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Assessment of mobility stations

Success factors and contributions to sustainable urban mobility

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Department of Civil Geo and Environmental Engineering

Chair of Urban Structure and Transport Planning

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Dissertation submitted to the Department of Civil Geo and Environmental Engineering to obtain the academic degree of a Doctor-Engineer (Dr.-Ing.)

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Preface

“The whole is greater than the sum of its parts” - Aristotle

My motivation for working on this dissertation is to contribute to a higher quality of life in our cities, and also to their competitiveness and resilience by finding scientific arguments for the implementation of measures and projects which contribute to sustainable urban mobility. Having worked on this dissertation was certainly an opportunity to do so.

For many decades, different kind of actors, from planning authorities, academia and advocacy groups, and many others, have been pushing different kinds of measures to shift trips from private cars to other modes.

The reduction of vehicle ownership and its share in the modal split are at the core of sustainable transport strategies as single occupied vehicles require by far more space and energy for every passenger kilometer travelled than any other mode of transport.

Hard and soft measures that either push or pull in the desired direction have been implemented in the past. From improving public transport services to congestion charging, and from mobility management to building cycling lanes the set of possible measures is quite diverse.

The rise of modern shared mobility services and their increasing acceptance in recent years are seen as another opportunity to promote more efficient and environmentally friendly mobility. Evaluations on the impacts of shared mobility services confirm that they increase accessibility and the use of alternative modes of transport other than the private car.

Despite these various efforts, cars are still on the roads and are most often used in the least efficient ways: they are parked for 95% of their lifetime, and when they are used, most often they transport just one passenger.

Is there any hope for cities experiencing rapid population growth and increasing demand for mobility? Is there a way to provide efficient and environmentally friendly mobility without excess congestion and without crowded public transportation? Is there a way to compete with the comfort and convenience of the door-to-door mobility offered by private cars?

I believe it is possible. I believe that by putting together various alternative mobility options to private cars, and by integrating them in a meaningful way within a consistent mobility and urban development concept, it is possible to change our mobility systems and contribute to the goal of sustainable urban mobility. I believe in the synergy of this integration - that the whole is greater than the sum of its parts.

This is what I believe, but what is reality? We don't know for sure.

This dissertation presents an assessment of mobility stations and their contribution to sustainable urban mobility. The work sheds light on various aspects related to the integration of various mobility services through mobility stations and their respective impacts on mobility behavior. The results are promising but more research is needed.

I wish the readers an insightful and inspiring walk through this work.

Acknowledgements

The work presented in this dissertation was carried out while working as a researcher at the Chair of Urban Structure and Transport Planning, mainly within the framework of the Evaluation of the Mobility Station at Münchner Freiheit (EVA-MS) on behalf of the City of Munich.

I want to thank sincerely my supervisor Prof. Gebhard Wulfhorst for the opportunity to work at his Chair. Throughout the last six years, I've had the opportunity to work on many different projects, teach my favorite topics, supervise the scientific work of our students, and do my own research. Through all these responsibilities, which felt more like opportunities, I was able to grow professionally in a field of work I am passionate about. Thank you very much for your trust during the last years and for your valuable support throughout the process of my dissertation.

I am also very thankful to Prof. Regine Gerike, my second supervisor, who supported me from the beginning of this dissertation with her feedback to my first ideas and exposé, during the development of this work, and later to my final draft. Thank you very much for taking the time to read my work and for providing me with your valuable comments. I appreciate your supervision very much and the time you put into this work.

I thank Prof. Udo Becker for his feedback to my exposé and my ongoing work during the evaluation of the Mobility Station at Münchner Freiheit. Thank you for answering my many questions, as well as for your continuous support and encouragement to work on this topic.

This work would not have been possible without the trust and support of Dr. Martin Schreiner at the Department of Public Order of the City of Munich. It was a big responsibility and an honor to carry out the evaluation of the project that he initiated, and I feel extremely lucky to have had such an interesting, exciting, and current topic for my dissertation.

I am thankful to all the stakeholders of the project: the Department of Urban Planning and Building Regulation, the Department of Public Order, the MVG, STATTAUTO, DriveNow, car2go, and P+R Park & Ride GmbH, for their valuable inputs during the evaluation of the Mobility Station at Münchner Freiheit. Through their representatives, they actively took part in interviews, helped develop the surveys, provided vital data, and gave feedback to the preliminary results.

I also want to thank Jochen Heller, Ina Kunze, and Alexander Probst from our evaluation partner Omnitrend, who were responsible for the technical implementation of the user and non-user survey, as well as Karin von Pappenheim from up2date, who carried out the focus groups with users and non-users as a neutral moderator.

Thank you to Mathias Kassel, the initiator of the mobility stations in Offenburg, for his support with information about the implementation and operation of these facilities, and for the opportunity to learn from them through two master theses supervised in the framework of this dissertation.

Thank you very much also to Dr. Markus Büchler for his feedback on one of the drafts and for the valuable comments to my work.

Special thanks go to my students who did their master theses and scientific projects on mobility stations and which were supervised in the framework of this dissertation: Lisa Luginger, Eva Heller, Maximilian Pfertner, Álvaro Alarcos, Jared Best and Mohammad Ezzeddine. Your work provided valuable information about a topic that has been barely explored and that I was able use for the investigation into the state of the art of mobility stations.

In the same way I want to thank the many research assistants at the Chair of Urban Structure and Transport Planning for their valuable support during the evaluation of the Mobility Station: Hema Sharanya Rayaprolu, Maximilian Pfertner, David Durán Rodas, and Tom Scriba. I also thank Tom Scriba for his detailed proof-reading of the entire document.

I am thankful to my colleagues at the Chair and from the mobil.LAB group for their valuable feedback, and for their moral support to finish this work.

Last but not least, I want to thank those persons that stayed closest to me through thick and thin while working on this dissertation:

To my family for their continuous support. Especially to my parents for always being there like a safety net, giving me the courage to try harder.

To Sven for listening patiently to the entire content of this work while riding our bikes, cooking, or sitting on the couch, and for helping me to stay healthy physically, mentally, and emotionally.

Abstract

Mobility stations are characterized by providing various mobility options in direct proximity to each other at a specific location. In comparison to ordinary intermodal facilities such as Bike and Ride (B+R) and Park and Ride (P+R) facilities, mobility stations not only enable intermodal trips, but also promote multimodal mobility behavior by providing diverse mobility options, including shared mobility services, that can be used either in combination with or independently from each other. The variety of mobility options enables users to choose one or a combination of transport modes for different trip purposes.

Between 2013 and 2016 more than six cities in Germany implemented mobility stations, similar facilities to the so-called “mobil.punkte”, implemented for the first time in 2003 in the city of Bremen. Moreover, similar facilities are being planned or have been already implemented in other European and North American cities.

Common goals for the implementation of mobility stations are promoting ecomobility, offering alternatives to private cars, and with that a reduction in private car ownership and usage. Expectations are high with respect to the contribution of these facilities to sustainable urban mobility. However, due to their recent development and implementation, little is known about their acceptance and perception, or about their impacts on mobility behavior and car ownership.

This dissertation presents an assessment of mobility stations guided by two main research questions: “*Do mobility stations contribute to the goal of sustainable urban mobility?”*, and “*What are the success factors for the implementation and operation of mobility stations?”*

Through an exploration of the state of the art of mobility stations and a detailed investigation of one pilot project, the Mobility Station at Münchner Freiheit in Munich, Germany, the contribution of mobility stations to the concept of sustainable urban mobility is assessed, and success factors for their implementation and operation are identified. Furthermore, other relevant aspects such as the acceptance, perception, and usage patterns of mobility stations are investigated.

The assessment indicates that mobility stations can contribute to sustainable urban mobility. However, with the available results at this stage, this research can only reveal a potential contribution to this concept. For this contribution to become a reality and relevant at the urban scale, mobility stations of different types should be replicated and expanded within a strategic framework for sustainable mobility, and their inherent multimodal mobility service improved in various ways.

Building on the assessment, this dissertation provides practical recommendations, organized in seven fields of action, for the development of mobility stations in a way that ensures that they would contribute to the goal of sustainable urban mobility.

Finally, considering the various limitations of this work, recommendations for further research are provided.

Kurzfassung

Mobilitätsstationen zeichnen sich dadurch aus, dass sie an einem bestimmten Ort verschiedene Mobilitätsoptionen in unmittelbarer Nähe zueinander bereitstellen. Im Vergleich zu herkömmlichen intermodalen Einrichtungen wie Bike and Ride (B + R) und Park and Ride (P + R) ermöglichen Mobilitätsstationen nicht nur intermodale Wege, sondern fördern auch multimodales Mobilitätsverhalten durch vielfältige Mobilitätsoptionen, einschließlich gemeinsam genutzter Mobilitätsdienste, die entweder in Kombination oder unabhängig voneinander genutzt werden können. Die Vielfalt an Mobilitätsoptionen ermöglicht es Benutzern, ein oder mehrere Verkehrsmitteln für unterschiedliche Wegezwecke auszuwählen.

Zwischen 2013 und 2016 implementierten mindestens sechs Städte in Deutschland Mobilitätsstationen, vergleichbar mit den "mobil.punkten", die 2003 erstmals in der Stadt Bremen realisiert wurden. Darüber hinaus sind ähnliche Projekte in anderen europäischen und nordamerikanischen Städten geplant oder wurden bereits umgesetzt.

Gemeinsame Ziele für die Implementierung von Mobilitätsstationen sind die Förderung des Umweltverbunds, die Bereitstellung von Alternativen zu Privatfahrzeugen und damit die Reduzierung von privatem Pkw-Besitz und -Nutzung. Die Erwartungen an Mobilitätsstationen, einen Beitrag zur nachhaltigen urbanen Mobilität zu leisten, sind hoch. Da das Konzept noch sehr neu ist, ist jedoch wenig über die Akzeptanz und Wahrnehmung von Mobilitätsstationen sowie über die konkreten Auswirkungen auf das Mobilitätsverhalten und den Besitz von Fahrzeugen bekannt.

Diese Dissertation betrachtet Mobilitätsstationen anhand zweier Forschungsfragen: *Tragen Mobilitätsstationen zum Ziel einer nachhaltigen urbanen Mobilität bei?,* und *Welche Erfolgsfaktoren ergeben sich für die Implementierung und den Betrieb von Mobilitätsstationen?*

Durch die Untersuchung des State of the Art von Mobilitätsstationen und die detaillierte Untersuchung eines Pilotprojekts, der Mobilitätsstation an der Münchner Freiheit in München, wird zum Einen der Beitrag von Mobilitätsstationen zur nachhaltigen urbanen Mobilität bewertet. Zum Anderen werden Erfolgsfaktoren für die Implementierung und den Betrieb von Mobilitätsstationen identifiziert. Dabei wurden auch weitere relevante Aspekte wie Akzeptanz, Wahrnehmung und Nutzungsmuster von Mobilitätsstationen untersucht.

Die Bewertung zeigt, dass Mobilitätsstationen zu einer nachhaltigen urbanen Mobilität beitragen können. Die verfügbaren Ergebnisse zeigen jedoch nur ein Potenzial hierzu. Damit dieses Potenzial ausgeschöpft wird und im städtischen Maßstab relevant wird, sollten Mobilitätsstationen im Rahmen eines strategischen Konzepts für nachhaltige Mobilität in großer Zahl, einer durchdachten räumlichen Verteilung und verschiedenen Typen umgesetzt werden und das enthaltene multimodale Angebot in Wert gesetzt werden.

Aufbauend auf der Bewertung liefert die Dissertation praktische Empfehlungen, die in sieben Handlungsfeldern für die Entwicklung von Mobilitätsstationen gegliedert sind. Die Handlungsfelder sind so organisiert, dass sichergestellt ist, dass Mobilitätsstationen zum Ziel einer nachhaltigen urbanen Mobilität beitragen.

Schließlich werden als Ergebnis einer selbstkritischen methodischen Reflexion Empfehlungen für die weitere Forschung gegeben.

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1. Introduction

During the last couple of years mobility stations started to spread throughout Germany. Cities like Bremen, Hamburg, Munich, Offenburg, Leipzig, Würzburg and Nuremberg have already implemented mobility stations in various amounts with different components and integration characteristics. Moreover, similar facilities are being planned or have been already implemented in other European and North American cities.

Common goals of mobility stations are to support multimodality and to reduce private car dependency, and expectations are high on their contribution to sustainable urban mobility (SUM). However, due to their recent implementation, little is known about their acceptance and perception, as well as on their impacts on mobility behavior and car ownership. Understanding these aspects are of extreme importance for cities and other actors adopting mobility stations as a strategy to achieve sustainable mobility and sustainable development.

This chapter presents an overview of challenges and opportunities for sustainable urban mobility and the potential contribution that mobility stations might have to this concept highlighting the relevance of this work. Considering this background, I state the overall goal of this dissertation and formulate research questions to guide the work. This is followed by a description of the research approach and the expected outcome. Finally, the structure of the document and content of the following chapters are presented.

1.1. Problem statement and relevance of this work

Challenges and opportunities for sustainable urban mobility

Nowadays more than half of the world's population live in urban areas and this proportion continues to grow. According to the Department of Economic and Social Affairs of the United Nations, 54% of the world's population was residing in urban areas in 2014, and it is expected that the continuing urbanization and overall population growth will add 2.5 billion people to the urban population by 2050, so that two thirds of the global population will live in urban areas (United Nations, 2014).

While cities provide opportunities for the development of individuals, such as access to services, education, and sanitation, among others, “[…] rapid and unplanned urban growth threatens sustainable development when the necessary infrastructure is not developed or when policies are not implemented to ensure that the benefits of city life are equitably shared” (United Nations, 2014).

With more people living in urban areas, the demand for mobility, and consequently traffic volumes within cities increase. According to van Audenhove et al. (2014) 64% of all travel kilometers are currently made within urban environments. Moreover, the total amount of urban kilometers travelled is expected to almost triple by 2050 reaching 67 trillions of person kilometers travelled per year. As a result, urban transport is considered to be the largest source of global transport-related carbon emissions and the largest local source of urban air pollution (Rode et al., 2017).

Uncontrolled urban growth leads to longer travel distances, thus exacerbating the well-known and widely documented negative impacts of transport such as traffic accidents, noise, air pollution, and greenhouse gases. When traffic demand exceeds the transport network capacity, there is congestion not only on the roads but in the entire transportation system. Congestion in turn causes negative effects on the economy (e.g. waste of time, loss in productivity), on the society (e.g. stress, less time for leisure and social activities), and aggravates further the impacts on the environment. Furthermore, air pollution, noise and traffic accidents have a negative impact on public health hindering the quality of life and competitiveness of cities.

It is clear that rapid urbanization imposes huge challenges for cities as the demand for resources such as water, energy, infrastructure and other goods increases. Yet, according to Banister (2008) “the city is the most sustainable urban form and it has to provide the location where most (70-80%) of the world’s population will live”.

Due to the increasing urbanization all over the world, there is a growing necessity in developing sustainable development strategies in urban areas. In the last couple of decades, an increasing number of organizations, governments and companies are becoming more engaged in contributing to the idea of *sustainability*. Various organizations and institutions, including city governments, use this term as a main goal in their development plans (e.g. sustainable development plan) or report on their achievements (e.g. sustainability reports). In the field of transport planning, we find examples of *sustainable transport (development) plans* or *sustainable urban mobility plans* including diverse strategies and measures to organize transport and mobility in a more sustainable way. An example of such efforts are the Sustainable Urban Development Plans (SUMPs) being developed in European cities and for which the "SUMP Guidelines" were developed (Wefering et al., 2014).

The reduction of vehicle ownership and its share in the modal split are at the core of sustainable transport strategies since single occupied vehicles require by far more space and energy for every passenger kilometer travelled than any other mode of transport (Bowman and Moll, 2002; Litman, 2015; Newman and Kenworthy, 2015).

Preconditions for sustainable urban mobility are thus, a dense and mixed urban structure, a high quality public transport supply and infrastructure for cycling and walking that in sum provide more efficient alternatives for mobility than private cars.

While urbanization brings about diverse challenges, it offers at the same time opportunities for sustainable development (e.g. through a sound integration of land use and transport). Concepts such as mixed-use development, Transit Oriented Development (TOD) and Transport Demand Management (TDM) strategies are easier to implement in urban areas due to a relative high building density and mix of functions.

Mobility stations as a strategy for sustainable urban mobility

Another opportunity for sustainable urban mobility are recent developments in technology and new mobility options such as shared mobility services and their integration.

In recent years, with the advances of Information and Communication Technologies (ICT) as well as innovations in vehicle technology, new mobility services such as carsharing, bikesharing, ridesharing (i.e. carpooling and vanpooling), ridesourcing (e.g. Uber and Clevershuttle) and other forms of vehicle-sharing have become more available and easier to use. Furthermore, a gradual change in the consumption culture towards more *using* and less *owning,* supported by internet platforms and smartphone applications make the use of many different modes of transport easier and more attractive. (Shaheen et al., 2015a)

These new mobility services, also known as shared mobility services, are proving to have an impact on mobility behavior and accessibility (Shaheen et al., 2015a). For instance, ridesourcing provides access to places where and/or at times when other mobility options are not available or safe to use (Rayle et al., 2016). Also, diverse studies conclude that carsharing contribute to reduce car ownership and car usage, while bikesharing can reduce travel distances by car or taxi and complement public transport. A detailed review on the effects of carsharing and bikesharing is presented in Section 3.3.

The possibility to book, use and pay for diverse mobility services in an easy way are improving further the access to alternative modes of transport (to private cars) and its attractiveness complementing the mobility supply. Innovations such as *Mobility as a Service* (MaaS), which combines different transport modes to offer a tailored mobility package through a single interface, offer a promising perspective for sustainable mobility (Jittrapirom et al., 2017).

All over the world there are examples of tools to facilitate multimodal mobility and intermodal trips, from multimodal travel planners, integrated mobility packages and multimodal smart cards. One of these tools are *mobility stations*, generally described as transport nodes where different mobility options, especially public transport and shared mobility services are spatially concentrated and virtually integrated through information and marketing.

Expectations are high on the contribution of mobility stations on sustainable urban mobility. This is because mobility stations serve as a bundled “pull-measure” by providing various alternatives to private cars, which might have synergetic effects in the competition against car ownership and single-occupant car trips.

Relevance of this work

As it was mentioned at the beginning of this chapter, mobility stations started to spread throughout Germany during the last couple of years. Between 2013 and 2016 more than six cities in Germany implemented *mobility stations*, similar facilities to the so-called “mobil.punkte”, implemented for the first time in 2003 in the city of Bremen.

In Munich two mobility stations, one public and one private[1], are being tested as pilot projects, and other sixteen mobility stations are being planned in the framework of three different projects (see Section 4.2.5 for more details). Anticipating this development, the City of Munich is preparing a resolution (*Sharing Beschluss*) to support the integration of shared mobility services within the city.

As mobility stations are a relatively new concept, by the time of starting this dissertation there was little knowledge on their acceptance and perception among (potential) users, their effects on mobility behavior and car ownership, and thus, on their contribution to sustainable urban mobility. Also, to the best of my knowledge there was not available information on success factors for the implementation and operation of mobility stations.

Especially with the integration of free-floating carsharing, there is added uncertainty about the impacts of a multimodal mobility supply on mobility behavior. Despite the well documented impacts of carsharing in reducing car ownership and total vehicle kilometers traveled by car, there is a concern that providing free-floating carsharing at public transport nodes might encourage public transport passengers and cyclists to travel more by car. On the other side, free-floating carsharing users might also switch to public transport or bikesharing. Thus, mobility stations can be seen as a double-edged sword when it comes to mode choice.

This work should answer many of the questions related to the acceptance and impacts of mobility stations, and the results shall support cities, especially Munich, in the process of planning, implementing and operating mobility stations, towards the achievement of sustainable urban mobility.

[1] The private mobility station was investigated as part of a master thesis supervised in the framework of this dissertation (see Section 3.2), and the public mobility station is the main case study of this dissertation (see Chapter 4).

1.2. Goal and research questions

Considering that mobility stations are becoming increasingly popular in German cities as a tool to support sustainable mobility, the motivation and overarching goal of this dissertation is: *to deliver recommendations for the successful implementation and operation of mobility stations towards the achievement of sustainable urban mobility*.

With this goal in mind, the following two main questions arise:

1. Do mobility stations contribute to the goal of sustainable urban mobility?
2. What are the success factors for the implementation and operation of mobility stations?

In order to answer these main questions, other questions need to be answered first, for example:

- What exactly are mobility stations?
- What are distinctive characteristics of mobility stations?
- What mobility services are offered at mobility stations?
- Who are (potential) users of mobility stations?
- How often and for which purposes are the mobility services at mobility stations used for?
- What are the effects of mobility services offered at mobility stations on mobility behavior?
- How do the effects of different mobility services are influenced by the direct proximity of other mobility services?
- What are possible effects of mobility stations on urban mobility?
- What is “sustainable urban mobility” and how do we measure (changes in) it?
- Which actors are involved in the planning, implementation and operation of mobility stations?
- What is the level of acceptance of mobility station among (potential) users?
- What is the perception of mobility stations among users?

1.3. Research approach and expected contributions

As there are many open questions and little knowledge to answer them due to the recent application of the concept, this research follows an inductive method. This means that no hypotheses are formulated. Rather, observations through a wide variety of methods will be done in order to find patterns on the many aspects of interest related to mobility stations and tentative conclusions will be delivered.

In order to answer the first research question, the concept of *sustainable urban mobility* needs to be operationalized. By means of literature review, existing definitions related to sustainable urban mobility and operationalization approaches are considered in order to develop a definition and operationalization approach that can be used to assess the contribution of mobility stations to this concept in the framework of this dissertation. (See Chapter 2).

Moreover, an investigation on the state of the art of mobility stations is carried out by means of literature review and on-site visits. Since the information on mobility stations was limited by the time of starting this dissertation, four master theses exploring different aspects of mobility stations were supervised in the framework of this work (see Section 3.2 for more details). In addition, literature research on the impacts of carsharing and bikesharing, the virtual integration of mobility services and the correlation between multimodality and car ownership was carried out. This was done to complement the findings on the effects of mobility stations on mobility behavior and car ownership. (See Chapter 3).

By means of literature review and data analysis, the Mobility Station at Münchner Freiheit (MSMF) and the context in which it is inserted are described (Chapter 4). Understanding the context of the project was important to better understand the results obtained by the different evaluation methods, and for delivering general recommendations for the development of mobility stations in urban areas like Munich at a later stage.

The MSMF, as a single case study, is investigated in detail through a combination of qualitative and quantitative methods (see Chapter 5). Through collaboration with the main stakeholders involved in the planning, implementation, and operation of the MSMF, an exhaustive evaluation exploring various aspects such as barriers and drivers for the implementation of the project, as well as awareness, acceptance, and perception among (potential) users, usage patterns of shared mobility services and potential effects on mobility behavior, is carried out.

The idiographic explanation of the MSMF (Chapter 6) and the findings on mobility stations and shared mobility services (Chapter 3) are used to assess the contribution of mobility stations on sustainable urban mobility, as well as to identify success factors for their implementation and operation (Chapter 7). Based on this, recommendations for planning, implementing and operating mobility stations towards the achievement of sustainable urban mobility are delivered (Chapter 8).

Finally, Chapter 9 presents the conclusions of this dissertation including recommendations for further research.

The expected contributions of this dissertation are:

1. A thorough understanding of the (potential) impacts of mobility stations on sustainable urban mobility;
2. identification of success factors for the implementation and operation of mobility stations towards sustainable urban mobility, and
3. recommendations for a more sustainable development of mobility stations.

1.4. Structure of the thesis

This dissertation is composed of eight chapters, three of which form the *core* of this work, one of them serves as a *mirror* to this core, two of them form the *assessment framework*, and other two form the *overall framework*. The content of each chapter is described in the following list. Then, their organization and relation to each other is presented in Figure 1.1 followed by an explanation.

1. Chapter 1 presented the motivation for working on this dissertation, the goal and research questions, as well as research approach and expected outcome.
2. Chapter 2 starts by presenting existing definitions related to sustainable urban mobility and operationalization approaches. Based on this, the

concept of sustainable urban mobility is defined in the framework of this dissertation and indicators to measure it are selected.

3. Chapter 3 presents the state of the art of mobility stations, including definitions and understandings of these and similar facilities. It continues with the development of mobility stations in Germany, their main characteristics and goals, as well as main findings on their acceptance, perception and impacts on mobility behavior. This is followed by selected findings on the impacts of carsharing and bikesharing, and the virtual integration of various mobility services on car ownership and mobility behavior, as well as the correlation between multimodality and car ownership.
4. Chapter 4 presents in detail the case study of the first mobility station in Munich, its history, development, stakeholders, characteristics and components as well as the context in which it is inserted.
5. Chapter 5 presents the various methods used for the evaluation of the MSMF and an assessment method to determine its contribution to the concept of sustainable urban mobility.
6. Chapter 6 presents the results of the evaluation of the MSMF and the corresponding analysis considering the findings on mobility stations and shared mobility services presented in Chapter 3.
7. Chapter 7 starts with an assessment of mobility stations on sustainable urban mobility based on the findings presented in Chapter 6 and Chapter 3. It continues with the presentation of identified success factors for planning, implementing and operating mobility stations, and concludes with a reflection on the methods.
8. Chapter 8 provides general recommendations for the future development of mobility stations towards the achievement of sustainable urban mobility.
9. Finally, Chapter 9, synthesizes the main findings of this dissertation presenting the conclusions and recommendations for further research.

Figure 1.1 presents the structure of the document showing the four parts in which the above-mentioned chapters are organized.

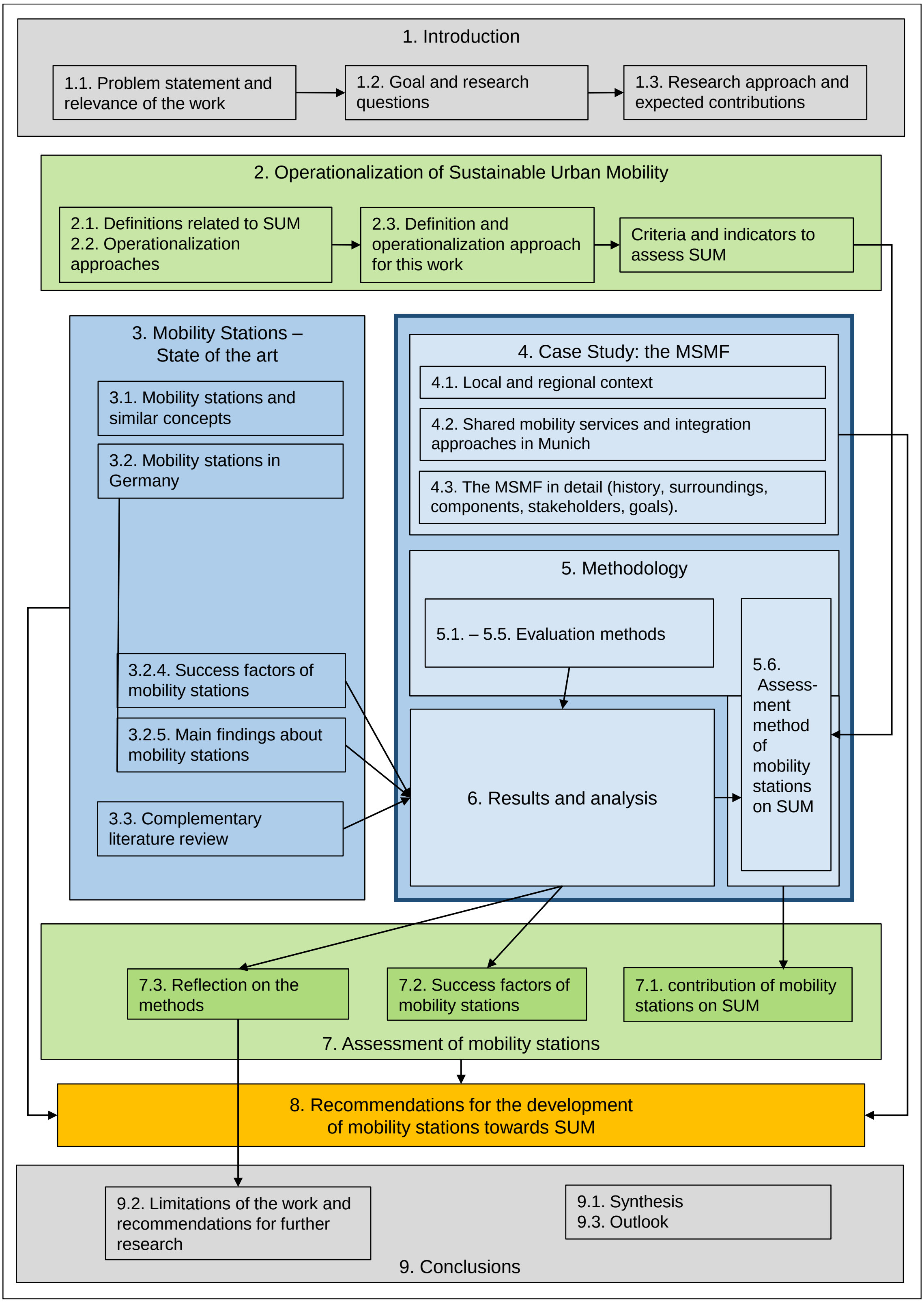


Figure 1.1: Structure of the document

The *core* consists of chapters 4, 5 and 6, providing an idiographic explanation of the Mobility Station at Münchner Freiheit (MSMF). This is complemented with the findings on mobility stations and shared mobility services presented in Chapter 3 (the *mirror*), supporting the analysis of results.

Chapter 2 and 7 provide the *assessment framework*. The operational approach developed to assess sustainable urban mobility in Chapter 2, forms the basis for the assessment of mobility stations on sustainable urban mobility, which is presented in Chapter 7. In addition, Chapter 7 presents the identified success factors and a reflection on the methods. All this, together with examples from other mobility stations and similar facilities, as well as the description of the case study, leads to recommendations for the development of mobility stations in a way that they contribute to sustainable urban mobility (Chapter 8).

Finally, Chapter 1 and Chapter 9 provide the overall framework of the work. The goal and research questions presented in Chapter 1 are confronted in Chapter 9. To which extent was the goal achieved and the research questions answered? What is next?

How to read this document

Each chapter begins with an introduction presenting briefly the content of the main sections and each section begins with a short description of its subsections. Large sections or subsections provide a summary of the main findings. Thus, the reader can get a general overview of the content by reading the introductions to chapters and sections, together with their summaries.

2. Operationalization of Sustainable Urban Mobility

As presented in Chapter 1, the overarching goal of this dissertation is to deliver recommendations for the successful implementation and operation of mobility stations towards the achievement of sustainable urban mobility (SUM). But, what does “sustainable urban mobility” mean, how can we measure it, and how can we assess the contributions of a project to this concept?

In order to determine the extent to which mobility stations contribute to sustainable urban mobility, it is necessary to:

1. provide an operational definition of the concept, and
2. identify measurable variables and indicators relevant to the concept that can be influenced by mobility stations.

In recent decades, definitions related to sustainable mobility, sustainable transport, or sustainable transportation have been put forward by individuals and organizations of different kinds - from international organizations such as the Organization for Economic Cooperation and Development (OECD) and the World Business Council for Sustainable Development (WBCSD), to state and city governments, NGOs, and research institutes.

In addition, different approaches for assessing sustainable transport and sustainable mobility have been developed by some of the organizations mentioned above and researchers in the field. Some of these definitions and operationalization approaches were reviewed and reflected upon with the aim to generate a definition of sustainable urban mobility and a suitable assessment method for this work.

Section 2.1 presents a literature review on definitions and Section 2.2 present a review of different operationalization approaches. Both subsections conclude with a summary of the literature taken into account for the development of a definition and an operationalization approach for this work, which are presented in Section 2.3. An assessment method to determine the contribution of mobility stations to sustainable urban mobility is presented later in Section 5.6 as this is part of the methodology used in this work.

2.1. Definitions related to sustainable urban mobility

In order to define the concept of *sustainable urban mobility* for this work, definitions of this and related concepts such as *sustainable transport* or *sustainable transportation* were reviewed. Through the search for definitions, it was found that other authors had already carried out extensive literature reviews and analyses of these concepts. For some examples see Hoyer (2000), Hall (2002; 2006), Zegras (2005), Zhang and Wei (2012) and Holden et al. (2013). Annex A presents some definitions of sustainable transport and sustainable mobility.

In the following section, a short review on the development of these definitions is presented followed by selected findings from the analyses carried out by other authors, which were taken in account for the development of an own definition.

2.1.1. Development of definitions

From the literature review, it becomes clear that many, if not all, of the definitions related to sustainable mobility or sustainable transport are influenced to some extent by the broader definition of *sustainable development* that the World Commission on Environment and Development, also known as the “Brundtland Commission”, put forward in 1987:

> *“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”* (WCED, 1987).

Based on this internationally adopted definition of sustainable development, the concept of *sustainable transport* came into use more explicitly in conference papers and policy documents in the following years (Zegras, 2005). In 1994, the OECD initiated an international project to define *Environmentally Sustainable Transport* (EST) (McCrae and Boulter; Zegras, 2011).

A few years later, the OECD pointed out in the proceedings of the Vancouver conference “Towards Sustainable Transport” that “sustainable transportation is a subject about which reasonable and informed people can have quite disparate and strongly held opinions” (OECD, 1997) showing that a common understanding was difficult to achieve.

Despite this difficulty, the OECD and other organizations and individuals defined or described sustainable transport in different contexts. Some of these definitions have been analyzed and discussed in the past by other authors. In the following pages, selected findings from these analyses and discussions are presented.

2.1.2. Selected findings

Hall (2002) reviewed 22 documents dated from 1996 to 2001 dealing with sustainable transport and observed that the international community had reached a consensus that the concept of sustainable transport can be defined under the three E's of environment, equity, and economy.

Based on his literature review, Zegras (2005) indicated that most definitions of sustainable transport involve three basic concepts: 1) access (or accessibility), 2) recognition of resource constraints (financial, economic, natural, cultural), and 3) equity.

Considering the wide range of issues under each of the above-mentioned "three E's", Hall (2002; 2006) proposed a comprehensive definition and developed principles of sustainable transport. Arguing that national governance ensuring peace and development is a vital element of sustainable development, but had not yet been considered in existing definitions, Hall (2006) added the aspect of *governance* and identified several core principles to guide government actions to support the objectives of sustainable transportation and sustainable development.

Goldman and Gorham (2006) examined the concept and implementation of sustainable transport and traced efforts to define and operationalize the notion of sustainable transport in the urban context. They noted two broad clusters of work: those that envision sustainable transportation as a *policy pathway*, and those that envision it as a *policy end-point* (Goldman and Gorham, 2006). Recognizing the *porous nature* of the transport system, which is intertwined with other systems, the authors suggest adopting a system-based vision for policy development in the transportation sector.

More than a decade after the Vancouver conference, Zhang and Wei (2012), reviewed national and international definitions and connotations of sustainable transportation and concluded that "*while the definitions reveal that there is no standard way in which sustainable transportation is being considered, there seems to be a consensus that progress must occur on at least three fronts: economic, environmental, and social* *sustainability"*. Considering that much attention is fixed on the impacts of transportation systems on these three aspects, the authors suggest to add the dimension of *quality of life* as a central aspect of sustainability of urban transport and suggest that people-oriented indicators reflecting public health, traffic safety, and happiness should be considered in further research. (Zhang and Wei, 2012)

According to Holden et al. (2013), by the time of their publication, there was still not a political nor a scientific agreement on the definition of sustainable passenger transport, which could help politicians solve challenges at the global or regional level. According to the authors, the focus on sustainable transport in the literature had changed during the previous two decades, and sustainable passenger transport problems had been addressed in new ways representing an increasing number of disciplines applying different methodological approaches.

Based on some examples from the literature, Holden et al. (2013) argue that the concept of sustainable transport is about to include every desirable aspect of transport, which entails the risk of becoming meaningless. Thus, the authors redefined the concept based on the Brundtland definition (see page 14) and suggested an assessment method based on, to their understanding, four equally important main dimensions, namely:

1. safeguarding long-term ecological sustainability,
2. satisfying basic human needs,
3. promoting intragenerational equity, and
4. promoting intergenerational equity.

Contrary to the models that focus on the balance between environmental, social and economic issues, the authors argued, based on the Brundtland definition, that economic growth is not one of the main dimensions of sustainable development but one of the potential means to facilitate the fulfillment of the main dimensions (Holden et al., 2013). Their proposed assessment method is presented in the next section.

2.1.3. Summary

The review of definitions related to sustainable urban mobility in the framework of this dissertation confirms the findings that other authors have made in the past, that is that most definitions of sustainable transport, sustainable transportation or sustainable mobility refer to aspects of the three so called pillars of sustainability: environment, society and economy (Hall, 2002; 2006; Zhang and Wei, 2012). Also, through the literature review and by reflecting on the definitions provided, it was observed that:

- in some cases, the terms *mobility* and *transport* are used interchangeably;
- the defined subject (sustainable transport or sustainable mobility) can be seen either as tool to achieve a higher goal, such as quality of life, or as a goal in itself;
- definitions refer to a given system (e.g. transportation system in general, urban mobility, mobility within a sector - e.g. “passenger transport”);
- definitions change over time, just as the systems they refer to and the perceptions, values, and knowledge of the people that contribute to them and give meaning to the concept also change over time.

In summary, there is not a universal or unique definition for sustainable urban mobility because the ideas related to this concept strongly depend on the context, the actors pursuing and contributing to the concept as well their own personal opinions, knowledge and values in that particular context at that particular time.

Definitions are necessary though, for the formulation of goals and objectives, which in turn allow for the development of action plans at the local, regional and global levels. In this sense, it is important to define indicators and methods for monitoring progress towards the goal and objectives, and thus, the success of such plans.

2.2. Operationalization approaches

While researchers and organizations have already worked towards defining the concepts of sustainable transport and sustainable mobility, efforts have been made as well to operationalize them. This section presents a review of these efforts.

2.2.1. An operational definition of sustainable mobility

According to Zegras (2005), none of the definitions of sustainable transportation considered in his dissertation offered an operational definition[2]. With the aim to understand the role of a city's built environment in the sustainability of its mobility system, Zegras derived an operational definition of sustainable mobility as *"maintaining the capability to provide non-declining accessibility in time"*. Zegras (2005)

To measure the concept, Zegras draws from measures of accessibility and recognizes mobility as a throughput: "[a]ll else equal, we want more accessibility with less mobility throughput" (Zegras, 2011; Zegras, 2005). According to the author, this mobility throughput can be roughly represented by a measure of distance traveled, weighted according to the various "capital drains" that each transport mode implies. Such *capital drains* or *depletion of capital stocks* are understood as the consumption of different resources for mobility.

Recognizing the complexity of such capital drains, he proposes Vehicle Distance Traveled as simplified proxy for the mobility throughput in his operational definition (see above) and presents an index of sustainable mobility in a stylized equation:

Index of sustainable mobility = accessibility – transport consumption (VDT)

Zegras (2005) recognized that his definition leaves some issues unresolved, such as the intergenerational and intragenerational well-being and the intra-sectoral value of resource use. Moreover, Zegras indicated that his definition suffers from many of the problems that other sustainable transport definitions confront, and that instead of offering a purely operational definition, his definition of sustainable urban mobility remains as a more general form of guidance in understanding the concept: the definition might enable recognizing *more* sustainable mobility where there is higher accessibility at lower transport throughput, but it does not say whether mobility *is* sustainable (Zegras, 2005).

[2] A possible exception according to the author is the one provided by Lee Schipper in 1996: "Transportation is sustainable when the beneficiaries pay their full social costs, including those paid by future generations" (Zegras, 2005)

2.2.2. An operational approach for sustainable transport development

With the aim to operationalize the concept of *sustainable transport development* while considering the process character of sustainability, Gerike (2005; 2007) proposed a *corridor of sustainable transportation development* consisting of three task fields: 1) the allocative task field, 2) the social task field, and 3) the resource task field.

The establishment of these task fields is based on a theoretical discussion which recognizes human needs as the central focus of sustainable transport development since sustainable development is regarded as development designed to meet the needs of people today and in the future (based on the Brundtland definition, see page 14). In her work, the market is considered the most flexible mechanism for identifying and satisfying needs and should therefore be used to facilitate sustainable transport development. (Gerike, 2005; 2007)

Considering the above, the goal of measures within the *allocative task field* is to support the qualities of the market mechanism for the satisfaction of human needs. However, it is recognized that the market mechanism does not guarantee the satisfaction of needs of all people today or in the future, as the definition of sustainable development requires. (Gerike, 2007)

As a result from insufficient consideration of distributive aspects by the market mechanism, distributive task fields are suggested considering the goals of intragenerational and intergenerational equity (Gerike, 2007). These distributive task fields are the *social task field* and the *resource task field* mentioned above.

The aim of the *social task field* is to guarantee a basic transportation supply for all people, while the goal of the *resource task field* is the formulation of limits for the consumption of natural resources. These distributive task fields form the boundaries, which should not be exceeded by the activities in the transport sector:

- The lower boundary consists of the basic transportation supply to be guaranteed within the social task field and should not be fallen short.
- The upper boundary is defined by the carrying capacity limits, to be formulated in the resource task field and should not be exceeded.

Within these two boundaries, the allocative task field should reduce market distortions in order to allow the qualities of the market mechanism to unfold unhindered, and thus allow the satisfaction of needs beyond those provided by the social task field.

Figure 2.1 shows the corridor of sustainable development defined by the three tasks.

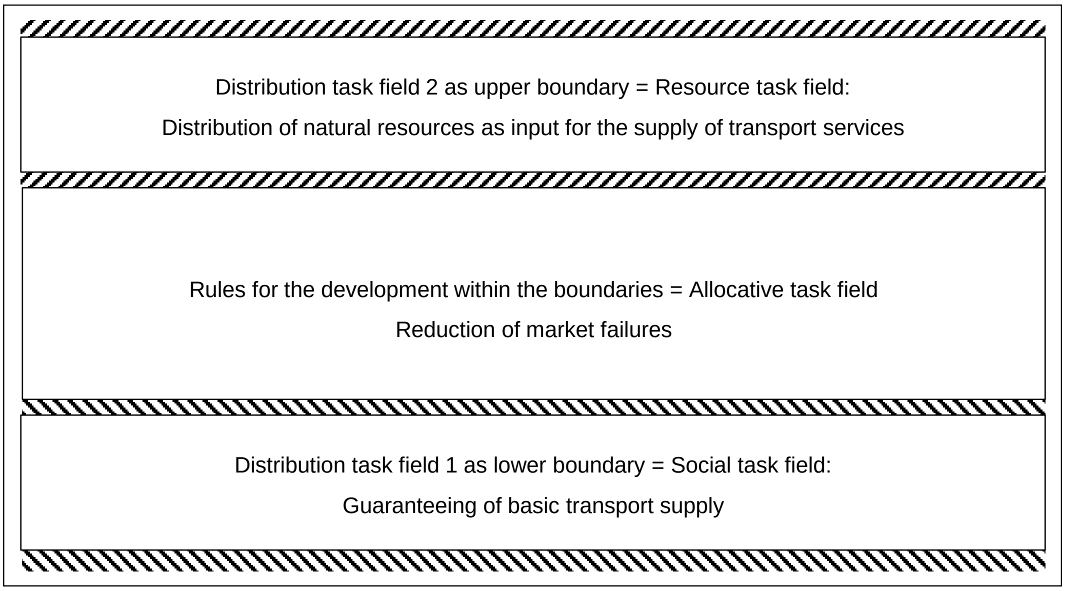


Image source: reconstruction based on original in Gerike (2007)

Figure 2.1: Corridor of sustainable transportation development

In order to concretize the development corridor, Gerike (2007) suggests some criteria for describing the task fields:

- In the case of the allocative task filed, external costs are recommended as they key criterion in order to reflect the operating functionality of market mechanisms in the transport sector.
- In the case of the resource task field, CO_2 emissions are recommended as a key criterion because they are directly related to energy use and to the use of limited natural resources. Moreover, its reduction is an important goal of climate protection, which is increasingly accepted and is the subject of international negotiations.
- In the case of the social task field it is argued that for the fulfillment of needs two conditions must be met:

1. The destinations necessary for the realization of basic existence functions (shelter, work, access to provisions, education, and recreation, as well as access to transport and communication) must exist in reasonable quality and quantity.
2. The existing destinations must be accessible to people through transport offers.

Criteria for determining a basic transportation supply are thus accessibility analysis and its contrast with space analysis as an efficiency measure, the satisfaction of people with their inclusion into local transport policies, and the level of agreement of people that the conditions for satisfying their basic needs are given, among others.

Finally, according to Gerike (2007), while science can provide information of suitable criteria, putting the development corridor in concrete terms is a highly normative task that can only be done within a societal discussion. Thus, the author emphasizes public participation as an important means for people to articulate and satisfy their needs that should be taken in account in the spatial and transport planning tasks.

2.2.3. A business approach to measure sustainable mobility

Another interesting operationalization approach is the one developed by the World Business Council for Sustainable Development (WBCSD), which has been evolving since 2001 with the publication of their report "Mobility 2001" (WBCSD, 2001).

The WBCSD definition of sustainable mobility as *"the ability to meet the needs of society to move freely, gain access, communicate, trade, and establish relationships without sacrificing other essential human or ecological values, today or in the future"* (WBCSD, 2001), includes – as many others do – aspects from the three so-called pillars of sustainability (environment, society, and economy).

With the aim of measuring this concept, a set of 12 indicators were identified and classified into two groups of measures (WBCSD, 2001):

- measures to be increased: access to means of mobility, equity in access, appropriate mobility infrastructure, inexpensive freight transportation; and
- measures to be reduced: congestion, emissions , noise, environmental impacts, disruption of communities, accidents, demand for non-renewable energy, and solid waste.

This approach has the advantage that the two groups of measures represent both the positive (what should increase) and negative (what should be reduced) aspects of mobility and transport, in an easily understandable way. However, this approach has some limitations in the ways some of these aspects were described and how their interrelations were understood.

For instance, people may agree that *access to means of mobility* and the *equity of access* should increase in order to help fulfill the needs of society, thus supporting achieving an ideal level of sustainability. However, the different ways these aspects are understood can result in disparate and counterproductive strategies.

As a concrete example, if the particular description of the aspects mentioned above implies that, to increase equity in access those unable afford owning and driving a car in the initial situation should be able to do so, the negative aspects associated with increased car ownership such as congestion, emissions, and noise would also increase, instead of decreasing as the approach suggests.

This example shows that clear definitions of the involved aspects (or variables) and their interactions are crucial in developing meaningful strategies towards the goal of sustainable mobility.

Building upon their first set of indicators, the WBCSD proposed a new set of 12 indicators in 2004, which in their view made up the most important dimensions of sustainable mobility (WBCSD, 2004). The new indicators were used to evaluate both personal mobility and freight transport and the more elaborate descriptions were the result of a wide consultation process and literature review (WBCSD, 2004).

Finally in 2015, the WBCSD proposed another set of 19 indicators as "[…] a tool for cities to evaluate the current situation of a mobility system, understand its evolution over time and to evaluate the potential impact of selected solutions[…]" (WBCSD, 2015). The document describes the aspects to be measured, the indicators to be used, and methodologies for their calculation in detail.

The 19 indicators are scaled from 0 (most negative score) to 10 (most positive score) and the base for the scaling is based upon data from Lisbon and various cities in Belgium, literature research, a deductive choice, or long term sustainability goals (WBCSD, 2015). The values on the scale can be understood as thresholds that should be achieved in order to consider mobility as sustainable, which enables identifying areas of opportunity.

This WBCSD approach allows a comparison of the level of sustainable mobility between different cities by rating the 19 indicators using the 0-10 scale for each city. However, one disadvantage of this approach is that both the indicators and the scale are derived from an ideal vision of what sustainable mobility should look like, as defined by others. Thus, in individual cases these general indicators and/or their thresholds might not be appropriate for measuring the concept in context. Also, the WBCSD approach represents the vision of sustainable mobility from an industry group, which might not necessarily be the vision from a local government.

The review by Zegras (2011) of the first two sets of WBCSD indicators (2001 and 2004) suggests that the greatest challenge to operationalizing sustainable mobility indicators effectively is due to their global focus. This observation applies the newer indicator set of 2015 as well.

2.2.4. A local approach for evaluating urban mobility

A local approach for evaluating sustainable urban mobility is suggested by the Guidelines for Developing and Implementing a Sustainable Urban Mobility Plan (SUMP)[3]. Although a definition of *sustainable urban mobility* is not provided, an understanding can be derived from the definition of what a SUMP is: *"[t]hey [the guidelines] define a Sustainable Urban Mobility Plan as a strategic plan designed to satisfy the mobility needs of people and businesses in cities and their surroundings for a better quality of life*" (Wefering et al., 2014).

[3] The SUMP guidelines are the result of a thorough and European-wide expert consultation process organized between 2010 and 2013 as part of a service contract for the European Commission (Wefering et al., 2014)

The document provides guidance for developing and implementing a SUMP in four main phases and eleven steps, each of which are broken down into activities.

At different points in the process, four activities related to the operationalization of sustainable urban mobility can be identified:

- Activity 3.1: “Prepare an analysis of problems and opportunities”
- Activity 3.2: “Develop Scenarios”
- Activity 5.2: “Develop SMART (Specific, Measurable, Achievable, Realistic and Time-bound) targets“, and
- Activity 8.1: “Arrange for monitoring and evaluation”

The above-mentioned activities require describing the current local situation of transport and mobility through the collection and analysis of data, creating scenarios and targets, as well as monitoring the achievement of the latter.

The guidelines, however, do not specify which indicators should be measured, because their selection depends on the initial situation and the targets set at the local level. Instead, it is suggested to get more specific guidance on the selection and use of indicators from other sources such as a report from the DISTILLATE Project (see Marsden et al. (2005).

2.2.5. Sets of multiple indicators

In addition to the various indicator sets from the WBCSD (see Section 2.2.3), other examples of sets of indicators as well as methodologies for their measurement at the urban level are provided in the framework of European sustainable mobility projects. Table 2.1 presents some of these efforts.

Based on a review of various indicator initiatives, Zegras (2011) observed that these are ambitious efforts from different perspectives (e.g. business sector and academic sector), reflecting different purposes, scales, and value systems. Considering more thorough reviews of indicator efforts by other authors, Zegras observes the overwhelming number of indicators derived through these efforts and the failure to clarify the link between the proposed metrics and the objectives. He also indicates that indices (e.g. a sustainable transport index) could be a path “through the dense multi-indicator forest” (Zegras, 2011).

Table 2.1: Sets of indicators to measure sustainable mobility or transport in the framework of different projects

Project	Indicators sets	Source
SPARTACUS	7 indicators classified in the three dimensions of sustainability (environment, society, economy)	(Lautso, 2003)
PROSPECTS	11 indicators classified in 7 sub-objectives and three levels according to availability of data.	(Minken et al., 2002)
DISTILLATE	Over 70 indicators classified in “key outcomes” and intermediate “outcomes”, as well as in 13 “ECTM” areas pertaining to the three pillars of sustainability. In addition, a method for prioritizing the selection of indicators is provided.	(Marsden et al., 2005)
CIVITAS CAPITAL	Set of 28 indicators, classified in 9 categories, that cities can use to measure how well their transport and mobility system is performing.	(Rye and Stanchev, 2016)

2.2.6. Composite indexes

Shen and Hermans (2017) recognized the complexity of sustainability as a matter that is affected by numerous factors and that no single indicator is capable of measuring it. The authors considered the development of a composite indicator (CI) a valuable approach for evaluating the sustainability of urban mobility.

In their paper, the authors provided guidance for developing a sustainability index that would be able to assess the impact of mobility on the urban quality of life (Shen and Hermans, 2017). The seven methodological steps suggested by the authors are:

1. developing a theoretical framework that clearly defines the phenomenon and its subcomponents to be measured based with a set of suitable indicators;
2. selecting appropriate indicators using eight criteria: relevant, measurable, understandable, has data available, reliable, comparable, specific, and sensitive;
3. collecting indicator data (quantitative and qualitative),
4. data processing and analysis (e.g. detection of outlying observations, data normalization, and multivariate analyses),

5. weighting of indicators: applying a weighting scheme in order to deduce an appropriate weight for each indicator;
6. aggregation of indicators (linear or geometric);
7. robustness test by means of uncertainty and sensitivity analyses.

The first four steps seem to be important for operationalizing the concept of sustainable mobility in a concrete way, even if is not intended to build a composite index.

Considering the large amount of indicators found in the literature and the difficulty of continuously collecting data for each of them, it is desirable to have an approach consisting of a few representative indicators of sustainable urban mobility which could be easier to monitor.

2.2.7. Sustainable passenger transport measured with four indicators

As previously mentioned, Holden et al. (2013) redefined *sustainable passenger transport* based on the Brundtland definition, and suggested an assessment method based on, to their understanding, four equally important main dimensions (see Section 2.1). These dimensions were then in turn adapted to the passenger transport sector.

In their paper, the authors argue that:

- the main dimensions should be given priority over less important dimensions, and unless threshold values related to these main dimensions are met, transport cannot be deemed as sustainable;
- the main dimensions and their threshold values represent equally important targets, excluding the possibility of trading off an underperformance on one indicator against an over performance on another;

Considering the above arguments, the authors argue against reducing sustainability to a single composite index (it shall be assured that each dimension reaches the thresholds values), and also refuse the other extreme of using a long list of indicators for measuring sustainable transport (Holden et al., 2013).

Furthermore, Holden et al. (2013) argue that sustainability should be addressed at a global level as we are all part of a single system with complex interactions among all its parts. Thus, dimensions, indicators, and thresholds are derived from global challenges.

Holden et al. (2013) then defined one indicator for each of the four dimensions and determined threshold values that have to be met until 2030 in order to consider passenger transport as sustainable, arguing that the development of indicators in the right direction is good but not enough.

Table 2.2 presents the four indicators to measure sustainable passenger transport and thresholds suggested by the authors.

Table 2.2: Indicators to measure sustainable passenger transport and corresponding thresholds

Sustainable development dimension	Sustainable passenger transport dimensions	Indicator	2030 threshold
Safeguarding long-term ecological sustainability	Impacts of transport activities must not threaten long-term ecological sustainability	Daily per capita energy consumption for passenger transport	Maximum 5.6 kWh per capita per day
Satisfying basic human needs	Satisfying transport needs	Daily per capita traveled distance by motorized transport	Minimum 9.2 km per capita per day
Promoting intragenerational equity	Promoting intragenerational transport equity	Public Transport Accessibility Level (PTAL)	Minimum PTAL 3
Promoting intergenerational equity	Promoting intergenerational transport equity	The amount of renewable to total energy used for transport	Minimum 15%

Source: Holden et al. (2013)

For more information regarding the selection of indicators and setting the thresholds values see Holden et al. (2003)

2.2.8. Summary

This section explored various approaches to operationalizing sustainable mobility and related concepts. Some operationalization approaches are based on lists of indicators which cover a wide variety of aspects including environmental, social, and economic components.

However, operationalization approaches based on large numbers of indicators hardly help to measure sustainable mobility or sustainable transport.

One reason for this is that often it is not practical to measure all of the indicators in such a list due to cost and/or time restrictions.

But even if all of these indicators could be quantified, the interrelations among variables that these indicators represent are often not considered. Overlooking such interrelations might lead to ambiguous results and hinder the design of effective measures towards the goal of sustainable mobility.

For instance, an intended development of one indicator might cause an unintended development on another. Some examples of counteractive effects of measures deemed as sustainable are presented in Table 2.3.

Table 2.3: Examples of counteractive effects of measures deemed as sustainable

Measure deemed as sustainable	**Effect in line with most sustainable mobility concepts**	**Counter effect not in line with most sustainable mobility concepts**
Network performance improvements	Travel time is reduced by increasing speed in the transportation system, through intelligent transport systems, green waves, etc.	An increase of speed in the transportation system might increase the number of accidents and fatalities, or induce more car traffic and thus, emissions.
Vehicle efficiency standards	An increase in vehicle fuel efficiency might reduce fuel consumption per kilometer traveled, thus emissions and user mobility costs are reduced.	A reduction in costs might as well lead to more travel, which could be considered positive for the user but it counteracts the goal of reduced emissions.
Congestion charging	Congestion charging leads to a reduction of traffic volumes within a city reducing congestion, noise and air pollution.	This measure could represent a disadvantage for some users, especially low-income commuters that do not have another alternative, thus being counterproductive for accessibility of vulnerable groups and equity in access.

Considering the above, the formulation of a clear goal and objectives, as well as understanding the interrelations among variables within the system being investigated, should help to identify key variables and effectively reduce the number of indicators to be measured.

Using a composite index for measuring sustainable mobility as suggested by Shen and Hermans (2017) could be useful for comparing the sustainability level of cities and communicating the results to the public. However, the aggregation of various indicators involves time consuming steps and does not necessarily help develop strategies for achieving sustainable mobility (i.e. it does not allow to identify levers for changing the system).

The approach of Holden et al. (2013) is interesting in that it concentrates on four main dimensions, defines the corresponding set of indicators, and sets thresholds derived from global challenges. Following their argument that we are all part of a single system (i.e. the earth), their reasoning for using global challenges for threshold values makes sense. However, for evaluating projects at the local level, these thresholds might be too broad or inappropriate. What if, for example, people can already fulfill their needs with less than 9.2 km by motorized transport? Is then passenger transport not considered sustainable because this indicator of a main dimension is below the minimum threshold in their framework?

Through the review of various operational approaches and guidelines on the use of indicators for measuring sustainable transport and sustainable mobility, the following lessons for this study were gathered:

- It is important to elaborate a precise definition of the concept that is to be operationalized, which in turn can help to identify aspects that need to be measured; in the case of sustainable urban mobility, it is important to develop a vision on how such an abstract concept would look and operate, and thus, an operational definition;
- It should be possible to realize this vision through the formulation of clear objectives. The SUMP Guidelines suggest to define SMART (specific, measurable, achievable, realistic, and time-bound) targets (Wefering et al., 2014).
- The achievement of such objectives should be measurable through appropriate indicators. Literature suggest that indicators should be relevant, measurable, understandable, have data available, reliable, comparable, specific, and sensitive, among other characteristics (Shen and Hermans, 2017; Joumard and Gudmundsson, 2010).

- Distinguishing between positive aspects to be increased and negative aspects to be reduced, as in the first WBCSD approach, seems to be an easy to understand and useful approach. However, a clear definition of these aspects and the interrelations among them should be taken into account when developing strategies towards the goal of sustainable mobility.
- It should be taken into account that some aspects might be impossible to assess or predict, for example when they result from the interactions with other systems and the consequences are not foreseeable (e.g. the effect of autonomous vehicles on road safety and the performance of the transport system are difficult to predict, just as the effect of acid rain caused by air pollution from mobile sources was impossible to predict).

Building upon these learnings I suggest an operationalization approach for sustainable urban mobility in the framework of this dissertation (see Section 2.3).

2.3. Definition and operationalization of SUM for this work

In the next subsections I present a definition and an operationalization approach for sustainable urban mobility for this work, which have both been developed considering definitions and operationalization approaches presented in the previous two sections.

2.3.1. Definition of sustainable urban mobility for this work

In this work, the word ***sustainable*** is understood as an adjective used to describe a system, a structure, organization, or community – among other things – that can endure for an undefined period of time using resources of the system it belongs to in a way that they are not depleted.

While the words transport and mobility are used interchangeably in some contexts, in this work a distinction between the two is made:

- ***transport*** is understood as a tool consisting of infrastructure, services, vehicles, fuels, and rules which enables mobility. We can also refer to this as the transportation system;
- ***mobility*** is understood as the *potential and realized movement* of persons and goods between two different locations in a given system (such as a city), to

fulfill their needs. *Potential mobility* is the given possibility for people to move while *realized mobility* is the actual change of location, the realized movement between two different locations. In this context, mobility is also understood as a need in itself (movement for the sake of movement).

Considering the definitions of the terms above, as well as the previous definitions and background context of sustainable transport and mobility put forward in Section 2.1 (see also Annex A for selected definitions), I propose the following definition for the framework of this dissertation:

> *"Sustainable urban mobility is the result of transportation systems that allow goods to be delivered and all people to fulfill their needs within an urban environment in a way that the resources needed for this are not depleted, allowing future generations to do the same".*

As most of the definitions in Section 2.1, this one considers:

- natural limits of available resources by indicating "*in a way that the resources needed are not depleted" (*environmental component of sustainability).
- the fulfillment of human needs, by indicating that sustainable mobility *"…allows goods to be delivered and all people to fulfill their needs*" (social component of sustainability),
- the goal of intragenerational equity, by indicating that sustainable mobility allows "*all people to fulfill their needs"*), and
- the principle of intergenerational equity, by indicating that mobility shall be realized in a way that the resources consumed are not depleted, and thus "*allowing future generations to do the same*".

The economic component is not considered in this definition. In agreement with Holden et al. (2013) "*economic growth is not one of the main dimensions of sustainable development but one of the potential means to facilitate the fulfillment of the main dimensions*". Also, it is argued that economic activity can only perpetuate in a balanced system delimited by the maximum thresholds of resource consumption and minimum thresholds of fulfillment of needs, similar to the boundaries that Gerike (2005) suggest for the corridor of sustainable transport development.

The suggested definition does not specify what "needs" are, however, it is recognized that defining them and a minimum level of fulfillment is an important step for policy making and concretizing the concept through the implementation of measures.

The definition does not include aspects such as air quality, safety, noise, or comfort, as many other definitions do, but it concentrates on the consumption of resources. In Section 2.3.3 I argue why it is meaningful to concentrate on the consumption of four key resources.

2.3.2. Operationalization approach

Considering the definition above, the concept of sustainable urban mobility requires maintaining the fulfillment of human needs while using resources below their regeneration rate within a given system (e.g. an urban area) for an undefined period of time.

In theory, if the fulfillment of needs of a given population in a given urban area (understood as the system) during a given period of time stays constant, while the consumption of resources within that system decreases within the same period of time, the *value* of the sustainability of urban mobility would increase. Mathematically, this relation could be expressed as follows:

$$sustainable\ urban\ mobility \propto \frac{fulfillment\ of\ needs}{consumption\ of\ resources}$$

The idea of maintaining the fulfillment of needs is very similar to what Zegras (2005) proposed in his operational definition of the same concept as "maintaining the capability of non-declining accessibility over time". My approach sees accessibility as a means for the fulfillment of needs and the mobility throughput or "capital drains" of Zegras are expressed here as the consumption of resources.

Similar to the first WBCSD approach, this approach identifies two main aspects: the fulfillment of needs which should be maintained or increased (depending on the initial situation), and the consumption of resources which should be reduced.

At this point, it should be possible to realize the vision of sustainable urban mobility expressed in my definition through the formulation of SMART objectives (see Section 2.2.8).

Based on the definition presented in Section 2.3.1, two main objectives required to achieve the goal of sustainable urban mobility can be defined:

1. to maintain or increase the fulfillment of needs of all individuals, and
2. to reduce the consumption of resources required for mobility.

With these two objectives in mind, indicators representing each of these aspects should be identified. Ideally the indicators should be relevant, measurable, understandable, have data available, reliable, comparable, specific, and sensitive (see Section 2.2.8).

Practical considerations

After exploring different approaches to operationalize the concept of sustainable urban mobility, it became clear that measuring it is an extremely complex task because it refers to:

- the *fulfillment of human needs*, which (the needs) are different at the individual's level, depend on the context where individuals live, and change constantly over time. Thus, measuring the extent to which needs are fulfilled could be impractical;
- the *use of resources* below their regeneration rates, which (the resources) are available in different amounts depending on the context, the time, and on how the system boundaries are defined. Thus, determining if the resources are being consumed below their regeneration rates requires an extensive and expensive collection of data.

Nevertheless, it is clear that a definition of the system and its spatial and temporal boundaries are necessary in order to monitor the development of some indicators.

When defining system boundaries, one must be aware that, although it is necessary for practical purposes, this delimitation might lead to an incomplete picture of reality, and that the interactions of the defined system with other systems should be considered in a further step (there is an universe out there interacting with our theoretically defined system - e.g. commuters entering and leaving the physical boundaries of a city, energy production elsewhere feeding the vehicles in our system, etc.).

The quantification of the fulfillment of human needs in a system of interest, such as an urban area, would require asking everyone in the study area how well their needs are fulfilled. Considering that human needs are very diverse depending on the context, can be contradictive, and change over time, a direct quantification of this fulfillment would be impractical.

As for the consumption of resources, the questions are: What resources are consumed for mobility?, How much of these resources are available in a given system?, At which rates are these resources consumed?, and What are their regeneration rates?

By answering these questions it should be possible to define some thresholds for the maximum consumption of resources. The availability of resources for mobility (e.g. space and energy) will depend on how the system boundaries are defined. In addition, it should be considered that the availability of resources can also be different among individuals within the same system based on personal characteristics, preferences, and attitudes. For example, individuals have different budgets (time and financial resources) for mobility.

In summary, to quantitatively determine if mobility is sustainable or not, and to measure changes in its sustainability, it is necessary to:

1. define system boundaries where both the fulfillment of human needs and the consumption of resources can be quantified,
2. define a minimum threshold for the fulfillment of needs that should be maintained,
3. quantify the fulfillment of needs to determine if they are over the minimum threshold,
4. define limits for the use of resources (maximum threshold) considering their regeneration rates, so they are not depleted,
5. quantify the consumption and regeneration rates of resources and determine if the net consumption is below the maximum threshold.

Furthermore, to measure progress towards the achievement of an ideal level of sustainable mobility in a given system, it would be necessary to quantify the fulfillment of needs and the consumption of resources over time, so as to determine if the defined thresholds would be kept in the future.

These tasks, however, are not within the scope of this dissertation. Recognizing the difficulty in quantifying these aspects, I suggest identifying indicators which reflect the fulfillment of needs and the consumption of resources related to urban mobility, and signifying how they should change in order to move towards the vision of sustainable urban mobility expressed in my definition (see Section 2.3.1).

2.3.3. Criteria for the assessment of sustainable urban mobility

According to the operationalization approach presented above, we can say that within a given system, if the fulfillment of needs stays constant or even increases while the consumption of resources is reduced to a level below their availability and regeneration rates, then there would be a positive development towards the goal of sustainable mobility.

The access[4] to opportunities and mobility options, as well as the consumption of resources can be monitored by diverse indicators. Monitoring changes in these indicators can help to assess the influence a measure has on sustainable urban mobility. In the following subsections, both aspects and some indicators which can be used for assessing them are described.

2.3.3.1. Fulfillment of human needs through accessibility

To fulfill human needs it is necessary to have access to diverse locations (work places, schools, markets, etc.) where these needs can be fulfilled, but also it is necessary to have the physical, mental, and financial capacity to access these locations.

The fulfillment of human needs requires *access to opportunities* and *mobility options* to reach those opportunities. Thus, indicators representing this access should stay constant or increase over time, depending on the initial situation and considering a minimum threshold of access.

The *access to opportunities* can be assessed by considering the *amount, quality, spatial distribution*, and *availability* of opportunities, as well as the effort and/or costs involved in reaching different locations. (See Geurs and van Wee, 2004).

[4] Following the use of terms suggested by Geurs and van Wee (2004), access is used when talking about the person’s perspective and accessibility when using a location perspective.

Similarly, the *access to mobility options* (infrastructure, vehicles and services) can be assessed by considering their *amount, quality, spatial distribution*, and *availability*. Moreover, aspects such as *awareness*, *ease of physical access, usability,* and *affordability* are important for having access to mobility options.

In addition, for a complete evaluation of these criteria, it is important to know if, and to what extent, the aspects mentioned above contribute to the fulfillment of needs of the target population in the study area (understood as the system).

Considering the goal of intra-generational equity, the same level of access to opportunities and mobility options should be available to each and every person in the system, regardless of their gender, age, income, education, etc. Thus, the supplied opportunities should satisfy the demand of the target population, and the mobility options should be appropriate for all individuals and the needs that they have (i.e. it should be considered that children, some older people, and handicapped people cannot drive, or that some people can’t ride a bike, that goods needs to be transported, etc.)

Furthermore, aspects such as *connectivity* and the *quality of infrastructure* linking opportunities and mobility options are measures of accessibility that could be taken in account when assessing the access to opportunities and mobility services.

2.3.3.2. Consumption of resources for mobility

As defined in Section 2.3.1, *potential mobility* is the given possibility for people to move while *realized mobility* is the actual change of location between two different locations. Mobility (potential and realized) requires space, energy, time, and in some cases, for example when using vehicles and services, money or financial resources. In Table 2.4 it is described how the four above-mentioned resources are consumed for potential and realized mobility.

Table 2.4: Resources consumed for potential and realized mobility

Resource consumed	For potential mobility	For realized mobility[5]
Space	Space is consumed by standing vehicles during the time they are idling or parked. The amount of occupied space is proportional to the amount of standing vehicles, their footprint area or volume, and the time they are idling or parking. It can be measured in area or volume over time (e.g. m^2*hour or m^3*hour).	Space is consumed by moving vehicles or persons and is proportional to their amount, their footprint area or volume and the time they are moving. Thus, the space consumed is also a function of speed (the higher the speed, the less time a person or vehicle is in movement for a given travel distance, but the space needed for the movement is larger considering safety distances). In the case of vehicles, the space occupied for mobility is inversely proportional to the vehicle occupancy. It can be measured in area or volume over time per person kilometer traveled (e.g. m^2*hour/Pkm)
Energy	Energy is consumed when vehicles are idling (e.g. at a traffic light, or in a traffic jam) and is proportional to the specific energy consumption of a vehicle when idling (which depends on vehicle characteristics such as size and technology), and the idling time. It can be measured in any unit of energy over time (e.g. kWh).	Energy is consumed in various ways for the movement between two locations: from muscle power for walking and cycling, to different power sources for the propulsion of vehicles. Energy consumption is proportional to the distance traveled, and a function of the speed and energy efficiency of the vehicle (which depends on vehicle characteristics such as size and propulsion technology). It can be measured in any energy unit over time per Pkm (e.g. kWh/Pkm).
Time	Time for potential mobility is consumed when waiting for a mobility service (bus, taxi, etc.) looking for a vehicle (e.g. a shared vehicle randomly located in a service area), when standing at a red light or when stuck in traffic congestion. It can be measured in any unit of time over time (e.g. hours spent in congestion per year).	Time for realized mobility is consumed while moving between two locations. The amount of time consumed for mobility is directly proportional to the distance and inversely proportional to the travel speed (when speed is larger than 0). Traveled distances depend on the distribution of opportunities within an area and travel speed depends on the characteristics of the transportation system (infrastructure, vehicles, services and rules). It can be measured in any unit of time per Pkm (e.g. min/Pkm).

[5] As realized mobility is defined as the movement of persons between two locations, this can be measured in terms of person kilometers (Pkm).

Resource consumed	For potential mobility	For realized mobility[5]
Money	Money for potential mobility is consumed by paying for the rights to use a mobility option before using it over a given period of time (e.g. costs of vehicle ownership over time, including vehicle purchasing, maintenance, insurance, taxes, and fixed parking costs; memberships to mobility services such as monthly fees for shared mobility services, parking fees, etc.). The cost of public transport passes could be partially considered in the category of potential mobility when they are underused. It can be measured in any unit of wealth or currency over time (e.g. €/month)	Money for realized mobility is consumed to cover the direct costs for traveling such as fuels, tolls, tickets, public transport passes, etc. These costs are often proportional to the distance traveled, but there might be some exceptions (e.g. the costs for using public transport when using a monthly pass do not depend on the distance). Costs also depend on the transport mode used and the context (i.e. the availability of mobility options, the urban structure, the existence of subsidies, and if the external costs for mobility are internalized or not). It can be measured in any currency per Pkm (e.g. €/PKm)

Besides the consumption of resources for mobility, the transport system consumes:

- space for transport infrastructure (roads, bike lanes, sidewalks, terminals, stations, depots, etc.);
- energy is consumed in up-stream processes such as the construction of infrastructure, and for manufacturing and transporting vehicles and fuels.
- Finally, time and money are needed for the planning and construction of infrastructure, and the designing and manufacturing of vehicles.

The consumption of space and energy by transport and mobility involves upstream and downstream processes, which in turn involve the consumption of other resources and have negative effects on the environment and the society.

For example, energy consumption for mobility results in the emission of greenhouse gases, which in turn contribute to climate change, and pollutant emissions which have adverse health impacts. Depending on the energy source's type and location, the amount, location and type of transport-related emissions may vary. For instance, electric vehicles do not produce tailpipe emissions within the geographical boundaries of an urban area (i.e. the system), but the production of electricity elsewhere does produce different types of emissions at different rates depending on the power source.

Moreover, an imbalance between the demand for mobility and the capacity of the transportation system leads to congestion, not only for private transport but also in public transport services. Congestion in turn causes delays, resulting in a loss or waste of time, energy, space, and financial resources, as well as reducing comfort, increasing stress levels, and adversely affecting human health. This is especially true in urban environments were the demand for mobility increases rapidly as the population grows, while the transportation system is restricted by the available resources, mainly space and financial resources.

Depending on the vehicle fleet's characteristics (size, weight, power source, etc.) each mode of transport consumes different amounts of space and energy for travelling the same distance. Also, depending on the characteristics of the transport system and other variables such as time of the day, day of the week, weather, level of service and transport policies, each mode of transport consumes different amounts of time and financial resources for the same trip or purpose.

The above-mentioned negative effects of mobility are proportional to the consumption of resources. Thus, by reducing the consumption of resources for mobility, the negative effects of mobility and the side effects of the imbalances mentioned above can be reduced accordingly. This is done partially by keeping distances to a minimum, thus, integrated urban and transport planning, as well as accessibility planning are important, but also important is using those modes of transport which consume the least amount of resources.

Concentrating on the consumption of these four resources helps to simplify the operationalization of sustainable urban mobility. However, the upstream and downstream processes related to the consumption of resources within an urban area (system) might overstep the system boundaries and their effects should be kept in mind when assessing the impact of a measure on the concept of sustainable urban mobility.

2.3.3.3. Summary of criteria, sub criteria and possible indicators

Considering the discussion above, and looking at other examples of indicators sets, criteria, sub-criteria, and indicators for my suggested approach were identified. Table 2.5 presents some indicators that can be used to assess sustainable urban mobility.

To observe a positive development towards the goal of sustainable urban mobility, the fulfillment of needs, and therefore the indicators used to measure this fulfillment, should increase or at least stay constant, while the consumption of resources should decrease.

Depending on the study area and the observation period, different methods can be used to quantify the different indicators. In Section 5.6, an assessment method to evaluate the contribution of mobility stations on sustainable urban mobility will be presented. The method draws from the same criteria presented below, but it adapts the indicators to the system that is being analyzed.

The proposed approach and assessment method have some limitations that are discussed in Section 7.3.6, after it was applied to assess the impact of mobility stations on sustainable urban mobility.

Table 2.5: Summary of criteria, sub-criteria and possible indicators to assess sustainable urban mobility

Criteria	Sub-criteria	Indicators
Fulfillment of needs	Access to opportunities	Supply of opportunities (amount and spatial distribution of opportunities) for the target population.
		Quality and availability of opportunities for the target population.
		Degree to which the supply of opportunities meets the demand of the target population and thus, contributes to the fulfillment of needs.
	Access to mobility options	Supply of mobility options (amount and spatial distribution of mobility options) for the target population.
		Awareness of mobility options by the target population
		Availability of mobility options for the target population
		Ease of physical access to mobility options for the target population.
		Usability of mobility options for the target population (ease of use of mobility services).
		Affordability of mobility options (the extent to which the target population is able to pay for available mobility options).
		Degree to which the mobility options meets the demand of the target population, and thus contribute to the fulfillment of needs.
Consumption of resources	Space consumption	Area or volume occupied by standing and moving vehicles in the study area over time within a defined period of time (e.g. m^2 * hours/year)
	Energy consumption	Total energy consumption for mobility in the study area within a defined period of time (e.g. kWh/year).
	Travel time	Total travel time dedicated to mobility by the target population in the study area within a defined period of time (e.g. hours/month)
	Travel costs	Total travel costs for mobility of the target population in the study area within a period of time (e.g. €/month)

3. Mobility Stations – State of the art

This chapter presents the state of the art of mobility stations and similar instruments, which integrate various mobility services.

In Section 3.1, definitions and descriptions of mobility stations and similar instruments under different names, such as mobile stations, mobility points, and mobility hubs, are explored in detail in order to have a common understanding of what these terms mean.

As mobility stations are the main subject of this dissertation, and most of these facilities can be found in Germany, Section 3.2 concentrates on the development, characteristics and current findings of examples from this country. Since mobility stations have been recently implemented, information about their acceptance and impacts on mobility behavior is still limited.

To supplement the recent findings on mobility stations, a literature review covering the impacts of shared mobility services typically found at mobility stations, the integration of these and other mobility services, and more general trends in multimodality, is presented in Section 3.3.

In this chapter, *multimodality* and *intermodality* are two terms frequently used. Definitions of these and related terms can be found in various documents[6]. In this work the following understandings of the terms are adopted:

- *multimodality* refers to a mobility behavior characterized by the use of different modes of transport within a defined period of time (e.g. a week);
- *intermodality* refers to the ability and possibility to combine two or more modes within a single trip.

In this sense, there is a *multimodal supply* when there are at least two reasonable transport mode alternatives available for the users' actual mobility needs, while *intermodal infrastructure* makes it possible to use a combination of different modes within one trip. Similarly, *multimodal services* enable or facilitate the use of different modes for

[6] BMVT (2016) presents a literature review of 28 studies from different countries.

different trips, while i*ntermodal services* enable or facilitate a combination of different modes within one trip. (BMVT, 2016; FGSV, 2017).

Finally, when a person is open to the use of different transport modes and is ready to choose the mode that is subjectively considered as the optimal one for each trip, that is referred to as a *multimodal attitude* (BMVT, 2016).

3.1. Mobility stations and similar concepts

What are mobility stations? In order to answer this question, existing definitions or descriptions of mobility stations and similar concepts were reviewed. Additionally, concrete examples of existing facilities regarded as mobility stations were investigated through literature review, and in some cases through on-site visits.

The following subsections presents an overview of these existing examples, definitions and descriptions, followed by a summary of the results.

3.1.1. Mobility stations

The first example of facilities regarded as mobility stations is found in the City of Bremen, Germany, where two “mobil.punkte”, the first in the city, were implemented in 2003 (BBSR, 2015).

The so-called *mobil.punkte* consist of reserved parking spaces for carsharing vehicles as well as bike parking facilities on public space, closely located to public transport stops and in some cases to taxi stands (Luginger, 2016). In addition, blue ‘steles’ with a unique design mark the presence of these facilities.

Beyond the spatial concentration of various transport modes at the mobil.punkte, public transport subscribers in Bremen also receive preferential rates for carsharing (BSAG, 2018), and there is an integrated marketing and information for these two mobility services.

Figure 3.1 shows an example of a *mobil.punkt* in Bremen with the characteristic blue stele (left), the bike parking facilities and the reserved carsharing spaces in close proximity to a public transport stop.

Image source: Freie Hansestadt Bremen (2005)

Figure 3.1: Mobility station in Bremen

The next example of facilities regarded as mobility stations are the so-called *switchh punkte* in Hamburg, Germany*,* which were first implemented in 2013. Figure 3.2 shows the first *switchh* station at the public transport station “Berliner Tor”.

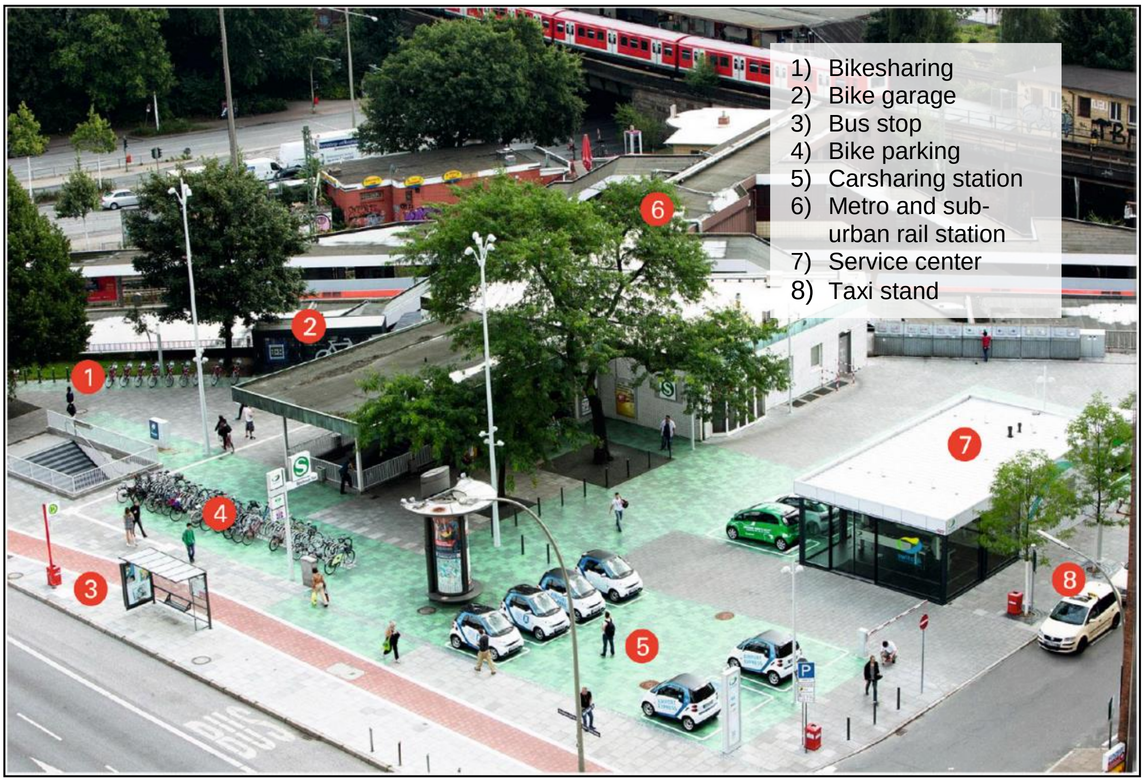


Image source: Hamburger Hochbahn AG; legend: (Landeshauptstadt Kiel, 2016) (translated)

Figure 3.2: Switchh station at public transport station “Berliner Tor”

The switchh station at Berliner Tor (see Figure 3.2 above) offers reserved parking spaces for carsharing and rental cars, bike parking facilities including a bike garage, a bikesharing docking station, a taxi stand, and a customer service center all combined in an area with immediate access to public transport.

Like the *mobil.punkte* in Bremen, the *switchh* stations are distinguished by a stele with a unique corporate design. In addition, green-colored parking spaces reserved for carsharing vehicles make these facilities highly visible. Figure 3.3 shows the green parking spaces and the stele with the *switchh* logo at one of the stations.

Image source: own photograph (October, 2015)

Figure 3.3: Mobility station in Hamburg

In addition to the spatial concentration, the different mobility options are also virtually integrated through:

- combined marketing and a common registration process for the various mobility services,
- an integrated ‘mobility package’ that includes registration and initial starting credit for the use of the included shared mobility services with a monthly fee,
- an access medium, the *switchh card*, that allows to access shared bikes and cars, and

- a smartphone application that enables planning trips and locating diverse mobility options such as public transport, shared mobility services, and taxis.

In the years following these initial examples, mobility stations were implemented in other German cities. This further development is presented in Section 3.2. Meanwhile, additional concepts, ideas, guidelines, and plans for mobility stations were put forward by different organizations.

Definitions of mobility stations as part of concepts and guidelines

In 2014, a proposal for the construction of a network of mobility stations in Offenburg and the surroundings described them as a *“[…] starting point or a connection point, where vehicles of different transport modes (motorized vehicles or bikes) are available for different uses. The motorized vehicles shall be offered in the form of carsharing. The bikes can be provided as a public rental system*“ (Stadt Offenburg, 2014).

According to the proposal, the mobility stations should be located near public transport stations wherever possible, in order to provide seamless connections between modes. This way, users could be mobile without a private car and could choose the most convenient transport mode for their purposes (Stadt Offenburg, 2014).

Figure 3.4 presents a visualization of a mobility station in Offenburg.

Image source: (Stadt Offenburg, 2014)

Figure 3.4: Visualization of a mobility station in Offenburg

A general idea of the mobility station concept is provided by Berg (2016): "*mobility stations, also called mobility points, connect different mobility services in a compact area. Public transport stops and stations, in combination with other mobility options, such as carsharing, bikesharing, taxi stands, coach stations, carpooling, bike parking, charging infrastructure for electric cars, P+R and B+R facilities, as well as information centers, become transfer points of multimodal mobility*". Figure 3.5 represents this idea.

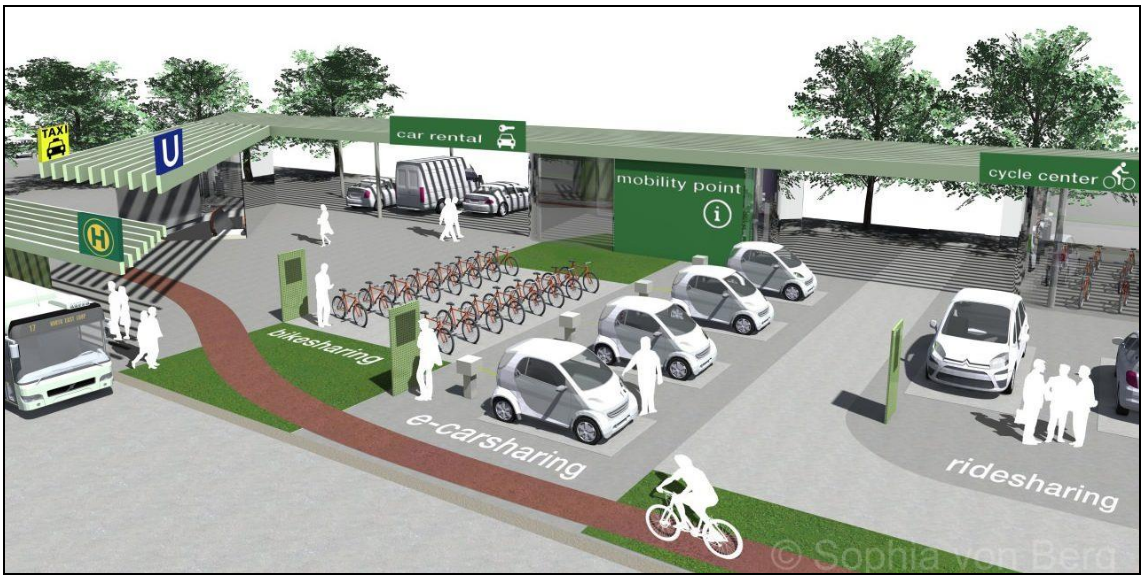


Image source: Sophia von Berg

Figure 3.5: Visualization of a mobility station

Berg (2016) also pointed out that, at mobility stations, "*there is always a spatial concentration of local and regional transport services as well as complementary mobility services facilitating the transfer between diverse transport modes*".

Similar to the definitions presented above, the definition proposed by Jansen et al. (2015) also describes *mobile stations* as multimodal nodes where different transport modes, including shared mobility services, are available. Furthermore, in their definition, the connection to public transport and the prioritization of cycling and walking over motorized individual transport is considered to be a basic requirement of every mobility station. (Jansen et al., 2015)

For the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) in Germany, the degree of modality at mobility stations only plays a relative role (BBSR, 2015). In their view, bi-modal nodes can be regarded as mobility stations if they present a high degree of connection with the "Umweltverbund*"* (ecomobility)[7].

According to BBSR (2015) *"[t]he central feature of a mobility station is the, in its respective local context, above-average connection of different transport modes, paired with a marketing message to promote ecomobility. In general, this 'transport-related' message is supported by the corresponding design elements of the station. The connection is designed in such a way, that the local transfer between the transport modes is facilitated through the physical concentration of the mobility options."* (BBSR, 2015)

Thus, in their view, bi-modal nodes (e.g. Park and Ride or Bike and Ride facilities) or multimodal nodes (e.g. railway station), must not necessarily be regarded as mobility stations since the required marketing effect is either inherent to the system or not recognizable. (BBSR, 2015)

According to the "Concept for Mobility Stations" published by the City of Kiel, Germany, mobility stations are generally understood as *"spatial bundling of different sustainable mobility services with the goal of promoting multimodal and intermodal mobility".* (Landeshauptstadt Kiel, 2016)

The document also suggests that mobility stations should be distinguished from "single stations" or stations where only one transport mode is available (e.g. a bus stop). Figure 3.6 shows a design approach for possible information elements at mobility stations and single stations.

[7] *Umweltverbund* is a German word that refers to the group of environmentally friendly modes of transport: non-motorized transport (walking and cycling), public transport and carsharing. Deutsche Bundestag (2017). In English one may refer to ecomobility.

Image source: (Landeshauptstadt Kiel, 2016; 2016) (translated)

Figure 3.6: Design approach for possible information elements at mobility stations and single stations

As it can be observed in Figure 3.6 above, both mobility stations and single stations utilize the same design and are seen as part of a network where they are interconnected.

Figure 3.7 below presents this schematization of interconnected stations of different sizes and with different components into one system.

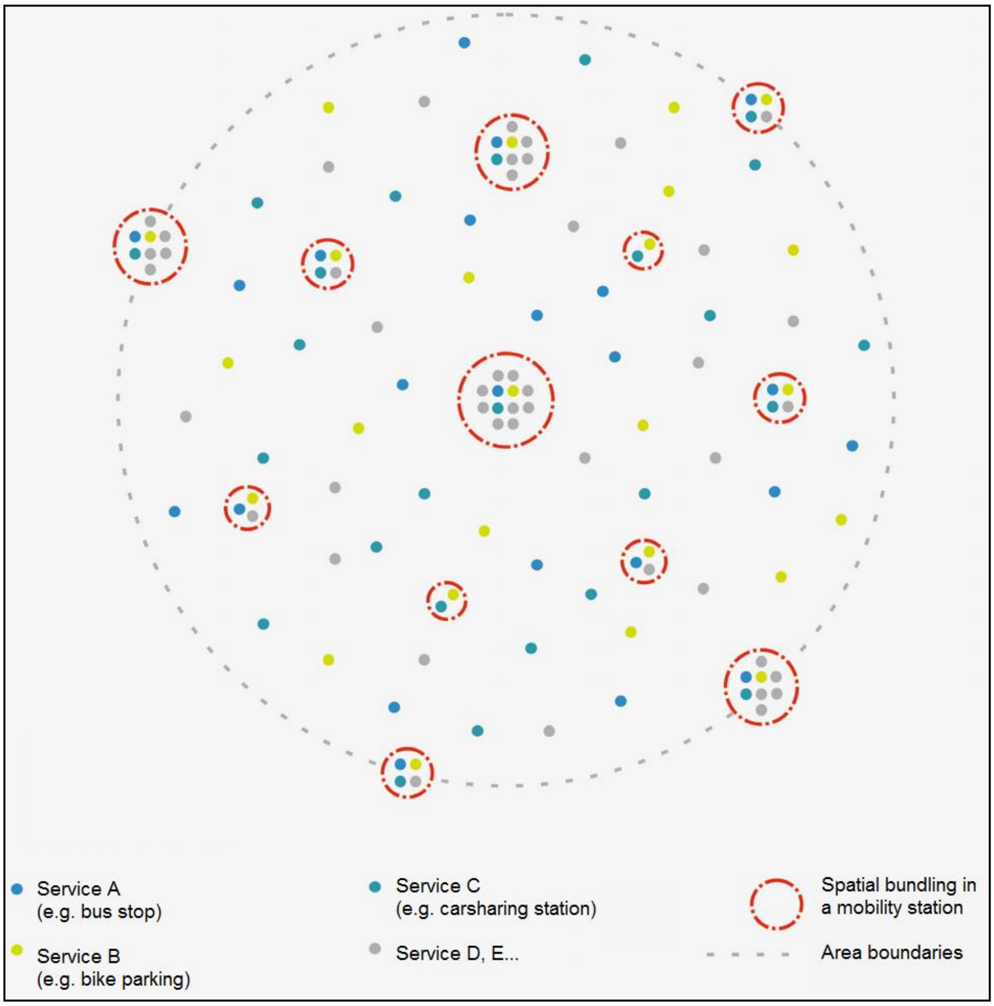


Image source: (Landeshauptstadt Kiel, 2016; 2016) (translated)

Figure 3.7: Schematization of interconnected mobility stations and "single stations"

Similar to the ideas presented in the *Concept for Mobility Stations* of the City of Kiel, the *Handbook for Mobile Stations* indicates that these facilities can have different configurations depending on their location and individual requirements, while regional connections between them are meaningful (Zukunftsnetz Mobilität NRW, 2015).

In the handbook, the visibility of these facilities is highlighted as one of their characteristics in addition to the spatial concentration of various transport modes describing them as *„[v]isible connection points and interfaces of ecomobility with a systemic integration of several transport modes in direct spatial connection"* (Zukunftsnetz Mobilität NRW, 2015).

Figure 3.8 presents a vision of a mobile station found in the handbook.

Image source: (Zukunftsnetz Mobilität NRW, 2015)

Figure 3.8: Vision of a mobile station

3.1.2. Mobility points

In Austria, the cities of Vienna and Graz feature similar instruments to integrate mobility services physically and virtually. The City of Vienna provides a description in their City Development Plan (STEP 2025) of what they could be:

> *"A mobility point shall guarantee uncomplicated and quick access to a low-emission mobility supply around-the-clock. This can act as a central facility in urban development areas or strengthen structures in existing neighborhoods. Vehicles and services of different types can be booked and used. Especially in new city development areas, these mobility services can be clearly bundled in one place"* (Stadtentwicklung Wien, 2015)

The so-called „tim-Standorte" in the City of Graz are an example of existing mobility points defined as "centralized mobility hotspots", where it is possible to use carsharing, rental cars or electric taxis, and which are easily accessible by public transport or bike. (tim - graz, 2018).

Figure 3.9 presents a design element showing the variety of transport modes available at one of the "tim" stations.

Image source: own photograph (September, 2016)

Figure 3.9: A "tim" station in Graz

3.1.3. Mobility hubs

Meanwhile in North America, similar concepts to mobility stations, mobile stations and mobility points have been called *mobility hubs*. Metrolinx, a government agency of Ontario, Canada, provided the following definition in their Mobility Hub Guidelines in 2011:

> *"A mobility hub is more than just a transit station. Mobility hubs consist of major transit stations and the surrounding area. They serve a critical function in the regional transportation system as the origin, destination, or transfer point for a significant portion of trips. They are places of connectivity where different modes of transportation – from walking to riding transit – come together seamlessly and where there is an intensive concentration of working, living, shopping and/or playing." (Metrolinx, 2011)*

In the city of San Diego, United States of America, mobility hubs are described as *“transportation centers located in smart growth opportunity areas (areas that will support mixed-use, transit-oriented development) that are served by high-frequency transit. They provide an array of transportation services, amenities, and urban design enhancements that bridge the distance between transit and where people live, work, and play.”* (San Diego Forward, 2017). Figure 3.10 presents the Mobility Hub Concept that is part of the Regional Mobility Hub Implementation Strategy in San Diego.

Image source: (San Diego Forward, 2017)

Figure 3.10: Illustration of a mobility hub as in San Diego, United States of America

Finally, a similar concept with a strong connection to land use was found in a draft of mobility hub guidelines prepared for Los Angeles Department of City Planning *(urban design studio, 2017)*:

> *“Mobility Hubs provide a focal point in the transportation network that seamlessly integrates different modes of transportation, multi-modal supportive infrastructure, and place–making strategies to create activity centers that maximize first–mile last mile connectivity”.*

3.1.4. Summary

After reviewing the definitions presented above it became clear that the terms m*obility station, mobile station* and *mobility point*, which are often used in Germany and Austria, all refer to practically the same idea. *Mobility hubs*, as they are defined in North America are similar to mobility stations but their descriptions include a stronger focus on the integration of land use and transport.

Understanding of mobility stations

Based on the definitions presented above, there seems to be consensus that mobility stations, and similar concepts called mobile stations and mobility points, are transport nodes where different mobility options are spatially concentrated, thus, enabling multimodality and intermodality. The spatial concentration of various mobility options:

- allows users to access them and to choose among them depending on their trip purpose (multimodality);
- allows easy transfers between them (intermodality).

Other definitions indicate that mobility stations can be of different sizes and offer different mobility services depending on their location and local demand. While the exact number of mobility options that should be provided at mobility stations is not specified, the types of mobility options or services, which should be part of mobility stations, vary across definitions, and range from different types of shared mobility services, to public transport, and private modes.

Understanding of mobility hubs

Based on the three definitions of mobility hubs presented in Section 3.1.3, it is observed that these, like mobility stations, are understood also as multimodal transport nodes, but in all cases there is a strong emphasis on the integration and concentration of urban functions such as living, working and recreation alongside these nodes.

From this analysis, it can be concluded that the definitions of mobility stations are more concentrated on the transport supply, thus, they are seen mainly as *nodes*; while the North American definitions of mobility hubs combine aspects of transport supply and land use components, thus, they are seen as *nodes and places*. This might be due to the fact that the integration of land use and transport is already established (or better established) in Europe than in North-America, thus there is no need to emphasize this integration in the European concepts. However, the idea of understanding multimodal hubs as places (beyond just transport nodes), could be considered in the future for the development of mobility stations in areas where the integration of land use and transport is suboptimal.

Scope

The review of these definitions was useful in delineating the scope of this dissertation. In the following section, I concentrate on mobility stations in Germany. However, having already looked into definitions and examples from other countries has provided some insight into what mobility stations can be beyond multimodal mobility nodes. In Chapter 8, I provide recommendations for the development of mobility stations considering both the European and the North American understandings.

3.2. Mobility stations in Germany

In the last few years, mobility stations began to spread throughout Germany. After Bremen and Hamburg (see section 3.1.1), cities like Munich, Offenburg, Leipzig, Würzburg, and Nuremberg implemented mobility stations to varying degrees, and with different components and integration characteristics.

Because mobility stations are a relatively new concept, and because many of these systems are still in the planning phase, there was limited information on their development, effects on mobility, or success factors. In order to fill this information gap, mobility stations in various German cities were studied as part of four master theses supervised in the framework of this dissertation.

As a first step, Luginger (2016) investigated the development of mobility stations in four German cities (Bremen, Hamburg, Offenburg and Leipzig) and analyzed the level of integration of mobility services considering eight levels or tiers of integration. Through expert interviews, success factors for the implementation and operation of mobility stations were identified.

In a second step, mobility stations in Offenburg and Würzburg, and the private mobility station in Munich were evaluated in the framework of other three master theses:

- Heller (2016) evaluated the perception and acceptance of mobility stations in Offenburg, Germany, as well as their effects on mobility behavior by means of user and non-user surveys.
- Pfertner (2017) evaluated the perception and effects of mobility stations in Würzburg, Germany on mobility behavior, car ownership, and CO_2 emissions by means of user surveys and analysis of operational data of the carsharing and bikesharing systems included in the multimodal mobility offer.
- Alarcos (2017) evaluated, by means of user and non-user surveys, the acceptance and perception of a private mobility station in a residential development in the north of Munich (Domagkpark), as well as the effects on car ownership and mobility behavior among users. In addition, a process evaluation by means of interviews and a "learning histories workshop" was carried out to better understand the barriers and drivers for planning, implementation, and operation of the mobility station.

The methods used for the investigation of the mobility stations in the framework of the master theses mentioned above built upon those used for the empirical investigation carried out for the Mobility Station at Münchner Freiheit (MSMF) in the framework of this dissertation. However, the investigations carried out in the framework of the master theses are less detailed than the one for the MSMF.

In the following sections, the development of mobility stations in Germany, as well as their characteristics and goals are presented, including selected findings from the research works mentioned above.

3.2.1. Development of mobility stations in Germany

According to the Federal Institute for Research on Building, Urban Affairs, and Spatial Development (BBSR), the first two mobility stations in Germany were set up in the City of Bremen in 2003 (BBSR, 2015). Due to the positive experiences from the initial phase (see Section 3.2.5.1), more stations were implemented in the following years (Schlansky, 2014). As of March 2016 there were ten *mobil.punkte* and fourteen *mobil.pünktchen*[8] in Bremen (Luginger, 2016).

In 2012, the public transport operator in Hamburg (Hamburger Hochbahn AG) started the pilot project "switchh" with the goal of integrating public transport with other mobility services (Luginger, 2016). The first *switchh* station was opened in May 2013 at the metro and suburban rail station "Berliner Tor" (see Figure 3.2 in Section 3.1.1), and by March 2016 there were nine of them (Luginger, 2016). As of September 2017, there were 14 *switchh* stations at metro and sub-urban train stations offering free-floating carsharing by two providers, station-based carsharing, bikesharing, and public transport together (switchh, 2017).

In the following years, mobility stations started to appear in other cities such as Munich, Offenburg, Leipzig, Würzburg, and Nuremberg. Figure 3.11 presents an overview of the development and key figures of selected mobility stations in Germany.

Note that this list is not complete and only some selected examples are included Across Germany, examples of mobility stations were also found in Berlin, Wolfsburg, Hannover, Meschede, Offenbach, Fellbach and Mettingen (Kindl et al., 2018).

For more details regarding the development of mobility stations, see BBSR (2014), BBSR (2015), Krismanski (2015) and Luginger (2016). An updated inventory and analysis of mobility stations is provided by Kind et al. (2018).

[8] The mobil.pünktchen are smaller versions of the mobil.punkte consisting of two to three parking spaces in residential areas but are not necessarily located close to public transport stops (Luginger, 2016).

Bremen – mobil.punkte

- Start: April 2003
- Stations: 10 (as of March 2016)
- Lead manager: City of Bremen

Image source: Freie Hansestadt Bremen.

Hamburg – switchh

- Start: May, 2013
- Stations: 14 (as of September 2017)
- Lead Manager: Public Transport Operator (Hochbahn AG)

Image source: Hamburger Hochbahn.

Munich – pilot project at Münchner Freiheit

- Start: November 2014 (with carsharing)
- (in full operation since October 2015 when bikesharing was added to the Station.
- Stations: 1
- Lead manager: City of Munich and MVG

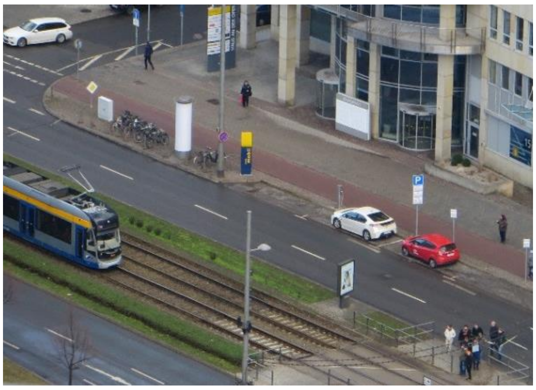
Image source: (MVG, 2015).

Offenburg – einfach mobil

- Start: June 2015:
- Stations: 4
- Lead Manager: City of Offenburg

Image source: (klima-log, 2018).

Figure 3.11: Development of Mobility Stations in Germany and key figures



Leipzig – Leipzig mobil

- Start: July 2015
- 26 stations
- Lead Manager: Public Transport Operator (Leipziger Verkehrsbetriebe)

Image source: own photograph.

Würzburg – Mobilstationen

- Start: October 2015
- Stations: 9
- Lead Manager: City of Würzburg

Image source: (Main Post, 2018).

Munich - Domagkpark (private)

- Start: May 2016
- Stations: 1
- Lead manager: Neighborhood association Domagkpark

Image source: Wogeno.

Nürnberg

- Start: October 2016
- Stations: 8
- Lead Manager: City of Nürnberg

Image source: Stadt Nürnberg.

Figure 3.11: Development of Mobility Stations in Germany and key figures

3.2.2. Common characteristics

The mobility stations in the six different cities were analyzed in order to determine which common characteristics exist among them. The following subsection present the results of this analysis followed by a summary regarding these common characteristics.

3.2.2.1. Mobility options

The mobility stations in the different cities provide different mobility services in close proximity to each other, although not all of them are available in every station.

Table 3.1 presents an overview of the mobility services which can generally be found at the mobility stations in each city, as well as the type of design element that indicates the presence of the mobility stations.

Table 3.1: Mobility options generally found at the mobility stations in Germany and type of design element to indicate their presence

City	Public transport	Taxi	Station-based carsharing	Free-floating carsharing	Bikesharing	Bike parking	Charging station	Others	Design element
Bremen	X	X	X			X			Stele
Hamburg	X	X	X	X	X	X			Stele
Munich	X	X	X	X	X	X	X (cs)		Information screen
Offenburg	X		X		X	X	X (cs)		Modular structures
Leipzig	X	X	X		X	X	X (pc)		Information and booking terminal
Würzburg	X		X		X	X			Stele
Munich (Domagkpark, private)			X		X	X	X (*)	Electric cargo bike (1), e-bikes(2), e-scooters (2)	Sign
Nuremberg	X		X		X	X			Stele
(cs): for carsharing; (pc): for private cars; (*): for diverse type of electric vehicles									

The most common mobility services at mobility stations are public transport, station-based carsharing, bikesharing, and bike parking. Free-floating carsharing is only available in Hamburg and Munich. Charging stations for electric cars (shared or private) are provided in four mobility station systems. In contrast to all other mobility stations, the private mobility station in Domagkpark, Munich is located on private ground and is not directly connected to public transport.

3.2.2.2. Design elements

Beyond the spatial concentration of mobility options, a unique characteristic that distinguishes mobility stations from other stations where two or more mobility services are in close proximity, are the design elements (steles or modular structures), which together with logos and colors in the form of a uniform corporate design, communicate that the mobility options belong together and can be combined. Figure 3.12 shows some examples of these design elements.

These design elements vary in their characteristics and functions, for example:

- The steles in Bremen and Nuremberg are merely for the purpose of indicating the location of the mobility stations, while
- the steles in Hamburg and Würzburg also provide additional information about the integrated mobility services.
- In Munich, the on-site information screen provides real-time information about the different mobility services available.
- The booking-terminals in Leipzig provide real-time information about the mobility services as well, and is possible to book directly at the terminals.
- In Offenburg, the modular elements with a homogeneous design serve as a holistic design element which incorporate other functions such as bike storage facilities and a sheltered docking station for shared bikes (see Figure 3.13).

Practically all of the mobility stations are visible from public space (there is one exception in Hamburg where one mobility station is located in an underground garage).

Stele at a mobility station in Bremen

Image source: Freie Hansestadt Bremen

Information stele at a mobility station in Hamburg

Image source: own photograph

On-site information screen at the mobility station in Munich

Image source: own photograph

Information and book terminal at a mobility station in Leipzig

Image source: own photograph

Information stele at a mobility station in Würzburg

Image source: own photograph

Stele at a mobility station in Nürnberg

Image source: Stadt Nürnberg

Figure 3.12: Examples of design elements at mobility stations in German cities.

Image source: Kienzler (2018)

Figure 3.13: Modular structure at a mobility station in Offenburg

3.2.2.3. Virtual and organizational integration of mobility services

Beyond their physical proximity at mobility stations, the various mobility services are integrated through different instruments facilitating the access and use of mobility services.

In all cities there is at least one website providing information about the different shared mobility services, and the location of different mobility services is provided through a website and/or a smartphone application.

The multimodal mobility services in Hamburg and Leipzig are integrated through a common registration process, tariff discounts for registration or the use of mobility services, a monthly fee that includes credit for the use of shared mobility services, as well as a common access medium like a smart card or a smartphone application. This form of virtual integration is typical of Mobility as a Service, a relatively new concept for multimodal integration (see Jittrapirom et al., 2017).

Table 3.2 presents an overview of the different ways of virtual and organizational integration in various cities.

Table 3.2: Elements of virtual integration of mobility services at mobility stations in Germany

Integration element	Bremen	Hamburg	Munich	Offenburg	Leipzig	Würzburg
Website provides information about the different shared mobility services.	X	X	X	X	X	X
Website provides information about the locations of different mobility services.	X		X	X		X
Smartphone application allows to plan trips and locate different mobility services.		X	X		X	
Integrated registration (one time registration for different mobility services)		X		X	X	
Free registration for shared mobility services and some starting credit.		X	X (pt)			
Tariff discounts on shared mobility services for public transport subscribers (e.g. exemption of monthly fees).	X			X	X	
Monthly fee that includes credit for the use of shared mobility services (mobility package).		X			X (bs)	
Multimodal card as an integrated access medium.	X	X		X	X	
Integrated bill for the use of the different mobility services.					X	
(pt): for public transport subscribers only; (bs): only bikesharing.						

For more details on the integration of mobility services in Bremen, Hamburg, Leipzig and Offenburg, see Luginger (2016). For more details on the integration of mobility services in Würzburg see Ezzeddine (2017) and Pfertner (2017).

3.2.2.4. Corporate design

In most cities featuring mobility stations, a brand or corporate design related to the integrated multimodal mobility offer was created.

In these cities, the logos are present on the design elements at the mobility stations (steles, modular structures, or booking terminals) and the websites. In Bremen, Hamburg and Würzburg, parking spaces are marked with the respective logos. Offenburg might be city where the brand of the multimodal mobility service is most present: the “einfach mobil” logo can also be seen on the carsharing vehicles and shared bikes.

Table 3.3 presents an overview of the different corporate designs adopted in some of the cities and the different physical and virtual elements where they are present.

Table 3.3: Overview of corporate designs adopted in cities with integrated multimodal mobility services and elements where they are present

City	Corporate design / trade mark	Design elements	Parking spaces	Vehicles	Marketing material	Website
Bremen	mobil.punkt	X	X		X	X
Hamburg	switchh Hamburg verbunden	X	X		X	X
Offenburg	EINFACH MOBIL	X		X	X	X
Leipzig	Leipzig mobil	X			X	X
Würzburg	mobil STATION WÜRZBURG	X	X			X
Nürnberg	mobil punkt	X				X

Some of the brands' names imply the goal of the integrated multimodal mobility offer, for example in my own interpretation:

- mobil.punkt: availability of mobility options at one location (point);
- switchh: here (in Hamburg-Harburg), you can switch between modes or here you can switch from car to ecomobility.

3.2.2.5. Summary

The analysis of the mobility stations across Germany shows that they can be of different sizes and include different elements. However, some characteristics that mobility stations have in common are:

1. Physical concentration of mobility services at one location that allows users to choose among them, depending on the purpose of their trip, and to combine them accordingly. The most common services are public transport, carsharing, bikesharing, and bike parking.
2. Location on public space, and thus, visibility and easy access to the station and ready public access to the mobility options (with exception of the private mobility station in Domagkpark).
1. Use of design elements such as steles, information screens or modular elements to indicate the presence of the mobility stations and the corresponding services.
2. Use of a brand and/or corporate design which communicates to users that different mobility options belong together presenting the different mobility services as an integrated multimodal mobility offer, and as an alternative to car-ownership and usage.
3. Virtual integration of different transport modes through information, marketing, and/or shared tariffs facilitating access and use of various mobility options.

The main distinctive characteristic of the German mobility stations is the spatial concentration of different transport modes that promotes ecomobility, and facilitates intermodality and multimodality. The physical concentration of mobility options, usually on public space, makes the multimodal mobility offer more visible and “touchable”.

As a whole, mobility stations promote the use of sustainable mobility options and/or ecomobility. The physical and virtual integration of mobility services promotes multimodal and intermodal mobility, which in turn might reduce the need to own and use a private car.

3.2.3. Common goals

Mobility stations are mainly implemented by either cities, public transport operators, or both in a cooperation agreement. However, there are examples of private mobility stations such as the one in Domagkpark, Munich.

The implementation and operation of mobility stations have different goals depending on the city and the lead managers behind the projects.

In general, in cities where the lead manager of the project is the city itself, the focus lies on changing mobility travel patterns towards more space and energy efficient modes, specifically to reduce of car ownership and car use and therefore parking pressure. This in turn is usually aligned with each city's urban and transport development goals, and /or environmental and climate goals set in their respective local strategies or plans.

In cities where the Public Transport Operators (PTOs) have the lead, the focus is on the expansion of their services through mobility services that complement public transport, although this strategy is often aligned with the city's goals.

The private mobility station in Domagkpark, which is both privately owned and operated, is part of a mobility concept put forward by the neighborhood association with the goal of reducing the number of parking spaces required by the city for each housing unit (Stellplatzsatzung) and thereby to save construction costs (Alarcos, 2017). This is achieved by providing residents with sufficient mobility options.

Basically, the implementation of mobility stations has the goal of promoting ecomobility, offering alternatives for private cars, and with that, a reduction in private car ownership and usage. Others goals are to promote the efficient use of mobility options by demonstrating the benefits to the environment and the users.

Table 3.4 summarizes the goals of mobility stations in some selected cities.

Table 3.4: Goals of mobility stations in Germany

City (lead)	Goals	Source
Bremen (City)	– To decrease the dependency of privately owned vehicles and to relieve inner-city neighborhoods from parking pressure.	(Freie Hansestadt Bremen, 2005)
Hamburg (PTO)	– To contribute to changing the mobility behavior of Hamburg's citizens by providing attractive alternatives to private cars. – To acquire additional customers.	(Luginger, 2016)
Offenburg (City)	– To promote sustainable local mobility while supporting shared mobility (using shared vehicles instead of owning) in combination with electric mobility. – To reduce the space needed for parking through a reduction in car ownership. – To enable users to decide the best mode for them depending on their trips' purposes, strengthening multimodal travel behavior. – To reduce mobility costs for users.	(Luginger, 2016)
Leipzig (PTO)	– To change mobility behavior of Leipzig's citizens towards sustainable mobility. – To improve the image of the local public transport service as a modern organization, which supplies and integrates with transport modes of the future. – To increase the attractiveness of local public transport and the number of users. – To promote sustainable mobility and reduce private car ownership.	(Luginger, 2016)
Würzburg (City)	– To combine mobility options, with public transport as the backbone of sustainable mobility, all under the roof of the city. – To increase the visibility of carsharing and to make it more accessible to the public. – To reduce in car ownership and the demand for parking space (on private and public ground).	(Pfertner, 2017)
Munich (MF) (City)	– To offer citizens diverse mobility services suitable for every trip purpose, so that owning a car becomes unnecessary.	(MVG, 2015)
Domagkpark (Neigborhood association)	– To reduce the need for parking spaces (on private ground) and save construction costs.	(Alarcos, 2017)
Nuremberg (City)	– To support multimodality. – To increase the awareness of carsharing. – To reduce the parking pressure in densely populate neighborhoods.	(Stadt Nürnberg, 2018)

3.2.4. Success factors of mobility stations

Based on expert interviews conducted with actors involved in the implementation and operation of mobility stations in Bremen, Hamburg, Offenburg, and Leipzig, Luginger (2016) identified success factors and lessons learned. These are summarized in Table 3.5.

Table 3.5: Success factors and lessons learned with the implementation and operation of mobility stations

City	Success factors / lessons learned
Bremen	For user acceptance – high visibility and good accessibility, and the practicality of returning a vehicle (due to reserved parking spaces) – the terms „mobil.punkte“ and „mobil.pünktchen“ have been established among citizens and politicians For the political support: – the proven effect of reduction in parking pressure and the limited financial resources for alternatives such as parking garages
Offenburg	For implementation: – Timely involvement of all possible actors (from the beginning to the end) – External financing
Leipzig	For implementation: – The system should work properly before public implementation – The legal framework plays an important role – A broad network of partners would have facilitated the implementation – Readiness to take some risks
Hamburg	For the implementation: – favorable conditions at the political and administrative level, – support from diverse stakeholders (city officials, business leaders, etc.) and committed proponents, – good cooperation between the Public Transport Agency (PTA) and the Public Transport Operator (PTO), as well as other mobility service providers, – Agile project management: fast and decisive reactions to barriers and current development progress, – Readiness to take some risks For the operation: – When the product is established under its own brand (switchh) quick decisions can be made without consulting every stakeholder – An unique brand offers the advantage of advertising with the respectability and trust in the new company and enables testing different things that would otherwise would not be possible
	Source: summary based on the work of Luginger (2016)

3.2.5. Main findings about mobility stations

As mobility stations are a relatively new concept, there are only a few studies regarding their acceptance and their impacts on urban mobility. To the best of my knowledge, by the time of writing this dissertation, besides the evaluation of the first two mobility stations in Bremen (See Section 3.2.5.1. below), there were no other publicly available studies on the impacts of mobility stations on mobility behavior or their acceptance.

To fill this information gap, mobility stations in the cities of Würzburg and Offenburg in Germany, as well as one private mobility station in Munich (Domagkpark), were investigated as part of master theses supervised in the framework of this dissertation (See introduction to Section 3.2).

In the following subsections, selected findings on the impacts of the mobility stations in Bremen, Offenburg, and Würzburg on mobility behavior and their acceptance are presented. The case of Domagkpark is not considered further in this section due to fundamental differences between private and public mobility stations, which made the results difficult to compare. For details about the acceptance and impacts of this private mobility station see Alarcos (2017).

3.2.5.1. Mobility stations in Bremen

Two years after the implementation of the first two mobility stations (mobil.punkte) in Bremen, customers living within a radius of 500 meters of these facilities were interviewed by telephone (n=189). The results indicated that 30% of private customers got rid of their own vehicle after becoming carsharing members, and 55% claimed to have foregone a planned purchase (Freie Hansestadt Bremen, 2005). In comparison, a survey among carsharing users in Bremen, Aachen and Cologne in 2000, revealed that 21% got rid of a car and 11% indicated to have forgone a planned purchase because of carsharing (Koch, 2001).

Although exact numbers of the usage rates of the mobility stations are not disclosed to the public, it has been reported that the mobil.punkte are used more frequently than other carsharing stations not located on public space (Luginger, 2016). This might indicate that mobility stations attract a higher number of users due to greater visibility and easier access compared to other carsharing stations.

This could also explain the better results in reducing car ownership among carsharing users living close to mobility stations, although is difficult to compare the results from the two different surveys mentioned above.

3.2.5.2. Mobility stations in Offenburg and Würzburg

The acceptance of mobility stations in Offenburg and Würzburg and their (potential) impacts on mobility behavior, among other aspects, were investigated by means of user surveys similar to the user survey used for the main case study of this dissertation (see Chapter 5.2). Table 3.6 presents general information about both cities and the user surveys carried out.

Table 3.6: General information about Würzburg and Offenburg and the user surveys carried out

City		Offenburg	Würzburg
Population		60,000	127,000
Population density		766	1,452
Cars per 1,000 inhabitants		493	631
Modal split (%)*	Motorized individual transport	48	49
	Public transport	6	16
	Non-motorized modes	46	35
Number of mobility stations		4	9
Implementation time frame		May – September 2015	October 2015
Evaluation time frame		September - October 2016	January – February 2017
User survey sample		n = 77	n = 98
		61 carsharing users	84 carsharing users
		16 bikesharing users	14 bikesharing users
Gender of respondents (%)	Male	59	66
	Female	41	31
Age groups of respondents (%)	< 18	6	0
	18 - 29	14	31
	30 - 39	15	28
	40 - 49	26	17
	50 - 59	36	19
	> 59	4	6
Sources		Heller (2016)	Pfertner (2017)
* Data about modal split in Würzburg is from 2008 and in Offenburg from 2006.			

As the cities differ in size, structure, and transport supply, the findings are not directly comparable but some similarities in the results can be recognized.

While the shares of each gender among respondents in both cities are quite similar, the age of respondents is not. In both cities, most of the respondents are men but the majority of respondents in Offenburg are 40 years old or older, while in Würzburg the majority is under 40 years old.

Users are defined as carsharing or bikesharing customers who rented a vehicle or bike at a mobility station in their respective cities. Due to the low number of bikesharing users who took part in the surveys, the results presented below are heavily influenced by the answers provided by carsharing users.

Unless otherwise indicated, the findings about Offenburg are from Heller (2016) and those from Würzburg are from Pfertner (2017).

Awareness of mobility stations

In the surveys, users were asked to indicate by which means they became aware of the mobility stations. Table 3.7 presents the percentage of users who mentioned a specific source of awareness (multiple answers were possible).

Table 3.7: Sources of awareness of the mobility stations in Offenburg and Würzburg

City	Offenburg	Würzburg
Sources of awareness	Users who became aware of the mobility station through this source (%) (multiple answers possible)	
Passing by	41	56
Info Pillar (in Würzburg)	n.a.	52
Advertisement	18	42
Media	35	13
Friends	23	11
Smartphone apps	0	22
Others	32 (carsharing provider)	32 (social networks, websites, active search)
Sources	Heller (2016)	Pfertner (2017)

In Würzburg, the “info pillars” or steles are an important source of awareness, and the media played an important role in raising awareness in both cities.

Depending on the city, there are different sources of awareness of the mobility stations, which are more or less noticed by the users. This depends mainly on the media response and the advertising efforts of the involved partners.

However, it should be noted that the physical presence of mobility stations is the main source of awareness, as “passing by” was the most mentioned source among users in both cities. According to Heller (2016) *passing by* is also the main source of awareness among non-users in Offenburg, mentioned by almost 80% of them.

Access mode to mobility stations

Users in both cities were asked which mode of transport they used to access the station before starting a trip with a shared mobility service. Table 3.8 presents the percentage of users who mentioned each transport mode.

Table 3.8: Access mode to mobility stations in Offenburg and Würzburg

City	Offenburg	Würzburg
Access modes	Users who accessed the station by this mode (%)*	
By foot	57	65
own bike	41	14
Public Transport	1	16
own car	2	1
as car passenger	0	1
bikesharing	2	0
carsharing	0	0
Others	0	3
Sources	Heller (2016)	Pfertner (2017)

In both cities, the majority of users walked to a mobility station before starting a trip with a shared mobility service. The second most used mode of transport to access to stations in Offenburg is a private bike, and in Würzburg, public transport.

The high share of users who walk to the mobility stations indicates that most users live in the immediate surroundings. The fact that most users in both samples are station-based carsharing users further supports this assumption.

Moreover, the shares of users who access the mobility stations by other modes of transport indicate that these facilities are enabling intermodal trips.

Important components of mobility stations

Users in both cities were also asked to rate the importance of existing and potential components of the mobility stations. Table 3.9 presents the percentage of users in each city that rated a component as "very important" or "somewhat important". Items in parenthesis are not available yet at the mobility stations in the respective cities.

Table 3.9: Important components of mobility stations as rated by users in Offenburg and Würzburg

City	Offenburg	Würzburg
Components	Users who rated the components as important* (%)	
Availability of carsharing	95	94
Connection to public transport (bus/train)	77	85
Availability of bikesharing	52	49
On-site information	(46)	37
Possibility to use electric carsharing	80	(57)
Possibility to rent pedelecs/electric bikes	35	(29)
Taxi stops	(19)	(14)
Possibility to rent cargo bikes	(55)	(32)
Lockers/baggage spaces	(45)	(34)
Packstation	(20)	(31)
Sources	Heller (2016)	Pfertner (2017)
*sum of "very important" and "rather/somewhat important" (non-existing component)		

As it can be observed, carsharing was considered as at least "somewhat important" by almost all of the users in both cities. It is important to note that the sample of respondents in both cities is heavily dominated by carsharing users. For the same reason, it is interesting to see that for almost half of the users (weighted average), bikesharing is an important component of mobility stations. In addition, the connection to public transport was rated as important by a large majority of users in both cities.

The share of users in both cities who consider non-yet existing components as important, indicates that there is potential to expand the range of services at mobility stations. The opportunity to use electric carsharing seems to be an especially highly appreciated component. Even in Würzburg, where is not yet available, a large majority of users considered it important.

Effects on mobility behavior

The stations' effects on mobility behavior in Offenburg and Würzburg were explored by asking users whether or not they agree to some statements regarding changes in use of mobility services due to the mobility stations, and if they considered them as alternatives to private cars. Table 3.10 presents the percentage of users who indicated to "completely agree" or "rather agree" to the different statements.

Table 3.10: Share of respondents that agree to statements related to effects on mobility behavior due to the mobility stations

City	Offenburg	Würzburg
Statements	**Users who agree* to the statement (%)**	
I became customer of [shared mobility service] because the mobility stations made me aware of the offer	26	59
Since I use the mobility station(s) I use [carsharing service] more often	36	74
Since I use the mobility station(s) I use public transport mode often	14	23
Since I use the mobility station(s) I use [bikesharing service] more often	9	12
Thanks to the mobility station(s) I can always be sure to have an appropriate transport mode available	67	73
New mobility offers like the mobility stations contribute to making the own car unnecessary	86	83
Sources	Heller (2016)	Pfertner (2017)
	*sum of "completely agree" and "rather agree"	

The results indicate that the mobility stations in both cities promote a multimodal mobility behavior:

- 26% of users in Offenburg and 59% of users in Würzburg declared to have become customers of a mobility service due to the mobility stations,
- in both cities, mobility stations contribute to the use of public transport and shared mobility services more often,
- a large majority of users in both cities agree that due to the mobility stations, they can always be sure to have an appropriate transport mode available.

Furthermore, over 80% of users in both cities agreed that mobility stations contribute to making the own car unnecessary.

These results can be regarded as positive, considering that in both cities the main goals of proving mobility stations include the promotion of ecomobility and the reduction of car ownership and usage.

Acceptance of mobility stations

Finally, mobility stations are well accepted among users in both cities. In Offenburg, 59% of users would like to have more mobility stations, 28% do not know, and 15% are against expanding the system. In Würzburg 73%, would like to have more and the rest are against adding more mobility stations (note: the option "I don't know" was not given to respondents in Würzburg).

3.2.6. Summary

Due to their recent implementation, the acceptance and perception of mobility stations, as well as their impact on mobility behavior are not yet completely understood. The above presented results, however provide some insights into these aspects.

In general, it can be said that mobility stations are well accepted by current users and that they promote multimodality. Many users became customers of a shared mobility service due to the mobility stations, and others increased their use of other mobility services.

The results, however, are still not enough to determine the effects of mobility stations on mobility behavior. Longitudinal studies on travel patterns and changes in car ownership among users are necessary to have more significant results.

In order to gather more information about the potential effects of mobility stations on mobility behavior, various studies on carsharing and bikesharing (as main components of mobility stations) were reviewed. The results of this literature review are presented in the next section.

3.3. Complementary literature review

This section presents the results of an extensive literature review aimed to complement the limited information on the (potential) effects of mobility stations.

The literature review covers the development of carsharing and bikesharing and their impacts on mode choice and car ownership as these are the two shared mobility services found on most mobility stations in Germany (see Section 3.2.2.1).

Additionally, the impacts of the integration of mobility services provides some insights into their potential to support the use of alternative modes of transport. Finally, findings on the correlation of multimodality and car ownership are summarized.

3.3.1. Carsharing: overview, development and impacts

This section presents an overview of carsharing, its development and impacts on mode choice and car ownership.

In general, carsharing consists of a fleet of shared vehicles that can be used by many individuals. There are different types of carsharing services operating all over the world, with different business models and conditions for its use.

Table 3.11 presents an overview of the most common types of carsharing services.

Table 3.11: Description of different types of carsharing services and examples

Type of carsharing	Characteristics / main features	Examples
Station-based roundtrip carsharing	Consists of a fleet of shared vehicles allocated in one or many stations. Usually, each vehicle has a designated parking space at the station. Thus, vehicles have to be returned to the same station they were rented from. Vehicles are usually shared by members of one organization or a cooperative, who pay for using a car based on traveled distance and time in addition to a base monthly or annual fee.	Zipcar, United States; Communauto, Canada; STATTAUTO, Germany.
Station-based one-way carsharing	Similar to station-based roundtrip carsharing, station-based one-way carsharing consists of a fleet of shared vehicles that can be picked up and dropped off at designated stations. The start and end stations are not necessarily the same.	Autolib', Paris, France; Auto-mobile, Montréal, Canada;
Zone-based carsharing	Similar to the station-based operation model, zone-based carsharing consists of a fleet of shared vehicles allocated to defined zones within an operational area – called parking zones, instead of stations. Usually, the shared vehicles don't have a reserved parking space within the zone. Thus, vehicles can be found anywhere within a zone and must be returned to their zones after use, but not necessarily to the same exact location where they were rented out from.	DB Flinkster, Germany; BeeZero, Germany.
Free-floating carsharing	Free-floating carsharing consists of a fleet of shared vehicles that can be picked up and dropped off practically everywhere within a service area. The fleet is usually owned by a company, and users have access to the vehicles through a smart card or smartphone application.	Car2go and DriveNow in multiple cities.
Peer-to-peer carsharing	Peer-to-peer carsharing consists of a fleet of vehicles owned or shared by many different individuals which can be organized through a platform operated by a third party.	Tamyca, Autonetzer, Croove.

3.3.1.1. Carsharing development

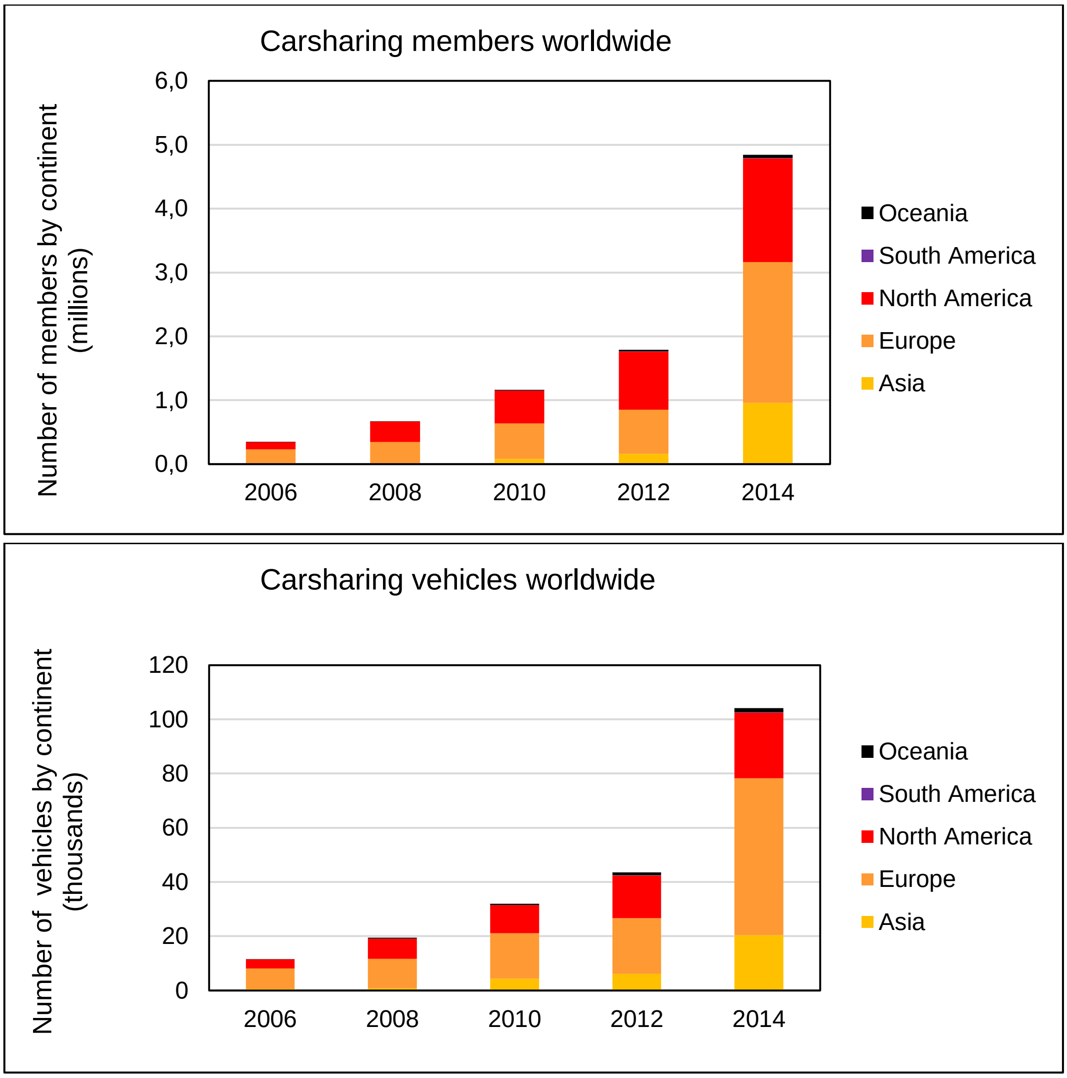
The earliest carsharing experiences can be traced back to a cooperative called "Sefage" which initiated services in 1948 in Zurich, Switzerland (Shaheen et al., 1998), but it was until the mid-1980s that carsharing became popular in Switzerland and Germany (Shaheen, 2012).

According to Martin et al. (2010b) modern carsharing began in North America during the mid-1990s, starting in Canada and then in the United States (U.S.), and as of July 2009, there were more than 378,000 members served by 9,818 vehicles throughout North America (Martin et al., 2010a). According to Loose (2010), at the beginning of 2009 there were 205 carsharing providers in fourteen European countries with more than 380 thousand customers and almost 12 thousand vehicles.

Up until 2010, most carsharing services available across the world were roundtrip or station-based. According to Shaheen et al. (2015b), one-way carsharing systems began in Europe through experimental programs in the 1970s and pilot programs in the 1990s in Japan, Singapore, and the United States. Although most of them failed for different reasons such as economic viability concerns, underuse, and ineffective or inefficient technologies, they are considered to have laid the foundation for modern carsharing (Shaheen et al., 2015b).

In 2009, the first pilot project with free-floating carsharing was launched in Ulm, Germany by Daimler under the commercial name of car2go (swp, 2014). That same year, car2go was launched in Austin, Texas, though it was initially only available to City of Austin employees, and in 2010 it was opened to the general public (Kortum, 2012). Since then, free-floating carsharing services started to appear in other cities all over the world, provided by different companies. According to Shaheen et al., (2015b), as of July 2014 there were about 17 one-way carsharing operators (ten of which were free-floating) with programs across ten countries.

The *Innovative Mobility Carsharing Outlook* reports that as of October 2014, carsharing was operating in 33 countries, and an estimated 1,531 cities with approximately 4.8 million members sharing over 104,000 vehicles (Shaheen and Cohen, 2016). Figure 3.14 shows the development of carsharing from 2006 to 2014 in both membership and vehicles.

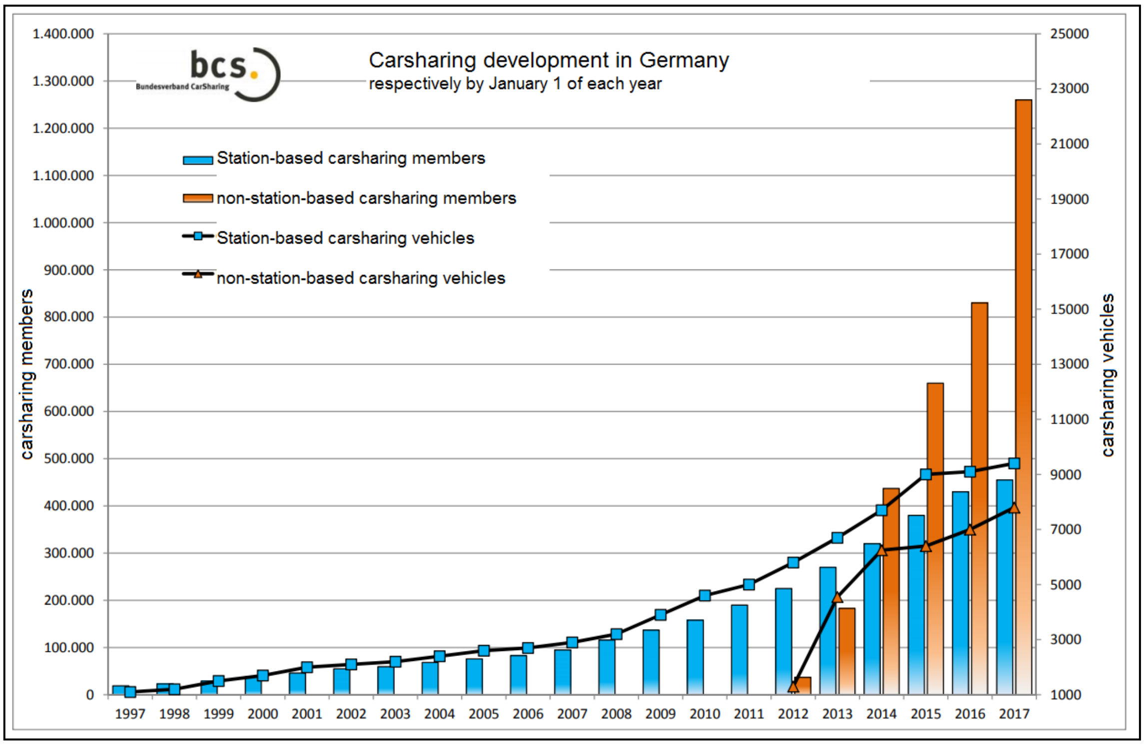


Source: own elaboration with data from Shaheen and Cohen (2016)

Figure 3.14: Development of carsharing in a) number of members and b) number of vehicles

From the 4.8 million of carsharing members in 2014, 82% were registered as customers of round-trip services and the rest belonged to the one-way services. As for the carsharing fleet, 77% of vehicles belonged to round-trip services and the rest to one-way services (Shaheen and Cohen, 2016).

In Germany, the number of carsharing members and vehicles has also grown steadily in recent years, especially since the introduction of free-floating carsharing. Figure 3.15 shows the number of members and vehicles associated with station-based and "non-station-based" (free-floating) carsharing systems as of January 1 of each year since 1997 (Bundesverband CarSharing e. V., 2018).



Source: (Bundesverband CarSharing e. V., 2018) (translated)

Figure 3.15: Development of carsharing in Germany

As of the beginning of 2017, there were about 1.7 million carsharing members and more than 17 thousand vehicles from about 150 German carsharing providers (Bundesverband CarSharing e. V., 2018).

The steady growth of carsharing in members, vehicles, and organizations speaks to an increasing acceptance of this shared mobility service.

3.3.1.2. Selected findings on carsharing

Numerous studies have examined the acceptance of carsharing, the motivations for using it, the demographics of its members, as well as the impacts of carsharing on car ownership, mobility behavior, and GHG emissions, among others (Behrendt, 2000; Haefeli et al., 2006; Huwer, 2004; Martin and Shaheen, 2011b; 2011a).

In the following section, I concentrate on the impacts carsharing has on car ownership, vehicle kilometers traveled (VKT), and on the use of other modes of transport, from selected studies in North America and in Germany.

Effects of station-based carsharing in North America

Until 2010, most of the studies on carsharing in North America had focused on one organization within a single city (Millard-Ball et al., 2005) and most of the evaluations occurred when the organization was just beginning operation (Martin et al., 2010a). The literature review carried out by the authors (ibid) summarizes the results of these evaluations indicating that carsharing contributes to reducing car ownership among its members and avoiding future car purchases. Also, as carsharing evolved, reductions in VKT by car were found to be more pronounced (Martin et al., 2010a).

According to Martin and Shaheen (2010), among the most consistent findings of past research is that carsharing reduces car ownership. Moreover, according to the authors, as carsharing has matured in North America, emerging evidence suggests considerable reductions in VKT by car among carsharing members (Martin and Shaheen, 2010).

In 2008, a survey among 6,281 members of ten carsharing organizations (station-based and roundtrip) in the United States and Canada was carried out and the results were published in multiple studies. A review of these publications yielded the following selected findings:

- The sample of respondents owned 0.47 vehicles per household before carsharing and 0.24 vehicles per household after carsharing (Martin et al., 2010a).
- It is estimated that each carsharing vehicle in North America replaces 9 to 13 private vehicles (Martin et al, 2010).
- The average observed VKT of respondents before joining carsharing was 6,468 km/year, whereas the average observed VKT after joining carsharing was 4,729 km/year. This reduction constitutes a decline of 27% in the before-and-after mean driving distance (Martin and Shaheen, 2011a).
- While some carsharing users increased their use of public transport, others decreased it. Across the entire sample, the results showed an overall decline in public transit use that was statistically significant and a statistically significant increase of walking, cycling and car-pooling (Martin and Shaheen, 2011c).

Effects of free-floating carsharing in North America

A more recent study on the impacts of car2go (free-floating carsharing) in five North American cities (Martin and Shaheen, 2016) indicates that:

- between 2% to 5% of members sold a vehicle due to car2go, and another 7% to 10% prevented (or avoided) a vehicle purchase due to car2go.
- The estimation of VMT change suggests there is a net reduction in VMT that results from the presence of car2go. The average reduction in VMT across the five cities is estimated to be of 11%.
- While the majority of respondents reported no change in their public transit use as a result of car2go, in every city there are people that both increase and decrease their use of public transport as a result of car2go. However, in most cities more people decrease their public transit use rather than increase it as a result of car2go.
- A majority of respondents reported no meaningful change in walking due to car2go, but in four of five cities, at least 20% reported walking more frequently compared to the roughly 10% that reported walking less frequently due to car2go.
- In all cities, the percentage of respondents reducing or increasing cycling due to car2go is below ten percentage points, while the rest (over 87%) reported no change.

Effects of station-based carsharing in Europe

The study “The State of European Car-Sharing” summarizes the findings of other various studies regarding the demographics of carsharing users, their motivations for using carsharing, as well as the environmental effects of carsharing in Europe (Loose, 2010). Considering the results of various studies, it was found that carsharing participants in Europe own a below-average number of personal cars in comparison to other households and that each carsharing vehicle replaces between four to eight personal cars (Loose, 2010).

Furthermore, the various studies reviewed by Loose (2010) indicate that some carsharing customers got rid of (at least), one car or decided against a planned vehicle purchase.

The percentage of carsharing customers who got rid of car ranged from 14% in Frankfurt, Germany to 40% in Great Britain, and the share of customers that decided against a planned vehicle purchase ranged between 10% in Brussels, Belgium and 55% in Bremen, Germany (Loose, 2010).

Regarding the impacts of carsharing on car ownership summarized above, Loose (2010) indicates that even if studies don't yield scientific proof that carsharing is the causal trigger for a reduction in car ownership, it can be established that carsharing households, on a statistical average, have access to fewer personal cars than comparable population groups. Loose (2010) suggests that the cost structure of carsharing has an impact on mode choice and vehicle kilometers traveled by carsharing participants. He argues that due to cost transparency of carsharing, users make more efficient choices for traveling.

Effects of station-based carsharing in Munich

Since the main case study of this dissertation takes place in Munich, the impacts of carsharing in this city were explored in further detail and are presented below.

A 1996 survey among STATTAUTO (station-based carsharing) customers in Munich (Krietemayer, 2003) (n = 596), and in 2002 (n = 700) revealed that:

- 21% and 14% of users in 1996 and 2002 respectively, got rid of a private car due to their membership with STATTAUTO, and
- 35% and 34% in 1996 and 2002 respectively avoided buying a car due to carsharing.
- The yearly VKT of carsharing customers was reduced from an average of 11,300 km before becoming a STATTAUTO member to an average of 2,500 km after becoming a member.
- While the use of private cars was reduced, the use of public transport was increased.

In the surroundings of Munich, similar results were found a decade later: 17% of carsharing participants of STATTAUTO disposed of a car because of carsharing and 30% avoided a purchase due to carsharing (MVV, 2012a). Moreover, it was found that carsharing participants reduced their annual VKT by 60% from 9,600 km to 3,600 km on average (MVV, 2012b).

Effects of zone-based and free-floating carsharing in Munich

The Carsharing Evaluation in Munich (EVA-CS) (team red, 2015) surveying customers of free-floating and zone-based carsharing services revealed that:

- 12% of carsharing users got rid of a car in their households, 40% abstained from buying a car, and 27% considered giving up a car in the upcoming year.
- At least half (49%) of these respondents (from the previous bullet point) indicated that carsharing had either a “rather big” or “very big” role in these decisions.
- It is estimated that the total vehicle kilometers travelled by the households which got rid of a car is on average 50% lower than those households that did not.
- Considering the total VKT by private car and by carsharing among users, it is estimated that at least 5% is reduced due to the abolishment of private cars.
- The influence of carsharing on the use of public transport is not clear. Among carsharing users who reduced the number of cars in their households, the use of public transport increased. However, the statements about the use of public transport among all carsharing users indicate a reduction in the use of public transport.
- The most prominent reasons for the use of carsharing as revealed by the respondents include cost savings, affordability, flexibility in combining with PT, and the perception that it is a modern and environmentally friendly service.
- Another attitudinal observation is that owning a car is no longer considered a status symbol.

A more recent survey regarding the impacts of zone-based (Flinkster, n=227) and free-floating (DriveNow, n=819) carsharing in Berlin and Munich, Germany carried out in the framework of the WiMobil project (Giesel and Nobis, 2016) found that:

- 72% of ZBCS and 43% of FFCS users live in households without a private car.
- The most common reason for not owning a car is that private car is not necessary, comes with high costs, and because carsharing is considered to be sufficient.
- 6.5% of FFCS and 15.3% of ZBCS users declared to have shed a car because of their participation in carsharing.

The analysis of Giesel and Nobis (2016) shows that the likelihood of shedding a car increases if a person frequently uses CS, and with increasing numbers of memberships of ZBCS systems. Thus, the combination of both business models, in particular, seems to have the biggest impact on car ownership. Heavy users and people who combined both CS systems shed a private car more often. However, worth noting is that non-car owners, 18% of DriveNow and 6% of Flinkster, are planning a purchase. (Giesel and Nobis, 2016)

Kopp et al. (2015) analyzed overall travel behavior of FFCS members (men between 25 and 45 years living in Munich or Berlin) with an innovative survey design based on a GPS tracking smartphone application, and compared it to that of men in the same cities and of the same age group who do not use carsharing (NCS) during one week.

Their analysis showed that FFCS users are more intermodal and multimodal in their behavior than NCS. While FFCS users report more trips, they cover shorter distances and differ substantially in their mode choice with shares of cycling significantly higher, and shares of private car trips significantly lower compared to NCS. (Kopp et al., 2015)

According to the authors the difference in the availability of mobility tools is the basis for the mode choice behavior, which is also affected by locational characteristics and the spatial structure they live in: FFCS have lower car ownership, similar bike ownership, higher percentage of public transport period tickets and better access to public transport in terms of distance and service level, and they also live in denser areas which generally have a better local supply of goods and other facilities. (Kopp et al., 2015)

3.3.1.3. Summary

The above reported impacts of carsharing vary across studies and regions, as well as the types of carsharing models being evaluated.

In general, the impacts of SBCS and ZBCS on car ownership and VKT seem to be greater than the impacts of free-floating carsharing services. The difference in the magnitude of impacts could be explained by the differences in the business models (free-floating carsharing is used more for spontaneous trips while SBCS and ZBCS are used more often for planned trips). The fact that free-floating carsharing has been in operation for less time compared to the other two models could also explain some differences in the results, as well as differences in the demographics and attitudes of users.

As for the differences across regions, there are different factors which might influence the results, such as the time when the evaluations were carried out, the average duration of membership across individuals and their frequency of use, the demographics of the sample, the transport supply in the respective study areas, and the specific characteristics of the service, to name a few.

While the methodologies behind the estimated impacts may vary between the different studies, there is a core consensus that carsharing contributes to:

- reducing car ownership among users: users either get rid of at least one of their cars, or avoid purchasing one due to their participation in carsharing;
- reducing overall VKT by car: even though some users increase their car VKT due to their access to a vehicle through carsharing, the overall car VKT among carsharing members is reduced, mainly due to the users shedding cars and an increased use of other modes;
- reductions in personal emissions among carsharing members due to a reduction in car VKT, and due to better technology and/or fuel economy of the shared vehicles than the average fleet;
- changes in the use of other modes: mainly an increase in the use of non-motorized modes and both a reduction and increase in the use of public transport.

Other reported benefits of carsharing are a reduced demand for parking space or a reduced amount of vehicles on the road due to the amount of private vehicles that carsharing vehicles replace (Loose, 2009; Glotz-Richter, 2016; Martin et al., 2010b).

These results, however, should be interpreted with care: unless the cars the users got rid of were scrapped, and thus completely removed from the general fleet, they are, in fact, still on the road. This means that the overall car ownership in a country, city, or even in a neighborhood is minimally directly influenced by carsharing in the short term.

Carsharing provides access to cars to those households which cannot afford to own one, and thus increases accessibility and saves mobility costs by reducing the burdens of owning a car (purchase costs, insurance, maintenance, etc.). At the same time, however, carsharing, especially the free-floating services, could be a trigger for carsharing members to buy a car in the future, once the benefits of driving and/or specific features of carsharing cars are experienced by the users.

Although most studies on carsharing report positive results in terms of car ownership and VKT reductions, the question of whether users have purchased a car (or might) as a result of their carsharing memberships is missing from most evaluations.

Furthermore, the decision to get rid of a car or purchase one is usually a long term decision and is mainly influenced by a combination of factors, such as changes of residence location, changes in life situation, economic reasons, etc., and being a member of a carsharing service is only one of them. Thus, even though respondents of surveys on the impacts of carsharing indicate that the numbers of vehicles in their households changed due to their participation in carsharing, it is not always clear to what extent carsharing played a role in this decision.

Other limitations on the interpretation of results of carsharing stuidesare the disproportional response rates in surveys which could result in specific types of users being unrepresented in the sample (Schreier and Schwieger, 2016).

In any case, further cross-sectional and longitudinal studies are required to better understand the impacts of different carsharing models.

3.3.2. Bikesharing: overview, development and impacts

Bikesharing consists of a fleet of bicycles shared by members of an organization. As of today, there are four main types of bikesharing systems. Table 3.12 presents a description of each type and examples.

Table 3.12: Descriptions of different types of bikesharing systems and examples

Type of bikesharing system	Description	Example
Station-based bikesharing with docking station	Consists of a fleet of bikes distributed throughout a service area, available at docking stations where they must be rented and returned (to lock the bike, it is necessary to dock it at the station). One-way trips are possible, which means that the bikes can be returned at a different station than the one they were rented from.	Most bikesharing systems all over the world (e.g. Capital Bikeshare, (Washington, D.C; velib, Paris)
Station-based bikesharing without docking station	Similar to the station-based bikesharing with docking station, the bikes are assigned to spots within a service area where they have to be returned to after use. The bikes don't need a docking station to be locked since the lock is integrated into the bike mechanism.	nextbike in Leipzig, Germany.
Free-floating bikesharing	Similar to the station-based bikesharing system without docking stations, the free-floating bikes have an integrated lock which removes the need for a dock. The bikes are available and can be returned anywhere within a service area.	Call a Bike in various German cities, obike in various cities.
Hybrid bikesharing	Hybrid bikesharing is a combination of both station-based and free-floating bikesharing. Bikes can be either docked at stations or left (locked) anywhere within a service area.	MVG Rad, Munich.

3.3.2.1. Bikesharing development

Bikesharing is reported to have started in the mid-1960s in Amsterdam in the Netherlands as a public fleet of bikes placed unlocked throughout the city and free to use for everyone (Shaheen et al., 2010; DeMaio, 2009) followed some years later by other cities such as La Rochelle, in France and Cambridge in the United Kingdom (Shaheen et al., 2010).

The so called "second generation of bikesharing", using a coin-deposit system, started in the 1990s in different cities in Denmark (DeMaio, 2009; Shaheen et al., 2010).

Although the first attempts failed mainly due to vandalism, bikesharing systems have developed since, incorporating advanced information technologies for reservations, pick-up, drop-off, and information tracking, as well as innovative techniques for redistributing bikes and docking them (Shaheen et al., 2010). Figure 3.16 shows the development of bikesharing from the first to the fourth generation.

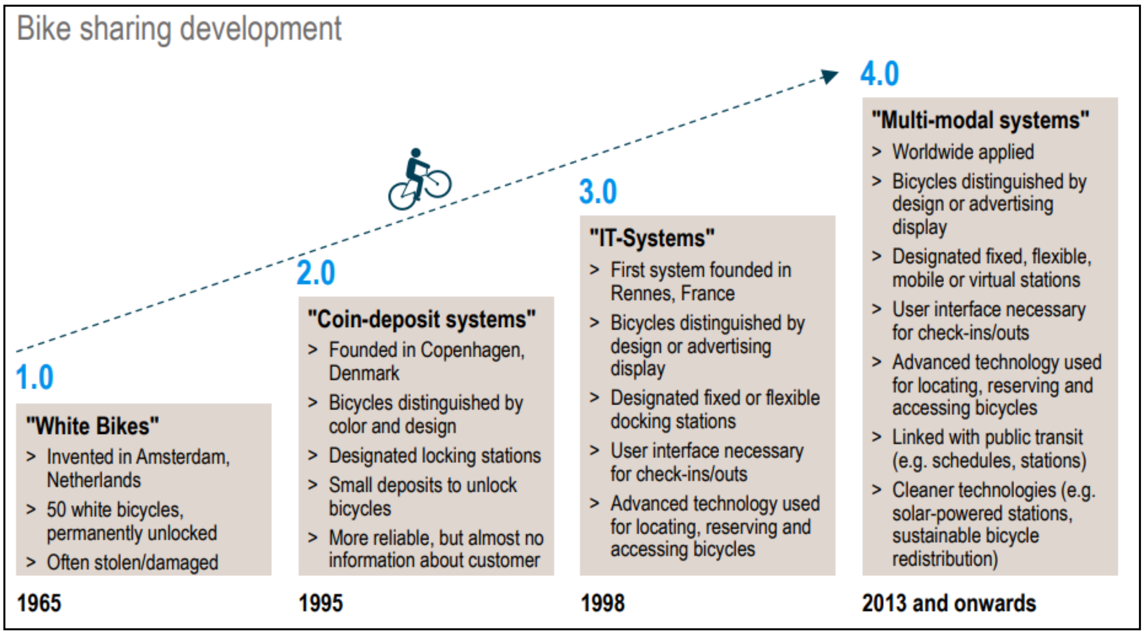


Image source: (Roland Berger, 2015)

Figure 3.16: Development of bikesharing from the first to the fourth generation

According to a study of Roland Berger Strategy Consultants, as of April 2015 there were around 600 bikesharing schemes with more than 640,000 bikes in operation worldwide, and the size of the global market was expected to grow by 20% per year through 2020. (Roland Berger, 2015).

By the end of 2017, a total of 1,188 public use bicycle programs and over 2.2 million bikes all over the world were registered through the bike-sharing world map (Meddin, 2017).

Bikesharing continues to develop both in technology and the type of services offered. In the last couple of years, some bikesharing systems began to offer bikes with electric assistance (pedelecs) (Fishman, 2014) and the number of dockless bikes has been increasing as well. Meddin (2017) reports that by the end of 2016 there were 11,000 pedelecs and 550,000 mobile app based dockless bikes operating in bikesharing systems all over the world.

3.3.2.2. Selected findings on bikesharing

As with carsharing, many studies have been done in various cities investigating the impacts of bikesharing on mobility behavior.

According to DeMaio (2009), bikesharing has had effects on increasing cycling, transit use, decreasing greenhouse gases, and improving public health. DeMaio (2009) also reported increased cycling in Barcelona, Lyon, and Paris. However, according to Midgley (2011), as of 2011 there was little meaningful data on benefits or impacts of bicycle-sharing schemes, and the most noticeable benefit at the time was increased bicycle use

Bikesharing in North America

During 2011 and 2012, a survey among members of bikesharing systems in four North American cities (Montréal, Toronto, Washington D.C. and Minnesota) was carried out (n=10,661). Regarding the impacts of bikesharing on car ownership, Shaheen et al. (2012) report that:

- 5% of respondents (from the 75% of the total sample with access to a vehicle) got rid of a car in their households, and 7% considered getting rid of car since they joined bikesharing.
- Among respondents who sold a car since they joined the bikesharing projects, 55% considered the bikesharing program at least "somewhat" important in their decision to sell or consider selling their vehicle.

This means that from the entire sample, only 2% considered bikesharing to be "somewhat" to "very important" to their decision to sell or consider selling a vehicle (Shaheen et al., 2012).

With respect to changes in mobility behavior, the results of the study show that bikesharing can either reduce or increase both public transport use and walking, but in general reduces driving and the use of taxis (Shaheen et al., 2012). More precisely, the results across the entire sample indicate that as a result of using bikesharing:

- 18% of respondents use more often and 39% use less often public transport, while the rest do not report any changes in the use of this mode,
- 23% of respondents walk more often and 34% walk less often, while the rest do not report any changes in their frequency of walking,

- 72% of respondents ride a bike (any bike) more often and 5% ride a bike less often,
- 46% of respondents use a taxi less often, while 53% do not report any change,
- 40% of respondents drive a car less often, while 60% do not report any change.

According to the authors, the survey results suggest that bikesharing plays a different role in different cities. For example, in denser cities with extensive public transportation infrastructure, bikesharing appears to serve as an extension of the public transport system. While bikesharing facilitates some people to reach their destinations sooner than they will do with bus or rail (and thus some trips by public transport are substituted by bikesharing), it also facilitates others to use public transport more in all cities. (Shaheen et al., 2012)

One limitation of these results, as indicated by the authors of the study, is that the travel activity changes are self-reported and thus, subject to uncertainties in personal recollection and travel activity measurement (Shaheen et. al, 2012). The authors also consider the possibility of non-response bias as a limitation of the study, although it is assumed to not have a large effect on the results, as the survey's questions were not sensitive in nature (ibid). Last but not least, the authors recognize that the results reflect the behavior of early adopters of a minimal set of operators (four), and thus are not generalizable across other bikesharing systems (ibid)

Multi-city analysis: Australia, United States and United Kingdom

A more recent multi-city analysis on the impacts of bikesharing on car use is provided by Fishman et al. (2014). The authors compiled survey results from five cities, in which users of the respective bikesharing programs were asked to indicate which mode of transport they would have used for their last journey with bikesharing if the service would have not been available.

Figure 3.17 shows the percentages of the substituted modes of transport indicated by respondents.

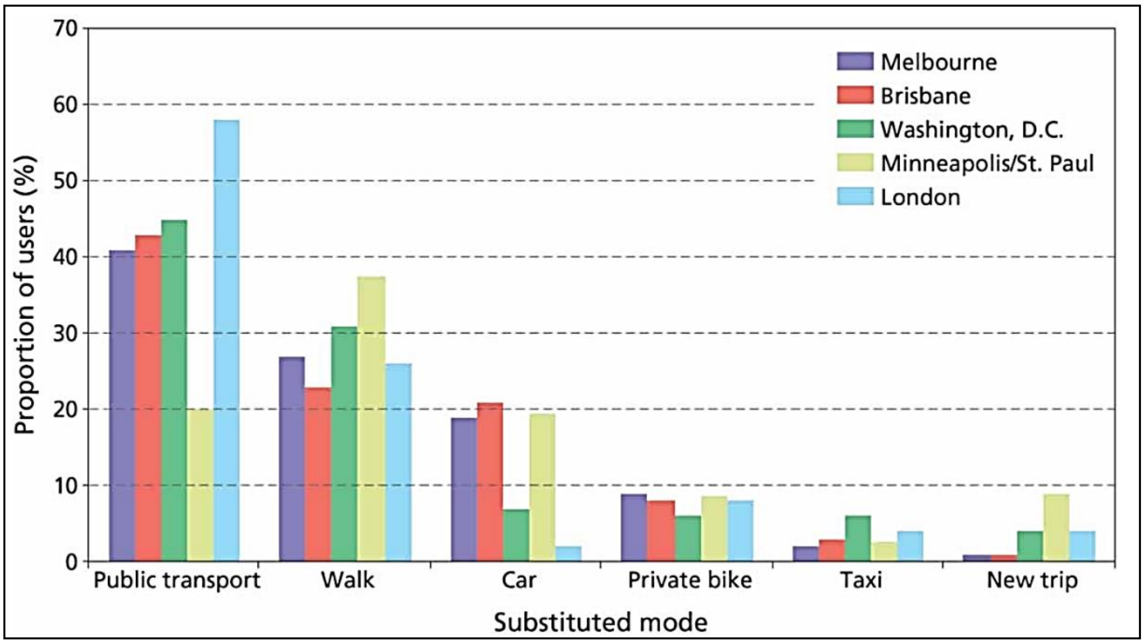


Image source: (Fishman, 2015)

Figure 3.17: Mode substitution with bikesharing in selected cities

Since the paper is focused on better understanding the magnitude of changes to car use as a consequence of bike share programs, the further analysis concentrates on the trips by car that are substituted by bikesharing, and no explanations regarding the differences on the substitution of modes in the different cities is provided.

However, the results show that a substantial proportion of bikesharing trips substitute public transit (between 20% in Minneapolis/St. Paul and almost 60% in London), and walking (between 23% in Brisbane and 38% in Minnesota), while the substitution of car trips by bikesharing varies from 2% in London to 21% in Brisbane (Fishman et al., 2014).

Bikesharing in Germany

More specifically, in Germany an evaluation of four public bikesharing systems (Ruhrgebiet, Nuremberg, Stuttgart and Usedom) during the pilot phase (BMVBS, 2013) revealed that:

- The modal split of bikesharing users is less characterized by the use of motorized individual transport than that of people identified as non-users of bikesharing (10 to 15% less).
- Bikesharing users, independently of the bikesharing system, cycle more often and use public transport more often than non-users (5 to 7% more).

- Twice as many bikesharing users possess a public transport pass compared to non-users.
- In comparison to persons of the same age group, bikesharing users are more mobile: they perform more and longer trips.
- Users of bikesharing travel more often with public transport on average, but also regularly use a car.
- Bikesharing mainly replaces trips by walking and public transport and about 10% of bikesharing trips replace car trips.

According to the study the bikesharing systems evaluated were often used by multimodal persons (BMVBS, 2013). The study also indicates that bikesharing users perform twice as many intermodal trips compared to non-users, and about a third of the trips with bikesharing also included a leg with public transport.

According to the authors, both findings support the thesis that the integration of bikesharing and public transport is meaningful (ibid). Furthermore, according to the study, the tariff integration of bikesharing and public transport attracts a relevant user group, and the analysis of temporal use patterns of bikesharing suggests that bikesharing complements public transport (ibid).

Regarding the immediate impacts of bikesharing on mode choice, Rabenstein (2015) presents some results of user surveys in four German cities (Kassel, Mainz, Nuremberg, and in the Ruhrgebiet). Users in these cities were asked which mode of transport they would have used if the bikesharing system was not available. For this analysis, only frequent trips (at least one trip per month) were considered (Rabenstein, 2015). The results indicate that:

- between 22% and 35% of the trips would have done by foot or a private bike,
- between 49% and 64% of the trips would have done by public transport,
- between 1% and 10% of the trips would have been done by car,
- between 6% and 11% of respondents would have not made the trip.

According to Rabenstein (2015) when interpreting these results, the following aspects should be considered:

- the bikesharing systems were not completely established at the time of the surveys,
- the marketing actions were more directed to public transport users than to drivers,
- the observed main user groups were public transport oriented with a low car accessibility, especially students with access to preferential tariffs,
- one of the goals of the bikesharing systems was to relieve pressure from some of the public transport lines which were suffering of capacity problems,
- the statistical accuracy of the results is limited due to the low number of surveys carried out in each city.

3.3.2.3. Summary

The reported impacts of bikesharing on car ownership and mobility behavior vary across studies. The variation in results might be due to differences in the evaluation methods, as well as in the systems being analyzed. Factors such as urban structure and transport supply in the respective study areas, weather, time of the year during which the surveys were carried out, as well as the demographic characteristics of the sample, to name a few, might impact car ownership and travel behavior in different ways.

Other issues affecting the accuracy of results regarding changes in the frequency of use of transport modes are that these are self-reported (Shaheen et al, 2012), and the small sizes of the samples (Rabenstein, 2015).

The literature review of Fishman (2014) highlights the limitations on knowledge, particularly in two areas of interest for this study: sampling of non-bikeshare users and the impacts of bikesharing. According to the author, no standard methodology has been established yet to accurately and consistently measure the impacts of bikesharing programs on car use, climate change, traffic congestion, or public health.

However, from the literature review there seems to be a consensus that:

- Bikesharing increases cycling, especially in cities were cycling was not established before introducing bikesharing,

- Bikesharing replaces trips by car to some extent, however, bikesharing membership has little influence on the decision to get rid of a car.
- Trips with bikesharing mainly replace trips by public transport and walking, but at the same time the systems improve access to public transport.

3.3.3. Integration of mobility services and mobility behavior

An efficient integration of multiple mobility services has the potential to compete against the flexibility and convenience of private cars by enabling comfortable, cost and time-effective door-to-door travel (van Nes, 2002).

The benefits of integrating mobility services have already been observed and documented, an example of which would be the integration of various public transport providers within the so-called “Verkehrsverbund”[9] in Germany (Pucher and Kurth, 1996). The authors report that since the establishment of *Verbund systems* in the cities of Hamburg, Munich, Rhein-Ruhr, Vienna, and Zürich, ridership increased between 16% (in Hamburg) and 63% (in Vienna) during a period when car ownership and use were sharply rising (Pucher and Kurth, 1996).

According to Zimmerman and Fang (2015), public transport has the most customer appeal and is most efficient when it is planned and operated as a seamless, integrated system. This is especially true in urban environments where public transport must increasingly compete with private vehicles which offer door-to-door travel at any time (Zimmerman and Fang, 2015).

More recently, the concept of “Mobility as a Service” (MaaS) has been proposed as a new strategy to integrate various mobility services into one platform, in a way that users can obtain information about different modes of transport, access them through one medium, such as smart card, ticket, or smartphone application, and to pay for their use using a single account (Kamargianni et al., 2015; Kamargianni et al., 2016; Jittrapirom et al., 2017).

[9] Verkehrsverbund is a construction similar to Transportation Authorities, Public Transport Associations or Transport Consortiums which integrates various providers of transport services in one organization.

The MaaS concept builds on the developments of ICT technology and the increasing availability of new shared mobility services such as carsharing and bikesharing (Kamargianni et al., 2016). By providing seamless travel solutions which are accessible and affordable, it is expected that such integrated multimodal systems would contribute to reducing both car ownership and use (Jittrapirom et al., 2017).

Since the concept of MaaS systems is relatively new, little research has been done into the impacts of such integration services on travel behavior (Kamargianni et al., 2016).

Interesting insights from a six-month field operational test in Gothenburg, Sweden, during which 195 participants tested “UbiGo”, a MaaS concept which included integrated information, access and payment for public transport, carsharing, bikesharing, and taxi have been presented in numerous papers (Sochor et al., 2015; Karlsson et al., 2016; Strömberg et al., 2018).

Their results indicate that, in general, UbiGo contributed to a reduction in private car use, and to an increased usage of public transport, shared mobility services and active modes. Figure 3.18 shows the reported changes in choice of transport after the trial of UbiGo.

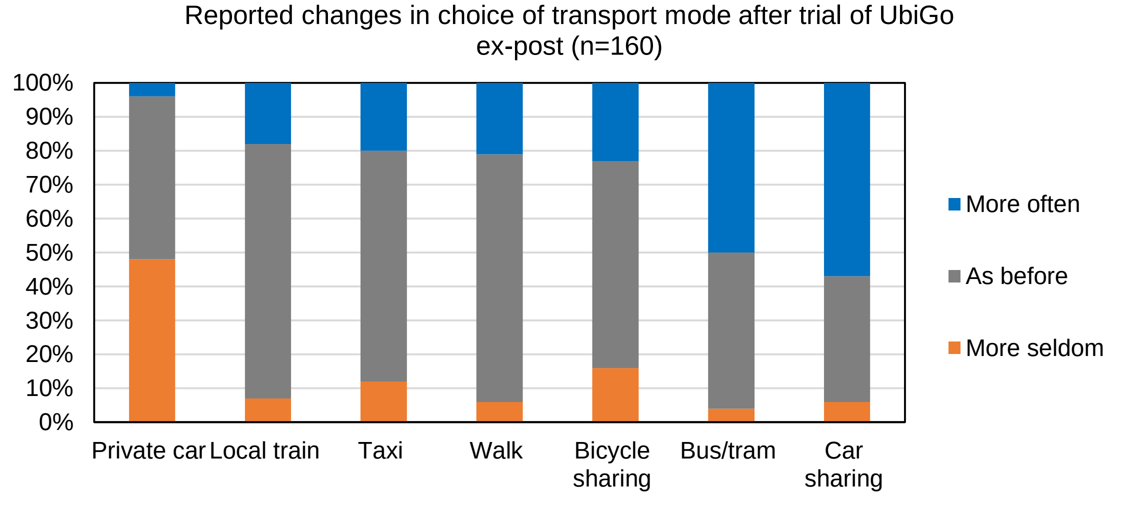


Image source: own elaboration with data from Karlsson et al. (2016)

Figure 3.18: Reported changes in choice of transport mode after trial of UbiGo

According to Strömberg et al. (2018), previous car users reduced their use of private cars and increased their use of public transport (PT) and active modes. Moreover, participants who did not have access to a privately owned car but thought they needed one discovered that they managed well without (ibid).

Based on their empirical findings, the authors suggest that a service approach, such as UbiGo, has the potential to reduce the need for private car ownership, and enable people to change their mode choices and travel patterns (Sochor et al., 2015).

3.3.4. Correlation of multimodality and car ownership and usage

According to Buehler and Hamre (2016), based on a review on recent findings on multimodal motorists (10 studies published since 2005), most studies agree that multimodal car use (i.e. multimodality) is correlated with not owning a car, not having a driver's license, younger age, living in a smaller household, and having good access to public transport.

More specifically, in Germany, it was found that since the turn of the millennium, car use has decreased among young adults (between 18 and 29 years old) and at the same time, one of the underlying trends was an increasing share of young drivers using alternatives modes of transport (i.e. rising multimodal behavior). (Kuhnimhof et al., 2012)

Contrary to the findings mentioned above Heinen and Mattioli (2017) investigated the trends in individual mobility in England and their findings suggest that there is not necessarily a relationship between aggregate levels of car use and the average individual level of multimodality (Heinen and Mattioli, 2017). The authors indicate that some studies on the trends in multimodality often imply that an increase in the latter corresponds to a reduction in car use. However, the different meanings given to this term in scientific investigations and the various methodologies used to measure multimodality make it difficult to compare their findings.

Also, Heinen and Mattioli (2017) state that "studies on the correlates of multimodality are often based on cross-sectional data, and as such, no causal relation can be drawn from them".

3.3.5. Summary

The literature review presented above suggests that shared mobility services on their own already have a positive impact towards reducing car ownership and usage, while promoting the use of other modes of transport.

Furthermore, the findings regarding mobility stations in Würzburg and Offenburg (see Section 3.2.5.2) and the field operational test of a MaaS concept (Section 3.3.3) indicate that the integration of various modes of transport, either physically through mobility stations or virtually through concepts such as MaaS, facilitates multimodal mobility. Both instruments seem to increase the use of shared mobility services and public transport among users.

Various studies suggest that multimodal mobility behavior is correlated to low car ownership, but there is little evidence of a causal relationship. Thus, results on the correlation between multimodality and car ownership and use should be interpreted with care.

These findings suggest that the impacts of integrated multimodal mobility services (e.g. mobility stations and MaaS) could have a synergetic effect on the promotion of sustainable travel behavior, including a reduction in car ownership and usage. However, as of today, there is not yet enough evidence of such an impact.

The detailed investigation of the Mobility Station at Münchner Freiheit in Munich, as the core of this dissertation, should add knowledge to the findings presented in this Chapter.

4. Case Study: The Mobility Station at “Münchner Freiheit”

The Mobility Station at Münchner Freiheit (MSMF) is a pilot project initiated the by City of Munich and the public transport operator in the city (MVG) in 2014, and is the main case study of this dissertation.

This chapter presents detailed information about the MSMF and the context in which it is embedded. This information is intended to help the reader understand the circumstances in which the pilot project is implemented, and thus to better understand the results obtained from its evaluation (presented in Chapter 6).

Section 4.1 presents the demographic characteristics of the City of Munich and the region, the characteristics of the transport infrastructure, and trends in the mobility of the area. It concludes with a description of transport-related challenges affecting the city, as well the strategic framework to cope with them.

As an essential element of mobility stations, the shared mobility services in Munich are presented in Section 4.2. The shared mobility services are described, starting with their development, the current regulatory framework, and the status quo, providing an overview of the current supply of these services within the city. Then, the ways shared mobility services have been integrated with the local public transport and the development of mobility stations in Munich, as another integration approach, are presented.

Finally, Section 4.3 describes the Mobility Station at Münchner Freiheit in detail. It includes information about its development, its location and surroundings, its components, its stakeholders and the operational model, as well as the goals of the pilot project.

4.1. Local and regional context

4.1.1. Demographic characteristics of Munich and its region

Munich is located in the south of Germany, and with 1.5 million inhabitants, it is the third largest city in Germany after Berlin and Hamburg. With more than 4,400 inhabitants per square kilometer, Munich is the most densely populated city in the country (Landeshauptstadt München, 2015b; 2017).

The city is the center of the Munich Metropolitan Region (MMR), which consists of other urban agglomerations distributed over 26,000 km² (EMM, n.d.). Figure 4.1 shows the location of Munich within the MMR and the population density across the region at the municipal level.

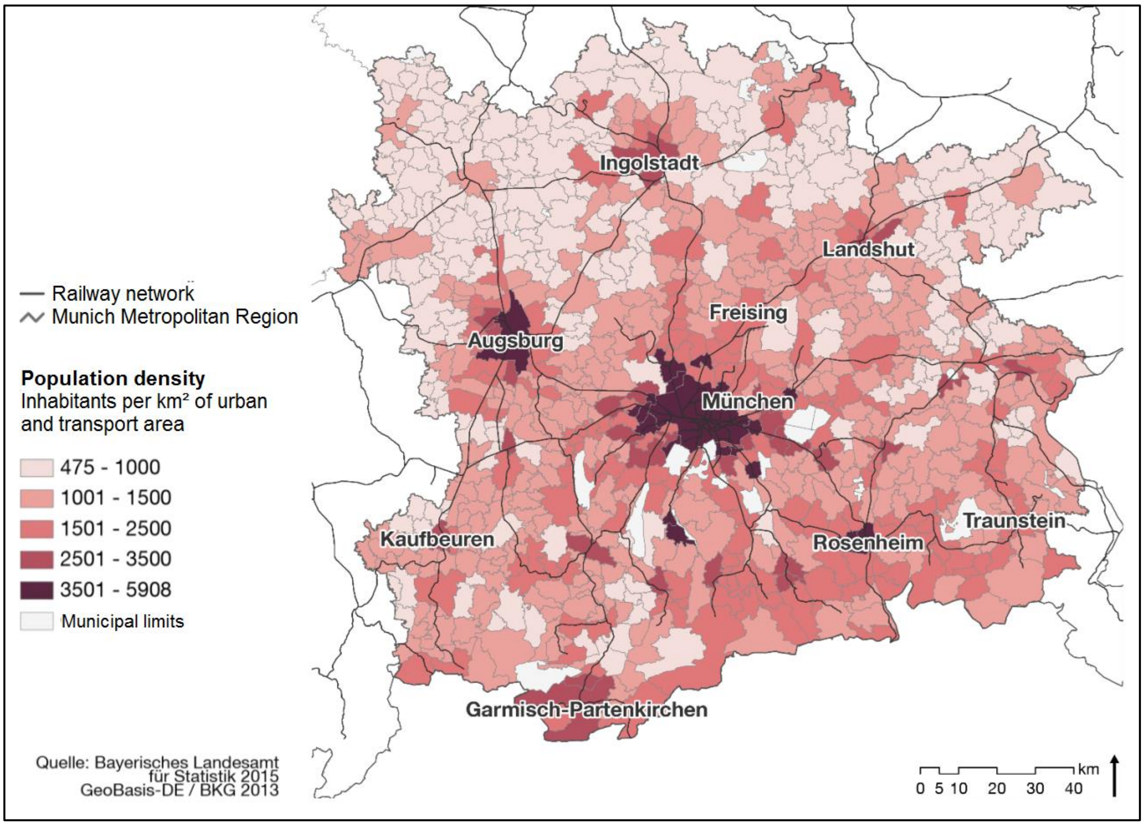


Image source: (Thierstein et al., 2016) (translated)

Figure 4.1: Map of the Munich Metropolitan Region showing its major agglomeration centers and respective population densities.

The city and its region have been experiencing steady population and economic growth in the last decades. The population in Munich grew 15% between 2004 and 2014, and a similar growth rate is anticipated until 2030, at which point the city would hold more than 1.7 million inhabitants (Landeshauptstadt München, 2015b). The MMR had a population growth of about 20% between 1990 and 2015, reaching a total population of approximately 6 million inhabitants (EMM, n.d.).

Data between 2000 and 2015 shows that the amount of employees[10] living outside the city increased by 21% in that period, reaching 355,000 (BBSR, 2017). Other sources indicated that, already in 2010, about 360,000 commuters[11] traveled every day to Munich, (Landeshauptstadt München, 2010).

Although there is no available information on mode choice of these commuters, it is clear that the increasing amount of work related trips puts additional pressure on both the public transport system and the road network around and within the City of Munich.

Finally, population growth has led to a higher consumption of space. In 1980, 11,4% of the area in the Munich Region[12] was used for settlement and transport infrastructure, and in 2016 this had risen to 17,6% (RPV, 2018). According to Zimmerman and Heinelt (2012) weak regional planning is the cause of the growing urban sprawl in the Munich Region, which reinforces the dependency on private cars.

4.1.2. Transport infrastructure

4.1.2.1. Road network and parking infrastructure

The City of Munich is well connected to the MMR and beyond through eight motorways and six main roads. The A99 highway, with a length of about 54 km, surrounds most of the City of Munich as a ring road, although with a gap in the southwest of the city.

[10] It refers to employees subject to social insurance contributions (in German: Sozialversicherungspflichtig Beschäftigte)

[11] The number of commuters reported in Landeshauptstadt München (2010) and the number of employees in Munich subject to social insurance contributions that live in a different municipality, are not necessary the same due to differences in the way these numbers are estimated (See BA (2017).

[12] It refers to the planning region 14 (Planungsregion 14) which comprises 5,504 km².

Within the municipal boundaries, another ring roadway, the 2R also known as the “Mittlerer Ring” (Middle Ring), has a length of 28 km and intersects six of the eight motorways leading to Munich. Finally, the “Altstadtring” (old city ring) is the innermost ring road of the city and surrounds the historical city center.

Figure 4.2 shows the main motorways leading into Munich and the three ring roads. The three ring roads might serve as an orientation for the reader later, when looking at the specific location of the Mobility Station (marked with a star) and its corresponding influence area.

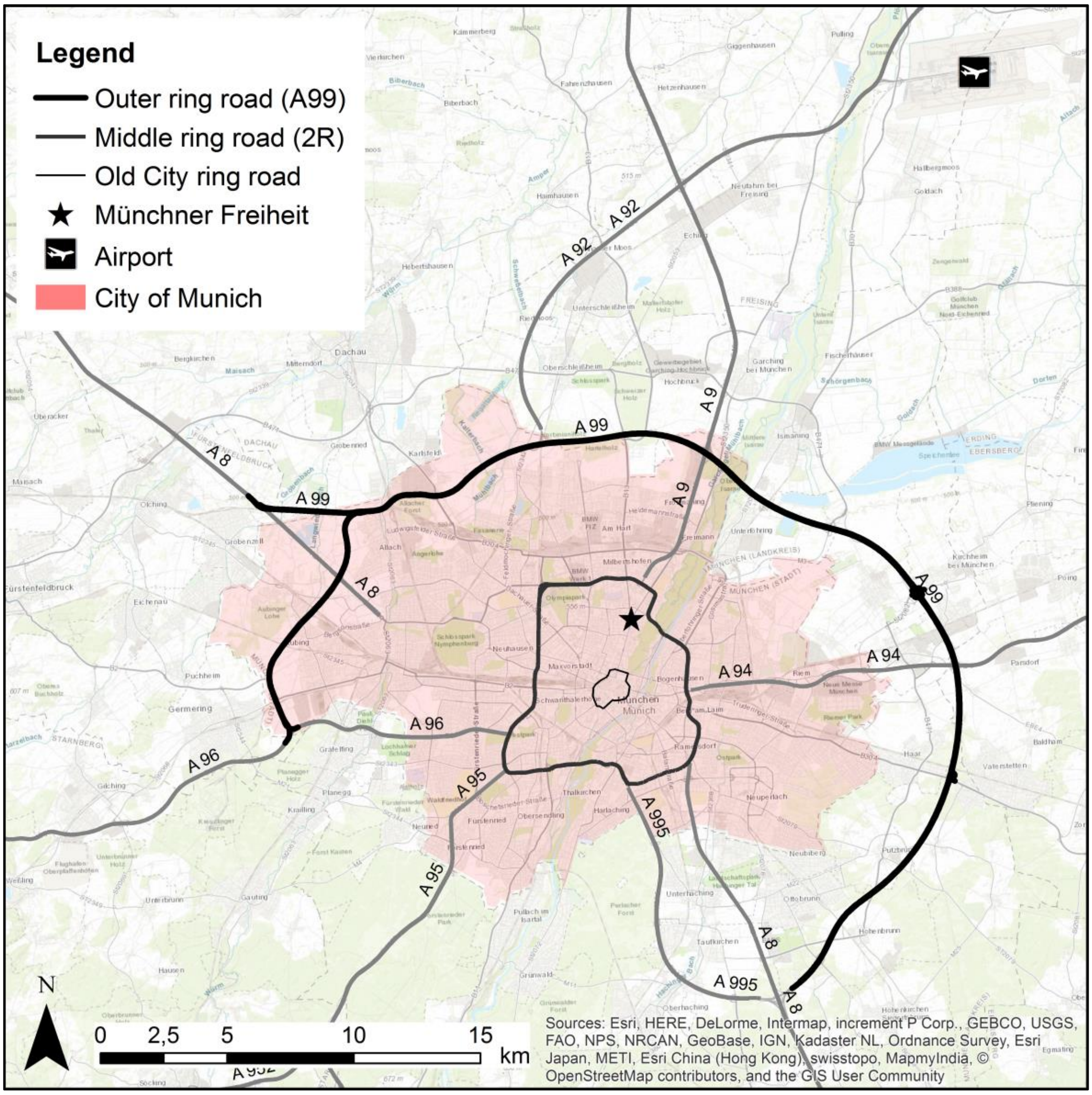


Image source: own elaboration

Figure 4.2: Road network in Munich and surroundings

The Middle Ring is one of the most heavily used roads in Munich, carrying up to 145,000 vehicles per day (Landeshauptstadt München, n.d.a). Other urban roads with speed limits of up to 50 km/h across the city serve as further axes connecting the ring roads and smaller streets. Of all the streets in Munich, 85% have a speed limit of 30 km/h, most of which are mainly in residential areas (Landeshauptstadt München, 2010).

Parking infrastructure

In Munich, there are 62 parking zones mainly located within the Middle Ring, comprising about 80,000 managed public parking spaces. Moreover, there are special parking regulations in the old city center (*Blue Zone*) and around the main railway station (Landeshauptstadt München, n.d.b)

In addition to the on-street managed parking spaces, there are other parking facilities for visitors, commuters, and residents including:

- 24 car parks with about 7,400 parking spaces,
- 8 neighborhood parking garages with about 1,100 parking spaces available for residents in the respective neighborhoods,
- 4 parking lots (*CityParken*) with about 1000 parking spaces, open for all car drivers.

The neighborhood garages and the four parking lots are managed by the municipal company *P+R Park and Ride Gmbh.*

4.1.2.2. Public transport network

The City of Munich is served by an extensive local and regional public transport network. The local public transport network consisting of metro, tram, and bus systems is operated by the municipal company *Münchner Verkehrsgesellschaft mbH* (MVG), while *DB Regio* operates the *S-Bahn* (suburban railway).

MVG and DB Regio are the two most important public transport providers in Munich and its region. The services of these and other companies are organized, coordinated, and integrated into a single tariff system managed by the Transport and Tariff Association, *Münchner Verkehrs- und Tarifverbund GmbH* (MVV). The MVV service area comprises about 5,530 km².

Suburban railway network

The City of Munich is well connected to the region through 434 km of suburban railway (MVV, 2015), transporting up to 840,000 passengers on workdays (Deutsche Bahn, 2017b).

Figure 4.3 shows the “S-Bahn” network in relation to the region and to the motorway ring road (the A99). As it can be observed, seven out of the eight commuter rail lines converge in the so-called “Stammstrecke” (trunk line) through the city center, while tangential connections between the lines in the periphery are missing.

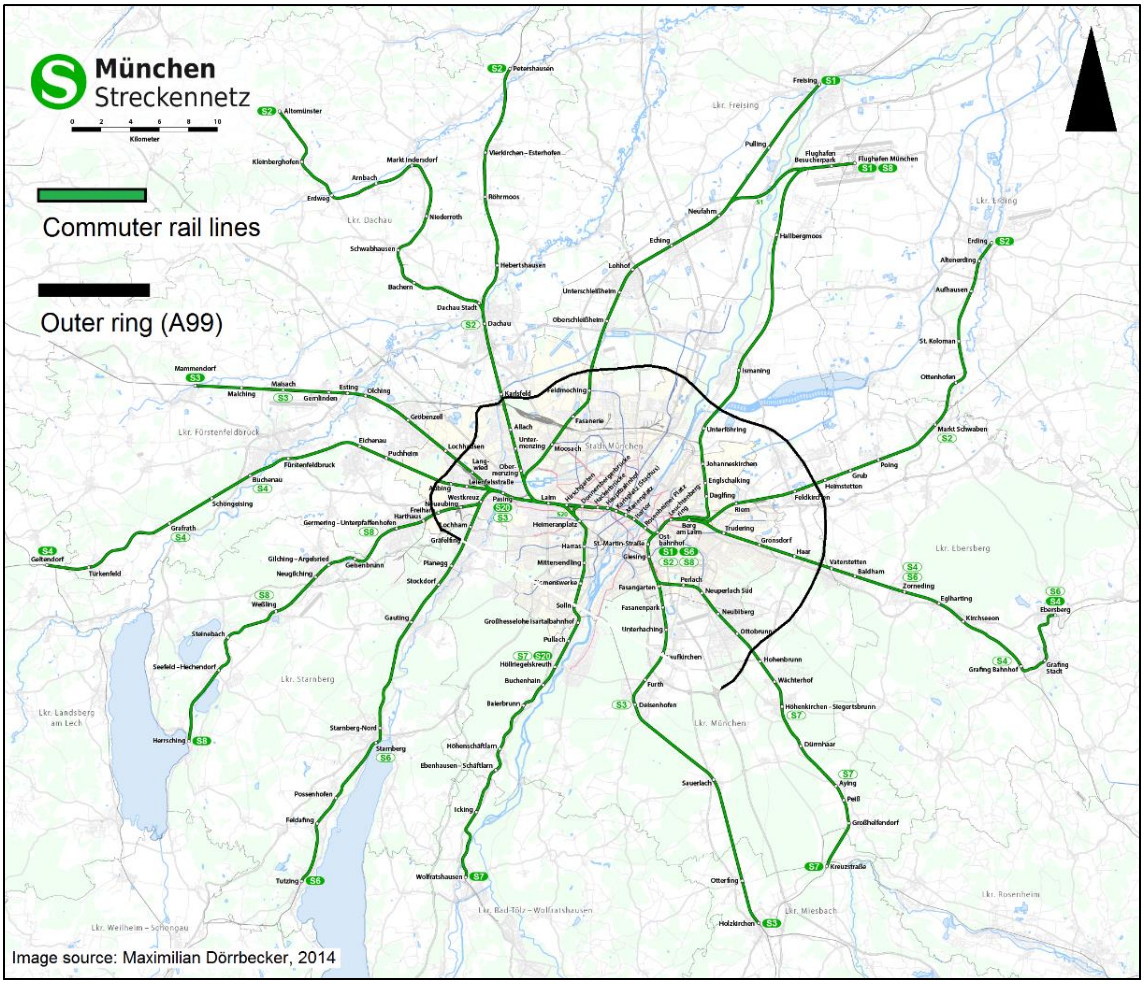


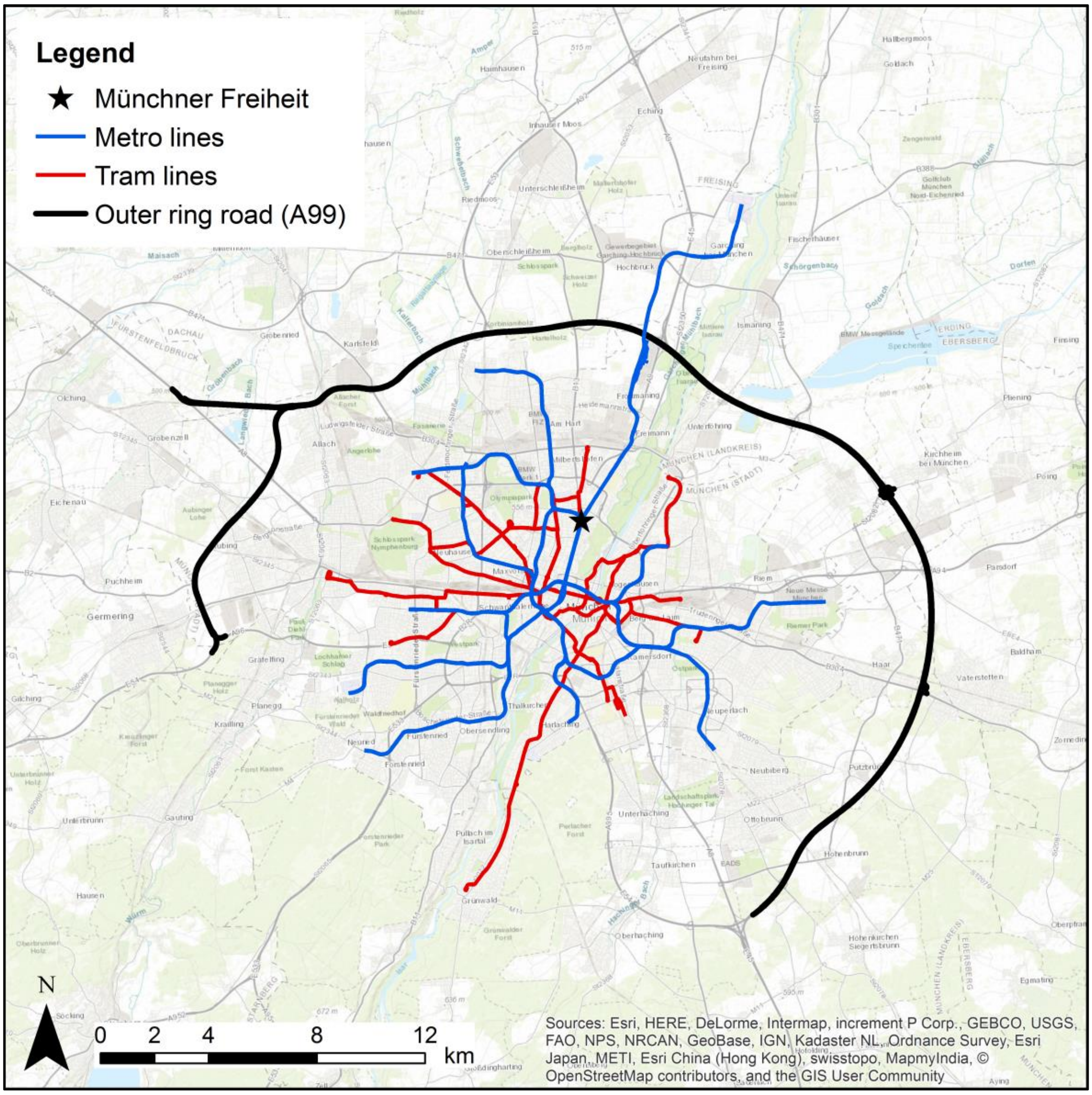
Image source: Dörrbecker (2014) (Adapted)

Figure 4.3: Commuter railway network connecting to Munich

Due to this network configuration, the number of trains passing through the trunk line is limited, and due to the steady growth in passenger numbers, the trunk line has already reached its maximum capacity. A second trunk line, now in construction, is expected to double the number of trains passing through the city and expected to be finished by 2026 (Deutsche Bahn, 2017c; 2017a).

Local public transport network

Within Munich, the urban public transport network consists of 95 km of subway, 82 km of tramway and 495 km of bus lines (Statistisches Amt München, 2017b). Around 1,200 stops and stations are located throughout the city, so that all homes are within 400 meters of a station of some sort (MVG, 2016). Figure 4.4 shows the metro and tram lines in Munich.



Source: own elaboration

Figure 4.4: Metro and tramway network in Munich

According to the public transport operator in Munich (MVG), the demand for public transport increased by 28% between 2004 and 2015, reaching a total of 566 million passengers per year (MVG, 2016). Due to the increased demand for public transport and the limited ability to increase the supply, among other factors, the system is currently operating over its capacity (Wortmann, 2017).

4.1.2.3. Cycling network

The cycling infrastructure in Munich consists of 1,200 kilometers of paths and lanes, 450 km of which follow roads with minimal and slow car traffic, 500 km of which are separate bicycle paths, and 260 km of which run through public parks and along country roads and pathways (Landeshauptstadt München, 2010).

Figure 4.5 shows the 14 main routes connecting the city center to the surroundings, as well as the inner and an outer cycling ring routes, which have a length of 15 and 48 kilometers, respectively.

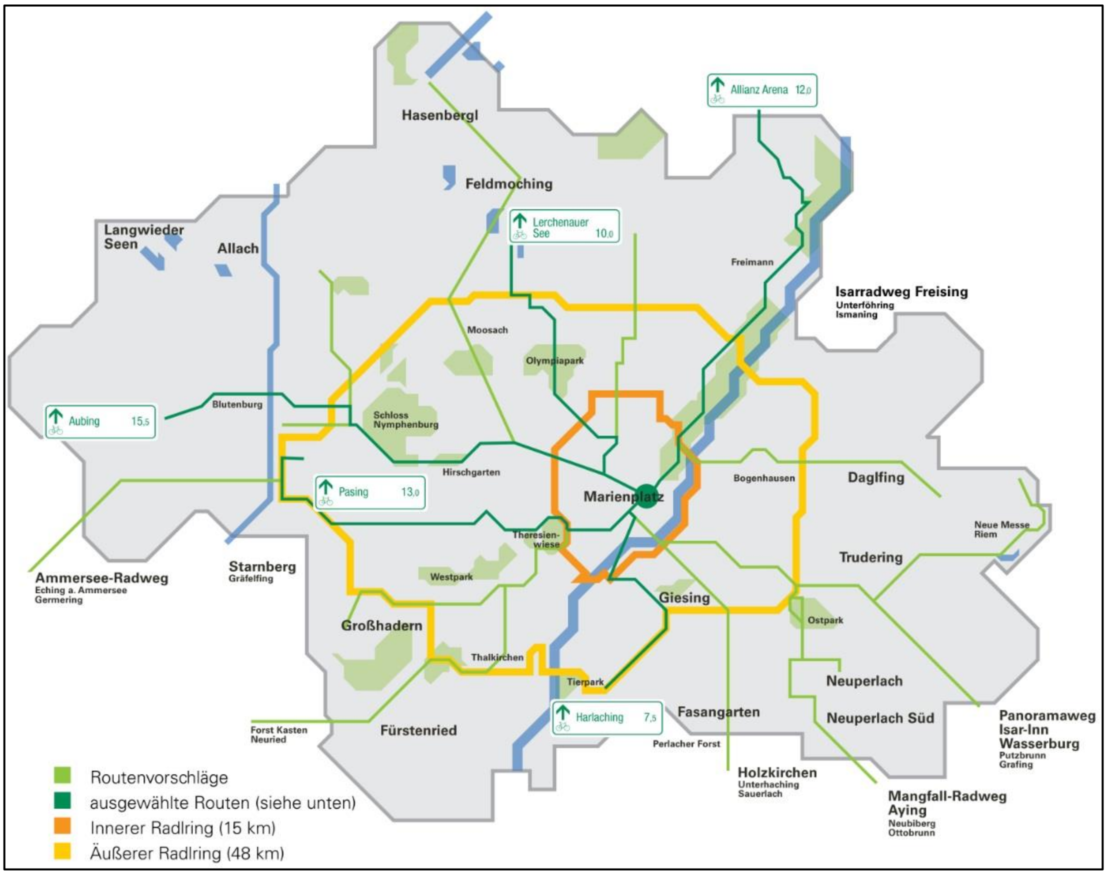


Image source: (Gscheid mobil, 2018)

Figure 4.5: Main cycling routes in Munich

Next to the main cycling routes and rings, there are about 60 *“Fahrradstraßen”* (cycling streets) where cyclists have priority over other modes of transport, and 380 one-way streets where cycling in the reverse direction of traffic (contra or counter flow cycling streets) is allowed (Gscheid mobil, 2018).

4.1.2.4. Intermodal infrastructure

Within Munich and its region there are various types of infrastructure which enable intermodal transport (transfers between different transport modes), including:

- 28,400 Park and Ride (P+R) parking spaces in the entire MVV service area, of which about the half are at 38 Park and Ride facilities managed by the municipal company *P+R Park & Ride GmbH*.[13]
- 55,800 Bike and Ride (B+R) spaces in the MVV service area, of which about the half are within the City of Munich.

In addition to the above-mentioned intermodal facilities, there are 52 „P+M“[14] areas near highway nodes with a total of 1,700 parking spaces across the MMR to support carpooling for commuters (IHK et al., 2012). According to a survey among users of these facilities, the main reasons for carpooling were reducing the costs of driving and environmental consciousness, while time savings were not relevant for the majority (Kreipl and Willfahrt, 2010).

4.1.3. Mobility figures

Modal split

According to the latest comprehensive mobility survey in Munich, in 2008 a total of 4.2 million trips per day were carried out and 44 million kilometers were traveled by 1.26 million inhabitants. In average every person performs 3.4 trips per day and the average trip distance is 12 km, while the average trips duration is 26 minutes. (infas, 2010)

Figure 4.6 presents the results on modal split obtained by this and other studies.

[13] The 38 P+R facilities are financed by the City of Munich and are specifically available for public transport users

[14] P+M stands for „Parken und Mitfahren“ which means „Park and Pool“.

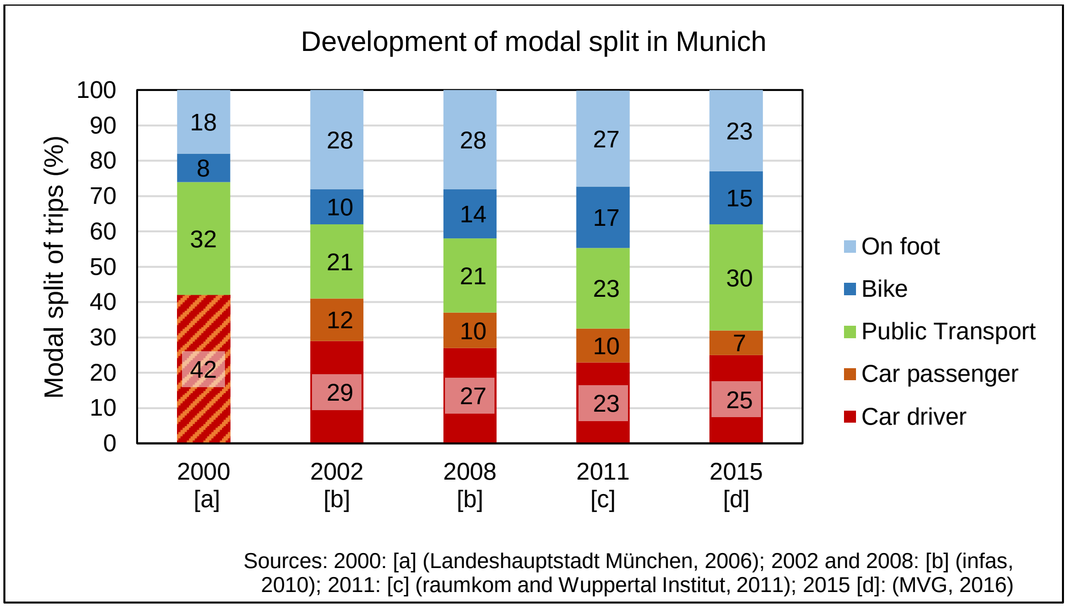


Figure 4.6: Development of modal split in Munich

Although the methodologies and data used to determine the modal split vary across studies, the results indicate that in the last couple of years the mode share of trips by public transport, cycling, and walking in sum have increased, while the share of trips by car has decreased.

Car ownership

The decrease in the share of trips by private car contrasts with the increasing amount of vehicles registered in the city. Actually, the number of cars registered in Munich has increased at rate higher than the population grew over the same period.

While the population in Munich increased by 15% between 2006 and 2016, the number of passenger cars[15] increased by 17% in the same period. As of December 2016, there were 701,131 passenger cars and 1,542,860 inhabitants registered to the City of Munich (Statistisches Amt München, 2017a), which resulted in an average motorization rate of 454 vehicles per 1000 inhabitants.

Figure 4.7 shows the development of the population, the fleet of passenger cars, and the resultant motorization rate between 2006 and 2016 in Munich.

[15] The number of passenger cars includes privately owned cars and those registered by companies (gewerblich).

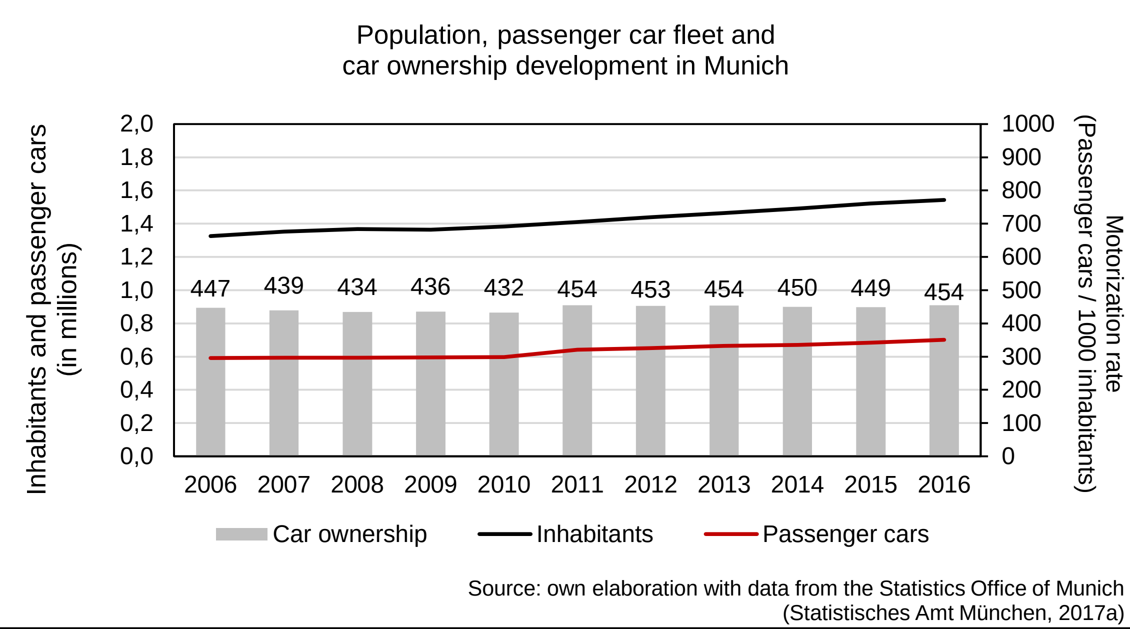


Figure 4.7: Development of population, passenger car fleet and car ownership in Munich between 2006 and 2016

The fact that the number of cars registered in Munich increased while the modal share of trips by car reduced could be an indication that, even though car traffic might be increasing (due to more cars), each car registered in the city is actually being used less often than in the past.

Thus, it is possible that the total Vehicle-Kilometers Traveled (VKT) of each car is reducing while the amount of time each car remains unused and parked is increasing. This is consistent with observations across Germany of the development in the number of cars (increasing) and the simultaneous change in vehicle kilometers traveled per car (decreasing) (Kickhöfer, 2018).

Public transport subscriptions and bicycle ownership

As of 2013, the share of Munich residents with a public transport pass was 43% (Landeshauptstadt München, 2013) and about 80% of the Munich population owned at least one functioning bike in 2008 (infas, 2010).

Although it is not possible to determine the effect of owning a public transport pass on mobility behavior, the public transport authority in Munich (MVV) suggests that the effect of holding a public transport pass is similar to owning a car: once a public transport pass is available, the use of the system increases (Landeshauptstadt München, 2013).

Freight transport

Last but not least, commercial transport contributes in great part to the overall motorized traffic in Munich. It is estimated that one third of the 2 million trips with motorized vehicles in Munich in 2010 corresponded to commercial transport. (BLSD, 2014; Landeshauptstadt München, 2014d)

Despite some improvements in the efficiency of commercial transport, traffic volumes of commercial transport have been increasing since 2002 and made up 38% of the total VKT in Munich in 2010. (Landeshauptstadt München, 2014d)

4.1.4. Transport-related challenges and strategic framework

The development of the modal split can be regarded as positive, considering the urban development goals of the city. However, the ever increasing number of inhabitants, vehicles, commuters, and commercial traffic cause a higher demand for transport and mobility. This exacerbates the negative effects of transport on the quality of life and requires additional efforts to counteract them. The following subsections present the most relevant transport-related challenges and the current strategic framework to cope with them.

4.1.4.1. Challenges

In recent years, two transport-related problems have mainly caught media attention: congestion (Völklein, 2011b; Harloff, 2018) and air pollution (BR, 2018; Hutter, 2017). These and other transport and mobility related challenges are presented below.

Congestion

Munich ranks as the most congested city in Germany, where drivers spend on average 49 hours per year in congestion, and average congested speeds are between 8 and 9 km/h (INRIX, 2017).

Congestion, however, exists in the public transport network as well. Due to the increasing number of passengers, the local and regional public transport network is operating over its capacity (Völklein, 2015). The suburban rail network is especially problematic, as its frequent disruptions affect the entire transport system (Krügel, 2018).

Parking pressure

The increasing amount of private vehicles registered in Munich, as well as those of commuters, causes increasing parking pressure within the city. According to a recent newspaper article, the 14,000 P+R spaces available in Munich are often full, which encourages many of the estimated 380,000 commuters to drive into the city (Schubert, 2018b)

The increasing parking pressure leads to more frequent illegal parking, which causes traffic problems, accidents, and hinders the quality of life in the city (Welte, 2016; Braatz, 2017).

Air pollution and greenhouse gases

Road transport is the main source of nitrogen dioxide (NO_2) emissions in Munich (StMUV, 2015), and in the last months, the possibility of banning diesel vehicles, considered to be the main source of NO_2 emissions, has been discussed (Schubert, 2018a).

In addition to local air pollution, the transport sector is a major source of greenhouse gas emissions, a leading cause of global climate change. In Munich, the transport sector accounts for about 20% of total CO_2 emissions in the city (Landeshauptstadt München, 2012; Kenkmann et al., 2017).

Traffic safety

Despite numerous efforts to improve traffic safety in Munich and its surroundings, the number of traffic injuries and fatalities is still high. In 2016, there were over 54,000 traffic accidents yielding 7,634 injured persons, of which 691 were severely injured, and 19 died (Polizeipräsidium München, 2017). One year later, the number of injured reduced slightly to 7,276, but the number of severely injured increased to 760 (11.3% more than in 2016) and the number of deaths also increased to 27 (42% more than in 2016) (Polizeipräsidium München, 2018).

Housing costs

Last but not least, the steady population growth in Munich and its region over the last decades has placed significant pressure on the real estate market, especially within the City of Munich (Büttner, 2016).

With rising costs for renting and owning a home in Munich, in combination with relatively affordable fuel prices, it is becoming increasingly popular for many households to locate themselves in more remote areas with more affordable housing costs (Büttner, 2016; Thierstein et al., 2016).

This has consequently led to longer travel distances and a higher dependency on private vehicles for mobility, which then in turn again contributes to the above mentioned problems.

4.1.4.2. Strategic framework

The increasing transport demand in Munich and the MMR has created diverse transport-related challenges which require interdisciplinary, cross-sectoral and regional cooperation. In Munich, various plans and exchange platforms between organizations and local governments provide a strategic framework for the implementation of transport related measures.

Transport Development Plan

The Transport Development Plan (TDP) of Munich published in 2006 forecast a growth in population and workplaces in Munich and its surroundings, as well as the corresponding transport demand through 2015 (Landeshauptstadt München, 2006).

In line with the long-term framework for orientation and development “PERSPECTIVE MUNICH”, specifically Principle 7: To maintain and improve mobility for all road and transport system users and manage traffic and transportation to the benefit of the city, the TDP presented a strategic concept consisting of various measures aimed at three main goals (Landeshauptstadt München, 2006). Table 4.1 summarizes these goals and some of the measures included in the TDP.

The goals and measures of the TDP were set in line with other regional and urban development plans with the aim of reducing the negative impacts of transport such as air pollutant and greenhouse gas emissions, noise, land consumption, and the corresponding consumption of social, ecological, and economic resources. In addition, the TDP focuses specifically on barrier-free and gender equity aspects. (Landeshauptstadt München, 2006).

Table 4.1: The three main goals of the Transport Development Plan and corresponding measures

Goal	Measures
1. **To reduce traffic**: all measures oriented to avoiding traffic and shifting it to environmentally friendly modes have the highest priority. The share of trips by foot, bike and public transport should rise.	• A parking management scheme oriented to reduce car traffic and to shift traffic to environmentally friendly modes of transport. • A car parking routing system to reduce the time and resources needed to search for parking.
2. **To shift traffic**: through the extension of public transport, individual motorized transport shall give more space to freight transport that cannot be shifted to other modes. Through various measures, the conditions for freight transport shall be improved.	• Extension and improvement of the public transport network and services in line with a dedicated Public Transport Plan (*Nahverkehrsplan*); • Extension of P+R and B+R infrastructure to support intermodal trips to this mode of transport; • Various measures to increase cycling as part of a dedicated Transport Development Plan for Cycling approved in 2002. • Improvement of the quality of walking infrastructure and public spaces as part of the Inner City Concept (*Innenstadt Konzept*). • Implementation of mobility management program aimed at informing citizens about alternatives to private car.
3. **To manage traffic**: the remaining motorized transport that cannot be avoided or shifted should be organized in a sustainable way through the use of telematics.	• Extension and improvement of the road network to ensure an optimal performance of the highway system. • Traffic management measures. • Measures to optimize freight transport.
Source: own classification based on the Transport Development Plan (Landeshauptstadt München, 2006)	

Other plans with transport-related measures

Other plans with transport-related measures are the Local Public Transport Plan (Nahverkehrsplan); Transport Development Plan for Cycling (Radverkehrsplan), and the Inner City Development Plan (Innenstadtkonzept).

In addition to the TDP, the local Air Quality Plan and Climate Protection Plan include various measures to reduce transport-related impacts on the environment, especially pollutant and greenhouse gases. (Landeshauptstadt München, 2012; StMUV, 2015).

Barriers to implementation

Due to political reasons, as of today most plans and programs are outdated, either because their development took a very long time, their goals were not ambitious enough, and/or because many of the included measures were not consequently implemented. Furthermore, in 2014 the political situation changed reinforcing this trend. In the current political circumstances in Munich, informal processes and communication have become more relevant for the implementation of measures aimed to solve traffic problems.

Drivers for implementation: exchange and cooperation platforms

Beyond the local authorities, there are two relevant platforms in Munich supporting the development and implementation of sustainable transport and mobility measures within the city and its region: the so-called *Inzell Initiative* and the *Europäische Metropol Region München* (EMM).

These platforms have contributed to the implementation of relevant measures such as the parking management scheme, public transport acceleration, mobility management, and an integrated concept for the promotion of electric mobility (IHFEM), among others, by facilitating the communication between relevant stakeholders, providing scientific studies, and implementing pilot projects which helps to facilitate political decisions.

Other measures such as the mobility management program ‘Gscheid mobil’, and the cycling campaign *‘Radlhauptstadt’* have been implemented in the last couple of years to promote using other modes of transport instead of private cars (MVG, 2016; raumkom and Wuppertal Institut, 2011).

The relative good quality of the infrastructure and services and the measures oriented towards reducing car traffic, shifting trips to ecomobility options, and improving traffic conditions might have contributed to increase the share of trips by public transport and non-motorized modes (see Section 4.1.3). Nevertheless, the ever increasing mobility demand requires additional efforts.

Modellstadt 2030

In 2017, the Inzell-Initiative started a discussion about the mobility challenges in Munich indicating that without a “courageous bundle of measures” the quality of life and mobility in the city will reduce significantly. The first due to a higher presence of vehicles and emission problems and the second due to continuous congestion and increasing parking search traffic. As a consequence, the attractiveness of Munich as a business location is expected to reduce as well. (Inzell Initiative, 2017)

It is estimated that in order to maintain the quality of life and mobility in Munich, the development of public transport and cycling should double by 2030, while only 10% of this necessary development is currently considered realistic (Inzell Initiative, 2017). With this in mind, the Inzell Initiative proposes the following bundle of push and pull measures in the framework of a project initiative called *Modellstadt 2030* (model city 2030) with the overall goal to improve the quality of life and the quality of mobility:

1. Pull measures (improvements to the supply) with:
   - shared mobility: flexible bus lines, car/ride/bike sharing, ride pooling;
   - electrification of all types of vehicles,
   - connectivity with assistance systems, and
   - self-driving vehicles.
2. Push measures (political and regulatory framework):
   - special lanes with minimum vehicle occupancy
   - adaptation of the legal framework.

The next section presents why and how shared mobility services, and their integration in multimodal approaches in Munich, represent an opportunity to improve the quality of mobility and the quality of life, as the Inzell Initiative aims through the above mentioned project initiative.

4.2. Shared mobility services and integration approaches in Munich

Over the last years, global, regional, and local trends have laid the foundations for the development of shared mobility services and their acceptance. This in turn facilitates multimodal mobility and calls for new approaches for meaningful integration into the wider transportation system.

As presented in Section 4.1, Munich as many other cities, is experiencing a rapid population growth, but there is limited space to accommodate the corresponding increasing traffic volumes. Limited space and increasing costs for mobility and housing call for new approaches to deal with the transport related challenges mentioned above.

At the same time, gradual changes in the consumption culture towards *more using* and *less owning*, a phenomenon related to the so-called sharing economy, supported by internet platforms and smartphone applications make the use of many different modes of transport easier and more attractive.

In addition, advanced Information and Communication Technologies (ICT), innovations in vehicle technology, and new business strategies are bringing new mobility options to the market. These technological and societal developments, together with an adaptive legal framework are facilitating further multimodal mobility behavior in Munich.

The need for a better utilization of space and of the transport system calls for new approaches and instruments to support further this multimodal behavior. This is where mobility stations, as one of various instruments for the integration of mobility services, come into play.

Figure 4.8 demonstrates the trends supporting multimodality and thus the development of mobility stations.

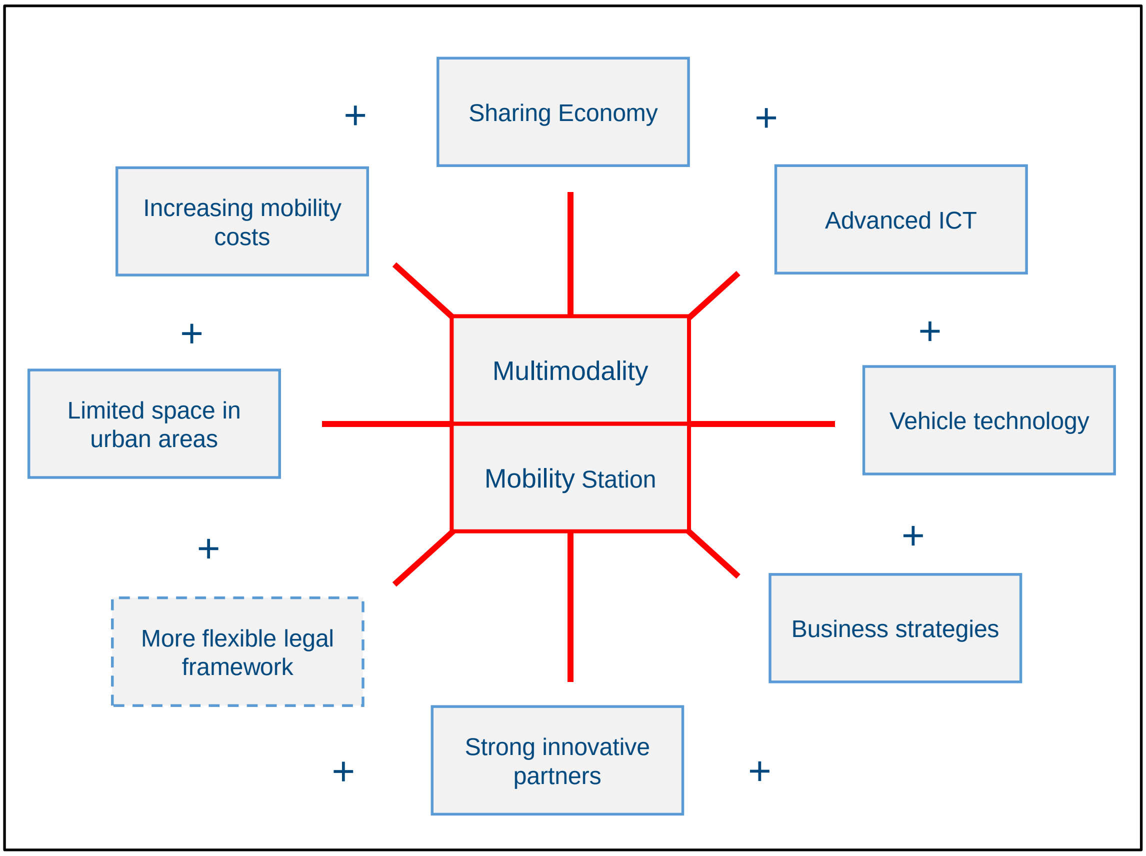


Image source: Martin Schreiner

Figure 4.8: Trends supporting multimodal mobility and mobility stations

The following sub-sections present the development of shared mobility services in Munich, the current legal framework, the status quo, and integration instruments including mobility stations.

4.2.1. Development of shared mobility services

The first documented shared mobility service in Munich is the station-based carsharing service provided by *STATTAUTO*, founded in 1992 (STATTAUTO München, n.d.b). It took almost a decade until *Deutsche Bahn* (German Railways) started to operate the bikesharing system *Call-a-bike,* and some more years to start their carsharing service *Flinkster*.

In the following years, new shared mobility services started to operate in Munich. Some have remained until today but some have retired from the market. Table 4.2 summarizes the dynamic development of shared mobility services in Munich.

Table 4.2: Development of shared-mobility services in Munich

Date	**Start / end of shared mobility services**
April 1992	*STATTAUTO*, a SBCS service, was founded in April 1992 and by 1994 had 600 users, 30 vehicles and 14 stations. (STATTAUTO München, n.d.b)
April 2000	In April 2000 *Call a Bike*, a free-floating bikesharing service, started operations in Munich and gained 27,000 users within few months. In October 2001, Deutsche Bahn (German Railways) bought the system and continued the operation. (Sassen, 2009)
2009	*Flinkster*, a carsharing service provided by Deutsche Bahn started operations in Munich. (team red, 2015)
April 2011	*ZebraMobil*, a ZBCS system began operating in Munich. (ZebraMobil, 2013)
June 2011	*Nextbike*, a station-based bikesharing system (without docks) started operations in Munich with 300 shared bikes. (Völklein, 2011a)
June 2011	A joint venture of BMW and the car rental company Sixt introduced the first free-floating carsharing service in Munich *DriveNow* with 300 vehicles. (Kuntz, 2011)
June 2013	*car2go*, another free-floating carsharing provider started operations in Munich with 300 vehicles. (Carsharing News, 2013)
June 2013	*ZebraMobil*, which had grown to a fleet of 70 vehicles, retired from the market. (ZebraMobil, 2013)
July 2013	Another ZBCS provider, *Citeecar*, started operations in Munich. (Völklein, 2013; Elias, 2015)
November 2014	*scoo.me*, the first scooter sharing provider in Munich, started operations. (Hüsing, 2014)
October 2015	The Public Transport Operator (MVG) launched its own bikesharing system *MVG Rad* with about 1200 bikes and 24 stations of 125 planned, operated by *Nextbike* (SWM, 2015) replacing the bikesharing system provided before by the latter.
December 2015	*CiteeCar*, which had grown to a fleet of around 144 cars, applied for insolvency and went out of business at the beginning of 2016. (Carsharing News, 2015)
February 2016	STATTAUTO launched a pilot project of a ZBCS service called *STATTAUTO Flexy*. (STATTAUTO München, n.d.a)
August 2017	*Emmy* started to operate a fleet of 50 shared electric scooters. (Green City, 2017)
August 2017	In August 2017 *oBike*, a Singapore-based company, started a free-floating bikesharing service in Munich with 350 bikes and grew rapidly to 7000 within a month.(Schubert, 2017a)
August 2017	BeeZero, a ZBCS starts operations in Munich with 50 hydrogen-powered vehicles. (dpa, 2016)
March 2018	BeeZero announced its retirement by July 2018 from the market due to economic unfeasibility. (BeeZero, 2018)
March 2018	A new ZBCS provider, Oply, joins the market with 100 vehicles. (Zick, 2018)
April 2018	scoo.me retires from the market due to economic unfeasibility. (Weimer, 2018)

4.2.2. Regulatory framework for shared mobility services

Before July 2017, reserving carsharing spaces on public ground for carsharing vehicles in Germany was only possible through a special permit (Sondernutzungserlaubnis). In 2017, the “Carsharing law” entered into force in Germany providing a legal framework to allow carsharing vehicles parking on public space. (Bundesministerium der Justiz und für Verbraucherschutz, 2017).

Until 2009, German cities strictly monitored the implementation of bikesharing systems. In March 2009, however, the City of Hamburg lost a lawsuit against the company Nextbike, which tried to forbid the company from operating in the city. Since then, open space has been open to bikesharing providers. (Fischer, 2018; Abendblatt, 2009)

While bikesharing and scooter sharing can be implemented without major restrictions in Munich, free-floating and zone-based carsharing systems are required to pay a fee to the city for the use of public parking spaces, and there used to be a limit on the amount of vehicles that can be offered.

The fee for each FFCS vehicle was €1,800 per year and €240 per year for each ZBCS vehicle until March 31, 2016. Moreover, there was a supply limit of 300 FFCS vehicles per provider (Landeshauptstadt München, 2015a).

Due to the positive results of the Carsharing Evaluation in Munich (EVA-MS) carried out between 2013 and 2014 (see Section 3.3.1.2), the city council removed the limit on the number of vehicles and permits, and approved a reduction of the fees by half: €900 per year for each FFCS vehicle up to 600 vehicles (every further vehicle is exempted from the fee), and 120€ per year for each ZBCS vehicle (Landeshauptstadt München, 2015a; 2015a).

The regulatory framework for carsharing keeps developing as new providers enter the market, further political initiatives create pressure, and new scientific results, as those from this work, become available. This is the reason why the administration of the City of Munich currently plans to present a new resolution in 2018 to the City Council for further integrated development of all aspects of sharing mobility in Munich.

4.2.3. Shared mobility services - status quo

As of today, there are more than 13 providers of shared mobility services in Munich, including carsharing, bikesharing, and scooter sharing. Table 4.3 provides an overview of the main shared mobility services available in Munich, and key figures of these businesses.

Table 4.3: Existing shared mobility services in Munich and key figures

Type of shared mobility service	Commercial name	Start of operation	Number of vehicles / zones / stations	Source
Station-based carsharing	STATTAUTO	April 1992	450 in 115 stations	(MVG, 2017)
	Stadtteilauto	n.a.	30 vehicles in 6 stations	(not available)
	Drive-CarSharing	n.a.	40 vehicles in 8 stations	(MVG, 2017)
Zone-based carsharing	Flinkster	2009	130 in 56 parking zones	(Flinkster, 2018)
	STATTAUTO Flexy	September 2016	17 in 13 parking zones	(MVG, 2017; STATTAUTO München, n.d.a)
	Beezero	August 2016	50 in 15 parking zones	(MVG, 2017)
	Oply	March 2018	100 in 36 parking zones	(Zick, 2018; Oply, 2018)
Free-floating carsharing	DriveNow	June 2011	819 (85 electric)	(Landeshauptstadt München, 2016)
	car2go	June 2013	515	(Landeshauptstadt München, 2016)
Free-floating Bikesharing	Call a Bike	April 2000	1400	(Schubert, 2017b)
	OBike	August 2017	7000	(Schubert, 2017a)
Hybrid bikesharing (free-floating and docking stations)	MVG Rad	October 2015	1200 bikes in 118 stations	(Schubert, 2017b; MVG, n.d.)
Scooter sharing (free-floating)	emmy	August 2017	50 electric scooters	(Green City, 2017)

In addition to the eight carsharing providers, there are four private (peer-to-peer) carsharing platforms, namely *Croove, HoppyGo, DRIVY,* and *Snappca*r offering a wide variety of private vehicles for rent.

Furthermore, ridesourcing services such as *Uber and Clevershuttle* are also available in Munich. Finally, in Munich there are more than 100 taxi stands and about 3,500 taxis in operation.

Due to the wide variety of shared mobility services in Munich, the city was considered the “capital of sharing” in Germany in a benchmarking study regarding the status quo of the digitalization of mobility in 25 cities (PWC and DLR, 2017).

The following subsections present further details about the main shared mobility services in Munich.

4.2.3.1. Carsharing

Station-based carsharing

As of today there are three main SBCS providers offering more than 500 vehicles of different categories in about 130 stations.

STATTAUTO München is the largest SBCS provider in Munich with a fleet of 450 vehicles distributed across 115 stations, of which 113 are located on private ground (mainly underground parking garages) and the other two are located on public ground. Other providers have smaller fleets of 40 vehicles or less in correspondingly a smaller amount of stations (see Table 4.3).

All station-based carsharing (SBCS) services in Munich are roundtrip. That means that all vehicles have an assigned parking space and they must be returned to the same station where they were rented out.

Figure 4.9 shows the STATTAUTO stations distributed all over the city of Munich.

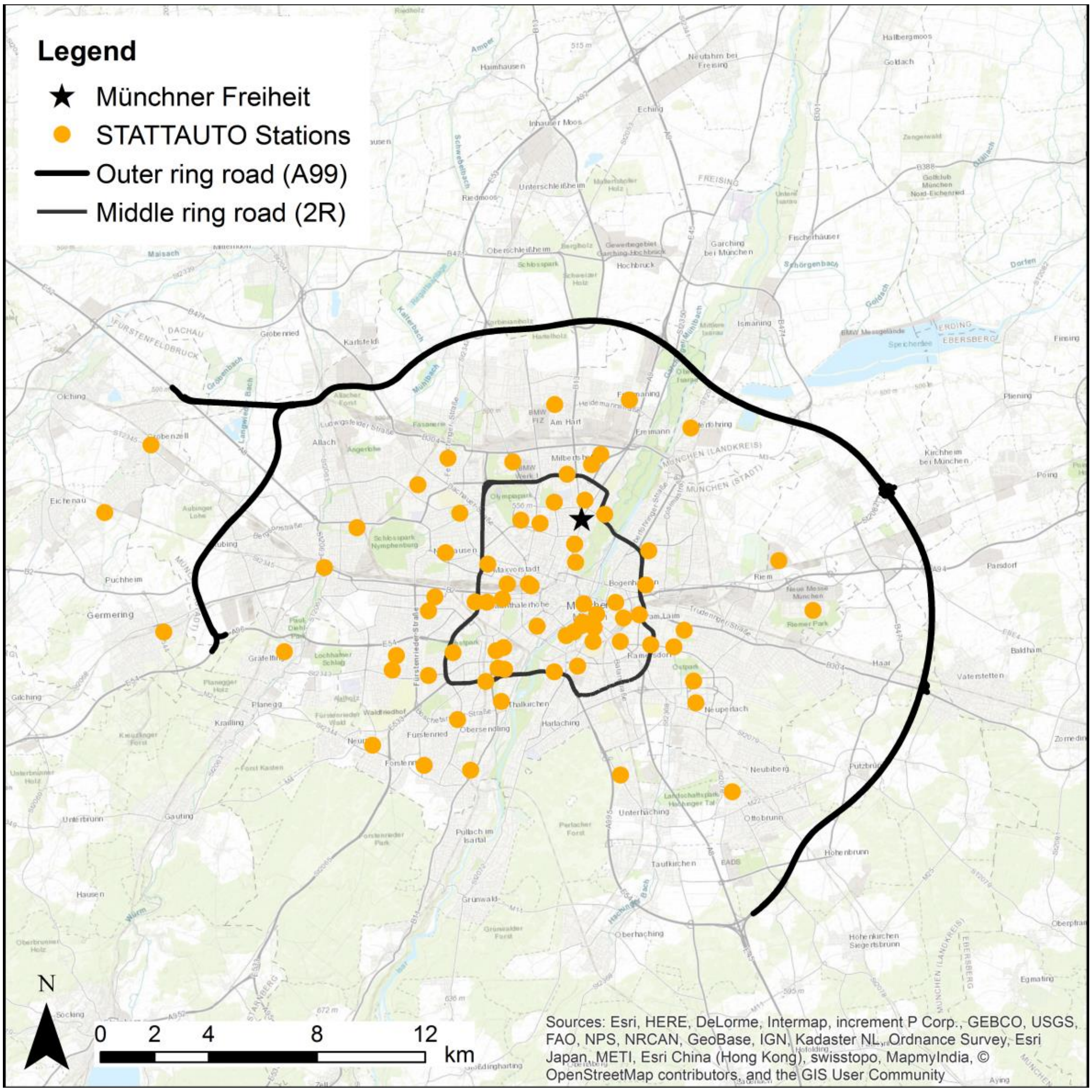


Image source: own elaboration

Figure 4.9: Location of STATTAUTO Stations in Munich

Zone-based carsharing

Another form of carsharing in Munich is the so-called “teilflexibel” or zone-based carsharing (ZBCS). The main difference to SBCS, is that ZBCS vehicles are mainly located on public space and they belong to parking zones instead of private parking garages. Thus, the cars are relatively more visible than SBCS vehicles as they are located directly on the street. However, ZBCS vehicles don’t have a guaranteed parking space and users have to look for the vehicles within the zone any time they want to use them, and later search for a parking space to return them to.

Currently there are three providers of ZBCS in Munich with a total fleet of about 300 vehicles (See Table 4.3) and most of the parking zones in which ZBCS operates are located within the Middle Ring.

Free-floating carsharing

With the roll out of *DriveNow* and *car2go* in 2011 and 2013 respectively, free-floating carsharing (FFCS) services were introduced to Munich. As of today both providers offer more than 1000 vehicles, of which 85 (those of DriveNow) are electric. Both FFCS providers have similar business models and share similar service areas (in the extended downtown area and Munich airport). Figure 4.10 below shows the service areas of both FFCS providers.

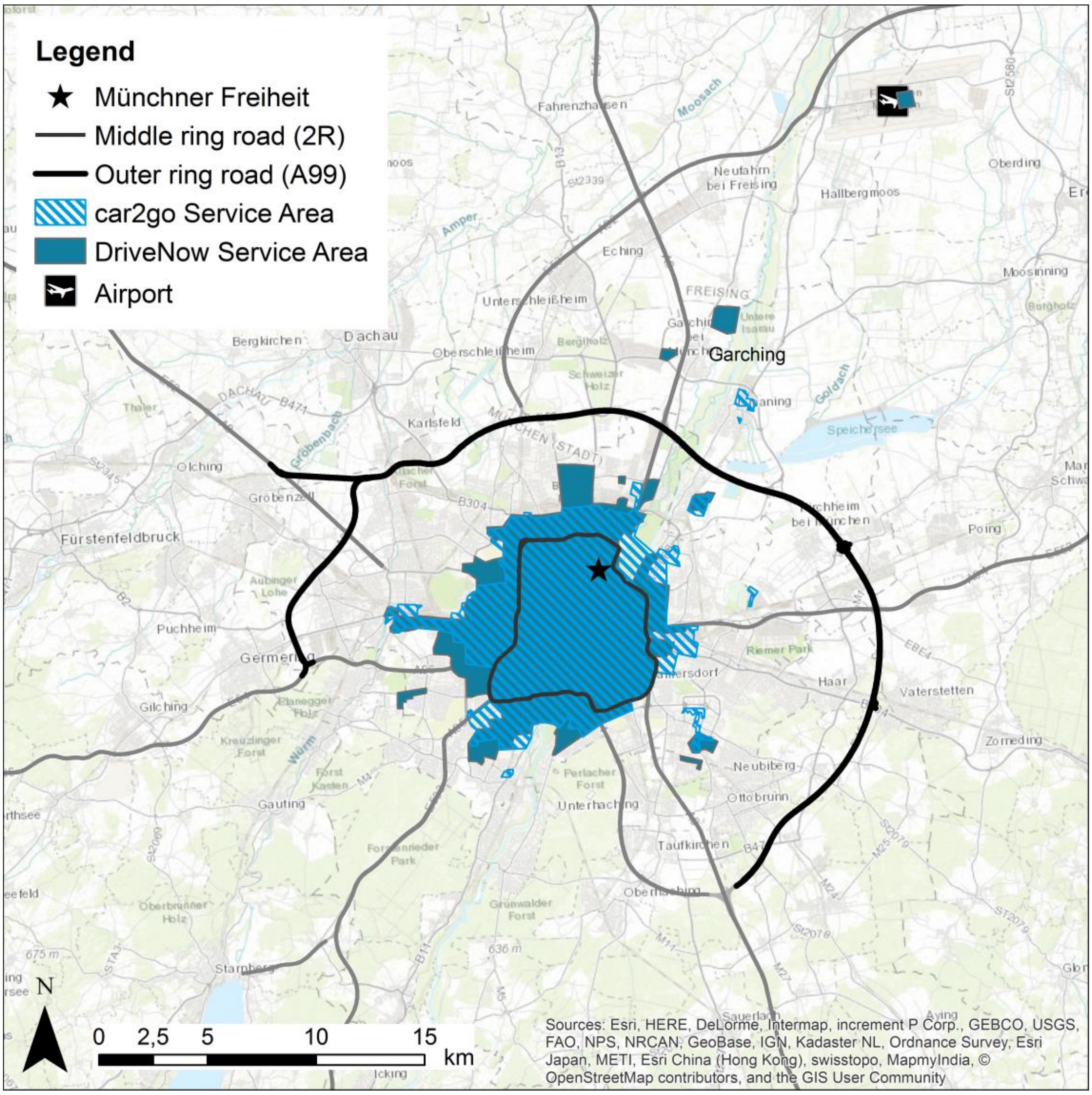


Image source: own elaboration

Figure 4.10: Service areas of free-floating carsharing providers in Munich

In contrast to SBCS and ZBCS, FFCS vehicles are neither station-bound, nor zone-bound, allowing one-way trips within a service area. While it is possible to leave the service area, the vehicles must be returned to it in order to end the rental.

4.2.3.2. Bikesharing

As of September 2017, there were three main bikesharing providers operating in Munich with a total fleet of about 10,000 bikes (see Table 4.3).

Call a Bike is a free-floating system, which means that it is possible to pick-up and drop-off bikes in publicly accessible places within a service area. It offers about 1400 bikes, which are available most of the year to users except for the winter months when they are taken off the streets to be repaired for the next season. The service area is delimited by the Middle Ring.

Since October 2015, the public transport operator (MVG) has provided its own bikesharing system, *MVG Rad*. It is a hybrid service, which means that it operates as a free-floating service, but it is also possible to take them off and put them back in docking stations. A ten-minute incentive to the user’s account is provided when the bikes are returned at a station. It offers about 1200 bikes and 118 stations within a service area beyond the Middle Ring.

Figure 4.11 shows the service area of Call a Bike and MVG Rad.

oBike is a free-floating bikesharing system offered by a Singapore-based company. It started operations in Munich in August 2017 with 350 bikes and grew rapidly to 7000 within a month. Although a service area is not clearly defined, the bikes are spread all over the city, way beyond the service areas of MVG Rad and Call-a-bike.

The rapid growth of the oBike fleet has caused irritation in Munich due to the sudden placement of bicycles on public space and the oBikes have been subject of vandalism (Schubert, 2017a). Although the manager of the company has promised to change the situation, the future of oBike in the city is unclear.

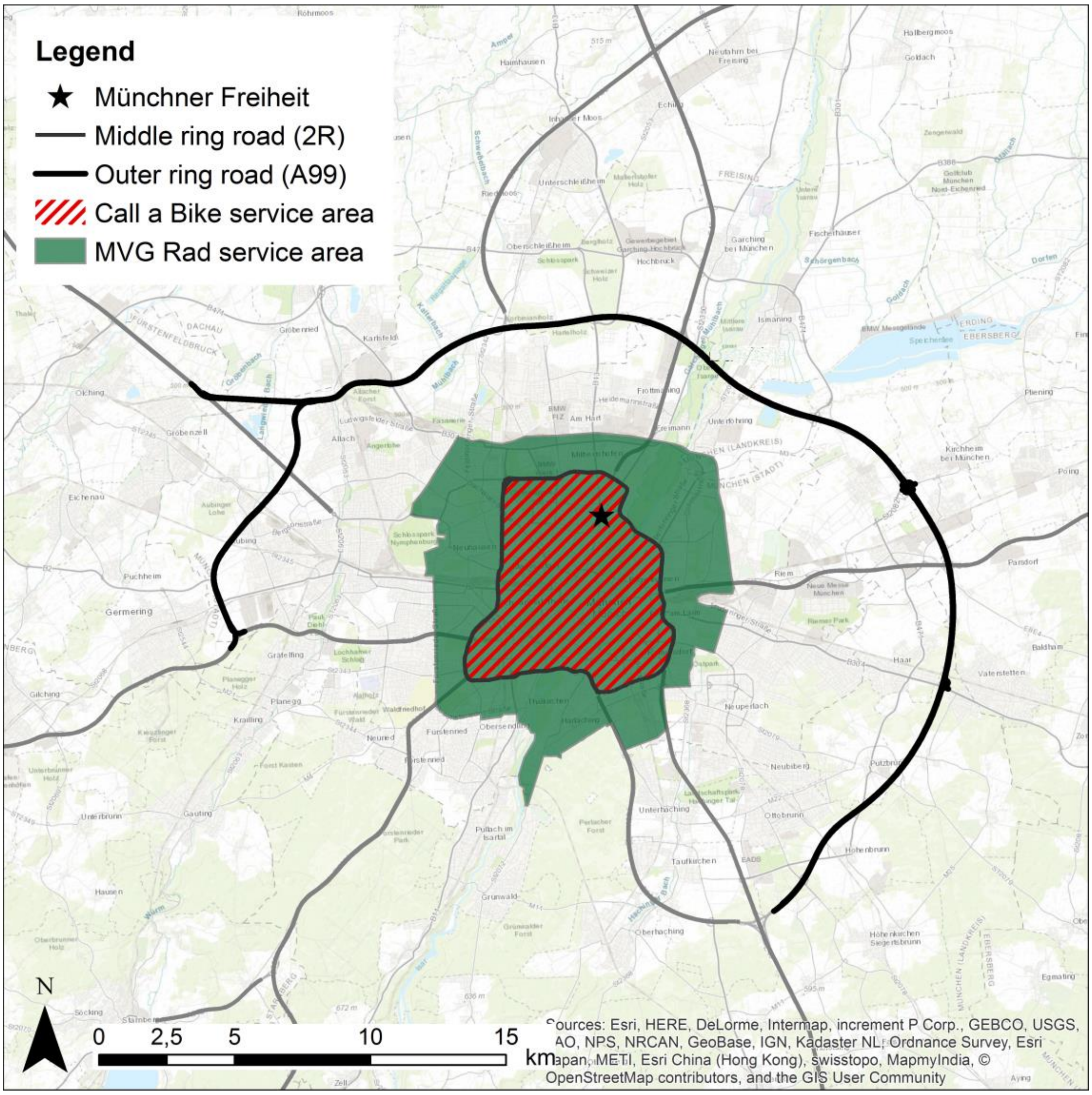


Image source: own elaboration

Figure 4.11: Service areas of two bikesharing providers in Munich

4.2.3.3. Scooter sharing

Similar to carsharing, scooter sharing consists of a shared fleet of scooters. In Munich, there is only one scooter sharing provider, *emmy,* (after *scoo.me* retired from the market in March 2018) offering 50 electric scooters powered with renewable energy. *emmy* operates as a free-floating system within main service area inside the Middle Ring and other smaller areas.

Compared to carsharing and bikesharing services, scooter sharing in Munich has a much smaller fleet and is not integrated at all with public transport services.

4.2.4. Integration of shared mobility services and local public transport

As presented before, the City of Munich has an extensive road, public transport, and cycling network as well as infrastructure to support intermodal changes between different transport modes, such as P+R and B+R facilities.

With the rise of shared mobility services, especially since 2011 when two new carsharing providers started operations in Munich, the need for better integration has become more important in the transport policy field.

Some of the shared mobility services presented above are integrated with the local public transport through information platforms and cooperation agreements. In the following section, the current forms of integration between the local public transport and shared mobility services is presented.

4.2.4.1. Integrated information

The website *MVG multimobil* provides integrated information about various shared mobility services, including:

- location of public transport stations and departure times of buses, trams and metro services;
- real time location of MVG Rad bikes and number of available bikes at MVG Rad stations.
- real time location of FFCS (car2go and DriveNow) and ZBCS (Flexy and BeeZero) vehicles, type of vehicle, fuel tank level, link for registration, one-time login option to reserve vehicles;
- service areas of MVG Rad, FFCS and ZBCS services, as well as the location of SBCS stations and a link to further information about the latter.
- location and availability of charging stations for electric vehicles.

Figure 4.12 shows an example of the information provided by MVG Multimobil.

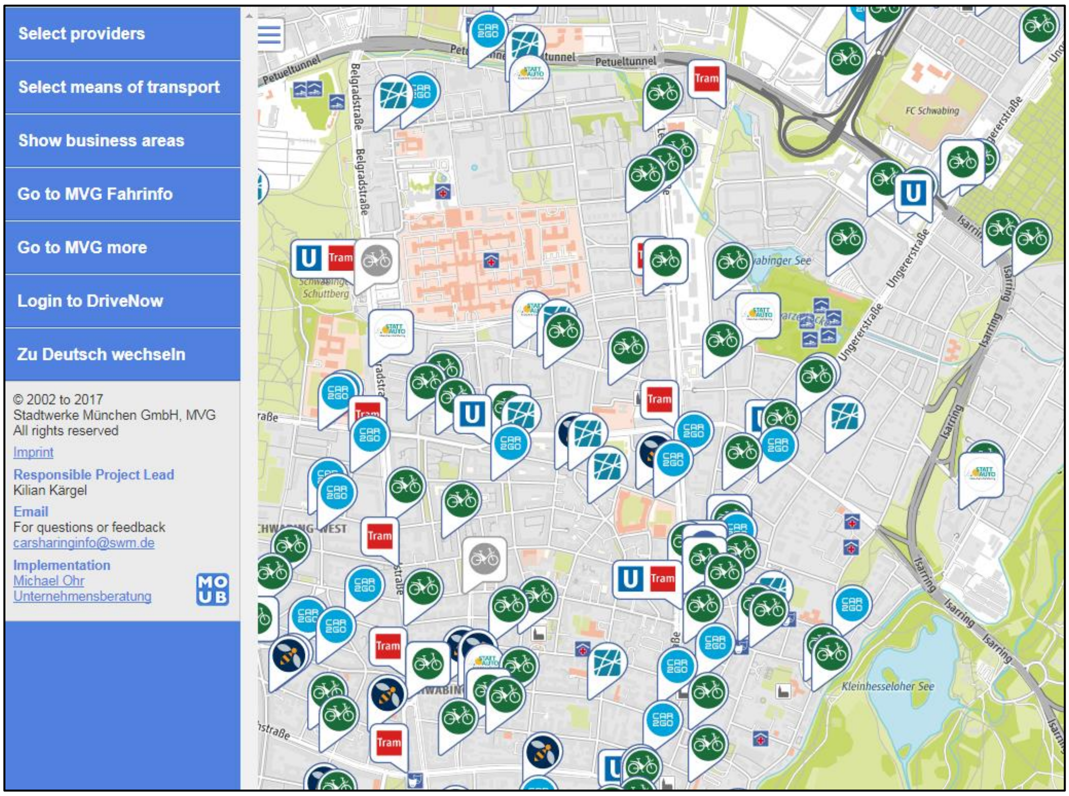


Image source: https://carsharing.mvg-mobil.de/

Figure 4.12: Screenshot of the MVG multimobil website displaying the location of available shared mobility services

In addition, the smartphone application *MVG More* provides similar information and functions as the *MVG multimobil* website, while it also enables renting MVG Rad bikes and reserving carsharing vehicles and charging stations.

Other shared mobility services such as *Flinkster*, *Call a Bike*, and the scooter sharing provider *emmy* are not integrated in this platform.

The *MVG Info* app serves as a trip planner for public transport services and online ticket booking. MVV and Deutsche Bahn offer their own applications which serve as trip planners for public transport and online ticket shops as well. All of these trip planners enable planning trips with different modes of public transport (suburban rail, metro, tram and bus), but do not include shared mobility services.

At a more general level, the website of the local mobility management program "Gscheid mobil" provides additional information not only about shared mobility services and public transport, but also about private modes including walking, cycling, and parking.

4.2.4.2. Tariff integration

The public transport operator (MVG) cooperates with almost all carsharing providers in Munich. Holders of a yearly public transport pass (IsarCard Abo) are entitled to a registration with various carsharing providers free of cost (or a 50% discount), and starting credit for FFCS. For an overview on tariff conditions and special discounts for public transport pass holders (see MVG, 2017).

MVG Public transport subscribers are also entitled to reduced annual fees and usage rates for MVG Rad. However, there are no tariff discounts on the use of other bikesharing systems, nor on the use of scooter sharing. Discounts for carsharing users on bikesharing or vice versa do not exist either.

4.2.4.3. Organizational integration

Some kind of organization integration is present: after registering for a carsharing provider, it is possible to validate the driver’s license (a step of the registration process) at some mobility information centers of the MVG.

4.2.5. Development of mobility stations in Munich

The idea of integrating various modes of transport better and supporting ecomobility was already part of the TDP, and it has been followed privately by housing development cooperatives and some other the projects supported by the Inzell initiative. In the following subsections, the details of these efforts are presented.

4.2.5.1. Past and present

The physical integration of various mobility services in Munich, beyond the existing P+R and B+R facilities, has its origins in 2012 in the housing cooperative *WOGENO*.

According to Raffl (2012), the STATTAUTO carsharing station in one of the housing buildings of the WOGENO cooperative was the first station where selected users had access to various modes of transport including two pedal electric bikes (pedelecs), a bike trailer, and two public transport tickets in addition to the carsharing vehicles. The multimodal service integrated the above mentioned mobility options under one roof aiming to increase their flexibility and attractiveness, and to guarantee residents with full mobility without the own car. (Raffl, 2012)

In 2014, the Mobility Station at Münchner Freiheit was inaugurated as a pilot project initiated by the City of Munich in cooperation with the PTO (MVG). The development and characteristics of this mobility station, as the main case study of this dissertation, are presented in detail in section 4.3.

Following the example of the first private multimodal station, in May 2016 another private mobility station was implemented in a new housing development area called *Domagkpark* with financial support from the City of Munich. This mobility station is part of a mobility concept put forward by the neighborhood association with the goal of reducing the number of parking spaces required by the city for each housing unit (Stellplatzsatzung), and thereby save construction costs (Alarcos, 2017).

4.2.5.2. Future

As of today, there are plans to implement another 16 mobility stations in the framework of three different projects supported by the Inzell Initiative:

- *smarter together (2016-2019),* 8 stations in the city outskirts;
- *city2share* (2016-2020), 4 stations in central neighborhoods; and
- *ECCENTRIC* (2016-2020), 4 stations in the new residential development *Domagkpark* and business area *Parkstadt Schwabing*.

These projects are led by different consortia in different parts of the city. Figure 4.13 shows the location where these projects are located.

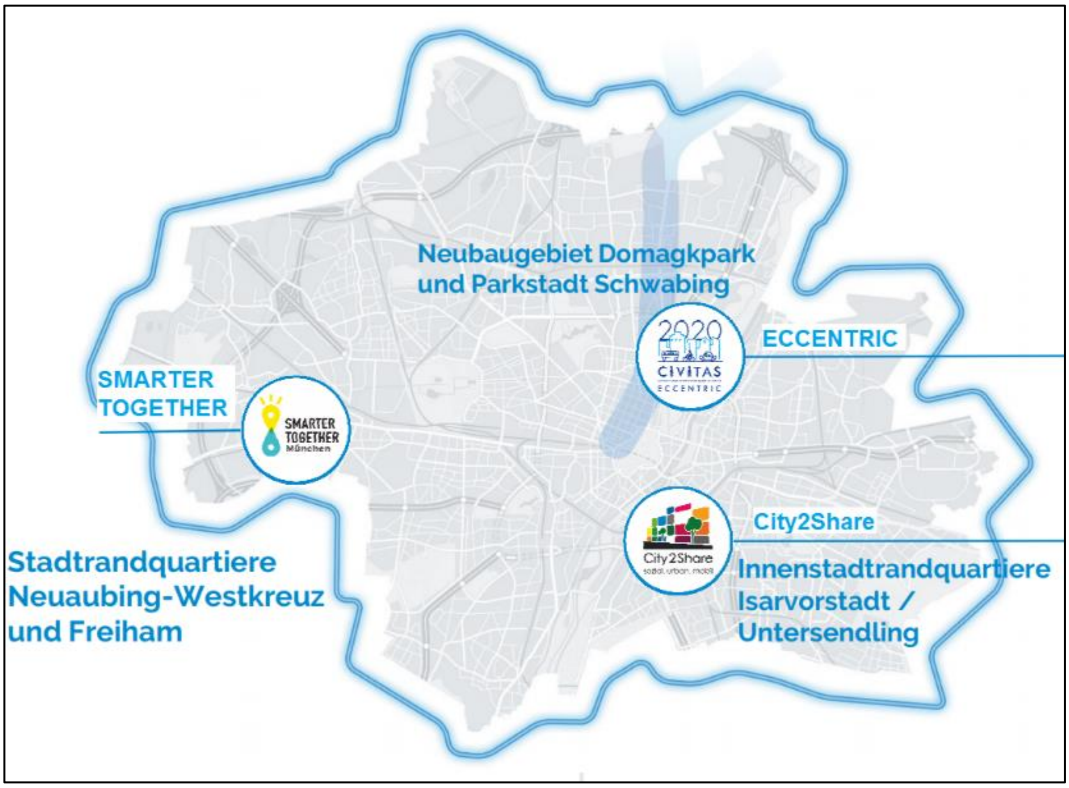


Image source: (Inzell Initiative, 2017)

Figure 4.13: Location of project where mobility stations are planned to be implemented

Being a part of different projects, the mobility stations have different features and are utilizing different possibilities for their implementation as well. Their evaluation represents an important opportunity to learn about their acceptance in different contexts and with different components.

4.3. The Mobility Station at Münchner Freiheit

The Mobility Station at Münchner Freiheit (MSMF) is a pilot project led by the City of Munich in cooperation with Munich City Utilities (SWM) and MVG, and is the main case study of this dissertation.

The following sub-sections present information about the development of the Mobility Station, its influence area, its physical components, and the marketing strategy as an essential part of it. Then, the stakeholders and the goal of the project will be presented as well.

4.3.1. Development of the Mobility Station

The public transport station at Münchner Freiheit has been in operation since 1971 when the U3 and U6 metro lines were opened. In 2009, a joint tram and bus station was built as a terminal for the new number 23 tram line between the station and Schwabing Nord to the north. Figure 4.14 shows the characteristic green canopy roof covering the new tram and bus station.

Image source: Richard Huber, 2012

Figure 4.14: Green canopy roof covering the new tram and bus station at Münchner Freiheit

Currently, the U3 and U6 metro lines, the number 23 tram line, and the bus lines 53, 54, 59, and 142 all connect at the Münchner Freiheit station.

On April 2014, the Munich City Council commissioned the Department of Public Order (KVR) to lead the construction and operation of the Mobility Station at Münchner Freiheit. At the same time, it was commissioned to carry out a scientific evaluation of the Mobility Station in coordination with the Department for Urban Planning and Building Regulation (Landeshauptstadt München, 2014a; 2014b).

The construction works started in September 2014. For the implementation of the Mobility Station, ten public parking spaces were converted into six reserved parking spaces for carsharing and an area for 15 MVG Rad bikes, through a special use regulation (Sondernutzung). Also, the bike path which was originally going on the sidewalk was re-designed to run on the street (between the car lanes and the reserved carsharing parking spaces). Figure 4.15 shows the configuration of the station.

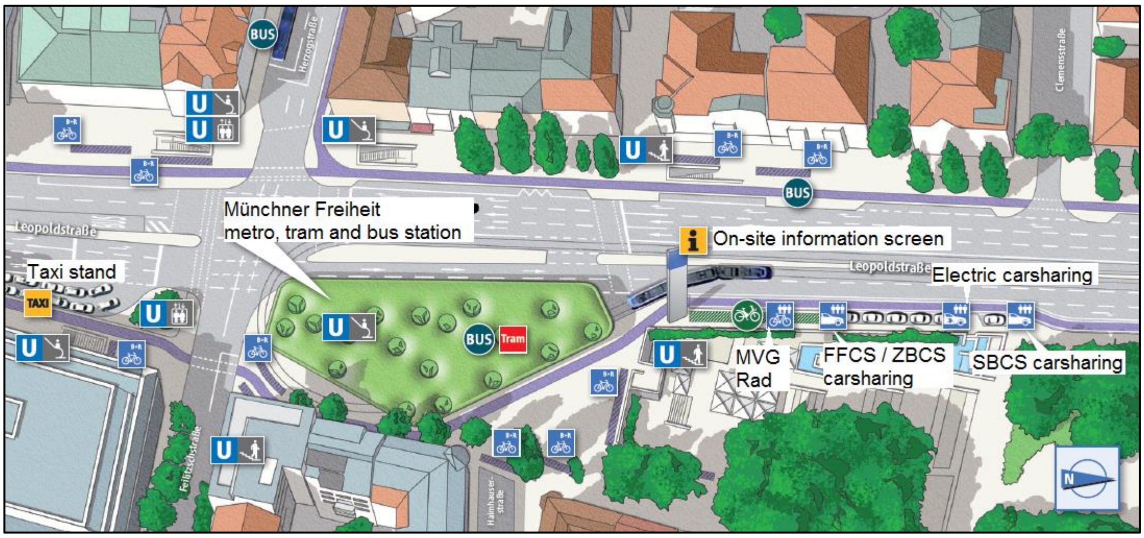


Image source: (MVG, 2015) (adapted)

Figure 4.15: The Mobility Station at Münchner Freiheit and its components

The pilot project of the Mobility Station began on November 6, 2014 in the framework of the EUROCITIES conference where it was presented as an innovative measure for sustainable mobility (Landeshauptstadt München, 2014c).

4.3.2. Location and influence area

The Mobility Station at Münchner Freiheit is located in “Schwabing” a densely populated district with 12,800 inhabitants per km^2. This is a wealthy, young, and dynamic urban area with attractive residential locations and jobs, as well as multiple cultural, shopping, and recreational destinations.

More precisely, the Mobility Station is located in the sub-district "Münchner Freiheit" which has about 17,000 inhabitants. Figure 4.16 shows the development of population, passenger car fleet and car ownership in this sub-district from 2006 to 2016.

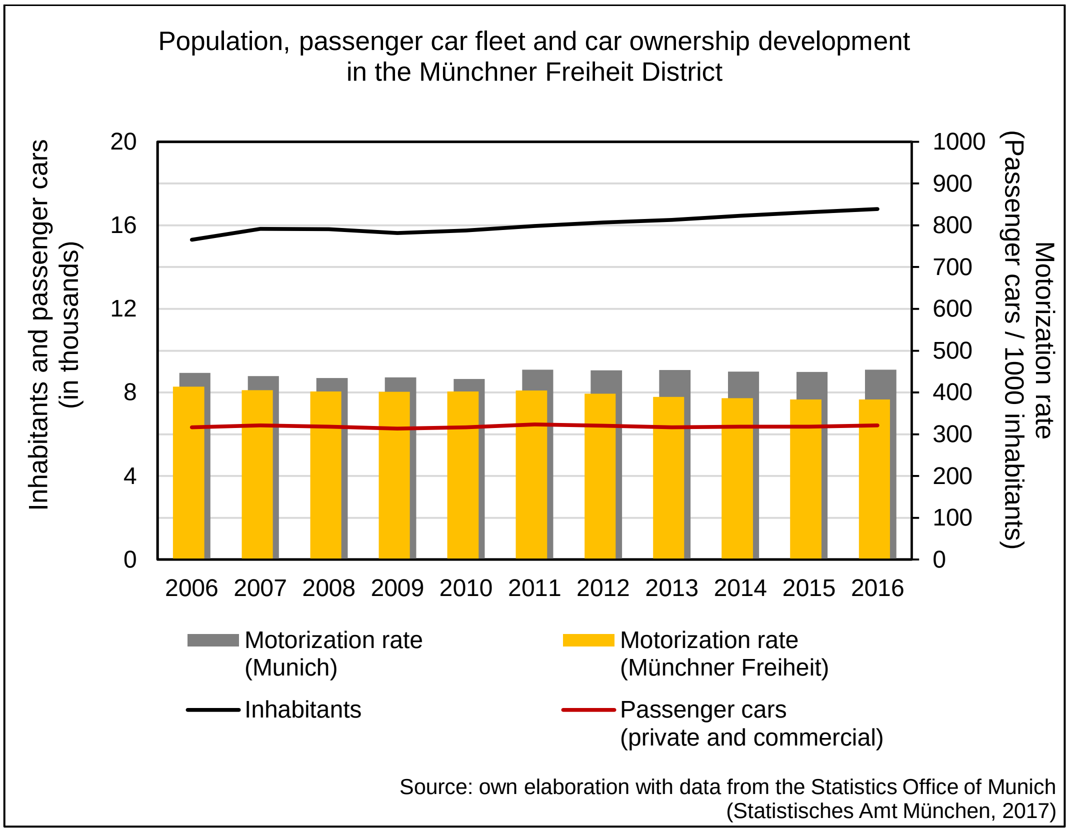


Figure 4.16: Development of population, passenger car fleet and car ownership in München between 2006 and 2016

In contrast to the motorization rate in Munich, which increased from 447 to 454, this parameter has reduced from 413 passenger cars per 1000 inhabitants in 2006 to 382 in 2016 in the sub-district Münchner Freiheit.

Around 18,000 people live in a walking distance of 10 minutes from the Mobility Station[16]. This area is well served by public transport services and lies within the service area of free-floating carsharing and bikesharing services.

[16] own calculation based on geographic and statistical data.

In addition to free-floating carsharing vehicles and bikesharing bikes, which are usually available in this area, a STATTAUTO carsharing station with 10 vehicles is about 300 meters away from the Mobility Station, while the next MVG Rad station is beyond the 10-minute walking distance. Figure 4.17 shows the public transport stations and one SBCS station in the immediate surroundings of the Mobility Station.

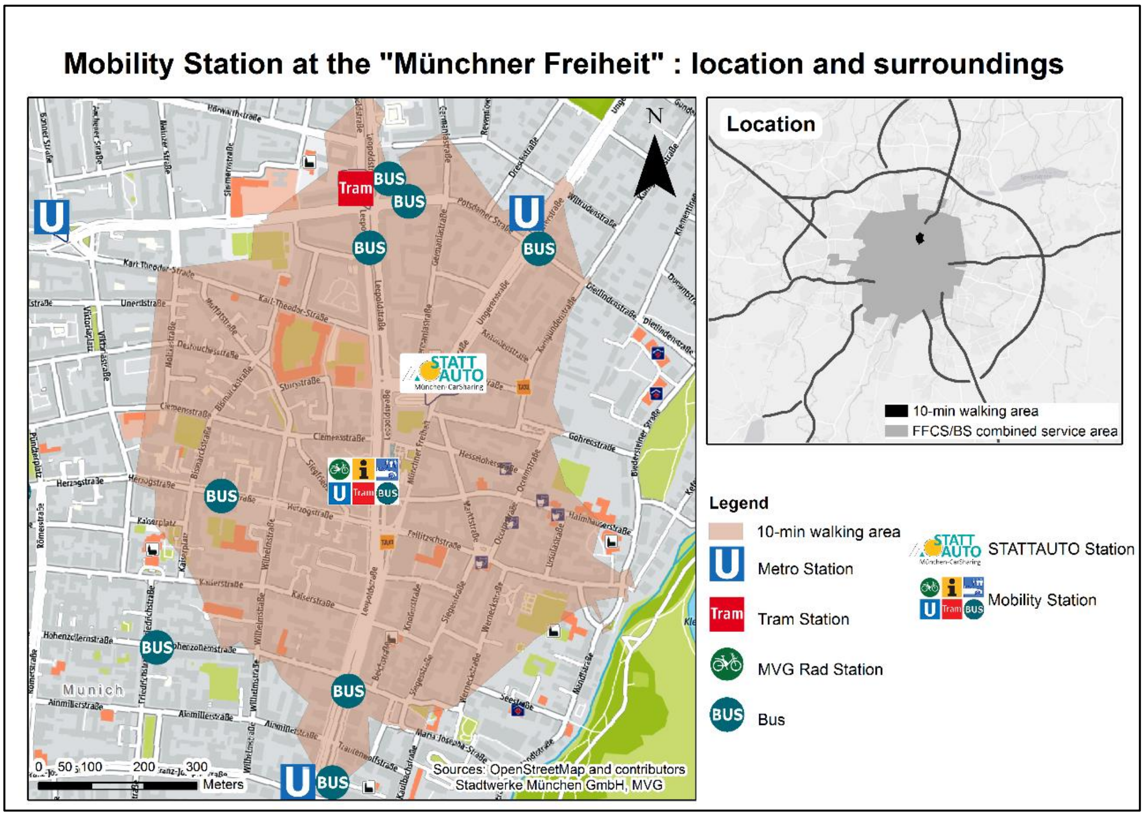


Image source: Maximilian Pfertner (2017)

Figure 4.17: The Mobility Station at Münchner Freiheit. Location and surroundings

The immediate surroundings of the Mobility Station are characterized by mixed land-use with housing, business, retail, and leisure activities spread throughout. The station is also a central point for Munich’s Schwabing neighborhood, and is surrounded by many shops, cafés, restaurants, bars, and important services like banks and a post office. Additionally, Munich’s central park, the *Englischer Garten*, is only a few minutes away by foot.

Figure 4.18 shows the diversity of locations within 400 meters from the Mobility Station.

Image source: David Durán (2017)

Figure 4.18: Type of locations in the immediate surroundings of the Mobility Station

Moreover, within the immediate surroundings of the Mobility Station (approximately within 100 meters) there are other amenities and services such as restaurants, cafés and shops, and a small kiosk, which is open 24 hours a day.

4.3.3. Physical components

In addition to the existing public transport station with metro, tram, and bus connections, as well as a taxi stand in close proximity, the Mobility Station consisted of the following new elements at the beginning of its operation in November 2014:

- 1 reserved parking space for one SBCS (STATTAUTO) vehicle;
- 3 parking spaces reserved for conventional (non-electric) carsharing vehicles, to be shared among the two FFCS providers (DriveNow and car2go) and one ZBCS provider (CiteeCar);
- 2 parking spaces reserved for electric carsharing vehicles;
- 1 charging station for electric vehicles next to the two parking spaces reserved for electric carsharing vehicles;
- 1 on-site information screen providing real time information about the services at the Mobility Station.

In October 2015, when the bikesharing system provided by the public transport operator (MVG Rad) began operation in Munich, one docking station was installed at the Mobility Station between the reserved parking spaces for carsharing and the on-site information screen. Since then, the Mobility station has been considered to be in “full operation”.

Figure 4.19 shows an image of Mobility Station with its main elements.

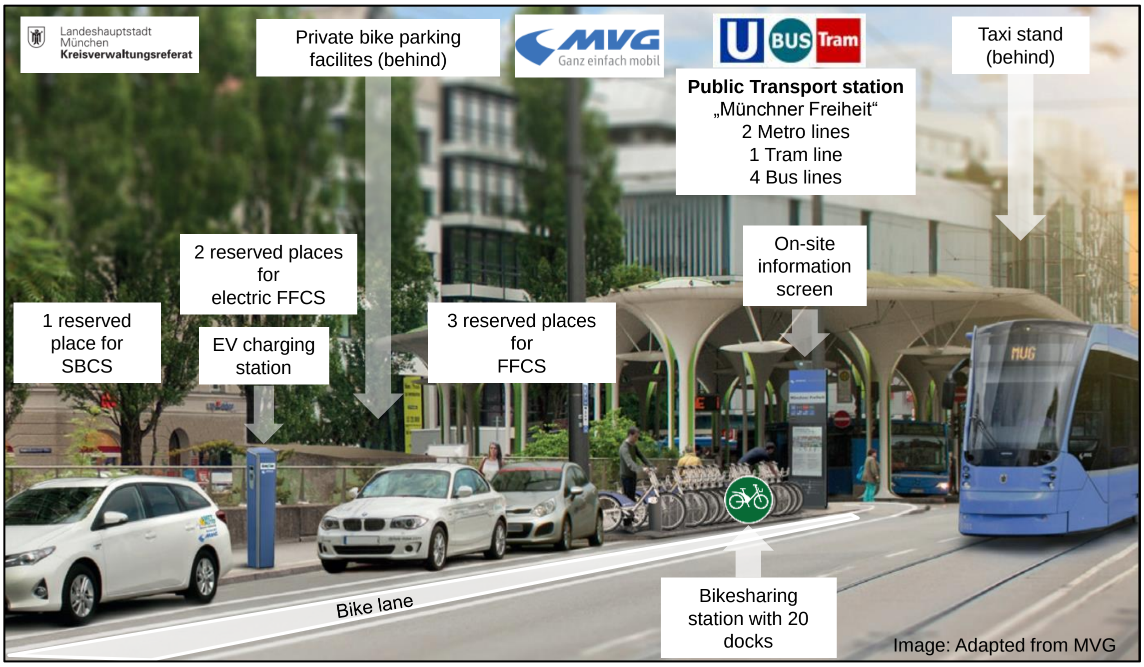


Image source: Adapted from (MVG, 2015)

Figure 4.19: Mobility Station at Münchner Freiheit showing its main components

As can be seen in Figure 4.19 above, the bikesharing station is located between the public transport station and the reserved parking spaces for carsharing. This configuration was intended to make public transport passengers looking for a carsharing vehicle become more aware of the bikesharing service by passing by it first.

The information stele located between the public transport station and the shared mobility services serves as design element that informs visitors about the integrated multimodal mobility offer. In addition, an interactive screen (on the south side of the stele) provides real-time information on the availability of the different shared mobility services and departure times of public transport services at the Mobility Station (similar to the information provided in the MVG multimobil website, see section 4.2.4.1). Figure 4.20 shows images of both sides of the information stele.

Image source: own photographs

Figure 4.20: The information stele a) from the north side and b) form the south side with the interactive information screen

Next to a clear design, marking, and signposting, an intensive marketing campaign was considered to be an important element for the successful achievement of the transport-related goals of the Mobility Station (Landeshauptstadt München, 2014a). The next subsection presents more information about the marketing campaign and advertisement efforts.

4.3.4. Information and Dialogue Marketing

4.3.4.1. Social media, newsletters

Shortly after the beginning of the operation of the Mobility Station, the carsharing providers informed their customers through newsletters and social media of the possibility to rent and return carsharing vehicles, as well as to transfer to public transport or visit the surroundings at the station. Figure 4.21 shows two examples of announcements posted on social media by the end of 2014.

DriveNow, November 21, 2014:
“Return your BMW or Mini and transfer to metro or tram. The new Mobility Station at Münchner Freiheit makes it possible: three reserved parking spaces for carsharing and two parking spaces next to a charging station for our ActiveE vehicles are already available. This way transferring with DriveNow will be even easier!”

Source: Facebook

Car2go, December 15, 2014:
“Now, you can rent and return your car2go at the marked areas for carsharing vehicles at the new Mobility Station at Münchner Freiheit. With this, car2go fits perfectly with a visit to the Schwabing Christmas Market”

Source: Facebook

Figure 4.21: Announcements posted on social media by carsharing providers

4.3.4.2. Dialogue marketing

In October 2016, the specialized marketing company *Omniphon* carried out a marketing campaign to inform households in the surroundings and passersby about the Mobility Station and the various mobility services available there (Omniphon, 2017). This was done on behalf of the City of Munich and in cooperation with MVG.

The marketing campaign was done following the same concept of the already successful mobility management program of the City of Munich *'Gscheid mobil'.* It consisted of two main communication channels, namely information per post and face-to-face communication (Omniphon, 2017).

Information per post

By the end of September 2016, 5000 households in the surroundings of the Mobility Station were addressed by post with a letter signed by the city mayor and informed of the Mobility Station and the mobility services available. An extract of the letter reads like this:

> *"as an inhabitant of this city you know that being active in Munich means being mobile. The diverse transport supply offers you enormous flexibility.*
>
> *This is especially true at the Mobility Station at Münchner Freiheit, where the right mode of transport for almost any trip is available. Next to metro, bus, tram, and taxi, you can find the public bikesharing system 'MVG Rad', as well as reserved parking spaces for the various carsharing offers. A charging station for electric carsharing vehicles complements the offer.*
>
> *Test this offer and try to be mobile without your own car during a week. If you are not yet a public transport subscriber, we give you the possibility to try public transport for one week for free. Order your free week-pass for the public transport services within the MVV inner area."*

In addition, the addressed households had the possibility to order information material about the mobility services, and order a public transport pass valid for one week (Schnupperticket) by phone, online, or by post. Those households from which any answer was received, got a reminder letter of these opportunities by mid-October (Omniphon, 2017).

Of the 5000 households contacted, 15% replied and ordered informational material. Considering that the Mobility Station had already been in operation for almost two years (only one year since full operation), this response rate was considered satisfactory (Omniphon, 2017).

Face-to-face communication

For this part of the marketing campaign, personnel of the company Omniphon approached passers-by around the Mobility Station during different weekdays at different times of the day in order to inform them about the different mobility options available. To support this, a flyer with information about the different options and the possibility to order more information for free was distributed. (Omniphon, 2017)

According to the report of the company, the approached persons showed and open attitude. Many of them knew already the various mobility services, although they were not consciously linked to the term of “mobility station”. Some questions about the bikesharing and carsharing models were answered during the conversation with the promotors. Some people ordered informational material, although below the expectations. (Omniphon, 2017)

4.3.5. Stakeholders and operational model

Both public and private actors are involved in the implementation, development, operation, and evaluation of the pilot project.

The awarding authority is the City of Munich, while MVG constructed and operates the Mobility Station. MVG is, at the same time, the public transport operator and provider of the bikesharing system MVG Rad. SWM (Munich City Utilities) provided the charging station for the electric carsharing vehicles.

The City of Munich, through the Department of Public Order (KVR) and the Department of Urban Planning and Building Regulation (PLAN) was in charge of converting the 10 parking spaces and giving the MVG a special use permit (Sondernutzungserlabunis) removing the requirement to pay the public land usage fees.

The MVG, as the operator of the Mobility Station commissioned the municipal company *P+R Park & Ride GmbH* with the supervision and maintenance of this facility. For this service, the MVG charges carsharing providers for the use of the carsharing spaces.

The participating carsharing providers are DriveNow, car2go, and STATTAUTO (CiteeCar participated in the project until it went bankrupt by the end of 2015). Their role is to ensure that vehicles are regularly available at the station and to inform their clients about the services at the mobility station. Moreover, they played an important role in the evaluation of the pilot project (see Section 5.2.2).

Figure 4.22 presents the main stakeholders of the Mobility Station and the operational model.

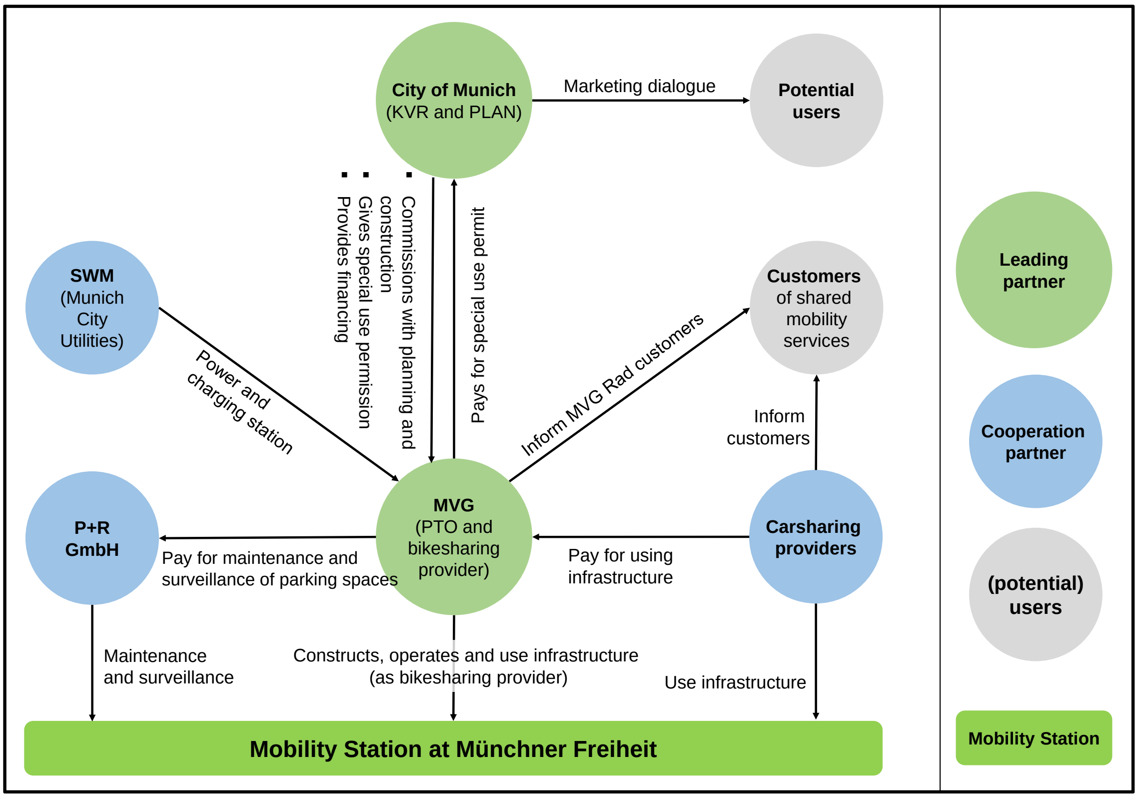


Image source: own elaboration, partially following the nomenclature and representation of operational models of mobility stations in other German cities by (Krismanski, 2015)

Figure 4.22: Constellation of stakeholders of the Mobility Station at Münchner Freiheit

4.3.6. Goals

The goal of the Mobility Station at Münchner Freiheit is to provide citizens with a suitable transport mode for any and every trip purpose, in a way that owning a car eventually becomes unnecessary (Landeshauptstadt München, 2014a).

More specifically with the Mobility Station, as a pilot project the main stakeholders aimed to test its impacts on:

- promoting a modal shift to space and resource friendly mobility forms,
- reducing parking demand and thus, gaining space for other uses and increase its attractiveness,
- reducing overall traffic volume in motorized individual transport,
- reducing private costs for citizens and companies, as well as public costs.

By providing the right transport mode for any trip purpose easily and at any time it is expected that car ownership among the users, and thus, the demand for parking spaces on public ground will reduce. Moreover, the vehicle kilometers traveled by cars should reduce as well.

Another objective of the pilot project is to gain experience with the operation of the mobility station, from the development and implementation processes to the viability of the legal concepts, the economic feasibility of these projects, and the adequacy of the operational model. Other interesting aspects are the acceptance of the project by users and the stakeholders, as well as the motivation and deciding factors that make users use private cars, sell or otherwise get rid of them, or avoid buying one.

The evaluation methodology, by which some of these aspects were investigated, is presented in Chapter 5. The evaluation results presented in Chapter 6 explored some of the aspects mentioned above. Furthermore, this dissertation used these results and the findings on other mobility stations and shared mobility services (presented in Chapter 3) to assess the contribution of mobility stations on sustainable urban mobility and to identify success factors for their implementation and operation. Both the assessment and the success factors are presented in Chapter 7.

5. Methodology

The pilot project of the Mobility Station at Münchner Freiheit (MSMF), the main case study of this dissertation, was evaluated on behalf of the City of Munich. By means of different methods, the barriers and drivers for the implementation of the project, the awareness, perception and acceptance of the Mobility Station and its components, as well as effects and potential effects on mobility behavior, among other aspects were investigated.

In order to better understand the results obtained by the different methods, the context of the pilot project and its implementation were analyzed. This includes the description of the area around the Mobility Station and the City of Munich, which has been presented in Chapter 4. Figure 5.1 shows the main methods used to evaluate the MSMF and to describe its context.

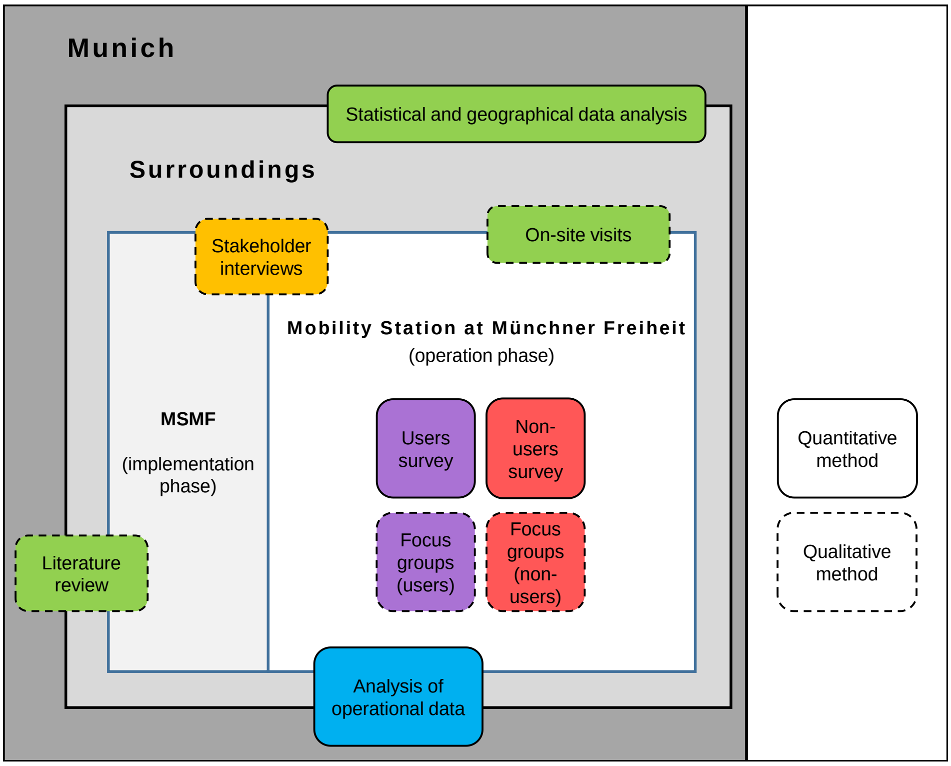


Figure 5.1: Methods used for the evaluation of the Mobility Station at Münchner Freiheit and the description of its context

As can be observed from Figure 5.1, a holistic evaluation approach consisting of quantitative and qualitative methods was applied to evaluate the Mobility Station.

While the literature review and the on-site visits were rather complementary to the central evaluation, the most important methods carried out mainly during the operation phase are the following:

1. **Stakeholder interviews:** the main goal of the interviews was to identify the main barriers and drivers for the implementation of the Mobility Station. Furthermore, these interviews helped to engage the stakeholders in the evaluation of the Mobility Station, especially in the development and implementation of the user survey and later in the provision of operational data from their respective mobility services.
2. **User survey:** the goal of the user survey was to understand the general characteristics and mobility patterns of the users, their level of awareness, perception and acceptance towards the Mobility Station, as well as their experiences and ideas on how to improve the concept. The focus groups complemented the insights provided by the survey and the analysis of operational data provided more details regarding the use of shared mobility services.
3. **Non-user survey:** the general goal of the non-user survey was to learn about the levels of awareness and perception of the Mobility Station of this group, barriers to the use of shared mobility services, as well as their demographic characteristics. The reasons for not using shared mobility services and the conditions for potential use were further explored in the focus groups.
4. **Focus groups:** the goal of the focus groups was to understand further the findings of the user and non-user surveys. In addition, they were helpful in identifying barriers and drivers for the use of shared mobility services, as well as in generating new ideas for the further development of the Mobility Station and, in general, of an integrated multimodal mobility service.
5. **Analysis of operational data:** the analysis of operational data aimed to obtain further details regarding the use of shared mobility services in connection with the Mobility Station.

While quantitative methods such as the surveys and the analysis of operational data provide important information to understand the general acceptance, perception, and utilization of the mobility services at the Mobility Station, they do not provide explanations as to why they might be. Here, focus groups, as a qualitative method, were useful in understanding the reasoning of both users and non-users of the mobility services. Each of these methods are presented in detail in Sections 5.1 to 5.5.

Beyond the evaluation of the many different aspects described above, one of the main research questions of this work is:

Do mobility stations contribute to sustainable urban mobility?

To answer this question, an operationalization approach for sustainable mobility was proposed in the framework of this work (see Section 2.3). Then, considering the type of information that was possible to obtain by the evaluation methods and other information available, an assessment method following the operational approach was developed. This is presented in Section 5.6.

Figure 5.2 shows the timeline of the project highlighting important events and the time when the different methods were carried out, as well as the corresponding analysis of results and assessment.

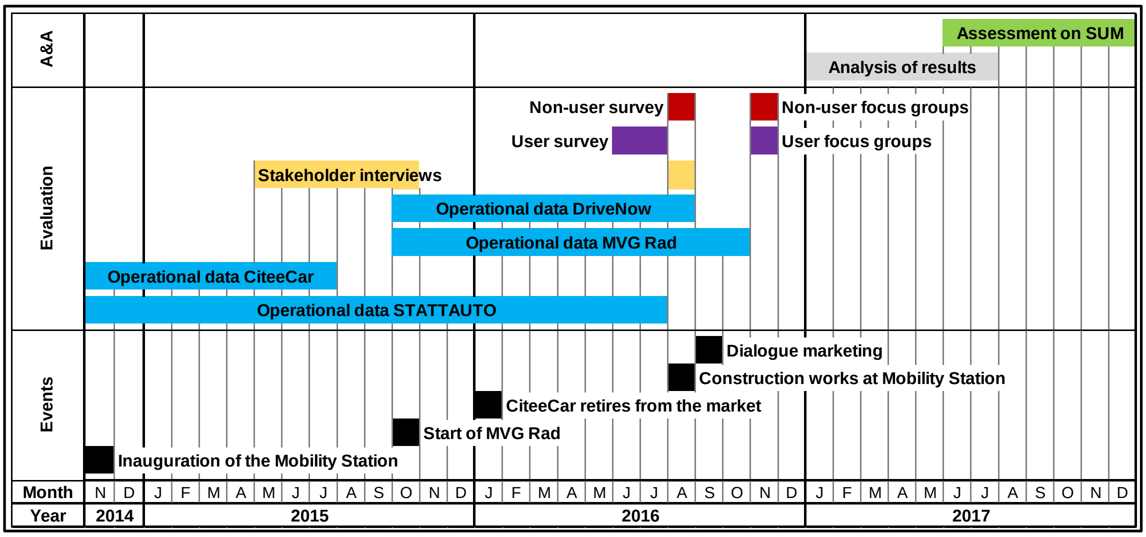


Figure 5.2: **timeline of the pilot project and time when the different methods were carried out**

The results obtained by the five methods described above are presented in Chapter 6. These, together with the findings about other mobility stations and shared mobility services (presented in Chapter 3) are used to assess the contribution of mobility stations on sustainable urban mobility and to identify success factors for their implementation and operation. Both the assessment and the success factors are presented in Chapter 7.

In the remainder of this chapter, the main methods used to evaluate the Mobility Station are described in further detail. The author aims that by providing this level of detail, the different methods can be reproduced and adapted to later evaluate the same Mobility Station, and similar projects in Munich or other cities.

5.1. Stakeholder interviews

Interviews were carried out with the stakeholders of the Mobility Station (see Section 4.3.5 about the stakeholders) at the beginning of the evaluation.

As part of the interviews, it was possible to obtain general information about the stakeholders, their roles within the pilot project, their motivations to participate, as well as their individual goals and expectations.

The stakeholders provided information (in retrospective) about the implementation phase, and about the first experiences and observations directly at the Mobility Station and in its surroundings during the operation phase. Their insights helped to understand the implementation process enabling the identification of barriers and drivers which in turn made possible to identify success factors.

These interviews were also useful in developing ideas for optimization and improvement for the different phases of the project.

5.1.1. Goal and objectives

The main goal of the interviews was to identify the main barriers and drivers for the implementation of the Mobility Station.

The specific objectives of the stakeholder interviews were:

1. to obtain general information about the different actors and the roles they played during the planning and implementation of the Mobility Station,
2. to understand the motivations (goals and / or expectations) for taking part in the pilot project,
3. to identify barriers and drivers regarding the implementation of the Mobility Station,
4. to identify potentials for improvement and optimal operation of the Mobility Station,
5. to investigate if, from the point of view of the stakeholders, it makes sense to have more mobility stations, and if so, where they might be located and how they should be equipped.

Furthermore, the interviews helped to engage the stakeholders in the evaluation of the Mobility Station, especially in the development and implementation of the user survey and later in the provision of operational data from their respective mobility services.

5.1.2. Design

The interviews were semi-structured allowing interviewees to divert from the questions and bring new inputs into the conversation. The interviews focused on the planning and implementation phases of the pilot project and posed the following questions:

1. Which role did the stakeholder play during the implementation and operation of the Mobility Station?
2. What are their motivations for participating in the pilot project?
3. What are their expectations?
4. What problems or barriers were experienced during the implementation phase?
5. What ideas for improvement regarding the implementation and operation of the Mobility Station do they have?
6. What experiences and observations have they made during the initial phase of the project?

5.1.3. Implementation

Most of the interviews were carried out between May 2015 and October 2015. An additional interview was carried out a year later with another stakeholder (P+R Park & Ride GmbH), which was more involved in the operation phase, and another one was carried out after the evaluation was concluded in order to fill information gaps (see Table 5.1).

Table 5.1: Overview of stakeholder interviews and dates when they were held

Stakeholder	**Date of interview**
STATTAUTO (SBCS carsharing provider)	20/05/2015
DriveNow (FFCS carsharing provider)	26/05/2015
car2go (FFCS carsharing provider)	16/06/2015
Department of Urban Planning and Building Regulation (PLAN)	23/06/2015
CiteeCar (ZBCS carsharing provider, went in bankrupt in December 2015)	15/07/2015
MVG (as public transport operator and bikesharing provider with MVG Rad)	12/10/2015
P+R Park & Ride GmbH	05/08/2016
Department of Public Order (KVR)	04/01/2018

The interviews lasted approximately one hour each and were recorded with the permission of the interviewees. Most of the relevant information obtained through the interviews is presented in Section 6.1. Other relevant inputs from these interviews are indicated in the text.

5.2. User survey

The user survey was carried out between June and July 2016, eight months after the Mobility Station was considered to be in "full operation" (see Section 4.3.1 about the development of the Mobility Station).

Users are defined as those who are customers of at least one of the three carsharing providers participating in the pilot project (DriveNow, car2go and STATTAUTO) and/or the MVG Rad bikesharing system, who also have rented or returned a carsharing vehicle or an MVG Rad bike at the Mobility Station.

Public transport and / or taxi passengers at Münchner Freiheit are not considered users, even though public transport and taxi are considered to be components of the Mobility Station.

Persons that arrive or leave the station at Münchner Freiheit by bike or as car passengers are not considered users either, even though the bike and ride facilities are also considered to be a component of the Mobility Station.

5.2.1. Goal and objectives

The goal of the user survey was to understand the general characteristics and mobility patterns of the users, their level of awareness, perception and acceptance towards the Mobility Station, as well as their experiences and ideas on how to improve the concept.

The specific objectives of the user survey are:

1. to understand the demographic characteristics of the users and the mobility options available to them;
2. to obtain details regarding the frequency of use and purpose for using the mobility services at the Mobility Station, especially with regard to the use of the new shared mobility services and their usage in combination with other modes of transport (or not);
3. to identify the components and characteristics of the Mobility Station that are important to the users;
4. to identify problems experienced by the users as well as ideas for improvement,
5. to determine if the Mobility Station offers an added value for the users,
6. to estimate the impacts of the Mobility Station on the mobility behavior and car ownership of users,
7. to identify success factors of the Mobility Station from the perspective of the users.

5.2.2. Development and design

The user survey was developed in close collaboration with the stakeholders in order to consider the different aspects which each partner wanted to understand, and that their customers were approached in the right way. While there were many interests and open questions from the stakeholders, it was also necessary to make sure that the questionnaire was short enough to avoid respondents dropping out the survey. Also it had to be considered that FFCS users had been already approached in the past to take part in other surveys for other research projects such as “EVA-CS” and “WiMobil” and thus, might be resistant to participate in another survey.

The user questionnaire was built upon the questionnaire previously used to evaluate the impacts of carsharing in Munich in the framework of the research project “EVA-CS” (team red, 2015). The original questionnaire was adapted in order to address questions related to the multimodal character of the Mobility Station and to explore specific aspects of interest to the stakeholders. A threshold of 10 minutes was suggested by researchers and stakeholders as a reasonable amount of time in order to get sufficient response rate. The questionnaire underwent many reviews and changes until a commonly agreed version was achieved. Experts in the field of sustainable mobility and multimodal mobility, including those that developed the questionnaires for EVA-CS and WiMobil contributed as well with their experience in shaping the questionnaire.

An online survey was chosen as the most convenient way to contact the users, because the carsharing users, at least, were already familiar with them. Online surveys are also considered to be a cost-effective method and have already proved successful in the framework of other similar research projects in the past (e.g., EVA-CS and WiMobil).

A household survey in the surroundings of the Mobility Station was not considered to be appropriate because the users do not necessarily live in the area. Users of the Mobility Station can come from anywhere, whether they are residents of other areas of Munich who work in the area, or are simply visitors and tourists to the city. A household survey would bring a small sample of users, not enough to generate significant results. Instead it was decided to contact users via e-mail through the mobility service providers after they used one of the mobility services at the Mobility Station.

Design

The user questionnaire consists of five sections, in which different aspects about the Mobility Station and the users were explored (see Table 5.2).

Table 5.2: Section content and specific aspects of the user survey

Section content	Specific aspects
General questions about awareness and use of mobility services at the Mobility Station	– Awareness and sources of awareness – Frequency of use of mobility services at the Mobility Station – Purposes for the use of mobility services at the Mobility Station
Detailed questions about the most recent trip (also referred to as the "last trip") with any of the shared mobility services that either started or ended at the Mobility Station.	– Reasons for using the Mobility Station (identification of added value) – Mode of access/egress to/from the Mobility Station – Activity at origins and destinations of trips starting and ending at the Mobility Station – Location of origins and destinations of trips starting and ending at the Mobility Station – Transport mode replaced for the trip with the shared mobility service – Relevance of reserved parking spaces for carsharing and docking station
Questions about the importance of the individual components of the Mobility Station and its intermodal connections, as well as the user experience and the identification of problems and ideas for improvement.	– Relevance of the on-site information screen – Problems and ideas for improvement – Importance of individual components – Importance of intermodal connections – Importance of amenities at the Mobility Station and its surroundings
General perception and potential changes in mobility behavior	– General perception and acceptance of the Mobility Station – Potential changes in short-term mobility behavior – Potential changes in long-term mobility behavior
Demographic questions about the users, general knowledge and use of mobility services as well as changes in car ownership independent of the Mobility Station	– Gender – Age group – Education – Household size and characteristics – Mobility portfolio (access to and use of different modes of transport) – Changes in car ownership during the last year (independent of the Mobility Station) and reasons for it. – Place of residence (zip code)
Recruitment for focus groups	– Contact data in case of willingness to participate in focus groups

All sections of the questionnaire, except for the second one, are exactly the same for all respondents. For the second section, which includes questions about the last trip, four versions with slight differences were created for respondents addressed by each the providers (MVG Rad, DriveNow, car2go and STATTAUTO). A general version of the survey in English is provided in Annex B-1.

Pre-tests

The questionnaire was tested on-line by experts in the field of mobility, and also by those without experience in the field in order to make sure that it was understandable, easy to answer, and that the required time to answer would be kept under the defined threshold of ten minutes.

In the final test version, the option of “No answer” (n.a.) was introduced for some of the questions, as during the tests, it was found that for these questions, none of the answer options were suitable. Some other questions, especially those considered important for the objectives of the survey, remained compulsory.

Estimated response rate and incentives

Literature suggests a likely response rate of 10-20% without incentives for similar surveys (Theobald et al., 2003; 2003). The response rate in the EVA-CS project was between 10% and 35%. However, this rate seemed optimistic for this study, considering that Munich’s carsharing users have been somewhat overwhelmed with questionnaires due to recurring studies in the past years, including EVA-CS and WiMobil.

To ensure a reasonable response rate the City of Munich offered an unusual incentive of ten Euro for each completed questionnaire. Typically, such surveys in Germany offer monetary incentives in the form of draws (InnoZ, 2016; Hartung, 2015; RWTH Aachen, 2016). The mobility service providers in turn offered this incentive to their customers in the form of credit on their respective accounts after completing the questionnaires. The City of Munich paid for the total sum to each of the mobility service providers after the survey period.

5.2.3. Sampling

As explained before, users of the Mobility Station are defined as those customers of the respective shared mobility services who have rented or returned a vehicle or bike at the Mobility Station. Due to the recent implementation of the Mobility Station, the size and characteristics of this universe (i.e., population) are not known. Thus, the sampling frame for the user survey was the set of customers who used these services at the Mobility Station from mid-June to the end of July 2016.

5.2.4. Implementation

The user survey was carried out between mid-June and the end of July 2016. Based on booking data, the shared mobility providers identified clients who used the Mobility Station (renting or returning a carsharing vehicle or MVG Rad) during a week and invited them via e-mail to participate in the survey.

To ensure data protection, providers sent an e-mail with an encrypted code linked to the online survey so that the answers could not be traced back to any specific customer. The providers were informed only that the questionnaire was filled out so they could grant their customers the corresponding incentive. Through this process, it was guaranteed that customer data was protected and their answers remained anonymous.

It was decided to contact users within maximum one week after their usage of a service at the Mobility Station to facilitate recollection of the last trip.

Before sending out the invitation e-mails to the online survey, the providers filtered their operational databases to ensure that customers were addressed only once during the survey period.

Figure 5.3 shows the development of responses among users of DriveNow and MVG Rad as well as the percentage of completed questionnaires classified by the response time (time between sending out the invitation e-mail and finishing the survey).

It was not necessary to send reminders because the response rate was higher than expected (above 60% for MVG Rad users and approximately 30% for DriveNow). It is assumed that the high response rate might have been due to the incentive offered to respondents (2 free hours for MVG Rad customers, 1 hour for SBCS customers and 30 free minutes for FFCS customers).

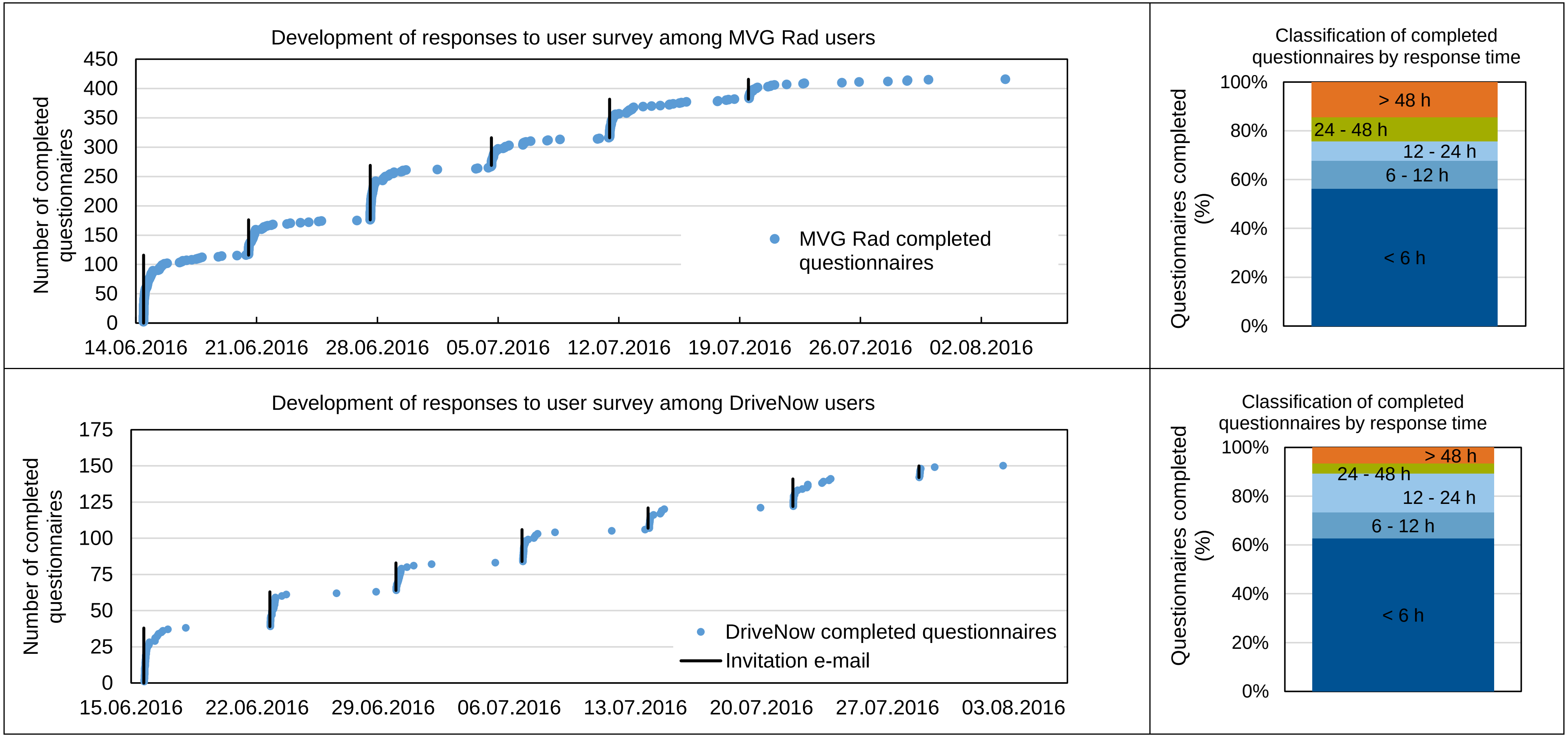


Figure 5.3: Development of responses to user survey among users of MVG Rad and DriveNow and classification of completed questionnaires by the response time.

In the case of car2go, the agreement between the provider and the customers at the time of registration hindered the possibility of contact for this study. Only customers who used the Mobility Station the previous week and who also agreed to, at the time of registration, contact for marketing purposes got an invitation e-mail. Therefore, the number of replies was unsatisfactorily low among car2go users. For this reason it was decided after a few weeks to contact all customers who had used the Mobility Station in the previous 6 months. However, this did not significantly increase the number of respondents.

In the case of STATTAUTO, the number of customers who use the Mobility Station within a week was much lower compared to the number of free-floating carsharing customers. This is because, generally, station-based carsharing is used for longer periods than free-floating carsharing. Thus, it was also decided to contact users who had used the Mobility Station during the previous nine months, that is to say, since the Mobility Station started full operation (October 2015).

The distribution of respondents according to the mobility service they were identified to be customers of is shown in Figure 5.4.

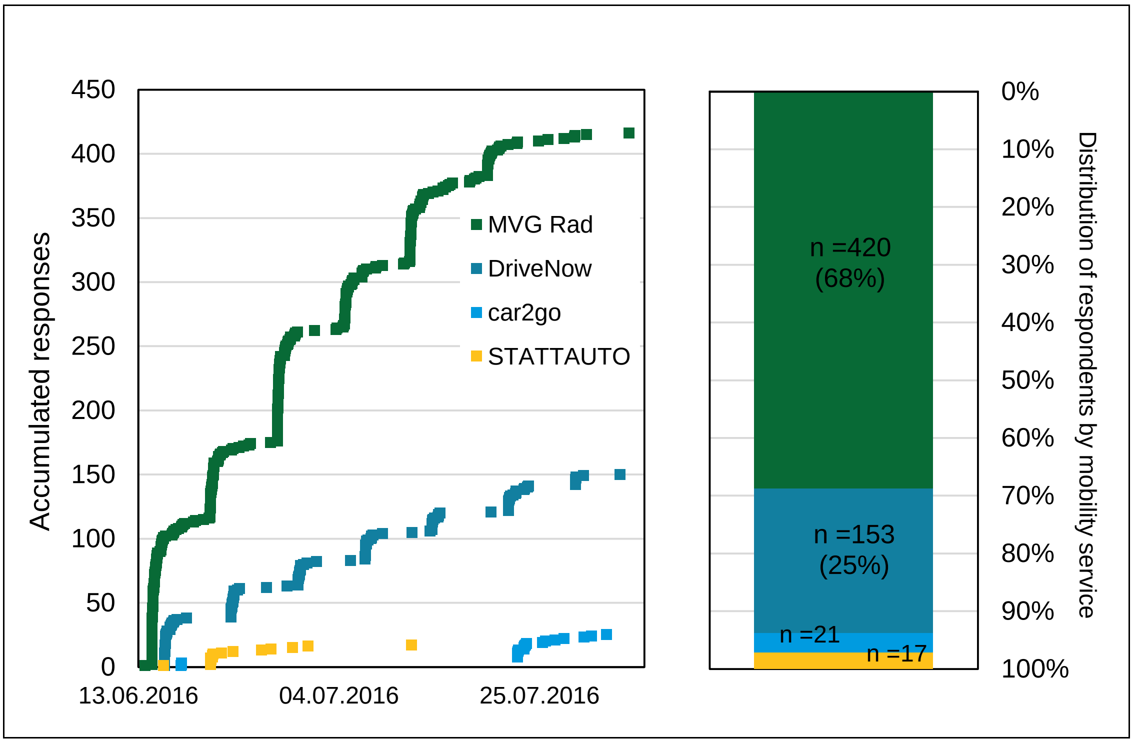


Figure 5.4: Accumulated responses during the survey period and distribution of respondents by mobility service

The analysis of responses by the different subgroups of users is presented in Chapter 6.

5.3. Non-user survey

The non-user survey was carried out in October 2016, after the marketing campaign of the Mobility Station had been carried out. See Section 4.3.4 for more information on the campaign.

Non-users are defined as those persons who have never rented or returned a carsharing vehicle or MVG Rad bike at the Mobility Station. However, non-users (of the Mobility Station) might have used these shared mobility services elsewhere.

5.3.1. Goal and objectives

The general goal of the non-user survey was to learn about the levels of awareness and perception of the Mobility Station and the shared mobility services of this group, as well as their demographic characteristics.

The specific objectives of the non-user survey were:

1. to understand the demographic characteristics of non-users;
2. to understand the level of awareness of the Mobility Station as well as sources of awareness among non-users;
3. To understand the level of awareness regarding shared mobility services;
4. to identify barriers to using shared mobility services in general and, if used elsewhere, barriers and potentials for using them at the Mobility Station.

5.3.2. Development and design

To find and address the non-users of the Mobility Station, it was decided to carry out face-to-face interviews among public transport and taxi users, as well as passersby at the Station.

In contrast to the user survey, the non-user survey was much shorter and required less interaction with the stakeholders. A threshold of three minutes was defined as a reasonable time for face-to-face interviews.

The non-user questionnaire consisted of four sections (see Table 5.3).

Table 5.3: Section contents and specific aspects of the non-user survey

Section content	**Specific aspects**
General questions about awareness	– Awareness – Sources of awareness
Knowledge and use of carsharing services provided at the Mobility Station.	– Knowledge/awareness of the carsharing providers – Use of carsharing providers – Barriers for the general use of carsharing services – In case of general use, reasons for not using carsharing services at the Mobility Station – Conditions for potential use and acceptance
Knowledge and use of MVG Rad	– Knowledge/awareness of MVG Rad – Use of MVG Rad – Barriers for the general use of MVG Rad – In case of general use, reasons for not using MVG Rad at the Mobility Station – Conditions for potential use and acceptance
Demographic questions	– Gender – Age group – Mobility portfolio – Place of residence
Recruitment for focus groups	– Contact data in case of willingness to participate in focus groups

The goal was set to achieve 400 completed interviews at four different locations with the following share among the locations:

- Metro platform (underground): 30%
- Tram und bus stop: 30%
- Taxi stand: 10%
- Passers-by: 30%

An English version of the survey is provided in Annex B-2.

5.3.3. Sampling

As explained before, non-users of the Mobility Station are individuals who have never rented or returned a carsharing vehicle or MVG Rad bike at the Mobility Station, but have the potential to do so. Due to the recent implementation of the Mobility Station, the characteristics of this universe (i.e. population) are not clearly defined or understood.

Therefore, the sampling frame for the non-user survey were public transport users and passersby in the immediate surroundings of the Mobility Station.

The non-user survey was carried out between October 10 and October 21, 2016 at different times of the day, especially during peak hours (7:00 to 9:00 and 15:00 to 20:00) and at some points during midday (12:00 -14:00).

In total, 590 people older than 18 years old were interviewed at the four different locations. About 20% of those approached turned out to be users of the Mobility Station and were therefore not interviewed further. The distribution of respondents by location is shown in Figure 5.5.

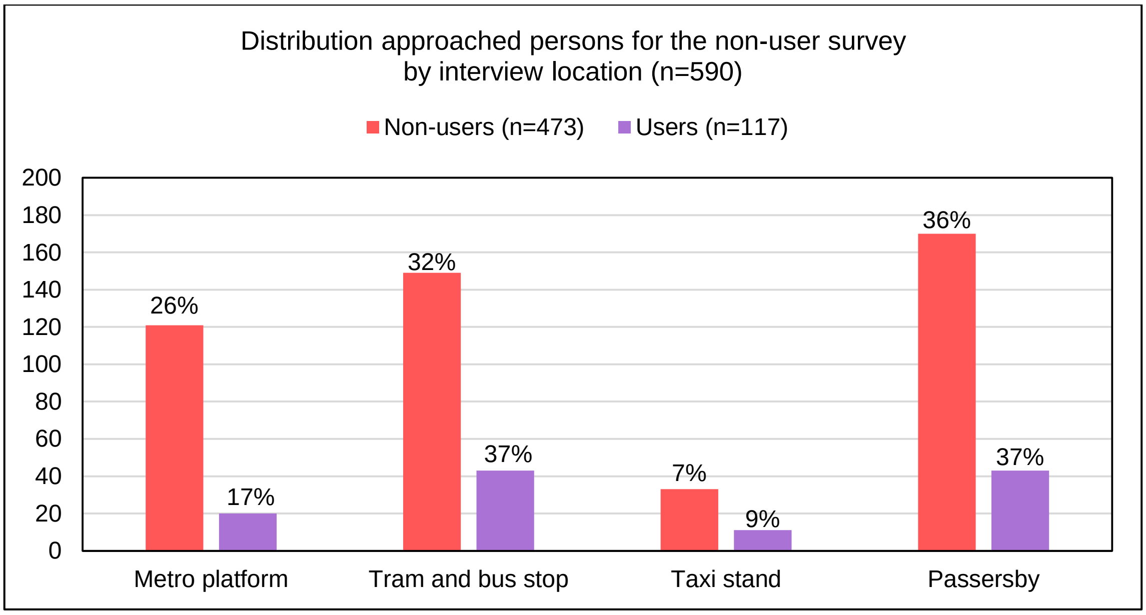


Figure 5.5: Distribution of respondents of the non-user survey by interview location

5.3.4. Implementation

The face-to-face interviews were carried out by professional interviewers of the specialized company Omnitrend[17] using a smartphone application where the answers of the respondents were classified into previously defined categories (see non-user survey in Annex B-2).

[17] Omnitrend is a specialized company in market research in the field of mobility. Omnitrend also carries out other surveys for public transport operators and agencies in Munich and the region.

Public transport users, taxi riders, and passersby were approached at the four predefined locations mentioned above.

Before the actual non-user questionnaire started, users of the Mobility Station were filtered out by asking those willing to participate in the survey if they have rented or returned a carsharing vehicle or MVG Rad bike at the Mobility Station in the past. In case of a positive answer, the interview was finished, as the person had been identified as a user. See Figure 5.6.

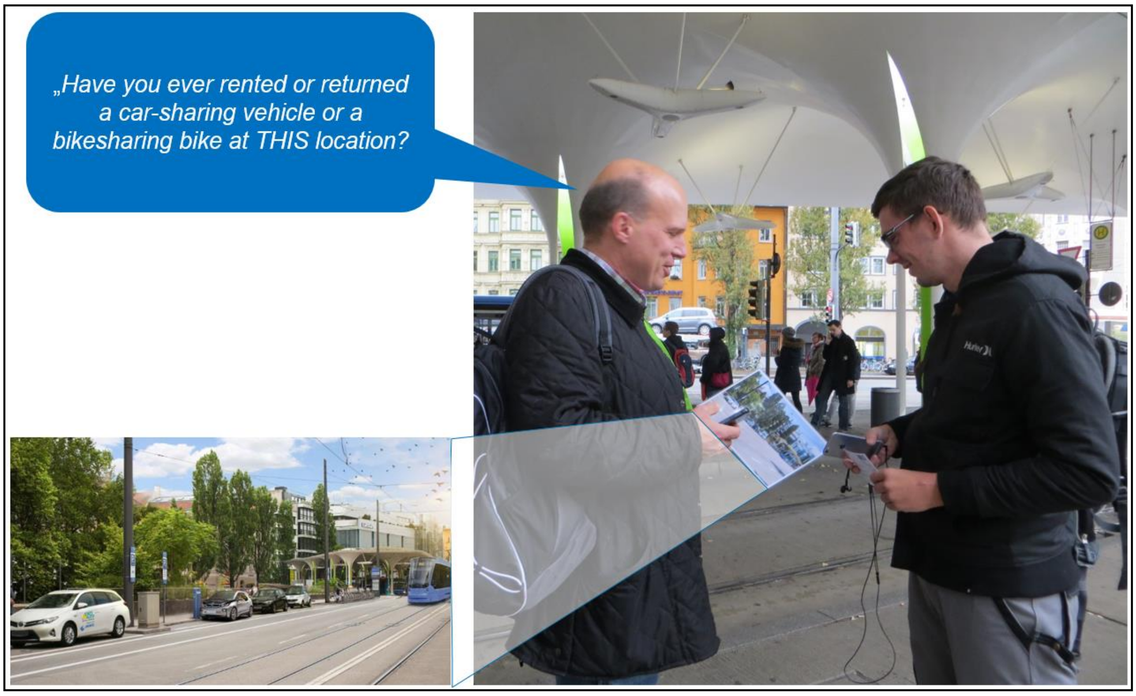


Image source: left (MVG, 2015), right: own photography with permission of the interviewer and interviewee

Figure 5.6: Approach to filter out users from the face-to-face interviews

At the end of the interview, non-users were informed of the possibility to participate in a group discussion with a duration of two hours and an incentive of €50 (fifty Euro) in cash. Unfortunately, only one person was interested in participating in the focus group. The recruiting of participants for the non-user focus group was then carried out by a third party (See Section 5.4.3).

5.4. Focus groups

To understand further the results obtained in both the user and non-user surveys, focus groups were carried out by a professional moderator of the specialized company *up2date,* who had not been involved in any phase of development of the Mobility Station.

5.4.1. Goal and objectives

The goal of the focus groups was to understand further the results of the user and non-user surveys. Specific objectives of the respective focus groups were:

- To further understand the acceptance and perception about the Mobility Station and shared mobility services among users and non-users, and
- to generate new ideas for the further development of the Mobility Station and mobility stations in general.

5.4.2. Development and design

After partially analyzing the results of both, the user and the non-user survey, and presenting them to the stakeholders, several questions arose and two main topics for the group discussions were identified:

1. Familiarity with, use of, and attitudes towards shared mobility services:
   a. Which providers of shared mobility services are familiar among users and non-users?
   b. What are the motivations for using shared mobility services?
   c. What are typical occasions when shared mobility services are used?
   d. What are reasons for not using shared mobility services? What are the barriers?
2. Awareness and perception of the Mobility Station at the Münchner Freiheit:
   a. What is the level of awareness of the Mobility Station?
   b. What are the main sources of awareness?
   c. What is the relevance of the on-site information screen?

d. What is the level of acceptance of the Mobility Station?

e. Is there a perceived added value in the diversity of mobility options at one location?

f. What are typical uses of shared mobility services at the Mobility Station?

The focus groups were carried out separately for users and for non-users. Based on the list of questions, interview guides were developed for each of these groups.

Table 5.4 presents an overview of the topics and specific aspects covered during the user focus group. The complete interview guides in English are provided in Annex B-3.

Table 5.4: Section content and specific aspects of the user focus group

Section content	Specific aspects
Warming-up phase associative environment	– Associations, feelings and attitudes towards the Mobility Station at the Münchner Freiheit
Knowledge, use and attitudes towards the shared mobility services, image of providers and substitution of transport modes.	– Awareness and use of shared mobility services – Typical occasions when using shared mobility services – Changes in mobility behavior – Substitution of transport modes – Motivations for the use of shared mobility services
Understanding of the Mobility Station,	– Awareness and sources of awareness – Relevance of the on-site information screen – Characteristics of a trip using shared mobility services starting or ending at the MS – Substitution of transport modes due to the MS – Added value, advantages, disadvantages
Personal assessment of the Mobility Station and optimization approaches	– Experiences – Perception and comparison of free-floating and station-based systems – Potentials for improvement – Awareness of similar concepts in other cities – Future development
Outlook and general acceptance	– Acceptance of more mobility stations in the City and assessment of their potential to reduce car ownership.

Table 5.5 presents an overview of the topics and specific aspects covered during the non-user focus group. The complete interview guides in English are provided in Annex B-4.

Table 5.5: Section content and specific aspects of the non-user focus group

Section content	**Specific aspects**
Warming-up phase associative environment	– Associations, feelings and attitudes towards Mobility in Munich
Mobility behavior	– Mobility behavior in general – Motivations for using different transport modes – Main modes of transport used – Potential changes in mobility behavior
Knowledge, use and attitudes towards shared mobility services	– Associations and attitudes towards shared mobility services – Awareness of shared mobility services – Use of shared mobility services – Typical occasions for using shared mobility services – Changes in mobility behavior due to the use of shared mobility services – Reasons for using different transport modes including shared mobility services – Changes in car ownership and reasons for it – Barriers for the use of bikesharing and potential use – Barriers for the use of carsharing and potential use
Perception and evaluation of the Mobility Station, its providers, potential acceptance /use	– Awareness, sources of awareness – Relevance of the on-site information screen – Awareness and attitudes towards the providers of shared mobility services at the Mobility Station – Barriers for the use of the MS – Acceptance of the Mobility Station and potential use – Associations to the users of the Mobility Station – Awareness of similar concepts – Ideas for development – Comparison between free-floating and station-based systems – Added value of the MS – Assessment of location – Future development
Outlook and general acceptance	– Acceptance of more mobility stations in the City and assessment of their potential to reduce car ownership.

5.4.3. Recruitment of participants

By means of the user survey, 233 respondents agreed to participate in the focus groups and gave their contact data. *up2date* recruited ten users out of this list by contacting them randomly by phone. Through a screening process, it was ensured that the demographic characteristics of the users were represented by the participants of the user focus group, and that there was a similar share of carsharing and bikesharing users.

The face-to-face interviews yielded only one potential participant for the non-user focus group. Thus, non-users were recruited by qualified personnel of the test studio, where the focus groups later took place. The test studio used their existing database to contact potential participants by phone. The selection of participants was done in a way to represent the demographic characteristics of the non-users according to the population of the non-user survey. To increase the chance that these persons were potentially familiar with the Mobility Station, public transport users living close the Mobility Station who had never used shared mobility services there were recruited.

5.4.4. Implementation

The focus groups for users and non-users took place in the facilities of a test studio in Munich on November 17 and November 21, respectively, and each lasted two hours.

The studio facilities consisted of a room with a round table, microphones, and a video camera. The room also has a one-way mirror behind which it was possible to observe the discussion without interfering. Observers of the focus groups included the author and representatives of the main stakeholders, who were able to raise additional questions shortly before the end of the discussion.

The group for the user focus group initially consisted of ten participants. However, at the beginning of the group discussion, one male participant decided to leave the room arguing that he was not aware that the discussion would be video recorded. As this issue seemed to make other participants uncomfortable, it was agreed to turn off the video, while it was accepted that the session will be audio recorded.

To avoid the incident of one participant leaving the focus group with users, during the recruitment of non-users, they were all clearly informed that the group discussion would be video-recorded.

The group of users was then conformed by 6 men and 3 women between the ages of 21 and 66 years old and had different occupational backgrounds. Table 5.6 presents the characteristics of the users as well as the transport modes available to them.

Table 5.6: Demographic characteristics, occupation and mobility portfolio of participants of the user focus group

Gender	Age	Occupation	Transport modes available	Use of shared mobility services
Female	32	Employed / Pharma	car, PT subscription	car2go, DriveNow, MVG Rad
Female	53	Employed / Tourism	car, Bike, PT subscription	MVG Rad
Female	66	Retired	Bike, PT subscription	STATTAUTO
Male	21	Student	Student PT ticket	DriveNow, car2go, MVG Rad
Male	23	Student	PT subscription	MVG Rad
Male	25	Student	Bike, Student PT ticket	MVG Rad
Male	26	Key Account Manager / IT	PT subscription	DriveNow, car2go
Male	45	Self-employed / Media	car, Bike	MVG Rad
Male	62	Musician	car, Bike, PT subscription	MVG Rad

The focus group of non-users was consisted of five men and five women between 19 and 44 years old, also with different occupational backgrounds. Table 5.7 presents the characteristics of the non-users as well as the transport modes available to them.

Table 5.7: Demographic characteristics, occupation and mobility portfolio of participants of the non-user focus group

Gender	Age	Occupation	Transport modes available	Use of shared mobility services
Female	19	Trainee / Hotel	car, bike, PT subscription	No
Female	29	Therapist / Health	bike, PT subscription	No
Female	36	Gym administrator / Wellness	car, bike PT subscription	No
Female	40	Sales person	bike, PT subscription	No
Female	44	Bank clerk / Finance	car, bike, PT subscription	No
Male	19	Student	bike, Student PT ticket	No
Male	25	Chef	car, bike, PT subscription	No
Male	37	Self-employed / Trade	bike, PT subscription	No
Male	36	Project manager / IT	car, bike, PT subscription	DriveNow, car2go
Male	52	Administrative employee	car, bike, PT subscription	No

On November 29, 2016, *up2date* delivered a report in the form of a presentation with the results of both focus groups (up2date, 2016).

5.5. Analysis of operational data

With the aim of understanding the usage patterns of the different mobility services at the Mobility Station, operational data of shared mobility services provided at this facility was analyzed.

The MVG Rad back-end data covers the period from October 9, 2015, when the Mobility Station started full operation, to October 31, 2016; the DriveNow back-end data covers the period from October 15, 2015, until August 29, 2016. CiteeCar (while still in operation) and STATTAUTO provided some operational data regarding the number and duration of rentals. Table 5.8 presents the type of data obtained from the mobility service providers.

Table 5.8: Operational data (units and format) of the shared mobility services provided at the Mobility Station

Type of information	DriveNow	MVG Rad	CiteeCar	STATTAUTO
Time period covered	15/10/2015 – 29/08/2016	09/10/2015/ - 31/10/2016	06/11/2014 – 15/07/2015	06/11/2014 – 22/07/2016
Number of trips/rental in dataset	3226	7148	121	130
Location of trip start and trip end	Address	Geographic coordinates (latitude and longitude)	Mobility Station (by default)	Mobility Station (by default)
Time of trip start and trip end	DD.MM.YYYY HH:MM:SS	DD.MM.YYYY HH:MM:SS	DD.MM.YYYY HH:MM	Not provided
Distance traveled per trip/rental	(km)	Not available	(km)	Total kilometers traveled since start of operations
Duration of trip/rental	(min)	(min)	(hours) estimated	Total number of hours in use since start of operations
Parking time	(min)	Does not apply	n.a.	n.a.

5.5.1. Trip analysis

Through data analysis it was possible to determine some statistics regarding the use of the mobility services such as:

- Average number of trips per month and day
- Ratio of rentals to returns for FFCS and bikesharing at the Mobility Station
- Average trip length
- Average trip duration

5.5.2. Temporal analysis

The data provided by DriveNow and MVG Rad were analyzed for different periods of time in varying lengths, such as months, weeks, and days.

This analysis of the hourly demand during the day, daily demand during a week and monthly demand during a year enabled the identification of temporal usage patterns for the use of the shared mobility services.

5.5.3. Spatial analysis

The data provided by DriveNow and MVG Rad was analyzed using Geographic Information Systems (GIS) allowing frequent origins of trips ending at the Mobility Station and frequent destinations of trips starting at the Mobility Station to be located.

The spatial analysis was based on a grid-based clustering method, which consisted of counting the end locations of rentals and start locations of returns of the shared vehicles inside 100-meter squares. A sensitivity analysis concluded that the 100-meter cells captured the demand and demonstrated the spatial distribution of rentals well for the purposes of the study. The 50-meter cells were too small, detecting only a few hot spots, while 250-meter cells were deemed too large to clearly locate hot spots on the map.

5.6. Assessment method of mobility stations on SUM

As mentioned in the introduction to this chapter, the Mobility Station at Münchner Freiheit was evaluated through various methods presented in Sections 5.1 to 5.5. The results obtained by these methods and the corresponding analyses are presented in Chapter 6.

While the different evaluation methods were used to answer many of the initial questions regarding mobility stations (see Section 1.2), one of the main research questions of this work is whether mobility stations contribute to sustainable urban mobility.

To answer this question, an operationalization approach for sustainable mobility was proposed in the framework of this work (see Section 2.3). This approach suggests assessing the development of two main criteria within a defined system:

- the *fulfillment of needs* through mobility should stay constant or increase for the target population, while
- the *consumption of resources* for mobility should decrease within a defined period of time.

When assessing mobility stations, the *target population* can be defined as the *users*, and the *defined period of time* as the time between implementation and the point in time when the evaluation was carried out. While these boundaries might be too narrow to assess sustainable urban mobility on the urban scale, they allow the assessment of the contribution mobility stations make to this concept.

Considering the system we are looking at (mobility stations) and the type of information obtained by the evaluation methods and other information available, an assessment following the operational approach was carried out.

In Section 2.3.3, sub-criteria and indicators were suggested for assessing sustainable urban mobility. However, not all of the indicators could be captured by the evaluation instruments presented in this chapter.

The following two subsections present the criteria and corresponding indicators that were able to be observed directly or indirectly in the framework of this work.

5.6.1. Indicators related to the fulfillment of needs

As discussed in section 2.3.3.1, the fulfillment of needs requires *access to opportunities* and *access to mobility options.* For these two sub-criteria, corresponding indicators were identified (see Table 2.5 in Section 2.3.3.3). Through the evaluation of the MSMF, the following indicators were observable:

Access to opportunities:

- The *supply of opportunities* in the immediate surroundings of the Mobility Station were assessed by means of GIS analysis and on-site visits (see Section 4.3.2), and also by considering the destinations that users visited after returning a shared vehicle at the Mobility Station as declared in the user survey (see Section 6.4.4.2).
- The *degree to which the supply of opportunities meets the demand* of users of the Mobility Station was indirectly assessed by considering how important users thought existing and non-existing services and amenities in the (immediate) surroundings of the Mobility Station were (see Section 6.5.4).

Access to mobility options:

- The *supply of mobility options* is assessed by considering the options offered at the Mobility Station (described in Section 4.3.3).
- The *awareness of mobility options* among users of the Mobility Station was evaluated by means of the user survey (see Section 6.3.2).
- The *availability of mobility options* to users of the Mobility Station was evaluated through the analysis of operational data (see Section 6.4.4).
- The ease of physical access to the mobility options at the Mobility Station was evaluated through the user survey, by looking at the access and egress modes to and from the Mobility Station (see Section 6.4.5) and through the stated descriptions of problems related to access (see Section 6.7.5).

5.6.2. Indicators related to the consumption of resources

As discussed in Section 2.3.3.2, potential and realized mobility consume space, energy, money, and time. For these four sub-criteria, corresponding indicators were identified (see Table 2.5 in Section 2.3.3.3).

Space and energy consumption

Estimating the consumption of space and energy required for mobility by users of mobility stations would require collecting detailed information about the trips performed by the users, including mode choice, vehicle occupancy, trip length, and trip duration, as well as the characteristics of the different vehicles used (e.g. size, propulsion technology, energy efficiency) and the total time they remained idling or parked (see Section 2.3.3.2). This information, however, is not available and it might be impractical to acquire in the future. Thus, proxy indicators for space and energy consumption can be used instead.

Considering that in the three cities where mobility stations were evaluated there was on average one vehicle for every two inhabitants (see Sections 4.1.3 and 3.2.5.2), and that the average car spends about 95 percent of its life parked (Shoup, 2017), *car ownership* is considered to be a good proxy for assessing space consumption for potential mobility. The effects of the MSMF on car ownership are presented in see Section 6.6.1.

Considering that in general, cars occupy the most space for every person kilometer traveled (Pkm) (Litman, 2015) (ibid) and consume the most energy per Pkm (Newman and Kenworthy, 2015) than any other mode, the Pkm by car of users can be used as a proxy to estimate the consumption of space and energy for realized mobility. This parameter, however, was not obtained through the evaluation of the Mobility Station. Thus, the consumption of space and energy for mobility was indirectly assessed by considering the potential impacts of the Mobility Station on mode choice (see Section 6.6.2).

Time consumption

Total travel time dedicated to mobility by the users of the Mobility Station within a defined period of time (e.g. hours/month) was not directly assessed. Travel time was indirectly and partially assessed by considering occasions when shared mobility services would be used (see Section 6.6.3).

Money consumption

Total travel costs for the mobility of the users of the Mobility Station within a period of time (e.g. €/month) was not directly assessed. Travel costs were indirectly and partially assessed considering the motivations for using shared mobility services (see Section 6.2.3).

5.6.3. Overview of assessed indicators

Table 5.9 presents a reduced list of indicators that were observable through the different methods used in this dissertation and the section where the corresponding results are presented. The assessment of the impact of mobility stations on the concept of sustainable urban mobility itself through these indicators is presented in Section 7.1.

Table 5.9: Overview of indicators assessed in the framework of this dissertation

Criteria	Sub-criteria	Indicators	Assessment	Section
Fulfillment of needs	Access to opportunities	Supply of opportunities at the Mobility Station and in its immediate surroundings for the users.	GIS Analysis and on-site visits, as well as destinations that users visited after returning a shared vehicle at the Mobility Station (user survey)	4.3.2. and 6.4.4.2.
		Degree to which the supply of opportunities meets the demand of the users and thus, contributes to the fulfillment of needs.	Importance of existing and non-existing services and amenities in the (immediate) surroundings to users (user survey)	6.5.4
	Access to mobility options	Supply of mobility options for the users.	Description of services at the Mobility Station	4.3.3
		Awareness of mobility options among users.	User survey, general awareness and sources of awareness	6.3.2
		Availability of mobility options to the users.	Analysis of operational data	6.4.4
		Ease of physical access to mobility options for the users.	User survey, access and egress mode, reports on problems related to access.	6.4.5 and 6.7.5
Consumption of resources	Space consumption	Area or volume occupied by standing and moving vehicles used by users of the Mobility Station over time within a defined period of time (e.g. m^2 * hours/year)	Indirectly assessed by considering potential impacts on car ownership	6.6.1
	Energy consumption	Total energy consumption for mobility of users of the Mobility Station within a defined period of time (e.g. kWh/year).	Indirectly assessed by considering potential impacts on mode choice	6.6.2
	Time consumption	Total travel time dedicated to mobility by the users of the Mobility Station within a defined period of time (e.g. hours/month)	Indirectly assessed by considering occasions for using shared mobility services (focus groups)	6.6.3
	Money consumption	Total travel costs for mobility of the users of the mobility station within a period of time (e.g. €/month)	Indirectly assessed considering motivations for using shared mobility services (focus groups)	6.2.3

6. Results and analysis

In this chapter, the results obtained by the various methods used to evaluate the pilot project of the Mobility Station at Münchner Freiheit (stakeholder interviews, analysis of operational data, user survey, non-user survey, and the corresponding focus groups) are presented. The results are organized by topics, regardless the method by which they were obtained and presented in the following seven sections:

- Section 6.1 presents the barriers and drivers for the implementation of the Mobility Station.
- Section 6.2 compares users and non-users in terms of demographic characteristics, available mobility options, and attitudes towards shared mobility services.
- Section 6.3 focuses on general awareness and sources of awareness of the Mobility Station among users and non-users.
- Section 6.4 presents information regarding the usage patterns of mobility services at the Mobility Station.
- Section 6.5 evaluates the overall acceptance and perception of the Mobility Station and identifies the components which are important to the users.
- Section 6.6 discusses the impacts and potential impacts of the Mobility Station on mobility behavior.
- Section 6.7 presents problems reported by the users regarding the Mobility Station and their ideas for improvement.
- Section 6.8 presents an overview of the results obtained and how these provide information to answer some of the initial questions posed at the beginning of this work.

Table 6.1 presents an overview of the different aspects of the Mobility Station and the methods applied for their evaluation.

Table 6.1: Evaluated aspects of the Mobility Station and methods applied

Aspect	Stakeholder interviews	User survey	Non-user survey	Focus group (users)	Focus group (non-users)	Analysis of operational data
6.1. Barriers and drivers for implementation	X					
6.2. Understanding users and non-users						
Demographic characteristics, mobility portfolio		X	X		X	
Motivations and barriers for the use of shared mobility services			X	X	X	
6.3. Awareness of the Mobility Station		X	X	X	X	
6.4. Usage patterns of the Mobility Station						
Development in the use of shared mobility services						X
Use frequency of mobility services and purpose		X		X		
Detailed analysis regarding the use of shared mobility services		X		X		X
Access to the Mobility Station by mode		X				
6.5. Acceptance and perception of the Mobility Station						
Added value		X		X		
Important components, important intermodal connections, important amenities		X				
Acceptance and perception		X		X	X	
6.6. Effects of the Mobility Station on mobility behavior		X		X		
6.7. Problems and ideas for improvement	X	X		X	X	

Note: the results of the user survey were published in a scientific journal in 2017 (see Miramontes et al., 2017). In this chapter the analysis of the results obtained through the user survey has been updated and considers the results obtained by other methods as well.

When possible and relevant, the results are compared to the findings from the literature review regarding mobility stations in other cities and shared mobility services presented in Chapter 3.

6.1. Barriers and drivers for implementation

The barriers and drivers for the implementation of the Mobility Station was explored through semi-structured interviews with the stakeholders involved in the pilot project.

This section presents the development of the MSMF from its conception as an idea to the actual implementation, the motivations of the stakeholders to participate in the project, as well as the barriers and drivers of its implementation which have been identified.

This information, together with lessons learned from other mobility stations (see Section 3.2.4) was used to identify success factors for mobility stations (see Section 7.2) and deliver recommendations for their implementation and operation (see Chapter 8).

The information provided below comes from the various interviews with the stakeholders. Although the interviews were recorded, this material is confidential and for internal use only. Thus, in the text is indicated from which interview the information comes from, but the reference is not included in the list of references.

6.1.1. Idea development, stakeholder involvement, and location choice

All the information in this subsection was obtained through the stakeholder interview with a representative of the Department of Public Order (KVR) on January 4, 2018.

Based on recent experiences with the new carsharing providers on public space and supported with evidence from the carsharing evaluation (EVA-CS[18]) which was in progress at the time (from mid-2013 to mid-2014), it was clear to KVR that in order to significantly reduce car ownership, it was necessary to offer citizens all alternatives “from a single source”. Dr. Martin Schreiner, Head of the Division of Strategic Projects and Fundamental Matters at KVR had the idea to implement a mobility station where all kind of mobility services could be integrated not only physically, but also virtually, especially in communication and marketing, through the city’s mobility management program *“Gscheid Mobil”* under the responsibility of his division.

In November 2014, the Eurocities Conference took place in Munich. The city’s Department of Labor and Economy (RAW), as the hosts of the conference, asked other

[18] See team red (2015).

Departments of the City of Munich for ideas to present in the framework of the conference.

The Department of Public Order (KVR) brought the idea of the Mobility Station, knowing that its implementation would be difficult in such a short time frame. The KVR knew it would require the participation and cooperation of different stakeholders such as the Public Transport Provider (MVG), the Department of Urban Planning and Building Regulation (PLAN), and the mobility services providers. Moreover, for the implementation of the project, it was necessary to find a location for the Mobility Station and acquire the building permits, which would require the removal of public parking spaces. The KVR also knew that due to the high parking pressure in the city, the removal of public parking spaces would prove politically difficult.

However, due to the political interest to present innovative ideas during the Eurocities Conference, the City Council supported the implementation of the project through a Municipal Decision on April 8, 2014 (Kreisverwaltungsreferat, 2014; Landeshauptstadt München, 2014a), which brought the main stakeholders, namely the Department of Public Order, the Department of Urban Planning and Building Regulation (PLAN), and the Public Transport Operator (MVG) together.

For the pilot project, it was necessary to find an attractive location with a good public transport supply including metro, trams, and buses. Due to the restricted time frame, the selection of the location did not follow a typical systematic decision process. The first choice, the metro station “Westfriedhof”, was ruled out due to ongoing construction works. Thus, the second choice, the metro station at “Münchner Freiheit” was selected. Both FFCS carsharing providers, DriveNow and car2go, preferred this location given the high number of existing customers in the surrounding area and that, due to high parking pressure, the use and development of FFCS had been limited.

6.1.2. Motivations of the stakeholders to participate in the project

For the Department of Public Order, one of the motivations for the pilot project was to offer citizens alternatives to private cars, with the aim to reduce overall car usage and car ownership (Stakeholder interview with representative of KVR, January 4, 2018).

From the side of the Department of Urban Planning and Building Regulation (PLAN), there were many open questions on the benefits the Mobility Station could bring to the citizens and to the city's vehicle traffic. They engaged in the evaluation of the project mainly to understand the effects on mobility behavior and the acceptance of the Mobility Station, as well as to gain experience for future development of mobility stations in Munich. (Stakeholder interview with representative of PLAN, June 23, 2015). Currently PLAN is preparing a city-wide concept for the implementation of mobility stations. Thus, the results of the evaluation shall serve as an input for it.

The Public Transport Operator (MVG) as a public company, indicated it had the same goals as the City, highlighting the importance of the provision of public services which includes the supply of mobility options to all citizens. With the new and upcoming mobility services, the MVG recognized that this supply needs to extend beyond traditional public transport services and it aims to be a diverse and inclusive mobility provider, though with public transport as the backbone of urban mobility. (Stakeholder interview with representatives of MVG, October 10, 2015).

In the case of the FFCS carsharing providers DriveNow and car2go, their motivations to be part of the pilot project were, first to offer their customers an easy and convenient option for the end of a rental, especially in that area with high parking pressure. Second, they wanted to test how customers react to the availability of reserved parking spaces, and finally to nurture the good relation with the City of Munich. (Stakeholder interview with representatives of DriveNow, May 26, 2015 and stakeholder interview with representatives of car2go, June 16, 2015).

For the SBCS provider, STATTAUTO, the provision of an additional parking space was less important due to the close proximity to another station with ten parking spaces. The motivation of STATTAUTO to join the project had more to do with higher visibility for the company and the marketing opportunity on public space, as compared to their other, less visible stations. Also of importance, was to collaborate with the City and to gain experience in the operation of carsharing in the public space in a ZBCS format, which was already planned by the company through their project, STATTAUTO Flexy. (Stakeholder interview with representatives of STATTAUTO, May 20, 2015).

At that time, CiteeCar was starting operations in Munich and they decided to participate in the project as it was in line with their business model, and they considered the idea of mobility stations as the right approach to reduce car ownership in the City. (Stakeholder interview with representative of CiteeCar, July 15, 2015).

6.1.3. Barriers

As the Mobility Station was a pilot project, there were different types of barriers for its implementation.

First, as the stakeholders initially came together, it was not immediately clear which responsibilities each held. The MVG took the leading role under a cooperation agreement with the Department of Public Order with the aim of quickly attaining all the necessary permits for the construction works and equipment installations, such as the charging infrastructure for electric vehicles, the on-site information screen, and the signposting of the parking spaces. (Stakeholder interview with representatives of MVG, October 10, 2015).

At that time, there was no carsharing law in Germany, which hindered the possibility of reserving public parking spaces exclusively for carsharing. Thus, it was necessary to appeal for a special use permission (Sondernutzung), which allows public parking spaces to be reserved for carsharing vehicles or other purposes. (Stakeholder interview with representative of KVR, January 4, 2018). Signs were installed to indicate which spaces were reserved for which carsharing providers. See Figure 6.1 below for examples of these signs.

Another barrier during the implementation process was that construction regulations in Munich prevented painting parking spaces with a striking color, which was part of the plans. At the end, a compromise was achieved in which the parking spaces were marked with a white symbol on the ground (see Figure 6.2 below). (Stakeholder interview with representatives of MVG, October 10, 2015).

Image source: own photographs (April, 2015)

Figure 6.1: Signposts installed at the Mobility Station to indicate that the parking spaces were reserved for specific carsharing providers

Image source: own photographs

Figure 6.2: Pavement marking in the reserved parking spaces for carsharing

Carsharing providers believed that the signs and pavement markings of the reserved carsharing spaces were still not visible enough. This was mentioned as a potential problem for them, if it resulted in a parking space reserved for carsharing being accidentally used by other cars. For FFCS and CiteeCar users, this would not be a big problem since they could still park anywhere else within the service area. For STATTAUTO users however, this would be more of a problem as they need to return the vehicle to this assigned space. (Stakeholder interview with representatives of DriveNow, May 26, 2015; with representatives of car2go, June 16, 2015; with representatives of STATTAUTO, May 20, 2015; and with representative of CiteeCar, July 15, 2015).

The municipal company *P+R Park & Ride GmbH* was assigned the role of surveillance of the parking spaces under a contract with the MVG. The participating carsharing providers were charged €100 per month paid to the MVG for this surveillance service, in addition to the fees paid to the City.

This extra fee was considered to be expensive considering the existing rates that they already paid to use parking spaces (FFCS providers and CiteeCar paid the city for using public parking spaces, and STATTAUTO paid for private parking spaces). The higher costs were accepted by the carsharing providers in the framework of the pilot project; however, they considered to be a problem if this fee had to be paid for the use of parking spaces at future mobility stations. Further mobility stations were actually warmly approved by all of them but not the additional fees. (Stakeholder interview with representatives of DriveNow, May 26, 2015; with representatives of car2go, June 16, 2015; with representatives of STATTAUTO, May 20, 2015 and with representative of CiteeCar, July 15, 2015).

All carsharing providers were asked about the possibility of competition caused by bringing together the different carsharing providers, as well as bikesharing, in one place. None of the carsharing providers considered this to be a negative aspect. FFCS providers believed that in Munich, there is a large enough market for all providers, and that most of their clients are already registered with another FFCS provider anyway. (Stakeholder interview with representatives of DriveNow, May 26, 2015; and with representatives of car2go, June 16, 2015).

Moreover, SBCS and ZBCS providers have observed a positive impact on new registrations since FFCS providers came to the market. With more money for marketing, the FFCS providers brought more attention to carsharing generally, so that both SBCS and ZBCS providers profited from it as well. (Stakeholder interview with representatives of STATTAUTO, May 20, 2015; and with representative of CiteeCar, July 15, 2015)

In summary, there is not a fierce competition in Munich for carsharing customers. Instead, the different carsharing providers see their different business models as complementary.

6.1.4. Drivers

Most stakeholders mentioned that having a deadline (the EuroCities conference) helped to accelerate the implementation of the pilot project.

According to the Department of Public Order, the political support granted by the City Council's decision which brought the main stakeholders together was also decisive for the timely implementation of the project. (Stakeholder interview with representative of KVR, January 4, 2018).

The fact that the chosen location was relatively far away from adjacent housing buildings was also considered as an advantage, because the public parking spaces for approximately ten vehicles were not the most attractive for residents, and therefore could be reserved for carsharing without public outcry. (Stakeholder interview with representative of PLAN, June 23, 2015).

Finally, the cooperation of the carsharing providers with the main stakeholders (MVG and KVR) contributed to a relatively smooth implementation process. (Stakeholder interview with representative of KVR, January 4, 2018).

6.2. Understanding users and non-users

Who are the users of the Mobility Station at Münchner Freiheit? Which modes of transport do they know and use? What are their motivations for using shared mobility services? Who are the non-users, to which mobility options do they have access to, and which barriers exist to using shared mobility services at the Mobility Station and in general?

By means of the users and non-users surveys, the demographic characteristics of both users and non-users, and their access to mobility options were explored and compared. These in turn were compared to the average Munich population, where comparable information was available. Moreover, the motivations and barriers for the use of shared mobility services were further explored by means of focus groups.

While the user survey was carried out online and had an average response duration of 10 minutes, the non-user survey was carried out in the form of face-to-face interviews, each lasting approximately 3 minutes. This restricted time frame limited the amount of questions that were possible to include in the questionnaire hindering a more detailed comparison between users and non-users.

Users of the Mobility Station can be classified in three subgroups according to the mobility service they were identified to be customers of:

1. bikesharing (BS) users: customers of MVG Rad;
2. free-floating carsharing (FFCS) users: customers of DriveNow and car2go, and,
3. station-based carsharing (SBCS) users: customers of STATTAUTO.

It should be noted that the sample of FFCS respondents is dominated by DriveNow customers, with 88% of the total FFCS sample. Also, the sample of SBCS customers is rather small (n=17) due to the fact that the STATTAUTO vehicle was rented in average five times per month. Therefore, all results regarding this group should be interpreted with caution.

6.2.1. Demographic characteristics

The analysis of demographic characteristics shows that more than 70% of users are men, while non-users present a more balanced distribution of women and men. Users are in general younger than non-users, and both are younger than the average Munich population.

Table 6.2 presents a summary of demographic characteristics of all users and the subgroups of users (FFCS, SBCS, and MVG Rad users) as well as non-users and the Munich population.

Table 6.2: Demographic characteristics of users, non-users and the Munich population

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="4">Users subgroups</th><th rowspan="2">Non-users</th><th rowspan="2">Munich</th></tr>
<tr><th>BS</th><th>FFCS</th><th>SBCS</th><th>Total</th></tr>
<tr><td colspan="2">Size of sample (n)</td><td>420</td><td>174</td><td>17</td><td>611</td><td>473</td><td>(-)</td></tr>
<tr><td colspan="2">Percentage of sample (%)</td><td>69</td><td>28</td><td>3</td><td>100</td><td>100</td><td>(-)</td></tr>
<tr><td rowspan="3">Gender of respondents (%)</td><td>Male</td><td>73.3</td><td>83.3</td><td>82.4</td><td>76.4</td><td>51.6</td><td>49.6</td></tr>
<tr><td>Female</td><td>24.8</td><td>16.1</td><td>17.6</td><td>22.1</td><td>48.4</td><td>50.4</td></tr>
<tr><td>n.a.</td><td>1.9</td><td>0.6</td><td>0.0</td><td>1.5</td><td>0.0</td><td>(-)</td></tr>
<tr><td rowspan="5">Age group of respondents (%)</td><td>18-29</td><td>55.5</td><td>41.4</td><td>17.6</td><td>50.4</td><td>42.7</td><td>19.2</td></tr>
<tr><td>30- 39</td><td>25.5</td><td>33.9</td><td>5.9</td><td>27.3</td><td rowspan="2">40</td><td>20.8</td></tr>
<tr><td>40-49</td><td>13.3</td><td>16.1</td><td>29.4</td><td>14.6</td><td>18.6</td></tr>
<tr><td>50-59</td><td>3.1</td><td>5.7</td><td>35.3</td><td>4.7</td><td>11.8</td><td>14.5</td></tr>
<tr><td>> 59</td><td>1.7</td><td>2.3</td><td>11.8</td><td>2.1</td><td>5.5</td><td>26.8</td></tr>
<tr><td colspan="2">Respondents with at least a bachelor’s degree (%)</td><td>64.3</td><td>62.1</td><td>88.2</td><td>64.3</td><td>n.a</td><td>29.9</td></tr>
<tr><td colspan="2">Average number of household members per household</td><td>2.1</td><td>2.0</td><td>2.1</td><td>2.1</td><td>n.a</td><td>(-)</td></tr>
<tr><td colspan="8">Sources: unless otherwise indicated, the values presented in this table come from the users survey and non-users survey respectively. Other sources: Gender and age of the Munich average population: (Landeshauptstadt München, 2017); share of population with at least a bachelor’s degree: (BLSD, 2014)</td></tr>
</table>

The demographic characteristics of FFCS users correspond to those obtained as part of the carsharing evaluation in Munich (EVA-CS) (team red, 2015), and the WiMobil study in Munich and Berlin (Müller et al., 2015) which in part validates the sample of users of the Mobility Station identified as FFCS carsharing users.

Demographic characteristics of bikesharing users in Munich were not available by the time of writing this dissertation. Thus, it was not possible to validate the sample of users of the Mobility Station identified as bikesharing users.

The demographic characteristics of STATTAUTO users in Munich reported by Krietemayer (2003) are different to those of the users of the Mobility Station identified as SBCS users (49% of women, 54% younger than 40 years old). However, due to the small sample size in this study, and the age of the previous sample, it is not possible to validate the first.

Non-users are in some aspects different than the average Munich population but due to the way they were recruited for the face-to-face interviews it is not possible to validate this sample (see Section 5.3.3).

6.2.1.1. Gender

More than 70% of bikesharing users and more than 80% of carsharing users were men. In contrast, the distribution of male and female non-users is more balanced like the overall Munich population (see Figure 6.3 below).

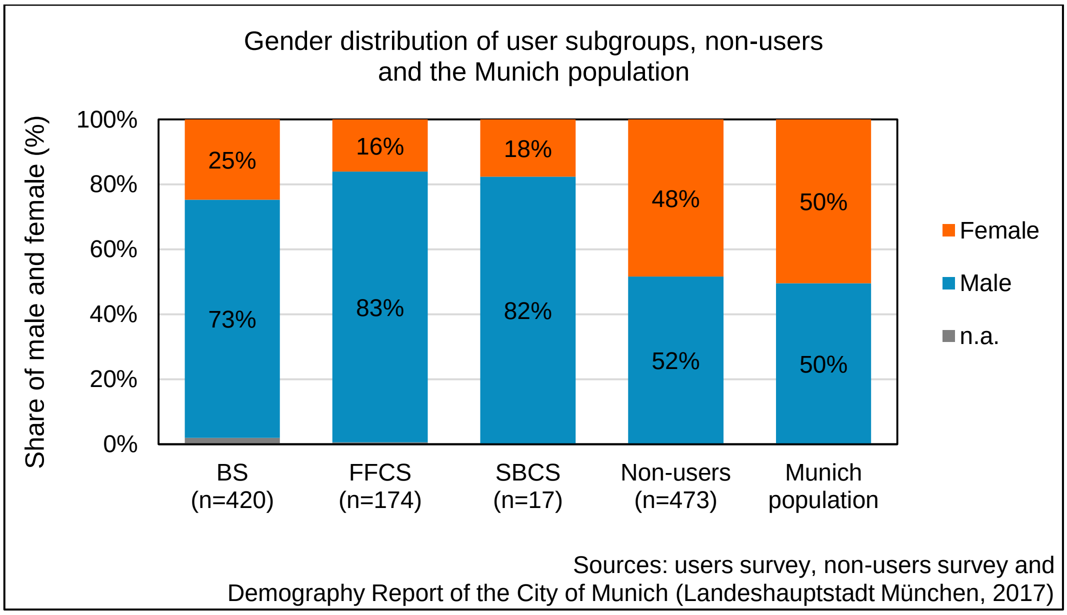


Figure 6.3: Comparison of gender distribution among user subgroups, non-users and the Munich population

The gender distribution of users of the Mobility Station at Münchner Freiheit is more or less consistent with that of users of mobility stations in Offenburg and Würzburg (see Section 3.2.5.2). While the proportions of male and female participants may vary, the majority of users of mobility stations in each of these cities are male.

6.2.1.2. Age

A rough[19] comparison between users and non-users regarding the age groups shows that there are no significant differences regarding their age and that both, users and non-users, are younger than the average Munich population (see Figure 6.4).

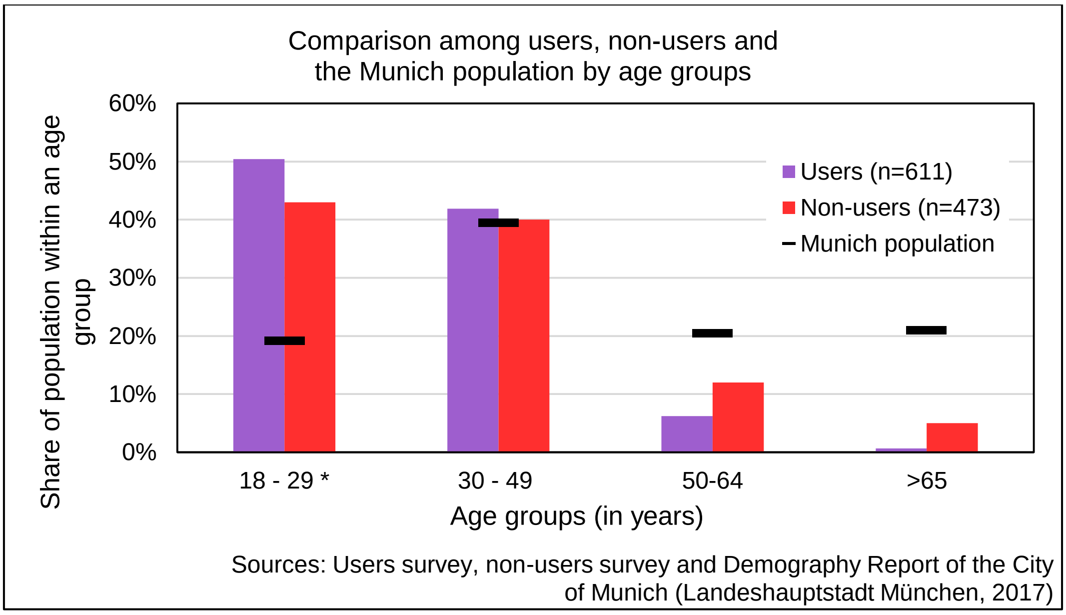


Figure 6.4: Comparison among users, non-users and the Munich population by age groups

This could be explained by the fact that older people are less mobile, thus they are not well represented in any of the samples.

In a more detailed analysis, the user subgroups are compared to the Munich population (see Figure 6.5).

Compared to the overall Munich population, FFCS and BS users are better represented by younger generations. About 80% of these subgroups is younger than 40 years old, while only 40% of the Munich population falls in this category.

[19] A more detailed comparison was not possible since the age of non-users was classified in more coarse age groups than those of the user survey.

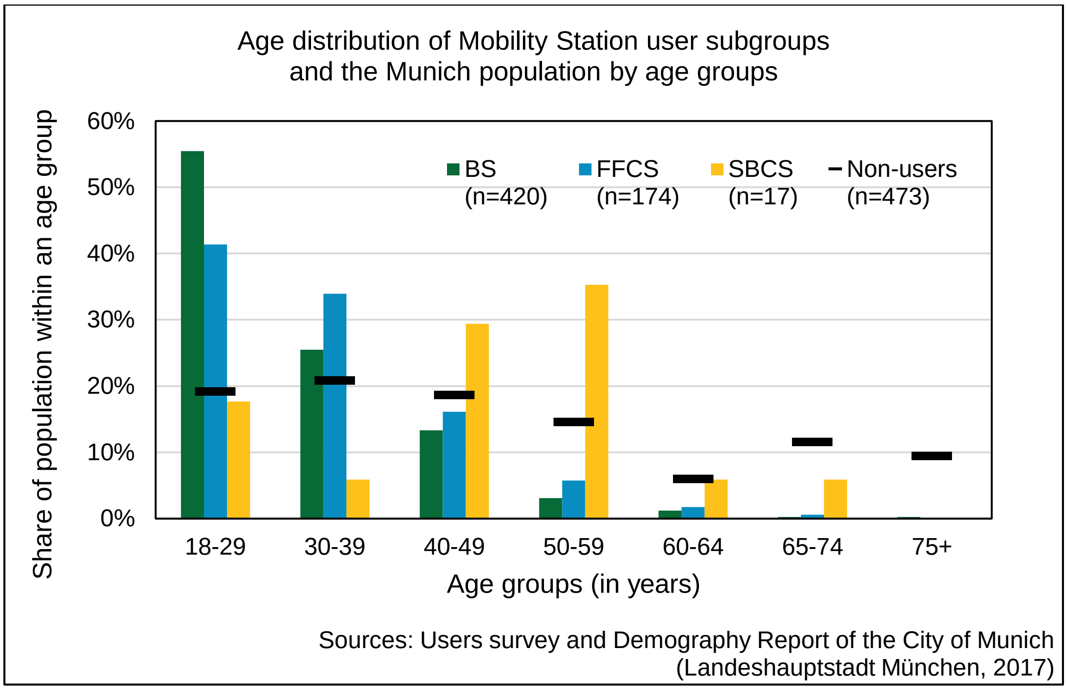


Figure 6.5: Comparison among users of different mobility services and the Munich population by age groups

Also, it is observed that BS and FFCS users are generally younger than SBCS users. Again, due to the small size of the sample of SBCS users, the results regarding this last group should be interpreted with care.

6.2.1.3. Education

The share of Mobility Station users with a bachelor's degree is 64%, more than double the share within Munich's population (29.9%) (BLSD, 2014). This is again consistent with the demographic characteristics of carsharing users in Munich (team red, 2015) as well as the users of shared mobility services in Offenburg and Würzburg (Heller, 2016; Pfertner, 2017). Due to the limitation of time for the face-to-face interviews, this information was not captured for the non-users.

6.2.2. Mobility portfolio

The *mobility portfolio* is understood in this context as the set of mobility options available to, and used by an individual. Users and non-users were inquired about which traditional modes of transport are available to them as well as their familiarity with and general use of shared mobility services.

The results show that users have a wider set of mobility options than non-users. FFCS users, BS users, and non-users all have a similar access to traditional modes of transport, but the use of shared mobility services is much lower among non-users. Among all users, SBCS users have the lowest levels of car availability and the highest share of possession of annual passes for public transport.

The following subsections present a detailed comparison of the availability of traditional transport modes and shared mobility use between user's subgroups and non-users.

6.2.2.1. Traditional modes of transport

The availability of "traditional" modes of transport such as private cars, public transport, and bicycles is fairly similar among FFCS, BS users, and non-users. See Table 6.3.

Table 6.3: Traditional modes of transport available to users and non-users

		User subgroups			Users	Non-users	Munich
		BS	FFCS	SBCS			
Size of sample (n)		420	174	17	611	473	(-)
Percentage of sample		69	29	2	100	100	(-)
Respondents with a public transport pass (%)		70.7	59.8	58.8	67.3	74	43%
Respondents with car availability (%)	Always	38.1	36.2	5.9	36.7	35.1	(-)
	Sometimes	30.0	30.5	23.5	30.0	26.9	(-)
	Never	31.9	33.3	70.6	33.4	37.1	(-)
Average number of cars available per household		0.8	0.7	0.1	0.8	n.a	0.9
Households with access to at least one bike (%)		89	90	100	89	n.a	83

Sources: unless otherwise indicated, the values presented in this table come from the user survey and non-user survey respectively. Other sources: Share of Munich population with a public transport pass (Landeshauptstadt München, 2013); Average number of cars available per household and share of households with at least one functioning bike in Munich (infas, 2010)

The majority of both users and non-users have a public transport pass. While almost 60% of carsharing users have some kind of public transport pass, more than 70% of bikesharing users and non-users have one (see Figure 6.6). In both cases this is well above the share of the overall Munich population (43%) with a public transport pass (Landeshauptstadt München, 2013) .

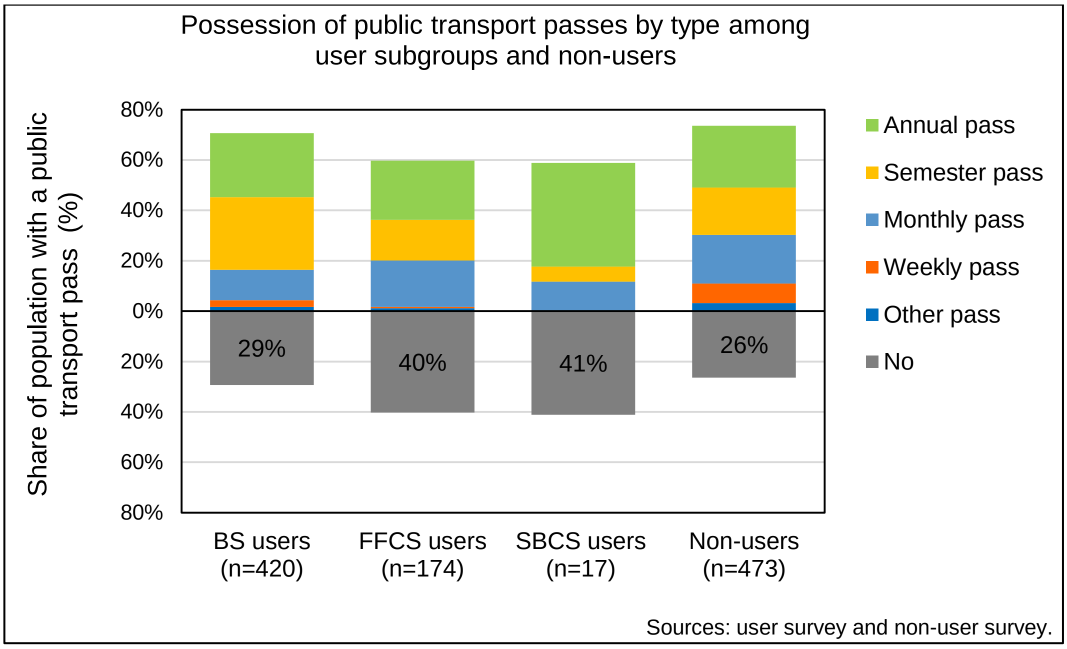


Figure 6.6: Possession of public transport passes by type among user subgroups and non-users

The number of cars per household among users of bikesharing (0.8), FFCS (0.7), and non-users (0.8) is quite similar and slightly below the average in Munich (0.9) (infas, 2010). This is consistent with various studies on carsharing which indicate that carsharing members own less cars than the average population (team red, 2015; Loose, 2010). SBCS users have the lowest amount of cars per households with an average of 0.1.

Regarding the availability of cars, it was observed that this aspect was very similar among BS users, FFCS users, and non-users. However, the availability of private cars among SBCS users is lower compared to these three groups and even lower compared to the EVA-CS control group[20] in which 73% always had a car available (see Figure 6.7).

[20] The EVA-CS control group refers to non-users of carsharing in München which were interviewed as part of the EVA-CS project (team red (2015).

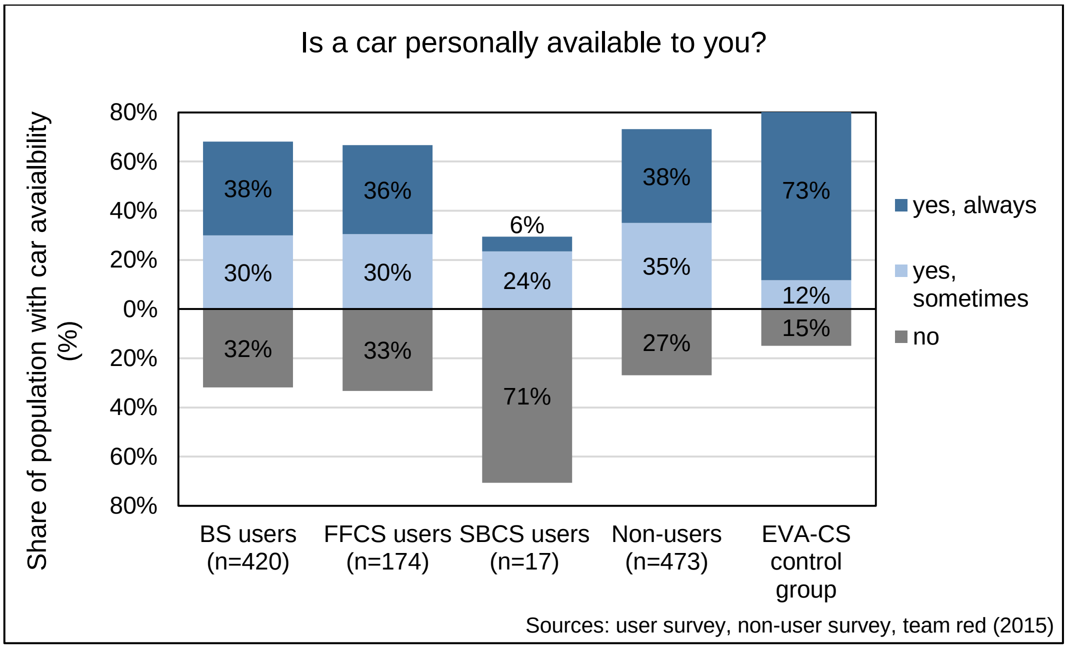


Figure 6.7: Availability of cars to user subgroups, non-users and the Munich average

Finally, almost all users (89%) have at least one functioning bike in their household. Due to the time limitation for the face-to-face interviews, non-users were not inquired about their possession of a personal bike. It is assumed though that non-users are similar in this aspect to the general Munich population among which 83% have at least one functioning bike (infas, 2010).

6.2.2.2. Shared mobility services

Regarding the familiarity with and use of shared mobility services, the differences among users and non-users are more evident than those regarding the availability of traditional modes of transport.

A large majority of users are familiar with and use a diverse set of shared mobility services, especially the mobility services the users were identified to be customers of. Many non-users are also aware of shared mobility services but only a few actually use them (see Figure 6.8).

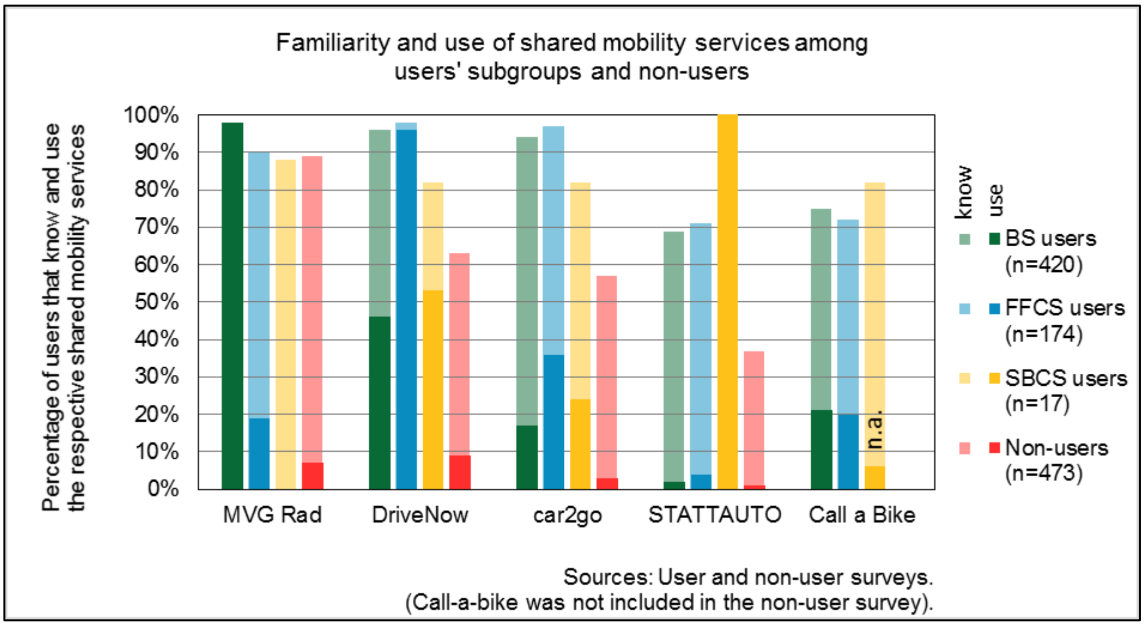


Figure 6.8: Familiarity and use of shared mobility services among users of the Mobility Station and non-users

Even though *Call a Bike* has been operating in Munich since 2000, and MVG Rad started operations by the end of 2015, about 20% more FFCS and MVG Rad users are aware of the latter.

A comparison between the familiarity and use of shared mobility services among user subgroups indicates that more STATTAUTO customers use FFCS (over 50% use DriveNow and over 20% use car2go) than FFCS customers use STATTAUTO (around 5%), though 71% are familiar with the provider. This could mean that the station-based service is not sufficient for STATTAUTO customers, while the free-floating service is sufficient for FFCS customers. However, this interpretation must be considered carefully since the sample of STATTAUTO customers is rather small compared to the sample of FFCS users.

While non-users can be considered “multimodal” it is clear that their multimodality level is lower than that of the users, even though it was not possible to estimate a multimodality index with the available information.

6.2.3. Motivations for the use of shared mobility services

The motivations for the use of carsharing and bikesharing among users of the Mobility Station, as well as typical occasions for their use, were further explored by means of focus groups. See Section 5.4 for more details about this method.

In general, it can be said that the use of shared mobility services is often motivated by economic reasons and that users of both carsharing and bikesharing appreciate the flexibility that shared mobility services offer for different occasions (up2date, 2016).

In the following sub-sections the motivations for the use of carsharing and bikesharing are presented in detail. The presented results are, unless otherwise indicated, based on the report delivered by the moderator of the focus groups (up2date).

6.2.3.1. Motivations for using carsharing

Based on the discussions with users, it can be said that the main motivations for using carsharing are the following:

1. Economic reasons:
    a. Carsharing is perceived to be cheaper than owning a car: users recognize that owning a private car may not be worthwhile financially; purchasing a car and maintaining it is perceived as too expensive, especially in the city.
    b. Carsharing can be cheaper than other options: in some situations, for example when traveling with other persons to some specific destinations such as the airport, carsharing can be even cheaper than using public transport; or it can be cheaper than using a private car and paying for parking.
    c. Economic incentives for the registration also play a role. The possibility to register for free, or with some kind of discount for public transport pass owners, was an incentive for some to become customers.

2. Flexibility:
   a. the possibility to use different types of vehicles depending on the purpose (i.e. a bigger vehicle to transport heavy goods, a convertible when the weather is nice, small vehicle for trips into the city); and
   b. the possibility of one-way trips.
3. Comfort: Users also appreciate that they do not have to worry about the maintenance and cleaning of their vehicles.
4. The possibility to use electric vehicles.

According to Loose (2010), costs considerations and convenience are also the main motivations for joining carsharing elsewhere in Europe.

6.2.3.2. Motivations for using MVG Rad

According to the group discussion with users, the use of MVG Rad was motivated by different aspects, such as:

1. free registration and tariff discount for public transport pass owners;
2. access to a private bike is not available at all, or the owners prefer to use the public bike at certain times, for example during winter;
3. curiosity: some users became curious after seeing advertisement and wanted to try it.

6.2.4. Barriers for the use of shared mobility services

The specific barriers for the use of carsharing and bikesharing were identified first through the non-user survey, and later by means of the focus groups, it was possible to understand these reasons further and identify potentials for future use.

In general, the main reason for not using shared mobility services was simply that they were not considered necessary. The available private modes (cars or bikes) and other mobility options were considered to be sufficient.

Based on the group discussions, it was found that while non-users have a positive opinion of shared mobility services, they cannot think of any occasions for using them because other modes of transport are sufficient for their daily mobility (up2date, 2016).

Moreover, based on the discussions with non-users, two other barriers were identified:

1. a lack of knowledge or incomplete information about shared mobility services: in contrast to users of shared mobility services, non-users perceive them as expensive, inflexible, and complicated.
2. a lack of willingness or motivation to become informed on how the shared mobility services function.

6.2.4.1. Barriers for using carsharing

From the discussions with non-users, it was evident that they had little knowledge about the carsharing services, and that they did not have complete information about the diversity of business models available. For example, some non-users considered carsharing too expensive, citing that the payment is per minute and that meant the cost for trips out of the city, or at times with high congestion, would be prohibitive:

"It has to get cheaper. To me, it's too expensive. And there has to be some way I can drive farther, for example, into the mountains. But I wouldn't want to pay some stupidly high amount to do so, since the cost is calculated by the minute. There should be weekend deals." (non-user, focus groups)

While this is true for the free-floating services, it shows a lack of familiarity with station-based services.

On the other hand there is some degree of openness towards carsharing, and some of the participants are considering becoming members:

"I've actually already thought about that. I think it's practical, now that DriveNow includes parking." (non-user, focus groups)

6.2.4.2. Barriers for using MVG Rad

Despite the general acceptance and positive opinion of MVG Rad, non-users cannot imagine a reason for using it personally, especially when their own bike is available.

In general, it was observed that non-users have little information about the system and at the same time a lack of motivation to inform themselves about it:

„I haven't actually looked into it. I've been too lazy. My needs are covered anyway, so it seems unnecessary" (non-user, focus groups)

Some non-users expect a more direct advertisement as well as incentives to test the service:

„I need an advertisement that's directed towards me. I always see it around, and it interests me somehow, but I never take the time to really look into it" (non-user, focus groups)

Nonetheless, there are some plausible scenarios for using MVG Rad. For example, for going out or when they have visitors but not enough bikes to make a trip together:

A few days ago, I thought to myself that it'd be cool, to take the bikes into Munich when you know you're going to be drinking later. Then you can just let the bike stay there. Other than through MVG Rad, I can't do that, I've always got to think about how I'm going to get my bike home. "(non-user, focus groups)

6.2.5. Summary

The characteristics of users and non-users presented in Section 6.2 are summarized below in Box 1.

Box 1. Who are the users of the Mobility Station and who are the non-users?

Users are:	**Non-users are:**
Predominantly male… More than 70% of users are men	**50 / 50** The sample of non-users present a balanced distribution of women and men
…young… About 80% of users are younger than 40 years old.	**…young-ish…** 80% is younger than 50 years old.

Both users and non-users are younger than the average Munich population: only 40% of the Munich population is younger than 40 years old.

…well educated… The share of users with a bachelor's degree is more than double compared to the overall population.	**…hard to say…** (This aspect was not captured in the face-to-face interviews due to time restrictions)
…multimodal and sharers… Next to the traditional modes of transport, users are familiar with and use different shared mobility services	**…multimodal but not really sharers…** Shared mobility services are fairly well-known among non-users, but only a small percentage actually use them.
The main **motivations** for using shared mobility services among users are: 1. saving money, 2. flexibility, 3. practicality.	The main **barriers** among non-users for using shared mobility services are that they are perceived as: 1. not necessary for daily mobility, 2. expensive, inflexible, and complicated

6.3. Awareness of the Mobility Station

By means of the user and non-user surveys, the level of awareness and sources of awareness of the Mobility Station of both groups were analyzed and compared. The awareness and perception of the Mobility Station among users and non-users was further explored through the focus groups. The latter also gave some insights about the relevance of the on-site information screen for users and non-users.

The following sub-sections provide further details on these results and how they were obtained.

6.3.1. General awareness

The majority of both users (60%) and non-users (62%) were in some way aware of the Mobility Station. Similar results were obtained in Offenburg and Würzburg (see Section 3.2.5.2) where more than 70% of users and around 50% of non-users were aware of the Mobility Stations in the respective cities (Heller, 2016; Pfertner, 2017).

For the interpretation of the results in this study, it has to be considered that the questions addressed to each group were slightly different:

- Users were asked if they were *consciously aware* that the Mobility Station at the Münchner Freiheit offered to them different alternatives to private car, which were connected and combinable[21]. See user survey in Annex B-1.
- Non-users were asked if they knew of the Mobility Station before that interview, after showing them a picture[22]. See non-user survey design in Annex B-2.

Thus, it is possible that more than 60% of users were aware of the Mobility Station but they did not consider themselves to be *consciously aware* that it offered them alternatives to private cars.

[21] The exact question in German was: „Ist Ihnen bewusst, dass es sich bei der Münchner Freiheit um eine Mobilitätsstation handelt, bei der Sie verschiedene Alternativen zum Privatauto gebündelt und kombinierbar angeboten bekommen?"

[22] The exact question in German was: „Kannten Sie vor diesem Interview die Mobilitätsstation hier an der Münchner Freiheit?"

While the awareness of the Mobility Station is relatively high, not everyone recognizes the concept behind it. Through the group discussions, it was observed that among both users and non-users, the term „mobility station“ is not widespread and that the Mobility Station at Münchner Freiheit is not recognized as one holistic concept that puts together all kinds of mobility services. Many users think that it is just an additional service for carsharing or bikesharing without recognizing the multimodal and intermodal character of the station (up2date, 2016).

6.3.2. Main sources of awareness

The main reason for being aware of the Mobility Station is due to its presence on public space. More than half of users and non-users became aware of the Mobility Station by walking past. See Figure 6.9.

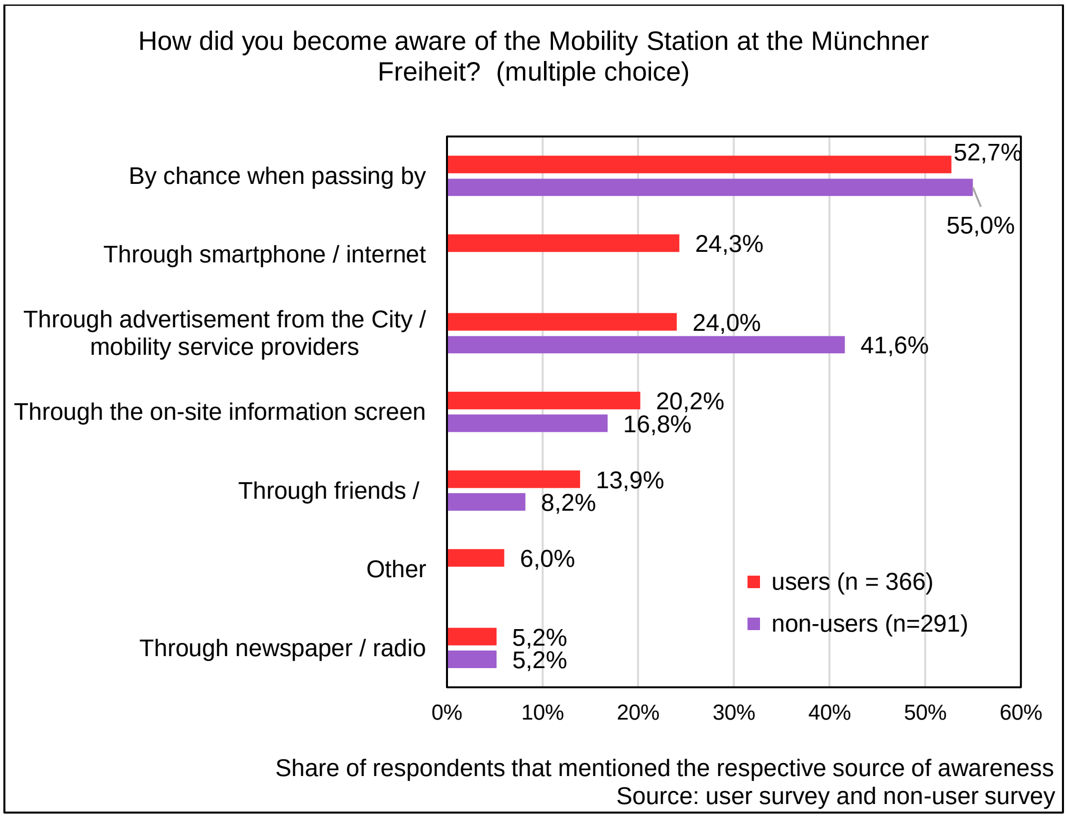


Figure 6.9: Sources of awareness of the Mobility Station among users and non-users

Walking past was also the main reason for being aware of the mobility stations in Offenburg (43% of users and 77% of non-users) and Würzburg (56% of users) as well (Heller, 2016; Pfertner, 2017). See Section 3.2.5.2 for more details on awareness sources in these cities.

About 42% of non-users said advertisement of the Mobility Station was the source of their awareness, while this was only true for 24% of the users. It should be mentioned that the non-user survey was carried out directly after the marketing campaign. This in part shows the marketing campaign's impact on awareness among non-users.

Almost 25% of users said they became aware of the Mobility Station through the internet or smartphone, while this was not a relevant source for non-users.

Another important source of awareness of the Mobility Station is the on-site information screen, which was mentioned by 20% of users and 17% of non-users. In Würzburg, the impact of the "info pillars", a design element comparable to the on-site information screen, was even higher: 52% of users became aware of the mobility stations in that city through these design elements (Pfertner, 2017). This was especially surprising considering that the info pillars in Würzburg are smaller and do not have an interactive screen as the information screen at Münchner Freiheit does.

Through the focus groups, it became clear that the on-site information screen was not consciously noticed by neither users nor non-users. None of the participants were able to say exactly what kind of information was available or what functions it had (up2date, 2016). According to the participants, the functions of the on-site information screen (real time information on the location of shared vehicles and departure times of public transport) were not considered relevant since this information can be obtained through their smartphones. Rather, they expected other functions such as registering for a mobility service or starting a rental (like the booking terminals in Leipzig).

The participants of the non-user focus group mentioned the charging station and the MVG Rad docking station, the latter being visible from the tram and bus stop, as noticeable elements (up2date, 2016), underlining once again the importance of visible elements on the cityscape for raising awareness.

These results highlight the importance of the visibility of the mobility stations in the urban landscape. Considering that "passing by" is the main source of awareness for users and non-users – in Munich and other cities in Germany as well – it can be said that the presence of visible elements on public space is the most important source of awareness for mobility stations.

6.4. Usage patterns of the Mobility Station

How often the mobility services at the Mobility Station are used and for what purpose? Where do they go when they rent a shared car or bike. From where do they come when they return a shared vehicle? Do users combine different mobility services or do they use them separately?

In order to understand how the Mobility Station is used, users were asked about their frequency of use of the different mobility options available on site, as well as the purposes for which they use them. Moreover, the analysis of operational data from the shared mobility services provides further detail on how they are used at the Mobility Station. Finally, access to and egress from the station by mode, as reported in the user survey, were analyzed.

Due to the limited time for the face-to-face interviews with non-users, usage patterns of mobility services for this group were not captured. In the following sections, usage patterns regarding the mobility services at the Mobility Station are compared among subgroups of users.

6.4.1. Development in the use of shared mobility services

The Mobility Station registered an increase in use since its rollout in November 2014 with carsharing services. Figure 6.10 below shows this development based on operational data provided by DriveNow and MVG Rad.

FFCS trips starting and ending at the station increased steadily from 114 in November 2014 to 400 one year later. The low number of FFCS trips in August 2016 might be due to the fact that during that month there was a construction site next to the carsharing parking spaces hindering their use. The one SBCS vehicle provided at the Mobility Station is used on average six times per month (not displayed in figure).

Bikesharing trips also increased from 200 in October 2015, when MVG Rad began operation at the station, to over 800 in August 2016, only showing a decrease during the winter months.

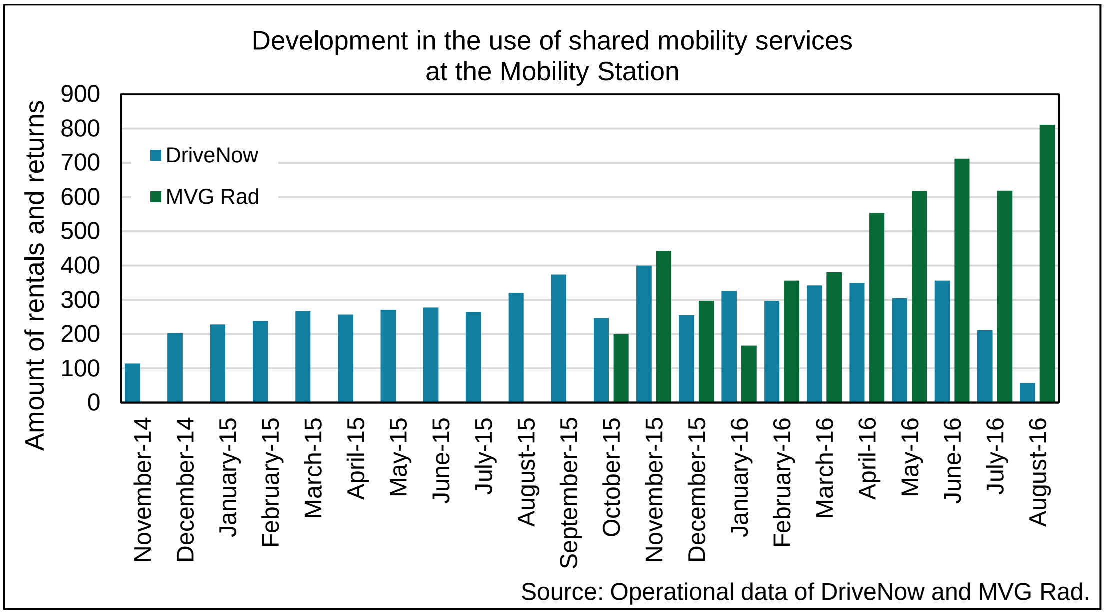


Figure 6.10: Development in the use of shared mobility services at the Mobility Station

Also, first observations from the FFCS carsharing providers indicated that more rentals than returns at the Mobility Station were happening and they had to bring vehicles back to the Mobility Station to satisfy the demand for rentals at this location (Stakeholder interview with representatives of DriveNow, May 26, 2015 and with representatives of car2go, June 16, 2015).

According to representatives of car2go, since the opening of the Mobility Station, the number of rentals at this location increased while rentals in the surrounding area slightly reduced in number, and it was assumed that the rentals at the Mobility Station were relocated from the surrounding area. CiteeCar had a similar experience: in addition to the vehicle assigned to the Mobility Station, another car was assigned to the parking zone where the Mobility Station is located. The car at the Mobility Station was booked significantly more often than the other car. As a result, the latter was taken out of operation from that zone. (Stakeholder interview with representative of CiteeCar, July 15, 2015). This indicates that the Mobility Station offers an added value to the customers, in comparison to cars randomly located in a parking zone or service area.

6.4.2. Use frequency of mobility services at the Mobility Station

One of the initial assumptions regarding the use of mobility services at the Mobility Station was that users of shared mobility services use the mobility service of which they are customers of, more often than any other mode of transport (see user survey in Annex B-1).

The results obtained from the user survey show, however, that the mobility service most frequently used by the three user subgroups at the Mobility Station is public transport. Around 70% of carsharing users (FFCS and SBCS) and 80% of MVG Rad users (BS) use public transport at least once a week. See Figure 6.11.

The second most frequently used mobility service is the one that the users were identified to be customers of:

- 21% of users identified as MVG Rad customers use MVG Rad many times a week, and 23% use it once a week.
- About 14% of users identified as FFCS (DriveNow or car2go) customers use FFCS many times a week, and up to 25% use FFCS once a week.
- 6% of users identified as STATTAUTO customers[23] use this option many times a week, and 18% use it once a week, as much as often as they use car2go.

Finally, it can be observed that some customers of MVG Rad use FFCS services relatively frequently and similarly some FFCS customers use the MVG Rad relatively frequently:

- 5% of MVG Rad users use free-floating carsharing services at least once a week and 17% once a month.
- Another 5% of FFCS users use MVG Rad at least once a week and 11% use it once a month.

While other mobility services such as taxis and bike parking racks are used less frequently, the frequency of use of the different mobility services at the Mobility Station by different user subgroups reveals some degree of multimodality among users. The initial assumption that users of shared mobility services use these more frequently than any other transport mode is thus incorrect.

[23] To be considered that the sample of STATTAUTO respondents is only 17, so that the 6% represents the answer of only one person and the 18% three persons that could be the same using STATTAUTO and car2go

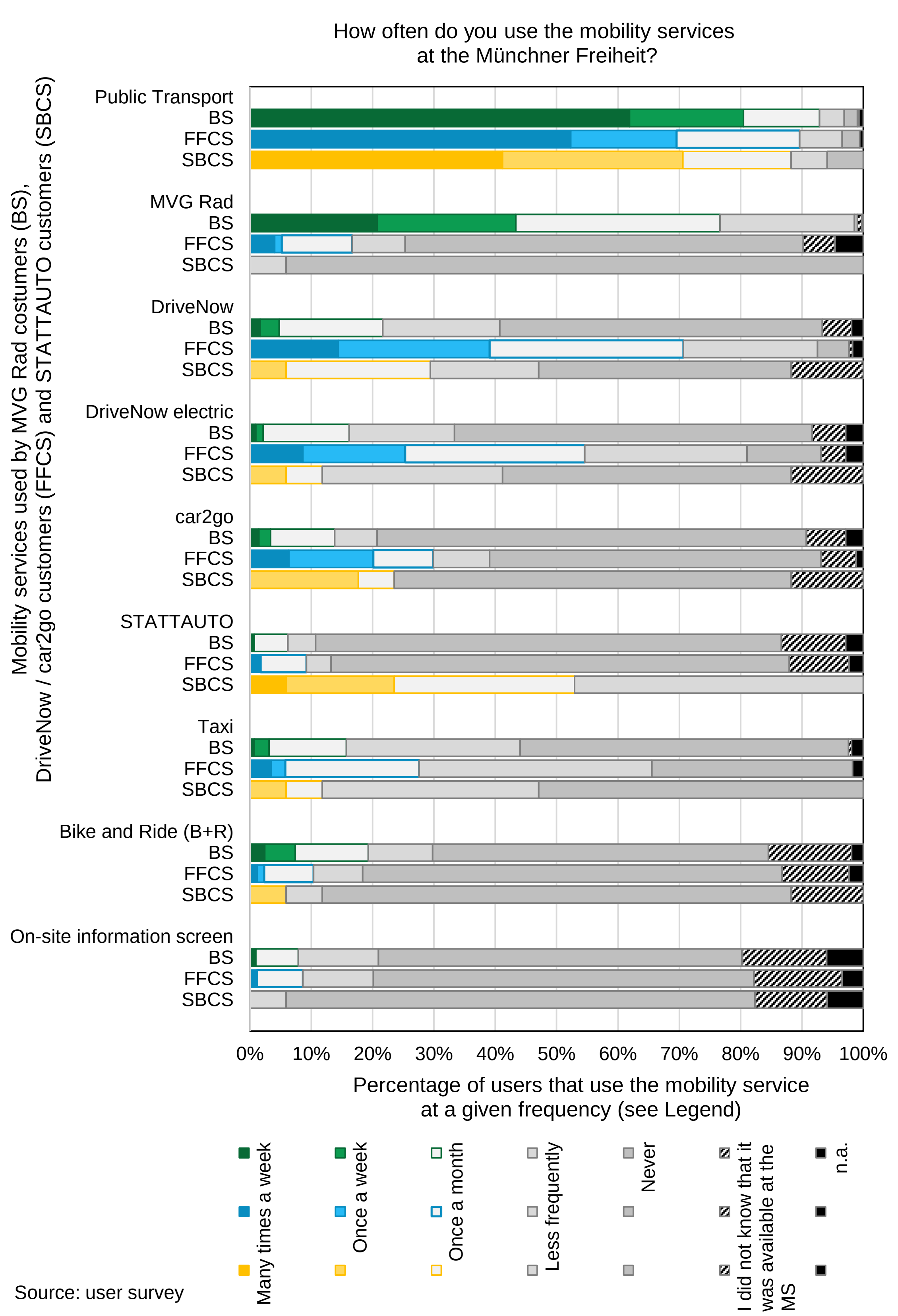


Figure 6.11: Frequency of use of mobility services at the Mobility Station by each of the three user subgroups

The share of users who were not aware of some of the mobility services available vary depending on the user subgroup and the mobility service in question. It is worth noting that the Bike and Ride facilities and the information screen are the components that are least known among users, indicating potential for improvement in the visibility and marketing of the various components.

6.4.3. Purpose for using mobility services at the Mobility Station

Users who claimed to use a mobility service at the Mobility Station at least once a month were asked to indicate for which purposes they use them in general. Worth mentioning is that the possible answers to this question were offered as multiple choice, and that there is not a direct connection between the frequency of use of a mobility service and the purpose (see user survey design in Annex B-1). That means, for example, that a respondent might use public transport every day to go to work and once a week for shopping. In this case both answers about the different purposes for using this mode have the same weight in the results.

To better understand the purposes for using different mobility services at Münchner Freiheit, the results were filtered to show only the purposes for which the mobility service in question was used at least once a week. See Figure 6.12.

The results show that the mobility services at the Münchner Freiheit are used for diverse purposes:

- 471 users (77% of all respondents) use public transport at least once a week and the three main purposes mentioned are: work/education, errands/shopping and leisure.
- 191 (31% of all respondents) use the MVG Rad at least once week, and similar to the purposes for using public transport, the three main purposes are work/education, errands/shopping and leisure.
- 141 (23% of all respondents) use FFCS at least once a week and the two main purposes are shopping and leisure, while trips to work/education and business related also play an important role.

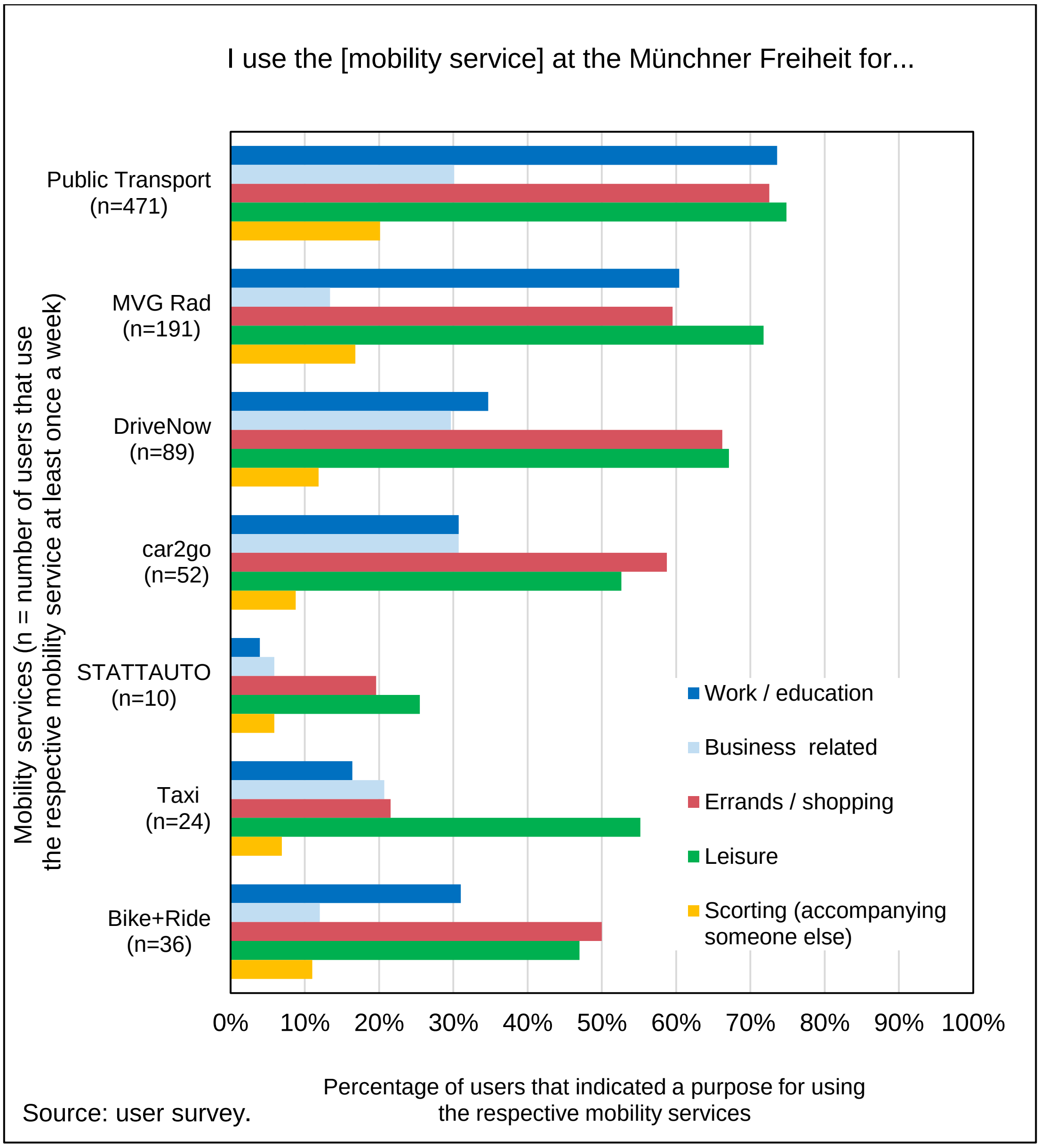


Figure 6.12: Purpose of using mobility services used at least once at the Münchner Freiheit by users of the Mobility Station

According to a survey among car2go and DriveNow customers (n=2881), the most common reasons for using FFCS are visiting friends and family (49%), going out to eat/drink (48%), shopping/transport (45%), for journeys to and from work (44%), and trips to the airport (31%) among others (car2go and DriveNow, 2015). Although the categories are not exactly the same, the results indicate that there are no main differences in the way users of the Mobility Station that use FFCS and other FFCS users use these services.

6.4.4. Detailed analysis regarding the use of shared mobility services

The user survey, especially through the questions on the last trip (see user survey design in Annex B-1), and supported by the analysis of operational data, details about the use of shared mobility services were obtained.

Table 6.4 presents a summary of the analysis of operational data of four providers of shared mobility services at the Mobility Station.

Table 6.4: Summary of operational data of four types of shared mobility services

Operational data	MVG Rad	DriveNow	STATTAUTO	CiteeCar
Timeframe of analyzed data	09/10/15 – 31/10/16	15/10/15 – 29/08/16	06/11/2014 – 22/07/2016	6/11/2014 – 15/07/2015
Total number of rentals analyzed	6335	3122	130	121
Number of users	-	2727	62	42
Average rentals per month	511	316[a]	6.3	15.1
Average rentals per day	17	11	0.2	0.5
Rental-return ratio	60%:40%	69%:31%	n.a.	n.a.
Average traveled distance per rental (km)	2.5[b]	13	104	53.2
Average rental duration[c] (minutes)	15	31	888	291
(a) August 2016 is not considered in this value because during that month the carsharing parking spaces were temporarily blocked for construction works. (b) Derived from the Euclidean distance between the start and end coordinates and a factor of 1.5 (c) Only „driving minutes“ considered (parking duration between trips within the same rental are not included)				

The average trip duration of trips starting or ending at the Mobility Station with MVG Rad is 15 minutes. It is not clear if this average trip duration is particular to this location, or if it is the same throughout the entire MVG Rad system. (Reiss and Bogenberger, 2017) report an average of 30 minutes with another bikesharing system in Munich (Call a Bike). However, the business models of these two bikesharing systems are somewhat different (see Section 4.2.3.2) which may have a large impact on average rental time.

The average trip distance of FFCS trips starting or ending at the Mobility Station is exactly the same as reported by Müller et al. (2015) for FFCS trips across Munich. Similarly, the average trip duration of trips starting or ending at the Mobility Station is exactly the same as the average trip duration reported by Bogenberger et al. (2016) for FFCS trips generally throughout Munich.

These results indicate that there are no differences between FFCS trips starting and ending at the Mobility Station and those performed in the rest of the city.

In the case of ZBCS and SBCS services, the average travel distance and trip duration are considerably larger than those with FFCS. This is explained by the fact that ZBCS and SBCS services are used for different purposes, and more often for trips over the weekend and during holidays.

As part of the user survey, respondents were asked if they could recall their last trip when they rented or returned a vehicle or bike at the Mobility Station, and in case of a positive answer, they were asked to provide details. The results show that:

- 87% of FFCS users could remember their last trip, 69% of which rented out a vehicle at the Mobility Station and 31% returned it.
- 96% of MVG Rad users could remember their last trip, 68% of which rented out a bike at the Mobility Station and 32% returned it.

The rental-return ratios of MVG Rad and FFCS as reported by the users were validated with the operational data provided by MVG Rad and DriveNow. See Table 6.4.

Due to the limited number of SBCS users who used the Mobility Station during the survey period, the details about their last trip were not analyzed further.

According to the user survey, for this last trip, 77% of FFCS users did not experience any problems looking for a parking spot and drove directly to the Mobility Station, while 23% looked first for a parking space elsewhere. Of those who looked for a parking space elsewhere, 9% took less than a minute, for 73% took between 1 and 5 minutes, and 18% took between 6 and 10 minutes.

Conservatively, the average search time for a parking space among those who were not aware of the Mobility Station, or at least the availability of reserved carsharing parking, is 3 minutes. Considering that the average travel time with FFCS is 30 minutes, it can be said that 10% of the total time of a trip was for searching a parking space. This indicates that the Mobility Station contributes to save time and money for those users that are aware of the reserved parking spaces available to them.

6.4.4.1. Temporal usage patterns of shared mobility services

Through the analysis of operational data, it was possible to identify temporal and spatial usage patterns of bikesharing and FFCS.

Bikesharing

The hourly distribution of trips with MVG Rad that start and end at the Mobility Station presents a peak between 7:00 and 10:00 AM, with 10% of the total trips and a second peak between 17:00 and 20:00 with 15% of the total trips. See Figure 6.13.

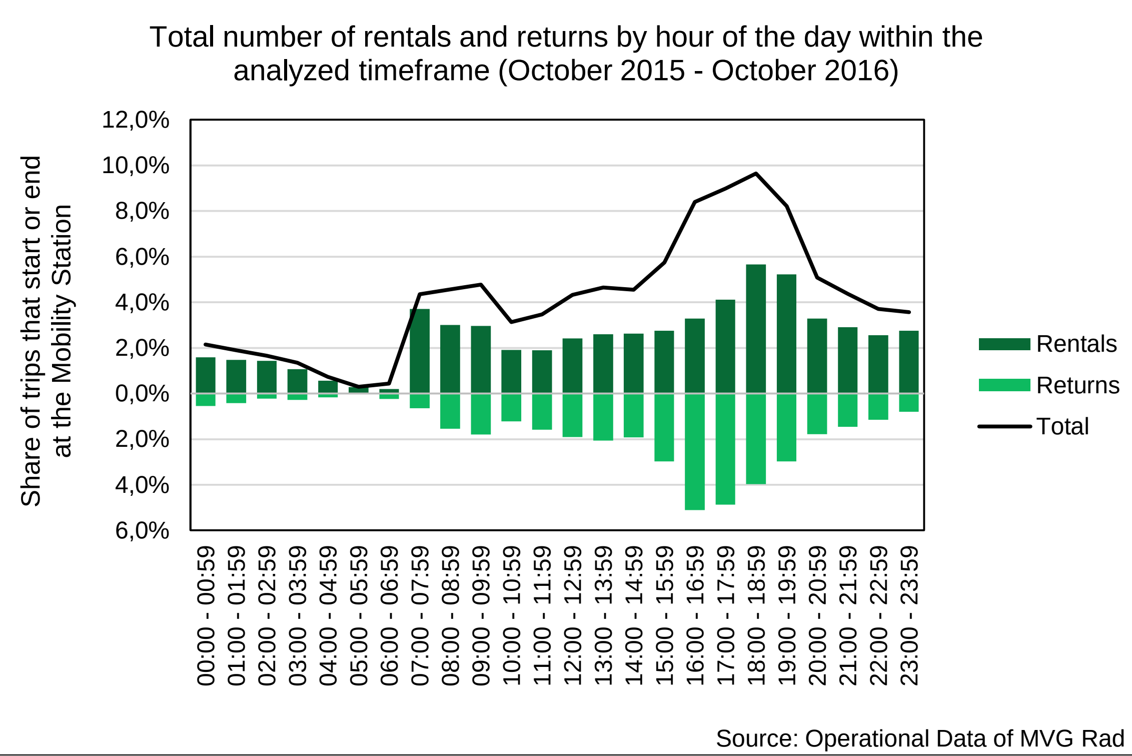


Figure 6.13: Hourly distribution of trips with MVG Rad starting and ending at the Mobility

Reiss and Bogenberger (2016) present the hourly distribution of trips with another bikesharing system operating in Munich (Call a Bike) for the period between March and December 2014. Although their analysis of trips by time of the day are presented separately for weekdays and weekends, similar trends to those obtained for the trips starting or ending at the Mobility Station with MVG Rad can be observed.

This indicates that the hourly usage patterns of bikesharing at the Mobility Station are similar to those in the rest of the city. However, for this comparison it should be taken in account that both bikesharing systems are different in their service areas and that the Call a Bike system does not have fixed stations as the MVG Rad system does.

Free-floating carsharing

The analysis of DriveNow operational data shows that FFCS is more frequently used in the afternoon and evening and less frequently in the morning (see Figure 6.14). This could give some indication that FFCS services are not mainly used for traveling to work during the morning peak hour, but rather for other purposes.

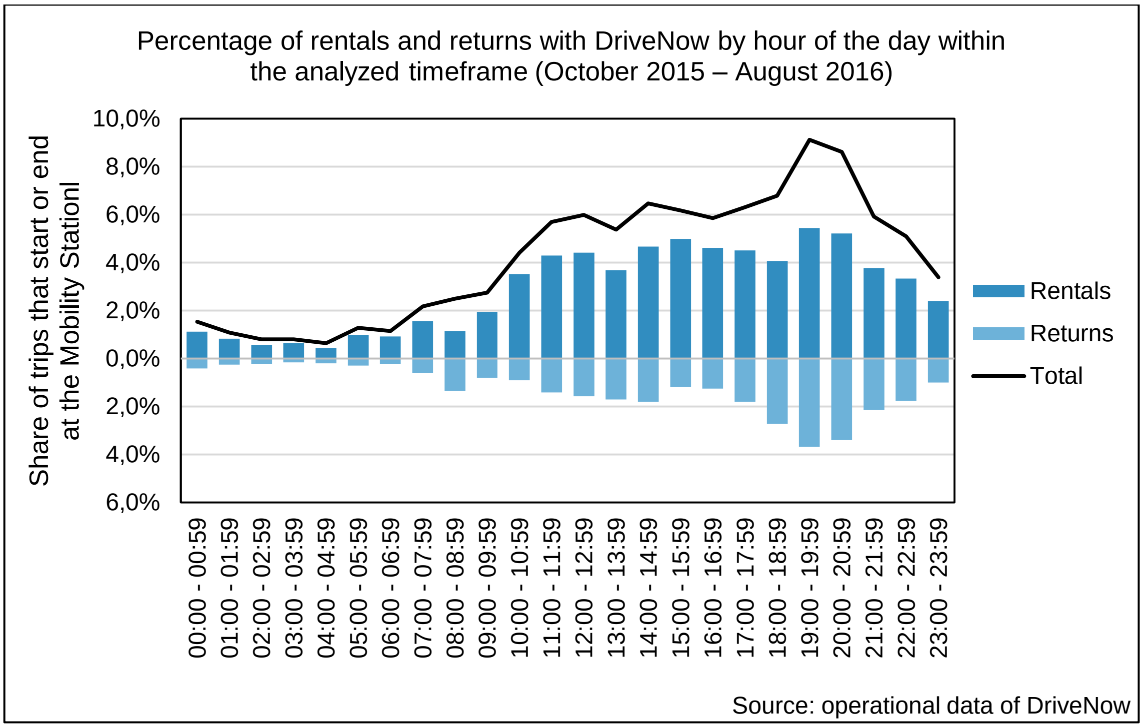


Figure 6.14: Hourly distribution of trips with DriveNow starting and ending at the Mobility Station

Schmöller and Bogenberger (2014) did a similar analysis of FFCS trips in Munich between January and October 2012 for the hourly distribution of trips showing a peak around 9:00 AM when about 5% of the trips started and a second larger peak around 20:00 when about 9% of the trips started. The analysis of operational data from DriveNow (first semester of 2013) and car2go (first semester of 2014) in the framework of the EVA-CS study shows a similar distribution of trips during the day (team red, 2015).

The distribution of trips starting and ending at the Mobility Station does not present a significant peak in the morning. Only the second peak between 19:00 and 20:00 corresponded to the hourly distribution of trips in Munich, with 9% of the trips starting at the Mobility Station. This indicates that the usage patterns of FFCS at the Mobility Station during the morning are different than in the rest of the city. However, there are no clear explanations for these differences

6.4.4.2. Location of destinations and associated activity

As part of the questions regarding their last trip, users were asked to indicate the destination of their trips and the associated activity at that destination (home, work, leisure, shopping).

The results show that both FFCS and MVG Rad are mainly used for home-related trips. About 80% of the trips with these shared mobility services started or ended at home, which indicates that these were used mostly by residents living close to the Mobility Station. Table 6.5 presents the destinations of trips with FFCS and MVG Rad that started or ended at the Mobility Station showing that the shared mobility services at the Mobility Station are used for a wide variety of purposes.

Table 6.5: Purposes for the use of shared mobility services for trips that start and end at the Mobility Station

	Destination of trips that **started** at the Mobility Station with…		Destination of trips that **ended** at the Mobility Station with…	
	MVG Rad	**DriveNow**	**MVG Rad**	**DriveNow**
Purpose	Percentage of users who declared to have used the mobility service for that purpose for their last trip (%)			
Home	43	41	39	43
Work	17	20	12	11
Leisure	31	15	38	30
Shopping	4	7	9	15
Other	5	17	2	2
				Source: user survey

For their last trip with a shared mobility service, about 40% of FFCS and MVG Rad users used the respective service to go home after ending a trip at the Mobility Station, and a similar share of about 40% was at home before starting a trip with a shared mobility service at the Mobility Station. Another significant share of users used the respective shared mobility services for leisure purposes.

Although users were asked to indicate the location of their destinations, the results were not useful due to a lack of accuracy (many respondents entered a zip code or mentioned the type of location they visited (e.g. “restaurant”). Nevertheless, operational data from MVG Rad and DriveNow was processed with the use of Geographic Information Systems (GIS) (see Section 5.5.3) to identify frequent destinations or areas visited with shared mobility services. Figure 6.15 to Figure 6.18 present the destinations and origins of trips with shared mobility services that started or ended at the Mobility Station.

Bikesharing

Both destinations and origins of trips with MVG Rad were often concentrated at other public transport stops, indicating that bikesharing was often used in connection with public transport (see Figure 6.15 and Figure 6.16).

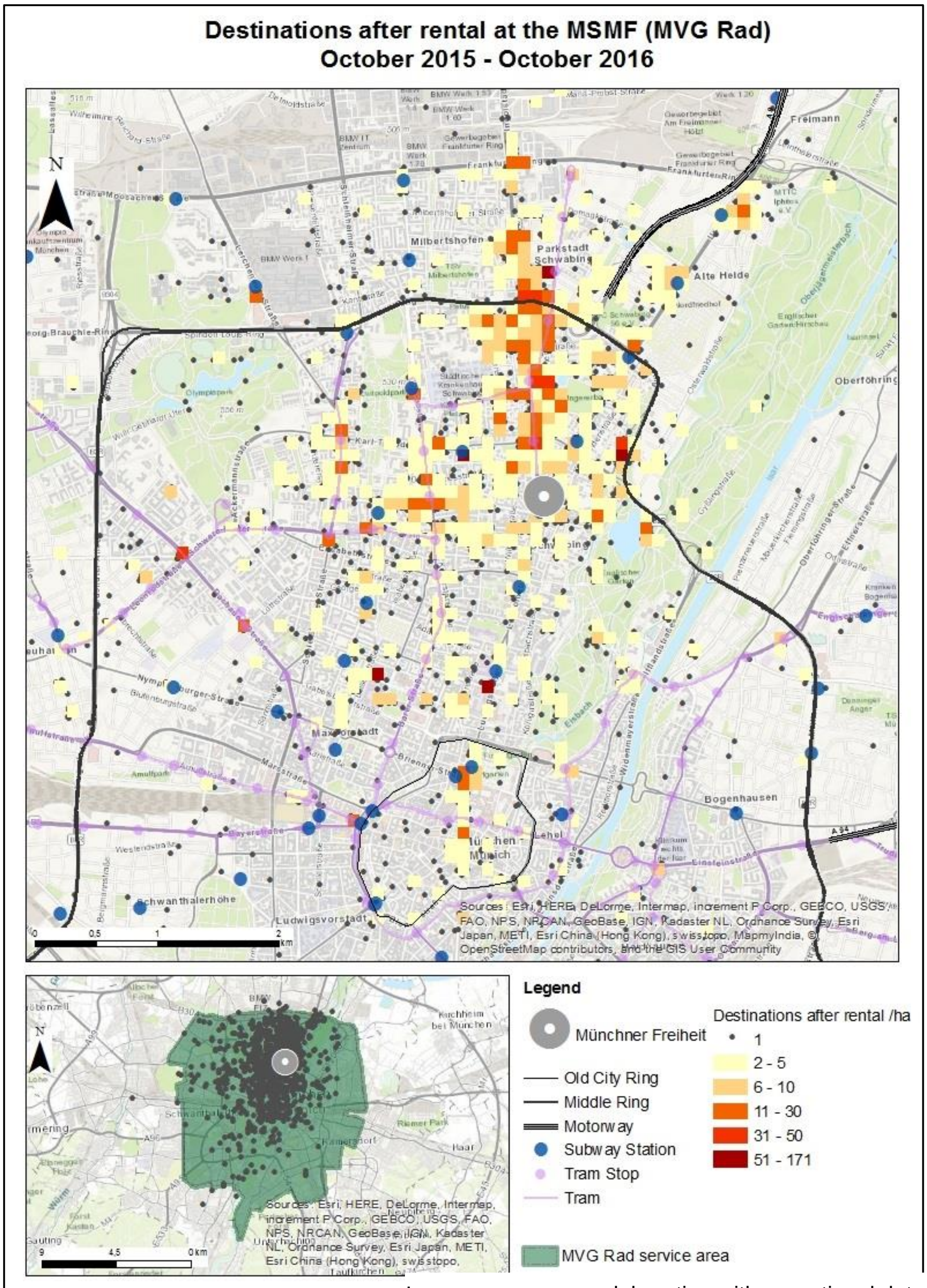


Image source: own elaboration with operational data of MVG Rad

Figure 6.15: Location of MVG Rad trip destinations after renting the bike at the Mobility Station at Münchner Freiheit.

Also, many MVG Rad trips were spread all over the nearby English Garden, which suggests that many trips were for leisure purposes.

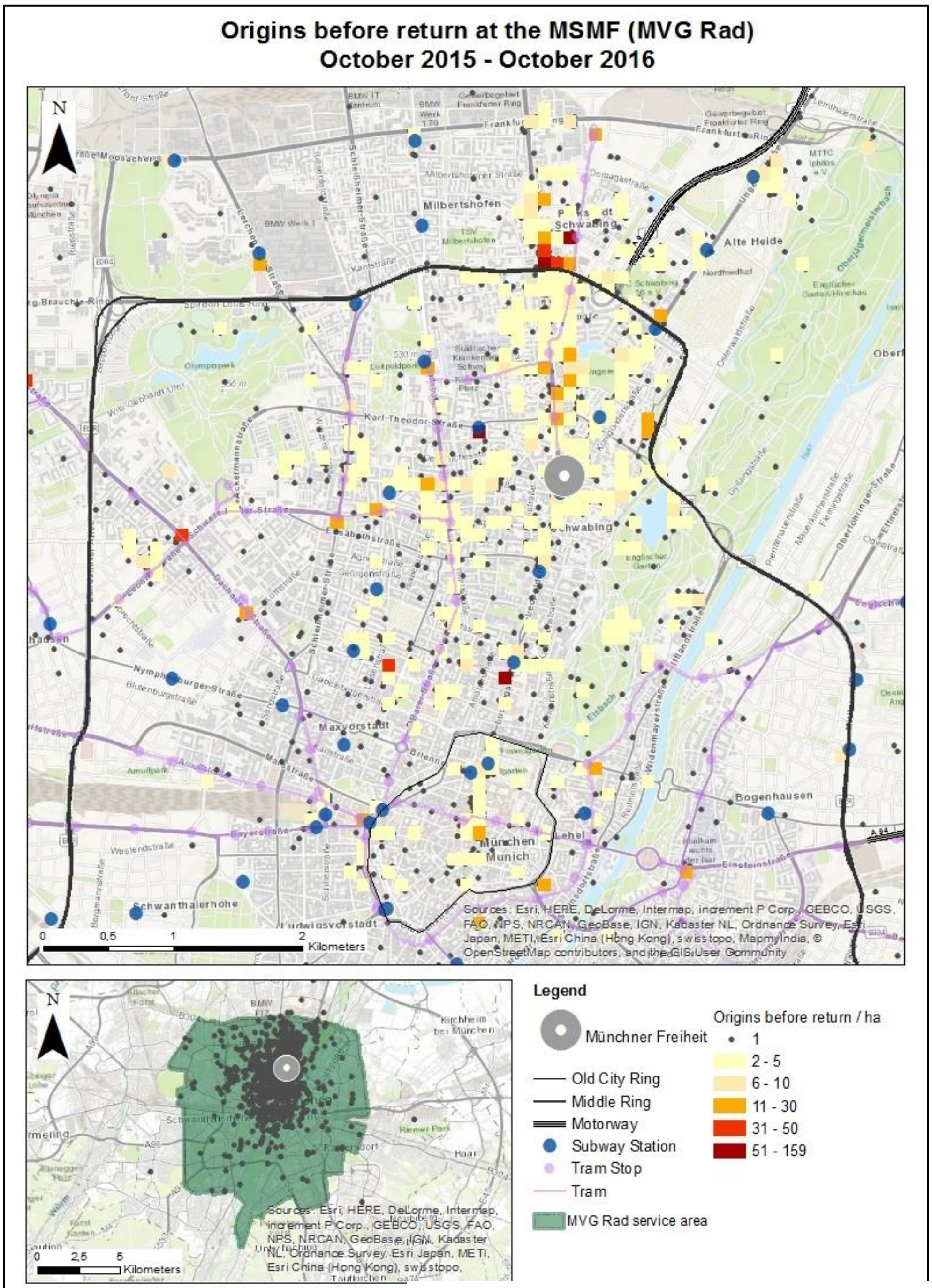


Image source: own elaboration with operational data of MVG Rad

Figure 6.16: Location of MVG Rad trip origins before returning the bike at the Mobility Station at Münchner Freiheit

Also of note is the concentration of origins and destinations to the north of the Mobility Station along the tramway. This could also indicate that bikesharing is used instead of public transport in certain circumstances.

Based on the group discussions with users, both possibilities (bikesharing being used in connection to public transport, and instead of it) were mentioned as possible use cases (up2date, 2016).

Free-floating carsharing

The spatial analysis of origins and destinations of trips starting and ending at the Mobility Station shows that FFCS was used for trips both within and outside the city. The origins and destinations of trips within the city seem to be concentrated around the Mobility Station indicating that FFCS could be used for round trips. This, however, seems to be true as well for all FFCS trips within Munich, according to the spatial analysis of FFCS trips in Munich done by Schmöller and Bogenbeger (2014).

While destinations are spread all over the service area, the spatial analysis of DriveNow trips that started at the Mobility Station shows that frequent destinations were the Munich airport, the nearby City of Garching (university and business campus), BMW Welt, and Parkstadt Schwabing, a residential and business district to the north of the Mobility Station (see Figure 6.17).

Some of the common destinations (airport, Garching, and BMW Welt) were also frequent origins for trips that end at the Mobility Station (see Figure 6.18).

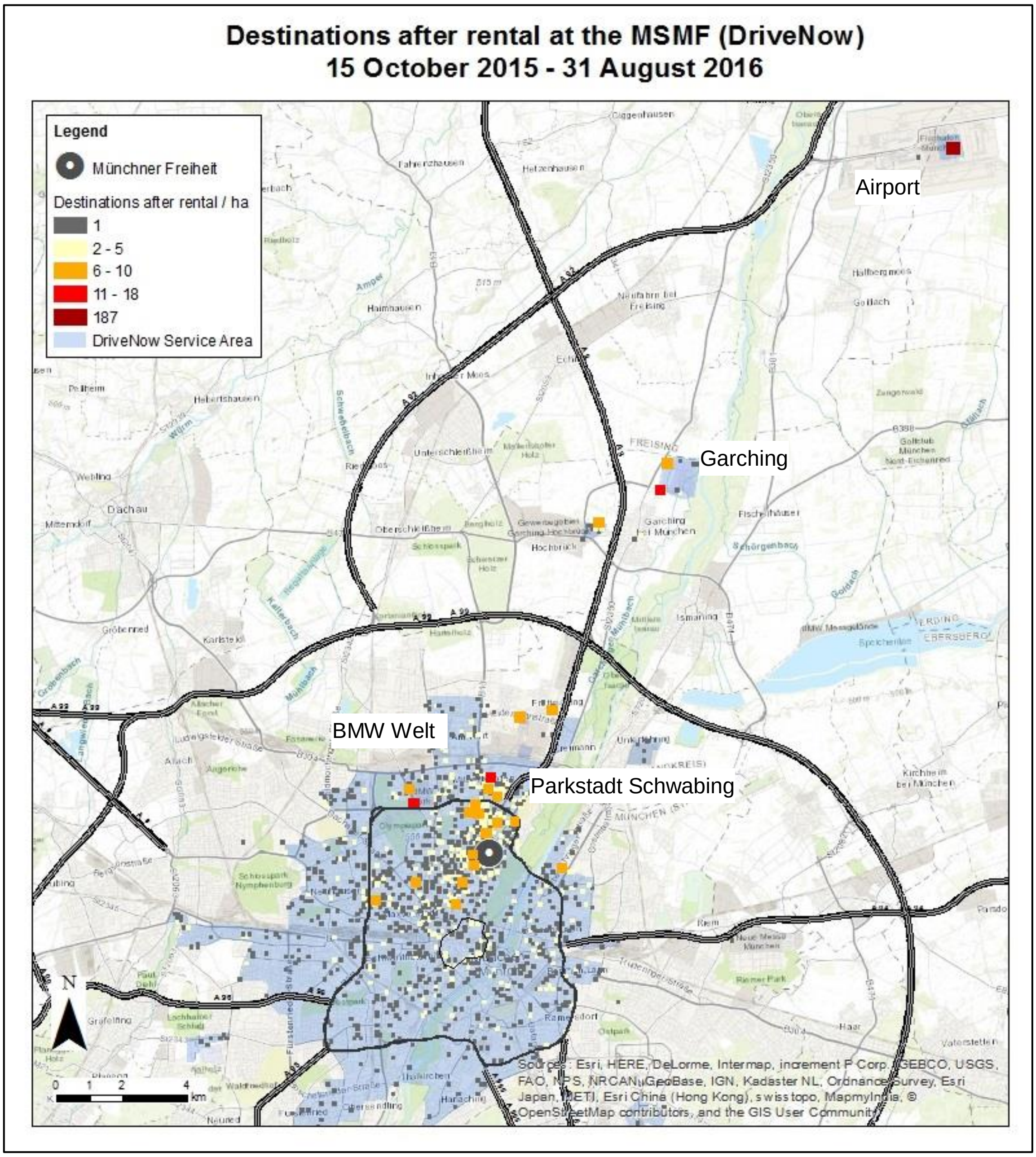


Image source: own elaboration with operational data of DriveNow.

Figure 6.17: Location of DriveNow trip destinations after renting the vehicle at the Mobility Station at Münchner Freiheit

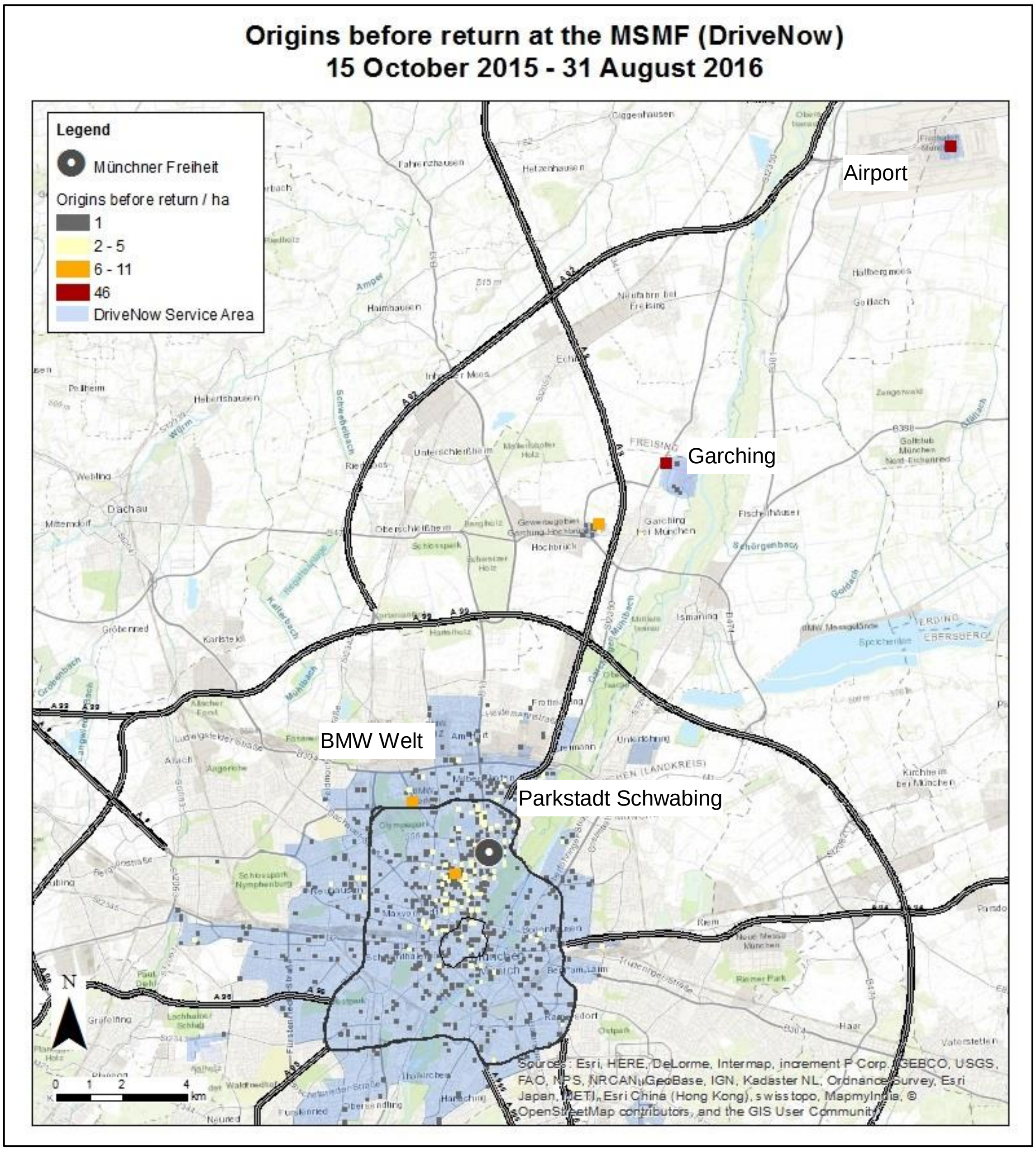


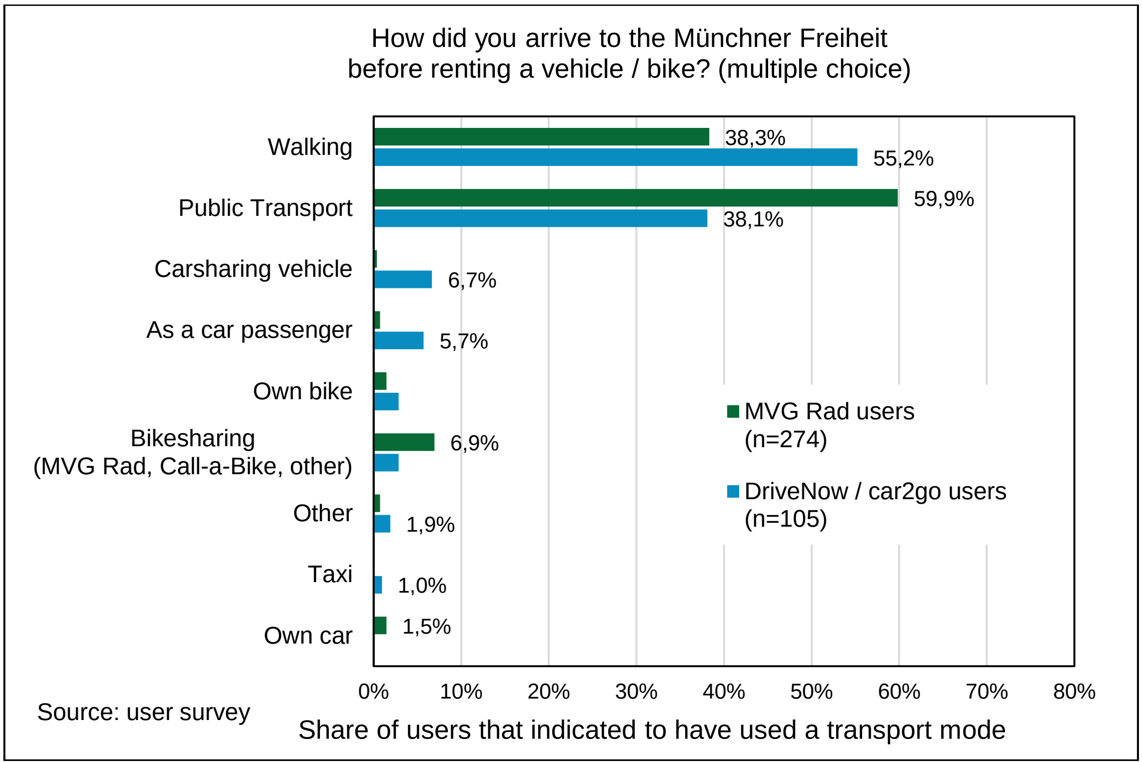
Image source: own elaboration with operational data of DriveNow.

Figure 6.18: Location of DriveNow trip origins before returning the vehicle at the Mobility Station at Münchner Freiheit.

6.4.5. Access to the station by mode

As part of the user survey, in the section about the last trip, respondents were asked how they reached the Mobility Station before renting a vehicle or bike, and in case of a return, how they continued their trip.

The main modes to access and egress from the Mobility Station are walking and public transport (See Figure 6.19).



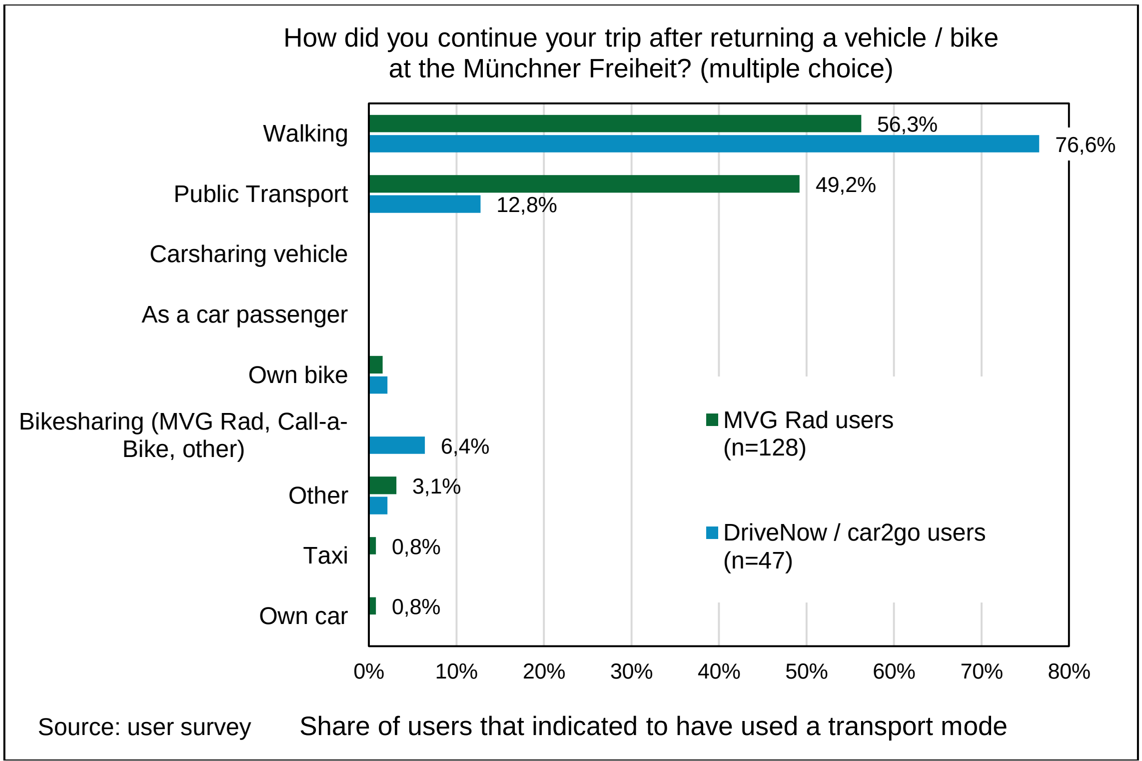


Figure 6.19: Mode used by two user subgroups to a) access the Mobility Station before renting a vehicle or bike, and to b) egress the Mobility Station after returning a vehicle or bike.

Also, the results indicate that a significant share of intermodal trips involving public transport and shared mobility services do take place at the Mobility Station. This underlines the importance of intermodal connections at this location.

Thirty-eight percent of FFCS users used public transport and 55% walked to the Mobility Station to rent a vehicle. This differs from shares reported for accessing randomly located carsharing vehicles in Munich (about 80% walk and less than 10% use PT) (team red, 2015), indicating that the Mobility Station facilitates intermodal transfers between public transport and carsharing.

Intermodal connections that combine bikesharing and carsharing do not seem to play an important role yet. However, 6% of FFCS users continued their trip with a shared bicycle after returning a shared car. During the group discussions this use case was mentioned by one of the participants:

> *“For me, ever since the [Mobility] Station has been there, I often try to drive past Münchner Freiheit as an in between stop instead of another metro station closer to me because there are bonus minutes for dropping it off there, and free reserved parking spaces for carsharing. Then I transfer from carsharing to an MVG Rad bike, and quickly bike home for the last couple of minutes, all instead of checking for a parking space around my place, since the parking situation there is pretty poor” (User, Focus groups)*

The high percentages of users walking to and from the Mobility Station indicates many users live, work, or do activities in the immediate surroundings of the Mobility Station.

In Würzburg and Offenburg the majority of users walked to a mobility station before starting a trip with a shared mobility service as well. The second most used mode of transport to access to stations in Offenburg is a private bike, and in Würzburg, public transport (see Section 3.2.5.2).

Based on the results presented above, it can be said that the public transport connection, a good quality of public space, and the integration of the Mobility Station with its surroundings seem to be relevant for the success of mobility stations.

6.4.6. Summary

The usage patterns of the Mobility Station presented in Section 6.4 are summarized below in Box 2.

Box 2. Usage patterns of the Mobility Station

The Mobility Station registered an increasing use since its rollout in November 2014.

In the case of FFCS and MVG Rad there are about twice as much rentals than returns.

The **most frequently used mobility services** (among users) at the Mobility Station are:

1. Public transport	Around 70% of carsharing users and 80% of MVG Rad users use public transport at least once a week.
2. "own*" shared mobility service	About 40% of FFCS and MVG Rad customers, and 24% of STATTAUTO customers use their "own" shared mobility service at least once a week.
3. another shared mobility service	20% of MVG Rad customers use FFCS at least once a month 16% of FFCS customers use MVG Rad at least once a month. 18% SBCS customers use FFCS once a week

Purpose: Public transport and MVG Rad are mainly used for trips to work or education facilities, doing errands, shopping and for leisure trips while FFCS is mainly used for shopping and leisure.

Key figures	MVG Rad	DriveNow	STATTAUTO	CiteeCar
Average rentals per month	511	316	6.3	15.1
Average rentals per day	17	11	0.2	0.5
Average traveled distance per rental (km)	2.5	13	104	53.2
Average rental duration (minutes)	15	31	888	291

Common destinations and origins of trips with:

DriveNow:

- Airport
- Garching
- BMW
- Parkstadt Schwabing

MVG Rad

- Other public transport stations
- English Garden
- Along the tramway line 23

Access and egress mode: The main modes to access and egress the Mobility Station are by walking and by public transport.

* "own" means the shared mobility service of which respondents were identified to be customers of.

6.5. Acceptance and perception of the Mobility Station

One of the objectives of this dissertation is to identify success factors for the implementation and operation of mobility stations. One of the most important success factors for any measure is the acceptance of the target group.

Does the Mobility Station offer an added value over using shared mobility services as they did before, without integrating them physically at one location? Which individual components of the Mobility Station and which intermodal connections are important to them? What is the level of overall acceptance among the users, what is their perception of the stations? What do non-users think about the idea of a Mobility Station? Are they potential users?

These questions were addressed by means of the user survey and the focus groups with both users and non-users. As part of the user survey, users were asked about the reasons for which they rented or returned a vehicle or bike at the Mobility Station, to determine if the Mobility Station offers an added value. Further, users were asked to rate how important certain aspects of the Station were to them, personally a) the individual components at the Mobility Station, b) the intermodal connections, and c) various amenities in the immediate surroundings.

The following sections present further details about the above mentioned aspects.

6.5.1. Does the Mobility Station offer an added value?

As part of the user survey, users were inquired about the reasons for renting or returning a shared car or bike at this location. The question was intended to identify an added value the Mobility Station provided compared to renting or returning a vehicle or bike elsewhere within the respective service areas (see user survey in Annex B-1).

The results indicate that users appreciate:

- the connection with public transport, before renting and after returning a vehicle at the Mobility Station.
- the high probability of finding a vehicle or bike at the Mobility Station, without even having to look at their smartphones,
- the ability to easily and quickly return a vehicle at the reserved parking spaces or to return a bike at the docking station.

Other important aspects of the Mobility Station are the possibility of using electric cars for FFCS users, and the incentive of 10 minutes of credit that MVG Rad users receive when returning a bike at the docking station (the latter, however, is not specific of the Mobility Station but of the entire MVG Rad system).

The following subsections provide further details on the reasons users had for renting and for returning a shared car or bike at the Mobility Station.

6.5.1.1. Why users rent at the Mobility Station

At first, it seems that the Mobility Station offers little added value for users: the two most frequent reasons for renting a vehicle or bike specifically at the Mobility Station are because a) the vehicles / MVG Rad bikes were the nearest available or b) these were located along their way, which can be true anywhere else in the respective service areas (see Figure 6.20).

However, there are three other prominent reasons for renting a vehicle or bike specifically at the Mobility Station:

1. Because of the good accessibility by public transport,
2. Because of the high probability of finding a vehicle or bike without needing to check for their availability before via smartphone apps or the internet,
3. Because at the station, it is possible to transfer to other transport modes

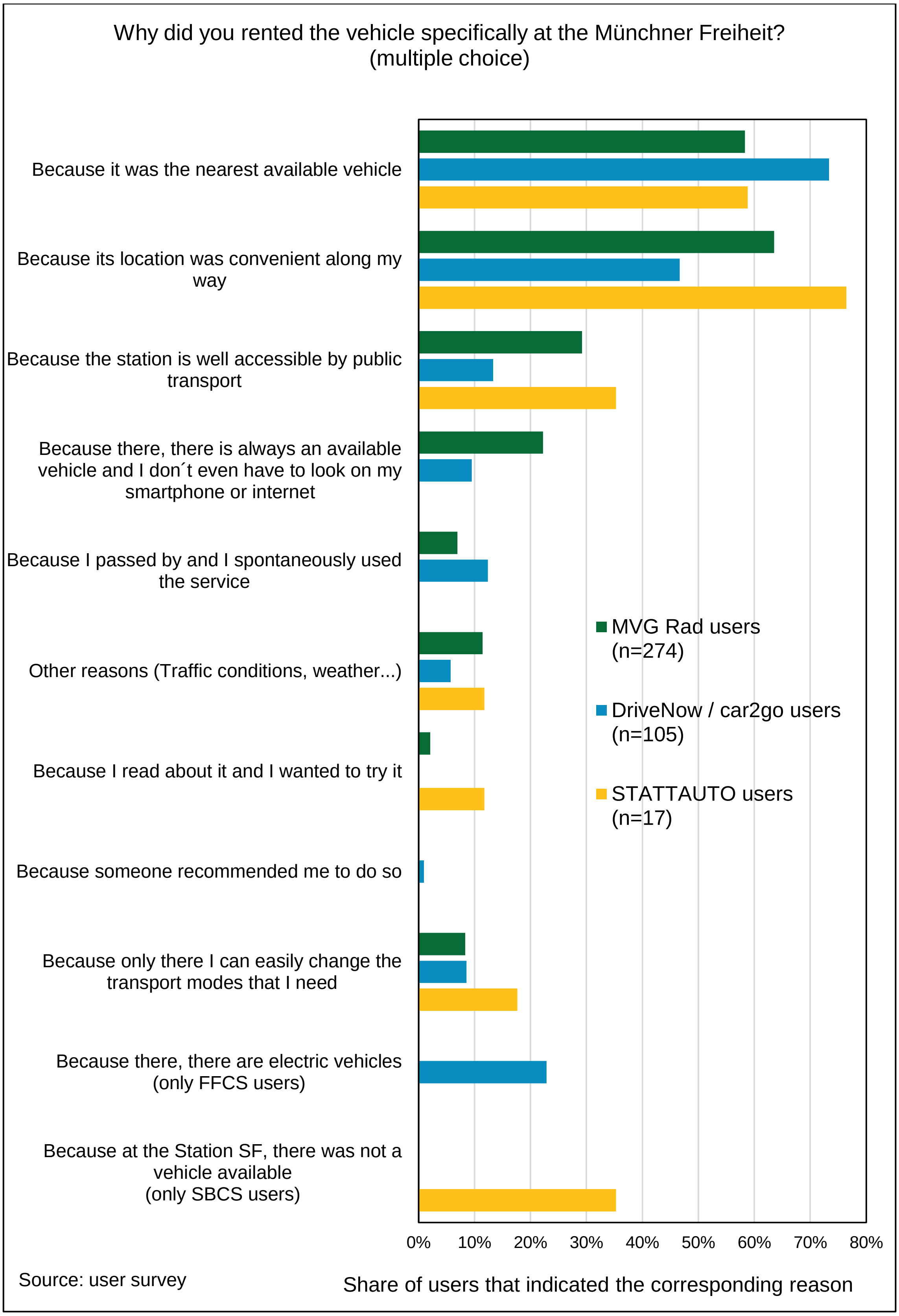


Figure 6.20: Reasons for renting a carsharing vehicle and MVG Rad bikes exclusively at the Mobility Station

For 23% of FFCS users, the chance to rent and use electric vehicles was a decisive factor for choosing the Mobility Station. Also, within the focus groups, both users and non-users expressed interest for electric carsharing vehicles:

"I think electric vehicles should generally be developed further. I would be really glad if all the carsharing providers only offered electric cars" (User, focus groups)

I'm pretty sure that's coming sometime in the future. Especially with the electric cars, people want to be more conscious and don't want to harm the environment (Non-user, focus groups)

The possibility to rent electric vehicles and charge them at the Mobility Station seems to offer an added value to FFCS users. (Müller et al., 2015) also report that electric carsharing vehicles had a positive impact on acceptance among carsharing users in Berlin and Munich.

The possibility of easy transfers between modes was given as a reason for choosing the Station only by a few respondents, indicating that there is a potential need to communicate the intermodal character of the station more clearly.

6.5.1.2. Why do users return vehicles at the Mobility Station?

Similar to the reasons for renting a carsharing vehicle or MVG Rad bike at the Mobility Station, the main reasons for returning a vehicle or bike there, as indicated by the users, indicate that the Mobility Station offers little added value:

- 75% of FFCS users and 56% of MVG Rad users said that their destination was in direct proximity, which can be true for other stations or destinations elsewhere in the respective service areas;
- 49% of MVG Rad users said that they returned a bike there because of the incentive of 10 free minutes that they get in form of credit on their accounts.

Figure 6.21 shows the various reasons that users had to return a vehicle at the Mobility Station.

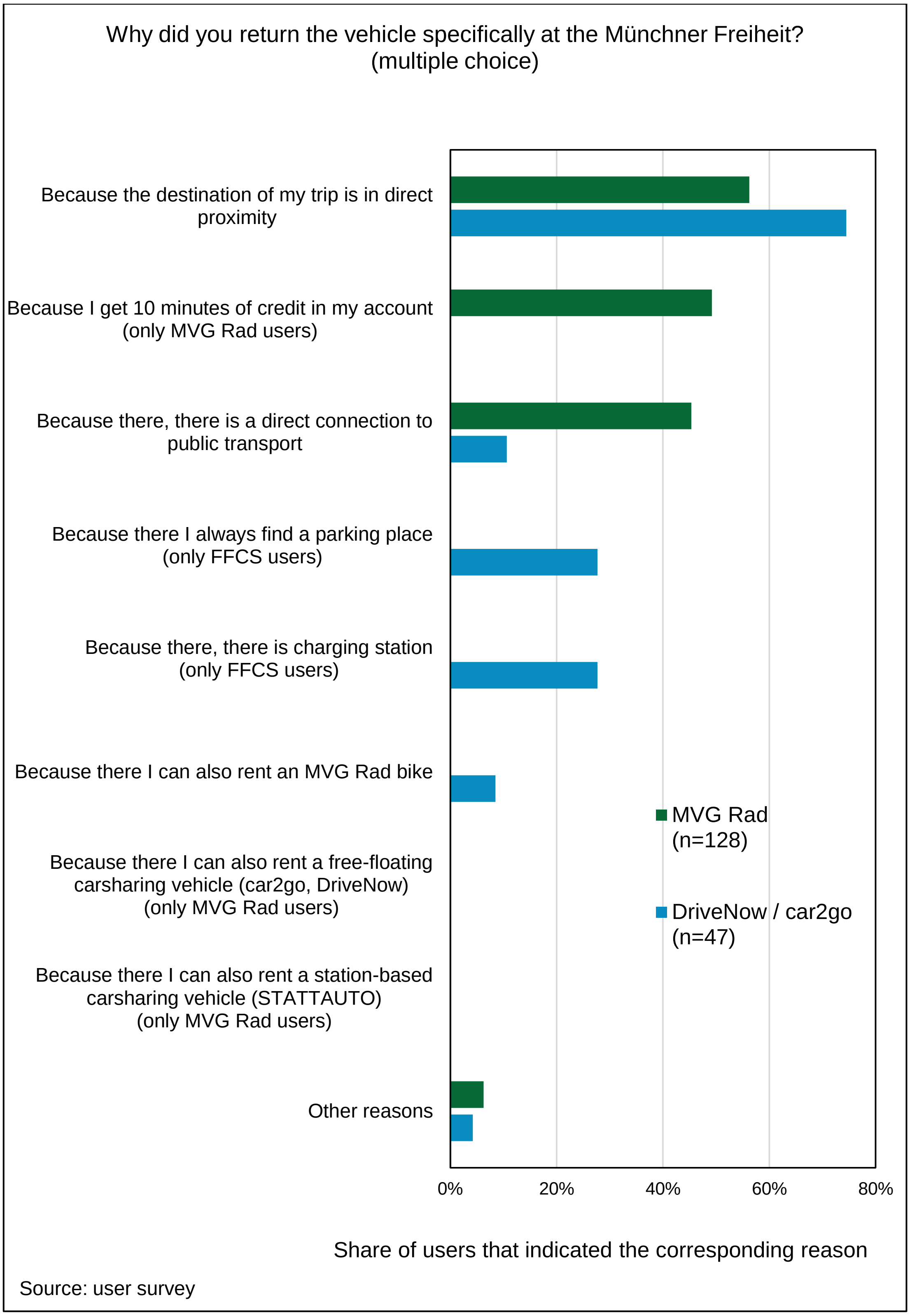


Figure 6.21: Reasons for returning a carsharing vehicle and MVG Rad bikes exclusively at the Mobility Station

The 10-minute incentive can be obtained by returning the bikes to any MVG Rad docking station, so this is not considered to be an added value particular to the Mobility Station, although it makes it clear that this incentive was important for the users in general.

However, other reasons indicated by the users suggest that the Mobility Station does offer an advantage for some users compared to returning a vehicle or bike somewhere else. Other main reasons particular to this location are:

1. the direct connection to public transport, mainly for MVG Rad users,
2. the availability of an electric charging point (for FFCS users), and
3. the high chance of quickly finding a parking space (for FFCS users).

Last, but not least, some FFCS users indicated that the reason for returning a carsharing vehicle a the Mobility Station was because there they can rent an MVG Rad bike, which indicates that the Mobility Station is also used for intermodal trips with shared mobility services.

SBCS users must return the vehicle to the Mobility Station, so they were not required to answer this question.

From the group discussions with users, it was confirmed that the reserved parking spaces were highly valued by carsharing users:

> *"What's been the main reason why I've used the Münchner Freiheit station, is that I can definitely say there will be free parking spaces. That is also a reason to not take your own car, since you know that when you drive somewhere with it, you have to return and drive several times around the block just to find a parking space." (User, focus groups)*

Direct access on the ground is also appreciated by the users, especially in comparison to underground garages or multi-story parking garages:

> *"Often with carsharing services there are these parking garages than you can use. But at them, there's either parking spaces on the top level or the bottom level of the garage. It really takes a lot of time until you're actually back in the station. And here, it's quite practical that it's right on the street. I can easily just drive off to the right, end my trip, and get out of the car, done and ready to continue. That's great." User, focus groups)*

6.5.2. Important components

As part of the user survey, respondents were asked to rate the importance of specific components of the Mobility Station. According to the users the most important components are:

1. those related to the use of their own[24] shared mobility services;
2. the connection to public transport, and
3. the possibility to use other[25] shared mobility services.

Figure 6.22 shows the components of the Mobility Station that were important to the different user subgroups.

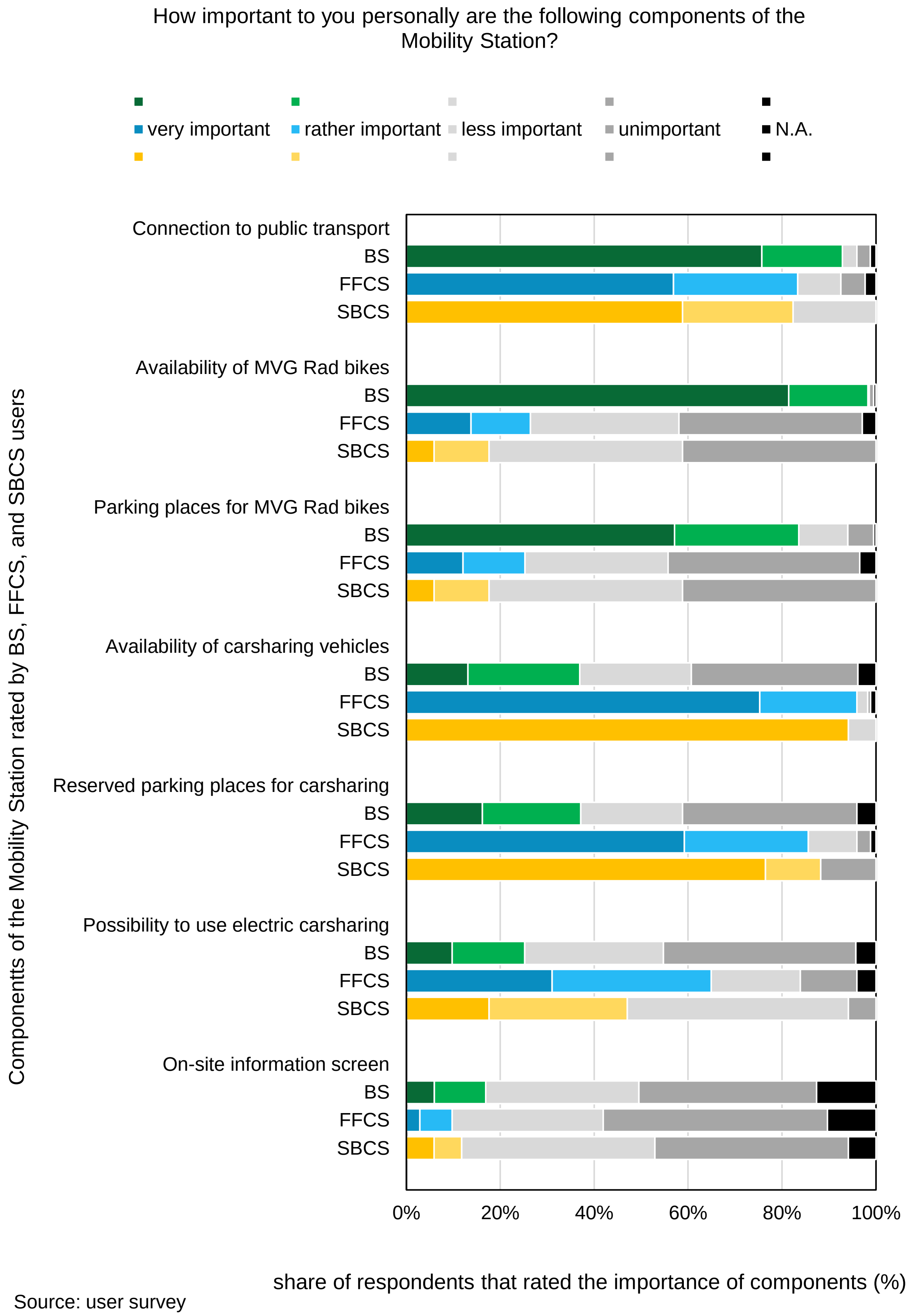
The importance of public transport at the Mobility Station was confirmed by the users when asked to rate the importance of different intermodal connections at the Mobility Station (see Figure 6.23 in Section 6.5.3). The importance of public transport among users of mobility stations was also confirmed by about 80% of users of these facilities in Offenburg and Würzburg who also rated this component as important (Heller, 2016; Pfertner, 2017).

The possibility to use electric carsharing is important for more than 60% of FFCS users, almost 50% of SBCS users, and about 25% of BS users. Similar results were obtained in Würzburg and Offenburg (see Section 3.2.5.2), where 57% and 80% of the users, respectively, considered electric carsharing an important component of the mobility stations (Heller, 2016; Pfertner, 2017).

The on-site information screen is the least important component from the users' point of view. Through the focus groups, the relevance of this component was further explored (see Section 6.3.2). Although the on-site information screen plays an important role for raising awareness of the Mobility Station, most users do not consider it as important. As revealed by the focus groups this is because they already have access to the same information provided by the on-site screen through their smartphones (up2date, 2016).

[24] "own" means the shared mobility services of which the users were identified to be customers of

[25] "Other" refers to shared mobility services of which the respondents were not identified to be customers of



Source: user survey

Figure 6.22: Importance of the components of the Mobility Station for users of different shared mobility services

The analysis of the importance of components of the Mobility Station as reported by the different user subgroups indicates that there is a “crossed interest” regarding the mobility services:

- About 25 % of FFCS users and about 17% of SBCS users rated components of the Mobility Station related to bikesharing (availability of bikes and parking spaces for bikesharing bikes) as important.
- About 37% of BS users rated components of the Mobility Station related to the use of carsharing (availability of carsharing vehicles and reserved parking spaces for carsharing) as important.

This confirms that some users are already multimodal, as previously revealed by the frequency of use of shared mobility services (see Section 6.4) and that some might exhibit multimodal travel behavior. This mutual interest indicates that there is potential for increasing the multimodal and intermodal character of the Mobility Station.

A similar observation was obtained in Offenburg, where 75% of bikesharing users considered carsharing components important and about 40% of carsharing users considered bikesharing components important (Heller, 2016).

6.5.3. Important intermodal connections

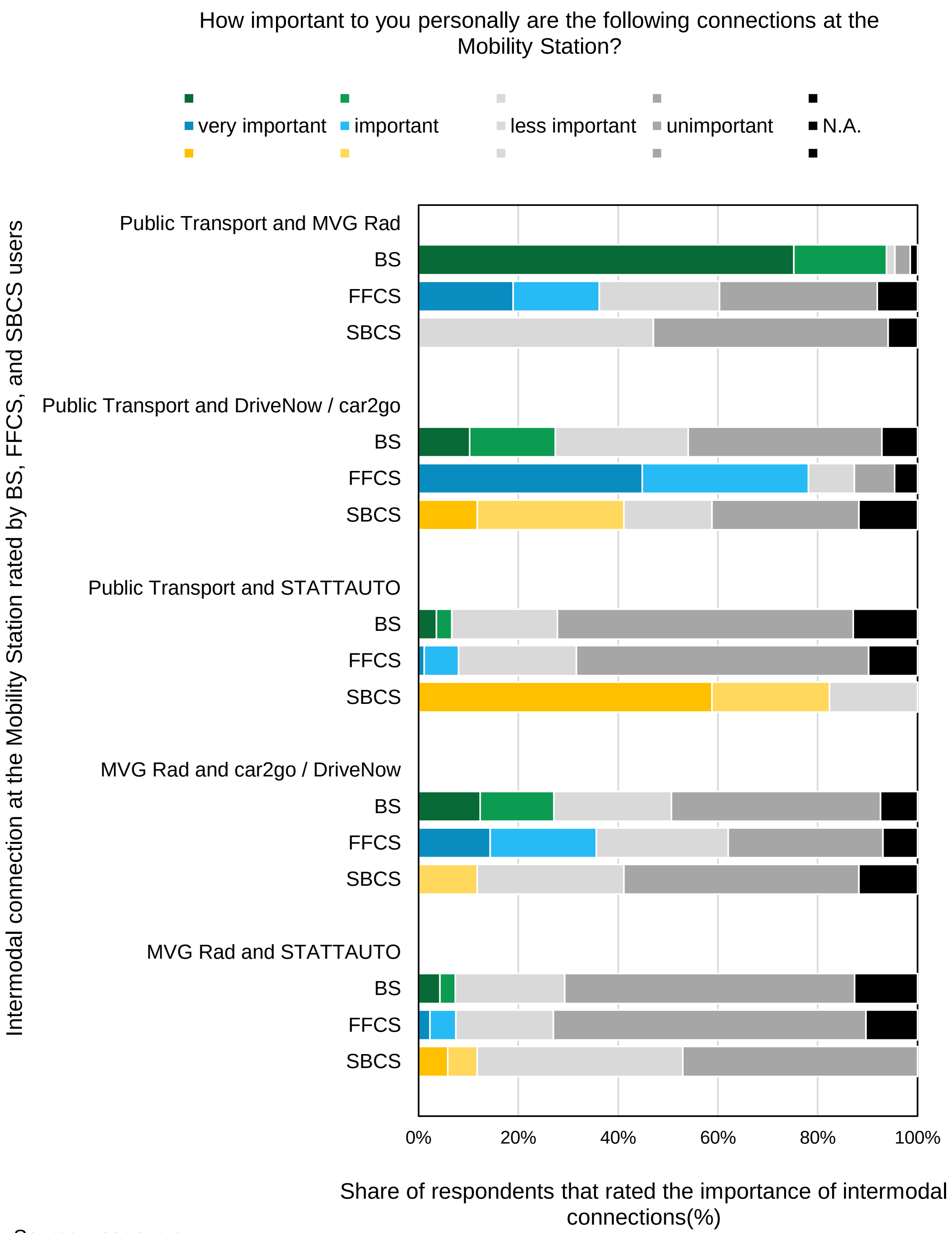
As part of the user survey, respondents were asked to rate the importance of five different intermodal connections at the Mobility Station. According to the users the most important intermodal connections are:

1. public transport and their “own” shared mobility service,
2. their own shared mobility service and other shared mobility services,
3. other shared mobility services and public transport.

This shows that FFCS and MVG Rad users have similar interests regarding intermodal connections, especially between these two services, while intermodal connections with SBCS (STATTAUTO) are rather unimportant to them.

SBCS users are rather interested in the intermodal connection of SBCS services with public transport in the first place, and with FFCS in second place, while other intermodal connections involving MVG Rad are rather unimportant to them.

Figure 6.23 shows the importance of intermodal connections as rated by the three different user subgroups.



Source: user survey

Figure 6.23: Importance of intermodal connections at the Mobility Station for users of different shared mobility services

6.5.4. Important amenities at the Mobility Station and its surroundings

Which interactions exist between the Mobility Station and its surroundings? Should mobility stations be “only” transport nodes where all kinds of mobility services are available, or can a mobility station integrate and offer other non-mobility-related functions, as seen in the vision of the North American mobility hubs?.

As part of the user survey, participants were asked to rate the importance of existing and non-existing amenities and facilities around the Mobility Station. Figure 6.24 shows the different kinds of existing facilities rated by the users.

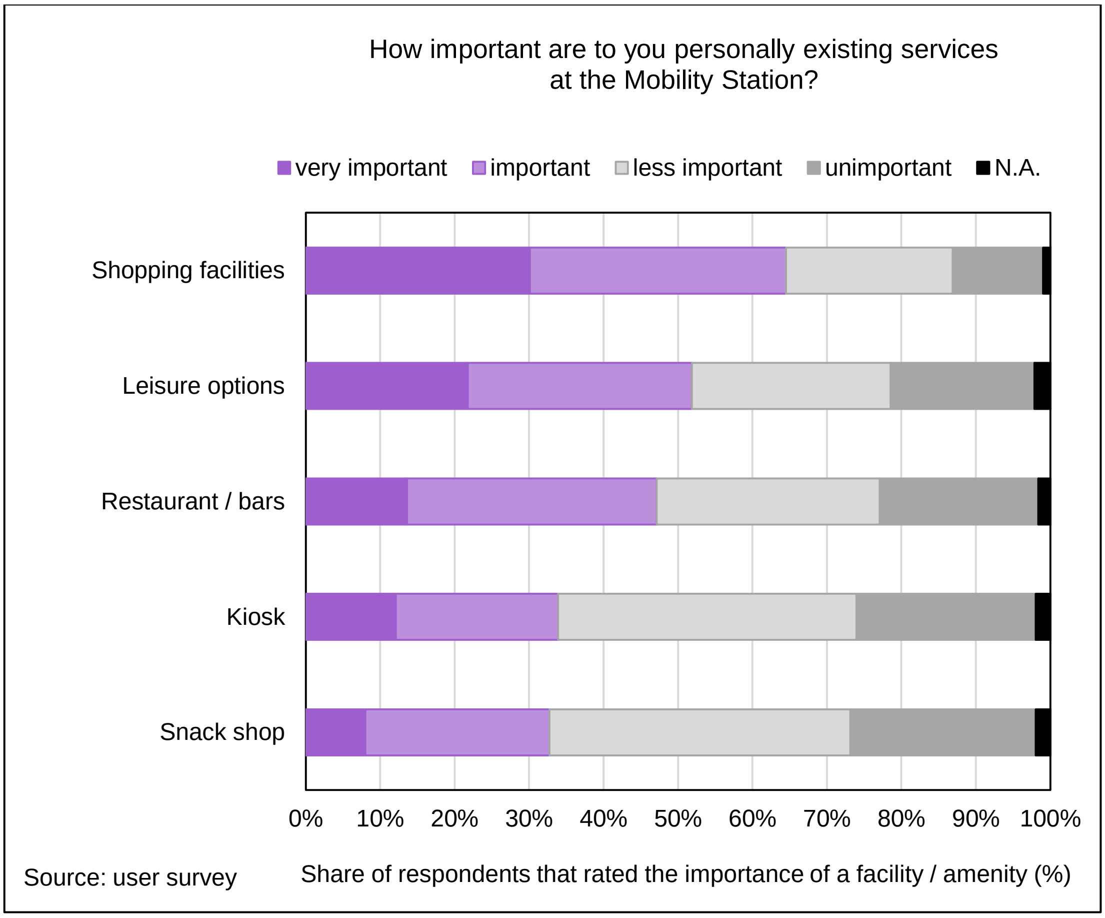


Figure 6.24: Importance of existing services according to the users

These results show that non-mobility related services are important for a considerable share of users and indicate that there is a possibility to integrate mobility stations further with their immediate surroundings. The results also indicate that the Mobility Station has the potential to, and does, satisfy diverse needs at one location.

Figure 6.25 shows the importance of not-yet existing amenities as rated by the users.

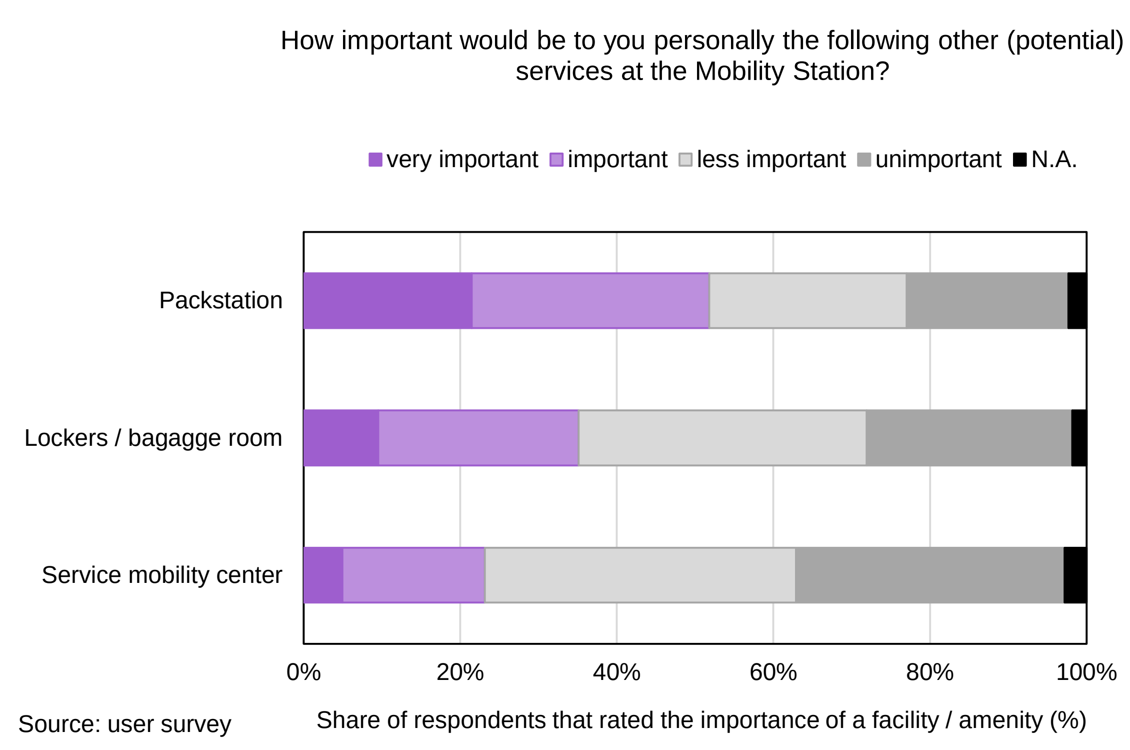


Figure 6.25: Importance of not yet existing services at the Mobility Station according to the users

In general, the users' interest in not-yet existing amenities shows that the Mobility Station has the potential to offer more than mobility services, and that there is a real opportunity to combine several activities at one location.

6.5.5. Acceptance and perception

To evaluate the general acceptance of the Mobility Station, users were asked towards the end of the questionnaire (user survey) – after they provided details about their last trip and after they rated the importance of individual components and intermodal connections – if they would like to have more mobility stations.

The results indicate that the Mobility Station is accepted by the majority of users:

- Almost 70% of users would like to have more mobility stations in Munich,
- About 30% do not know, and
- only 2.5% would not like to have more.

Similar results were obtained in Offenburg and Würzburg where a majority of users respectively, approve the idea of having more mobility stations in their respective cities (see Section 3.2.5.2) (Heller, 2016; Pfertner, 2017).

By means of focus groups, the acceptance and perception of the Mobility Station among users and non-users was further explored. After a short explanation of the idea behind the concept, both users and non-users approved the idea of having more mobility stations in Munich (up2date, 2016).

It is to be noted though, that from the group discussions it was also perceived that the personal relevance of the Mobility Station among the users is still average. The Mobility Station was not the only reason for them to have used shared mobility services. At this point, it was seen as a “nice-to-have” option (up2date, 2016). Nevertheless, users didn’t want to lose access to it: as the moderator talked about the possibility of removing the Mobility Station, the participants expressed that that would be a pity.

From the stakeholder interviews, it became clear that the carsharing providers also approve the idea of the Mobility Station, and perceive a benefit for their customers.

Preferred locations for future mobility stations

According to the user survey and the group discussions with both users and non-users, further mobility stations should be implemented in four types of locations:

1. Central areas and transport nodes within the inner city
2. Transport nodes with metro and suburban rail services
3. Areas outside the inner city with high demand, such as the airport or the convention center (Messe).
4. Residential areas with low public transport coverage

“I use carsharing occasionally, and I notice that mostly you pay the parking fees just while you’re searching for a spot. The clock keeps ticking, so that essentially the users pay for the parking fees, even though they’re “covered”. That’s why I think the idea of the Münchner Freiheit is good, since there’s reserved carsharing spaces. You really need them on every transport node.” (non-user, focus groups).

”I’m not really sure if it makes sense to put cars at such a node of public transport. If the bus drivers strike, okay. Normally it would make more sense to put the cars where there is no public transport connection.” (non-user, focus groups)

Carsharing providers also consider necessary to provide reserved carsharing parking spaces in residential areas where accessibility by public transport is limited or where parking pressure is high. However, there is a general concern that by providing carsharing parking where public transport is not available, the latter would be replaced by carsharing. This effect, however, can be influenced by various strategies implemented by planning authorities. In Chapter 8, some recommendations on this aspect are provided.

6.5.6. Summary

Box 3 below presents a summary of the various aspects related to acceptance and perception of the MSMF presented in Section 6.5.

Box 3. Acceptance and perception of the Mobility Station

The Mobility Station offers an **added value to users**, they appreciate:

1. the connection with public transport and shared mobility services
2. the high probability of finding a vehicle or bike
3. the relatively ease of returning a vehicle or bike
4. the possibility to use electric cars (through carsharing)
5. the easy transfer between modes

There is a reciprocal interest towards mobility services among users subgroups, according to them, …

the most important components are:

1. their own* shared mobility services
2. the connection to public transport
3. the availability of other shared mobility services

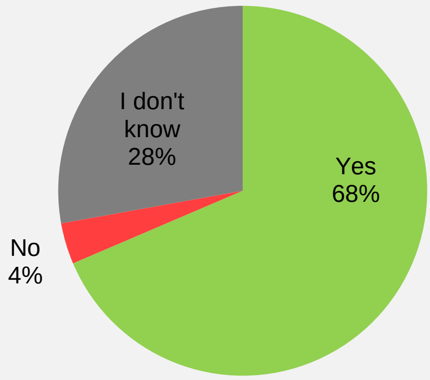
the most important intermodal connections are:

1. own* shared mobility service and public transport
2. own* shared mobility service and another shared mobility service
3. another shared mobility service and public transport

Existing and non-existing amenities and services are also important to some users.

The overall acceptance of mobility stations is positive:

Would you like to have more mobility stations in Munich?
(n = 611 users)



Preferred locations are:

- Central areas and transport nodes within the inner city
- Transport nodes with metro and suburban rail services
- Areas outside the inner city with high demand (e.g.airport or the convention center)
- Residential areas with low public transport coverage

* *own* means the shared mobility service of which respondents were identified to be customers of.

6.6. Effects of the Mobility Station on mobility behavior

Of special interest to this study is to understand the impacts of the Mobility Station on mobility behavior in the short and long term. Does the Mobility Station influence car ownership or mode choice? Does it contribute to increase multimodal behavior?

These questions are partially answered by means of the user survey and the focus groups. Findings from similar investigations in other cities and on shared mobility services (see Sections 3.2 and 3.3) assist in validating the findings regarding the impacts of the pilot project.

The following subsections present various results organized in three categories:

1. Effects on car ownership (Section 6.6.1)
2. Effects on the use of other mobility services (Section 6.6.2)
3. Substitution of transport modes when using shared mobility services (Section 6.6.3)

6.6.1. Effects on car ownership

In agreement with the stakeholders who contributed to the development of the user survey, it was considered that the Mobility Station had not been in operation long enough to have a real effect on car ownership. Thus, the user survey did not inquire about the influence of the Mobility Station on the decision of acquiring or getting rid of a car.

Nevertheless, as part of the user survey, in the demographics section, participants were asked if they had disposed of or acquired a private car in the last year and their reasons for it (see user survey in Annex B-1). Furthermore, the potential of the Mobility Station to reduce car ownership and support multimodality was explored through the user survey and the focus groups. The following subsections present further details on these results.

6.6.1.1. Absolute change in vehicles owned by users of the Mobility Station

In contrast to some studies on the impacts of carsharing and bikesharing, the user survey did not aim to directly find out if the Mobility Station motivated users to get rid of a car. That is to say, it did not ask *“did you sell a car because of the Mobility Station?”* or *“did you postpone the purchase of a car because of the Mobility Station?”.*

However, as mentioned above, users were asked if they had disposed of or acquired a private car in the last year and their reasons for doing so. Figure 6.26 shows the responses from all users and the different user subgroups to the first question.

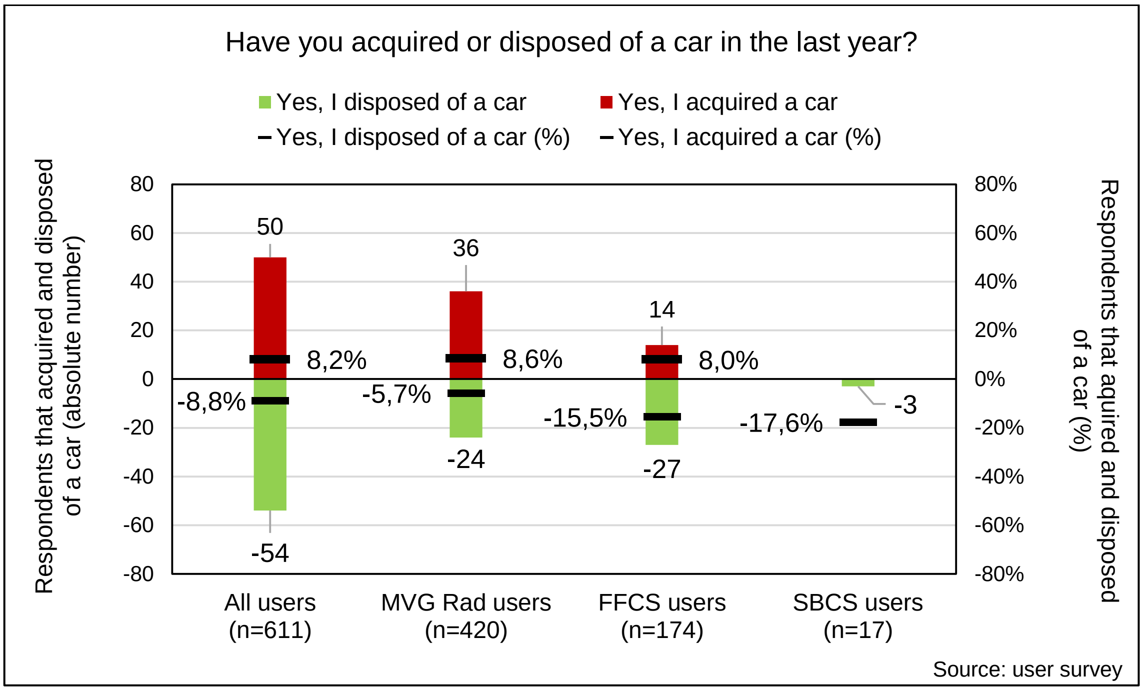


Figure 6.26. Changes in car ownership among users and user subgroups

The results indicate that the absolute number of vehicles owned by the users of the Mobility Station had marginally changed in the previous year. A further differentiation between the user subgroups shows that:

- more MVG Rad users purchased a car than disposed of one,
- more FFCS users than MVG Rad users disposed of a car,
- among FFCS users, twice as many disposed of a car than those that purchased one,
- among SBCS users, no cars were purchased, and even some disposed of a car.

These results are consistent with other studies on the impacts of shared mobility services, indicating that bikesharing does not have a significant effect on car ownership, while carsharing does (see literature review on the impacts of shared mobility services, Sections 3.3.1 and 3.3.2).

The results also indicate that there is a correlation between the frequency of using carsharing and disposing of a private vehicle. Among FFCS users who used carsharing at least once a week, 22% claimed to have disposed of a car while only 7% of them acquired one.

A similar correlation regarding the effects of carsharing on car ownership has been reported in Munich and Berlin (team red, 2015; Giesel and Nobis, 2016). According to team red (2015), carsharing customers in Munich who frequently used carsharing, disposed of more private vehicles than customers who used carsharing less frequently. According to Giesel and Nobis (2016) the analysis of FFCS and ZBCS users in Berlin and Munich shows that the likelihood of shedding a car increases if a person frequently uses carsharing.

6.6.1.2. Motivations for owning and for not owning a car

As part of the user survey, users were also asked about their reasons for purchasing or disposing of a car, which were then classified into categories by the author. As this was an open question, some respondents indicated more than one reason. Figure 6.27 and Figure 6.28 present the results based on this classification.

Reasons for acquiring a car

The analysis of responses shows that the many reasons for purchasing a car could be potentially covered by carsharing services. While there might be users who will always prefer to own a car, especially those that indicated having acquired one *for fun, pleasure and/or comfort* and *flexibility, independence and/or freedom*, some users might not be aware of other carsharing models which enable cost-efficient use of carsharing *for longer trips away from the city* (or the service area), *for transport,* or *for the weekend*. (See Figure 6.27).

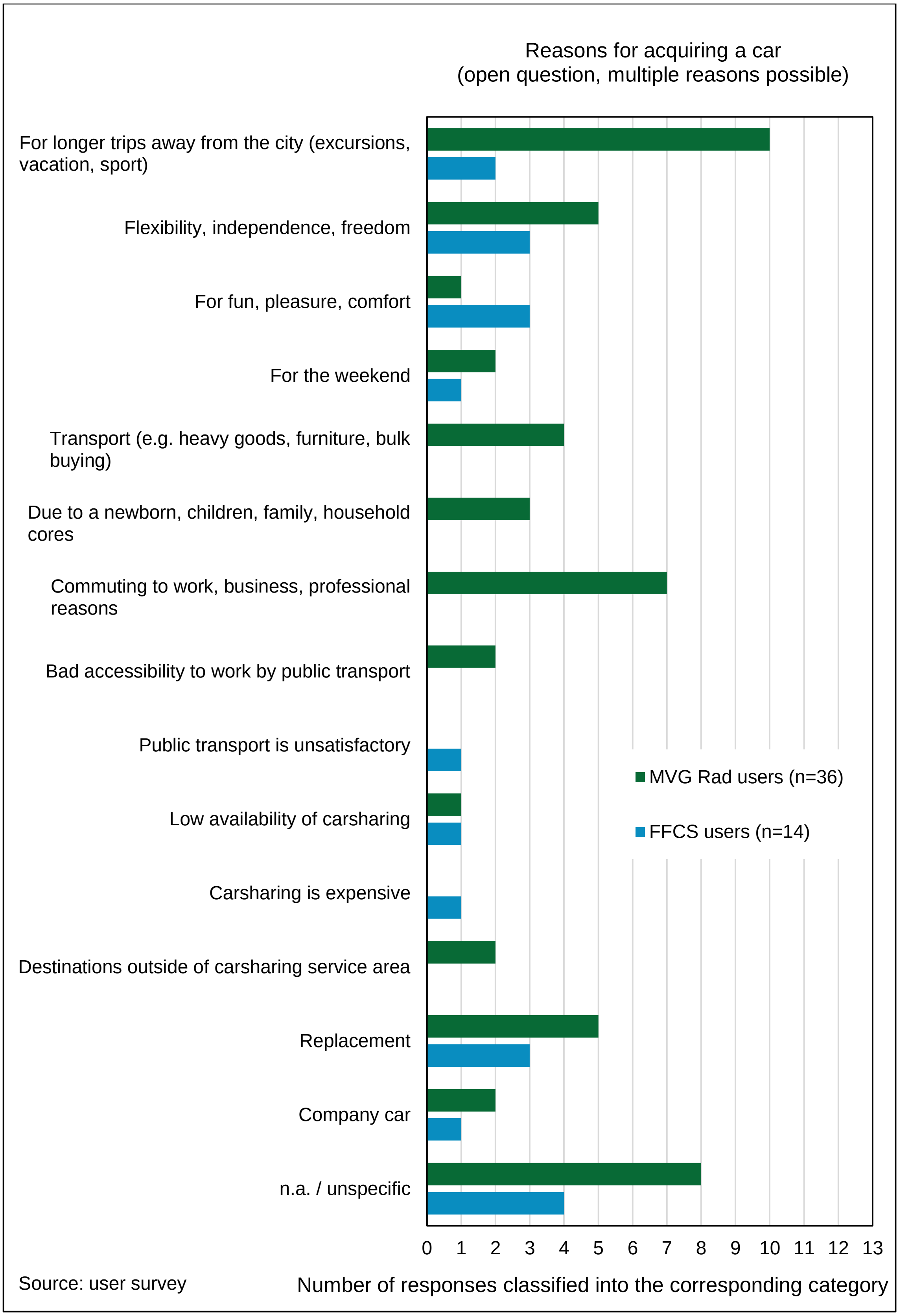


Figure 6.27: Reasons for purchasing a car among users' sub groups

It is worth nothing that some users mentioned the *low availability of carsharing* or that their *destinations are outside of the service area* as reasons for acquiring a car:

„Carsharing cars are not that available in my area, and my destinations are often outside the service area. That's why I have my own car, and also for vacations" (MVG Rad user, reasons for purchasing a car, user survey)

This indicates that these users are potential shedders of private cars if carsharing becomes more available. According to Giesel and Nobis (2016), the main condition to dispose of a car among carsharing customers in Munich and Berlin who still own cars is if "carsharing is always available". Also, a survey among car2go and DriveNow customers indicated that the main condition under which FFCS would be preferred over their own car was "*if the [FFCS] cars were more reliably in my area when I need one*" (74%) (car2go and DriveNow, 2015).

Commuting to work, business and professional reasons, and *bad accessibility to work by public transport* were important reasons for acquiring a car among MVG Rad users. Interestingly, these reasons were not mentioned by any of the FFCS users.

From the 50 vehicles purchased by the users during this time, eight of them seem to not add to the set of vehicles owned by the users, since five respondents indicated they were replacements of other cars, and the other three are company cars.

These results indicate that better accessibility to work and other destinations outside of the city, as well as further advertisement of carsharing business models other than FFCS could potentially further prevent people from buying cars. For this, mobility stations have the potential to increase accessibility by combining public transport and a diverse set of shared mobility services.

Based on the user survey, it was discovered that about 70% of FFCS and MVG Rad users are familiar with STATTAUTO, but less than 5% actually use it. Also, through the focus groups it was revealed that many non-users are not aware of the benefits of SBCS services. This indicates that better communication of the different business models and their benefits is needed to avoid the purchase of a car by existing users of shared mobility services.

According to Giesel and Nobis (2016) a combination of different types of carsharing has a stronger impact on reducing car ownership than a single type alone. Non-users also saw the combination of different types of carsharing as ideal:

> *"A little bit of a mixture [free floating and station based carsharing) would be sensible. I would use it more often and abstain from an own car in the long term, if Í wouldn't have the parking problem. Fundamentally, the free floating system is the best and most flexible, but I think that having carsharing-reserved parking spaces on traffic nodes, so that the chance of finding a space quickly is bigger, is still a good idea."(Non-user, focus groups)*

Reasons to dispose of a car

The main reasons for disposing of a car were *due to costs* and because *it became unnecessary.* Carsharing users indicated, among other reasons, to have disposed of their car *due to low use*, while this was not a reason for MVG Rad users. See Figure 6.28.

Another important reason to dispose of a car, especially among MVG Rad users, was *due to enough alternatives in the city*:

> *"It's not worth it in Munich. Public transport, carsharing, rental cars, and my bike have replaced my car. The offer should be developed massively, and the focus of the city should be to reduce the number private cars" (MVG Rad user, reasons for disposing of a car, user survey)*

Some users specifically mentioned public transport supply, while others mentioned carsharing as reasons for disposing of a car. A good supply of alternatives in combinations with parking pressure and congestion seem to motivate some users to get rid of a car:

> *"Because in Munich, I can get everywhere thanks to the MVV, my own bike, and bikesharing bikes. I also don't have to put up with the unbearable stress during the peak hours because at my work, it's hard to find a space after 6:30 in the morning, it's also hard to find a parking spot in my neighborhood, and my employer pays for a public transport subscription between work and my neighborhood" (MVG Rad user, reasons for disposing of a car, user survey)*

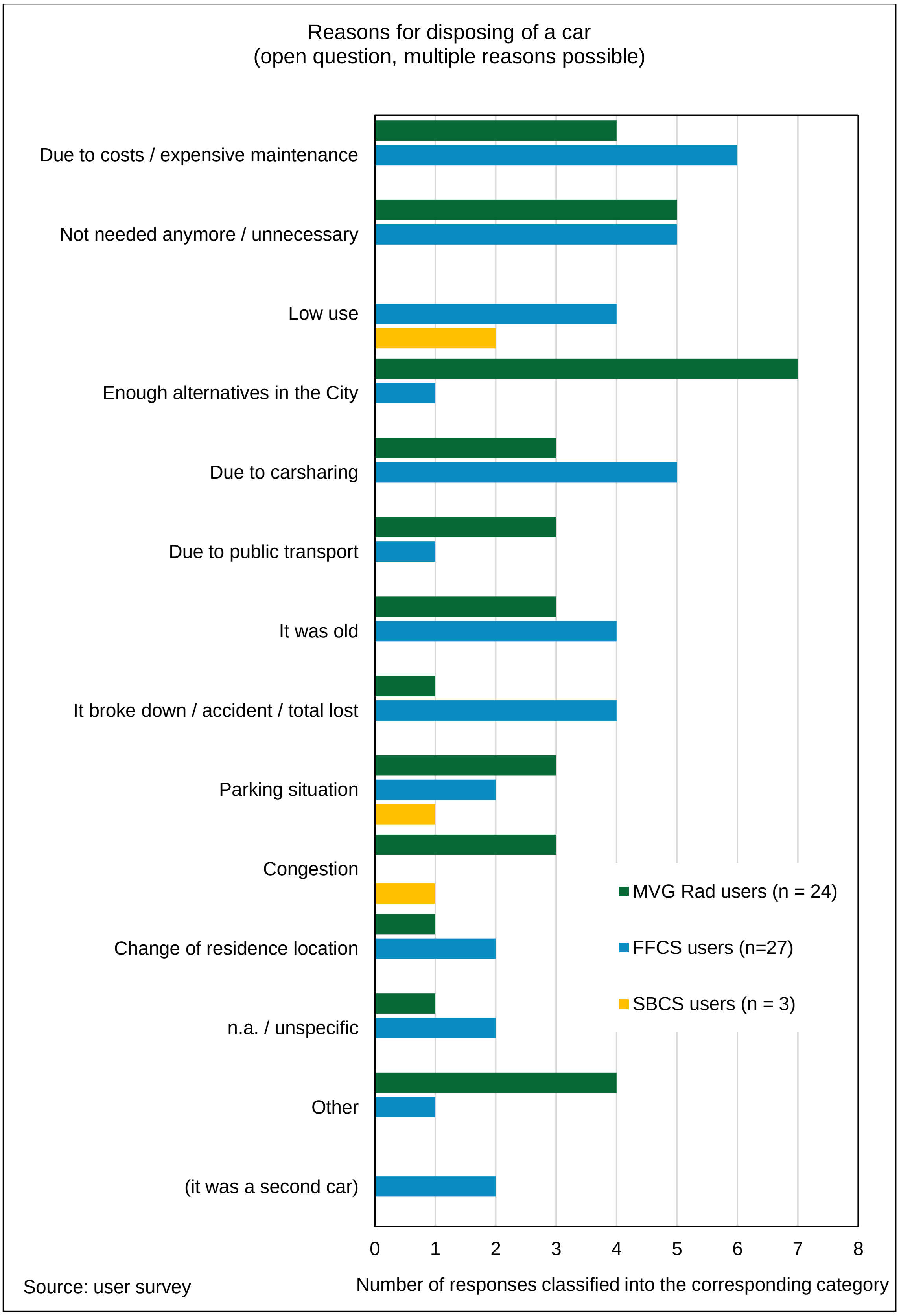


Figure 6.28: Reasons for disposing of a car among users' subgroups

According to Giesel and Nobis (2016) some of the main reasons for potentially shedding a car among carsharing customers in Berlin and Munich are if “carsharing is always available”, “well interconnected modes” and “better public transport”, which supports the results obtained by means of the user survey.

Other common reasons to get rid of a car were because “it broke down” or because “it was old”. According to some users these reasons motivated them to try to go without a private car or to become carsharing members:

„It was getting old (end of lifecycle), and afterwards I didn’t buy a new one to see whether or not I could live without a car. (MVG Rad user, reasons for disposing of a car, user survey)

“I had a car breakdown and had no time to deal with buying a new car. In the meantime, I registered with DriveNow and car2go. Being able to rent at and return cars to the airport, and also to ability to use them in other cities (I fly often), made this offer especially attractive to me. For long drives, most of the time I rent a car with Sixt.” (FFCS user, reasons for disposing of a car, user survey)

Also, in the focus group discussion with non-users, the potential of carsharing to reduce the need of a private car was expressed by one of the participants:

“If my car were to breakdown, I would definitely think about buying a new one or not. Just economically it doesn’t make sense. That is assuming you could find a carsharing provider that is so flexible enough that it can cover everything. Sometimes you need a hatchback to transfer a lot of stuff, sometimes a compact for the city. Currently there are no providers with a fleet big enough to handle that.“(non-user, focus groups)

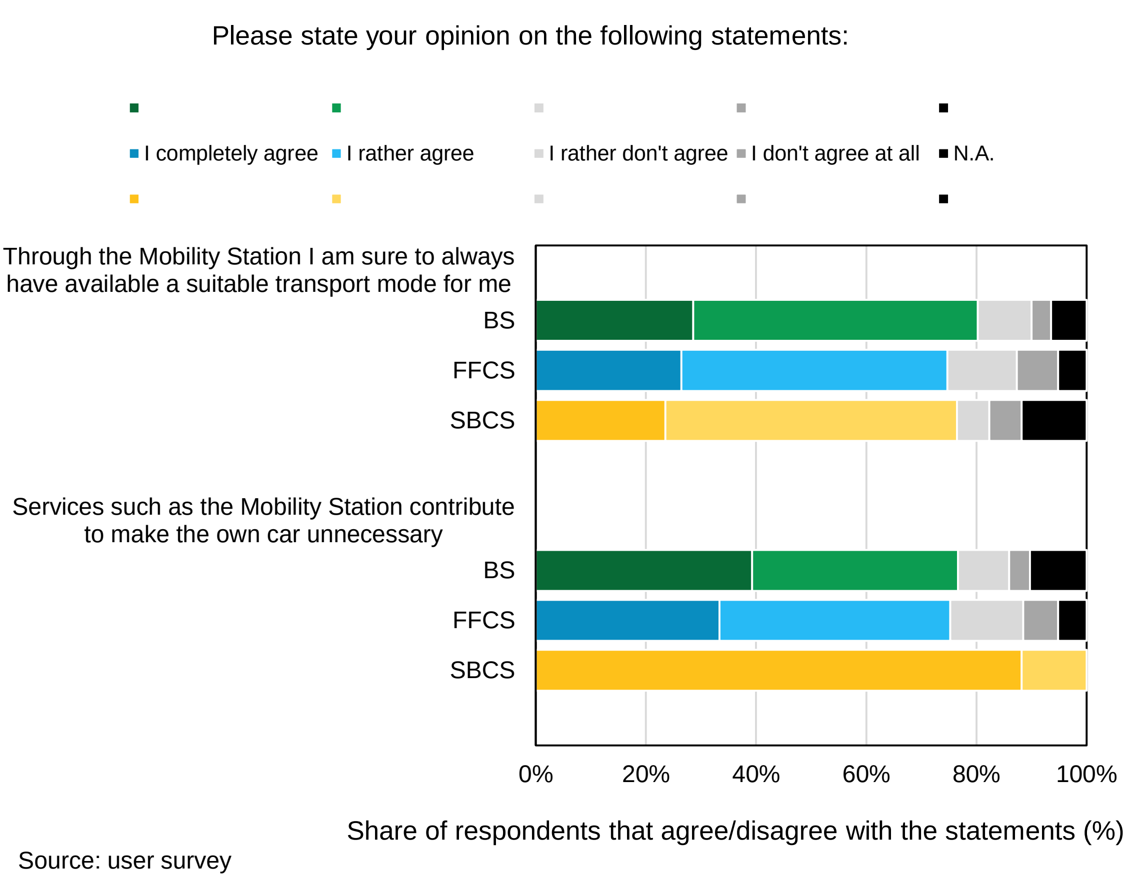
Finally, changing residence location and the parking situation also motivated some users to dispose of a car, while some mentioned being too annoyed with congestion.

The above presented results are similar to those obtained from a survey among car2go and DriveNow customers (n=2881) which indicated that 37% of them gave up a car in recent years (2015 – before 2011), from which about half indicated that FFCS played a role in that decision (car2go and DriveNow, 2015). Other frequently mentioned reasons for giving up a car were that the majority of destinations were also accessible by other modes of transport, that keeping up their own car was too expensive, low usage, and due to a change in life situation (ibid).

6.6.1.3. Perceived influence of the Mobility Station on car ownership

While quantitative impacts of the Mobility Station on car ownership cannot be derived through the analysis of the changing number of cars owned by users, the analysis of statements the users agree to can provide further indication on the impact of the Mobility Station on car ownership.

A large majority of users agree that through the Mobility Station they are *always sure to have available a suitable transport mod*e for them and that it *contributes to make the own car unnecessary* (see Figure 6.29).



Source: user survey

Figure 6.29: Agreement on statements regarding the Mobility Station on its potential effect on car ownership

Similar results were obtained in Offenburg and Würzburg (see Section 3.2.5.2) where a 67% and 73% respectively agree that due to the mobility stations, they can always be sure to have an appropriate transport mode available and over 80% of users in both cities agreed that mobility stations contribute to making the own car unnecessary. (Heller, 2016; Pfertner, 2017)

Even though users only agree to a statement and are not committed to any action, the fact that a large majority of users in the three cities agree to both statements, is remarkable. It shows that there could be a latent openness to the idea, or even a desire, that private cars become unnecessary when sufficient alternatives are provided.

Furthermore, through the discussion with users there is some indication that in the long term mobility stations can contribute to reduce car usage and that less cars are acquired overall, especially if they are in close proximity to where people live:

"Especially when you live two or three-hundred meters around the Mobility Station, the question of having your own car just isn't a question anymore." (user, focus groups)

6.6.1.4. Support of multimodality

According to the user survey, some users became members of a shared mobility service because they became aware of it through the Mobility Station. Moreover, users of different subgroups indicated to have become aware of another mobility service through the Mobility Station and are considering becoming customers. See Figure 6.30.

About 18% of carsharing users declared to become customers of carsharing because they became aware of the service through the Mobility Station and about 35% of FFCS users are considering to join another carsharing provider.

Similar results were obtained in Offenburg and Würzburg where 26% and 59% of users respectively, declared to have become customers of a mobility service due to the mobility stations (see Section 3.2.5.2).

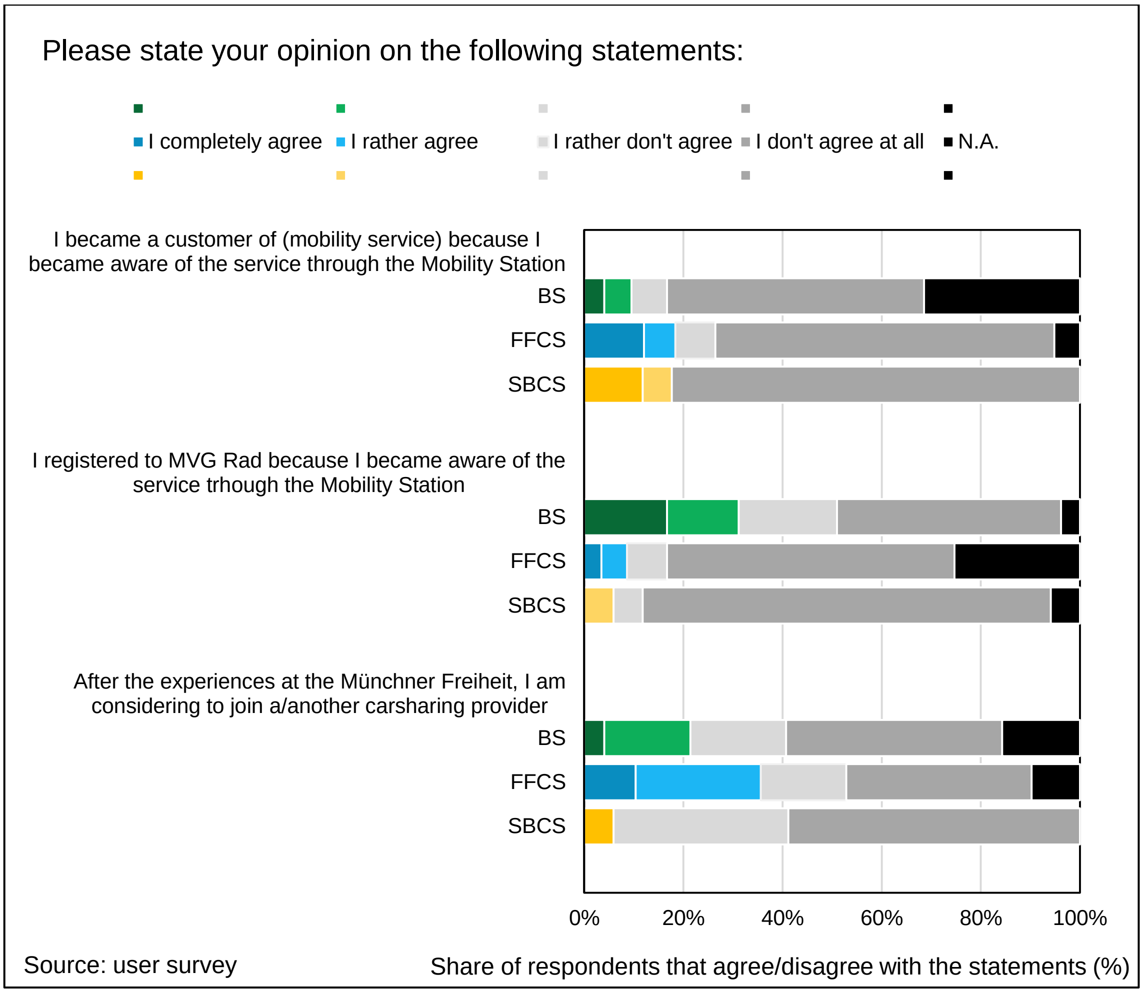


Figure 6.30: Agreement on statements regarding the Mobility Station and its influence on the use of shared mobility services

The results above indicate that mobility stations promote multimodality by making users aware of other mobility options and by motivating them to register with additional providers. As presented in Section 3.3.4, various studies indicate that there is a correlation between multimodal mobility behavior and low car ownership. This is another indication that that mobility stations could contribute to reduce car ownership.

6.6.2. Effects on the use of other mobility services

The impacts of the Mobility Station on the use of other mobility services were investigated by means of the user survey. Users were asked to indicate the extent of their agreement to statements related to changes in the frequency of use of some mobility services due to the Mobility Station. See Figure 6.31.

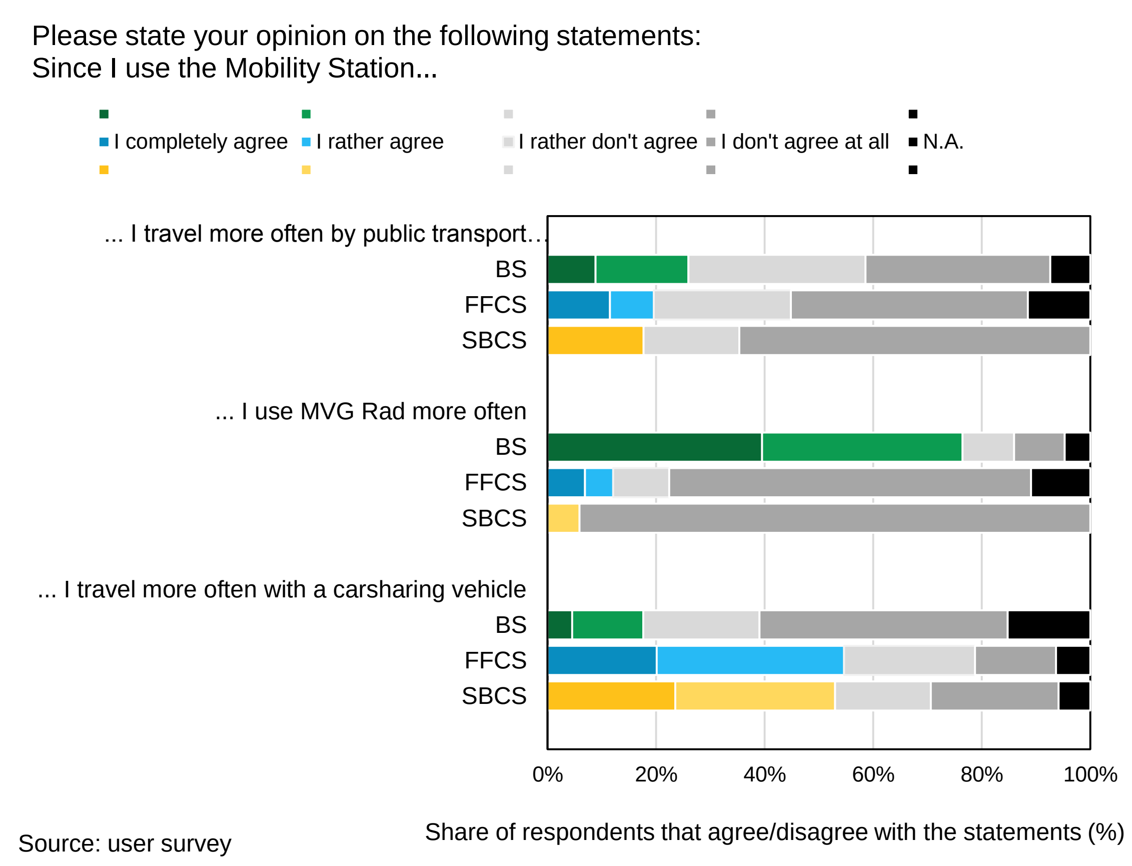


Figure 6.31: Declared changes in the frequency of use of mobility services due to the Mobility Station

About 20% of users stated they use public transport more often since they use the Mobility Station, and a majority of users stated using the mobility service they were identified to be customers of more often as well. The rest of users do not agree that they use mobility services more often due to the Mobility Station.

In the case of MVG Rad, the large share of users who declared to use the service more often might be explained by the fact that the docking station at the Mobility Station was installed at the same time MVG Rad started operations in the city.

Worth to notice is an increase in the use of other shared mobility services due to the Mobility Station among subgroups of users:

- about 18% of bikesharing users indicated to use carsharing more often due to the Mobility Station, and
- around 12% of FFCS users indicated to use bikesharing more often due to the Mobility Station.

In Offenburg and Würzburg the share of users that agree to use mobility services more often due to the mobility stations vary (see Section 3.2.5.2). In Offenburg and Würzburg, respectively:

- 14% and 23% of users, use public transport more often
- 36% and 74% of users, use carsharing more often, and
- 9% and 12% of users, use bikesharing more often.

The results indicate that mobility stations have an influence in increasing the use of public transport and shared mobility services. However, among the users who do not agree to the statements, it is not clear if they use less often the different mobility services or if no changes in the frequency of use took place. Also, without a further analysis of the results, is not possible to know what "more often" means.

In the future, this question should be asked differently. For example, users should indicate if a mobility station is the reason they use a mobility service more often, less often, or if no changes due to it occurred (see Section 7.3.2 for further reflections on the user survey).

Effects on the use of private cars

Due to the focus given to the effects of mobility stations on the use of the shared mobility services offered at them, the effect of mobility stations on private car usage was not investigated so far.

Thus, the impact of mobility stations on the use of private cars and other mobility services beyond those available at these facilities is not clear. Further surveys including detailed travel diaries or GPS tracking, in the framework of panel studies, are necessary to have a better understanding of this effect. See Section 7.3.2 for a reflection on the user survey and 9.2.2 regarding recommendations for further research.

6.6.3. Substitution of transport modes when using shared services

As part of the user survey, it was inquired what mode of transport would have been used if the shared mobility service used for their last trip would not have been available (see Figure 6.32).

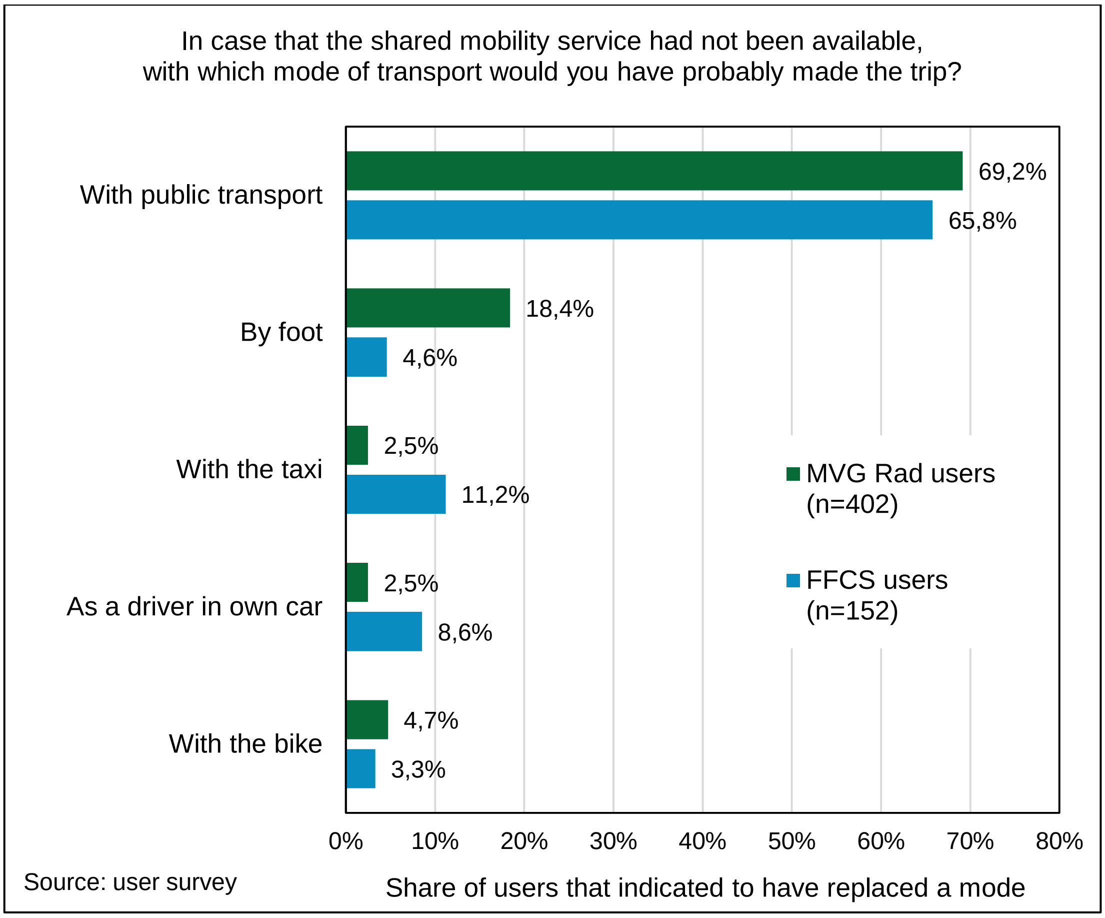


Figure 6.32: Modes of transport that users would have used in case that the shared mobility service would not have been available

The responses indicate that almost 70% of both FFCS and BS users would have used public transport. Some other MVG Rad users would have walked (18%), and carsharing users would have taken a taxi (11%), or the own car (9%).

These results might indicate that shared mobility services could be replacing public transport. However, it is also possible that shared mobility services are complementary to public transport.

As presented in Section 6.4.5, the majority of MVG Rad users accessed (60%) or egressed (49%) the Mobility Station by public transport. Also, among FFCS users, 38% accessed and 13% egressed the Mobility Station by public transport. This indicates that a significant share of trips with shared mobility services are used in connection with public transport.

In the focus groups, some of the use cases mentioned by the participants indicated that bikesharing is used when the wait times for public transport are too long, or as a mode for first/last mile to/from a public transport station.

> *"I'm often out and about at night, and the intervals of the buses and the trams that I need are often 20 minutes. Then, the idea came to me, I have maybe a 5-7 minute ride with a bike, and so I then started using MVG Rad. It's filling a void in the public transport of the city to bridge gaps in the interval times". (User, focus groups)*

> *"Quite often used for the last 7 minutes, that you have to walk from the metro station home. For that, I ride a bike and drop it off at my door, then I can ride it again to the metro station". (User, focus groups)*

Thus, bikesharing might replace public transport in some occasions, but it also complements it in some others.

Also during the focus groups, some use cases for using carsharing instead of public transport were presented by the participants:

> *"Especially when you have to get to the airport. For that it's already worth it to use carsharing when you have two people going. The ticket costs 11 Euro, and if there are two of you coming from the city center, you pay at most 25 Euros (with carsharing). And it's usually faster". (User, focus groups)*

> *"If you don't have an IsarCard subscription, and you're out and about in the city, and you need to go a short way, about 15 minutes, and there are three people together, it's even cheaper to rent a carsharing car together, instead of buying a one way ticket on public transport for everyone". (User, focus groups)*

This indicates that carsharing is used instead of public transport when the first offers a quicker and cheaper alternative.

A survey among car2go and DriveNow customers (n=2881) indicates that, among other reasons, FFCS is used instead of other modes of transport when it is the best and quickest way to reach a destination (79%), if a taxi is too expensive for the purpose of the journey (62%), or if the connections via public transport are infrequent/journey time is too long or many transfers are involved (53%) (car2go and DriveNow, 2015).

Finally, for the interpretation of these results, it should be taken in account that the answers refer to one particular trip, and that the majority of users of the Mobility Station – more than 70% - use public transport more than once a week. According to the Carsharing Evaluation in Munich (EVA-MS) users of carsharing perform in average between 1 to 2 trips per month with a carsharing vehicle (team red, 2015). This, in comparison to the frequency of use of public transport, indicates that carsharing is used rather for special occasions and does not replace public transport for daily mobility.

6.6.4. Summary

The impacts of the Mobility Station on car ownership cannot truly be measured through the number of cars purchased or disposed by the users, because there is no evidence of a causal relationship between its use and the decision to purchase or dispose of a car.

Based on the presented results, the impact of the Mobility Station on car ownership cannot be determined quantitatively because: first, the user survey did not aim to find a connection between using the Mobility Station and the disposal of a car; and second, because there are multiple factors that influence the decision to acquire or dispose of a car.

However, the already known effect of carsharing on car ownership was confirmed by users of the Mobility Station that are carsharing users: twice as much FFCS users disposed of a car than those that acquired one. Moreover, the share of frequent (“heavy”) FFCS users that disposed of a car is even bigger (22%) than the share of those that bought one (7%).

In addition, the detailed analysis of reasons for which users of the Mobility Station acquired or disposed of a car indicates that mobility stations have a great potential to reduce car ownership:

- One of the most frequently mentioned reasons for disposing of a car was the availability of enough alternatives and the good public transport supply in the city.
- Also, many of the users mentioned reasons for acquiring a car which could potentially be handled by using carsharing services.

A more subtle but important effect is perceived in the mindset of users: a big majority of users, over 70%, agree that services such as the Mobility Station contributes to make the own car unnecessary and that through the Mobility Station they are sure to always have a suitable transport mode available to them.

Furthermore, the Mobility Station raises awareness and adoption of alternatives to private car supporting multimodal mobility behavior, which according to various studies has correlation with low car ownership (Buehler and Hamre, 2016) (see Section 3.3.4 for a summary on the correlation of car ownership and multimodality).

Regarding the effect on the use of other mobility options, it can be said that the Mobility Station contributes to an increase in the use of shared mobility services and public transport among some users, but is not clear if contributes to a reduction in the use of these services among other users. Also it remains unclear how this facility influences the use of other mobility options such as the own car or the own bike.

Finally, a big majority of trips with shared mobility services replaced public transport. However, the information about the use of various mobility services indicates that bikesharing is rather used in combination with public transport and that carsharing does not replace public transport for daily mobility.

Based on the above, it can be said that mobility stations have the potential to further increase the availability of alternatives to a private car, and therefore can contribute to the reduction of car ownership.

However, in order to exploit this potential, the multimodal mobility offer at mobility stations must be enhanced in many ways, for example through virtual integration in the form of MaaS and through better marketing. Chapter 8 provides further details on how to enhance mobility stations.

6.7. Problems and ideas for improvement

Through on-site visits, personal observations, stakeholder interviews, the user survey, and the focus groups, different kinds of problems at the Mobility Station were identified.

The identification of problems also helped form ideas for improvement. Ideas for improvement came from either the users (through the survey and focus groups), the stakeholders, or from research into other examples of mobility stations (literature research and on-site visits), which was done as part of the investigation on the state of the art of mobility stations (see Chapter 3).

As a summary, the main problems can be classified in the following categories:

- Visibility: lack of visibility of the Mobility Station from the other side of the street and from the bus and tram stop
- Way finding: lack of wayfinding elements or signs to make people aware of the Mobility Station
- Cumbersome intermodal transfers
- Conflicts between different road users
- Difficult access to and egress from the Mobility Station with carsharing
- Technical and operational problems specific of the shared mobility services

Both problems and ideas for improvement for this specific case were used for the general recommendations when implementing mobility stations in Munich, and more generally (see Chapter 8).

The following subsections provide further details about the problems mentioned above and some ideas to solve them.

6.7.1. Visibility

Even though most users and non-users became aware of the Mobility Station by walking by, there is still potential to increase its visibility.

For example, the non-user survey revealed that among non-users who use carsharing in general, 17% did not know that the service was available at the Münchner Freiheit.

This suggests that there is potential for more advertisement of the Mobility Station among carsharing users and higher visibility in the public space.

Figure 6.33 shows a photograph of the Mobility Station from the other side of the street. Besides the signs for the reserved parking spaces for carsharing, which are still difficult to notice, there are no other elements indicating the presence of the Mobility Station from this point of view).

Image source: own photograph

Figure 6.33: The Mobility Station from across the street (Leopoldstraße)

The analysis of the group discussions suggests that there was a lack of a noticeable branding to make the multimodal mobility offer at the Mobility Station recognizable as such. Both users and non-users agreed that a recognizable element would be needed, so that future mobility stations would be easier to find in the cityscape (up2date, 2016).

The visibility of the Mobility Station could be improved by using larger signs with striking colors. This, however, is in conflict with current construction regulations in Munich. Thus, stronger involvement of the Building Department could facilitate an improvement in the visibility of further mobility stations in Munich.

6.7.2. Way finding

For public transport users who transfer from the metro to tram or bus, there are no clear signals indicating the presence of the Mobility Station.

„When one like me goes up from the metro and directly to the next bus or tram, then that with the carsharing does not strike one at all. Those bikes ok, one sees them". (non-user, focus groups)

Figure 6.34 shows a view from the entrance of the metro station of the bus and tram station looking north, where the carsharing spaces and the docking station are located.

Image source: own photograph

Figure 6.34: View to the North (in direction to the reserved carsharing parking spaces and bikesharing docking station) from the bus and tram stop at Münchner Freiheit

Users suggested installing signs on the mezzanine level of the metro station and in the immediate surroundings of the Mobility Station to indicate its location. Another idea is to relocate the on-site information screen or have an additional one on the mezzanine of the metro station so that the possibility of more people seeing it and become aware of the Mobility Station is higher.

6.7.3. Intermodal transfers

Even though the bikesharing station is *at* the Mobility Station, some users complain that the distance between the docking station and the metro entrance is too large.

„Bike station too far away from metro, the other side to the South would be much better, -if possible to open two bike stations. If one comes from the South, one must travel farther and then all the way back when one use the metro" (MVG Rad user, user survey)

Figure 6.35 shows an example path a user coming from the south with a bikesharing bike might take. After returning the bike, he or she has to walk all the way back to the entrance to the metro station.

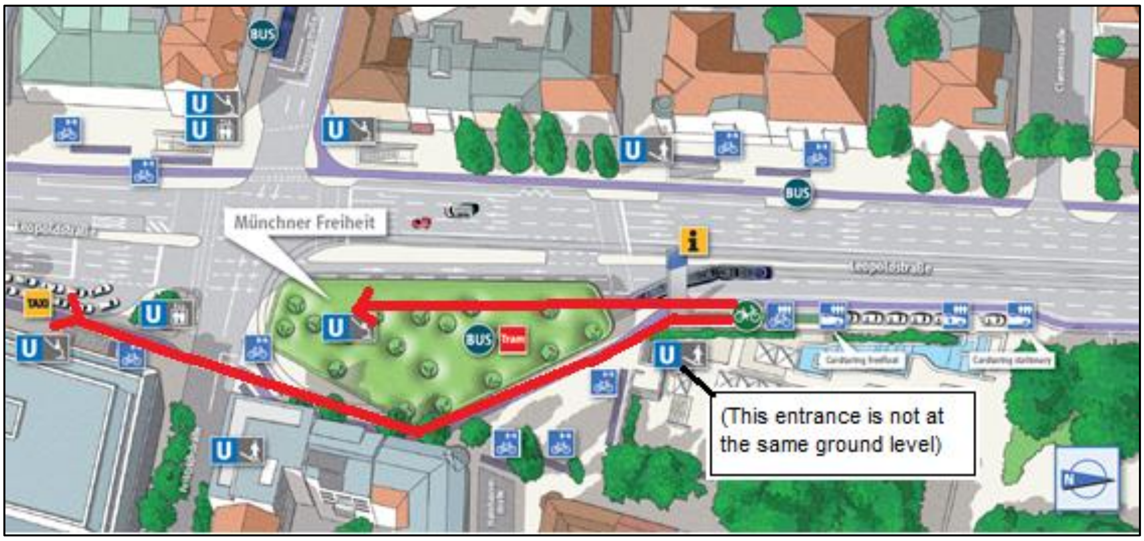


Image source: Adapted from (MVG, 2015)

Figure 6.35: Example of one user-case transferring from bikesharing to public transport

To facilitate the transfers from bikesharing to public transport and vice versa, users suggest that docking stations should be directly located at the entrance to the metro station to make the transfer between these two modes more convenient.

6.7.4. Conflicts between different road users

The current layout of the Mobility Station may cause conflicts between pedestrians, passengers of public transport, and cyclists, especially during peak hours. Figure 84 shows the bike lane obstructed by pedestrians and a potential conflict between a cyclist and the tram line.

„Here pedestrians are truly overrun by cyclists. The footway at this place is too narrow. For strollers, persons in wheel chair, elderly people or parents with children this is a scary dangerous place because the cyclists race through, unaware like crazy" (FFCS user, user survey)

Image source: own photographs

Figure 6.36: During peak hours there might be some conflicts among different road users.

6.7.5. Access and egress with carsharing vehicles

Users of carsharing indicated that it is difficult to park at the Mobility Station when coming from the north or when traveling south due to traffic restrictions and difficult maneuvering for U-turns.

> *“For those coming from the North , difficult to reach [the Mobility Station] to return cars (e-cars to charge)“ (FFCS users, user survey)*

> *“When one drive in direction to the city, there is not an easy, close, legal possibility to turn in order to come to the right lane. One must drive until Thieme street in order to turn, so 1.5 km detour, 5 traffic lights” (SBCS users, user survey)*

Figure 6.37 shows the detour that a car driver would need to do in order to park at the Mobility Station when coming from the North.

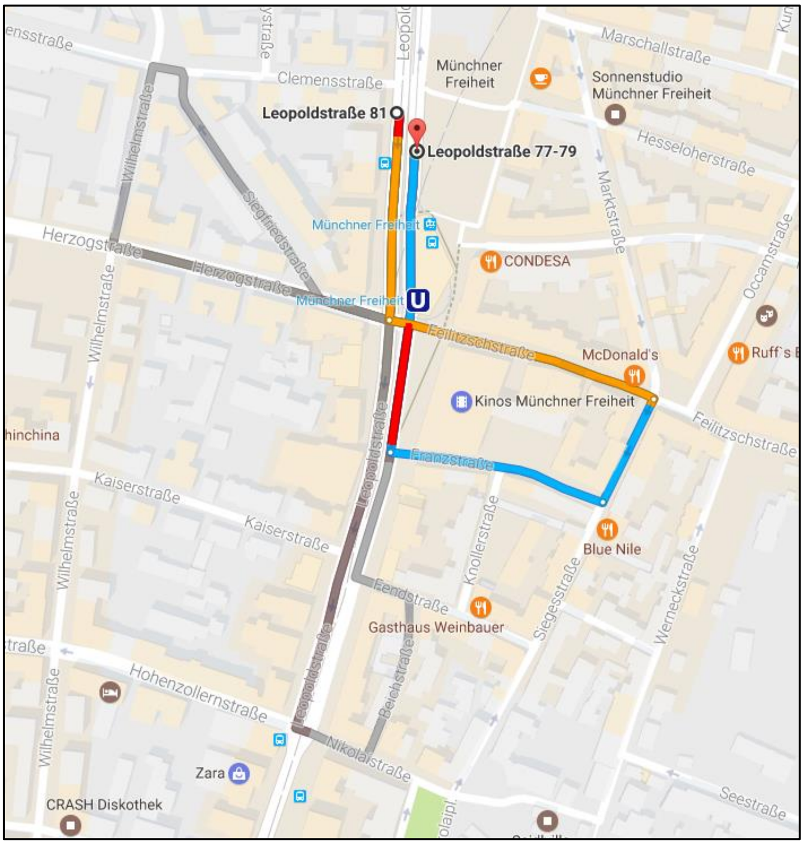


Image source: google maps

Figure 6.37: Route options for parking a car at the Mobility Station when coming from the North

An idea from the user survey was to place a „mirror station“, that is to say, to install reserved carsharing places at the other side of the street for those arriving from the north and those traveling to the south.

Another problem pointed out by users was the difficulty to enter or leave the Mobility Station when using carsharing due to the bike lane on the street next to the parking spaces, especially when there is a lot of car and bike traffic (see Figure 6.38).

Image source: own photographs

Figure 6.38: The bike lane between the reserved carsharing parking spaces and the car lanes makes parking difficult

According to carsharing users, the current layout also makes it difficult to load and unload vehicles. Thus, further mobility stations should preferably be located at less busy locations.

Finally, some users pointed out that the parking spaces reserved for carsharing were occasionally occupied by private cars, or that the parking spaces next to the charging station were occupied by non-electric (private or carsharing) cars.

This problem should be partially solved when the new carsharing law comes into force in Munich. Other hard measures such as automatic bollards as in Bremen and Würzburg could protect reserved parking spaces, but are more difficult to implement and operate than just installing signs.

6.7.6. Technical and operational problems

Most of the technical problems specific to shared mobility services were mentioned by users of MVG Rad. This included difficulties for renting or returning a bike either due to physical problems with the docking station or with the smartphone application.

Some FFCS users reported difficulties using the charging station due to lack of experience and suggested to provide some kind of guidance in printed or virtual form. Another difficulty is not knowing if a parking space or the charging station is available beforehand.

Among other ideas for improvement are to increase the availability of bikesharing and carsharing vehicles, as well as better protection of the reserved parking spaces.

6.7.7. Summary

As previously mentioned, the ideas for improvement addressing the problems mentioned above came from different sources: the users themselves through the survey and focus groups, stakeholders by means of interviews, and personal site-visits to other mobility stations.

While the few ideas presented above refer specifically to the Mobility Station at Münchner Freiheit, they were also useful for generating general recommendations for the future development of mobility stations. These recommendations are presented in Chapter 8.

6.8. Overview of results

This chapter presented the results obtained by various quantitative and qualitative methods answering many of the initial questions posed at the beginning of this work (see Section 1.2).

In addition, the findings about other mobility stations and shared mobility services which were obtained through an investigation of the state of the art (see Chapter 3) contributed to answer some of the initial questions as well. Table 6.6 presents an overview of these questions and the section were some results contributing to answering them is provided.

Table 6.6: Initial questions and sections in this work with information to answer them

Question	Section
What exactly are mobility stations?	3.1.
What are distinctive characteristics of mobility stations?	3.2.2.
What mobility services are offered at mobility stations?	3.2.2.
Who are (potential) users of mobility stations?	6.2.
How often and for which purposes are the mobility services at mobility stations used for?	6.4.
What are the effects of mobility services offered at mobility stations on mobility behavior?	6.6.
How do the effects of different mobility services are influenced by the direct proximity of other mobility services?	6.6.2
What are possible effects of mobility stations on urban mobility?	6.6.
What is “sustainable urban mobility” and how do we measure (changes in) it?	Chapter 2
Which actors are involved in the planning, implementation and operation of mobility stations?	4.3.5. and 6.1.
What is the level of acceptance of mobility station among (potential) users.	6.5
What is the perception of mobility stations among users?	6.5

Answering these initial questions was important in order to answer the two main research questions of this work: *Do mobility stations contribute to the goal of sustainable urban mobility?,* and *What are the success factors for the implementation and operation of mobility stations?*. The next chapter presents the assessment of mobility stations answering to some extent these main research questions.

7. Assessment of mobility stations

Do mobility stations contribute to the goal of sustainable urban mobility?, What are the success factors for the implementation and operation of mobility stations?

In these chapter, the results obtained through the empirical investigation of the MSMF (presented in Chapter 6) and the findings about other mobility stations and shared mobility services (presented in Chapter 3) are considered to answer the main two research questions of this dissertation. Moreover, the methods used for the empirical investigation are reflected upon, and recommendations for further improvement are delivered.

In Section 7.1, the contribution of mobility stations on sustainable urban mobility is assessed by looking into six different criteria, according to the assessment method presented in Section 5.6.

In Section 7.2, identified contextual factors and success factors for the implementation and operation of mobility stations are presented.

Finally, in Section 7.3, a reflection on the methods used for the empirical investigation is presented along with some ideas for improvement.

The assessment of mobility stations on sustainable urban mobility and the identification of success factors leads to recommendations for further development of mobility stations (presented in Chapter 8) and preliminary conclusions which are presented in Chapter 9. The reflection on the methods leads to the identification of limitations of the work and recommendations for further research which are presented in Section 9.2.

7.1. Contribution of mobility stations on sustainable urban mobility

Do mobility stations contribute to the goal of sustainable urban mobility?

This is the first main research question of this dissertation. In order to answer it, the assessment method presented in Section 5.6 was applied. This assessment method is based on the operationalization approach for sustainable urban mobility developed for this work (see Section 2.3.2) which consists of two main criteria and six sub-criteria.

Table 7.1 presents the criteria and corresponding sub-criteria assessed in the framework of this work.

Table 7.1: Criteria and sub-criteria assessed in the framework of this dissertation

Criteria	Sub-criteria
Fulfillment of needs	Access to opportunities
	Access to mobility options
Consumption of resources	Space consumption
	Energy consumption
	Time consumption
	Money consumption

The influence of mobility stations on the six sub-criteria is assessed by looking into corresponding indicators and how they are individually affected by mobility stations. As described in Section 2.3.2 to observe a positive development towards the goal of sustainable urban mobility, the fulfillment of needs, and therefore the indicators used to measure this fulfillment, should increase or at least stay constant, while the consumption of resources should decrease.

The assessment is mainly based on the results obtained through the evaluation of the Mobility Station at Münchner Freiheit. Table 5.9 in Section 5.6.3 provides an overview of how different indicators related to each sub-criteria were assessed. The following subsections provide details about this assessment.

Whenever possible and relevant, the findings regarding the mobility stations in Würzburg and Offenburg (see Section 3.2.5.2) and other findings from literature review (see Section 3.3) are taken in account for the discussion.

7.1.1. Fulfillment of needs

7.1.1.1. Access to opportunities

Depending on their location and integration with their surroundings, mobility stations can provide users with more or less access to different opportunities in their immediate surroundings, and the opportunity to fulfill diverse needs such as working, shopping, and leisure activities, among others.

Also, diverse services and amenities directly *at* the mobility stations, for example mailboxes, parcel stations, small kiosks, or an internet connection can support the fulfillment of diverse needs.

As discussed Section 5.6, the following indicators were selected to assess the access to opportunities as influenced by mobility stations:

- *Supply of opportunities* at the mobility station and its immediate surroundings for the target population, and
- *Degree to which the supply of meets the demand* of users and thus, contributes to the fulfillment of their needs.

Supply of opportunities at the Mobility Station and its immediate surroundings

Due to its particular location, the Mobility Station at Münchner Freiheit does provide access to diverse opportunities and activities in the (immediate) surroundings (see Section 4.3.2).

Users of the MSMF can benefit from the access to diverse opportunities before or after using the mobility services at the Mobility Station such as going home, going to work, shopping, grabbing a snack, or having dinner at the nearby restaurants, meeting friends, going the cinema, or visiting the nearby English Garden.

The same can be true for users of mobility stations in other cities, depending where these are located. For example, in Bremen and Würzburg, mobility stations are also located in areas where a wide variety of opportunities lies within close proximity. See Best (2016) and Ezzeddine (2017) for a place-node analysis in the respective cities.

In addition, the user survey revealed a wide variety of destinations associated with a purpose in the immediate surroundings of the Mobility Station after ending a trip with a shared mobility service (see Section 6.4.4.2).

Thus, it could be argued that the Mobility Station at Münchner Freiheit contributes positively to the level of access to diverse opportunities. It is not clear, however, to which extent the supply of these opportunities contributes to fulfilling the needs of users.

Degree to which the supply of opportunities contributes to the fulfillment of needs

Users of mobility stations in Munich, Offenburg and Würzburg were not directly asked if the existing opportunities in the immediate surroundings fulfilled their needs. However, it can be assumed that some of them do, since they are considered important by the users, even though the level of fulfillment of needs cannot be directly linked to the mobility stations with the available information.

The user survey revealed that existing facilities in direct proximity to the Mobility Station at Münchner Freiheit such as shopping and leisure facilities, and some non-existing facilities are important to a considerable share of the users (see Section 6.5.4) Similar results were obtained in Würzburg and Offenburg (see Section 3.2.5.2).

The fact that some users consider other facilities that are not available yet as important, indicates that mobility stations have the potential to fulfill other needs if such facilities can be accessed through them.

In Chapter 8, recommendations to facilitate further the fulfillment of needs through the integration of mobility stations with the surroundings (Section 8.3) and through integration of other amenities at these facilities (Section 8.4.1) are provided.

7.1.1.2. Access to mobility options

As discussed in Section 5.6, the following indicators were selected to assess the access to mobility options that can be influenced by mobility stations:

- *Supply of mobility options* for users
- *Awareness of mobility options* among users*,*
- *Availability of mobility options* to users*,*
- *Ease of physical access to mobility options* for the users,

Supply of mobility options

By their nature, mobility stations provide a diversity of mobility options which in turn can be used to fulfill diverse needs. The MSMF provides a wide variety of mobility options (see Section 4.3.3), and according to the user survey, the mobility options at the Mobility Station at Münchner Freiheit are used for a wide variety of purposes (see Sections 6.4.3 and 6.4.4).

It is not clear though, how exactly the supply of mobility options contributes to the fulfillment of needs. See recommendations for further research on this aspect in Section 9.2.2.2.

Also, a wide diversity of mobility options can contribute to increasing the fulfillment of needs and to reducing the consumption of resources. This diversity could also be increased to consider the needs of all citizens, not only current users. Section 8.1 provides recommendations on how to assure that the diversity of mobility options contributes to fulfill the needs of users considering the aspect of intragenerational equity, and Section 8.4 provides recommendations on how to reduce the consumption of resources for mobility.

Awareness of mobility options

Being aware of a mobility service is an important first step towards adopting it as part of one's mobility portfolio.

According to user and non-user surveys in the three cities where mobility stations were evaluated (Munich, Würzburg and Offenburg), about half of respondents became aware of the mobility stations when passing by (see Section 6.3.2). Furthermore, some users agree that due to the mobility station(s), they became aware of additional mobility options and some joined or considered joining another provider (see Section 6.6.1.4).

Due to the above mentioned results, it can be argued that mobility stations raise awareness about the diversity of options, which might then be adopted as part of the users' mobility portfolios. Nevertheless, the awareness of mobility options can be further increased. Recommendations for increasing awareness are provided in sections 8.1.3 and 8.1.6.

Physical access to mobility services

The location of mobility stations on open public space provides easy physical access to mobility options compared to stations (e.g. carsharing stations) located on private ground or in underground garages. Experiences in Bremen and Hamburg show that stations located on open public space are more frequented than other stations (see Section 3.2.5.1). Also, direct and open access at ground level is also appreciated by the users of the Mobility Station at Münchner Freiheit. See Section 6.5.1.2.

This is an indication that mobility stations facilitate physical access to mobility services. However, some access problems were revealed by the users of the Mobility Station at Münchner Freiheit (see Section 6.7.5). The ideas from the users were taken in account in providing recommendations for improving physical access of mobility stations (see Sections 8.2 and 8.3).

Other important aspects in assessing the physical access to mobility services, which were not assessed in the framework of this work, are the level of *barrier free access*, the *quality of infrastructure* and *connectivity*. See recommendations for further research in 9.2.2.2.

Availability of mobility options

The analysis of operational data of MVG Rad and DriveNow shows that about twice as many rentals than returns took place at the Mobility Station (see Section 6.4.4). This indicates that there is a high demand for the services, but not necessarily that this demand is satisfied. In fact, some users of the Mobility Station at Münchner Freiheit suggested increasing the availability of shared mobility services (see Section 6.7.6).

Also, data on the occupancy of parking spaces suggests that these are most of the time available (P+R Park & Ride GmbH, 2016). At the same time, some users complained that the reserved parking spaces were occupied by non-authorized vehicles when they wanted to use them (see Section 6.7.5).

Due to these results, it can be argued that the Mobility Station does increase the availability of mobility options. However, there is still room for improvement in this area. Section 8.7 provides ideas for an improved operation of mobility stations.

7.1.2. Consumption of resources for mobility

7.1.2.1. Space and energy consumption

As discussed Section 5.6.2, car ownership was selected as an indicator to assess the consumption of space for mobility, with respect to the possible effects of mobility stations.

In addition, mode choice was selected as indicator for consumption of space and energy associated with mobility, with respect to the impact of mobility stations.

Car ownership

Considering the results presented in Sections 3.2.5.2 and 6.6.1, it can be said that mobility stations can have a positive impact on the reduction of car ownership. Although it is not possible to quantify this impact, three main observations have been made:

- The well-known effect of carsharing on reducing car ownership is confirmed by the users of mobility stations identified as carsharing users: in Munich and Würzburg (Pfertner, 2017) more carsharing users got rid of a car, compared to those who acquired one in the past year.
- Mobility stations promote multimodality. According to the user surveys in Munich, Würzburg and Offenburg, the use of shared mobility services has increased among a significant share of users, and some of them became members of a shared mobility service because they became aware of it through the mobility stations.
- A large majority of users in the three cities agree that a) mobility stations contribute to make private cars unnecessary and that b) due to the mobility stations they can always find a suitable mode of transport.

Regarding the second observation, literature suggests that there is a correlation between high level of multimodality and low car ownership (see Section 3.3.4).

As for the third observation, it might be considered a weak argument, because users only agree to a statement and are not committed to any action. However, the fact that a large majority of users (around 70%) in the three cities agree to both statements, is remarkable. It shows that there could be a latent openness to the idea, or even a desire, that private cars become unnecessary when sufficient alternatives are provided.

Furthermore, some of the reasons among users of the MSMF for disposing of a car are a) *having a wide variety of mobility options, b) having access to carsharing,* and *c) having access to public transport* (see Section 6.6.1.2).

Due to the above mentioned results, it can be said that mobility stations have a clear potential in contributing to the reduction of car ownership among users, especially when carsharing is provided. Nevertheless, there are four main issues when assessing this indicator:

1. among bikesharing users in Munich, the opposite effect was observed: more bikesharing users acquired a car than those who got rid of one;
2. the decision to get rid of a car or acquire one is usually a long term one and is influenced by a variety of factors that were not fully investigated in this work;
3. the survey did not directly explore a link between the use of the Mobility Station and car ownership;
4. the available results reflect only a “snapshot” of reality.

Considering the limitations presented above, it is clear that more research is needed in order to understand the effects of the Mobility Station on car ownership. See reflections on the methods regarding the investigation on car ownership in Section 7.3.2.3 and recommendations for further research in Section 9.2.2.3.

Mode choice

As discussed in Chapter 2, single occupied cars consume the most space and energy for each person-kilometer traveled. Thus, car usage (VKT by car) could be used as a proxy indicator for the consumption of space and energy for mobility which can be influenced by mobility stations.

However, VKT by mode, and thus the modal shift from private car towards more space and energy efficient modes, was not sufficiently investigated in the framework of this work. Thus, energy consumption of mobility is indirectly assessed considering potential impacts on mode choice. Based on the analysis of empirical results and the literature on shared mobility services, three main observations can be made:

1. Diverse studies on the impacts of carsharing, including those carried out in Munich, conclude that carsharing users tend to shed cars and in consequence to drive less. Moreover, various studies report a net reduction in VKT by car among all members of a carsharing provider. See Section 3.3.1.2 on the impacts of carsharing.
2. Studies on the impacts of bikesharing, including those carried out in Germany, indicate that bikesharing can contribute to a reduction in car usage. The effects of bikesharing on the use of public transport, are however not clear. See Section 3.3.2.2 on the impacts of bikesharing.

3. At the same time, the empirical results of the evaluation of the Mobility Station at Münchner Freiheit show that there is a mutual interest in shared mobility services among subgroups of users (see Section 6.5.2), and that the Mobility Station contributes to increasing the use of shared mobility services in two directions: bikesharing users increase their use of carsharing, and vice versa: carsharing users increase their use of bikesharing (Section 6.6.2).

Although, the effects of mobility stations on the use of other mobility services were investigated in Munich, Offenburg and Würzburg (see Sections 3.2.5.2 and 6.6.2) and the substitution of modes with shared mobility services was investigated in Munich (see Section 6.6.3), the results are not enough to quantify impacts on overall car usage nor on mode choice.

Considering the above results, it can be said that the effects of mobility stations on VKT by car and on mode choice are still unclear: while literature suggests that shared mobility services contribute to reducing VKT by car, the empirical results indicate that the Mobility Station can also support a mode shift from more space and energy efficient modes (e.g. bikesharing and public transport) to less space and energy efficient modes (e.g. carsharing). Although, the opposite direction in mode shift is also possible, the net effect on VKT by car remains unknown.

Finally, the evaluations of mobility stations in Munich, Würzburg and Offenburg did not explore the (direct) effect of shared mobility services on the use of private cars. See reflection on methods in Section 7.3 and recommendations for further research in Section 9.2.2.3.

7.1.2.2. Time consumption

As discussed in Chapter 2, time is consumed for potential mobility (e.g. when waiting for a mobility service, or the time spent in finding one – a vehicle or a parking space) and for realized mobility (the time that it takes to go from A to B when moving). The sum of both is the time consumed for mobility.

The influence of mobility stations on time consumption was indirectly and only partially assessed. According to the participants of the focus groups, some occasions for using shared mobility services are when the waiting times for public transport are too long, or when traveling with these services cheaper and faster (see Section 6.6.3). This indicates that the options offered at mobility stations can save time for specific trips.

Also, there is some indication that the Mobility Station contributes to reducing the time spent searching a parking space when using carsharing (see Section 6.4.4).

Finally, it is assumed that mobility stations can contribute to the reduction of time consumption for mobility in different ways:

- By facilitating intermodal transfers,
- By reducing the search for parking when using carsharing
- By providing access to opportunities in the immediate surroundings, thus reducing travel distances and travel time for some trips,
- By providing access to facilities at the Mobility Station, thus facilitating "trip chaining" and avoiding trips.

These aspects, however, need to be investigated in detail (see Section 9.2.2.3 for some recommendations).

7.1.2.3. Money consumption

As discussed in Chapter 2, money is consumed for potential mobility (e.g. sunk and fixed costs of owning a car, annual fees for shared mobility memberships) and for realized mobility (e.g. fuel costs, tickets, tolls, parking).

The costs for mobility were not sufficiently investigated in the framework of this work. The results of the focus groups, however, indicate that the use of shared mobility services in Munich is often motivated by economic reasons. Carsharing is perceived to be cheaper than owning a car (see Section 6.2.3) and using shared mobility services can be cheaper than other options in some situations (see Section 6.6.3).

Also, other modes such as public transport, using a private bike, or bikesharing, can be more cost efficient than driving a car for some trips. Therefore, it is assumed that the provision of shared mobility services together with a multimodal tariff integration can contribute to reducing the costs for mobility among users, especially when a private car is relinquished due to having enough alternatives. However, all these aspects need further research (see Section 9.2.2.3 for some recommendations).

7.1.3. Summary

Due to the recent implementation of the mobility stations in the three cities where these projects were evaluated (Munich, Offenburg, Würzburg), with the results of the corresponding evaluations, it is not possible at this moment to derive definitive conclusions about their contributions to sustainable urban mobility. Rather, we can talk about a *potential* contribution of mobility stations to sustainable urban mobility.

The assessment of the six criteria indicates that mobility stations *can* positively influence sustainable urban mobility by:

- a) supporting the fulfillment of users' needs by providing and facilitating access to opportunities and mobility services, and
- b) reducing the users' consumption of resources for mobility by providing alternative mobility options to private cars and cheaper and faster mobility options than public transport depending on the purpose of a trip.

For this potential to become a reality and relevant on the urban scale, mobility stations should be replicated further, and its inherently associated multimodal mobility service should be improved in various ways. Chapter 8 provides recommendations for the implementation of mobility stations in a way that they contribute to sustainable urban mobility.

The following subsections provide further arguments on the above mentioned aspects. These arguments are mainly about the potential contribution of mobility stations to sustainable urban mobility.

7.1.3.1. Fulfillment of needs

Users of mobility stations can benefit from the access to diverse opportunities they get at these facilities and in their immediate surroundings. Also, mobility stations have an enormous potential to integrate other services and amenities at mobility stations, thus further facilitating the fulfillment of needs.

Combining the possibility to realize diverse activities or errands with the use of mobility services at mobility stations can contribute to the fulfillment of needs, and at the same time, can avoid or reduce unnecessary trips and thereby the associated consumption of resources.

For example, a user of the Mobility Station living close to the Münchner Freiheit, travels back home after work with the metro and before going home with a bikesharing bike he/she buys groceries for dinner in the immediate surroundings, thereby avoiding an additional trip (and the corresponding consumption of resources) to another shop which is not directly located along the way home.

Mobility stations contribute *per se* to improving access to diverse mobility services. Although there are many aspects which could be further developed, the assessment of the four indicators in Section 7.1.1.2 indicates that mobility stations contribute to increasing the level of access to mobility options among users.

In addition, mobility stations provide different mobility options that can be used for diverse purposes. Since mobility is considered to be a need in itself (see section 2.3.1), access to mobility options also contributes to satisfy the need of mobility “for the sake of mobility”.

Some aspects related to this access which were not assessed would be the *ease of use* of mobility options and their *affordability*. Furthermore, users of mobility stations were not asked if the current access to mobility options contributes to fulfilling their needs and to what extent. Considering the goal of intra-generational equity, additional aspects to explore would be if the mobility options available are sufficiently appropriate and affordable for all citizens beyond the current set of users.

Section 9.2.2.2 provides recommendations for further research on aspects related to the fulfillment of needs.

7.1.3.2. Consumption of resources for mobility

Regarding the impact of the Mobility Station on the reduction of resource consumption, there is limited information. The results indicate that mobility stations in general can contribute to reducing car ownership, especially when carsharing services are available. This in turn, can be translated to a reduction of total vehicle kilometers traveled among users, and thus, in a reduction in space and energy consumption in the long term.

Furthermore, the diversity of mobility services at mobility stations gives users the possibility to choose the most efficient and comfortable travel mode or a combination of various modes for the purposes of their trips. However, one must be aware that first, this choice is a subjective one, second, that the efficiency and comfort provided by a transport mode might be in conflict, and third, that there is not a transport mode that is the most space, energy, time and cost efficient for all trip purposes (i.e. a transport mode can be more energy efficient and cost efficient, but less time efficient for a specific trip in a specific situation).

For example, taking a bike to the airport might be the cheapest and most energy efficient way to get there, but the amount of effort and time needed might discourage most people from using this mode. On the other hand, using a shared car for the same trip might be more expensive and consume more energy than using public transport, but it can be more comfortable and faster.

Under the right circumstances, mobility stations can reduce both car ownership and car usage, thus reducing the consumption of space and energy for mobility. In addition, other aspects affecting the consumption of these resources such as an increase in vehicle occupancy, vehicle energy efficiency, and carsharing turnover, can be positively influenced by mobility stations.

In summary, mobility stations are instruments which support the use of alternative transport modes to private cars, acting as a bundled pull measure which can have positive effects in reducing car ownership and usage, thus reducing the consumption of space and energy for mobility in the short and long term. However, as discussed above, there is a risk of having the opposite effect: mobility stations can support the use of less space and energy efficient modes for certain trips. As an extreme example, public transport users or cyclists could replace these modes for a given trip and travel alone in a carsharing vehicle.

While the substitution of more space and energy efficient modes by less efficient ones for some trips could be assessed as negative considering the goal of reducing the consumption of resources for mobility, this assessment should be put in perspective considering the overall effect of a multimodal mobility offer on mobility behavior.

Also, to avoid an unsustainable development, local authorities must act as regulators and provide the necessary balance between pull and push measures. This is discussed as part of the recommendations for the implementation of future mobility stations to ensure that they contribute to reducing the consumption of resources for mobility (see Section 8.1).

The assessment of indicators related to space and energy consumption (car ownership and mode choice) are not sufficient to draw any conclusions on the effect of mobility stations on the consumption of space and energy for mobility. Similarly, reductions in travel time and costs for mobility were not sufficiently assessed and require further research. Section 9.2.2.3 provides recommendations for further research regarding the impacts of mobility stations on the consumption of resources for mobility.

7.2. Success factors of mobility stations

As discussed in Section 7.1, mobility stations can have a positive impact on sustainable urban mobility. But which factors are decisive in achieving the common goals of mobility stations – facilitating multimodal mobility and reducing car ownership and usage?

The second main research question of this dissertation is:

What are the success factors for the implementation and operation of mobility stations?

Considering the results of the empirical investigation (see Chapter 6) and the findings on other mobility stations (see Section 3.2), success factors for the implementation and operation of mobility stations, as well as for user acceptance were identified. Moreover, contextual factors that contribute to the successful implementation and operation of mobility stations were identified.

The following sections present further details about these identified success factors.

7.2.1. Contextual factors

As for the evaluations of mobility stations in Munich, Offenburg and Würzburg, these facilities have been received well in their cities, with a large majority of users approving the idea of having more of them (see Section 6.5.5 and Section 3.2.5.2).

Also, the continuous development of mobility stations in other cities such as Bremen and Hamburg indicates that mobility stations have an increasing public acceptance, not just among current stakeholders and users. All the above-mentioned cities have different characteristics regarding their size, density, transport supply and modal split. Their success indicates that mobility stations have a positive acceptance which exists regardless of these characteristics.

However, except for the mobility stations in Bremen, most mobility stations have been recently implemented. Thus, it is not yet clear if and how (to which extent, in which form) these characteristics contribute to make mobility stations successful.

Nevertheless, with the available information it is possible to identify five contextual factors that might be contributing to the success of these mobility stations:

1. Pressure on the transportation system and available resources
2. Cultural change
3. Existing shared mobility services
4. A good public transport supply as the backbone
5. Favorable political and administrative conditions

Below, the identified contextual factors are described in more detail.

Pressure on the transportation system and available resources

As presented in Chapter 3.2.2., the common goals for the implementation of mobility stations in German cities are the reduction in car ownership and the shift in travel patterns towards more efficient and sustainable transport modes.

These goals are often triggered by pressure on available resources and the existing transportation system which motivate cities and other actors to plan for mobility options alternative to the private car. Some example of triggers are:

- pressure on available space (e.g. parking pressure, lack of space for other uses such as green areas, public space, sidewalks, bike lanes, etc.);
- reaching the road network's maximum capacity (i.e. congestion);
- reaching the maximum capacity of public transport (e.g. overcrowding, delays, etc.);
- pressure on the environment (e.g. air pollution, noise, climate change);
- lack financial resources (e.g. for expanding road capacity, building tunnels, or multi-story / underground garages);.

Cultural change

Another contextual factor that might be contributing to a successful uptake of shared mobility services, and thus the acceptance of mobility stations, is a cultural change among citizens, especially young people, who are less concerned with material ownership, or at least less inclined to own vehicles, and are more open to share them.

A common trend in Germany is the increasing acceptance of shared mobility services and sharing in general, and the fact that private cars are losing their status symbol, especially among young people.

Existing shared mobility services

Also, having existing shared mobility services in a city seems to facilitate the implementation of mobility stations, as each provider comes to the table with experience with a specific product and a pool of users which become users of mobility stations, who are then exposed to various mobility options available.

In this sense, a wide variety of shared mobility services might also contribute to the success of mobility stations, when they are integrated in a meaningful way. See recommendations for improving the physical and virtual integration of mobility services in Sections 8.4 and 8.5 respectively.

A good public transport supply as the backbone

Not only the presence of existing shared mobility services, but also having a good public transport supply contributes to the successful uptake of shared mobility services, and thus to the acceptance of mobility stations.

As presented in Section 3.3, shared mobility services are actually often used in combination with public transport. This means that users of shared mobility services are already multimodal, which contributes to making mobility stations more attractive to them.

Favorable political and administrative conditions

For mobility stations to be successfully implemented, they first require political support, and then favorable administrative conditions that facilitate the planning and implementation process, as well as sufficient financing for the project.

This institutional support often comes along when the pressure on the transportation system and available resources (see above) reaches a level of public concern that demands action from the government.

7.2.2. Success factors for implementation and operation

Based on the experiences and lessons learned from the implementation of other mobility stations in Germany (see Section 3.2.4) and specifically the implementation of the MSMF (see Section 6.1) the following seven success factors were identified:

1. A proactive initiator
2. Institutional support
3. Early involvement of all possible stakeholders
4. Commitment of stakeholders
5. Setting a deadline
6. Good relationships and cooperation among stakeholders
7. Willingness to take some risks

These success factors are described in detail below.

A proactive initiator

The implementation of mobility stations requires the participation of multiple actors from both public and private institutions. A proactive initiator that brings all these actors together and motivates them to work for a common purpose is the first step in successfully implementing mobility stations.

Institutional support

Political, administrative, and financial support are important for the timely implementation of mobility stations, especially because their implementation often involves the participation of various city departments (urban and transport planning, building and environmental departments) and private companies, and the assignment of permissions, funds, and roles needs to be clear at the beginning.

Early involvement of all possible stakeholders

An early involvement of all possible stakeholders is important in order to take their individual motivations and goals into account, to find a compromise among the different interests, establish cooperation agreements, assure fair conditions for all partners involved, and to set a common goal and work towards it.

Commitment of stakeholders

An early involvement of stakeholders, finding a compromise between their different interests and setting a common goal are the basis for having committed stakeholders which in turn will contribute to a successful implementation.

Setting a deadline

Any project requires a deadline in order to get started. In the case of the Mobility Station at Münchner Freiheit, having a deadline was mentioned by all stakeholders to have contributed to the timely implementation of the pilot project.

Good relationships and cooperation among stakeholders

The implementation of mobility stations requires a good cooperation among all stakeholders. From the planning perspective, there are different city departments that need to cooperate in order to successfully implement mobility stations.

During the operation phase, various providers of mobility services will need to cooperate with each other, for example with the virtual integration of mobility services and for distributing and sharing the space at the mobility stations. Also, mobility service providers need to cooperate with the city in various ways, for example in determining the appropriate characteristics of their service offer at the mobility stations (amount and type of vehicles, space required, etc.).

Willingness to take some risks

Since mobility stations are a relatively new concept, there are still many questions regarding their impact, and thus the benefits that each stakeholder could receive, especially with regard to their individual goals.

This means that the involved stakeholders need to invest some time, effort, and financial resources without knowing the outcome in advance. However, the willingness to take some risks was mentioned as one of the success factors for implementing mobility stations in Hamburg and Leipzig.

7.2.3. Success factors for user acceptance of mobility stations

Mobility Stations, just as any other measure, need to be accepted by current and potential users to be successful, and for that, they have to offer an added value compared to what they already have.

The identification of success factors for the users' acceptance of mobility stations is mainly based on the evaluation of the MSMF (Chapter 6) and is often validated with findings from other mobility stations (see Section 3.2.5). Five main success factor were identified:

1. The **location on public space** which increases visibility of mobility services and provides easy physical access,
2. A **fixed location**, which contributes to a higher comfort when using a mobility service and the possibility to rebalance the distribution of shared vehicles,
3. the **spatial concentration of diverse mobility services** which promotes ecomobility and supports multimodality and intermodality,
4. **multimodal marketing** which contributes to raise awareness of the multimodal mobility service, and
5. the possibility to use **electric mobility** which has a positive acceptance among users.

These success factors are further described in the following subsections.

7.2.3.1. Location on public space

One of the most important factors of mobility stations is their location on public space, which ensures easy access to the mobility services and high visibility, which in turn has proved to be an important source of awareness among users and non-users.

Visibility

About the half of users and non-users of the Mobility Station in Munich became aware of it when passing by. In Offenburg and Würzburg, walking by was the main source of awareness. In addition, design elements such as the info-pillars in Würzburg and the on-site information screen in Munich are important sources of awareness (see Section 6.3.2).

Nevertheless, there is room for improvement in this area (see a description of problems regarding visibility in Section 6.7.1 and recommendations for improvement in Section 8.3).

Easy physical access

The location of mobility stations on public space provides easy access to the mobility options compared to, for example, carsharing stations on private parking spaces or in underground garages. In Munich parking spaces at ground level are highly appreciated by users (see Section 6.5.1.2).

In Bremen, it has been reported that the *mobil.punkte* are used more frequently than other carsharing stations not located on public space, and a similar trend was observed in Hamburg, where one mobility station, located in an underground garage, was less frequented than the other stations located on public space (Luginger, 2016) (see Section 3.2.5.1).

This might indicate that mobility stations attract a higher number of users due to greater visibility and easier access compared to other carsharing stations.

In Munich, a significant share of users of the Mobility Station access or egress the facility by foot (see Section 6.4.5). Walking is also the main mode of transport to reach mobility stations in Würzburg and Offenburg (see Section 3.2.5.2). This highlights the importance of placing mobility stations on easily accessible public space.

Physical access can still be enhanced though, as revealed by the user survey (see Section 6.7.5). Recommendations for improving access are given in Sections 8.2 and 8.3.

7.2.3.2. Fixed location

Designating and having a fixed location where mobility services can be found, offers an added value to users compared to using randomly distributed free-floating vehicles on the streets or having dispersed mobility options throughout a service area. Fixed locations provide a higher comfort when using a mobility service and the possibility to re-balance the distribution of vehicles through incentives.

Higher sense of availability and comfort when using a mobility service

A significant share of users indicated to have rented a shared mobility service vehicle at the Mobility Station at Münchner Freiheit because of the high likelihood of a vehicle being there, and so they wouldn't even have to look for availability using smartphones (see Section 6.5.1.1). Users know where to look for a vehicle and know they have a great chance to find one at the Mobility Station.

This indicates that having a fixed location where mobility services can usually be found, contributes to a higher sense of availability and comfort among users, because there is a high probability of finding a vehicle or bike at this location.

Also, having a fixed location allows having reserved parking spaces for carsharing, and an easy return of shared vehicles, which is highly appreciated by the users (see Section 6.5.1.2).

Possibility to re-balance the distribution of shared mobility systems

Incentives in the form of "time credit" for bikesharing users was an important reason for returning a bike to the Mobility Station (see Section 6.5.1.2).

Reserved parking spaces and docking stations at fixed locations can be coupled with incentives for returning vehicles and bikes at these places. This in turn should help to re-balance the distribution of shared mobility services.

7.2.3.3. Spatial concentration of diverse mobility services at one location

The results of the empirical investigation indicate that the spatial concentration of mobility services helps to achieve some of the common goals of mobility stations (see Section 3.2.3), namely:

- it communicates a "transport-related" message oriented to ecomobility (see Section 6.6.1.3 and 6.6.1.4),
- it supports a multimodal mobility behavior (see Section 6.6.1 and 6.6.2), and
- it facilitates intermodal trips (see Section 6.4.5 and 6.5.1).

Also, the spatial concentration complements the virtual integration of the various modes.

Communication of a "transport-related" message oriented to ecomobility

The diversity of mobility services in Munich is not particular to just the Mobility Station. As presented in Chapter 4, there is a well-established public transport supply and many shared mobility services all over the city, even more than those which are included at the Mobility Station.

The added value of mobility stations lies more on the spatial concentration of these diverse options at one location, which delivers a message of "*here you can access everything that you need for your mobility*" which can imply "*you don't need to own a car to fulfill your needs*".

This is revealed by the fact that a large majority of users of mobility stations in Munich, Würzburg, and Offenburg agree that through these facilities they are *always sure to have available a suitable transport mod*e and that the offer *contributes to making the own car unnecessary*. See Sections 6.6.1.3 (Munich) and 3.2.5.2 (Würzburg and Offenburg).

Support of multimodal behavior

Users of a mobility service appreciate the availability of other mobility services at the Mobility Station, especially public transport (see Section 6.5.2). This indicates that the spatial concentration of mobility services at one location offers an added value to users compared to having dispersed mobility options throughout a service area.

Moreover, the increase in the use of public transport and the adoption and use of additional shared mobility services (see Section 6.6.2) among users indicates that a multimodal mobility behavior is supported by mobility stations.

Easy intermodal transfers

While physical access to mobility services can be provided without mobility stations, the benefit of integrating diverse mobility services at one location is also relevant for facilitating intermodal transfers.

In the case of the MSMF, it was revealed that intermodal connections are taking place, especially in connection with public transport but also between shared mobility services and private modes (see Section 6.4.5). In addition, the user survey in Munich indicates that different intermodal connections are important to the users (see Section 6.5.3).

The particular configuration of the Mobility Station at Münchner Freiheit allows easy transfers between some modes (e.g. carsharing to bikesharing and vice versa) (see Section 4.3.3). However, based on the problems reported by the users some ideas for improvement applicable to future mobility stations were identified (See Section 6.7.3).

Potential for improvement and potential conflicts

The spatial concentration of diverse mobility options facilitates intermodal transfers and the choice of the most convenient mode of transport for a given trip or trip leg, which in turn can contribute to the reduction of consumption of resources (see Section 7.1.3).

A diverse set of mobility services can also contribute to the reduction in the consumption of resources for mobility because users have the possibility of consciously choosing the mobility service that is better suited for the purpose of a trip, but also because it is possible to combine different modes in an efficient way.

However, this diversity also poses the risk that more efficient modes of transport are replaced by less efficient modes (e.g. carsharing instead of bikesharing or public transport). However, cities can avoid this in various ways. Chapter 8 provides recommendations to ensure that mobility stations contribute positively to the concept of sustainable mobility (i.e. supporting the fulfillment of needs while reducing the consumption of resources).

7.2.3.4. Multimodal marketing and individual advertisement

While visibility on public space is important, marketing also plays an important role in raising awareness about mobility stations and their mobility services. In Munich, next to "passing by", advertisement was the second most mentioned source of awareness among non-users and the third most mentioned source of awareness among users (see Section 6.3.2). In Würzburg and Offenburg, advertisement and media were important sources of awareness as well (see Section 3.2.5.2).

It has been observed though, that some users become aware of individual mobility services associated to the Mobility Station through advertisement provided by the individual providers themselves. Although this might be positive, it entails the risk of advertising only for one service instead for an integrated multimodal mobility service. In Section 8.6 recommendations for an integrated multimodal marketing are provided.

7.2.3.5. Electric mobility

The opportunity to use electric carsharing is one of the reasons for which users rented or returned a vehicle at the Mobility Station (see Section 6.5.1). In addition, a large majority of users in Munich, Offenburg, and Würzburg considers the possibility of using electric carsharing important (see Section 6.5.2).

The results from the focus groups also indicate that electric mobility has a positive acceptance among both users and non-users of the mobility stations, not only with respect to carsharing, but also in regards to electric bikes and pedelecs (see Section 6.5.1.1).

Providing electric mobility options is a success factor for the acceptance of mobility stations and at the same time represents an opportunity for the reduction in energy consumption for mobility and the associated emissions within the city. Thus, electric mobility should be further integrated in the multimodal mobility offer at mobility stations (see recommendations in Section 8.4).

7.3. Reflection on the methods

The idiographic explanation (evaluation) of the Mobility Station at Münchner Freiheit is based on various qualitative and quantitative methods that complement each other. Each of the methods provided important insights to answer some of the different questions posed at the beginning of this work (see Section 1.2).

The quantitative methods such as the user survey, non-user survey and the analysis of operational data provided important information to understand the general acceptance, perception, and utilization of the mobility services at the Mobility Station. The analysis of results however, was not always enough to understand *why* those results were obtained. Qualitative methods such as the stakeholder interviews and the focus groups proved to be very insightful and helpful in understanding and interpreting further the results obtained by the quantitative methods.

However, after analyzing the results obtained by the various methods, it was observed that some questions remained unanswered or were only partially answered.

In this section, a reflection on the methods used for the evaluation of the MSMF, which in part were used for the two case studies presented in Section 3.2.5.2 (Offenburg and Würzburg) is presented, showing what can be improved in future evaluations.

7.3.1. Stakeholder interviews

The interviews carried out at the beginning of the evaluation of the MSMF provided detailed insights regarding the roles and motivations of the stakeholders, and their first experiences with operation and the implementation process of the pilot project. This enabled the identification of barriers and drivers of the project, which in turn made it possible to identify success factors for implementation.

In addition, this interaction facilitated further steps of the evaluation, for example:

- all stakeholders contributed to developing and implementing the user survey (see next section),
- the provision of operational data of mobility services from some providers,
- developing ideas for optimization and improvement for the different phases of the project.

Due to time constraints it was not possible to carry out interviews or a stakeholder workshop by the end of the evaluation. This would have helped to have a complete process evaluation and to learn more about barriers and drivers in each of the phases of the project. See recommendations for further research in Section 9.2.2.

7.3.2. User survey

The user survey can be considered as a successful method, considering the good response rate (see Section 5.2.4) and the information gained. For this, the engagement of the different stakeholders played an important role in developing and implementing the survey.

Despite the overall good quality of the user survey, after analyzing the results, it became clear that some questions did not provide the expected results. The following subsections provide further details about the different aspects of the survey that should be taken into account when developing a similar survey in the future.

7.3.2.1. Development and implementation

As mentioned above, the engagement of the different stakeholders played an important role in the development and implementation of the survey.

First, all stakeholders contributed to the conception of the survey. This was very important because the survey inquired about different aspects of a project that was practically unknown to everyone. Thus, there were many different hypotheses among the stakeholders about the acceptance of the project and its impacts.

Moreover, the survey was directed toward three different user subgroups of shared mobility services, which were only sufficiently known to their respective providers. Using their experience, it was possible to clearly formulate important questions for each user subgroup and in the case of single and multiple choice questions, to offer appropriate answer options.

Second, the mobility service providers helped to carry out the user survey by sending the invitation e-mails to their customers each week and crediting their accounts with incentives that the Department of Public Order (KVR) refunded later. The incentives provided by KVR are believed to be an important reason for the good response rate.

From the response time analysis it can be said that sending the invitation e-mails once a week was the right choice (see Section 5.2.4). On one hand, the effort required of the providers was not as big as if they had to do it every day, and for almost all respondents, (about 90%) it was still easy to recall their last trip, which was an important part of the survey (see Section 5.2.2).

In summary, the participation of various stakeholders in developing the survey, including the review of final test versions, helped to create a good quality questionnaire. Through their active participation it was also possible to find a good compromise between the content of the survey and its extent (see Section 5.2.2).

However, this cooperation also made the process very lengthy: it took about one year to develop the questionnaire, starting from a first draft to the final version. This should be taken in account when developing questionnaires in the future: the participation of various stakeholders is important for having a good quality questionnaire but it also requires time.

7.3.2.2. Sampling

As explained in Section 5.2.3, due to the recent implementation of the Mobility Station, the size and characteristics of the user population were not known. Thus, the sampling frame for the user survey was the set of customers who used these services at the Mobility Station from mid-June to the end of July 2016.

However, it is not clear how the sample of respondents represent the actual set of users, and how the characteristics of the latter are compared to those of the set of all users of the respective shared mobility services.

Thus, it is possible that some users of the Mobility Station are underrepresented in the sample. One clear example of underrepresented users are the customers of car2go (n=21), which represent only 12% of the sample of FFCS users (n=174) and the customers of STATTAUTO (n=17) which represent only 9% of the total sample of all carsharing users (n=191) (see Section 5.2.4).

Other possible underrepresented users are women and users older than 40 years old, but it is not possible to know this for certain, since the demographic characteristics of all users are not known as explained above.

Section 9.2.2.1 provides some recommendations for a better sampling of the users in future evaluations.

7.3.2.3. Aspects that need to be explored further

Purpose for the use of mobility services at the Mobility Station

To understand how the mobility services at the Mobility Station are used, users were asked to indicate how often they use them. If the answer was "at least once a month" or more often, each user were asked to indicate for which purpose they used the respective mobility services (multiple choice question).

However, the second question *"for which purposes do you use [mobility service] at the Mobility Station?"*, did not have a direct link to the frequency of use. It was a filtered question based on the frequency of use, but this filter was not obvious to the user (see user survey design in Annex B-1). Thus, the answers provided by the users regarding the frequency of use do provide some information about the different purposes for which the mobility services are used, but the link between frequency and purpose is not obvious.

For example, a respondent indicated to use carsharing at least once a week. Thus, in the following question he or she is asked to indicate for which purposes carsharing is used at the Mobility Station. The answers available were then *shopping, work*, and *leisure* and they all have the same weight in the results (see Section 6.4.3).

In the future, the question about the purposes for using mobility services at mobility stations should be directly linked to the frequency of use in order to better understand how the mobility services are being used, which in turn might help to better integrate land use functions in the surroundings of mobility stations.

Purpose of the trips in connection to the Mobility Station

Considering the above, it would be interesting to know how often users visit the different locations in the immediate surroundings of mobility stations (not only how important they are to them), and if they combine their trips with these activities, in order to explore the impact on reducing travel distances and avoiding trips due to the concentration of mobility options at mobility stations and diverse opportunities in their immediate surroundings.

The location of destinations associated with an activity when using shared mobility services at the Mobility Station was investigated through the questions regarding the users' last trip (see Section 5.2.2). Users were asked to indicate the location of their origins and destinations as well as the type of activity at both when using a shared mobility service at the Mobility Station (see user survey design in Annex B-1).

The question about the activity associated with the origins and destinations was single choice, thus predefined answers were provided to the users. However, the question about the location, on the other hand, was an open question. As a result, many of the answers turned out to be useless for identifying these locations correctly (e.g. zip codes, or general names of places e.g. "Restaurant").

In the future, users should have the possibility to mark their origins and destinations more precisely by using an interactive map. Another way to capture this information is the use of short questionnaires inquiring users about details regarding their trips directly before starting a trip and/or directly after ending the trip with the shared mobility services. Such questionnaires can be administered via the smartphone app of the respective service providers.

This information should help to investigate determine if a mobility station supports trip chaining, and thus the fulfillment of needs and reduction of consumption of resources for mobility at the same time (see Section 9.2.2.3 for some recommendations on further research).

Induced trips with shared mobility services

One of the questions in the user survey investigated the substitution of other modes with shared mobility services. This multiple choice question, however, did not include the option “I would not have done the trip”. Thus, the effect of shared mobility services in inducing trips remains unclear. In the future, the question about mode substitution should include this answer as an option.

Multimodality degree of users and non-users

Another aspect of interest when evaluating the effects of mobility stations is the multimodality level of users and non-users, since multimodality is correlated with low car ownership (see Section 3.3.4).

In the user survey in Munich, users were asked how often the different mobility services at the Mobility Station were used, thus, private car and other mobility services elsewhere were not included in the question (the frequency of use of private bikes was indirectly inquired by asking how often the Bike and Ride facilities at the Mobility Station were used). Thus, the results give an idea about the multimodality degree of users but it is not possible to estimate it more precisely.

Also, the lack of a control group with details regarding the frequency of use of various transport modes (e.g. non-users, rest of population), makes a comparison of the multimodality degrees between users and non-users impossible. See recommendations for further research in Section 9.2.2.3.

Effects of mobility stations on the use of other mobility options

The effects of mobility stations on the use of other mobility services was not sufficiently investigated.

Users of mobility stations in Munich, Würzburg, and Offenburg were asked to indicate the degree of their agreement with statements in the survey, with the aim of deciphering if mobility stations contributed to increasing their use of mobility services provided at these facilities (see Section 6.6.2).

Although the answer indicates that some users increased their use of some mobility services, it is not clear which effect mobility stations had on those users who did not agree to the statements (i.e. is not clear if they reduced their use of mobility services, or made any changes due to the mobility stations).

Also, the effects on the use of other modes of transport such as private cars and bikes remained unclear.

In the future, this question should include other modes of transport (e.g. private car, private bike) and be formulated differently: users should indicate whether mobility stations caused them to use a transport mode more often, less often, or if no changes due to it occurred.

This improvement however, still would not provide enough detail about the changes in the use of different transport modes caused by mobility stations (i.e. without further information about the frequency of use of different transport modes by the users, it is not possible to know what “more often” or “less often” really means). Another limitation of this question is that the responses are self-estimated and thus lack accuracy.

This information, especially the change in the number of trips and distances by different modes, is essential to quantify the impacts of mobility stations on the consumption of resource for mobility. See recommendations for further research in 9.2.2.3.

Effects of mobility stations on car ownership

As discussed in Section 5.6, in order to assess the contribution of mobility stations on sustainable urban mobility, their effect on car ownership and car usage should be determined.

Although understanding the effects of the mobility stations on car ownership are of utmost importance in assessing their influence on sustainable urban mobility, it was considered, in agreement with the stakeholders who contributed to the development of the user survey, that the Mobility Station had not been in operation long enough to have a real effect on car ownership. The abolishment or acquirement or private cars among users was inquired as another demographic question without any relation to the use of shared mobility services or the Mobility Station (see Section 6.6.1). See recommendations for further research in Section 9.2.2.3.

The answers to this and other questions related to car ownership provided some insights on the potential impacts of mobility stations in reducing space consumption for mobility. However, in order to have more decisive results, future evaluations should question directly the influence of a multimodal mobility service on the decision of users in getting rid of a car or acquiring one. The use of an open question for understanding these decisions was very useful (see Section 6.6.1.2) even though it did not have any relation to the use of the mobility stations. However, it should be considered that analyzing the responses to open questions takes more time to process than multiple choice questions.

7.3.2.4. Correlation analysis

The user survey explored many variables of interest that were presented in Chapter 6, but a correlation analysis was not performed. In future evaluations a correlation analysis should be carried out in order to find if and how the different variables relate to each other, thus, providing new insights to the results.

7.3.3. Non-users survey

The development of the non-user survey was easier, compared to the effort of developing the user survey. Although the results are considered to be of good quality, there are two aspects that should be taken in account when carrying out similar surveys in the future. The following subsections provide further details.

7.3.3.1. Sampling

As explained in Section 5.3, non-users of the Mobility Station are individuals who have never rented or returned a carsharing vehicle or MVG Rad bike at the Mobility Station, but have the potential to do so. Due to the recent implementation of the pilot project, the characteristics of the non-user population were not clearly defined. Therefore, the sampling frame for the non-user survey was comprised of public transport users and passersby in the immediate surroundings of the Mobility Station.

It is not clear however, if the sample of respondents represents the actual set of non-users. Although the face-to-face interviews were carried out during different weekdays and weekends, as well as at different times of the day, it is possible that some non-users of the Mobility Station are underrepresented in the sample.

A clear example of non-users that might be underrepresented in the sample are:

- those individuals younger than 18 years (by law, it was not allowed to interview them),
- the set of public transport users who travel either too early or too late during the day, and thus out of the usual times when the interviews were carried out,

- persons that avoid/reject being interviewed due to shyness, mistrust, or lack of time,
- residents living in the surroundings of the Mobility Station who are neither public transport users nor walk by this facility.

Section 9.2.2.1 provides some recommendations for a better sampling of non-users in future evaluations.

7.3.3.2. Missing details about the group of non-users

The questions for non-users were relatively clear at the beginning: do they know the shared mobility services that are available at the Mobility Station? And if they do, why don't they use them? And if they do use them – but elsewhere – why not at the Mobility Station?

Face-to-face interviews were selected as an appropriate method to address public transport and taxi users, as well as passers-by (see Section 5.3.2). Based on the experience of Omnitrend[26], it was decided to limit the number of questions so that the interview would not exceed three minutes.

Thus, the most important questions mentioned above, including some demographic questions were included. However, many other more in-depth details about non-users, such as the frequency of use of mobility services and the purpose for using them were not captured, making difficult to compare the travel patterns of this group to those of the group of users.

This could be addressed in the future by means of an online questionnaire, similar to the one for users, as it was done in Offenburg (Heller, 2016). See recommendations for further research in 9.2.2.1.

7.3.3.3. Correlation analysis

The non-user survey explored many variables of interest but a correlation analysis was not performed. A correlation analysis should be carried out in order to find if and how the different variables relate to each other.

[26] Omnitrend is a specialized company in market research in the field of mobility.

7.3.4. Focus groups

The insights provided by the focus groups were very useful in understanding the results obtained through the user and non-user surveys more deeply. However, some aspects of focus groups should be taken in account when carrying them out in the framework of further evaluations.

Also, as in the case of the user and non-user surveys, the focus groups are a „one shot case study“ which means that the results represent only the opinions of some individuals at a unique point in time. In order to have more reliable results, focus groups at different points in time during the life time of the project should be carried out.

The following subsections provide further reflections on the focus groups carried out in the framework of this dissertation.

7.3.4.1. Representability of user and non-users by the focus groups

The recruitment of participants for the focus groups was done in a way to fairly represent the demographic characteristics of the respective survey samples of users and non-users.

However, it has to be taken in account that focus groups consisted of maximum ten participants, and that their inputs, although important, do not statistically represent the opinion of the entire sample.

In order to increase the representability of both samples, and thus, the reliability of results, it would be necessary to carry out more focus groups at the same time. This, however, was restricted by time and financial resources for the evaluation.

7.3.4.2. Avoiding biased results and typical problems of focus groups

Experimenter’s bias

The so-called “experimenter’s bias” occurs when focus groups are carried out by the interested parties (e.g. the researchers) and the results obtained are then influenced by his or her own understating of the discussion. The fact that both focus groups were carried out by a professional moderator who did not have any stake in the project was important in order to avoid the experimenter’s bias.

Groupthink and social desirability bias

Also, the neutrality and experience of the professional moderator was important in avoiding two common problems of focus groups: groupthink and social desirability bias. The first refers to the phenomenon that some participants might hold back their opinions and agree to the opinions (which they don't necessarily agree with) of other participants who show more confidence. The second refer to the phenomenon that some participants give opinions that they think the moderator or the other participants wants to hear or are socially accepted.

The above mentioned problems were prevented in three ways:

- first, at the beginning of the focus groups, the moderator made clear to the participants that she was a market researcher and was appointed as a "neutral observer" to discuss with them about the topic of the Mobility Station at Münchner Freiheit.
- Second, she made clear that in the frame of marketing research, there are not correct or incorrect answers, but only interesting answers and opinions, so she encouraged them to talk openly about the different topics, especially if they think differently than the others.
- Third, throughout the discussion she made sure that every participant gave their opinion to the topics covered, especially those who were not as talkative.

Despite the efforts mentioned above, it is still possible though that both groupthink and social desirability bias have influenced the results, thus, they should be interpreted with care.

Reactive effects and testing arrangement

Another problem of focus groups is the lack of anonymity and that with the participation of other persons, there is not guarantee of confidentiality. This issue might hold some participants from giving their opinions or from participating at all.

For the sake of transparency regarding this issue, the recruited participants were informed in advance that the discussion would be recorded for further analysis. Moreover, at the beginning, the focus groups were reminded of this and they were also informed that the discussion was being observed from behind a one-way mirror.

A concrete example on how this issue might hold some persons from taking part in focus groups happened within the group of users: at the beginning of the session, when the moderator announced that the discussion was being video recorded and observed, one of the participants abandoned the test studio, arguing that he/she was not aware of this. While some other participants seemed to not be annoyed by this, it was agreed that the session would be audio-recorded only.

Personality bias

Another issue that might influence the results of focus groups is the personality bias. This refers to the fact that focus groups might be overrepresented by extroverted individuals who are ready to participate in group discussions in the first place, and who are ready to put their opinions forward.

For example, in the case of the non-user focus group, the participants might be rather open-minded and thus, their opinions regarding shared mobility services were relatively positive. However, this might be a biased insight, if less open-minded individuals who did not come to the discussion might have a different opinion towards shared mobility services.

7.3.4.3. Lessons learned

The non-user focus group qualitatively explored the mobility behavior of the participants, as this aspect could not be captured as part of non-user survey (see Section 7.3.3.2).

Through the analysis of the results from the non-user focus group it became evident that non-users mainly use public transport, and in some occasions their own bike or a private car for their mobility needs.

Understanding this was important to realize that non-users already have what can be considered sustainable mobility patterns, even though the majority have not adopted shared mobility services as part of their mobility portfolio (see Section 6.2.2).

At this point after the focus groups, it was then noticed that an important target group of mobility stations, and other sustainable transport strategies, had not been investigated: the group of so-called or “monomodal car drivers”.

For the planning and implementation of mobility stations and sustainable transport strategies in general, it is considered of paramount importance to understand the barriers and drivers to using alternatives modes of transport (alternative to the private car) of this particular group. See recommendations for further research in Section 9.2.2.1.

7.3.5. Analysis of operational data

The analysis of operational data was useful in understanding the details how shared mobility services at the Mobility Station are used. The temporal and spatial usage patterns of the mobility services at the Mobility Station were partially compared to usage patterns of the same or similar mobility services in Munich in order to identify similarities and differences. See Section 6.4.4.

Although the analysis of operational data provided detailed information about the use of shared mobility services at the Mobility Station at Münchner Freiheit, the comparison to usage patterns in the rest of the service area is limited in the following ways:

- Some of the usage patterns of MVG Rad were compared to available information regarding the use of another bikesharing provider in Munich (Call a Bike). This comparison, however is limited, since both bikesharing systems have different characteristics (see Section 4.2.3.2). For a better comparison between the usage patterns of MVG Rad at the Mobility Station and the usage patterns in the rest of the service area, additional operational data from this provider could be used in the future.
- Operational data of one of the FFCS providers (car2go) was not available for analysis, thus, it has been assumed so far that the usage patterns of FFCS correspond to those revealed by the analysis of operational data of the other provider (DriveNow). However, although both providers have similar business models, it is possible that there are differences in the usage patterns between both services, which were not captured in this evaluation.
- The comparison of the usage patterns of DriveNow at the Mobility Station with the patterns throughout the rest of Munich was done based on results from other studies (see Section 6.4.4). Although different publications provide information about usage patterns of FFCS in Munich, this corresponds to different periods of time, and it is possible that the usage patterns of a mobility service change as they develop. Ideally, operational data of the carsharing providers in relation to the Mobility Station and the rest of the service area

should be compared using the same methodology and for the same period of time.

Due to time restrictions and the main focus of this dissertation, operational data was analyzed only to some extent. In the future, operational data could be analyzed further and the usage patterns of shared mobility services at the mobility stations could be better compared to the patterns in the rest of their service areas. See recommendations for further research in 9.2.2.4.

7.3.6. Assessment method on sustainable urban mobility

The assessment method applied to determine the contribution of mobility stations to sustainable urban mobility (presented in Section 5.6) was developed in the framework of this dissertation after the evaluation on behalf of the City of Munich was carried out. The latter was comprised of the methods presented in Sections 5.1 to 5.5.

For this reason, the evaluation methods were not specifically designed to monitor the set of indicators suggested as part of the operationalization approach to sustainable urban mobility developed for this work (see Section 2.3.3). Consequently, some indicators were not included in the assessment and others were assessed indirectly. Therefore, the assessment of mobility stations' impact on sustainable urban mobility presented in Section 7.1 relies on partial evidence that was not directly intended for this assessment and does not allow definitive conclusions.

This can be improved further in future evaluations by designing the methods in such a way so that relevant indicators can be measured directly. Also the various qualities of the indicators suggested in the literature (Shen and Hermans, 2017; Joumard and Gudmundsson, 2010) should be considered when selecting indicators for the assessment.

Another issue concerning the operational approach, and thus the assessment method, is that it does not consider indicators related to the fulfillment of needs via the delivery of goods. This aspect can be included in future evaluations.

Furthermore, the assessment method does not consider the influence that the various variables related to each criteria might have had on each other. This is of extreme importance in trying to understand how the development of one aspect influences the other, and thus the overall concept of sustainable urban mobility.

For example, if the consumption of money reduces due to more affordable mobility services, does the consumption of space and energy increase due to induced travel demand? These interactions could be addressed by means of a system analysis and system modeling (e.g. the sensitivity model by Frederic Vester).

Finally, the assessment method, so far, is limited to observing the direction of indicators. However, this is not enough to determine if mobility is sustainable. In a further step, when local goals of sustainable mobility are clearly defined, threshold values can also be set, similar to the approach suggested by Holden et al. (2013) (see Section 2.2.7) but instead on the local scale.

Section 9.2 provides recommendations for further research into aspects related to different target groups, the fulfillment of needs, and the consumption of resources.

8. Recommendations

The evaluation of the Mobility Station at Münchner Freiheit and the evaluations of mobility stations in Offenburg and Würzburg indicate that the majority of both users and non-users in these cities approved of the idea of having more of these facilities (see Section 6.5.5).

Moreover, as discussed in Chapter 7, mobility stations can contribute to the fulfillment of needs and to the reduction of resources consumed for mobility among their users and thus positively to the concept of sustainable urban mobility. However, for this contribution to become relevant on the urban scale, mobility stations should be enhanced in various ways and expanded further within a favorable context for them to succeed (i.e. to achieve certain goals such as a reduction in car ownership).

This chapter presents a series of recommendations for the further development of mobility stations and suggestions to help ensure that they contribute meaningfully to sustainable urban mobility. The recommendations build upon the knowledge acquired during the development of this dissertation, specifically adding onto:

- the lessons learned from the evaluation of the Mobility Station at Münchner Freiheit (presented in Chapter 6),
- the findings from other mobility stations and shared mobility services (presented in Chapter 3),
- the assessment of the impacts of mobility stations on sustainable urban mobility (Section 7.1), and
- the identified success factors for the implementation and operation of mobility stations (Section 7.2).

The recommendations are organized in seven fields of action corresponding to different phases of the project: planning, implementation, and operation. Figure 8.1 below provides an overview of the seven recommendation categories, the phases they correspond to, and the subsections where they are explained in further detail.

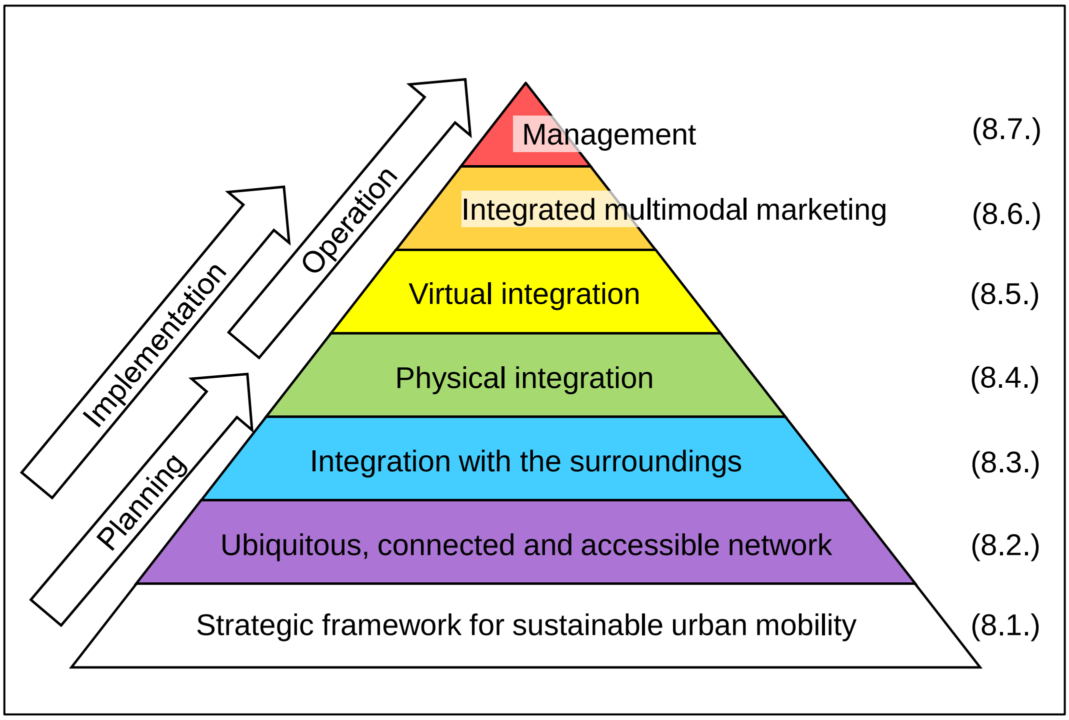


Figure 8.1: Fields of action for the development of mobility stations towards sustainable urban mobility

The *strategic framework for sustainable urban mobility* is the basis for all other recommendations. It shall provide the initial requirements for planning mobility stations in line with local sustainability goals and guaranteeing their acceptance and success.

A *ubiquitous, connected and accessible network of mobility stations* aims at reaching as many users as possible and facilitating their use of various mobility services other than the private car. The *integration of mobility stations with their surroundings* shall facilitate access to these facilities and other opportunities in close proximity, while increasing the awareness and attractiveness of the multimodal mobility offer.

The *physical integration of components* at mobility stations and the *virtual integration of services* shall further facilitate the use of various mobility services together for various activities, enabling users to fulfill their needs while reducing their consumption of resources for mobility.

Integrated multimodal marketing, as part of a local mobility management strategy, should provide users and potential users with the necessary information about the multimodal mobility offer and assist them in adopting new mobility services into their mobility portfolio.

Finally, the operation of the multimodal mobility service as a whole (mobility stations and instruments of virtual integration, and marketing strategy) consists of different tasks that need to be managed.

The following subsections provide further details about the different tasks of the different recommendation categories.

8.1. Strategic framework for sustainable urban mobility

Whether mobility stations will contribute to sustainable urban mobility or not depends greatly on how this concept is defined in the city or region where these facilities are to be implemented, the goals of individual stakeholders, and how much these goals align with local sustainable mobility goals.

Also, other measures either supporting or counteracting the desired effect of mobility stations can play an important role in how mobility stations contribute to sustainable urban mobility.

In order to assure that mobility stations, like any other measure, contribute to sustainable urban mobility, it is important to:

1. clearly define the concept, goals, and guiding principles at the local level through a broad participation process,
2. develop a plan for the implementation of mobility stations in line with the defined goals and principles,
3. consider the implementation of supporting measures.

This means that the strategic framework for sustainable mobility should indicate the direction to go while providing the necessary instruments, policies, and regulations. The following subsections provide further details on the three steps listed above.

8.1.1. Local definition of SUM goals and guiding principles

A locally accepted definition of sustainable urban mobility shall help to define concrete goals and guiding principles which all other plans, including the development of mobility stations, must support. Considering that cities and their transport systems are not isolated systems, the local definition of sustainable mobility should be in line with a regional and even a global vision of sustainability.

If local sustainable mobility goals do not exist or are considered to be outdated, the operational definition and the assessment method of sustainable mobility developed for this work could be reviewed and adapted by city officials when developing mobility stations.

According to the operational definition developed for this dissertation, sustainable urban mobility consists of two guiding principles:

1. maintaining or increasing the fulfillment of needs of all citizens through mobility, while
2. reducing the consumption of resources for mobility.

Thus, to ensure that mobility stations contribute to sustainable urban mobility, both criteria must be fulfilled.

Considering the aspect of intragenerational equity, when replicating and expanding on mobility stations, the needs of all potential users must be considered. These especially include the elderly, handicapped persons, children, and low-income populations.

As discussed in Section 2.3, the fulfillment of needs involves *access to opportunities* and *access to mobility options*. Both aspects should be considered when developing further mobility stations. It must be ensured that all citizens have equal access to opportunities and mobility services. While it might be impractical to provide the same level of access for everyone, a minimum level of access should be defined at the local level by the stakeholders involved and pursued in order to create "*mobility stations for everyone*".

To ensure that mobility stations contribute to reducing the consumption of resources, the most space, energy, time, and cost efficient modes could be incentivized over less efficient modes. However, as discussed in Section 7.1.3.2, rarely is one mode of transport the most efficient in all four aspects in all circumstances.

As time and money are rather individual resources, users should be free to decide how to consume them. Considering that space and energy are shared resources, and their consumption have social and environmental implications, the use of more space and energy efficient modes can be incentivized through various instruments when planning, implementing, and operating mobility stations. This could ensure that the more space and energy efficient modes become more comfortable and more affordable.

8.1.2. Planning mobility stations in line with local sustainability goals

Once an operational definition of sustainable urban mobility has been agreed to at the city or regional level, and goals and principles are clearly formulated, the planning of mobility stations can begin. Similar to the development of a Sustainable Urban Mobility Plan (see Wefering et al., 2014), ensuring that the mobility stations contribute to the local sustainable urban mobility goals requires that all stakeholders (planning authorities, mobility service providers, citizens, etc.) are involved in the planning process.

As summarized in Section 7.2.2, one important success factor when implementing mobility stations is the early involvement of all possible partners from the beginning. At this stage, common goals for mobility stations in line with the sustainable urban mobility goals at the city level should be agreed to by the stakeholders (city authorities, public transport operators and authorities, shared mobility services providers, etc.) and have the highest priority throughout the process. Additional individual goals of the stakeholders (e.g. profit, reducing costs, gaining customers, etc.) are allowed as long as they are not in conflict with these common goals.

An analysis of the context with the participation of various stakeholders will allow to determine the location, size and amount of mobility stations to be implemented. Depending on the characteristics of the surroundings (population density, land use, etc.) and the demographic characteristics of the population, the demand for the amount and types of mobility services and amenities at mobility stations may vary. A public participation process can help to identify the needs of the future users and ensure their acceptance of the project.

Finally, the characteristics of the multimodal mobility offer, which should also be in line with the guiding principles, should be defined at this stage. For example, aspects such as accessibility, affordability, functionality, usability, customer service, quality, safety, and environmental standards can be discussed in order to support the area's specific objectives.

Last, but not least, the roles and responsibilities of the different stakeholders should be clearly defined at this stage.

8.1.3. Supporting measures for mobility stations

Besides the careful design of mobility stations, supporting policies and corresponding measures could be implemented in order to reach the sustainable mobility goals set at the beginning of the planning process.

Mobility stations offer a wide variety of transport modes as an alternative to private car ownership, and thus they belong to the category of “pull measures” in transport planning. However, as indicated by (Gerike and Koszowski, 2017) “pull measures alone generate new traffic”, and the provision of mobility options alone might not be enough to shift certain trips away from cars. Thus, additional push measures might be necessary in order to reach the goals of mobility stations and the wider sustainable urban mobility goals.

For example, a common goal of mobility stations is to reduce car ownership and usage (see Section 3.2.3). While the integrated multimodal mobility offer at mobility stations will present citizens with alternatives to private cars, other measures such as congestion charging (i.e. decongestion pricing) and parking management could restrict the use of this mode and support the desired mode shift.

Furthermore, as mobility stations develop and their effects on reducing car ownership and usage become more evident, reactive measures should be implemented to avoid a re-bound effect.

For example, as car ownership and car usage reduce there might be less parking pressure and less congestion in certain areas, which might in turn motivate other people to own a car and drive in that area. To avoid such a re-bound effect public parking spaces and roads should continue to be transformed to accommodate other road users by widening sidewalks, providing new and/or wider bike lanes, and exclusive lanes for modes which are more space and energy efficient (e.g. HOV lanes, bus and taxi lanes, etc.) (see also Section 8.2.2). Also, this newly available space can be used for other uses such as bike parking infrastructure, green areas, and public space, among others.

Table 8.1 below shows some examples of measures, classified into four categories, which could be implemented at the city level to support the goal of mobility stations.

Table 8.1: Examples of measures which could be implemented at the city level to support the goal of mobility stations

Category	**Examples of measures**
Economic	• Surcharges to less space and energy efficient modes. • Internalizing the costs of driving alone. • Subsidies to more space and energy efficient modes. • Multimodal mobility package for one month in exchange of selling a car/not owning a car.
Education / Information	• Mobility management • Integrated multimodal mobility marketing
Engineering / Infrastructure	• Reduction in the supply of public parking spaces • Easy access by modes of ecomobility. • High Occupancy Vehicles (HOV) lanes (e.g. priority to cars with more than one passenger). • Privileged parking spaces for cars with more than one passenger (carpooling) and small cars.
Enforcement / Regulations	• Parking management • Congestion charging • Required number of parking spaces for housing units (maximum instead of minimum, reduced number)

Finally, to ensure that mobility stations contribute to sustainable urban mobility, thresholds for a minimum level of needs fulfillment and a maximum level of resource consumption must be set. The corridor for sustainable mobility suggested by Gerike (2005), and some thresholds as those suggested by Holden et al. (2013) could guide the development of mobility stations towards a sustainable mobility future.

8.2. A ubiquitous, connected, and accessible network

In order to offer a multimodal mobility service that can compete with the perceived comfort of driving a car from door to door, mobility stations should be part of a ubiquitous, connected, and accessible network of mobility stations.

In the same way that bus, tram, metro, and suburban railway stations are part of a public transport network, mobility stations of different sizes, located in different contexts, and offering different mobility options according to the local demand should be part of a diverse and integrated multimodal mobility network. Furthermore, in the same way that private vehicles can be parked on public space, public shared mobility services could have a “home” on private ground.

A network of mobility stations should reach as many users as possible, including those living in areas with insufficient public transport service - offering them reliable alternatives to private cars and enabling them to fulfill all their needs.

For this, the following aspects should be considered:

1. Use of existing public and private infrastructure to create a ubiquitous and diverse system of mobility stations,
2. Adaptation of connecting infrastructure between mobility stations to accommodate the traffic volumes of the various modes generated at these facilities, and
3. Facilitated access to mobility stations by the mobility services offered at them.

The following subsections provide further details on these aspects.

8.2.1. Use of public and private infrastructure

Different types of existing public and private transportation facilities can be upgraded to mobility stations by adding some components such as shared mobility services and the corresponding infrastructure (e.g. reserved parking spaces, docking stations) and design elements (e.g. information steles).

Most public transport stations are already multimodal nodes. Depending on their size, different types of facilities in close proximity such as bike parking infrastructure, parking spaces, and taxi stands already facilitate intermodal transfers to and from public transport services. At such stations, simple upgrades like additional design elements (e.g. steles, information screens) and the provision of shared mobility services would support multimodality transforming ordinary multimodal nodes into mobility stations.

Transforming existing public transport stops and stations into mobility stations might be the first logical step. However, in order to provide an attractive multimodal mobility offer that can effectively compete against the comfort and convenience of door-to-door mobility offered by private cars, ancillary mobility stations could also be located at public and private parking facilities, for example:

- Public parking spaces in residential and commercial areas could be reserved for shared mobility services (e.g. carsharing, bikesharing, cargo bikes, electric bikes, etc.) and bike parking. Strategic locations such as intersections could make the multimodal mobility offer highly visible and easy to access.
- At public parking garages and P+R facilities, some of the spaces - ideally those that are easier to access - could be reserved for shared cars, carpooling, and vanpooling, and as a meeting point for ridesourcing services. Moreover, space for private bikes and other mobility options fitting to the location and the needs of users could be added.
- Private parking facilities could also offer access to shared mobility services, especially those required by residents (e.g. station-based carsharing, cargo-bikes, and electric bikes), as it is the case of private mobility stations such as the one in Domagkpark in Munich. Further, private mobility stations should be integrated into the wider system of public mobility stations.

The additional mobility services at the above-mentioned facilities, in combination with the corresponding design elements, would transform public parking spaces and parking facilities into (ancillary) mobility stations.

Finally, other facilities usually intended to serve private cars only (such as gas stations and workshops) could provide space for shared mobility services. These areas could provide the necessary maintenance services and act as service centers providing information about the multimodal mobility offer, facilitating registration, and validation of driving licenses.

Transforming infrastructure which traditionally has been used exclusively for cars could be an important instrument for reaching car owners and drivers, making them aware of the multimodal mobility offer and its advantages over private car ownership and single occupancy driving.

8.2.2. Multimodal connecting infrastructure between mobility stations

Since one of the goals of mobility stations is to reduce car ownership and usage while increasing the use of ecomobility options, the infrastructure connecting mobility stations must be redesigned in order to accommodate the traffic volumes of the tips generated by the various modes available at these facilities.

The *Global Streets Design Guide* shows how the transformation of a car-oriented street into a multimodal street can actually increase the capacity of a street while reducing car traffic (see Figure 8.2).

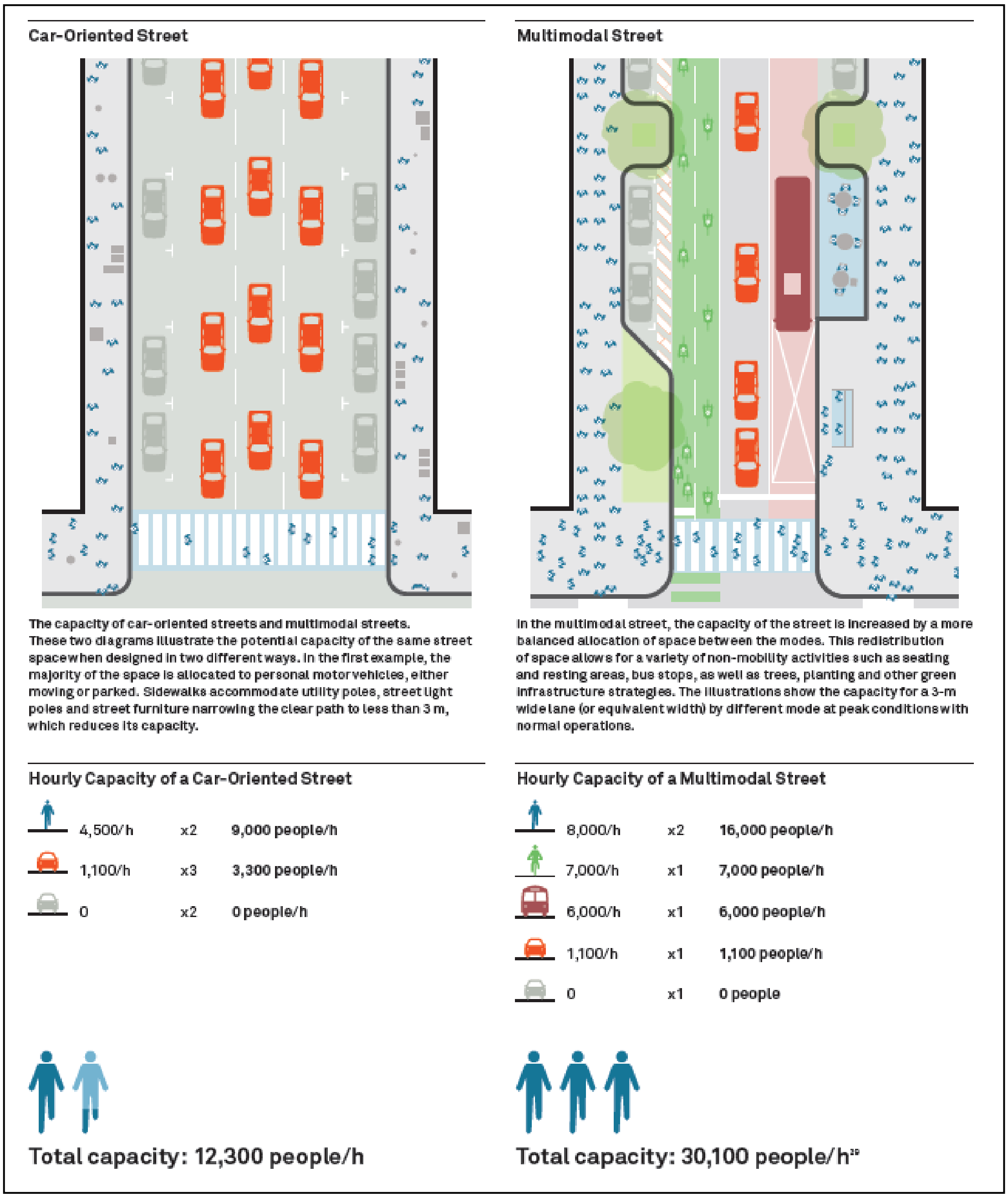


Image source: (GDCI and NACTO, 2016)

Figure 8.2: Car oriented street and multimodal street with corresponding passenger capacities at peak conditions with normal operations

Such street transformations can help reduce congestion and the risk of traffic accidents while improving air quality and the quality of public space.

8.2.3. Easy access

Finally, in order to compete against the comfort of driving a car from door to door, mobility stations must provide extremely easy physical access when using the alternative transport modes available at them.

Access by foot, bike, public transport, and shared vehicles should be made as easy as possible (e.g. avoiding detours) through a careful design of the station, the corresponding infrastructure, and considering potential conflicts between different road users. See Sections 6.7.3 to 6.7.5 for some example of problems related to access to the MSMF to be avoided and some ideas on how to provide easy access).

Considering the aspect of intragenerational equity, a barrier-free accessible design should be considered when planning mobility stations.

8.3. Integration with the surroundings

Besides multimodal infrastructure connecting mobility stations and barrier-free access, their integration with their surroundings is of special importance for sustainable urban mobility.

A careful integration of mobility stations into their surroundings can facilitate access to them and to other opportunities in close proximity, supporting trip chaining and thus enabling the fulfillment of needs while reducing the consumption of resources for mobility. Moreover, the integration of mobility stations with their surroundings can increase the visibility of mobility stations and thus the awareness of the multimodal mobility service among potential users.

The integration of mobility stations with their surroundings should imply their connection with ecomobility, promoting it over the use of private cars. The following three aspects regarding the integration of mobility stations with their surroundings should be taken in account:

1. a high quality of public space and walking infrastructure around mobility stations that guarantees an easy access by foot and other low-speed modes,
2. Wayfinding elements indicating the location of the mobility station, its elements, and opportunities in close proximity.
3. A high quality design of components at mobility stations to make them more attractive, comfortable and safe, increasing their visibility, acceptance and use.

Further ideas on the integration of mobility station with their surroundings can be found in the guidelines for mobility hubs in North America (see: Metrolinx, 2011; urban design studio, 2017; ICTC, 2017)

8.3.1. High quality of public space and walking infrastructure

The high percentages of users walking to mobility stations before or after renting a shared vehicle (see Section 6.4.5) indicates that the quality of public space and walking infrastructure at and around mobility stations is an important aspect to address. Also, walking by a station is an important source of awareness of mobility stations (see section 6.3.2).

Depending on the local context the type of integrating infrastructure may be different. Figure 8.3 below shows a tram and bus stop in Würzburg which is well integrated with its surroundings, enabling public transport users to reach the station easily.

Image source: Maximilian Pfertner

Figure 8.3: Bus stop in Würzburg, Germany as an example of good integration with its surroundings

The quality of infrastructure connecting mobility stations with their surroundings can be addressed through integrated city and transport planning, as well as neighborhood mobility and accessibility planning.

8.3.2. Information about opportunities in the immediate surroundings

The combination of activities and trips at mobility stations is an area of opportunity that transport and city planners should consider when planning these facilities.

According to the user survey in Munich, users of the MSMF visited different types of locations after ending a trip with a shared mobility service (see Section 6.4.4). Combining certain activities, such as shopping, going to the bank, or visiting the doctor with other trips through mobility stations could support trip chaining allowing users to fulfill some of their needs while reducing the consumption of resources for mobility due to the reduction of travel distances or even the avoidance of some trips.

Wayfinding signage and interactive screens at mobility stations can provide information about opportunities in the immediate surroundings and wayfinding signage in the immediate surroundings can advertise for mobility stations as well. Furthermore, in combination with real time information about mobility services, users can plan their trips in combination with other activities.

Figure 8.4 shows an interactive screen at a mobility station in Graz providing information about the surroundings and the timetable of the public transport services.

The implicit message of the integration of mobility stations with their surroundings could be similar to the one used by a local supermarket: *"einmal hin, alles drin*" which loosely translates to "your one stop shop". In the case of mobility stations, the message could be altered to "*one trip through, all you need to do*".

Image source: own photographs

Figure 8.4: Interactive screen at a public transport stop in Graz showing a) information about the surroundings, and b) the timetable of public transport services

8.3.3. High quality design of infrastructure and components

Being located on public space, mobility stations are already quite visible. However, this might not always be enough (see Section 6.7.1). A high-quality design of components of mobility stations can help make them more visible and attractive, which in turn can increase awareness of the multimodal mobility offer and the acceptance of the station.

The visibility of mobility stations can be increased through the use of modular elements, striking colors on the physical components of mobility stations, and way finding elements.

Below, some examples of high quality infrastructure (e.g. architectural elements, parking spaces and bike parking facilities), and components (e.g. information stele, charging station, information screen) are presented.

Modular elements

Modular elements can increase the visibility and comfort of mobility stations. Figure 8.5 shows a prototype for the stations in the City of Osnabruck and Figure 8.6 shows a modular element at a mobility station in Offenburg.

Image source: Stocker Design

Figure 8.5: Visualization of a prototype of mobility stations for the City of Osnabruck

Image source: Stocker design

Figure 8.6: Modular elements at a mobility station in Offenburg

These modular elements incorporate bike storage facilities and sheltered benches, among other amenities, and are illuminated at night for better visibility, providing objective and subjective security.

Steles, charging stations and information screens

Design elements such as information steles are very important in helping people recognize mobility stations (see Section 6.3.2). In addition, other elements such as charging stations and information screens might be used to increase the visibility of mobility stations.

Figure 8.7 shows a charging station, an information screen, and an information stele at a mobility station in Graz, Austria.

Images source: own photographs

Figure 8.7: Design elements at a mobility station in Graz, Austria. From left to right: a) charging station, b) information screen from behind, c) stele and information screen

The striking colors of the different components, part of the unique corporate design, increase the visibility of the mobility station from various angles and create a more recognizable brand.

Parking spaces and bike parking facilities

Another possible way of increasing the visibility of mobility stations is to mark parking spaces and bike garages with the logo of the brand of the station or multimodal mobility service and even painting them with a striking color.

Figure 8.8 shows the reserved parking spaces for carsharing and a bike garage at the *switchh* stations in Hamburg.

Image source: own photographs

Figure 8.8: Green colored parking spaces and bike garage with the switchh logo at mobility stations in Hamburg

8.4. Physical components and integration

As presented in Chapter 3, mobility stations in Germany nowadays mainly concentrate on providing diverse mobility options, the most common being public transport, station-based carsharing, bikesharing, and bike parking (see Section 3.2.2.1). However, mobility stations can offer other services, amenities, and mobility services and thus, further contribute to fulfill the needs of users while reducing the consumption of resources for mobility.

Users of mobility stations considered different types of mobility services important, as well as various types of amenities and services in direct proximity to these facilities (see Sections and 3.2.5.2, 6.5.2 and 6.5.4).

Depending on their location and context, the mobility stations should be of different sizes and integrate different types of components. Through an analysis of the local conditions and the preliminary participation process (see Section 8.1.2) the services, amenities and mobility services, as well as characteristics desired at mobility stations can be identified so that the supply can correspond to the demand at specific locations. For example, elderly people could be more interested in a taxi or ridesharing service in combination with comfortable waiting areas, while commuters might be more interested in having the possibility to use electric bikes and/or carpool.

By offering additional services and amenities, people could become more attracted to using the mobility services at the station. In addition, a careful configuration of the various components at mobility stations should facilitate access to the various amenities and mobility services, enabling easier intermodal transfers, reducing travel time, and increasing comfort for those combining transport modes.

One important aspect to consider is that the mobility services provided at mobility stations should consider the needs of different types of users (see Section 8.1.1). Moreover, considering the goal of reducing the consumption of resources for mobility, other mobility services which are more space and energy efficient than carsharing vehicles while offering similar advantages (e.g. e-bikes and cargo bikes) could be offered as well.

Preferably, the mobility services at mobility stations should be powered with electricity from renewable sources. This way, clean and silent mobility could be promoted over dirty and noisy modes of transport. The evaluations of mobility stations in three cities showed that electric mobility has a high acceptance among users and non-users, which supports their further development at mobility stations (see Section 7.2.3.5).

The following subsections provide further details regarding the components of mobility stations and their configuration which should be considered when developing further mobility stations.

8.4.1. Services and amenities

Different types of services and amenities at mobility stations can increase comfort for the users and the fulfillment of their needs, all while reducing the consumption of resources for mobility.

Depending on the location and size of a mobility station and the needs of the users, different types of services and amenities can be integrated at the station. Below some examples are presented. For further ideas see the Mobility Hub Features catalog (ICTC, 2017).

General information and real time information

General information about the mobility services, from printed material to digital information on interactive screens, can help users get more familiar with the multimodal mobility service.

At large and highly frequented stations, a service center can provide users with information and enable them to register for one or various mobility services or validate their driver licenses for using carsharing.

Real time information (e.g. departure times, locations of shared vehicles, availability of parking spaces) can also help users plan their trips while considering various mobility services and routes. Moreover, in combination with information about services and amenities at the station and in the surroundings, users can combine their trips with other activities (see Section 8.3.2).

Small shops and kiosks

While bigger shops might be located in the immediate surroundings of mobility stations, other smaller shops or kiosks can help users to fulfill some needs directly within the station. For example, at the Mobility Station at Münchner Freiheit, a kiosk, which coincidentally was opened around the same time that the Mobility Station was inaugurated, is open 24 hours a day and it offers passengers with snacks, drinks, newspapers, etc.

Image source: own photograph

Figure 8.9: Kiosk at Mobility Station at Münchner Freiheit

The wide offer of products and its modern design are some of the reasons for positive acceptance among passengers and passersby. Moreover, the fact that it is open at night gives an additional feeling of security to the station, especially to women (Graner, 2015; Kaufmann, 2016).

Storage

Lockers and other storage services can support users in combining their trips with other activities, increasing travel comfort, and making mobility more efficient. For example, package delivery lockers (e.g. Amazon lockers) allow users to pick and/or drop off packages while already out and about.

Similarly, refrigerated lockers can be used to store food and other items that need to stay cool. They can be used commercially (e.g. collect on-line purchased groceries or drinks) or privately.

These types of shared lockers might avoid additional trips, saving resources for users' mobility (space, energy, time, money). While this requires the packages to be delivered to the station, it might be more efficient than home deliveries due to failed delivery attempts and the aggregation of deliveries.

Figure 8.10 shows an example of refrigerated lockers that can be found in various metro stations in London since 2014, and which are used for various companies to deliver their on-line ordered products.

Image source: Transport for London

Figure 8.10: Refrigerated lockers at a public transport station in London

Also, heavy or bulky bags can be stored in non-commercial lockers while spending time at a mobility station and/or its surroundings.

Bike reparation services

A public bike pump and a toolset for repairing shared and private bikes can be provided at some stations. At large stations reparation services at workshops can be offered as well (Figure 8.11 for some examples).

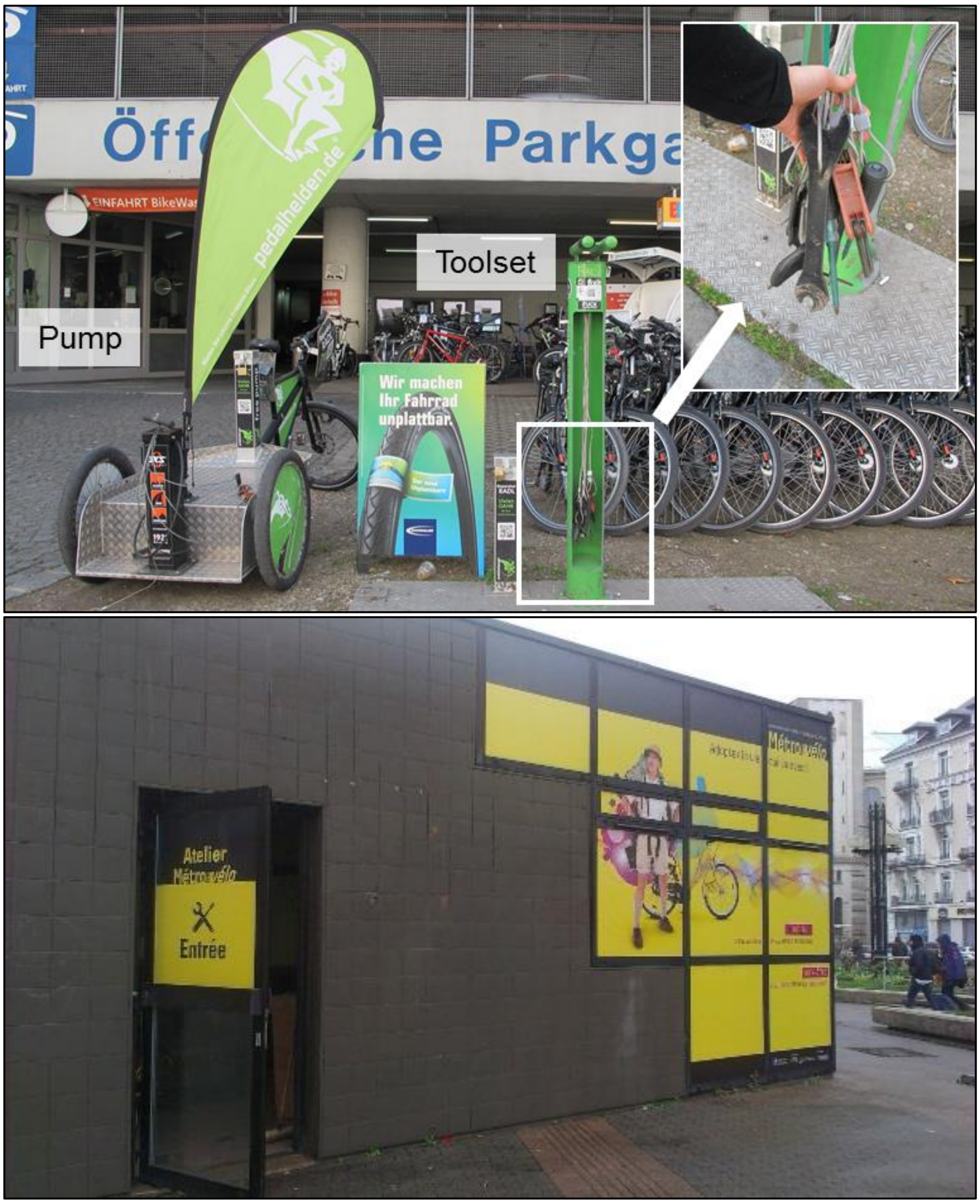


Image source: own photographs

Figure 8.11: a) public bike pump and toolset at a parking garage in Munich, and b) bike workshop at central station in Grenoble, France

Other amenities

Last but not least, other amenities such as mail boxes, newspaper boxes, ATMs, and internet connection can be incorporated at mobility stations providing additional comfort to users.

8.4.2. Mobility services

Mobility stations can provide different types of mobility services, such as public transport and shared mobility services as well as intermodal infrastructure (e.g. bike parking infrastructure) to facilitate their use and transfers between modes.

The mobility options at mobility stations should be diverse enough and combined with information on travel times, costs, and energy consumption so that users are able to choose the more efficient mode for a given trip and purpose. General information regarding the different options can be communicated through the different instruments of integrated multimodal marketing (see section 8.6), and real time information can be provided through information screens and multimodal mobility apps (see Section 8.5).

Various studies indicate that carsharing contributes to reducing car ownership and overall vehicle kilometers traveled (see Section 3.3.1.2), and the effect on reducing car ownership was confirmed by users of the MSMF identified as carsharing users (see section 6.6.1). Also, most carsharing providers offer vehicle fleets that are on average more energy efficient than the overall fleet of private vehicles. Thus, in order to reduce the consumption of space and energy for mobility in the long term, and to satisfy specific needs of the population that cannot be fulfilled with other modes of transport, carsharing should remain an essential part of mobility stations.

However, for certain trips, a carsharing vehicle might be too expensive and/or oversized, while a (shared) bike could require excessive physical effort, public transport could be inconvenient, and taxis too expensive. Thus, other types of vehicles could be included in the multimodal mobility offer.

Table 8.2 presents some examples of different types of shared mobility services and their advantages for specific occasions.

Table 8.2: Additional mobility services that can be offered at mobility stations and their advantages

Example of shared mobility service	Advantages
Electric bikes / pedelecs (pedal electric bikes)	Traveling long distances faster and more comfortably than with a normal bike and with less space and energy consumption than cars. For certain trips it can be even faster and cheaper than using a car.
(electric) cargo bikes	Transporting things that are too heavy for a bike with less space and energy consumption than using car. For certain trips it can be even faster and cheaper than using a car.
Electric scooters	Travel long distances faster than with a normal bike and with less space and energy consumption than cars. Less effort than with electric bikes or pedelecs.
Small (two seat) electric cars (e.g. smart, twizy)	Ideal for trips alone or with another person at times when other options are not available and/or to locations difficult to reach with other options.
Reserved spaces for carpooling and van pooling.	For trips to common destinations, is more space and energy efficient than traveling alone by car and cheaper for the users.
Ridesourcing meeting point (e.g. uber, clever-shuttle, lyft)	For trips to common routes, sharing a vehicles for some parts of the trips along the same (or fairly the same) route is more space and energy efficient than traveling alone by car and cheaper for the users.

Figure 8.12 shows an example of small electric vehicles (three wheelers) part of a shared system and available at various public transport stations in Grenoble, France.

Image source: own photograph

Figure 8.12: Shared electric small vehicles at a public transport station in Grenoble, France

In order to accommodate these other services, the necessary parking, and in the case of electric vehicles, the charging infrastructure, should be provided. This includes:

- Bike parking infrastructure, from single racks to a secured bike garage,
- Docking stations for (electric) bikesharing
- Charging stations and reserved parking spaces for (electric) carsharing
- Meeting points for carpooling
- Pick up and drop off point for ridesourcing services.

Providing reserved parking spaces for carpooling and ridesourcing at mobility stations can encourage the collective use of cars in combination with public transport and bikesharing. For example, *MatchRider* is a platform that helps people organize carpooling or ridesourcing using pre-defined meeting points to pick and drop off passengers. Mobility stations could offer such meeting points allowing people, for example commuters, to transfer to other modes of transport easily.

8.4.3. Configuration

An ideal configuration of mobility stations should allow users to easily find the different amenities and mobility services offered at them and use them comfortably, facilitate intermodal transfers, and prioritize more space and energy efficient modes over less efficient ones.

Proximity

The different mobility options should be as close to each other in order to easily find them, use them, and transfer from one to another.

For example, bikesharing stations can be located as close as possible to the entrances of metro stations, tramway platforms or bus stops. At big stations with various access points, bikesharing stations could be located next to each entrance.

Figure 8.13 shows a visualization of a mobility station where the various mobility options are at sight.

Image source: Hochbahn

Figure 8.13: Visualization of a mobility station in Hamburg (switchh punkt)

Some amenities can also be located in close proximity to mobility options depending on the demand for them (e.g. lockers, mailboxes)

Wayfinding elements

As physical proximity might not always be possible, wayfinding elements can be installed at a mobility station to facilitate finding the different components (e.g. reserved spaces for carsharing, bikesharing docking station, service center, etc.). These can be complemented by wayfinding signage in the surroundings of mobility stations.

In addition, way finding can be complemented virtually through smartphone applications that also integrate the ability to navigate between mobility options.

Comfortable and well dimensioned

Finally, the different components of mobility stations should be arranged in a way that it is comfortable and easy to use. For example by providing weather protected areas and seating facilities at meeting points, and through well-dimensioned parking spaces for carsharing allowing easy loading and unloading of vehicles

8.5. Virtual integration

Beyond the physical integration of multiple mobility services at mobility stations, the virtual integration of the services can facilitate their combined use, increasing their affordability, acceptance and use compared to private cars.

During the focus groups, users of the MSMF showed appreciation for the existing tariff integration of shared mobility services with public transport. Also, they indicated that the easier it is to use the various mobility services, the more attractive the offer would be for them (up2date, 2016).

The ideas from users and non-users for further virtual integration ranged from a unique online portal for finding the cheapest mobility option for a given trip, an online map showing the location of all available shared vehicles, the ability to register to various mobility services at once, a unique access medium (smart card or app) to use various different transport modes, and mobility packages for the combined use of different services (ibid).

Moreover, integration of mobility services through institutional cooperation has proved to have a positive impact on attracting users and changing their mobility behavior (see Section 3.3.3).

Once people become aware of the mobility services offered at mobility stations, the following steps are necessary for them to use each of the mobility services:

- **Information** about the mobility service: prices, conditions for use, service areas, availability, etc.
- **Registration** / creation of an account to use the mobility service by providing personal data, signing a contract, choosing a payment method etc.;
- **Pre-payment** for the use of mobility services (e.g. buying public transport tickets or long-term use passes, paying annual fees and/or buying credit time for using shared mobility services);
- **Planning** a trip with one mobility service or a combination of various mobility services, based on own preferences and on information regarding availability, travel times and costs, among other aspects;

- **Booking** / reserving the chosen shared mobility service(s) (e.g. reserving a seat in a shared vehicle including public transport, booking a ride with a ridesharing or ridesourcing application, ordering a taxi, reserving a shared vehicle or bike, etc.)
- **Accessing** the mobility service(s) (e.g. entering a public transport station holding a valid ticket, opening a shared vehicle, unlocking a shared bike, arrive to a meeting point and identify oneself before joining a carpool or ridesourcing service);
- **Post-payment** (e.g. when payment is done after completing a trip – taxi, ridesourcing, carpooling, etc.);

In order to facilitate the use of various mobility services both within a defined period of time (multimodality) or during a trip (intermodality), the above mentioned steps could be integrated in various ways.

Different instruments of virtual integration

The integration of the various steps mentioned above requires the cooperation of the various mobility service providers, which can lead to different types of integrating instruments such as:

1. Integrated information and registration through a unique platform (e.g. website or app),
2. Integrated tariffs and mobility packages for different types of users and budgets (e.g. EMMA contracts in Montepellier, France),
3. Integrated use (real time information on location and availability of mobility services, booking, access and payment) through a unique platform.
4. Integrated access to various mobility services and payment through a smart card.

Mobility as a Service

While the above mentioned instruments can exist independently from each other, they can be further integrated through the new concept of "Mobility as a Service" (MaaS). MaaS is a tool that can be adopted to integrate a multimodal mobility offer in the form of personally tailored mobility packages. Moreover, MaaS applications allow users to plan their trips considering various routes and transport modes and give them the ability to choose depending on personal preferences.

Tariff integration in the form of MaaS should tailor the mobility service portfolio of users according to their needs, optimizing the costs and increasing the affordability and attractiveness of the multimodal offer.

Some examples are *Optymod* in Lyon, France, and *Hannover mobil* in the homonymous city in Germany. The latter also includes information on services and events in the area. For a review of various MaaS applications (see Jittrapirom et al., 2017).

Multimodal products

The physical and virtual integration of various mobility services can be organized in a way that becomes a separate product. Some examples are *switchh* in Hamburg, and *Leipzig Mobil* in Leipzig.

8.6. Integrated multimodal marketing

In addition to the physical and virtual integration of mobility options, an integrated multimodal marketing (IMM) strategy can increase the acceptance of a multimodal mobility offer and ensure that it contributes to the concept of sustainable urban mobility (see Schreiner, 2007). .

For an effective IMM the following aspects should be taken in account:

1. Definition of a unified message,
2. development of a brand and corporate design,
3. using appropriate instruments for different target groups.

The marketing strategy should be in line with an overarching local mobility management strategy, if there is one, and with the common goals agreed to at the beginning of the planning process (see Section 8.1.1). Figure 8.14 illustrates how the different aspects of the IMM are aligned with the local mobility management strategy.

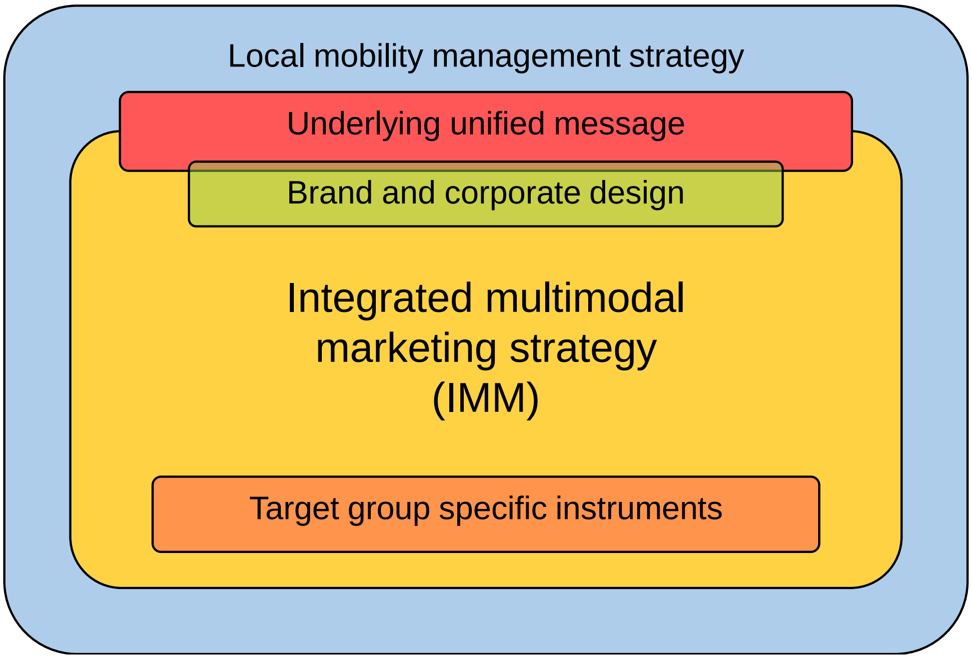


Figure 8.14: Aspects of an integrated multimodal marketing strategy

The following sections provide further details about these aspects.

8.6.1. Underlying unified message

A multimodal mobility service consists of various mobility services that are mainly offered by different providers.

To avoid that different and contradictory messages are communicated by the different mobility providers through their individual marketing efforts, a unified message in line with the common goals agreed to by the stakeholders from the beginning of their cooperation (see Section 8.1.1) should be defined.

If a local mobility management strategy exists, the underlying message of the integrated multimodal marketing strategy should be in line with it.

8.6.2. Corporate design

An important element of integrated multimodal marketing is a unique corporate design for the multimodal mobility offer. The need for a recognizable brand, colors and logotypes as part of a unique corporate design was highlighted by both users and non-users during the focus groups as a further means to catching the attention of more people (up2date, 2016). This is also important in spreading the message that diverse mobility services belong together and can be used together easily, thus advertising and supporting ecomobility.

Each of the mobility services offered at mobility stations might have their own brand (e.g. MVG Rad, DriveNow, STATTAUTO) and keep it. However, something like an “umbrella brand” shall communicate that these different mobility options are grouped together. By using the corporate design of the multimodal mobility offer it should be clear that the independently advertised mobility service is one part, and that there are other parts that form the whole offer.

In Section 3.2.2.4, the corporate design of various multimodal mobility offers in Germany was presented. A good example that could be adopted in Munich is the one developed for the mobility stations in Offenburg. The corporate design of “EinfachMobil” in Offenburg is present not only on design elements and the website, but also on the shared cars and bikes and a multimodal card which also displays the logos of the different partners (see Section 3.2.2.4).

Moreover, the EinfachMobil brand is being extended to the infrastructure (bike lanes are painted with the same green color) and it is designed in such a way that an extension of the multimodal mobility offer into neighboring communities can take place without major changes and still be recognized as part of the same integrated service.

In addition, the brand can also be used to communicate the benefits of the multimodal offer. For example in Offenburg “EinfachMobil” means “easily mobile”, and in Graz, Austria the multimodal offer is called “TIM” which stands for “täglich intelligent mobil” (daily intelligent mobile).

8.6.3. Marketing and communication instruments

As revealed through the group discussions with non-users, the two main barriers for the use of shared mobility services is a general lack of information about the conditions for use and prices of the different providers and a lack of willingness to acquaint themselves about these aspects (see Section 6.2.4). Some non-users even expect marketing “coming to them”.

Once a unified message and a corporate design have been developed and agreed to by the stakeholders, various marketing and communication instruments can be used to inform current users of the different shared mobility services and potential users about the integrated multimodal mobility offer.

The various marketing instruments in the framework of the integrated multimodal marketing strategy should be implemented in order to fill information gaps and to attract more people to use the multimodal service.

While each provider might carry out their individual marketing efforts, these must not contradict the overall goal of the multimodal in line with the common goals agreed to at the beginning of the planning process (see Section 8.1.2), and must be in line with the unified message (see Section 8.6.1).

In Munich, there is already a successful mobility management program called *Gscheid mobil*, which addresses different target groups and informs them about different mobility options through various instruments, such as a website and marketing dialogue. Once the virtual integration in Munich is improved (see Section 8.5), the mobility management of the city can incorporate information on the integrated multimodal mobility service.

Considering the aspect of intragenerational equity, the mobility management strategy should address different target groups, especially:

- those that are not well represented among the current set of users of shared mobility services (e.g. women, elderly),
- those in a situation that could lead them to buy a car (e.g. young people in the process of getting their driving licenses, young couples planning to start a family);
- those in a situation that could lead them to get rid of a car (e.g. new residents, those moving within the city)
- those who own a car.

The different target groups can be addressed in different ways and through different instruments to assist them in choosing the mobility services they need to fulfill their needs. The various marketing instruments can be used to provide general information about the mobility services offered, their conditions for use and prices, and the possibility of direct registration to various mobility services. Table 8.3 present some examples of target groups and suitable marketing instruments to address them.

Also, instruments tailored to each target group should communicate the various benefits of the individual and the integrated mobility services. Depending on the characteristics of the target groups some of the various benefits of the multimodal mobility service can be highlighted, for example:

- Economic and practical benefits of a multimodal mobility service against owning a car (general information comparing costs of using carsharing and/or the multimodal mobility offer against owning and maintaining a private vehicle, information about parking management scheme, fees, etc.)
- Environmental benefits of using the transport modes included in the multimodal mobility service
- Health benefits of using active transport modes.

Table 8.3: Examples of target groups, marketing instruments and highlighted benefits

Specific target group (examples)	**Instruments**
Car owners	Personal letters to those holding a parking permits, accompanied by information material and the possibility of registering with a one-week trial of a mobility package (e.g. dialogue marketing).
Persons in the process of getting their driver's license.	Informational material and presentations at driving schools. In the long term, it could be possible to integrate multimodal mobility education into the training program.
Young couples	Personal letters to those recently married and/or with a newborn, accompanied with information material and the possibility to register and one-week trial of a mobility package (e.g. dialogue marketing).
New residents	Personal letters to new residents accompanied with informational material and the possibility of registering with a one-week trial of a mobility package (e.g. dialogue marketing).
Elderly	Traditional communication methods (printed documents), face-to-face communication, events including some tests and guidance.
Young people	Internet, social media, posters.

8.7. Management

The multimodal mobility offer, including mobility stations and the different elements of the virtual integration, needs to be sustainably operated and managed.

As with public transport services, there might be many different mobility service providers and operators forming the multimodal mobility offer. However, in order to provide an effective multimodal mobility offer that contributes to sustainable urban mobility, different aspects of the services must be coordinated accordingly.

An effective operation of mobility stations oriented to support the goal of sustainable urban mobility it is shaped at the beginning of the process. During the planning phase a common goal in line with local sustainability goals should be agreed upon by the various stakeholders. Moreover, the characteristics of the multimodal mobility offer, which should also be in line with guiding principles, as well as a clear definition of roles and responsibilities should be determined at this stage (see Section 8.1.2).

The planning and implementation of mobility stations and their associated components (i.e.. virtual integration, marketing) involves various steps, including:

- selection of locations and design of stations,
- construction and installation of components,
- integration with the surroundings, installing way finding elements, etc.
- tariff integration and creation of mobility packages,
- creation of a multimodal mobility product and a brand,
- implementing other instruments of virtual integration (multimodal smart card, MaaS, etc.)

The operation of mobility stations and the corresponding virtual integration of mobility services involves various tasks, including:

- maintenance of infrastructure: e.g. keeping the station and its components (parking spaces, docking stations, B+R facilities, information screen, other services) clean and functional;

- management of infrastructure: e.g. charging fees for the use of infrastructure (parking spaces, kiosk, etc.), surveillance of parking spaces;
- operation of a service center: providing information about mobility services and multimodal mobility offer, facilitating registration, validation of driver's licenses, etc.;
- ensuring availability and reliability of mobility services: e.g. vehicles (cars, bikes, taxi, etc.) are always available and ready to use at mobility stations, and there are enough spaces to return a vehicle;
- ensuring functionality of amenities (e.g. information screen, storage services, internet connection);
- maintenance of a website, smartphone application, and other instruments of virtual integration,
- carrying out a marketing strategy.

As mentioned in Section 8.1.2, it is recommended that the characteristics and quality standards of the multimodal mobility offer such as accessibility, affordability, functionality, usability, customer service, quality, safety, and environmental standards are defined at the beginning of the planning process. As mobility stations develop, these characteristics and quality standards might be adapted.

The dynamic development of mobility services in Munich with companies starting operations, sometimes in unexpected ways (e.g. introduction of oBike) and others retiring from the market (see Section 4.2.1) shows that these initiatives need both to be further regulated but also supported.

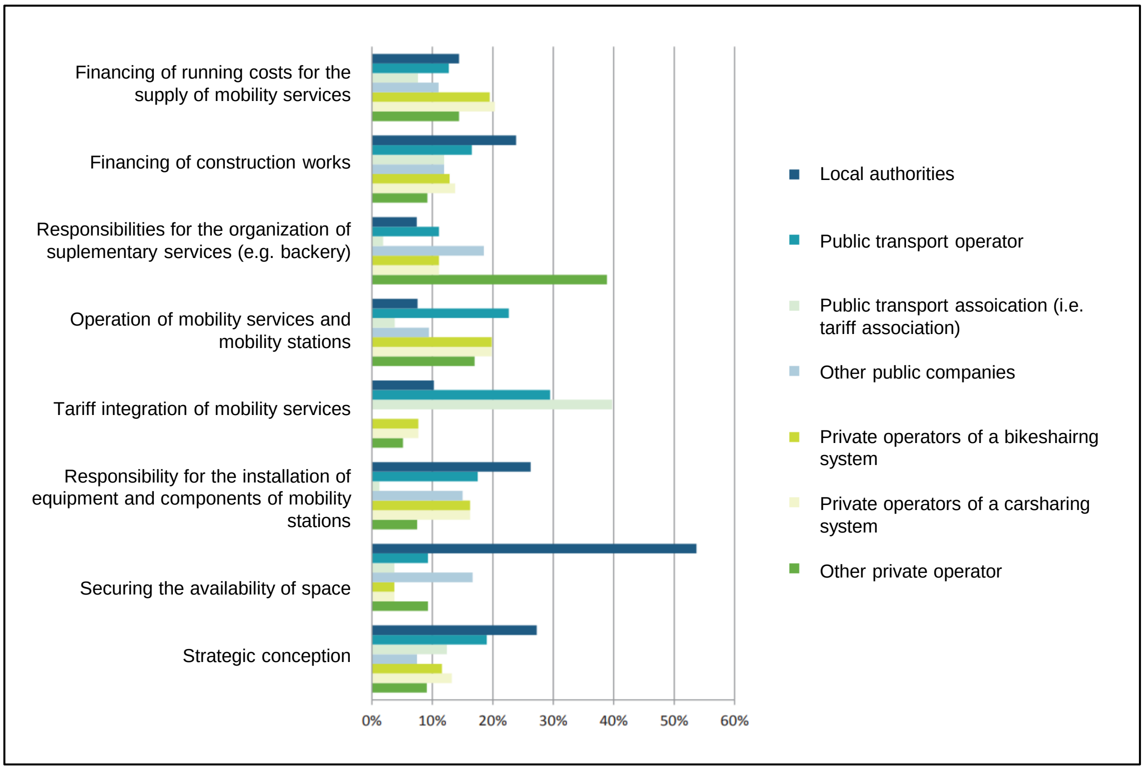
The different tasks mentioned above might be carried out by different partners and some of them can be given in contracts to third parties by carrying out a bidding process. This requires the definition of an actor taking the role of the coordinator. Through monitoring and evaluation of the different tasks, the contracts and quality standards can be modified accordingly.

Table 8.4 presents a possible distribution of roles among various actors for the seven fields of action in general and in Munich considering the local context.

Table 8.4: Possible distribution of roles for the seven fields of action in general and in Munich

Area of action	General	In Munich
1. Strategic framework for sustainable urban mobility	Local authorities through various relevant departments (transport, environment, construction, etc.) and through a public participation process	
2. A ubiquitous, connected and accessible network	Spatial and transport planning departments	Department of Urban Planning and Building Regulation (PLAN)
3. Integration with the surroundings	City planning and construction departments	PLAN, Baureferat
4. Physical components and integration	Public transport operators, carsharing providers with existing stations, building administrations, spatial and transport planning departments	MVG, STATTAUTO, PLAN
5. Virtual integration	Public transport authorities (i.e. tariff associations) or private companies through a bidding process	MVV
6. Integrated multimodal marketing	Local authorities or private companies through a bidding process	KVR
7. Management	Private companies through a bidding process or public companies	P + R Park & Ride GmbH

The distribution of roles presented above is only a preliminary suggestion which should be discussed further among local actors. A survey among various actors including public transport authorities and transport associations carried out in the framework of the Handbook for Mobile Stations (Zukunftsnetz Mobilität NRW, 2015) shows that there is not yet an agreement on the distribution of tasks during the planning and operation of mobility stations (see Figure 8.15). At the same time, this shows that different operational models are possible.



Source: Zukunftsnetz Mobilität NRW (2015) (translated)

Figure 8.15: Results of a survey regarding the distribution of tasks for planning and operation of mobility stations

Since both mobility stations are relatively new applications for organizing multimodal mobility, there is not yet an established operational model that can be deemed as the optimal one. Krismanski (2015) explored four examples of mobility stations and described their operational models. However, due to the recent implementation of the projects at the time of her publication, it was not possible to evaluate their effectiveness.

In Munich, there are three different projects concerned with the planning and implementation of mobility stations. Each of these projects are located in different contexts and are led by different consortia (see Section 4.2.5.2). Their future operation will test different operational models, thus providing a valuable opportunity to learn what works best in Munich.

In addition, the examples from other cities currently operating mobility stations, some of them in combination with MaaS applications and multimodal products, should be investigated further in order to learn about their operational models and evaluate their effectiveness.

9. Conclusions

This dissertation was motivated by the increasing amount of cities, especially in Germany, implementing mobility stations as a tool to organize mobility in a more sustainable way, and the little existing knowledge about their acceptance and contribution to sustainable mobility.

The vast amount of results and their analysis in this work have answered many questions posed at the beginning. Nevertheless, many questions remain open. Either some of the original questions could not be answered in the framework of this work, were answered only partially, or new questions arose.

This chapter presents a synthesis of the main findings (Section 9.1), the limitations of this work and recommendations for further research (Section 9.2), and concludes with an outlook on the future (Section 9.3).

9.1. Synthesis

Two main research questions guided this work:

1. Do mobility stations contribute to the goal of sustainable urban mobility?
2. What are the success factors for the implementation and operation of mobility stations?

The first question, it was first necessary to define the concept of sustainable urban mobility and operationalize it. In Chapter 2, an operational approach consisting of two main criteria and six sub-criteria was proposed for assessing sustainable urban mobility generally. Then an assessment method based on this operational approach was used to assess the contribution of mobility stations to the concept of sustainable urban mobility.

The idiographic explanation of the MSMF (in Chapter 6), together with the findings on the state of the art of mobility stations and shared mobility services (in Chapter 3), contributed to answering both main research questions.

In Chapter 7, the contribution of mobility stations to sustainable urban mobility was discussed following the assessment method developed for this work, and success factors were identified and presented. Finally, a reflection on the methods used for the evaluation of the MSMF was done identifying weaknesses and potentials for improvement.

The assessment of mobility stations indicate that mobility stations can contribute to concretize the concept of sustainable urban mobility (see Section 7.1). However, with the available information at the moment it is only possible to talk about a potential contribution to sustainable urban mobility.

For this contribution to become relevant on the urban and regional scale, mobility stations should be replicated further and improved in various ways. Only through a widely accessible network of mobility stations and an attractive and affordable multimodal mobility offer, one oriented to support the local sustainability goals, is it possible to significantly reduce the consumption of resources for mobility while supporting the fulfillment of the needs of the people.

The identification of success factors of mobility stations (see Section 7.2), together with the assessment of their impact on sustainable urban mobility, led to recommendations for their implementation and operation processes better support the goals of sustainable urban mobility (See Chapter 8). These recommendations are classified in seven fields of action and have specific purposes:

1. Developing a **strategic framework for sustainable urban mobility** to ensure that mobility stations contribute to local sustainability goals.
2. Creating a **ubiquitous, connected and accessible network** of mobility stations to provide a multimodal mobility offer that effectively competes with the comfort and convenience of private cars.
3. **Integrating mobility stations with the surroundings** to ensure that they are visible, accessible and attractive.
4. **Physically integrating mobility services and amenities** at mobility stations in such a way that they effectively promote multimodal mobility, facilitate intermodal transfers, and organizing mobility efficiently.
5. **Integrating mobility services virtually** to ensure that the multimodal mobility offer is easy to adopt and use, and affordable for various types of users.

6. Implementing an **integrated multimodal marketing** strategy in order to inform citizens of the multimodal mobility offer, and assist them in adopting new mobility options into their mobility portfolio.
7. **Managing** the multimodal mobility offer to make sure that the goals and objectives established at the beginning are reached.

These recommendations will need to be adapted to the local contexts where mobility stations are to be implemented. The various tasks will require the participation of various public and private actors such as local authorities, public transport operators and other public companies, and mobility service providers. Communication and cooperation between these actors is essential for a successful implementation.

While some of the tasks can be executed by private companies (e.g. construction works, shared mobility services, amenities, etc.), the involvement of city governments and relevant local authorities is of extreme importance in pursuing the goal of sustainable mobility since they are responsible for setting the strategic framework, defining quality standards, giving concessions and permissions, sub-contracting tasks, and controlling and evaluating the achievement of results, among others.

Considering the crucial aspect of intragenerational equity within sustainable mobility, it must be assured that mobility stations and their services are accessible and affordable to everyone.

Cities can and should play the role of integrators and regulators, bringing together the various stakeholders, setting sustainability goals, and steering the direction of sustainable mobility measures through the continuous development of regulations and policies.

The more dynamic and flexible mobility services are, the more regulations will be needed in order to ensure that the multimodal mobility offer is stable, reliable, and attractive to users. The dynamic development of mobility services in Munich with companies starting operations, sometimes in unexpected ways (e.g. the introduction of oBike) and others retiring from the market (see Section 4.2.1) shows that these initiatives need to be both further regulated but also supported.

As mobility stations develop, their strategic framework will need to adapt accordingly. If the objectives defined during the planning phase are being achieved, the strategic framework should adapt to continue to make progress in the same direction (e.g. more public parking spaces should be transformed to accommodate increasing traffic volumes of the other modes generated at mobility stations, or for other uses such as green areas and high quality public spaces. If the effects are not in line with the objectives, changes to the system and its operation must be implemented. For this, a continuous monitoring and evaluation of the project from time to time will assist decision making to ensure the mobility stations are supporting the stated objectives.

Despite having carried out a detailed investigation of the Mobility Station at Münchner Freiheit, and supporting the findings with other findings on mobility stations and shared mobility services, this dissertation does not provide definitive conclusions on the contribution of mobility stations toward sustainable urban mobility. This is in part due to the inductive research approach chosen for this dissertation.

However, tentative conclusions can be used to formulate hypotheses and carry out future investigations. The following section concentrates on the limitations of this work and provides recommendations for further research into the impacts of mobility stations on sustainable urban mobility.

9.2. Limitations of the work and recommendations for further research

As mobility stations are a relatively new concept, only limited information was available on their acceptance and impacts on mobility behavior. In order to fill this information gap, mobility stations in various German cities were studied as part of four master theses supervised within the framework of this dissertation. These evaluations provided important insights into the aspects mentioned above, however, they were limited in their scope and level of detail.

Various studies on the impacts of carsharing and bikesharing on mobility behavior were also reviewed (see Sections 3.3.1 and 3.3.2). However, these studies concentrate on the individual impacts of the respective shared mobility services and not on the impacts of an overall integrated multimodal mobility offer. To the best of my knowledge, only one MaaS application (UbiGo) has been scientifically evaluated (Sochor et al., 2015; Karlsson et al., 2016; Strömberg et al., 2018),, providing insights into the impacts of integrating various mobility services virtually.

In Chapter 6, the results obtained by the combination of the quantitative and qualitative methods were presented. They shed light onto what the barriers and drivers for the implementation of the MSMF were, as well as the characteristics of users and non-users, their mobility options, and the motivations and barriers for the use of shared mobility services. Furthermore, the awareness and acceptance of the mobility station, along with its usage patterns and effects on mobility behavior were explored. Finally, problems regarding the use of the mobility stations and ideas for improvement were identified.

The results obtained in the framework of this dissertation certainly contributed to answering many of the initial research questions posed at the beginning of this work (see Section 6.8). Also, supported by the findings from other mobility stations and shared mobility services (presented in Chapter 3), these results were used to assess the influence of mobility stations on sustainable urban mobility, and to identify success factors for the planning, implementation, and operation of mobility stations (Chapter 7).

Nevertheless, many questions remain open. In Section 7.3, a reflection upon the different applied methods pointed out the need for further analysis and research. The following subsections present the limitations of this work and recommendations for further research based on these reflections.

9.2.1. Limitations

The research carried out in the framework of this dissertation has five main limitations:

1. The empirical investigation is based on a single case study (the MSMF)
2. The period of time between implementation and evaluation is short and might not fully reflect the full impacts of a measure
3. The results stem from a single point of observation (in time)
4. Some user groups might be underrepresented in the evaluation
5. Lack of a control case study

Below, these limitations are described in more detail.

Single case study

One of the limitations of this dissertation is that it mainly concentrates on a single case study. Although the idiographic investigation of the MSMF provides information in great detail about the pilot project, it is unclear how its acceptance and impacts on mobility behavior (results in general) would be in a different setting (e.g. characteristics of the influence area).

The other two analyzed case studies (Würzburg and Offenburg) certainly add information about the acceptance and impacts of mobility stations in other contexts (different cities, different types of mobility stations, with different components) and confirm many of the findings of the MSMF (see chapter 6). However these evaluations were not as detailed as that of the MSMF and the sample of respondents were rather small (see Section 3.2.5.2).

Period of time between implementation and evaluation

Another limitation of this dissertation is the period of time between the implementation of the MSMF and the evaluation, which was only eight months after it was considered to be fully operation. Thus, the results regarding the acceptance of the MSMF and its impacts on mobility behavior are limited.

The same applies to the evaluations of the mobility stations in Offenburg and Würzburg which were evaluated approximately one year after their respective implementations.

Due to the relatively short period of time between the implementation and evaluation of mobility stations, the observed effects on acceptance and mobility behavior reflect only correspond to an initial phase and not to the completely established project.

Single point of observation

The three evaluations of mobility stations considered in this work (Offenburg, Würzburg, and Munich) all only used a single point of observation during the lifetime of the project. In order to better understand different results and validate them, it is necessary to repeat the evaluation at a later stage. Continuous evaluation over time should be carried out, for example, every year or every two years.

Representability of user groups

In Chapter 7, the limitations regarding the sampling of users and non-users of the MSMF were discussed, indicating that some segments of these groups might be underrepresented.

Also, in Offenburg and Würzburg the size of the samples are relatively small and bikesharing users are underrepresented, which adds uncertainty to the results.

Lack of a "control" case study

The evaluation of the MSMF included a survey of non-users which served in part as a control group for the user survey. This allowed the comparison of some characteristics of users with those of non-users.

However, in Munich there are other multimodal nodes offering similar advantages to the MSMF (e.g metro stations with docking stations for shared bikes). In order to better understand the advantages of mobility stations, it would be necessary to investigate users of these "ordinary" multimodal nodes and see which characteristics of mobility stations offer an added value.

9.2.2. Recommendations for further research

Considering the limitations presented above and the various aspects that could not be investigated in enough detail, some recommendations for further research are presented in this section.

The recommendations for further research are divided into six categories of aspects that should be further explored in order to understand better:

1. different target groups,
2. aspects related to the fulfillment of needs,
3. aspects related to the consumption of resources,
4. aspects related to the operation/performance of mobility stations,
5. aspects related to the interactions of land use and transport,
6. aspects related to the implementation process.

The evaluation of the above mentioned aspects should be repeated every year or every two years. One way to complete this evaluation is with panel studies (i.e. same people year after year taking part in the survey) if possible. Otherwise, the same survey with similar populations (i.e. users, non-users) should be carried out.

Ideally, the evaluation of different mobility stations should be standardized (using the same methodology, similar surveys, etc.), in order to compare the results between different case studies better. Also, it would be interesting to compare results with those of other ongoing evaluations of mobility stations (e.g. evaluation of mobility stations in Leipzig).

The following subsections present further details on the five categories of aspects mentioned above that should be explored further.

9.2.2.1. Understanding different target groups better

Better sampling

As discussed in Sections 7.3.2.2 and 7.3.3.1, it is not clear if the samples of users and non-users represent the corresponding populations well. These limitations can be overcome during a study with repeating evaluations by extending the observation periods and specifically addressing segments of these populations that were presumably underrepresented.

The identification of underrepresented segments of the population of users could be done if the characteristics of all users are known. Providers of mobility services should thus provide anonymous details on the demographic characteristics of their customers in the study area.

Addressing monomodal car drivers

Also, it was observed that the group of non-users of the MSMF are mainly public transport users (see Section 7.3.4.3). Although there are car owners among users and non-users, the mobility portfolio of these two groups showed that they are both multimodal (see Section 6.2.2). This means that an important target group was not specifically addressed, that of the monomodal car divers.

Since one of the main goals of mobility stations is to reduce car ownership, it would be interesting to address people who are neither users of shared mobility services nor of public transport, and who mainly use a private car for their daily mobility. This would enable a better understanding of their mobility needs, barriers and potentials for the use of shared mobility services, as well as their conditions for giving up car ownership. This way, the multimodal mobility offer could be improved and adapted to satisfy this sector of the population and more effectively reduce car ownership.

More details about non-users

Due to the limited duration of face-to-face interviews with non-users, in-depth details about non-users of the MSMF were not captured, making it difficult to compare this group to the users.

In order to obtain more details about non-users, online questionnaires similar to those used for the users could be used instead of or in addition to the face-to-face interviews

9.2.2.2. Aspects related to the fulfillment of needs

As presented in Section 7.1.1, two aspects related to the fulfillment of needs were explored: *access to opportunities* and *access to mobility options*. Based on the analysis of some indicators, these aspects were evaluated. However, in the future, some other indicators could be explored to better understand the contribution of mobility stations to the fulfillment of needs.

Accessibility analysis

Future research could further explore the access to opportunities through an accessibility analysis to and from mobility stations. Aspects such as quality of infrastructure, connectivity, and the quality of supply could be explored in further detail.

Perceived contribution of mobility stations to the fulfillment of needs

In future evaluations, a direct question on how the supply of opportunities, amenities, and mobility options contributes to satisfying the needs of users could be integrated into the surveys. The results obtained by the surveys could be explored further through personal interviews or focus groups.

Satisfaction, usability and affordability

Other aspects in relation to the fulfillment of needs related to the goal of intragenerational equity are the satisfaction, usability, and affordability of the different components of the mobility stations for different segments of the population.

9.2.2.3. Aspects related to the consumption of resources

In order to better understand the impact of mobility stations on the consumption of resources for mobility, it is necessary to compare the mobility behavior of users (including car ownership) and their travel patterns before the implementation of the mobility stations and some months after the implementation.

Also, the mobility behavior of users could be compared to that of non-users (as a control group) at different points in time during the lifetime of the project.

In the framework of this dissertation, the mobility behavior of users and non-users was explored only partially (see Section 6.2 and reflection on these results in 7.3.2 and 7.3.3). Due to the limited information on their number of trips by mode, it was not possible to estimate a multimodality index nor to quantify changes in travel behavior.

Furthermore, getting rid of or acquiring a private car among users was inquired as another demographic question without asking about any relation to the use of shared mobility services or the Mobility Station (see Section 6.6.1).

Travel diaries

The mobility behavior of users and non-users could be observed in detail during a week with the use of travel diaries. This would provide more details on the duration, length, and costs of all trips by different modes during the observation period and compare them to the control group. Thus, the consumption of resources for mobility (space, energy, time, and money) could be derived with more precision. Filling out travel diaries could be facilitated through a mobile phone app with GPS tracking provided that all personal data remains anonymous.

Specific and direct questions as part of a survey

Additionally, information on long term mobility behavior, characteristics of the mobility portfolio, and the budget spent for mobility could be obtained through a survey, for example by asking participants to provide the following information:

- Number of privately owned/leased vehicles per household or person, type of vehicle, age, average fuel consumption;
- Number of company cars per household or person, type of vehicle, age, average fuel consumption;
- VKT by car in one year (preferably measured at the tachometer);
- Number of days that a private car was used / remained parked;
- Number of privately owned bicycles, e-bikes, cargo-bikes, etc.;
- Type of public transport passes used;
- Amount and duration of memberships to shared mobility services;

- Average commuting time;
- Budget spent for mobility;
- Changes in the frequency of use of transport modes.

The more detailed information obtained through the travel diaries and the survey should allow more precise estimation of the effect of mobility stations on the consumption of resources for mobility: space, energy, time, and money.

Furthermore, users of mobility stations and/or a multimodal mobility offer should be asked about the self-perceived influence of these on their mobility behavior and car ownership and further explored by qualitative methods.

Multimodality index

Although some information about the availability and use of different transport modes among users and non-users was obtained through the respective surveys (see Section 6.2.2), it was not possible to estimate a multimodality index with the available information. This aspect is however of interest, since literature suggests that multimodality is correlated with low car ownership (see Section 3.3.4).

Future evaluations should consider gathering more detailed information about the mobility patterns of users and non-users in order to estimate their respective multimodality index and see if there is a correlation to car ownership or other variables of interest (e.g. acceptance of mobility stations, pre-disposition of getting rid of a car, etc.)

Trip chaining

Also, it would be interesting to know if and how trip chains are built by combining the opportunities, amenities, and mobility services at the mobility stations, and if this trip chaining contributes to preventing other trips and thus reducing the consumption of resources for mobility (space, energy, time, money).

This information could help to improve the configuration of mobility stations and their integration with the surroundings, with the possibility of optimizing for such trip chains and finding out if more trips are generated due to the supply of amenities.

Vehicle occupancy

Effects on vehicle occupancy were not measured in this evaluation, however, mobility stations have the potential to increase vehicle occupancy through the facilitation of carpooling and ridesourcing. This information could be useful in estimating the impacts of a multimodal mobility service on the consumption of resources for mobility, especially space, energy, and money.

Vehicle energy efficiency

In the long term, mobility stations could have a positive effect on energy consumption through the provision of more efficient vehicles than the average fleet.

Detailed information about the energy efficiency of the different modes offered at mobility stations and their use, compared to privately owned modes, can help to estimate the impacts of mobility stations on the consumption of energy for mobility.

Urban freight and delivery traffic efficiency

In the future mobility stations can become strategic points for the delivery of goods with the potential to avoid unnecessary trips due to failed attempts. This effect could be further explored in combination with the aspect of trip chaining mentioned above.

9.2.2.4. Aspects related to the operation and performance of mobility stations

The continuous analysis of operational data should help to better understand the use of shared mobility services in relation to the mobility station and their contributions to sustainable urban mobility. In addition, this analysis could help to improve the service and thus, steer the operation towards the desired direction.

In the framework of this dissertation, operational data from the mobility services used at the mobility station was compared to operational data at the city level. This comparison, however, had some limitations (see Section 7.3.5).

Trips with shared mobility services with mobility stations involved vs. other trips

In future evaluations, operational data of all mobility services offered at mobility stations could be classified between those trips starting or ending at mobility stations and those trips starting and ending elsewhere. Between these two types of trips, the following aspects could be compared: number of trips, duration of trips, hourly, daily, weekly, monthly, seasonal, and annual distribution of trips, helping to discover if trips to and from mobility stations are more efficient than other trips.

Carsharing turnover

More detailed information on the turnover of carsharing vehicles could enable the estimation of the consumption of space for mobility and compare it to that of private cars.

The continuous analysis of operational data should enable the estimation of the total time that the various mobility services are available at the mobility stations and in use. This information can also be used to estimate the use of space for potential mobility, and the consumption of space and energy consumption of actual mobility, and compare these with the average fleet of private vehicles.

Frequent origins and destinations

The analysis of operational data can help to identify frequent origins and destinations of trips at similar times during the day and to support organizing carpooling or ridesourcing (e.g. trips to the airport with savings for users, energy, and space) or in the implementation of new mobility stations.

This information should help to improve the operation, compare real availability against perceived availability, provide dynamic incentives in order to automatically rebalance stations (e.g. users are encouraged to bring vehicles or bikes to stations against some incentive in the form of time credit).

Easiness of intermodal transfers

The easiness of intermodal transfers at mobility stations could be explored by developing some kind of index, which considers the ease and time needed to transfer between the various modes of transport available.

9.2.2.5. Aspects related to the interactions of land use and transport

The interactions of land use (services and amenities at the facilities and in the surroundings) and transport components of mobility stations can be further explored by means of system analysis (see Wulfhorst, 2003) and through the node-place-model of Bertolini (1996).

Such analyses could assist in developing strategies for a better integration of mobility stations with their surroundings (see Section 8.3) as the guidelines for mobility hubs suggest (see: Metrolinx, 2011; urban design studio, 2017; ICTC, 2017)

9.2.2.6. Aspects related to the process.

In addition to an impact evaluation, a process evaluation should be carried out in order to identify factors of success, but also barriers to the planning, implementation, and operation of mobility stations. This includes for example interviews with different stakeholders during the various phases of the project and workshops (e.g. learning histories workshop).

9.3. Outlook

Mobility stations represent an opportunity for sustainable urban mobility as they aggregate not only various modes of transport that could replace private cars, but they also involve a wide variety of stakeholders, from local authorities to public and private companies, as well as citizens. Mobility stations can also serve as an instrument for bundling the necessary balance of push and pull measures aimed at achieving sustainable mobility.

Their implementation requires the involvement of various actors, an open dialogue between them and compromises to achieve a win-win situation: citizens can profit from an efficient, affordable, and environmentally friendly multimodal mobility service and companies can ensure the economic viability of the operation of their services.

This dissertation demonstrated that mobility stations can contribute to the concept of sustainable urban mobility by exploring the state of the art of mobility stations and shared mobility services, and by conducting a detailed in investigation of one case study. It also showed that for these benefits to become a reality, mobility stations should be replicated and expanded, and their inherently multimodal mobility service offer improved in various ways. Further, this dissertation provided recommendations for the implementation of mobility stations in a way that they contribute to sustainable urban mobility.

These recommendations are focused in providing an efficient and attractive multimodal mobility service that allows citizens to fulfill their needs without needing to own a car. Thus, it is expected that mobility stations contribute to reducing car ownership and car usage among their users.

An adapting strategic framework is essential for sustainable urban mobility

It is worth noting that a successful reduction in car ownership among users of mobility stations will not automatically lead to less parking pressure or more space for other uses, nor to the reduction in traffic volumes or congestion or air pollution, which are crucial problems in growing cities like Munich.

Without a supporting strategic framework, non-users of mobility stations could even become encouraged to acquire a (or another) car, and commuters and visitors encouraged to drive into the city as a result of users getting rid of cars and driving less.

Thinking globally acting locally

As mobility stations and the corresponding multimodal mobility service are established in a given area and space is gained for other uses, their development should be extended to neighboring areas (e.g suburbs, region). This way, commuters and visitors to and from other areas can also benefit from the multimodal mobility service and avoiding the use of single occupied vehicles.

Through a strategic expansion of mobility stations, regional and global challenges, such as climate change can be addressed, in line the motto “think global act local”.

From mobility stations to mobility hubs

Especially in low density areas with a poor mix of functions, mobility stations could become instruments for the integration of land use and transport as has been suggested by development strategies for mobility hubs in North America. However, also in urban areas with high density, mobility stations can be strategically integrated into their surroundings, supporting access by foot and creating high quality public spaces.

Furthermore, collaboration with delivery services and their integration at mobility stations could potentially contribute to reduce urban freight traffic.

Regulations, incentives and quality standards

The dynamic development of shared mobility services in Munich showed that they might need further support from local authorities to become better established in the city for two reasons: 1) to avoid that they go bankrupt, discouraging both entrepreneurs and citizens due to a lack of reliability, and 2) to avoid that they oversaturate cities with their services and subsequently leaving them behind, creating a pollution problem, as could be the case of oBike in Munich, and as it has been the case with similar bikesharing providers in some Chinese cities.

For a successful and permanent establishment of new mobility services in cities, local authorities should provide the necessary regulations and incentives and set quality standards as they have done for public transport and other public services. In a best case scenario, shared mobility services should become part of an integrated multimodal mobility offer in the form of Mobility as a Service (MaaS) or a multimodal product.

Embracing technology in the right way

Cities should embrace the opportunity technological advances bring for sustainable mobility. But, as technology and society develop, cities should also monitor developments in mobility behavior and vehicle traffic to be able to react quickly. Three main technological advances related to mobility stations are: electric mobility, intelligent transportation systems, and autonomous vehicles.

Electric mobility should certainly be further developed together with mobility stations. Mobility stations can provide the necessary infrastructure and shared mobility services can accelerate the penetration of electric vehicles (cars, bicycles, scooters) in cities, as well as their acceptance and affordability.

It is clear that electric vehicles produce less noise than conventional cars, and, depending on the energy source, can produce less emissions than their fossil fuel counterparts. Since the emissions are produced at the energy source, electric vehicles can help to reduce air pollution in the cities where they are used.

However, supporting electric mobility in cities should be done with care. Electric cars consume fairly the same space as any other car. The example of Oslo shows that massive incentives to electric cars can lead to an unsustainable development: too many electric cars using dedicated bus lanes created “clean congestion” and caused public transport to become less attractive, reducing occupancy rates and even increasing overall emissions.

Privileged (e.g. free of cost, reserved) public parking spaces for electric vehicles should only be available for shared vehicles, and other incentives to private electric vehicles should be avoided. This represents a great opportunity for massively supporting multimodal mobility instead of supporting car ownership with this new technology.

Today, there are more charging points for (private) electric vehicles than MVG Rad docking stations in Munich, which might contradict the sustainable mobility goals of the city. The question arises: *What does Munich want?*

Intelligent Transportation Systems can also support the goals of mobility stations by prioritizing the traffic flow of more space and energy efficient modes (e.g. public transport, non-motorized modes, and fully occupied vehicles).

As for autonomous cars, I have a similar reflection regarding the support of electric mobility: autonomous cars can contribute to sustainable urban mobility only if they are part of a shared system and of an integrated multimodal mobility offer. Otherwise, there is even the risk that congestion increases further due to empty vehicles roaming the streets.

Shared electric autonomous cars should become part of a multimodal service accompanied by reserved spaces at mobility stations for picking up and dropping off passengers, as well as the ability to park when there is no demand for their services (the idea that they can be driving empty waiting for passengers represents a waste of energy, an unnecessary consumption of more limited space and an increase in the risk of traffic accidents).

The future looks bright. It is up to us to make it brighter.

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Abbreviations

BBSR	Federal Institute for Research on Building, Urban Affairs, and Spatial Development (Bundesinstitut für Bau-, Stadt- und Raumforschung)
BS	Bikesharing
EVA-CS	Carsharing Evaluation
EVA-MS	Mobility Station Evaluation
FFCS	Free-floating carsharing
KVR	Department of Public Order (Kreisverwaltungsreferat)
MaaS	Mobility as a Service
MSMF	Mobility Station at Münchner Freiheit
MVG	Public transport operator in Munich (Münchner Verkehrsgesellschaft)
MVG Rad	Bikesharing system provided by the local public transport operator in Munich (MVG)
MVV	Local Transport and Tariff Association (Münchner Verkehrs- und Tarifverbund)
PLAN	Department of Urban Planning and Building Regulation (Planungsreferat)
PTO	Public Transport Opertor
RAW	Department of Labor and Economy (Referat für Arbeit und Wirtschaft)
SBCS	Station-based carsharing
SUM	Sustainable urban mobility
SUMP	Sustainable Urban Mobility Plan
ZBCS	Zone-based carsharing

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Annex A: Selected definitions of sustainable transport and sustainable mobility

Organization / Person	Definition	Year	Source
Transportation Association of Canada	A sustainable transportation system has the following characteristics: (a) In the natural environment: It limits emissions and waste (that pollute air, soil and water) within the urban area's ability to absorb / recycle / cleanse. It provides power to vehicles from renewable or inexhaustible energy sources. This implies solar power in the long term. It recycles natural resources used in vehicles and infrastructure. (b) In society: It provides equity of access for people and their goods, in this generation and in all future generations. It enhances human health. It helps support the highest quality of life compatible with available wealth. It facilitates urban development at the human scale. It limits noise intrusion below levels accepted by communities. It is safe for people and their property. (c) In the economy: It is financially affordable in each generation. It is designed and operated to maximize economic efficiency and minimize economic costs. It helps support a strong, vibrant and diverse economy.	1996	(Duncan and Hartman, 1996)
OECD	Sustainable transportation is achieved when needs for access to people, services, and goods are met without producing permanent harm to the global environment, damage to local environments, and social inequity. This implies rates of use of non-renewable resources that do not exceed the rates at which renewable substitutes are developed, and rates of emission and of concentration of substances that do not exceed the assimilative capacity of the environment."	1997	(OECD, 1997)
Richardson B.	Sustainable transport: A system in which fuel consumption, vehicle emissions, safety, congestion, and social and economic access are of such levels that they can be sustained into the indefinite future without causing great or irreparable harm to future generations of people throughout the world.	1999	(Richardson, 1999)
European Union Council of Ministers of Transport	A sustainable transportation system is one that: Allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations. Is Affordable, operates fairly and efficiently, offers a choice of transport mode, and supports a competitive economy, as well as balanced regional development.	2001	(European Union, 2001)

Organization / Person	Definition	Year	Source
	Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise.		
The World Business Council for Sustainable Development	Sustainable mobility is the ability to meet society's need to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values, today or in the future."	2001	(WBCSD, 2001)
OECD	Sustainable Transportation: Transportation that does not endanger public health or ecosystems and that meets needs for access consistent with (a) use of non-renewable resources at below their rates of regeneration, and (b) use of non-renewable resources below the rates of development of renewable substitutes.	2002	(OECD, 2002)
OECD	A system which provides safe, economically viable and socially acceptable access to people, places, goods and services while meeting generally accepted objectives for health and environmental quality, protecting ecosystems and minimising adverse impact on global phenomena such as climate change, stratospheric ozone depletion and the spread of persistent organic pollutants. Transport is environmentally sustainable if it does not endanger public health or ecosystems and meets mobility needs while using non-renewable resources below the rates of development of renewable substitutes and renewable resources below their rates of regeneration.	2002	(OECD, 2002)
PROSPECTS Project	(1) provide access to goods and services in an efficient way for all inhabitants of the urban area; (2) protects the environment, cultural heritage and ecosystems for the present generation, and (3) does not endanger the opportunities of future generations to reach at least the same welfare level as those living now.	2002	(Minken et al., 2002)
The mobil.LAB doctoral research group	Sustainable mobility ensures the individual fulfillment of basic needs and activities without negatively harming the environment, economy or society, whether now or in the future. It ensures affordable accesses to multiple mobility options, freedom of choice in terms of mode and access to life opportunities. Sustainable mobility, however, does not and should not require a reduction in mobility. Finally, it should be safe for all users and therefore minimize any type of negative effects on individuals, communities, the private sector and the environment.	2013	(mobil.LAB, 2013)

Annex B-1: User survey

Item	Questionnaire element			Purpose of the element
General information	Hello! Thank you for participating in this survey! You recently rented or returned a vehicle at Münchner Freiheit. For that reason you are invited to answer this questionnaire that the Technical University of Munich has developed in cooperation with us[27]. All your answers are of course anonymous. Please click to continue. (Link to the privacy statement)			To thank participants for taking part in the survey and give them some general information about the survey as well as of the privacy statement.
Explanatory text	Since October 2015 there are different mobility services such as carsharing and bikesharing available at the Münchner Freiheit bundled to complement the already existing public transport services.			To introduce respondents to the topic of the multimodal mobility "offer" at the Münchner Freiheit.
Section 1	**General questions about awareness and use of the mobility services at the Mobility Station**			
Item	**Question**	**Type of question**	**Possible answers**	**Purpose of the question / text**
1 Awareness	Were you consciously aware that these services are part of a Mobility Station by which different integrated and combinable alternatives to private car are available to you?	Single choice	• Yes • No	To determine if users were consciously aware of the idea behind the Mobility Station.
2 Sources of awareness	How did you become aware of the Mobility Station?	Multiple choice	• Through advertisement from the City / mobility service providers • Through the on-site information screen • I passed by and became aware of the Mobility Station • Through newspaper / radio • Through friends / acquaintances • Through smartphone / internet • Other	To identify relevant sources of awareness. Hypothesis: The Mobility Station, through its physical presence makes people aware of the multimodal "offer" in addition to the individual services away from / outside of the station. The marketing of the station makes people aware of the multimodal "offer" in addition to the individual services away from / outside of the station.

[27] With "us" meant the mobility service provider that sent the e-mail to their respective customers inviting them to participate in the survey.

3 Use frequency of mobility services at the Münchner Freiheit	Which mobility services at the Münchner Freiheit do you use and how often?	Matrix question	For each the following mobility services: • MVG Rad • Taxi • Public Transport (Tram, Bus, U-Bahn) • DriveNow • DriveNow electric • car2go • STATTAUTO • Bike and Ride (B+R) facilities • On-site information screen Only one answer possible: • Many times per week • Once a week • Once a month • Less often than once a month • Never • I did not know that (the service) was available at the Münchner Freiheit • N.A.	To estimate the frequency of use of the mobility services at the Mobility Station. To understand current mobility patterns of users. At the same time, it would be possible to estimate how known/unknown are the different mobility services at the Münchner Freiheit. Hypothesis: Users of shared mobility services use the mobility service of which they are clients more than other mobility services. (i.e. DriveNow customers mostly use DriveNow for their mobility, MVG Rad customers mostly use MVG Rad for their mobility). Users of shared mobility services are aware that the mobility service they are customer of is available at the Münchner Freiheit but they don´t know that other shared mobility services are available as well.
4 Purpose of use of mobility services at the Münchner Freiheit	(filtered questions for mobility services used at least once a month): The [mobility service, i.e. MVG Rad] at the Münchener Freiheit, I use it for…	Separate questions	Multiple answers possible: • Work / Education • Business • Errands / shopping • Escort / accompanying someone else • N.A.	To identify the purposes for which the mobility services at the Mobility Station are used. Hypothesis: FFCS generate trips to work / education that otherwise would have been made by public transport.

Section 2	Detailed questions about the last (most recent) trip with one of the shared mobility services that started or ended at the Mobility Station			
5	Can you remember the last trip that you did with a vehicle/bike that you rented or returned at the Münchner Freiheit?[28]	Single choice	• Yes • No	Filter question to avoid asking questions related to the last trip that respondents would not be able to answer.
Filter	If yes in 5: continue with question 6 (If not in 5: continue with question 16)			
6 Rental/return ratio	Did you rent or return a vehicle/bike?	Single choice	• Rented • Returned	Filter question to understand details about the most recent trip with the shared mobility services. The responses also allow to estimate the ratio of rents/returns at the mobility station. This information could be validated later with the back-end data of each provider.
Filter	(If rented: continue with Ea) (If returned: continue with Eb)			
Ea	The following questions refer to the last trip with the carsharing vehicle / MVG Rad that you rented at the Münchner Freiheit[29]			To make sure that respondents concentrate on their last trip with a carsharing vehicle or MVG Rad bike that they rented at the Mobility Station.
7a Added value of the Mobility Station	Why did you rented a carsharing vehicle / MVG Rad specifically at the Münchner Freiheit?	Multiple choice	• Because it was the nearest available vehicle • Because its location was conveniently located along my way • *only for SBCS users: Because at the Station SF (another station nearby), there was not a vehicle available	To know if the Mobility Station offers an added value for the users when renting vehicles / MVG Rad bikes at the mobility station or starting a trip there compared to renting them / starting a trip anywhere else in the service area. To know if the Mobility Station generate trips by shared mobility services. To know if the connection to public transport at the Mobility Station plays a role in the use of shared mobility services.

[28] Although it is possible to determine if a user rented or returned a vehicle or bike and send only the corresponding version of the questionnaire, it was decided to rather ask users for the following reasons: a) to avoid that users felt observed ("we know that you returned/rented a vehicle at this location", even if it is obvious that providers have this information; b) to give freedom to respondents to refer to a trip they remember ; c) It was easier to send only one invitation to all users that rented/returned a vehicle at the Mobility Station than sending separate links depending of the type of movement; d) this additional question would not make the questionnaire way longer.
[29] The questions in this section refer to the "Münchner Freiheit" instead of the "Mobility Station" to avoid that people would not understand what was meant with the last term.

			• Because I passed by and I spontaneously used the service • Because there, there is always an available vehicle and I don´t even have to look on my smartphone or internet • *only for FFCS users: Because there, there are electric vehicles • Because the station is very well accessible by public transport • Because someone recommended me to do so • Because I read about it and I wanted to try it • Because only there I can easily change the transport modes that I need • Other reasons (Traffic conditions, weather...)	To know if the connection to other modes at the Mobility Station plays a role in the use of shared mobility services.o understand the preferences of FFCS towards electric carsharing compared to conventional cars. Hypothesis: The mobility station offers a good possibility for combining different transport modes by allowing easy and short transfers. Users appreciate the availability of different mobility options at one location Users appreciate the connection to public transport FFCS users are interested in using electric carsharing. The Mobility Station generates trips by shared mobility services that otherwise would have been made by public transport. The Mobility Station generates trips by shared mobility services that otherwise would have not been made
8a Acces mode	How did you arrive to the Münchner Freiheit?	Multiple choice	• By foot • With my own bike • With a bikesharing bike (Call-a-bike, MVG Rad) • By public transport • With the own car • As a passenger in a car • With a carsharing vehicle • With the taxi • other	To understand how users reach the mobility station, and what kind of intermodal trips take place there. Hypothesis: The mobility station offers a good possibility for combining different transport modes by allowing easy and short transfers.
9a Activity at trip origin	Where were you when you made your way to the Münchner Freiheit? (Question aimed to know the activity at the origin of the trip and then its	Single choice	• At home • At work • I was shopping • I was doing a leisure activity • Other	To understand how the mobility services at the Mobility Station are used.

	physical location in combination with question 10a)			
10a Location of trip origin	Please indicate where you started your trip (Zip code, district, place)	Open question	Text field	To estimate approximately how big is the catchment area of the Mobility Station.
11a Activity at destination with shared mobility service	Where did you go with the carsharing vehicle / MVG Rad that you rented at the Münchner Freiheit? (meant to know the activity at the destination and not the physical location)	Single choice	• To home • To work • I went shopping / to do an errand • To a leisure activity • other	To understand how the mobility services at the Mobility Station are used.
12a Location of trip destination with shared mobility service	Please indicate the location of your destination (Zip code, district, place)	Open question	Text field	To identify frequent destinations of trips with the shared mobility services starting at the Mobility Station. To estimate approximately how far users of the mobility services traveled with the shared vehicles / bikes. This information could later be validated / complemented with the back-end data.
13a Mode substitution	In case that the shared mobility service had not been available, with which mode of transport would you have probably made that trip? *For SBCS users the question was: In case that the carsharing service had not been available, which <u>modes</u> (in plural) of transport would you have used during the rental?	Single choice *Multiple choice for SBCS users.	• With my own car • With a rental car • As passenger in a private car • By public transport • By taxi • With Uber or another similar ridesourcing service • With a “roller” • With the bike • By foot • Other	To identify which mode of transport is replaced when using shared mobility services. Hypothesis: Shared mobility services replace other more environmentally friendly transport modes and/or public transport. (Later, through focus groups the reasons behind, and under which circumstances shared mobility services replace other modes of transport were explored.)
Eb	(If returned in 6)	Explanatory text		To make sure that respondents concentrate on their last trip with a carsharing vehicle or MVG Rad bike that they returned at the Mobility Station.

	The following questions refer to the last trip with the carsharing/ MVG Rad that you returned at the Münchner Freiheit.			
7b Added value of the Mobility Station	Why did you returned the vehicle/bike specifically at the mobility station?	Multiple choice	• Because the destination of my trip is in direct proximity • Because there, there is a direct connection to public transport • *Only FFCS users: Because there I can also rent an MVG Rad bike • *Only MVG Rad users: Because there, I can also rent a free-floating carsharing vehicle (car2go, DriveNow) • *Only MVG Rad users: Because there, I can also rent a station-based carsharing vehicle (STATTAUTO) • *Only for MVG Rad users: Because I get 10 minutes of credit in my account • *Only for FFCS users: Because there I mostly find a parking space • *Only for FFCS users: Because there, there is charging station • Other reasons	To know if the Mobility Station offers an added value for the users when returning vehicles / MVG Rad bikes or ending a trip there compared to returning them / ending a trip anywhere else in the service area. To know if the Mobility Station generates trips by shared mobility services. To know if the connection to public transport at the Mobility Station plays a role in the use of shared mobility services. To know if the connection to other modes at the Mobility Station plays a role in the use of shared mobility services. To know if providing a charging station for electric carsharing vehicles was important to the FFCS users. Hypothesis: The mobility station offers a good possibility for combining different transport modes by allowing easy and short transfers. Users appreciate the additional and relatively „guaranteed“ possibility to return vehicle / MVG Rad bike at the Mobility Station. Users appreciate the connection to public transport Users appreciate the availability of different mobility options at one location The Mobility Station generates trips by shared mobility services that otherwise would have been made by public transport. The Mobility Station generates trips by shared mobility services that otherwise would have not been made

8b Activity at trip origin with shared mobility service	Where did you start the trip with the carsharing vehicle/ MVG Rad bike? (meant to know the activity at the origin of the trip and not the physical location)	Single choice	• At home • At work • I was shopping • I was doing a leisure activity • Other	To understand how the mobility services at the Mobility Station are used.
9b Location of trip origin with shared mobility service	Please indicate where you started your trip (Zip code, district, place)	Open question	Text field	To identify frequent origins of trips with the shares mobility services ending at the Mobility Station. To estimate approximately from how far users of the mobility services traveled with the shared vehicles / bikes. This information could be later validated / complemented with the back-end data.
10b Activity at destination (near Mobility Station)	Where did you go after returning the vehicle/bike at the Münchner Freiheit? (meant to know the activity at the destination and not the physical location)	Single choice	• To home • To work • I went shopping / to do an errand • To a leisure activity • other	To understand how the mobility services at the Mobility Station are used.
11b	Please indicate the location of your destination (Zip code, district, place)	Open question	Text field	To estimate approximately how big is the catchment area.
12b Location of destination (near Mobility Station)	How did you reach your destination after returning the carsharing vehicle/bike at the Mobility Station?	Multiple choice	• By foot • With my own bike • With a bikesharing bike (Call-a-bike, MVG Rad) • With my own car • With a taxi • other	To understand how users reach their destinations from the mobility station, and what kind of intermodal trips take place there. Hypothesis: The mobility station offers a good possibility for combining different transport modes by allowing easy and short transfers.
13b	*only for FFCS: Did you drive directly to the Mobility Station or did you look before for a parking space in the surroundings?	Single choice	• No, I did not have any problems looking for a parking space and drove directly to the station • I first looked for a parking space somewhere else	Question aimed to know if users know and appreciate the reserved parking places at the Mobility Station. Hypothesis:

Awareness of reserved parking spaces				FFCS users appreciate the additional and relatively „guaranteed“ possibility to return vehicle bike at the Mobility Station.
14b Time for parking search	(If looked for a parking space) How long it took find a parking space at the end of your rental?	Single choice	• Less than 1 minute • 1-5 minutes • 6-10 minutes • More than 10 minutes • I don´t know anymore	Question aimed to know how much carsharing users look for a parking space.
15b Mode substitution	In case that the shared mobility service had not been available, with which mode of transport would you have probably made that trip?	Single choice	• With my own car • With a rental car • As passenger in a private car • By public transport • By taxi • With Uber or another similar ridesourcing service • With a “roller” • With the bike • By foot • other	To identify which mode of transport is replaced when using shared mobility services. Hypothesis: Shared mobility services replace other more environmentally friendly transport modes and/or public transport. (Later, through focus groups the reasons behind, and under which circumstances shared mobility services replace other modes of transport were explored.)

Section 3.	**General questions about the importance of the individual components and intermodal connections at the Mobility Station, problems and suggestions for improvement**			
16 Relevance of on-site information screen	How important is to you the on-site information screen in choosing a mode of transport?	Single choice	• It does not have any importance • It has some importance • It is an important source of information • It made me aware of the mobility services • N.A.	To understand the importance of the on-site information screen as a tool to influence mode choice and raise awareness.
17 Experienced problems	Have you experienced problems at the Mobility Station (i.e. access, orientation, information, availability of vehicles/bikes, availability of parking places, etc.)	Single choice	• No, I did not have any problems • Yes I had problems	To identify problems with the use of the mobility services.

18 Details about problems	(If yes) Here you can tell us more details about the problems	Open question	Text field	To identify problems with the use of the mobility services.
19 Ideas for improvement	Which recommendations do you have for the optimal use of the Mobility Station?	Open field		To collect ideas for improvement and optimization of the mobility station.
20 Importance of intermodal connections	How important are to you personally the following connections at the Mobility Station?	Matrix question	For the following connections: • Public Transport and MVG Rad • Public Transport and car2go/ DriveNow • Public Transport and STATTAUTO • MVG Rad and STATTAUTO • Other Only one possible answer: • Very important • Rather important • Less important • Unimportant • N.A.	To know if intermodal connections at the Mobility Station are important to the users. To know which intermodal connections are more important to the users. Hypothesis: Users appreciate the availability of different mobility options at one location Users appreciate the connection to public transport
21 Importance of components	How important are to you personally the following “components” of the Mobility Station?	Matrix question	For the following aspects: • Availability of carsharing vehicles • Reserved parking spaces for carsharing vehicles • Availability of MVG Rad bikes • Parking places for MVG Rad bikes • On-site information screen • Possibility to use electric carsharing • Connection to Public Transport Only one possible answer: • Very important • Rather important • Less important • Unimportant • N.A.	To know which characteristics of the mobility station are more important to the users. Hypothesis: Users appreciate the availability of different mobility options at one location Users appreciate the connection to public transport Users appreciate the additional and relatively „guaranteed“ possibility to return vehicle / MVG Rad bike at the Mobility Station.FFCS users appreciate the additional and relatively „guaranteed“ possibility to return vehicle bike at the Mobility Station.

22 Importance of amenities	How important are to you personally the existing amenities at the Mobility Station	Matrix question	For the following options: • Shops • Kiosk • Restaurant / bars • Leisure options • Other Only one possible answer: • Very important • Rather important • Less important • Unimportant • N.A.	To understand the interactions between node and place. Die Nutzung der Mobilitätsstation wird durch attraktive Attribute im Umfeld beeinflusst, wie z.B. Einkaufsmöglichkeiten, Beleuchtung und hohe Sicherheit im öffentlichen Raum. Das Umfeld wird durch die Nutzung der Mobilitätsstation positiv beeinflusst
23 Importance of additional (potential) services	How important would be to you personally other services at the Mobility Station	Matrix question	For the following options: • Packstation • Mobility service/information center • Lockers • Other Only one possible answer: • Very important • Rather important • Less important • Unimportant • N.A.	To understand users preferences regarding amenities around the mobility station.

Section 4	**Questions to understand the perception about the mobility station and possible changes in mobility behaviour**			
24 Perception of the Mobility Station as alternative to private car and its influence on mode choice.	Please indicate your how much do you agree to the following statements:		To each of the following statements: 1. I became a customer of (mobility service[30]) because I became aware of "the offer" through the mobility station 2. Through the mobility station I am sure to always have available a suitable transport mode for me 3. I registered to MVG Rad because I became aware of the service through the Mobility Station[31] 4. Since I use the mobility station, I travel more often by public transport (metro, tram, bus) 5. After the experiences at the Münchner Freiheit I am considering to join another carsharing provider 6. Since I use the mobility station I use MVG Rad more often 7. Offers such as the mobility station contribute to make the own car unnecessary 8. Since I use the mobility station I travel more often with a carsharing vehicle Only one possible answer: • I completely agree • I rather agree • I rather don´t agree • I don´t agree at all • N.A.	To know if the mobility station invites people to become customers of a specific mobility provider. To know if the mobility station influences mobility behavior in short and long term towards multimodality: Short term: "since I use the mobility station I travel more often by (another mode of transport) Statements 4, 6 and 8 Long term: "I became customer of another mobility service provider because I became aware of it due to the mobility station". Statements 3 and 5. To understand the perception of users towards the mobility station. Statements 2 and 7. Hypothesis: The physical integration of diverse mobility services at one location and its availability gives the message that private cars are unnecessary.

[30] Mobility service provider that sent the invitation

[31] For MVG Rad users this question is practically the same as the first question (mistake)

25 Acceptance	Would you like to have more similar mobility Stations in Munich?	Single choice	• Yes • No • I don´t know	To understand the perception of users towards the Mobility Station.
26 Ideas for potential locations	If yes, where? Indicate a zip code, public transport stop or a crossroad	Open question	Text field	To know where is demand for Mobility Stations.

Section 5	**Demography questions, availability of traditional mobility options, awareness and use of shared mobility services**			
27 Gender	You are…	Single choice	• Male • Female • N.A.	To determine the user's demographic profile
28 Age group	To which age group do you belong?	Single choice	• Under 18 years • 18 – 29 years • 30 – 39 years • 40 – 49 years • 50 – 59 years • 60 – 64 years • 65 – 74 years • 75 years and older	To determine the users' demographic profile
29 Household size	Home many persons live in your household, including yourself?	Open question	Text field	To determine the user's demographic profile and household characteristics
30 Household characteristics	How many household members are under 18 years old?	Open question	Text field	To determine the user's demographic profile household characteristics
31 Driver's license	Do you have a driver's license?	Single choice	• Yes • No	To rate of percentage of users with a driver's license and compare with reference groups.
32 Car ownership	How many cars there are in your household? (private cars or business cars (Geschäftswagen/Dienstwagen) that are always available)	Open question	Text field	To understand the "mobility portfolio" of the users (mobility options available to the users, potential multimodality degree)

33 Car availability	Is a car available to you personally?	Single choice	• Yes, always, • Yes, occasionally • no	To understand the "mobility portfolio" of the users (mobility options available to the users, potential multimodality degree)
34 Cars abolished/ acquired	Did you acquire or disposed of a car in the last year?	Single choice	• No • Yes, disposed of a car • Yes, acquired a car	To identify changes in car ownership independently of the mobility station. To find out if there is a correlation between the use of shared mobility services and the frequency of use with car ownership.
35a Reasons for abolishing a car	(If disposed of a car) Why did you relinquished a car?	Open question	Text field	To identify reasons for abolishing a car independently of the use of shared mobility services.
35b Reasons for acquiring a car	(If purchased a car) Why did you purchase a car?	Open question	Text field	To identify reasons for purchasing a car independently of the use of shared mobility services and/or the Mobility Station.
36 Bicycles ownership	How many functional (?) bicycles there are in your household?	Open question	Text field	To identify the mobility options available to users.
37 PT passes	Do you have a public transport subscription?	Single choice	• Yes • No	To identify the mobility options available to users.
38 Type of PT pass	(If yes) What type of public transport subscription do you have?	Single choice	• IsarCardMonat (Monthly pass) • IsarCardWoche (weekly pass) • IsarCardAbo (year subscription) • Zeitkarte Ausbildungstarif (Special subscription for trainees) • IsarCardSemester (Six month subscription for students)	To know what type of public transport subscription the users have.

39 Mobility portfolio	Which of the following mobility services do you know and use?	Matrix question	For the following options: • MVG Rad • Call a Bike • STATTAUTO München • DriveNow • car2go • other carsharing Single choice: • I don´t know it at all • I know it but I don´t use it • I use it since (max?) one year • I use it longer than one year	
40 Education	What is your highest educational degree?	Single choice	• Hauptschulabschluss • Realschulabschluss (Mittlere Reife) • Fachhochschulreife (Abschluss einer Fachoberschule) • Abitur, allgemeine oder fachgebundene Hochschulreife (allg. oder berufl. Gymnasium) • Hochschulabschluss (Universität, Fachhochschule) • Anderen Schulabschluss • Schule beendet ohne Abschluss	To determine the user’s demographic profile. The options relate to all kinds of degrees in the German education system. The analysis was simplified by differentiating between those that had at least a Bachelor’s degree (Hochschulabschluss) and those that did not.
41 Place of residence	Where do you live? (zip code is enough)	Open field		To determine where users live and if there is a difference to where non-users live.

Section 6	**Invitation to focus groups**			
42	Invitation to participate in focus groups (two hours) against an incentive of €50. Are you interested?	Single choice	• Yes • No	To gain potential users for the groups.
43	If yes, question for contact data (Full name, e-mail address and phone number)	Fields to fill	Text fields	To be able to contact them later for inviting them to the focus groups.

Annex B-2: Non-user survey

Section 0	**Pre-data and selection of non-users**			
Item	**Question / Survey element**	**Type of question**	**Possible answers**	**Purpose of question**
0a	Interviewer selects the location of the interview and enters in the smartphone application.	Single choice	• Metro platform • Tram and bus station • Taxi stand • Passersby (somewhere else	To know the location of the interview and have the possibility to differentiate results according to the location of the interview. Hypothesis: Persons interviewed at the tram and bus stop are more aware of the Mobility Station than those interviewed at the underground metro platform.
0b	Interviewer enters the gender of the person he aims to interview (without asking).	Single choice	• Male • Female • N.A.	To understand the demographics of the non-users and compare them to those of the users. Hypothesis: The demographic characteristics of the non-users are more similar to those of the Munich population than to those of the users.
0c	The interviewer approaches one person at the given location and greets: “Hello, we are from the company Omnitrend and we are carrying out a survey on behalf of the City of Munich about the mobility services at the Münchner Freiheit. Do you have 3 minutes time? If yes: continue with question 1. If not: Thank you. Have a good day!	Single choice	• Yes • No	To explain the purpose of the survey and recruit respondents.
0d	If yes to question 0 and if there is doubt that the person is at least 18 years old: “Are you older than 18 years?” If yes to question 0b: Unfortunately, you are not part of the target group. Thank you! Have a good day!	Single choice	• Yes • No	To make sure respondents are older than 18 years.

Section 1	General questions about awareness and use of the mobility services at the Mobility Station			
Item	**Question / Survey element**	**Type of question**	**Possible answers**	**Purpose of question**
1	Since October last year there is here at the Münchner Freiheit a Mobility Station. That means that here carsharing vehicles and MVG Rad bikes are “offered” in direct proximity with buses, tram and metro. [Show picture of the Mobiltiy Station] Have you ever since the inauguration rented or returned a carsharing vehicle or an MVG Rad bike here?	Single choice	• Yes • No	To filter out those that have rented or returned a carsharing vehicle or bike at the Münchner Freiheit, since they are by definition users and to interview only those defined as non-users.
2	If yes in 1: (the person is a user): “Unfortunately you are not part of the target group of this survey. Thank you and have a good day!” If not in 1: “Did you know before this interview the Mobility Station here at the Münchner Freiheit?”	Single choice	• Yes • No	To understand the awareness of the Mobility Station among non-users
3	If not in 2: Skip this question. If yes in 2: “How did you become aware of the Mobility Station?”	Multiple choice Interviewer listen to the answer / answers and classifies it / them in the following categories:	• Through advertisement from the City / mobility service providers • Through the on-site information screen • I passed by and became aware of the Mobility Station • Through newspaper / radio • Through friends / acquaintances • Through smartphone / internet • I don’t know • Other (please explain):	To identify relevant sources of awareness. Hypothesis: The Mobility Station, through its physical presence makes people aware of the multimodal “offer” in addition to the individual services away from / outside of the station. The marketing of the station makes people aware of the multimodal “offer” in addition to the individual services away from / outside of the station.

Section 2	Knowledge, use and attitudes towards carsharing services			
Item	**Question / Survey element**	**Type of question**	**Possible answers**	**Purpose of question**
4	I will ask you know some short questions about your experiences with different car-sharing providers. Do you know [carsharing provider][32]?	Single choice	• Yes • No	To determine the level of knowledge regarding carsharing services in Munich among non-users. Hypothesis: Non-users are less aware of carsharing mobility services than users of the Mobility Station.
5	If yes: Do you use [carsharing provider] in general?	Single choice	• Yes • No	To determine if non-users of the Mobility Station, use carsharing services elsewhere.
6	If not in 5: Can you please tell us why you don’t use [carsharing provider]?	Multiple choice Interviewer listen to the answer / answers and classifies it / them in the following categories:	• I don´t need it, I have my own car • I don´t need it, I have other options • • It is not available where I need it • I don´t know exactly how it works • It’s too difficult /complicated (Use / registration) • It’s unsure to find a vehicle when I need it • I don´t have a smartphone • For me is enough another provider • I don´t have a driver’s license • I don´t know • other	To identify barriers and reasons for not using carsharing in general.

[32] Questions 4 to 8 were asked for each of the carsharing providers participating in the pilot project in the following order: DriveNow, car2go, STATTAUTO.

7	If yes in 5: You mentioned at the beginning that you have not used [carsharing provider] at the Münchner Freiheit. May we ask you why not?	Multiple choice Interviewer listen to the answer / answers and classifies it / them in the following categories:	• I did not know that it was available here • I don´t need it at this location • It is not geeignet for my daily trips • I prefer to use public transport • I prefer to use my own bike • I prefer to use my own car • I prefer to use bikesharing • I prefer to use the taxi • Other	To identify barrier and reasons for not using carsharing at the Münchner Freiheit.
8	(If yes in 4 and if yes in 5. Don't ask if answer to question 7 is "I did not know that it was available here, I don't need it in this location) What should be changed so that you use [carsharing provider] here at the Münchner Freiheit?	Multiple choice Interviewer listen to the answers and classifies them	• Other / new services there (shops) • More vehicles • More reserved parking places • Other • Nothing (use is not planned)	To identify potential improvements for the Mobility Station to raise attractiveness among non-users

Section 3	**Knowledge, use and attitudes towards MVG Rad**			
Item	**Question / Survey element**	**Type of question**	**Possible answers**	**Purpose of question**
9	And now I will ask you some questions about the MVG Rad: Do you know MVG Rad?	Single choice	• Yes • No	To determine the level of knowledge regarding MVG Rad in Munich among non-users. Hypothesis: Non-users are less aware of carsharing mobility services than users of the Mobility Station.
10	(If yes in 9): Do you use MVG Rad in general?	Single choice	• Yes • No	To determine if non-users of the Mobility Station, use MVG Rad elsewhere.
11	(If not in 10) Can you please tell us, what are the reasons for not using MVG Rad?	Multiple choice Interviewer listen to the answer / answers and classifies it / them in the following categories:	• I don´t need it, I have my own bike • I don´t need it, I have other options • It's too expensive • It's not available where I need it • I don´t know exactly how it works • It's too difficult / complicated • Unsure to find a bike when I need it • Unreliable operation • I don´t have a smartphone (with the necessary operation system) • I don´t know	To identify barriers and reasons for not using MVG Rad in general.

			• Other (i.e. not comfortable enough, bikes are no appropriate, weather, feeling unsafe on the streets)	
12	If yes in 9: You mentioned at the beginning that you have not used MVG Rad at the Münchner Freiheit. May we ask why not?	Multiple choice Interviewer listen to the answer / answers and classifies it / them in the following categories:	• I did not know that it was available here • I don´t need it at this location • It is not suitable for my daily trips • I prefer to use public transport • I prefer to use my own bike • I prefer to use my own car • I prefer to use another bikesharing provider • I prefer to use the taxi • Other	To identify barrier and reasons for not using MVG Rad at the Münchner Freiheit.
13	(If yes in 9 and if yes in 10. Don't ask if answer to question 12 is "I did not know that it was available here, I don't need it in this location) What should be changed so that you use MVG Rad here at the Münchner Freiheit?	Multiple choice Multiple choice Interviewer listen to the answers and classifies them	• Other / new services there (i.e. shops) • More bikes at the station • More places to leave the bikes • Other • Nothing (use is not planned)	To identify potential improvements for the Mobility Station to raise attractiveness among non-users

Section 4	**Demography**			
Item	**Question / Survey element**	**Type of question**	**Possible answers**	**Purpose of question**
14	To finish we ask you to answer some important statistics questions. How old are you?	Single choice Interviewer listen to the answer and classifies it in the following categories:	• 18 - 29 years • 30 - 49 years • 50 - 64 years • > 65 years	To determine the non-users' demographic profile
15	(If not mentioned already in question 6 as one of the reasons for not using carsharing) Do you have a driver's license?	Single choice	• Yes • No	To obtain the percentage of non-users with a driver's license and compare with group of users.

16	Do you have a car available to you?	Single choice	• No • Yes, all the time • Yes, some times	To understand the "mobility portfolio" of the users (mobility options available to the users, potential multimodality degree)
17	Do you have a smartphone with internet connection?	Single choice	• Yes • No	To obtain the percentage of non-users with access to internet through a smartphone. (Potential for using shared mobility services)
18	Do you have a public transport subscription?	Single choice	• Yes • No	To understand the "mobility portfolio" of the users (mobility options available to the users, potential multimodality degree)
19	If yes Which card is that?	Single choice Interviewer listen to the answer and classifies it in the following categories:	• IsarCardMonat (monthly subscription) • IsarCardWoche (weekly subscription) • IsarCardAbo (year subscription) • Zeitkarte Ausbildungstarif (special subscription for trainees) • IsarCardsemester (six month subscription for students)	To know what type of public transport subscription the users have.
20	Where do you live (What is your zip Code)?			To determine where non-users live and if there is a difference to where users live.

Section 5	**Announcement and invitation to participate in focus groups**			
Item	**Question / Survey element**	**Type of question**	**Possible answers**	**Purpose of question**
21	This autumn we will carry out some group discussions during two hours in order to know more about your suggestions and wishes about Mobility in Munich. You would get an incentive of 50€. Are you interested in participating?	Single choice	• Yes • No	To gain potential participants for the focus group with non-users.
22	If not: in case you change your mind you will find more information in this flyer[33]. If yes: We will need then your contact data.	Open question	• Name • Phone number • E-Mail Address	To be able to contact them later for inviting them to the focus groups.

[33] A flyer with more information about the goal of the focus groups was handed out to the respondents.

Annex B-3: Interview guidelines for focus groups with users

Item	**Questions**
Section 0	**Greeting and introduction (10 minutes)**
Introduction	Greeting, presentation of the moderator and the topic “Mobility Station at the Münchner Freiheit”. Short explanation of what is understood with the term, so everybody knows what they will be taking about. Bikesharing and carsharing services: use, opinions, wishes. Short explanation about the course of action, basic rules: • Collection of ideas and opinions • There are not right or wrong answers, participants are invited to openly talk about their opinions and points of view • The opinion of each participant is asked, there are acoustic problems when more than one person talk simultaneously • The moderator will ask further, interrupt or shorten, it should not irritate participants, it is just important to keep track of the time. • Indication that the discussion will be video-taped for later analysis and that there are other persons outside the room observing.
Round of introductions	Participants are asked to introduce themselves: • first name • age • occupation • Mobility (traditional transport modes they have access to and use): own car, bike, use of public transport, have a public transport subscription.
Section 1	**Warming-up phase: associative environment (10 minutes)**
Associations, feelings attitudes towards the Mobility Station at the Münchner Freiheit	Our discussion is about the Mobility Station at the Münchner Freiheit: • What goes through your head when you spontaneously think about the Mobility Station at the Münchner Freiheit? Which thoughts, images, feelings arise? • What is in your eyes particular at the Mobility Station? What stands out?

Section 2	Knowledge and use of carsharing and bikesharing, image of mobility service providers at the Mobility Station, substitution of transport modes (50 Minutes)
Awareness of shared mobility services	Which carsharing services do you know (only their names), and which bikesharing services come to your head?
Use of shared mobility services	Which carsharing and bikesharing services do you use, for how long and why you decide to use them?
Typical occasions for using shared mobility services	What are typical occasions in which you use carsharing or bikesharing? For which purposes, in which occasions? What advantages do you have from using carsharing/ bikesharing?. Please think about leisure and professional purposes (work, education).
Changes in Mobility behavior	Have you changed your mobility behavior since you use shared mobility services? Think about the choice of transport mode and the trips you do. Are there transport modes that you use more or less often, or not anymore at all because of carsharing or bikesharing?
Substitution of transport modes	Does carsharing / bikesharing replace other transport modes that you used to use in the past? Have you strongly reduced the use of a particular transport mode? If yes: which advantages do you have from carsharing / bikesharing compared to that transport mode?
Reasons for using different transport modes including shared mobility services	In case public transport is used less often or not used anymore: In which situations do you use shared mobility services instead of public transport and why do you prefer for those purposes shared mobility services and not public transport? Does the mobility station at the Münchner Freiheit play a role here? If yes, which one? In case private car is less often used or not used anymore at all: Why do you use your private car less often / not at all anymore? What is the role of public transport on this?
Role of the Mobility Station in changes of car ownership	Is there someone that have relinquished his/her own car or did not buy one due to carsharing or bikesharing? For which reasons? Did the Mobility Station played a role on this? If yes, which one?
	Specific questions about the Mobility Station
Awareness of the Mobility Station	Do you know which providers are available at the Mobility Station? What goes through your head when you think about [shared mobility service provider], How do you assess this provider? (in case a provider is not mentioned): Who is customer of this provider? To those that are not customers of a provider: Would you be interested in becoming a customer? If not, why not?
Sources of awareness	Can you remember how or through whom you became aware of the Mobility Station?

Relevance of the on-site information screen	(showing picture of the on-site information screen so everybody knows what is meant): which role did this on-site information screen played? Do you know the functions of the on-site information screen? (If yes): do you use them? What do you use? What do you think? Is it important at all that here information or services are offered? Why important? Why not important? Which information / services at the on-site information screen are or would be helpful for you?
Characteristics of a trip with shared mobility services starting or ending at the Mobility Station	Think specifically of the last time you rented or returned a carsharing vehicle or bike at the Mobility Station. Describe as detailed as possible, from where did you come, what did you want to do and why did you decide to rent or return the car or bike at the Mobility Station / Münchner Freiheit? Why did you decided that day to use carsharing / bikesharing and not another transport mode? Which concrete advantage had the shared mobility service that day?
Substitution of modes due to the Mobility Station	Assuming that the shared mobility service would not be available, what would have you done? And how problematic would that be?
	In general: how have you used the carsharing / bikesharing at the Münchner Freiheit? How often (regularly, occasionally, sporadically)? And in which occasions?
	Who have used (rented or returned) both, carsharing and bikesharing at the Münchner Freiheit? Who has only used carsharing? Who has only used bikesharing? To users of bikesharing and carsharing at the Mobility Station: what are for you personally decisive advantages of being able to use various mobility options at the Münchner Freiheit? To users or bikesharing or carsharing at the Mobility Station: Why have you not used carsharing / bikesharing there? Would that be a possibility interesting for you at all? If not: why not? At the Münchner Freiheit you have, next to carsharing and bikesharing, the possibility to use metro, bus, tram or taxi, do you use these options? If yes: In which typical situations (i.e. to work, business activities, and leisure) do you use them or combine them? Does this depend on the time of the day or week? And why? If not: why not?

Section 3	**Personal assessment of the mobility station and optimization approaches (40 minutes)**
Experiences, personal advantages and disadvantages	Which experiences, positive or negative, have you had when using the Mobility Station? Which personal advantages does the Mobility Station has for you? Are there also disadvantages from your point of view? If yes, which ones? And why is this a disadvantage for you?
Comparison between station-based and free-floating shared mobility services	If you compare the station-based services with the so called “free-floating” services, what do you think is better to have at the Mobility Station? What is worst? And why?
Potential for improvement	Are there aspects that one generally could improve at the Mobility Station? What should be done, so that the mobility services would be interesting to as much people as possible?
Awareness of similar concepts in other cities	Do you know perhaps Mobility Station in other cities? If yes, is there something there, something good or differently solved in comparison to the Münchner Freiheit / that should be done in Munich? How do you assess the arrangement / location of the different transport modes that belong to the mobility station? For example the distances and paths between public transport, MVG Rad bikes and carsharing vehicles? Is that ok or is it possible to do it better? How is it with the weather protection? Is it enough or would you expect something else?
Added value of the Mobility Station	What do you think: How important is for users of the mobility station at the Münchner Freiheit to have access to various different transport modes? Does this offer an added value? Or is this variety rather something “nice to have”? Why is an added value? Why not? If low added value or not added value: How could be possible to achieve a real incentive, so that as much people as possible would notice/appreciate various services? How, from your point of view could the interest to this variety be strengthened? Assuming that the Mobility Station would be removed, what would that mean for you? How would you react? (at the end is explained that this is not planned, the spontaneous reactions help to have a better estimation of the real personal relevance and the substitution behavior…)
Future development	What do you think: Would you in future use bikesharing / carsharing services at the Münchner Freiheit more often as today, the same or less? Why do you think so?
Section 4	**Outlook, general acceptance (10 minutes)**
	Assuming you would work for transport planning at the city of Munich: would you build more mobility stations? If yes, why? And how would you design these? If not, why not? What do you think: can a variety of central mobility Stations, like at the Münchner Freiheit contribute so that less private cars are bought or used? Why yes/ why not?

Annex B-4: Interview guidelines for focus groups with non-users

Item	Questions
Section 0	**Greeting and introduction (10 minutes)**
Introduction	Greeting, presentation of the moderator and the topic “Mobility in Munich, bikesharing and carsharing, attitudes, use, wishes, ; perception of the Mobility Station at the Münchner Freiheit” (short explanation of what is understood with the term, so everybody knows what they will be taking about. Short explanation about the course of action, basic rules: • Collection of ideas and opinions • There are not right or wrong answers, participants are invited to openly talk about their opinions and points of view • The opinion of each participant is asked, there are acoustic problems when more than one person talks • The moderator will ask further, interrupt or shorten, it should not irritate participants, it is just important to keep track of the time. • Indication that the discussion will be video-taped for later analysis and that there are other persons outside the room observing.
	Participants are asked to introduce themselves: • first name • age • occupation • Mobility (traditional transport modes they have access to and use): own car, bike, use of public transport, have a public transport subscription.
Section 1	**Warming-up phase: associative environment (10 minutes)**
Associations, feelings, attitudes towards Mobility in Munich.	We start with the very general topic of mobility in Munich, moving around in Munich. With “Mobility” I mean, how people go from A to B in Munich, independently if for leisure or professional purposes, for example going to work. • What goes through your head, when you think about “Mobility in Munich”? Which thoughts, feelings, images come to you?
Section 2	**Mobility behavior (20 minutes)**
Mobility behavior in general	How do you move around in Munich? Which modes of transport do you use? Think of all transport modes available such as private car, motorbike, roller, metro, tram, bus, S-Bahn, Taxi, bikes, walking, etc.
Motivations of using different transport modes	Why do you use these transport modes? What are the strongest arguments for that? What makes you use the different transport modes and which role does the environment, health or cost play?

Main modes of transport used	Which transport modes do you mainly use? • For going to work or school • For leisure, sport, going out, excursions, visiting friends, • For daily shopping, big shopping? • When going alone or with the family or friends?
	And how is this depending on situations or the weather? Do you go by bike when the weather is nice and with the car if it's raining?
Potential changes in mobility behavior	Is anyone of you planning to change something in the future? For example changing transport modes? Getting a public transport subscription? Use more often the bike, getting rid of a car, and why?

Section 3	**Attitudes towards carsharing / bikesharing and use of shared mobility services (30 minutes)**
Associations, attitudes towards bikesharing and carsharing	What goes through your head when you think about bikesharing? Which thoughts, feelings, images come to you? And what do you relate to carsharing? Which thoughts, feelings, images come to you?
Awareness of shared mobility services	Which bikesharing services do you know (only their names), and which carsharing services come to your head?
Use of shared mobility services	Raise your hands: who use carsharing? Who uses bikesharing? To users of carsharing and bikesharing: which shared mobility services do you use and for how long? Why did you decide to use them?
Typical occasions for using shared mobility services	What are typical occasions in which you use carsharing / bikesharing? Why for this purposes / Occasions? Which specific advantages have the use of carsharing / bikesharing in these occasions? Please think about both, leisure time and work or education purposes.
Changes in Mobility behavior	Since you use shared mobility services, has your mobility behavior changed? If yes, how? Think about the choice of transport modes and the trips you do. If not mentioned: Are there transport modes that you use more or less often, or not anymore at all because of carsharing or bikesharing?
Reasons for using different transport modes including shared mobility services	In case public transport is used less often or not used anymore: In which situations do you use shared mobility services instead of public transport and why do you prefer for those purposes shared mobility services? In case private car is less often used or not used anymore at all: Why do you use your private car less often / not at all anymore? What is the role of public transport on this?

Changes in car-ownership	Is there someone that have relinquished his/her own car or did not buy one due to carsharing or bikesharing? For which reasons?
Barriers for the use of bikesharing and potential use	To participants that don´t use bikesharing: • Why you don´t use bikesharing (so far)? • Who of you can imagine to use bikesharing in the future? If is not imaginable: why not? • What should happen so that bikesharing would be attractive? • Under which conditions could you imagine to use bikesharing? Which services should be offered?
Barriers for the use of carsharing and potential use	To participants that don´t use carsharing: • Why you don´t use carsharing (so far)? • Who of you can imagine to use carsharing in the future? If is not imaginable: why not? • What should happen so that carsharing would be attractive? • Under which conditions could you imagine to use carsharing? Which services should be offered?

Section 4	**Perception and evaluation of the Mobility Station, image of providers, potential use (40 minutes)**
Awareness of the Mobility Station	Since October, last year there is at the Münchner Freiheit a so called “Mobility Station”. Here carsharing and MVG Rad bikes are closely available to bus, tram and metro. (showing picture, so that everyone know what is meant by that) Were you aware of this before this discussion, before we invited you to it?
Sources of awareness	• If yes, can you remember how or through whom you became aware of this station?
Relevance of the on-site information screen	• (Showing picture of the on-site information screen so everybody knows what is meant): which role did this on-site information screen played? • Do you know the functions of the on-site information screen? (If yes): and what functions do you expect? • Assuming that you would like to use the Mobility Station at the Münchner Freiheit, either carsharing or bikesharinf, how or where would you want to get information? • Is it important to you that directly at the on-site information screen information or services are available? Why important? Why unimportant? Which information / service would be helpful for you?

Awareness and attitudes towards the specific providers of shared mobility services at the Münchner Freiheit	• Do you know who is / are the provider(s) of this Mobility Station?
	• Who of you know:
	    ○ MVG Rad?
	    ○ DriveNow?
	    ○ Car2go?
	    ○ STATTAUTO?
	• For all known providers:
	• What goes through your head spontaneously when you think about (provider)? What do you know about this provider? How do you assess this provider?
	• If not mentioned before: who is customer of this provider?
	• To non-customers: how interesting would be for you to become a customer? If not interesting, why not?

Barriers for the use of the Mobility Station	• You all previously said that you use public transport or taxi often at the Münchner Freiheit, but none of the shared mobility services so far: • Why have you not used yet the shared mobility services? What is your personal reason against using them?
Acceptance of the Mobility Station	• Do you perceive in general an advantage of the MS at the Münchner Freiheit? What do you think is good? • Is there in your opinion also disadvantages of the Mobility Station at the Münchner Freiheit? What bothers you? • Does the mobility Station at the Münchner Freiheit make the use of carsharing and bikesharing more attractive? Why yes, why not?
Associations to the Mobility Station and the users	How do you imagine the typical user of the Mobility Station at the Münchner Freiheit? Do we perhaps need to differentiate between carsharing users and bikesharing users? Please describe as exact as possible what comes to your “geistigen Auge”. If not spontaneously mentioned, ask separately for bikesharing and carsharing (to investigate the “identification potential”) : • Man / woman / both? • Age group? • What does s/he do professionally / in private? • Why does s/he use the Mobility Station, for which purposes, in which occasions? • Can you be friends with him/her? Is sympathetic or the unsympathetic?
Potential use of the Mobility Station by non-users	Can you imagine to use carsharing or bikesharing at the Münchner Freiheit in the future? Why imaginable, why not imaginable? What should be done, so that you have interest to try the share mobility services at the Münchner Freiheit? Which conditions should be there? Which services, conditions are interesting for you in this context? Even if for you the services at the Münchner Freiheit are not interesting: what should be done in general so that the Mobility Station is interesting for as many people as possible?

Awareness of similar concepts in other cities	Do you know perhaps Mobility Station in other cities? If yes, is there something there, something good or differently solved in comparison to the Münchner Freiheit / that should be done in Munich?
Ideas for development	In some cities, like in Hamburg, it is possible to use carsharing bikesharing and public transport with only one card. Would this be a good idea for Munich? Why yes/ why not?
Comparison between station-based and free-floating shared mobility services	If you compare the station-based services with the so called “free-floating” services, what do you think is better to have at the Mobility Station? What is worst? And why?
Added value of the Mobility Station	What do you think: How important is for users of the mobility station at the Münchner Freiheit to have access to various different transport modes? Does this offer an added value? Or is this variety rather something “nice to have”? Why is an added value? Why not? If low added value or not added value: How could be possible to achieve a real incentive, so that as much people as possible would notice/appreciate various services? How, from your point of view could the interest to this variety be strengthened?
Assessment of location	How do you generally assess the location of the Münchner Freiheit? Was this a good choice for such a “Mobility Station”? Why yes, why not? Which role do shops, kiosk, restaurants and bars play in your assessment?

Section 5	**Outlook, general acceptance (10 minutes)**
Future development	Assuming you would work for transport planning at the city of Munich: would you build more mobility stations? If yes, why? And how would you design these? If not, why not? What do you think: can a variety of central mobility Stations, like at the Münchner Freiheit contribute so that less private cars are bought or used? Why yes/ why not?

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