb für Bau-und Planungsliteratur. (in German)

Staufenberg, J. (2016). Norway to 'completely ban petrol powered cars by 2025'. Independent. June, 4. Available at: https://www.independent.co.uk/environment/climate-change/norway-to-ban-the-sale-of-all-fossil-fuel-based-cars-by-2025-and-replace-with-electric-vehicles-a7065616.html (Accessed 15.9.2018).

Steg, L. (2005). Car use: lust and must. Instrumental, symbolic and affective motives for car use. Transportation Research Part A: Policy and Practice, 39(2-3), 147-162.

UN Habitat (2016). World cities report 2016. Urbanization and development: Emerging futures. New York: Pub. United Nations.

Weiss, M., Dekker, P., Moro, A., Scholz, H. & Patel, M. K. (2015). On the electrification of road transportation – A review of the environmental, economic, and social performance of electric two-wheelers. Transportation Research Part D: Transport and Environment, 41, 348-366.

Weltevreden, J. W. & Rotem-Mindali, O. (2009). Mobility effects of b2c and c2c e-commerce in the Netherlands: a quantitative assessment. Journal of Transport Geography, 17(2), 83-92.

5.2 Implementation cases in Finland

T. Surakka

This chapter is based on publicly available material and the partner presentations in Smart Commuting General Assembly meetings and End Seminar. Although the presentation materials of these events have not been published before, we asked the partners to send us versions without any confidential information for the reporting purposes. In addition, we have asked permission to publish the pictures used in this chapter, and our partners have also verified the information used in this chapter before publishing.

We had three company partners with their own budget in the project: AC2SG Software Oy, Liikennevirta Oy (Virta), and Tuup Oy (currently Kyyti Group Ltd). Also, the Growth Corridor Finland, our co-operation partner (without own budget in the project) in Finland, supported implementations within their network.

5.2.1 AC2SG Software Oy

AC2SG Software Oy (AC2SG) is a software solution start-up founded in 2012. Their solutions are based on either software products, specific development projects, consulting services or a combination of them. So far, AC2SG has been focusing on the electric vehicle charging business, demand response and distributed energy generation and storage, and lately on Mobility-as-a-Service consulting and development.[11]

Although typically smart grid development is focused on the technical infrastructure, AC2SG's viewpoint on Smart Grids is that the essential aspects for the proliferation of Smart Grids are information and the new services and possibilities that they offer to the consumers. The technological advancements are important and significant for the overall energy industry and its effectiveness. However, in practice, the customers pay for the investments and make choices on the use of smart grid technologies. Thus, the most important aspect in the smart grid development and technology utilisation is the use of the information to manage the grid differently than in the past.[12]

The use of information was the starting point of the service development in AC2SG during this project. Having worked closely before with multiple customers on planning the infrastructure for electric vehicle charging, AC2SG turned their attention to the assessment of the electric vehicle (EV) charging infrastructure, when it has been deployed, and the customers are beginning to use it. Especially, as the infrastructure network turns bigger and there are dozens of charging points and hundreds of users, the task of analyzing the usage and trends gets increasingly difficult. At the same time, this task becomes more and more important. In order to deal with these challenges, AC2SG introduced a new service that allows this analysis to be performed as a service, with quick turnaround time.[13]

AC2SG started the development from the consumer perspective, i.e., what makes a charging point or a new service compelling to the customer, and how information about this can be used for steering the behaviour in a positive manner ("opt-in"). They were especially interested in the capabilities and the use of e-mobility to positively impact commuting, e.g., by designing

[11] https://en.ac2sg.com/

[12] https://en.ac2sg.com/about-ac2sg-software-oy/about/

[13] https://en.ac2sg.com/solutions/ev-usage-analysis-service/

charging locations and new services for commuters so that private EV use could be efficiently combined with public transport.[14]

The service offering from AC2SG for analyzing the performance and the usage of the EV charging infrastructure was launched in August 2016[15] and tested with the EV charging data for Helsinki (since summer 2015). The data was acquired through Virta, and in this respect, this analysis was related to the strengthening charging network in the corridor based on the collaboration between AC2SG, Virta and the municipalities in GCF. The situation in 2017 in the capital area was that the locations of the charging points were not chosen based on the viewpoint of commuting, although some charging points are near metro and train stations (Figure 7). This fairly small dataset already showed the potential to be analysed in various ways and combined with other data to enhance its usefulness. And although no attempt was made to impact people's behaviour in commuting, new park+ride+charge incentives for parking outside of town centres could be envisioned.[16]

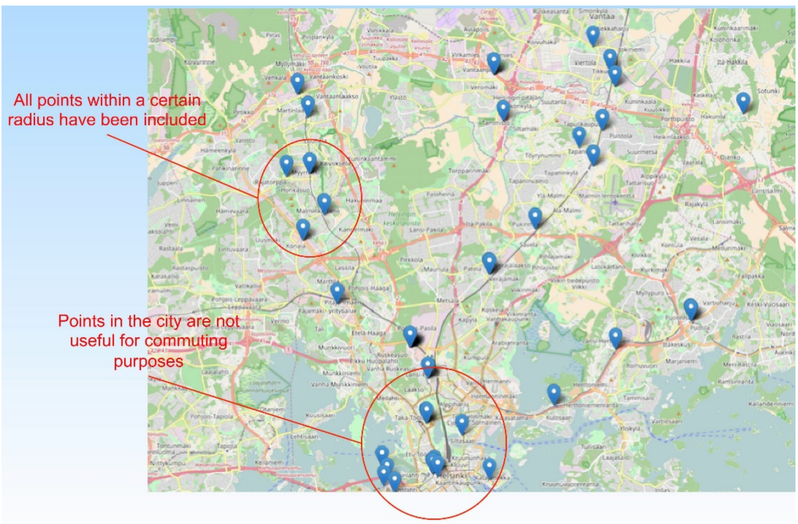

Figure 7. The approach in the EV charging infrastructure analysis to identify locations near public transport. © AC2SG Software Oy, used with permission.

The insights from the analysis mentioned above led to a development effort in collaboration with the University of Tampere and the city of Tampere where the efficient positioning of EV charging infrastructure was considered as a part of the future transport and city planning. AC2SG Software's role was the optimisation of the location of infrastructure based on a number of factors: usability, park+ride use, shared cars, and utilisation of public transport locations. During this development effort, city planning data was utilised and also extended by enhancing current CItyGML models with EV charging infrastructure data.

As a result, a mobility and service hub concept was developed for the new tramline in Tampere (Figure 8). In this concept, certain stations in this line would be developed into mobility hubs with a set of services connecting the needs of users and more sustainable mobility with the wider aims of city and transport planning. In addition to promoting the use of active modes

[14] Smart Commuting 1st General Assembly, 15th June 2016, Vienna, Austria

[15] https://ac2sg.files.wordpress.com/2016/08/analysis-service-overview-aug-2016-v1_0.pdf

[16] Smart Commuting 2nd General Assembly, 21st March 2017, Winterthur, Switzerland

in close proximity of the tramline, sustainable mobility in this concept included the combination of private and shared electric vehicle use with mass transport services when mobility needs originate from outlying city regions (Car City Fabric).

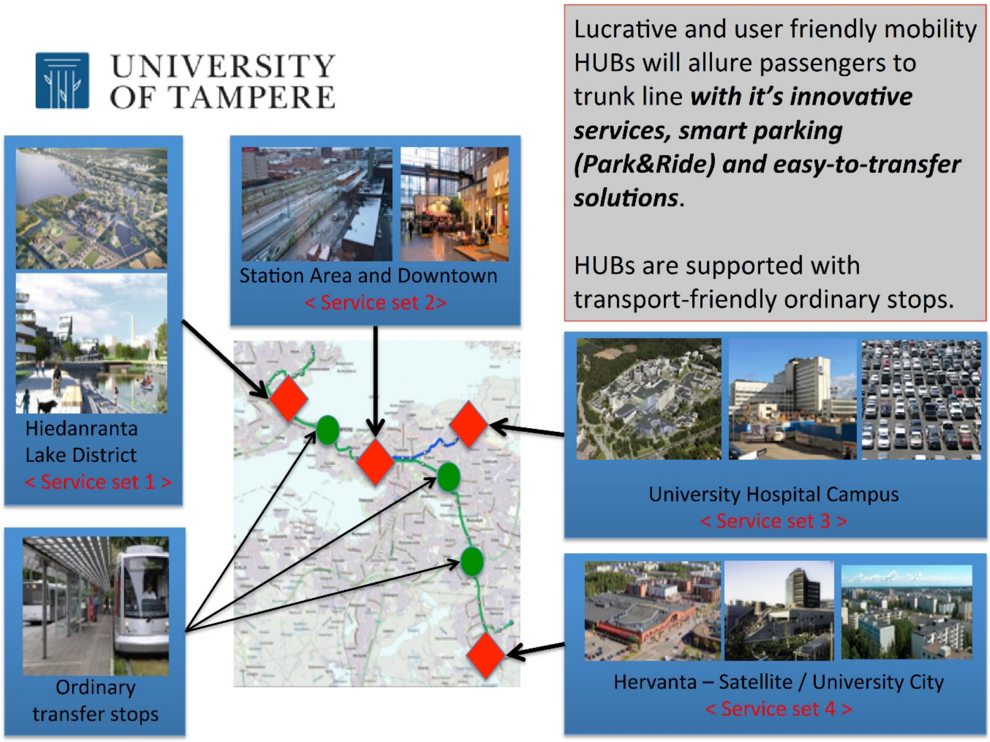

Figure 8. Mobility and service HUB concept for the new tramline in the city of Tampere[17].

5.2.2 Liikennevirta Oy

Liikennevirta (Virta) was founded in December 2013 by 18 Finnish energy utilities to build a national charging network and to prepare for the future of transport. Even before launching their services packages in Finland, Virta acquired their first international customers by providing the necessary tools to support electric vehicles and renewable energy[18]. Virta enables B2B vendors to make business from electric vehicle charging services with comprehensive end-to-end cloud-based and open interfaced IT solutions. Currently, Virta is the market leader offering their service packages in 9 countries and 70 cities around Europe[19].

In this project, Virta focused on two solutions for making work-related travel more sustainable: IT-platform services for electric bus charging operations and electric vehicle charging service solution for apartments and workplaces.[20]

[17] Lintusaari, J. (2017) Smart Mobility HUBs. Presentation held at the closing seminar of the BOMAAS project, 23.10.2017, Team Finland –house, Helsinki, Finland. Available at: https://tapahtumat.tekes.fi/uploads/ae5e31197/6_Lintusaari-9141.pdf (Accessed 15.10.2018)

[18] https://www.virta.global/about-us

[19] Smart Commuting 3rd General Assembly, 30th November 2017, Tampere, Finland

[20] Smart Commuting 1st General Assembly, 15th June 2016, Vienna, Austria

Services for electric bus charging operations are more and more important as a fast-growing number of European cities are changing bus fleet to electric-operated due to national energy policies and environmental requirements, such as restricting diesel combustion engines in inner-city areas.

However, the charging station reliability is a challenge as the technology is still new[21]. To prevent problems for travel chains in commuting, Virta set out to maximise reliability and create an efficient, flexible backend system for the multiple stakeholder use in e-bus operations and charging. During late 2016, Virta implemented service packages to electric bus charging providing infrastructure management tools, reporting and payment services, i.e., invoicing of used electricity from bus operators[22]. In 2017, Virta installed system services for infrastructure management and invoicing of several 400kW opportunity chargers for 12 e-busses in Helsinki region with the actual charging infrastructure coming from two different suppliers. At the same time in Turku region, Virta installed systems services for infrastructure management to two 300kW opportunity chargers (Figure 9) and six 50kW depot chargers serving in total six electric busses[23].

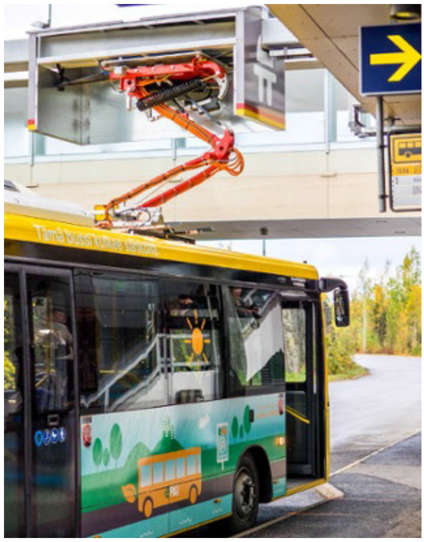

Figure 9. Turku Energia's opportunity charger.

Although larger public charging networks exist in big cities, the lack of charging opportunities in condominiums, apartments and workplaces is slowing the electric vehicle adoption. Electric vehicle owners are often denied for charging opportunities because of non-existing payment solutions for the consumed electricity and thus easy to implement solutions are needed to provide charging point possibilities in these properties[24]. Virta developed a service concept aimed to improve the sustainability of work-related travel with an easy-to-use electric vehicle charging service solution for housing cooperatives and workplaces (Figure 10).

[21] https://www.virta.global/news/virta-provides-backend-services-for-electric-bus-charging

[22] Smart Commuting 2nd General Assembly, 21st March 2017, Winterthur, Switzerland

[23] Smart Commuting 3rd General Assembly, 30th November 2017, Tampere, Finland

[24] Smart Commuting 1st General Assembly, 15th June 2016, Vienna, Austria

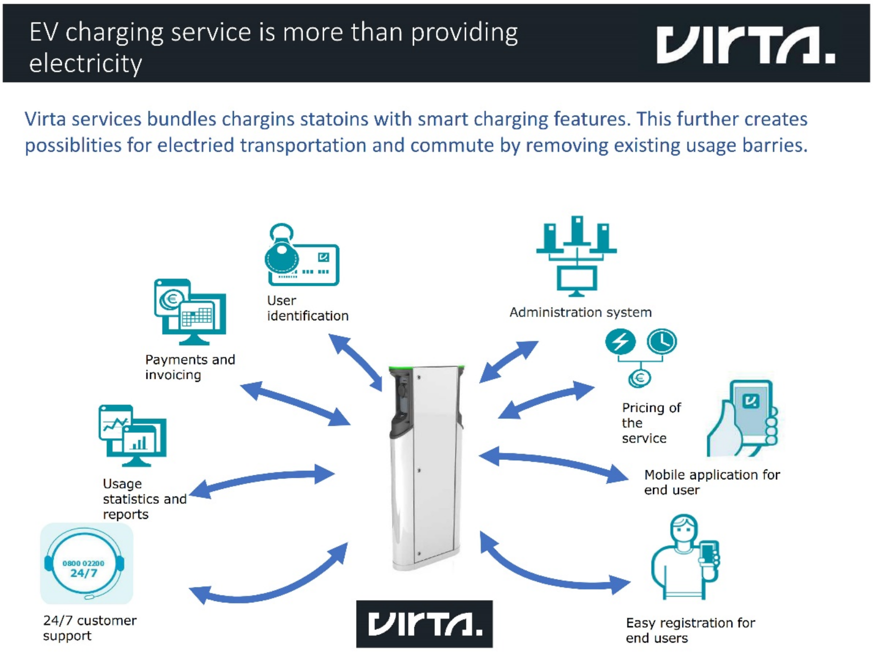

Figure 10. Virta service bundle, which is compatible with a large number of charging station manufacturers.[25]

Currently, Virta's smart management system, available to all Virta Bundle customers, is optimized for the ease of use. The most important features are[26]:

- The charging point owner can set a price for charging in the management system, and base it either on the amount of electricity charged, the time of charging, or both. The income from the charging points is automatically transferred to their bank account once a month through Virta's billing system. This eliminates all unnecessary paperwork, making the experience hassle-free and straightforward. For example, in a residential building, the price can be set as the price of electricity plus a suitable hourly rate. By setting a suitable price, the EV drivers can repay the investment made by the housing cooperative.
- The management system is also used for sharing station user rights, user statistics and controlling charging remotely. For example, only those EV drivers can use private charging stations who are allowed to use the device in the Virta management system. The EV driver can use the same mobile app and RFID for charging at home, at work and at public stations. As the owner, you can always be aware of who has the right to charge at your charging point(s). This is especially important for residential buildings and companies, who want to share charging points only with residents or employees.
- The charging point owner can also use the Virta management system for viewing statistics, controlling charging remotely and reporting any issues. Statistics on used kWh,

[25] Smart Commuting 2nd General Assembly, 21st March 2017, Winterthur, Switzerland

[26] https://www.virta.global/news/virta-management-system

number of charging events, and number of EV's charging can all be viewed in the system. If a station is not working properly, owner can use the admin panel to check its status, restart the station remotely if needed, and start and stop charging events in the panel. If an issue cannot be resolved, owner can also report the problem and allow Virta professionals to take care of the problem.

5.2.3 Kyyti Group Ltd.

Kyyti Group (Kyyti) is one of the largest Finnish MaaS players starting their operations in 2016. During this project, Kyyti developed a new improved application, a new service offering for employers with special mobility needs, operated by shared taxi service in major Finnish city regions (Oulu, Turku, Tampere and in the Capital area) and expanded internationally (Figure 11). Although this project cannot be credited for all of this, this chapter looks at the period when these development efforts were made with resources from this project and from other sources.

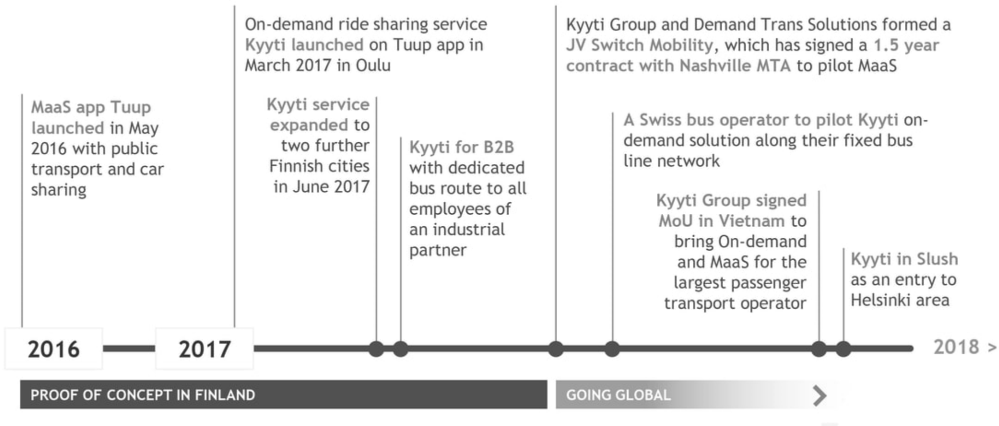

Figure 11. Kyyti storyline.[27]

The development effort started with Tuup MaaS application and objectives to develop tailored service offerings to corporate customers and to international markets based on the early application[28]. At that time, the application and MaaS services were operational in two cities, Turku and Hyvinkää, and all the actors in MaaS sector in Finland eagerly waited for the new possibilities that a new transport code (see Deliverable 3.1 Current socio-technical regime in the chosen regions[29] for more information) would open up. In June 2016, Pekka Möttö became the new CEO of Kyyti, bringing in valuable insights from OnniBus.com, which is a high-quality inter-city express bus service in Finland with a dynamic pricing and a strong branding. In March 2017, Kyyti on-demand ride service was added to the application, and the application won the best mobile service award in Finland in the Utility and Infotainment category of that year[30].

[27] https://www.kyyti.com/team.html

[28] Smart Commuting 1st General Assembly, 15th June 2016, Vienna, Austria

[29] https://smartcommuting.files.wordpress.com/2018/03/deliverable-3_1.pdf

[30] http://2017.bestmobileservice.fi/winners

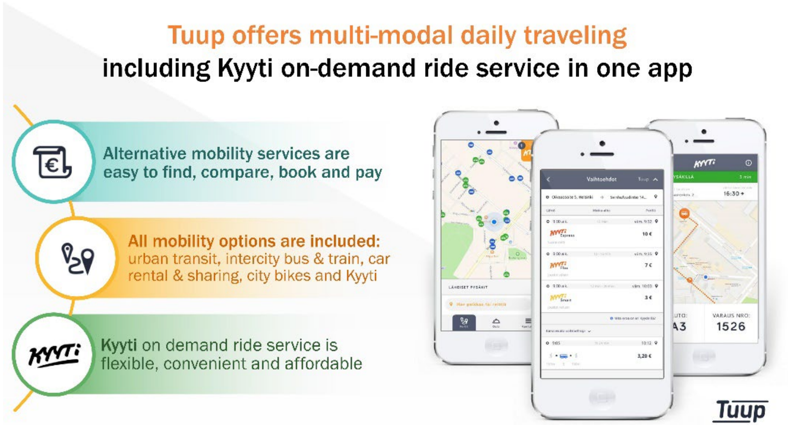

Figure 12. Tuup MaaS application features.[31]

Kyyti on-demand ride service (Figure 12) was introduced into major Finnish cities in 2017. In a very short time, the application got tens of thousands downloads, and the on-demand service was well received by the users. The service is dynamically priced, and customers can choose from three service levels and receive a lower price by being flexible in waiting and/or travel time. The affordable pricing of the service is based on shared capacity and optimised use of the fleet. Kyyti service is designed to complete the demand-responsive service spectrum and replace/supplement existing fixed route service, especially in hard to serve areas[32].

Figure 13. Kyyti on-demand ride service.[33]

In this respect, Kyyti also proved to be the gateway for corporate customers into the era of intermodality - with first B2B customer starting to use the service in 2017 (Figure 13). The needs of these corporate customers and the viewpoints of Swiss stakeholders, explored further during the second General Assembly, became the focal points of these development efforts

[31] Möttö, P. (2017) Tuup's approach to Mobility as a Service. Presentation held at the "Reboot Finland - D.Day for Transport and Mobility" event, 20.6.2017, Espoo, Finland. Available at: https://tapahtumat.tekes.fi/uploads/8b4061090/21_Pekka_Mtt_Tuup_-4662.pdf (Accessed 15.10.2018)

[32] https://www.kyyti.com/english.html

[33] Smart Commuting 2nd General Assembly, 21st March 2017, Winterthur, Switzerland

from the projects perspective[34] (See also Chapter 4). Together with the announcement of collaboration with DemandTrans (USA)[35] and Mai Linh Group (Vietnam)[36] in 2017, the start of 2018 saw a concrete pilot project in Brugg, Switzerland[37] with the name of Kollibri[38].

5.2.4 The Growth Corridor Finland

The Growth Corridor Finland (GCF) is a cooperation network and an innovation platform consisting of 20 municipalities and cities, three Regional Councils, four Chambers of Commerce and four Ministries: the Ministry of Employment and the Economy, the Ministry of Transport and Communications, the Ministry of the Environment and the Ministry of Education and Culture. As a geographical area GCF stretches from Helsinki to Tampere as a string of cities (Figure 14), but also the city of Seinäjoki (connected by railroad to the GCF) is represented in this collaboration network. It forms the forefront basis of national competitiveness; more than 50 % of Finland's GDP is produced in this area. In addition, GCF is the biggest pool of workforce in Finland with more than 350 000 daily commuters[39]. The role of Growth Corridor Finland network is to support different actors in the development of the transport corridor according to GCF vision, which includes becoming the leading experimental platform on intelligent traffic services and systems in Europe[40].

Figure 14. Growth Corridor Finland as a string of cities.

The backbone of the smart accessibility in GCF is the railway line running from the capital region in South, through the string of cities to Tampere, the most populous inland city in Nordics (Figure 15). Connected to this backbone, GCF set out to investigate the requirements and the role of Mobility-as-a-Service as a part of publicly financed transport, railway station areas as a part of modern lifestyles, the electrification of transport, connections to Europe (European collaboration projects such as Interreg BSR project NSB Core), and new ways of working[41].

With the main target to develop and support the smart accessibility in the region, a Growth Agreement between the Finnish Government and Growth Corridor Finland was signed[42]. One of the instruments of this agreement is additional funding for innovative experiments and developing measures for period 2016-2018. These development measures are expected to generate true cooperation between the public and private sector, universities, and research institutes as an ecosystem. During the agreement period, over 40 companies have collaborated in the development activities, and these activities have resulted in over 20 pilots and events in the GCF[43].

[34] Smart Commuting 2nd General Assembly, 21st March 2017, Winterthur, Switzerland

[35] https://www.kyyti.com/news-switch.html

[36] https://www.kyyti.com/news-vietnam.html

[37] Smart Commuting 3rd General Assembly, 30th November 2017, Tampere, Finland

[38] https://www.seniorenbrugg.ch/web/Dokumente/pdf/HV1803/Faktenblatt_Flexible_Verkehre_Detailliert_20180213.pdf

[39] https://suomenkasvukaytava.fi/briefly-in-english/

[40] http://suomenkasvukaytava.fi/wp-content/uploads/2015/01/Growth-Corridor-Vision-_1_3_2020.pdf

[41] Smart Commuting 1st General Assembly, 15th June 2016, Vienna, Austria

[42] Smart Commuting 2nd General Assembly, 21st March 2017, Winterthur, Switzerland

[43] https://suomenkasvukaytava.fi/briefly-in-english/

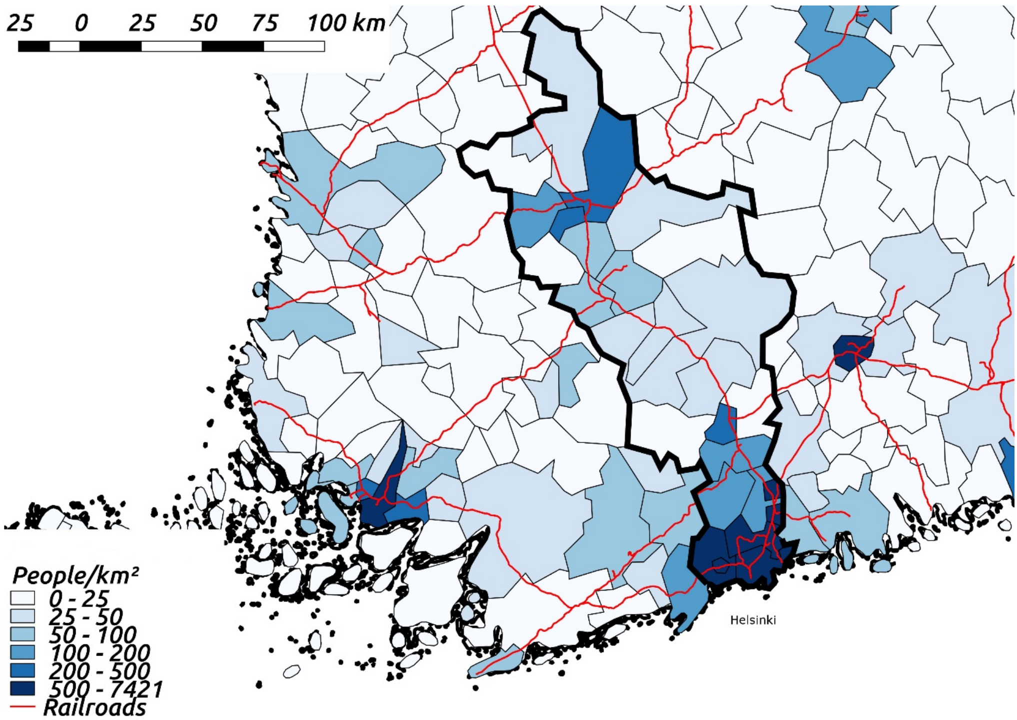

Figure 15. The population density and railroad lines in the main geographical area of Growth Corridor Finland.[44]

The first of these pilots completed in 2017 were the testing of autonomous minibuses in Hämeenlinna (Figure 16) and Espoo, developing a concept for delivering groceries for commuters in Seinäjoki, and testing the suitability of e-bikes as a first/last mile solution in Hämeenlinna. Together with the feedback from public events, these pilots further emphasised the role of railway station areas can have in supporting modern lifestyles in the region. In the theme of agile and sustainable mobility, remote check-in was also tested for one month in Hämeenlinna[45].

The year 2018 has witnessed three new pilots funded from the Innovative Regional Experiments funds. The themes of these new pilots are similar to the previous ones:

- Coreorient (http://coreorient.com/) to develop sustainable mobility services for the railway station areas and mobility hubs in GCF.
- Shareit Bloxcar (https://bloxcar.fi/company) is developing together with several partners new business models combining the best aspects of public transport and sharing economy.
- A partnership led by Sensible 4 (http://sensible4.fi/aigo) is piloting urban shared autonomous mobility in all weather conditions.

[44] Smart Commuting 2nd General Assembly, 21st March 2017, Winterthur, Switzerland

[45] Smart Commuting 2nd General Assembly, 21st March 2017, Winterthur, Switzerland

Figure 16. The autonomous bus tested in Hämeenlinna. Picture copyright Anne Horila, used with permission.

5.2.5 Samocat - a last mile transport pilot

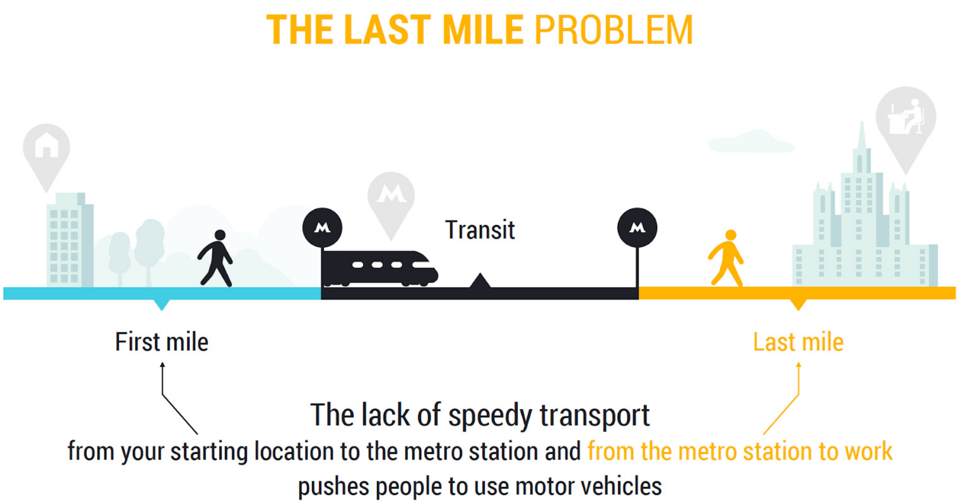

Figure 17. The last mile problem[46].

Samocat Sharing Ltd[47] is an international start-up with Russian roots. The company developed a kick scooter sharing system aimed to solve the first/last mile problem for urban areas (Figure

[46] Anant Shiv (2018) Analysis of last mile transport pilot: Implementation of the model and its adaptation among local citizens. Master's thesis in the International Design Business Management master's programme in Aalto University. http://urn.fi/URN:NBN:fi:aalto-201804032022

[47] http://www.samocat.net/

17). There are first/last mile transport solutions, such as bikes, cars and taxi sharing. Due to the fact that these solutions are rather popular, an adequate amount of research has been done in the MaaS sphere considering their feasibility, user experience and overall infrastructural challenges they bring. However, considering the last mile problem context, the research is rather limited. The recent introduction of city-bikes in Helsinki area is a positive step but these bicycles are not highly mobile when it comes to going through subways, metro stations, shopping malls or university campuses, and they require dedicated parking spaces. The introduction of kick scooters as daily transport could help this problem greatly with its docking station's ability to be hanged up on the wall in tight spaces. The preparations for the service execution are minimal because the infrastructure requirements for such a service are satisfied with normal bicycle and pedestrian lanes.

The system consists of the hardware part (kick scooters and station assembly) as well as a mobile app platform for the payment, system interaction and fleet management. Considering the potential of this service in the context of MaaS, which offers consumers access to a range of vehicle types and journey experiences, the kick scooter sharing system is an ideal candidate for MaaS ecosystem as a last mile transport solution.

The master thesis of Anant Shiv focuses on understanding stakeholders' collaboration, the required business model and user behaviour and experiences for a new first/last mile transport service by analysing a three-month kick scooter sharing pilot. It was done in collaboration with the city of Espoo (https://www.espoo.fi/en-US), Business Finland (https://www.businessfinland.fi/), ACRE (Aalto University Campus and Real Estate, https://aaltocre.fi/en/), and Student Union of Aalto University (AYY, https://ayy.fi/en). The pilot project was carried out in Aalto University Otaniemi campus. The data was collected with the help of user surveys, interviews, trip data and background documents.

The three-month pilot attracted 217 users with 969 rides completed, six stations at major locations serving 40 kick scooters 24/7. The overall adaptation of the service was fairly natural among local residents consisting of students, university staff, visitors and nearby high-school students. Most used stations were those near two main bus stations showing the synergistic effect, which such service can bring with other modes of transport.

The research findings confirm that Samocat sharing contains all the elements that are needed in order to be an ideal mobility service provider and becoming an integral part of MaaS ecosystem, though there are certain hurdles that need to be overcome. First and foremost is the user experience. Overall, users were positive about the user interface including physical layout and riding experience. The mobile application was a field where Samocat needed to work hard as the service is one of its own kind and due to the difference in operating mechanism, it may meet certain ability barriers for motivated users. The second topic is the business model. The current business model was designed keeping the pilot in mind, but for a sustainable business, the pricing model needs to be redesigned. The most important point here is to collaborate with sponsors and MaaS providers to bring financial means as well as users who would fulfil it partially. Having a flexible pricing model that suits most of the user needs is vital keeping offers and exclusive deals as sales catalysts. Third factor is marketing. When starting, Samocat went with the strategy "install and forget" where users come to know about the service when they see it. For a fitting launch of the service, it is vital that Samocat create an attractive marketing plan to involve as many users as possible and highlight the pricing model and subscription benefits transparently.

5.2.6 Evaluation of MaaS value propositions

Megatrends such as social change, urbanisation and globalisation, services and sharing economy, scarcity of resources, and technological advances are affecting societies and economy in several ways. Over past decades, public investments have expanded and improved mobility services across urban areas. However, the transport sector is moving towards advanced mobility supported by strong technology development. Despite the changes happening in ideas and concepts related to mobility, it is a challenge to attract people out of their cars to use public transport or other shared ways of travelling. There are several reasons why many people still prefer to use their own car such as multi-modal purposes of travelling, the availability of alternative ways to commute, and the convenience of travelling. The Mobility-as-a-Service (MaaS) concept and its several applications in many countries address these public transport challenges. MaaS is a service model that frames the mobility based on customer needs, preferences and priorities in which users major commuting needs are offered and satisfied with a single or several mobility service providers.

The master thesis of Iman Asadi[48] focussed on the B2C value proposition offered by a selected number of MaaS providers to determine, how they differ in respect of their offerings to target users, and how they fit with the framework of an ideal mobility service provider. There are two targeted groups for the service: first, travellers who use the services for mobility purposes, and second, businesses and other sectors who cooperate with MaaS providers to run their own services and fulfil user requirements. For the analysis, a framework was built by reviewing several studies on quality indicators in transport. The following characteristics were included:

- Transit mode options: the variety of transport modes that are integrated into a service.
- Service availability: the coverage and possible ways to access the service.
- Service reliability: the capability of the transport system to maintain regular headways or adhere to the schedule and a consistent travel time.
- Information: the availability of the information that is provided by the service for planning and starting a journey.
- Payment options: the available options for users to subscribe and pay for the service.
- Price: the cost of using or subscribing to the service with the cost of other available options, such as a public transport and a taxi.
- Seamlessness: providing a seamless experience for its user including all the steps for planning, choosing, paying, starting, and ending a journey.
- Customer support: resolving possible issues and needs for help with the service making it more pleasant and easier for users.
- Environmental and health impacts: the information provided to the users about the impacts of their travelling mode on their personal health and environments.

Four case services, including Whim, Moovel, Go La, and Moovit, were analysed. By doing that, the performance, strengths, and weaknesses of targeted providers were identified both from the viewpoints of end users and business partners. The data was collected from information available online. In addition, a two weeks testing period for each service was used to evaluate the service availability and reliability during the period. As a result, a set of recommendations

[48] Iman Asadi (2018). Mobility as a Service. Four Case studies. Master's thesis in the International Design Business Management master's programme in Aalto University. http://urn.fi/URN:NBN:fi:aalto-201806293797

is provided to enhance and boost the MaaS development by improving and optimizing its offerings to target groups.

After the benchmark, it was clear that each of these services had some advantages and disadvantages compared to others. Although it is difficult to name a service as the best among others, Whim service in Finland fits best with the MaaS concept. Whim is the only service that offers several mobility modes as a monthly subscription to the user. In fact, it is the only service that also includes all the transport options offered in Helsinki city, in addition to providing a seamless experience to move from A to B.

The wide range of available mobility modes and payment options in these four cases indicates the fact that MaaS' biggest challenges for being adopted and integrated into the current transport system are the difficulties and the challenges of bringing different stakeholders and competitors to share their data and work together. It seems that those countries that are more open to support such phenomena and force or make this collaboration possible are better places for MaaS to be implemented and fully available.

MaaS has a great potential for the daily commuting. From the user's point of view, it can address several difficulties of using public transport service. However, several unclear areas of MaaS make it difficult to define a concrete approach for its implementation. One of the main unclear aspects of the concept is its business model and the B2B offering. The future of MaaS depends heavily on the B2B side of the phenomenon. Defining a concrete business model for MaaS to provide a clear idea of how it benefits the stakeholders competing with each other, makes it easier for those businesses involving in MaaS to decide on implementing it into their services and thus enables MaaS growth as the solutions addressing mobility and daily commuting of travellers.

6. Designing mobility services and solutions

6.1 Conceptualising Mobility-as-a-Service: a user-centric view[49]

R. Giesecke, T. Surakka & M. Hakonen

6.1.1 Introduction

There is a significant lack of understanding of what MaaS is on the conceptual level. Reviewing the state-of-the-art of MaaS research, we conclude that MaaS has all the attributes of a 'hyped' socio-technical phenomenon: it seems to be a loosely connected patchwork of optimistic political dogma, activists' enthusiasm, an anecdotal evidence of successful services and a firm belief of investors in transport network companies such as Uber. However, as a paradigm shift, MaaS has electrified public decision makers and unleashed a wave of innovations in SMEs. Also, MaaS forces researchers to work in multi-disciplinary collaboration, transcending traditional research fields, such as traffic planning, computer science, social sciences, transport systems and organizational behaviour. Consequently, while embracing the innovative spirit of the MaaS paradigm shift, we aim to outline critical conceptual issues of MaaS.

Globalisation, local workforce needs and substantial differences in living costs and salaries across urban, regional and national borders are active drivers of increased mobility. Among the various solutions for coping with such increased mobility, besides avoiding travel in the first place, Mobility-as-a-Service (MaaS) stands out in two ways. First, MaaS has the inherent potential to decrease the use of private cars. Second, MaaS allows – at least on a conceptual level – the transport of passengers and goods by the same vehicle. Thus, MaaS is potentially more sustainable, regarding the environment than any form of personal transport other than walking or cycling.

In the public discourse, MaaS is widely regarded as the next paradigm change in transport. Service providers are expected to offer for travellers an easy, flexible, reliable, price-worthy and sustainable everyday travel, including, for example, public transport, car sharing, car leasing, and road use, as well as more efficient options for goods shipping and delivery. From an end-user perspective, MaaS needs to be user-centric, easy to plan, book and pay, as well as seamless during the actual trip, integrating all transport means and systems, using real-time data, and responding to a broad range of individual user priorities. MaaS also needs to be socially inclusive and permeable to national borders, transport modes, governance types, and other boundaries (cognition, cultures, languages, and currencies).

---

[49] Giesecke R., Surakka T. & Hakonen M. (2016). Conceptualising Mobility as a Service: a user-centric view on key issues of mobility services. Conference paper presented at the Eleventh International Conference on Ecological Vehicles and Renewable Energies (EVER16), Monte Carlo, Monaco, April 6-8, 2016. Available at (requires purchase or subscription): http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7476443

Such perceptions are by far too optimistic at this moment, but there is a realistic chance to achieve such kinds of MaaS offers at the end – when MaaS is adequately conceptualised. For this chapter, we regard MaaS as a socio-technical phenomenon. Such phenomena can be described by analysing the actual technologies driving them and the socio-technical context behind the phenomenon. Such setting is often portrayed in the form of the business ecosystem. Also, the socio-technical phenomenon needs to be defined by its key issues – for instance, its nature, its benefits and on which levels these benefits happen, e.g., on user-, society- and environmental level.

6.1.2 The end-user perspective

The primary distinction here is that some factors such as weather cannot be influenced by the end-user, whereas others are a direct result, for example, from the end-users attitudes and behaviours, which can be changed, at least in the long run. However, some of these end-users' abilities and especially disabilities are intrinsic properties and thus do not change quickly, e.g., the need to use a wheelchair. What the user will address when being asked for an optimal travel offering is often a mixture of needs, e.g., taking into account comfort needs and specific fears when travelling in darkness or with children, but also costs, the traffic network and -offers and commuting needs that are usually defined externally.

Figure 18 shows this complex mixture of internal and external factors that affect each other and in the end influence an individual mobility behaviour. Some of these interconnections are direct and have two-way effects, while others are indirect and appear as end-user perceptions of how different possibilities meet their needs. One way of reducing the end-user related factors is to merge several factors into one overall element, which we call convenience. This factor addresses comfort perceptions, as well as the accessibility and the directness, and a range of further factors, which may vary from person to person. Thus, the convenience is a fuzzy construct, but it helps to understand how, e.g., trip costs and trip distance affect user behaviour. We exemplify convenience in Figure 18 through mapping some currently available mobility offerings distinguished into a short-range and long-range travel. Figure 18 illustrates the principle, not the actual costs or conveniences. Still, mobility offers aimed at providing higher convenience should have better business potential than others, for the same costs.

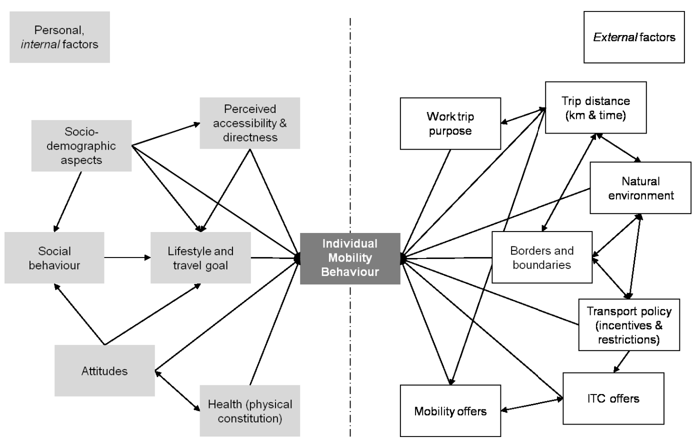

Figure 18. Factors influencing individual mobility behavior (based on the English version of Kemming, Brinkmann & Greger, 2007, supplemented).

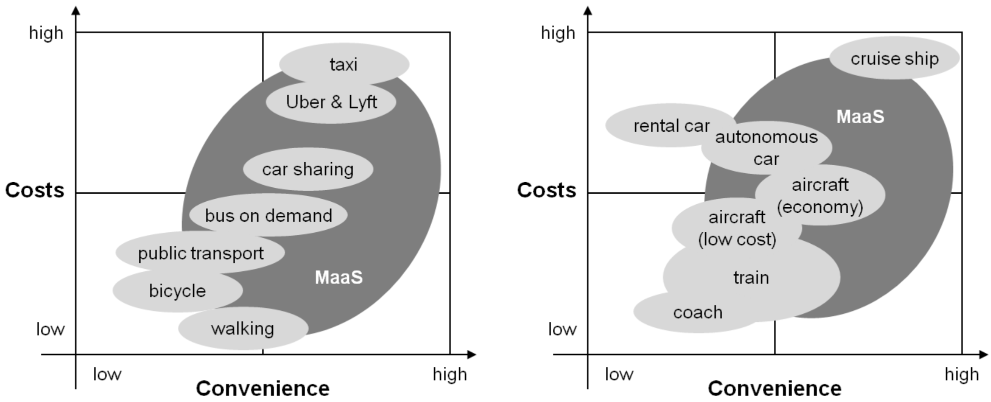

Figure 19. The end-user perspective on short-range and long-range mobility offers (schematic illustrations).

As indicated in Figure 19, end-users are cost sensitive and appreciate the convenience. When asked why they use car, people come up with arguments like the following ones:

- The car is more comfortable
- Need for shopping on the way home
- Need to fetch or deliver kids and spouse
- Need to travel to 'difficult' places during the workday
- Public transport routes are too complicated (not direct enough)
- Work is based on travel and an employer does neither accept nor reimburse other options

We do not claim that this list of arguments is complete, nevertheless, it illustrates how many arguments can be linked to the convenience. The question is, how do different MaaS offerings respond to these arguments? Some researchers have used service levels when categorising different offerings. These levels are typically (see e.g., Kamargianni, Matyas, Li & Schäfer, 2015, 51): 1) journey planner, 2) booking system, 3) real-time information, 4) smart intermodal ticketing, and 5) pay-as-you-go for all transport modes. The problem here is that those levels will become a standard for all kinds and types of transport shortly, even for the public transport. Furthermore, these levels do neither inherently include payload combinations, for instance, a passenger, a 15 kg shopping bag, a baby-buggy, and two kids, nor are the levels of convenience included. Thus, current MaaS providers may need to think far more out of the box and need to investigate in much more detail what the actual user acceptance criteria are in different user segments.

6.1.3 MaaS on a conceptual level

In summary, MaaS currently aims at transporting persons and sometimes goods over a predefined distance, often by combining different means, by making intelligent use of ICT and, less commonly, ITS, in a way that is distinctly more sustainable than the use of a private car.

With these insights, we propose a tentative, conceptual four-step model of MaaS as follows:

1. The actual transport offer needs to be explicit and specified. Ideally, it is used over short and long distances, using a wide variety of different transport means smartly.
2. End users need either save costs while keeping the level of convenience equal (including accessibility, directness, comfort), or increase convenience while keeping the cost level the same. Change to more sustainable behaviour on an individual level is in principle possible – however, the mechanisms are complex and often unpredictable. On the level of the general population, we only know that change may take a long time.
3. MaaS needs to encompass existing offers, such as public transport, car- and bike-sharing and taxi services on demand. The interlink with ITS is of utmost importance, as real-time data and especially real-time traffic control allow operators to implement modal preferences, for instance, to enhance transport convenience of the most sustainable means of transport. Such preference leads us to the final step, the sustainability.
4. Finally, MaaS needs to be as sustainable as possible, taking into account all dimensions of sustainability. This goal requires intensive stakeholder collaboration within the local MaaS ecosystems and also on the regional, national, and international levels, especially with standardisation bodies, authorities, and policymakers.

References

Kamargianni, M., Matyas, M., Li W. & Schäfer, A. (2015). Feasibility study for "mobility as a service" concept in London. UCL Energy Institute, London, UK. Available at: https://www.ucl.ac.uk/bartlett/energy/sites/bartlett/files/maas.pdf

Kemming, H., Brinkmann W. & Greger, S. (2007). Verkehrsverhalten Sozialer Gruppen: Soziale Aspekte Der Mobilität. Institut für Landes- und Stadtentwicklungsforschung und Bauwesen des Landes Nordrhein-Westfalen (ILS NRW). Available at: https://www.ils-forschung.de/files_publikationen/pdfs_protected/trends07-1.pdf

6.2 Service level description and assessment

J. Asamer, B. Biesinger, S. Knopp, P. Nolz & M. Reinthaler

6.2.1 Introduction

This chapter is based on ICoMaaS-conference article[50]. It focuses on the assessment of micro transport services that operate a fleet of vehicles. Such services are used in settings where the goal is to bridge the gaps of public transport in rural and urban areas. The main goal is to transport people between rural places and public transport hubs such as train stations. In comparison to taxis, the fees of such services are quite low. However, multiple customers are driven in the same car at once, and demands must be pre-announced. Municipalities might be willing to subside such services since they profit from the affordable public transport, decreased local emissions, and avoiding car-induced traffic in neighbouring urban centers. We investigated measures for improving operating costs and user convenience of such services based on methods stemming from operations research. Trade-offs between customer travel times and operating costs are analysed and optimised for a real-world setting.

6.2.2 Indicators of services

Service levels and performance indicators. Service levels of demand responsive transport services are divided into those that are directly observable by the users of the service and those only relevant for the operators of the demand responsive transport systems. Regarding the service levels observable to passengers, the following main key performance indicators are investigated, e.g.:

- The difference between the desired time of departure (or arrival) and the departure time confirmed by the operator.
- The punctuality in the sense of the deviation of the confirmed time of departure and the actual time of departure.
- The detour duration is determined by the difference between the actual duration of the passenger's trip and the shortest possible duration of that trip. Detours can appear in demand responsive transport services to combine trips of multiple passengers.
- The number of other passengers and additional stops that take place during the trip.
- The price of the trip paid by the customer.

In addition, there is a range of performance indicators relevant for the operator of the system, e.g.:

- The average cost of performing a trip for the operator.
- The composition of the fleet to be used in terms of vehicles sizes and numbers.
- The operating hours during which each car of the fleet is used.
- The usage of the fleet in terms of a percentage of time the vehicle is transporting passengers.

[50] Asamer, J., Biesinger, B., Knopp, S., Nolz, P. & Reinthaler, M (2017). An optimization based analysis of a micro transportation service. 1st International Conference on Mobility as a Service, ICoMaaS, Tampere 28.-29.11.2017 Conference Proceedings 1st International Conference of Mobility as a Service, 48 - 51.

- The average number of passengers transported at the same time.

6.2.3 Optimization based analysis of real-world data

For this project, a range of data was provided by IST-mobil, the operator of a demand responsive transport service in Korneuburg, Austria. This data comprises transport requests recorded over a period ranging from May 2015 to June 2016. It consists of 257 days for which operational data was available. On average, each day comprised 50 requests. A request states the start and end locations requested, as a well as the time of that request and the number of passengers to be transported. In addition, GPS data of driven routes was available. This data was used to determine instances of a variant of a pickup and delivery vehicle routing problem. Solutions for this problem then specify the optimal routes driven by the fleet of vehicles that is operated. An integer linear programming approach as well as a Variable Neighborhood Search based approach was used to compute optimal routes for a fleet of vehicles fulfilling the given requests. The considered fleet is composed of taxi vehicles. That fleet is further divided into fixed and flexible vehicles. Fixed vehicles are paid by the hour and have fixed service times. Flexible vehicles are only paid per kilometre in case they are in service. Fixed vehicles are also paid a distance-based fee, which is, however, much lower than that of the flexible vehicles. These properties are taken into account in the model. The solution method and modelling are then used to analyse a range of properties from the given data, which is presented in the following.

We varied time window durations, the vehicle capacity, and the number of flexible vehicles. In the following experimental results, if no other indication is given, time window durations of 15 minutes, a vehicle capacity of 8 passengers and zero flexible vehicles are used. Per default, pooling is allowed. This basic characteristic of micro transport services allows combining rides of multiple users. Splitting, i.e., using more than one vehicle for a request of a group of people, is not considered except when stated otherwise.

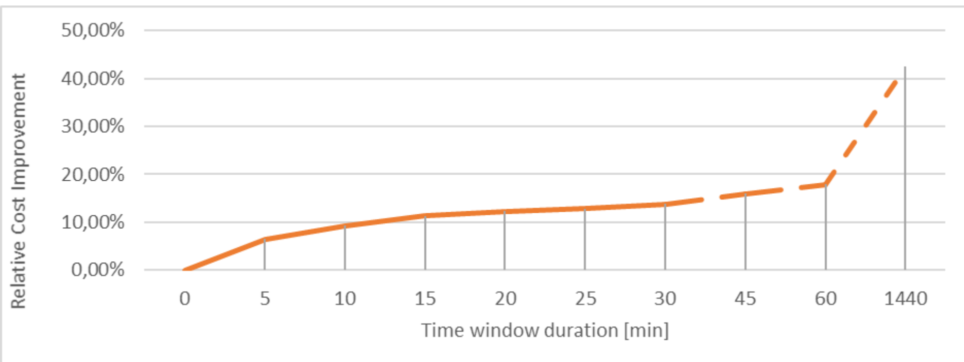

Figure 20. Cost reduction depending on different time window flexibility values.

Figure 20 shows results analyzing the impact of different time window durations. A time window models possible waiting times as well as detour durations. For both, maxima can be specified using a time-window-based modelling. Depending on the allowed duration, we observe an impact on the costs. For example, allowing a maximum combined waiting time and a detour duration of 15 minutes can reduce operating costs by around 10% on average when compared to the solution allowing no waiting time or detour durations at all. The extreme case of 1440 minutes on the right-hand side of the graph is not a realistic time one would allow for waiting.

Still, it is interesting since it shows that the fleet has a capacity of subsuming much more requests, which supports the assumptions that such fleets can be operated much more efficiently, if more vehicles are used.

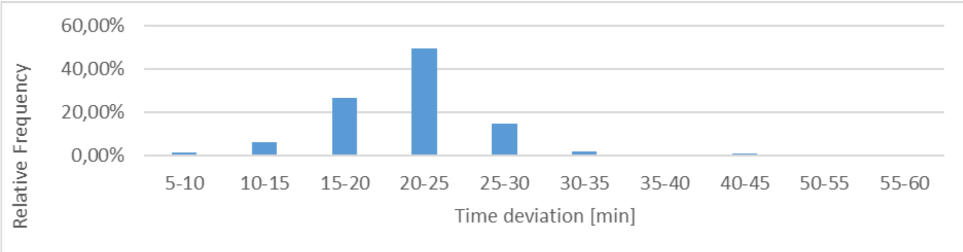

Figure 21. Frequency of time deviations in the model.

Figure 21 shows frequencies of time deviations observed in the experiments. It relates to instances where the maximum length of time windows was fixed to one hour. This shows that allowing one hour as a guarantee has a lesser disadvantage for most of the requests. We see that most requests are still served within well below an extra duration of 30 minutes.

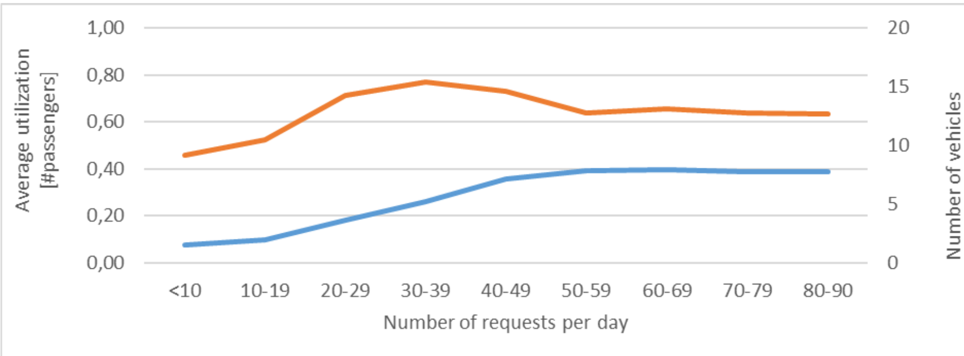

Figure 22. Average utilisation (orange line) and number of vehicles (blue line) depending on the number of requests.

Figure 22 shows the average utilisation of the cars in the vehicles fleet. It is defined in terms of the number of passengers transported. For example, a value of 0.5 means that a car is 50% empty and 50% of the driven distance filled with at least one passenger. We observe that the utilization improves in cases where there are more requests per day. This is explained by the increased possibility to combine requests. However, starting from around 40 requests per day, this number decreases again. This is explained by the increased number of vehicles in use.

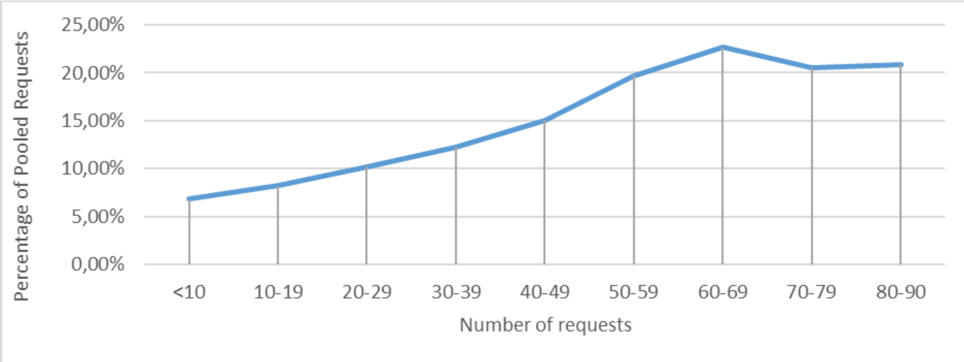

Figure 23. Percentage of pooled requests.

Figure 23 shows the percentage of pooled requests. Complementing Figure 21, we observe an increase in the percentage of pooled requests with a growing number of requests per day. This shows that the demand responsive transport service profits from a larger user base resulting in less costs per request.

6.2.4 Transferability of demand responsive transport services

The aim of demand responsive transport services is to enable the region-wide mobility for all citizens and fill existing gaps in the public transport. Therefore, an assessment of how the service would perform in a novel region where it is not in operation yet would be an important factor for facilitating such an extension. This assessment has several steps:

- Assessment and analysis of individual regional mobility demand and gaps in mobility system. The number of potential users of the system influences the utilization of the vehicles and consequently the profitability of the whole system. Therefore, a thorough analysis of potential users of the system is the key requirement. This analysis includes factors such as the number of users, and the regularity and predictability of the usage (frequent usage with a priori ordering, or occasional usage with spontaneous ordering), but also willingness to wait before being picked up or after being delivered, e.g., at the train station, as well as willingnesss to share the vehicle space with others and to accept a detour.
- Definition of accumulation/access points in the region. Depending on the number of potential users living in the focal area, access points, where users are picked up and delivered, should be determined. The more access points are defined, the more convenient the system is for users in terms of accessibility and flexibility, but the more detours might be necessary / accepted to exploit vehicle capacity usage.
- Development of a tariff system. For the system to be profitable in a region, the tariff system needs to be adapted to user requirements. The marginal cost of accumulating users on one trip done by one vehicle needs to be traded of against the inconvenience imposed on the users in terms of waiting time or additional ride time because of a detour. Eventually, a different tariff could be offered to frequent users ordering a priori compared to occasional users ordering spontaneously.
- Involvement of vehicle fleet operators/taxi companies. To guarantee an optimal usage of vehicles, a shared fleet performing multiple transports during the day for different

operators could be beneficial. The pool of vehicles would then be integrated into the scheduling system and optimally assigned to (new) requests, allowing for a balanced and cost-minimal usage of vehicles, while respecting user requirements.

Methodology and data for assessing transferability. In the following, an outline of a methodology for assessing the transferability of a service to a novel region is given:

1. Derive test instances from input data. This includes the geographical coordinates (of the access points) of the requests as well as the distance and travel time matrix to be calculated for an underlying digital roadmap.
2. Investigate scenarios for relevant parameter settings. This comprises the size of the operating area, the number and capacity of vehicles per time interval, additional temporal considerations (duration between desired and confirmed dates, maximal user ride time), constraints for pooling and splitting requests.
3. Optimise test instances. Determine plans for the given instance on the scenarios to be investigated using a suitable optimisation method.
4. Evaluate solutions based on key performance indicators, e.g., considering fixed and variable cost, utilisation of vehicles in capacity and time, total driven distance.
5. Present a report containing analysis & figures as decision support.

Scalability. A scalability analysis was conducted to further assess the impact of a potentially larger user base. It addresses the question what would happen to the indicators if the service was used more broadly. For this, we used again the data from 257 days between May 2015 and June 2016 with about 50 requests per day. We generated a larger instance from these recorded requests. For this, we first accumulated all requests into one big set of 13.000 requests. From this we generated artificial requests by random sampling without replacement. By this method we obtain instances with 200, 300, 400, and 500 requests per day, which are then used in further computational experiments.

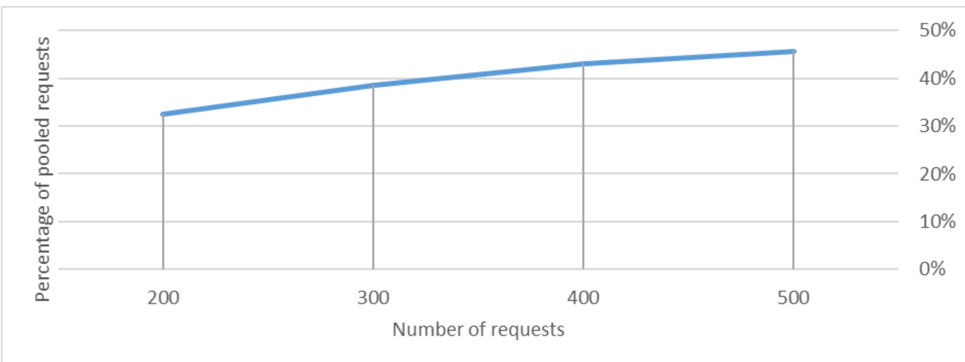

Figure 24. Impact of pooling depending on the number of requests.

Figure 24 shows the percentage of requests that are pooled for the instance generated as described before. We observe that the percentage of pooled requests increases with the number of requests per day. This confirms the assumption that scaling is an important issue for demand responsive transport services. The wider the user base of such a service means that the more efficiently it is operated and vehicles driven around without any passengers is avoided.

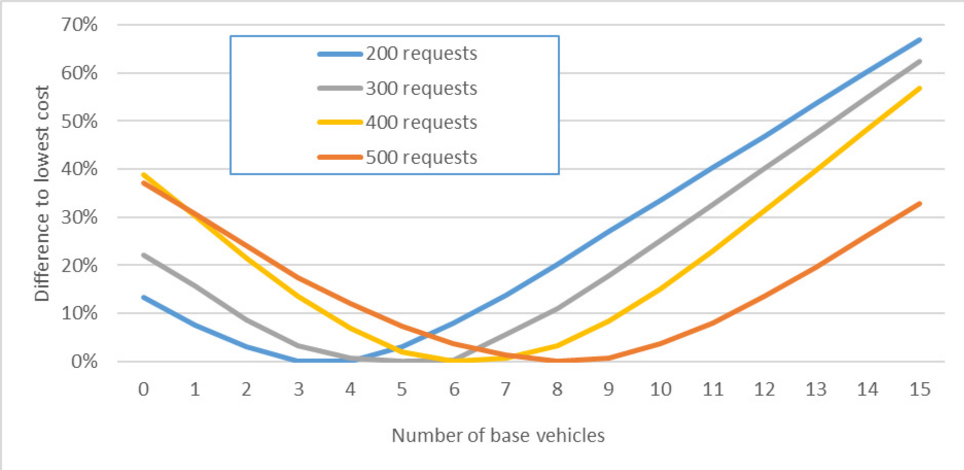

Figure 25. Cost comparison depending on the number of base vehicles.

Figure 25 compares the costs that arise for the operator of a demand responsive transport operator, based on a cost model of the real-world case in Korneuburg. The fleet is split into base vehicles and flexible vehicles. The base vehicles cause a fixed cost per hour but are cheaper per distance driven. The graph shows that the optimisation model can help as a decision aid to determine the right number of vehicles. Costs depend on the number of base vehicles that are used. If too few base vehicles are used, then too many flexible vehicles are needed to satisfy all requests. This yields higher costs due to the higher cost per kilometre of the flexible vehicles. If too many base vehicles are used, then they have a low utilisation but still they require a fixed cost per hour to be paid. To summarise, an optimisation based analysis can help in decision making for demand responsive transport services. Various scenarios can be analysed and decisions can be taken based on the results of computational experiments.

6.3 Configuration of the optimisation framework

J. Asamer, B. Biesinger, S. Knopp, P. Nolz & M. Reinthaler

To perform the optimisation-based analysis, we need to set up suitable optimisation models and solution methods. An integer linear programming model (ILP) used here takes the specific cost structure of our real world case into account. It is an adaption of a model presented by Desaulnier et al. (2010) adding a distinction between the two different vehicle types. To tackle larger instance, also a meta-heuristic solution approach is proposed.

Integer linear programming model (ILP). We tackle the optimisation problem by formulating a mathematical model that can be solved using integer linear programming solvers. At the same time, this provides a formal problem description. For are given a set of nodes $V = B \dot{\cup} P \dot{\cup} D$ where B denotes depot nodes, P denotes pickup nodes, and D denotes delivery nodes the complete graph $G = (V, E)$ describes connections in an underlying road network. The travel time between two nodes $i, j \in V$ is given by $t_{i,j} \in \mathbb{R}$. For a pickup (delivery) node $i \in V$ its corresponding delivery (pickup) node is denoted by $v_i \in V$. The fleet of vehicles $K = K_s \cup K_f$ is composed of standby vehicles K_s and flexible vehicles K_f, which differ in their usage costs. For each vehicle $k \in K$, we are given its start location $s_k \in B$ and end location $e_k \in B$, and its capacity $C_k \in \mathbb{N}$. Costs differ for loaded and unloaded vehicles, so costs per distance for loaded vehicles are denoted by $c_s^l \in \mathbb{R}^+$ and $c_f^l \in \mathbb{R}^+$, and for empty vehicles by $c_s^e \in \mathbb{R}^+$ and $c_f^e \in \mathbb{R}^+$, with $c_s^e \leq c_s^l$ and $c_f^e \leq c_f^l$. For each node $i \in V$, we are given a time window $[a_i, b_i]$ and a service duration $s_i \in \mathbb{R}^+$ reflecting the desired departure time of passengers and a travel duration which include a buffer time that is varied within the numerical experiments. For each node $i \in V$, its load $l_i \in \mathbb{N}$ specifies the number of passengers that want to get in ($l_i > 0$) or out ($l_i < 0$) at i. A sufficiently large constant $M \in \mathbb{R}$ is introduced for modeling purposes. The following integer linear programming model is an adaption of the formulation given in (Desaulnier et al. 2010) to the problem at hand. It uses the following variables. Binary variables $x_{i,j}^k$ describe if an arc $(i,j) \in E$ is used by the vehicle $k \in K$. Binary variables $x_{i,j}^{k,l}$ specify if an arc $(i,j) \in E$ is used by a loaded vehicle $k \in K$. Binary variables $x_{i,j}^{k,e}$ specify if an arc $(i,j) \in E$ is used by an empty vehicle $k \in K$. Variables $T_i \in \mathbb{R}$ determine for nodes $i \in N$ the start time of the service. Variables $L_i \in \mathbb{N}$ determine for nodes $i \in N$ the load (in number of passengers) when a vehicle leaves that node.

The formulation of the model is provided in Figure 26. The objective function (1) reflects the aim of minimising costs, which depend on the load and type of the vehicle. Constraints (2) to (11) are taken from (Desaulnier et al. 2010) for modelling classical dial-a-ride constraints. In addition, constraints (12) and (13) are introduced for distinguishing loaded from empty vehicles. The general purpose mixed integer linear programming solver IBM ILOG CPLEX Optimizer, version 12.6.2, was used. For resolving larger instances, a metaheuristic approach based on a best insertion construction heuristic and a subsequent variable neighbourhood descent was applied.

$$min \quad \sum_{(i,j)\in E} \left(\sum_{k \in K_s} x_{i,j}^{k,l}\, c_s^l + x_{i,j}^{k,e}\, c_s^e + \sum_{k \in K_f} x_{i,j}^{k,l}\, c_f^l + x_{i,j}^{k,e}\, c_f^e \right) \tag{1}$$

$$s.t. \quad \sum_{k \in K} \sum_{j \in N} x_{i,j}^k = 1 \quad \forall\, i \in P \tag{2}$$

$$\sum_{j \in N} x_{i,j}^k - \sum_{j \in N} x_{j,v_i}^k = 0 \quad \forall\, k \in K \;\; \forall\, i \in P \tag{3}$$

$$\sum_{i \in P \cup \{e_k\}} x_{s_k,i}^k = 1 \quad \forall\, k \in K \tag{4}$$

$$\sum_{i \in N} x_{i,j}^k - \sum_{i \in N} x_{j,i}^k = 0 \quad \forall\, k \in K \;\; \forall\, j \in V \tag{5}$$

$$\sum_{i \in D \cup \{s_k\}} x_{i,e_k}^k = 1 \quad \forall\, k \in K \tag{6}$$

$$T_i + s_i + t_{i,j} \leq T_j + M \cdot (1 - x_{i,j}^k) \quad \forall\, k \in K \;\; \forall\, (i,j) \in E \tag{7}$$

$$a_i \leq T_i \leq b_i \quad \forall\, i \in V \tag{8}$$

$$S_i \leq S_{v_i} \quad \forall\, i \in P \tag{9}$$

$$L_j \leq L_i + l_j + M \cdot (1 - x_{i,j}^k) \quad \forall\, k \in K \;\; \forall (i,j) \in E \tag{10}$$

$$L_i = 0 \quad \forall\, i \in B \tag{11}$$

$$x_{i,j}^{k,e} + x_{i,j}^{k,l} = x_{i,j}^k \quad \forall\, k \in K, (i,j) \in E \tag{12}$$

$$\sum_{j \in V} x_{i,j}^{k,l} \geq \frac{L_i}{C_k} \quad \forall\, k \in K, i \in V \tag{13}$$

Figure 26. Integer linear programming model.

Variable Neighborhood Search (VNS). With the integer linear programming formulation, we are only able to solve instances up to 36 requests within the time limit of two hours. For tackling larger instances, we developed a metaheuristic approach using the framework of a general variable neighbourhood search (VNS) (Mladenović & Hansen, 1997). The goal of the VNS is to compute (near-) optimal routes in a short amount of time, however, without giving any guarantees about optimality. In the developed VNS, we first constructed an initial solution by following a best insertion strategy, which starts from a set of empty routes and iteratively adds a request (in an arbitrary order) to the route and position that result in the least cost increase. The resulting solution is then further improved via a variable neighbourhood descent (VND) algorithm using a nested neighbourhood structure of cardinality four. These four considered neighbourhood structures, each defining types of allowed moves, i.e., small changes from the starting solution, are intra-relocate, exchange, inter-relocate, and block-relocate. The relocate neighbourhood structure re-assigns a request by moving it from one position on a first trip to another position in a second trip. These positions can be within the same trip (intra-relocate), or within different tours (inter-relocate), yielding two variants of that neighbourhood. In the exchange neighbourhood structure, the positions of two requests from two different trips are swapped. A move in the block-relocate neighbourhood changes the position of a consecutive sequence of requests. After no improvement can be found in these neighbourhoods anymore and a local optimum is reached, a shaking procedure makes random changes to the incumbent solution and the VND starts anew. The magnitude of these changes increases for each iteration of the VND, in which no improvement was found after eight moves in the inter-relocate neighbourhood. The VNS terminates after a given number of iterations or a given amount of time, yielding the best solution found during the search.

Assessment of Solution Methods. To determine the quality of the solution methods, we conducted a range of numerical experiments. Table 1 provides an overview. We see that the integer linear programming approach is only suitable for small instances. The gap of the VNS approach to the best solutions found is very small and well below one percent on average. Though the VNS is a heuristic approach, the results of Table 1 confirm that implemented VNS approach yields high-quality solutions. Figure 27 visualises two examples of solutions obtained by the two implemented solution methods.

Table 1. Comparison of Variable Neighborhood Search with results of the ILP model.

#locations	percentage	#solved exactly	VNS gap to best
<20	7.0%	80.6%	0.30%
20-39	15.6%	65.6%	0.32%
40-59	3.5%	38.9%	0.23%
60-79	8.2%	11.9%	0.08%
80-99	11.7%	0.0%	0.00%
100-119	17.1%	0.0%	0.00%
120-139	24.5%	0.0%	0.00%
140-159	10.1%	0.0%	0.00%
160-180	2.3%	0.0%	0.00%

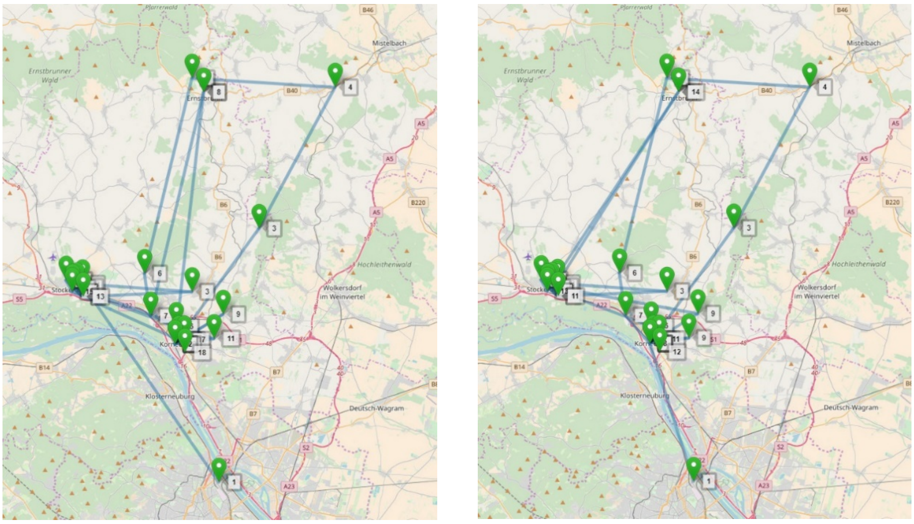

Figure 27. Different solutions for the same instance: left hand side ILP, right hand side VNS.

6.4 Cross-border transfer of a systemic Mobility-as-a-Service –related innovation

T. Haahtela, T. Surakka, E. Viitamo, J. Asamer, M. Reinthaler & A. Horila

During the project, we investigated the transferability of MaaS-related on-demand shared taxi services from one cultural and geographical context to another using an in-depth case study method. Our target region of analysis for the transfer is an area known as Growth Corridor Finland (GCF), a region stretching from Helsinki to Hämeenlinna, Tampere and Seinäjoki region as a string of cities.

There is empirical evidence of transferring systemic innovations from one context to another. For instance, Schaffers and Turkama (2012) explores the transferability of systemic innovations in homecare and independent living, energy efficiency, manufacturing networks and citizen participation. According to their findings, the living labs approach can be used for cases that call for the user-behaviour transformation or business-model innovations. There are also knowledge about new MaaS concepts and how they change the mobility behaviour of the users (Smile 2015), and some indications of the determinants of a successful business based on MaaS pilots (Karlsson, Sochor & Strömberg, 2016). However, there is not yet clear evidence of the main success factors of full-scale MaaS concept nor how to transfer systemic MaaS innovations from their original context to new markets when the whole transport system may be affected.

Our primary research question was to identify the conditions under which the systemic MaaS innovation can be transferred from one cultural and socio-technical context to another. In particular, we examined what kinds of elements and approaches are required in this transfer. We also investigated, how the socio-technical framework of Geels (2012) can be applied when analysing the transferability of the MaaS solutions from one cultural and socio-technical context to another.

To provide insights into the transferability of the ISTmobil[51] concept (see also chapter 5.1 and 6.2) to Finland, we compared it with three other similar kinds of on-demand transport services: Kutsuplus[52], Kyyti[53] and UberPOOL[54]. Kyyti is a Finnish mobility service that provides door-to-door transport by combining different passengers' mobility needs most optimally by shared rides. UberPOOL is a service where Uber driver picks up and drops off multiple riders going in the same direction. All these services are based on smart software and route optimisation. These services have a digital interface linked to the public transport. Therefore, they complement the public transport rather than compete with it. These services are somewhere between the traditional public transport and taxi services both in their flexibility and pricing scheme. However, there are also differences between these services. The main characteristics of the services are summarised in Table 2.

Table 2. Comparison of different on-demand shared mobility services.

Service:	*ISTmobil*	*Kutsuplus*	*Kyyti*	*UberPOOL*
Dynamic capacity	yes	no	yes	yes
Market based	subsidized	subsidized	yes	yes
Operator	Private start-up	Regional transport authority	Private start-up	Private start-up
Pricing model	fixed	fixed	dynamic	dynamic
Reduced price for flexibility	no	no	yes	Yes
Only professional drivers	yes	yes	yes	no

In our classification, the dynamic capacity means that the number and size of vehicles used is flexible instead of being fixed. Kutsuplus used a fixed number of dedicated vehicles for their service. ISTMobil and Kyyti use ordinary taxis as the means of transport. Their number is determined by the demand-driven capacity expansion logic. The capacity of UberPOOL is based on market-pull where the number of the vehicles is determined by the end customers' demand. In our classification, 'market-based' means that the service is not subsidised by the

[51] See: http://www.istmobil.at/

[52] See: https://www.hsl.fi/sites/default/files/uploads/8_2016_kutsuplus_finalreport_english.pdf

[53] See: http://www.kyyti.com

[54] See: https://www.uber.com/en-SG/drive/singapore/resources/uberpool/

municipalities or other authorities. ISTmobil is subsidized by the municipals and hence is considered to be a part of the public transport system. Kutsuplus was a testing platform for the Helsinki Regional Transport Agency and heavily subsidised while Kyyti and UberPOOL are market-based services. Except for the regional transport agency operated Kutsuplus, all the other services are operated by private start-ups.

ISTmobil has a fixed pricing of four euros for each starting five kilometres. Kutsuplus had a specified pricing per the length of a trip. Kyyti has a dynamic pricing according to the market demand. In UberPOOL, the price is dynamically determined by the markets. In all services, the price of the ride is known in advance. In our classification, price reduction on flexibility means that a customer gets a discount, if he or she accepts a little longer and uncertain travel time. Kutsuplus and ISTmobil models do not have a price reduction as a result of flexibility while UberPOOL has some price reduction on flexibility. However, the concept of flexibility is a more essential feature in Kyyti to reduce the ride cost by pooling more passengers. This is done by offering customers three different service categories whereby the price and travel time will vary accordingly.

From the viewpoint of transport and commuting, there are many similarities between the Growth Corridor Finland and Korneuburg, where ISTmobil started its operations. Both areas have good railway and highway connections with large cities nearby, and a high number of passengers commuting daily in both regions. Therefore, GCF is geographically and demographically similar enough for the comparison and analysis. The question remains how the taxi firms in Finland would consider the change. Currently, both municipalities and governmental organisations have an obligation to provide a reasonably priced or even free rides for many customer groups with special needs. As previously there have not been other alternatives available, taxis have been mostly responsible choice for these transport needs. As a result, approximately 80 % of the taxi trips in rural areas are paid either by the municipalities or by the Finnish Social Insurance institution KELA. If a service like ISTmobil would enter the Finnish market, it could decrease the number of these taxi rides by pooling customers. Potentially the service could also reduce the number of buses driving nearly empty in rural areas and could collect passengers to hubs for further bus and train connections, thus indirectly increasing the use of public transport.

Municipal authorities and their policies in Finland have a significant role as an enabler for the demand responsive service concepts to succeed. If the present operations continue – i.e., keeping the existing bus lines and timetables and supporting the current policy of subsidised taxi rides – demand responsive services such as ISTmobil concept is unlikely to get enough passengers. As buses are also heavily subsidised in the rural areas, the question is what kinds of subsidizing policies should apply also to the on-demand services. Probably the most challenging aspect in the change is to consider the public transport in another way: if there is a last mile solution available, how should it change the ways public transport and the routes are organized.

The market potential is another interesting issue. First, we analysed the population density and structure in both areas. Figure 28 illustrates this density in the GCF and Korneuburg district.

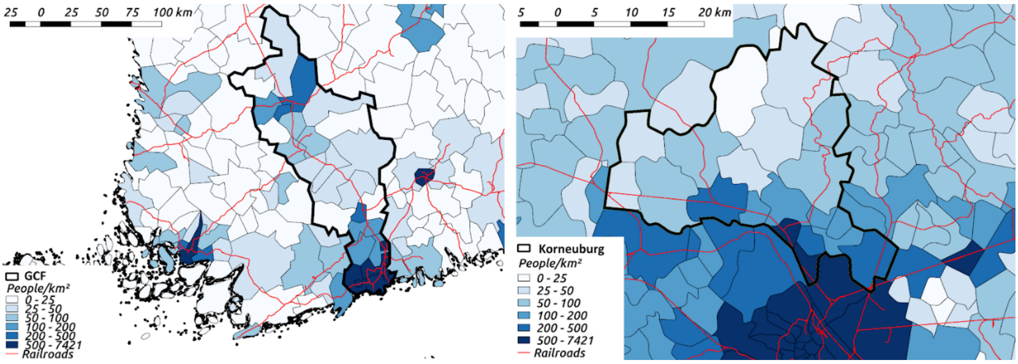

Figure 28. Population density and main railways in Growth Corridor Finland (GFC, left) and in Korneuburg district, Austria (right).

There is a certain window of opportunity regarding the number of customers and population density that should be reached by the service. In the urban city areas with a high population density, high capacity public transport is probably a better solution. On the other hand, if the rural areas have a too low population density or there are no clear transport connection hubs, a demand responsive concept may not have enough customer base. Also, as public transport has already been quite limited in some rural areas, many families have two private cars in their household, which may reduce the market potential.

There are differences in the size and population density between the areas. However, the GCF includes several regions that have differing population densities within the municipalities. If the picture of the GCF on the left would be shown in detail, there could be found similar areas around the cities and municipalities (e.g. Hyvinkää, Hämeenlinna, Nurmijärvi, Riihimäki), which could adopt the service concept of ISTmobil for their outskirts and neighbouring areas. The city centres and their bus and train stations could then serve as connection hubs for further transport needs. This is also the way, how ISTmobil service is used in Korneuburg area. On the other hand, within the Growth Corridor area, there are some rural areas where the population densities and the number of potential customers are too low and the difference with these areas is that population is more clustered into villages in rural areas in Austria, while the locations of houses in Finland are highly dispersed in the countryside.

The result of our analysis indicate that there are many different aspects to be considered. Even if the legal and technical aspects would fit, there are many issues related to the potential market size and the local transport subsidising policies. The conclusion is that the socio-technical framework of Geels (2012) is a good starting point for analysing the applicability of a new MaaS-related service in another cultural and geographical context. When applied thoroughly, it shows quickly the similarities and dissimilarities between the regions, and hence, the aspects that are relevant to focus on in a more detailed analysis. However, the framework is rather burdensome to use. Therefore, new complementary tools and methods are required to analyse the cross-border transfer and successful adoption of MaaS-related innovations.

References

Geels, F. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy, 31(8/9), 1257-1274.

Geels, F. (2012). A socio-technical analysis of low-carbon transitions: Introducing the multi-level perspective into transport studies. Journal of Transport Geography, 24, 471-482.

Karlsson, M., Sochor, J. & Strömberg, H. (2016). Developing the 'service' in Mobility as a Service: Experiences from a field trial of an Innovative travel brokerage. Transportation Research Procedia, 14, 3265-3273.

Schaffers, H. & Turkama, P. (2012). Living Labs for cross-border systemic innovation. Technology Innovation Management Review, 2(9), 25–30.

Smile (2015). http://smile-einfachmobil.at/pilotbetrieb_en.html (accessed 28.4.2017).

G Desaulniers, J Desrosiers, A Erdmann, MM Solomon, and F Soumis. VRP with Pickup and Delivery. In The vehicle routing problem, pages 225-242. Society for Industrial and Applied Mathematics, 2001.

Mladenović, N., and P. Hansen. Variable neighborhood search. In Computers & Operations Research 24 (11), pages 1097-1100, 1997.

7. Catalogue of design principles for sustainable mobility solutions

F. Härri & M. Hoppe

The Smart Commuting project collected and evaluated empirical data in the three case districts: Basel-Stadt, Growth Corridor Finland and Korneuburg. On this basis, recommendations for mobility strategies for growth regions can be made as to how the commuters' mobility could be dealt with better and in a more sustainable way. Commuter flows are constantly growing in the urban regions of Europe. The results are traffic jams at peak times, overloaded public transport systems and rising costs. At the same time, lifestyles and the working styles are becoming more dynamic and versatile. Traditional offices could be replaced by mobile or home-office workplaces; flexible working time models and part-time work are increasing. Mobility strategies must be adapted to these trends. Technological development and new business models, in particular, can contribute to a better organised, environmentally friendly mobility. This project has focused in particular on new digital service concepts such as Mobility-as-a-Service (MaaS), which combine the planning, booking and payment of mobility in one system. in this project we have investigated the potential of such systems to encourage a shift from mobility based on private car to more sustainable modes of transport, such as public transport or active modes. Regions and policymakers must create the necessary and appropriate framework conditions to enable such systems and to develop their respective potential. For this reason, strategy recommendations for commuter regions, especially for administrations and legislators, are structured thematically and listed in next chapters.

7.1 Design principles for strategies regarding commuters

7.1.1 Trends in lifestyles and work-life relations

Employment and work arrangements are relevant for commuting by their very nature: they strongly influence the need for commuting trips in terms of distance and frequency. Few years ago, full-time work was the general rule. Today, a part-time employment with additional side-line tasks (family, education) is getting more and more frequent and, therefore, increases the need for more dynamic and individual mobility solutions. The trend to a more dynamic and individual work-life balance can be underlined by our results (see chapter 2). It is apparent that only a little more than half of all respondents of our survey had a full-time job, whereas around 40% stated that they are doing a part-time job. Based on the findings from Basel, this trend should be taken into account by **coordinating mobility strategies with employment strategies** and by **creating incentives for companies to promote part-time**

and flexible work. This not only meets the demand of employees regarding their type of employment, but could also reduce their need for rush hour travel.

Around one fifth of the surveyed employees stated that they are also teleworking from home, and 5.9% stated that they work during their commuting trip. These numbers reflect that the classical working at the main workplace is still dominant. However, **teleworking** can help to reduce commuting and therefore should **be taken into account within mobility strategies**. By creating incentives for employers and employees, working from home-office can specifically be promoted.

7.1.2 Mobility behaviour of commuters

When comparing commuting distance with commuting time, it became apparent that the data variability regarding the distance is far bigger. This supports the assumption that people mostly think and decide time investments when planning their commuting trips. Therefore, **faster commuting modes tend to increase the mean commuting distance while not lowering the mean commuting time.** Especially for a long distance travel, faster services should, therefore, be established with care, as these faster connections also increase the number of commuters for whom this connection is attractive. As the classification of commuters based on a cluster analysis (see chapter 2) of the survey showed, the long commuting distance is associated with a lower probability of enjoying the journey. At the level of **spatial planning**, attempts can be made in **order to lower distance to work by providing** affordable housing near work centres or a stronger mix of industrial, commercial and residential housing.

7.1.3 Focus on the reasons why people commute during peak hours

One of the main sustainability issues within the current commuting regimes are the peak hours. Therefore, it is necessary to identify the reasons, why people actually need to commute during peak hours. By far the most chosen answer is "**requirement of job**" with more than 60% of all respondents selecting this option. This is an important result suggesting to focus on such policy measures that would have strongest effects on a more sustainable commuting regime. In addition, important reasons are "**childcare**" (15.7%), "**company culture**" (18.7%) and "**habit reasons**" (16.1%). This leads to two promising areas were participatory processes in commuting could be located: mobility management within companies and improving child care close to the living area or working place of employees.

7.1.4 Promoting active mobility

Considering the reasons of why respondents use a bicycle for commuting, it becomes clear that the factor "**sport**" is on the top of the list with almost three quarters of all respondents mentioning this reason. Nonetheless, the reason "**faster**" is also a very strong incentive for using bicycles (58.9%), as well as the aspects of "**flexibility**" (63.8%) and being "**cheaper**" (40.8%). In addition, the profiling of commuters suggests that it is more likely for users of active modes to enjoy their travelling than for such with no predominant mode of travel.

As almost every household in the Basel area (95%) has a bicycle, the support of this very sustainable form of transport can be considered as a "**low hanging fruit**" in terms of the sustainable transport. A clear strategy for improving bicycle use is therefore needed. This comprises, for example, **improving the infrastructure for safe active mobility**, communicating and promoting the sport and health aspect while considering fact that **active mobility commuters enjoy their commute more** than commuters using other forms of transport.

Another strategic focus of future-oriented mobility strategies could be **electric bikes** or **E-Bikes**. For example, around one fifth of the surveyed households in Basel possess one or more E-Bikes, and a bit under one fifth of the respondents use an E-Bike on a regular basis for their commute. This may indicate that E-Bikes are specifically bought for commuting activities. **Promoting E-bikes by marketing events, creating (financial) incentives, special parking spaces for E-Bikes and power sockets** can further promote this technological trend, which can clearly be considered as being more sustainable than the car.

7.1.5 Ensuring accessibility to mobility in rural areas

In Basel, an analysis regarding the mean satisfaction with the current commuting mode was performed. A "mobility satisfaction index" was created by calculating the mean values of different satisfaction items such as comfort, price, and time asked in the survey and taking the overall mean of these means. This overall satisfaction index was then calculated for every municipality in the Basel area. It became apparent that the **satisfaction is definitely higher within the larger municipalities**, generally fitted with better mobility services. While this insight for itself is not surprising, it highlights a big issue that during next years, the biggest growth in terms of jobs and citizens will occur in the surroundings of the larger areas. The issue of low satisfaction with the commuting situation is therefore likely to get even worse if no countermeasures are taken. Future mobility strategies should therefore focus on the **development of new mobility services in the outskirts and rural areas**. This could be achieved by improving the access to the public transport network and by promoting less traditional forms of transport means such as call-a-ride, ride-sharing, carpooling, MaaS and so on.

7.1.6 Promoting flexible and user-oriented alternatives

Car users appreciate the **high flexibility** and the **short travel times** provided by the car. More than a third of all respondents also stated that they needed the car to **transport goods**, which is an aspect that new mobility systems like MaaS or new sharing systems can easily offer, especially by combining different and more sustainable modes of transport. When creating new commuting strategies and offers, user-oriented services that address the commuters' demands and are harmonised with their daily activities are needed. As our results show, commuting are often combined with other activities. Apart from the already mentioned purchasing activities, '**social activities**', '**leisure**' or '**sport**' are very often combined with commuting travels. A large number of commuters stated that they already frequently search the internet for information, i.e., timetables or route information. This shows that users are open to regular advice on the best travel alternative via their mobile phone or the Internet, which is a promising prerequisite for the use of MaaS. Therefore, legislators and policymakers would do well to create the conditions for the establishment of such user-oriented and tailor-made mobility solutions. This can be done by **opening of booking systems or promoting market entries for new companies and start-ups**.

7.1.7 Effective parking strategies

Another important, often mentioned aspect why people use a private car is the factor "**free parking-space at work**". This should be taken into account when performing, e.g., mobility management in companies. Policymakers could also address this by not allowing free parking spaces in towns and at work, as long as it is in their authority. **Parking management** should be used as a tool for supporting sustainable commuting wherever possible. This is especially the case when new buildings are built or when companies are relocating or expanding their activities. People who live or work in a building with an underground car park might also be forced to use these parking spaces instead of cheaper, but space-consuming over-ground parking lots.

7.1.8 Increasing the attractiveness of public transport

Public transport users in Basel consider their mode of transport more often as a cheaper alternative compared to other modes of commuting. In addition, respondents appreciate the '**reliability**' and the possibility '**to avoid traffic jams**' thanks to public transport. The factor '**weather**' is also quite popular among the respondents. In addition, the factor '**faster**' seems to have a positive impact on the attractiveness of public transport. The factor '**possibility to work during commuting**' is still a relevant reason for some users. The survey also comprised a question about factors that would motivate participants to use more public transport. On top of the list is the item '**cheaper tickets**'. These results show, which factors the users value in the public transport and thus where the focus should be placed on a planned increase of attractiveness of the public transport. **Employers can also be included in these measures**, especially regarding ticket costs. In Switzerland, many companies already support their employees by reimbursing tickets.

7.1.9 User groups: Young age groups

In the survey data, it became apparent that **younger age groups use the car less**. By default, this corresponds to a trend, which also has been observed in other studies. Young people showed a decreasing interest in private car-based mobility, which showed itself, e.g., with a lower driving licence possession. However, it may be that a peak in this development is reached. In the last Swiss micro-census (2015), it became apparent that the reduction of driving licences among young people stopped. In the Basel commuter survey, similar effects were also seen. However, efforts should be done to build upon this trend, especially as young people seem to be more interested in mobility alternatives: regarding the openness towards mobility alternatives, the group with the highest openness towards these alternatives is the youngest one. Our analysis suggests that age is significantly related to a higher openness to car-/ridesharing. As a car- or ridesharing is still neither widely accepted nor used, there is a need for awareness raising. **Policies or information campaigns would gain the most response when targeting young people**, which are already open for sharing systems and these services can then widen their customer base with an increasing awareness of the whole society due to word-of-mouth marketing.

7.2 Design principles for strategies regarding stakeholders and decision-makers

7.2.1 Administrative stakeholders

Combining the findings of the network analysis and the stakeholder survey in Basel region, it becomes apparent that stakeholders belonging to the category 'Administration' often have a pivotal function in collaboration network and can, therefore, generally be seen as influential due to their many ties to other stakeholders. Hence, their views and actions are relevant to the future development of the commuting system. However, the online survey revealed that the stakeholders of this category partially show a lower enthusiasm for innovations. While this may be understandable when it comes to innovations that are questionable regarding environmental sustainability, such as privately owned autonomous vehicles, their lower enthusiasm for congestion charges surprises. Thus this stakeholder category is crucial to push changes in this field forwards. Even stakeholders of the category 'industry', i.e., private, non-transport companies, were more in favour of congestion charges. Although they did not show disapproval, 'Administration' was also somewhat averagely enthusiastic towards MaaS and car-sharing systems. Creating awareness and support in this field reveals one starting point in creating successful measures and form conditions for better mobility services.

7.2.2 Use the readiness of stakeholders to contribute to new mobility systems

Another starting point is the current readiness of stakeholders to contribute to innovation implementations such as MaaS actively. Therefore, to support the development towards a better and more sustainable commuting among all stakeholders, additional participatory processes need to be actively promoted. A challenge, however, is the lack of willingness to finance and to invest in this field. Therefore, special consideration should be given to this subject, e.g., through public-private-partnerships. In addition, individual policy recommendations should be developed for each stakeholder category and be confirmed with participatory processes.

7.2.3 Use the openness of transport companies

One promising starting point for implementing new mobility solutions is the general openness towards innovations and new mobility trends of the (also very influential) stakeholders in the category 'transport company'. Even if some stakeholders report challenges in collaboration with public incumbents, their enthusiasm to implement new systems and solutions is a great stepping stone for inducing changes in the current transport market and making commuting more sustainable and user-friendly.

7.2.4 Respecting local differences and frame conditions

One striking observation was the difference in the structures of stakeholder networks in the case study regions. The response and completion rate to the survey was profoundly different between the three case areas. Even within the case area Basel, the types and numbers of participating stakeholders are very diverse depending on their country of origin (CH, F, DE). While more people are commuting daily from France to Basel than from Germany to Basel, the number of identified France-based stakeholder is much lower than the number of German stakeholders. This observation may indicate that there persist cultural differences in stakeholder collaboration between countries and regions. Thus, when mobility planning needs to be done trans-regional like in Basel, this aspect needs particular attention.

8. General recommendations for decision-makers

T. Haahtela, R. Hackl & M. Hoppe

European countries differ significantly from each other culturally and geographically, and the differences within the countries are considerable as well. The specific climate for change, the commitment from various stakeholders and the already existing infrastructure in each country mean that the transition pathways towards the multimodal, sustainable, smart and electrified mobility will be different, and also the timeframe for the change will vary from one region to another. Therefore, the actions required in each country and region are different and should be considered domestically. Nevertheless, the following ten recommendations hold to the majority of the countries:

1. Better evaluation and awareness of the potential of on-demand services
2. Developing and implementing new last mile solutions for commuters
3. Deliveries and logistics: last mile of goods
4. Platforms and APIs for Mobility-as-a-Service
5. Electrifying transport
6. Shared vehicles
7. Mobility hubs for efficient multimodality
8. Better user-centric planning of services
9. Activating employers and employees
10. Changing the current mobility paradigm

None of the suggestions requires significant investments in infrastructures. The development and solutions are mostly based on acting and commuting smarter as the consequence of exploiting the potential of digitalisation and new mobility services. Technology is neither limiting the development. Instead, the bottleneck is the lack of experience of the users from different mobility alternatives, and how they can be combined together. In addition, the lack of cooperation and some organisational competition between and with large and monopolistic national service providers is another hindrance of development.

Therefore, the main message is to increase the knowledge transfer and advance a culture that supports cooperation between different parties. We have to learn from the best practices: the culture of on-going piloting, courage to try and to develop new services and concepts, and to openly share the experiences with others.

8.1 Better evaluation and awareness of the potential of on-demand services

In different countries, there are several new types of on-demand services available and concurrently developed different new concepts. However, there is a lack of in-depth analyses of these alternatives and their overall impacts on the local transport systems. The analysis should take into account the cost-benefit analysis of the services. When the analysis is done, the findings should be shared between countries. Also, as the new concepts develop further based on the customer feedback and lessons learnt from other cases, this analysis should be an ongoing activity. While markets will gradually solve the development of the new mobility service concepts, governments and cities should give financial support. This support and guidance also enhance the possibility to link the on-demand services to the sustainable and multimodal public transport system and MaaS framework, whereas purely market-based solutions might not take the sustainability considerations and city infrastructure use into account in their operations.

8.2 Last mile solutions

There is still a need for new concepts and services to enhance the last mile services. The situation with the last mile solutions is similar to the on-demand solutions: there is a significant need for an analysis of different alternatives and their costs and benefits. A detailed study of different implementations and lessons learnt is needed. Also the on-demand services mentioned in the previous paragraphs might be one significant alternative. Cities are encouraged to implement several alternative solutions in parallel, e.g., different bike sharing systems and kick scooters. The electrification of these last mile solutions is a viable alternative. Furthermore, there is room for improving the light traffic lanes and systems. Different EU cities should compare their alternatives and share the best practices on this topic. Municipal authorities have, so far, implemented most solutions. However, other organisations with their commuters should also get involved: large companies, business parks, apartments, and campuses have many potential daily users who would benefit if there would be better last mile solutions.

8.3 Deliveries and logistics: the last mile of goods

One significant driver for the future mobility is logistics and the last mile of goods and groceries. If people would get their groceries and other items delivered directly to their home door or close-by at specific times of day, they might not use a private car for commuting. Therefore, it is essential to support the last mile of goods. Similarly to the MaaS API and framework development, we suggest supporting the development of shared logistics boxes for sending and receiving parcels independent from any operator. This increases the competition and reduces the risks of global or national postal services to exploit their monopoly power on logistics. The basic guidelines in this development should be similar to those MaaS API and platform: networked, open, interoperable, scalable, extendable and distributed. At the same time, these boxes can act as exchange points in sharing economy for any kinds of goods. We suggest that legislation, construction regulations, and architects take into account this development. Floor plans for the first floor in new apartments should be planned in a way that leaves room for parcel logistics, and other possible alternative uses of that space.

8.4 Platform and APIs for Mobility-as-a-Service

Currently, the multimodality is not viable choice in most of the EU countries. It is still mostly impossible to buy a single (mobile) ticket for a whole travel chain between two cities. To ease passengers' mobility, governments should foster the development of e-tickets and MaaS APIs. Also, governments should provide certain national databases and services to support this development. Customer identification, anonymisation and user data management and standardised APIs for these are examples of such strategic parts that should be managed on a country level. There have been many projects to provide guidance for this, but so far none of these has resulted into a solution that would become commonly accepted and adapted by the markets. However, examples from different industries suggest that such a complex system should be both modular and flexible, and support NOISED approach (Networked, Open, Interoperable, Scalable, Expandable and Distributed/decentralised). This ensures that none of the transport modes or actors will have a dominating role in development. Gradually the best alternatives will be developed and merged into de facto standards. It is not a problem, if national systems between the countries are slightly different. If the NOISED principles are followed, the systems will become very similar and allow all service providers to connect their services to the platform. Once the platform and APIs are mature enough, the government should provide support for regional transport authorities to make their systems compatible with the common system.

8.5 Electrifying transport

The electrification of the transport reduces local emissions and global CO_2 emissions and provides more silent transport. Quite much has already been written about electrifying transport, but we would like to emphasise the following aspects: First, more effort should be put on the electrification of buses and public transport. While ordinary private cars are standing most of the time, electrified or not, buses operate throughout the day. Therefore, higher investment costs are offset by lower operating costs. Also local emissions are reduced more when old diesel buses are replaced with new electric ones. Secondly, when supporting electrifying the transport, private cars should not be considered and used similarly as in the era of internal combustion engine. The focus should be on supporting multimodality. This can be partly achieved by the optimal location of charging stations and smart park'n'ride charging. The third suggestion is to provide housing cooperatives small financial aids to install charging stations. Also, new buildings and apartments should already have EV chargers and also readiness (cabling) to extend later the charging opportunities.

8.6 Shared vehicles

Shared vehicles are becoming more popular. This reduces the need of parking places and reduces people's needs to invest their money in something that they need only occasionally. Shared vehicles are also one viable solution to the quite common last mile problem. Cities could support car sharing by providing dedicated parking lots for them. Similarly, city planning could enforce new office buildings and housing apartments to reserve some of their parking lots for shared vehicles. Cities and municipalities should also consider sharing some their own vehicle fleet during weekends and off-hours to citizens. Another car-sharing scheme is the peer-to-peer sharing. In the near future, all cars manufactured should have by default keyless driving and ability to be shared via a mobile app. Cities and government could start programs to support also this form of car sharing as a part of the smart mobility and sharing economy. The message to EU is to ensure that manufacturers 1) make cars openly shareable by anyone, and 2) car manufacturers do not complicate by technical or juridical means the use of their cars for sharing economy.

8.7 Mobility hubs needed for efficient multimodality

Transport hub logic is a good concept for the city and transport planning both inside and between the cities. The efficient use of the public transport requires the different modes of transport to be closely interconnected. These hubs act as linkage points between last-mile solutions and the fast high-capacity transport. Typically, these hubs also offer other private and municipal services to citizens when they are open. If it is not possible to use existing hubs to the high-capacity public transport because of the geography and current infrastructure, then cities should consider new services and investments to create such hubs.

8.8 Better user-centric planning of services

City and transport planning should be based both on soft and hard facts. Currently, decisions are based on the top-down decision-making and fine-tuning of the existing solutions. However, in the future, the focus should be on the needs of different customer groups instead of making decisions based on averages. To overcome this situation, more participatory methods are needed in the city and transport planning. To get more detailed information, mobile feedback collection methods should be used for guiding service development, as the knowledge of peoples' opinions on new mobility services and their motivations to use them is still partly unknown. One viable alternative would be to use Eurobarometer surveys to get a better knowledge of people's opinions on new mobility services.

8.9 Activating employers and employees

When considering smart commuting, more emphasis should be put on employers and employees. While a general high-quality public transport is the cornerstone, also company specific needs should be taken into account. For example, public transport schedules do not match well with working hours of the shift work, and therefore many employees commute by a private car. We recommend that public transport planners also survey the large companies and their employees to find ways to improve the use of public transport. The companies could also find ways to increase the sustainability of the employees' commuting. Partly employer-sponsored PT tickets are a recommended way to reduce unnecessary driving. Our case company results also show that different smart ways to combine rides and to schedule them to connection hubs can ease getting qualified employees to commute from a longer distance to a workplace.

8.10 Changing the current mobility paradigm

There is a need to design and organise mobility in a different way to promote sustainable commuting modes. Instead of providing services based on single modes, the mobility chains need to be addressed by focusing on seamless, intermodal door-to-door trips from a user's perspective. This includes pursuing the goal of optimising the transport system in terms of the resource consumption and emissions. Besides increasing the competitiveness of such an individualised, flexible public transport service, the efficiency is also increased by tapping underused resources.

Aalto-ST 6/2018

Smart and Mobile Work in Growth Regions

In this project, new ways of combining work and life with new intelligent transport system services were explored and new concepts to support sustainable CO2-free commuting and mobile, multi-locational work were created. The mobility of the workforce is increasing due to technology development, commuting and the nature of work, which has many consequences as long commuting may decrease the productivity of work and leave less time for relaxation, resulting in lowered wellbeing. Cities also have to address commuting when planning technical solutions, developing services and calculating their finance schemes. Smart Commuting - Smart and Mobile Work in Growth Regions project (2016-2018, www.smartcommuting.eu) is one of the projects in joint programme JPI Urban Europe (www.jpi-urbaneurope.eu).

ISBN 978-952-60-8349-0 (printed)
ISBN 978-952-60-8350-6 (pdf)
ISSN 1799-4896 (printed)
ISSN 1799-490X (pdf)

Aalto University
School of Science
Department of Industrial Engineering and Management
www.aalto.fi

BUSINESS +
ECONOMY

ART +
DESIGN +
ARCHITECTURE

SCIENCE +
TECHNOLOGY

CROSSOVER

DOCTORAL
DISSERTATIONS