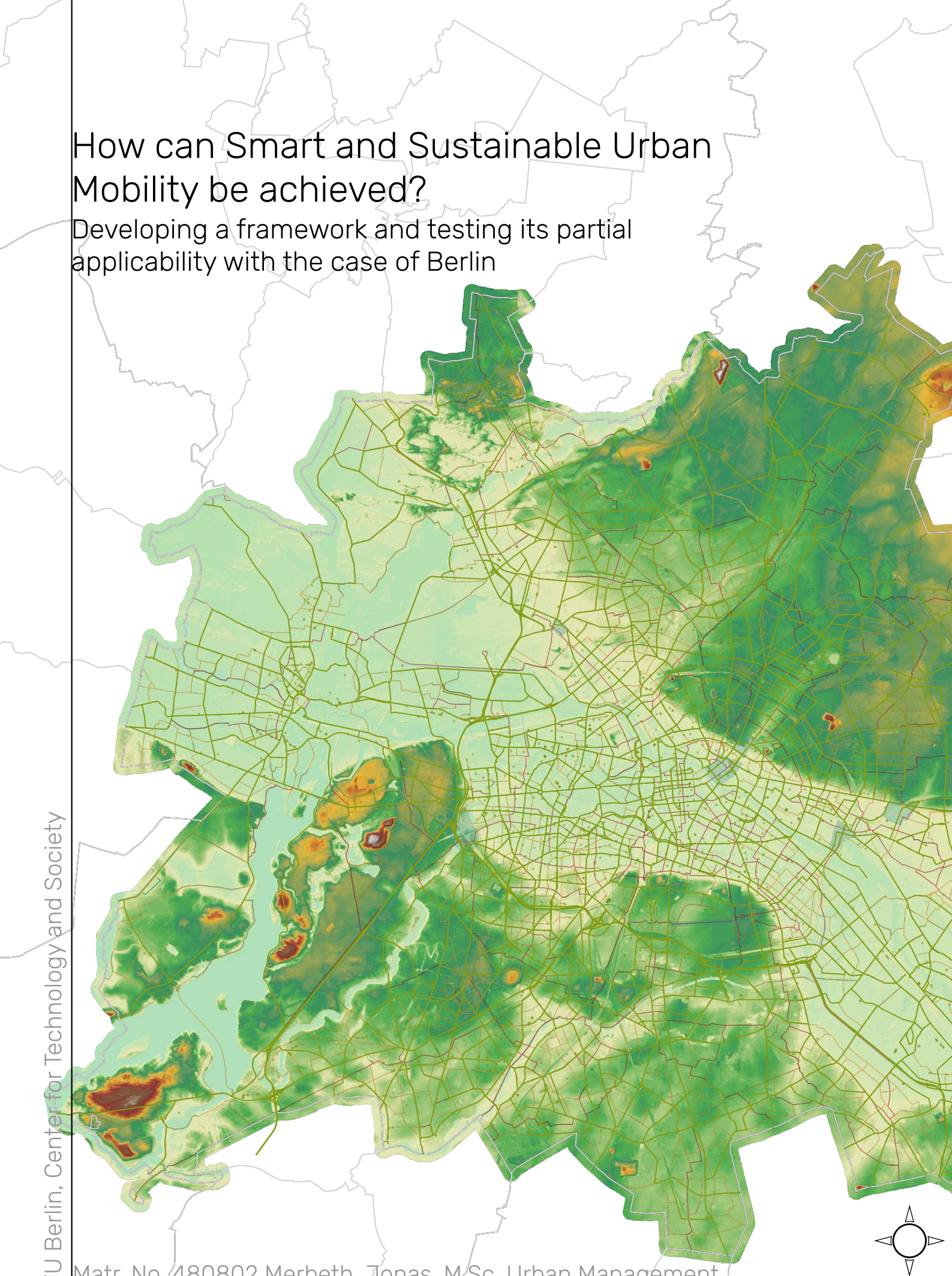
How can Smart and Sustainable Urban Mobility be achieved?

Developing a framework and testing its partial applicability with the case of Berlin



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How can Smart and Sustainable Urban Mobility be achieved?

Developing a framework and testing its partial applicability with the case of Berlin

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Statement of authenticity

This thesis contains no material which has been accepted for the award of any other degree or diploma in any institution. To the best of my knowledge and belief, the research contains no material previously published or written by another person except where due reference has been made in the thesis text.

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Jonas Merbeth

Berlin, January 31st, 2024

Abstract

Keywords: Smart City, Smart Mobility, Sustainable Mobility, Framework, Berlin

The concepts of Smart Cities and Smart Mobility are probably two of the most controversial and hot topics in urban and regional planning at the moment. Expectations of planners, architects, engineers, and politicians in these concepts to provide answers to many pressing questions of urbanity are tremendous. While some glorify them as stars in the sky, which can lead humanity the way to tackle pressing issues in urban areas, others find them not only completely useless, but even dangerous.

But what is actually behind ideas, concepts, and approaches of a Smart City? How can we define the smartness of a city? What is Smart Mobility and how can it be used? How are Smart Cities and Smart Mobility approaches interrelated? Does a generic approach of Smart Mobility exist, which can help to achieve a more Sustainable Mobility of the future? And how can such a framework be adapted to a specific city?

The following master thesis will provide initial attempts in trying to answer these mentioned questions. Therefore, existing definitions and concepts of a Smart City, as well as of Smart Mobility and Sustainable Mobility will be analysed in the beginning. A short history of these concepts, their interrelation and potential embeddedness within the urban space will be shown. Existing trends and patterns of mobility will help to understand pressing issues of the time. An analysis of sustainability within mobility will help to deep-dive into potential solutions. Best practices of Smart Mobility projects will provide potential solutions for achieving Sustainable Mobility by using ideas and concepts of Smart Mobility. In a next step, the researched problems will be combined with potential solutions, that can (but not solely should) derive from concepts and ideas of smartness. Therefore, the term of smartness in relation to mobility is defined and concepts of smart mobility are explained.

In a next step, advantages and disadvantages of Smart Mobility concepts are summarized. A literature review will help to understand the potential clustering of these concepts. The existing research gap of clustering these concepts will be, at least partially, closed by providing an own approach. The applicability of this created SASUM-framework will then be reviewed by using the specific case study of Berlin. Results of conducted interviews with experts from various fields of urban and regional planning will complement the results of the literature review and will shape the final outcome of the self-created framework. In the penultimate step, the case of the German city of Berlin will be used, to review the applicability of this created framework. Lastly, policy recommendations for this specific use case will be given shortly and combined with a general discussion as well as its limitations.

The thesis therefore aims in contributing to the strongly emerging debate about Smart Cities and Smart Mobility. The author’s goal is the development of a basic framework, that combines goals of Smart and Sustainable Mobility with potentially helpful technologies and tools. This approach can potentially help cities and municipalities to achieve a more sustainable and ecological-friendly transportation of its traffic-system, without neglecting the requirements of users’ needs. It can achieve a more sustainable transportation, that strives for eco-friendly, user-centred, and technologically advanced urban transportation of the future.

Acknowledgements

I want to dedicate this arduous thesis to my mum, who always gave me the strength to believe in my capabilities and accomplishments. She instilled in my values and norms and always made sure to take moral and human values as the basis of all action. Thank you, Jumbo, for always teaching me, how to follow your passions and interests and never lose track of your inner, morale compass. I also want to deeply thank my stepdad Tino, who always supported me with enriching discussions and conversations. He did not solely support me intellectually, rather providing opportunities to think outside the box and seeing the world through different eyes. Lastly, I want to thank my grandfather, who supported me with enriching political, societal, and architectural discussions and who gave me some new thoughtful insights.

Thanks to my home country Germany for always providing excellent academic and intellectual resources and guidance. A big thanks especially to the *Bauhaus-University of Weimar* for providing excellent teaching and lessons within my bachelor's degree in Urbanism. Thanks to the *Technical University of Berlin* for its opportunity to continue this academic journey with the master's degree within the Urban Management Program. Another thanks to the *Technical University of Istanbul* for providing excellent support within my semester abroad. It helped tremendously shaping my interests and my further educational development within the field of urban and regional planning.

Furthermore, I want to the thank the whole team of the Urban Management Program for all provided teachings and lessons within this master's degree. In particular, I want to thank the *Zentrum für Technik und Gesellschaft (ZTG)* for the opportunity of writing this thesis within the institute. Especially I want to thank my advisor, Dr.-Ing. Wulf-Holger Arndt, for his guidance, support, ideas and help throughout the whole process of developing and writing this thesis. His contributions, intellectual and academic support and knowledge helped tremendously to structure, shape and cluster frameworks, concepts, and ideas within this thesis.

I want to thank my company, the *DKSR* for their support and believe in my abilities as a consultant in the field of Smart Cities. Their projects, ideas and discussions have been the basis of this thesis and encouraged my deeper interests in this field. Special thanks to Dr.-Ing Alanus von Radecki for co-advising this thesis with his outstanding knowledge. Thanks to all my colleagues for their advisory and input in several projects regarding Smart Mobility. Their contributions and thoughts always helped rethinking perspectives of urbanity.

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1 Introductory overview

The motivation for writing this thesis derived from an inner drive of contributing to the academic discourse, how the urgently needed turnaround in sustainability of transportation and the user-centred creation of mobility can be achieved. My last years of academic work and participation in the private sector with the focus of fostering projects of Smart Cities and Smart Mobility strengthened the desire for a holistic understanding of these topics and their applicability to urban spaces.

This inner drive is the first reason, why the focus of this thesis lays on concepts and frameworks of Smart Cities and Smart Mobility. The motivation derived from the aim of deeply understanding these concepts and analyse, how they can help to increase the sustainability of a certain system. The underlaying urban question is, how the constantly growing urban areas can handle the satisfaction of its users on one hand, but also tackle the issue of sustainability on the other.

Additionally, the topics of Smart Cities as well as Smart Mobility are trending phenomena in urban discussions. Their relevance for urban managers and urban planners arises through the needed holistic analysis of urban space and its potential for a sustainable, social, and economical development of urban areas. Beyond that, supporters of Smart Mobility concepts claim, that it can help to provide a more quantitative basis of urban space for all involved stakeholders, mainly naming politicians, construction companies, planners, architects, and of course local citizens. Due to the topicality of Smart City concepts and the increasing technical possibilities, a conceptual but also practical thesis is needed, to partially close the currently existing research gap within the field of Smart Mobility.

Another reason is the rapid urbanization rate globally. A process, that has started within Germany already years ago but is still ongoing. Within the last decades, most cities and urban areas have been growing constantly. More and more people moved to cities, resulting in the development of more complex and interconnected urban areas. This increase in complexity results from the growing effects of and relationships between urban indicators. Possible solutions for the analysis, planning and realization for user-centred urban areas are often promoted by supporters of the Smart City-movement. They often claim, that using Smart City-approaches can thereby provide a more holistic and generic approach towards analysing this complexity of urban areas by providing technical tools to measure the urban in a quantitative manner.

But what is behind the idea of a Smart City? How are concepts of a Smart Mobility interwoven with the Smart City? Are these approaches solely about using technology to analyse the urban or is there more about it? And can Smart Mobility approaches help to shift mobility into a more sustainable direction?

Therefore, the thesis is striving for a partial academic contribution for answering these questions. Firstly, theoretical approaches of Smart Cities and Smart Mobility are defined. Best practices are shown, and advantages and disadvantages are analysed. A combination of literature analysis of Smart Mobility clusters in combination with conducted interviews of experts working in the field will shape a self-created evaluation matrix. The embeddedness of the framework within the Smart City-strategy of a certain city (here Berlin) will allow a first check of its applicability. Lastly presented policy recommendations will round-off this work.

1.1 Research problem and related research question

While overall greenhouse gas (GHG) emissions in Germany decreased in the last decades, the emissions of the transportation sector have slightly increased. (Wilke, 2023a) The goal of Germany of decreasing GHG emissions in mobility has failed. Several policy recommendations (such as electrification of mobility, increase in public transport and the strengthening of environmental technologies and monitoring) have not been implemented successfully so far. (Lambrecht, 2019) Furthermore, the satisfaction of user's needs is often not met due to a lack of monitoring tools and technologies to analyse and therefore interpret urban traffic data and its usage.

Because of that, the fundamental research interest lays in an understanding of the contribution, concepts of the Smart City and Smart Mobility can play an important role in achieving a more environmentally friendly, socially acceptable, and economically balanced urban transport in the future. Therefore, the fundamental research question is:

> **How can Smart City and Smart Mobility concepts and frameworks contribute to achieve a more sustainable urban mobility under consideration of the satisfaction of users' needs?**

This research questions aims in using ideas, concepts, and thoughts, mainly of the concepts of Smart Mobility, to achieve a more sustainable urban transportation. Within this thesis, the current tendencies and frameworks of Smart Mobility will be therefore analysed. The potential subdivision of the concept will be researched. A self-created evaluation matrix will help to bring together aims and goals, a Smart and Sustainable Mobility should strive for. A toolbox will help to choose the best possible method for the individual goals.

Therefore, the related and underlaying sub-questions are:

> **What is a Smart City and how ca it be defined? How are concepts of Smart Mobility embedded within the Smart City? What is the underlaying concept of Smart Mobility and how can it be achieved?**
>
> **What are opportunities and limitations of Smart Mobility concepts? What can they achieve and what not?**
>
> **What is Sustainable Mobility and how can Smart Mobility frameworks help to achieve it?**
>
> **How can Smart Mobility concepts be clustered into groups? And how can a self-created framework bring together aims and goals with technologies and tools of Smart and Sustainable mobility?**
>
> **How can this self-created framework be used by municipalities to create a Smart and Sustainable (urban) Mobility system?**

These sub-questions will help to analyse the beforehand mentioned main research question. The analysis of concepts of Smart Cities and Smart Mobility will help to understand its components and potential definitions. These definitions will subsequently help to shape characteristics of Smart and Sustainable (urban) Mobility systems.

A literature review will not solely help to understand definitions, frameworks, and concepts, but further find potential clusters of Smart Mobility concepts. These clusters, together with the previously mentioned characteristics and conducted interview will form the basis of the framework. The applicability of this framework will then be tested by using a certain case study of a city, here Berlin. The framework aims in complementing municipal guidelines for their purposes of creating a Smart and Sustainable (urban) Mobility system.

1.2 Hypothesis and explanation

As already stated, Smart City and Smart Mobility are trending phenomena of urban and regional planning. They claim to understand urbanity in a more holistic, generic, and quantitative manner. But how can they actually contribute to achieve a more Sustainable Mobility of cities?

Therefore, the following hypothesis will be proposed:

> *A shift towards a more Sustainable Mobility can solely be achieved by using Smart Mobility concepts, frameworks, and technologies.*

Within this thesis, I will prove or disprove this hypothesis by analysing theoretical literature, analyse potential best-practices and develop a self-created framework. The aim is thereby to check, what potential characteristics a Smart and Sustainable (urban) Mobility should contain, to be called sustainable.

The term of sustainability is thereby not solely focussed on environmental issues. Rather it includes an economic, social, and environmental sustainability, that furthermore includes the satisfaction of its users. The term of smartness is used to describe the method (here the technology or tool) that can be used to achieve these aims of sustainability.

The case study of Berlin will help to prove or disprove not solely the created framework, rather the stated hypothesis. It will help to understand, in which ways, smartness or the use of technologies and tools can contribute to achieve a Sustainable Mobility. But it will also help to understand the limitations, weaknesses and threats, these concepts bring with them.

The overarching aims of this thesis is proving this hypothesis from a generic and holistic way on one hand but give a practice-oriented answer on the other. This approach ensures the broadest possible answer to the question.

2 Research design

The research design of this thesis is strongly following the idea of a mixed-method approach. A theoretical literature review in combination with best practices and conducted interviews will be used to answer the stated research question and hypothesis.

Thereby and within the first section, the research question, related sub-questions and the hypothesis will be given. Expected outcome is a narrow and conclusive research question with the associated hypothesis. A short introduction to the topic will conclude this chapter.

Within the next step, the research design and flow of thoughts will be explained. While within this paragraph, the overall structure and the underlaying research design is explained in written form and visually, the next paragraphs will explain the selection of the topic and its justification, the triangulation, and a sample description, which is concluded by a summary of data sources and collections.

The next research step is the definition of used terms of Smart City, Smart Mobility and Sustainable Mobility and their relation to each other. Underlaying concepts, frameworks and ideas are analysed from a theoretical point of view, best practices and examples will round off this chapter. Results are an overview of concepts and a table or overview of own criteria for Smart and Sustainable Mobility according to the literature.

The next step aims in combining the concepts and cluster them into categories. Thereby, existing literature and theories, how these concepts can be categorised, will be taken as an example. This will result in potential categories of Smart and Sustainable Mobility solutions, which all contain the aspects of sustainability. Another step, that is done within here, is the analysis of the expert-interviews. Therefore, the so-called Mayring-method was used to analyse the answers of the 9 experts (3 conducted interviews and 6 qualitative questionnaires). Results are strengths as well as weaknesses of Smart Mobility concepts to achieve a Sustainable Mobility. This will help to review the applicability for the specific use case of Berlin.

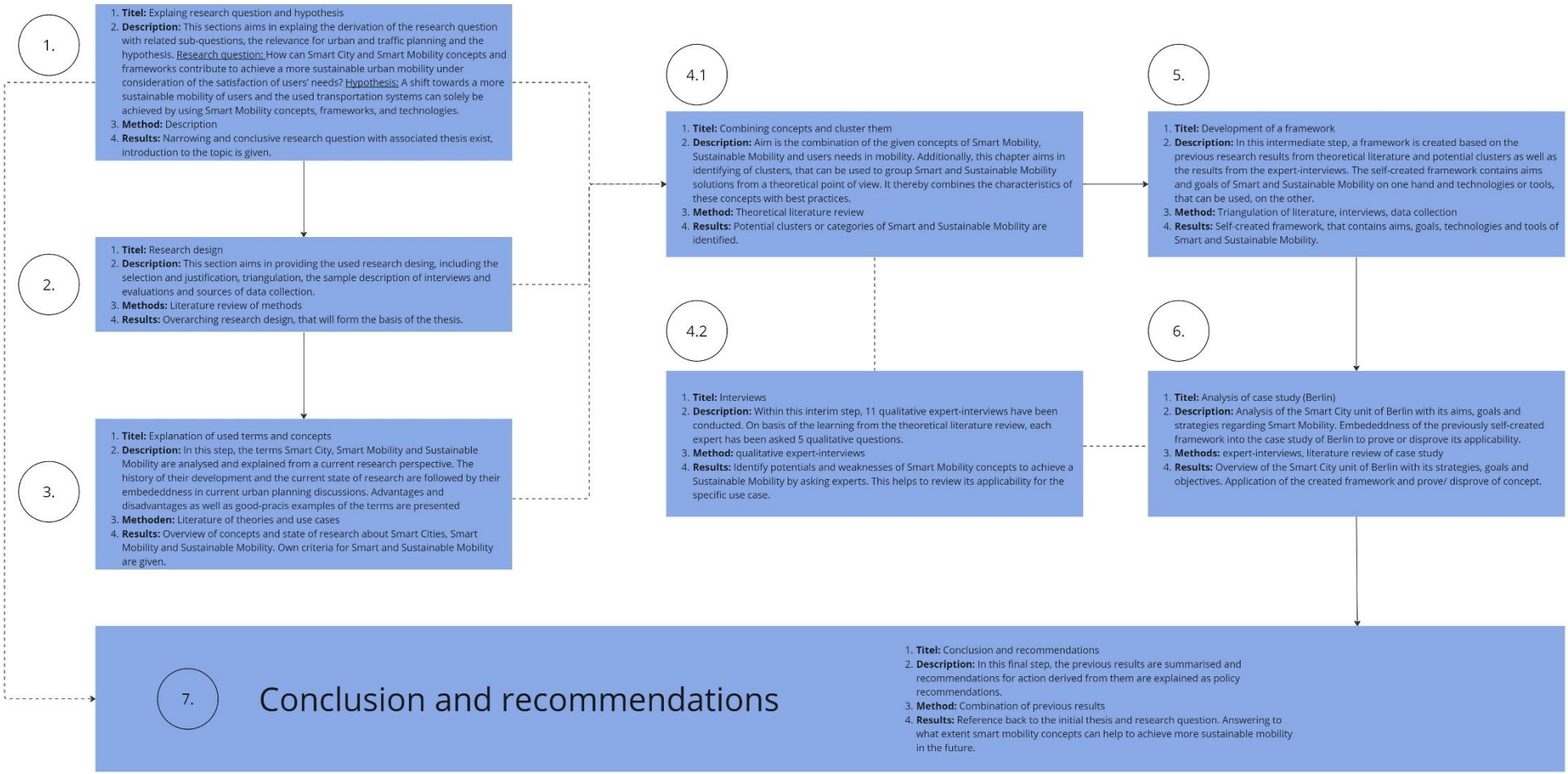
The next step is probably the most important of the thesis. It contains the development of a framework, that explicitly describes, how a Sustainable Mobility can be achieved by using Smart Mobility concepts. It thereby contains two streams: the aims and goals of Smart and Sustainable Mobility on one hand and the methods, such as technologies and tools on the other. The thereby used method of triangulation combines the findings of the theoretical literature review, the case studies, best practices, and the answers of experts.

For the prove or disprove of this framework, a case study is presented within the next step. The case study is thereby the city of Berlin, which is suitable, because of its strong focus on Smart City-concepts. The framework will thereby help to identify underlaying aims and goals of planning strategies for sustainability on various administrative levels and combine them with potentially useful technologies and tools.

The last step of the research will contain a conclusion and (policy) recommendations for municipalities (in general) and for the case study of Berlin (specifically) and how they can achieve a Smart and Sustainable Mobility within their city. All findings are summarized and referenced back to research question and hypothesis. Lastly, a potential follow-up research is presented.

The following figure will illustrate this description of the research design graphically:

Figure 1: Research design



Source: Elaborated by the author

2.1 Selection and justification

As described earlier, this master thesis is using the mixed-method approach. Qualitative and quantitative research go hand in hand. Thereby the theoretical literature of the concepts is combined with information of case studies and best practices. The conducted interviews contribute with insights from experts and round-off this work.

The thereby used research approach is a qualitative one. This is well-suited for revealing the complexity of the concepts of Smart Mobility and Sustainable Mobility. Additionally to its complexity, the researched topics are kindly new real-life phenomenon and are therefore only poorly investigated so far and especially suitable for this approach. (Miles & Huberman, 1994). The basic idea is “that knowledge about reality can only be obtained through ‘the eyes of someone else’” (Jonker & Pennink, 2009). Considering the idiosyncratic and unexplored character of the research issue at hand, this approach seems appropriately.

This thesis follows an explorative design. It is chosen due to the novelty of the chosen phenomena of Smart Cities and Smart Mobility. The explorative design is applied with the aim of producing new approaches and propositions in this field. According to Mayring, the basic idea is that one "wants to get as close as possible to the object of research in order to derive new, differentiated questions” (Mayring, 2020, p. 10). Thereby the explorative approach is especially well suited for topics that have solely been rudimentarily researched. (Mayring, 2020)

On one hand, the clustering of the concepts of Smart Cities and Mobility and the relationship towards Sustainable Mobility can be considered deductive and are therefore going from a known theory. On the other hand, the exploration of the case study in relation with the created framework is partially inductive, going from specific examples, cases and best practices towards the creation of a generic framework. As some theorems about Smart Cities and Smart Mobility exists, it can be called deductive. Because of the circumstances, that potential clusters of Smart Mobility just partially exist, it can be considered partially inductive, trying to identify a new theory or theorem about this clustering.

This thesis is thereby inductive and deductive at once. Therefore, the used method can be described as abduction. The abduction has similar characteristics in some respects to the mixed-method approach. While the mixed-method approach focuses on combination of quantitative and qualitative research, abduction yield a plausible conclusion, which do not eliminate uncertainty or doubts. (Walton, 2014) It takes the most likely answer or best available option (ibid.), which is exactly the case by analysing the broad variety of Smart and Sustainable Mobility concepts and approaches. This approach is therefore well suited and supplements the used mixed-method approach.

The conducted expert interviews are thereby collected in, what is called, a semi-structured way. Five qualitative guiding questions formed the basis of these interviews. The survey method was thereby open, the chosen experts were free in choice between answering directly within the questionnaire or within a digital meeting. In this context, the interviewees are to be understood as experts, since they function as knowledge mediators through their subjective perspectives, job positions, and qualifications. (Helfferich, 2022) Thereby all questions are phrased as open, to leave space for all potential answers, that are directly or indirectly answering the related questions. This ensures, that only the information, that the respondent takes from his or her knowledge and experience, are given.

The usage of open questions also means, that the range of answers can be very wide. This should not directly be seen as negative as it creates the possibility to identify different problems and address new aspects. (Baur & Blasius, 2014) According to literature the usage of open questions are that the respondent cannot or will not answer. (Baur & Blasius, 2014) To avoid this effect, only persons who volunteered for the interviews or questionnaires were chosen.

2.2 Data triangulation

This thesis is using different sources of information. Theoretical literature of Smart Cities, Smart Mobility and Sustainability and related fundamental academic research, reports, and papers from various institutions. Use case-based literature that combines theorems with existing real-life projects and practical examples. Quantitative datasets from various sources and additionally qualitative expert-interviews are used additionally.

For combining these different sources of information, the method of data triangulation was used. This method can be used in qualitative research to "[…] obtain a more substantive facet of reality with a richer and wider coverage of concepts" (Nuttavuthisit et al., 2019). The idea behind is, that the researcher uses multiple sources of data for its analysis, the so-called data-triangulation. Thereby "data triangulation is combining different kinds of data and relating them to increase validity of the research" (Nuttavuthisit et al., 2019, p. 100). Triangulation can be expanded to the use of different collection methods (method triangulation), the use of different theories (theory triangulation) or the use of different investigators or interviewers (investor triangulation). (Nuttavuthisit et al., 2019)

As stated earlier, the overall used method is the mixed-method approach, that combines quantitative and qualitative research. This can be seen similar to the method-triangulation and more specifically the triangulation of quantitative and qualitative research. (Wilson, 2014) This overarching method of the triangulation was used within this thesis, quantitative data sets of research for statistics, graphs, and data collections, especially of Sustainable Mobility are used as well as quantitative data analysis of research about clusters of Smart Mobility. This was supplemented with qualitative research about specific case studies, personal assessments of researchers within theoretical articles and the conducted expert interviews.

These expert interviews contained 5 open questions in a questionnaire. All three interviews were conducted online, the six questionnaires were sent via Mail from the respective experts. Each interview was recorded acoustically for later transcription. The transcription followed the rules: Phonetic idiosyncrasies are not recorded - Spoken content is to be reproduced verbatim - Responses are smoothed by omitting pauses or stuttered passages - Punctuation is smoothed in favour of readability. This simplified transcription system was used "for the reconstruction of subjective perspectives" (Dresing & Pehl, 2015, p. 844). A transcribed version of the interviews can be found in the Annex.

The interviews were analysed by using the Mayring-method as a qualitative content analysis, which was developed by Philip A. E. Mayring in 1988 and then constantly developed further. (Mayring, 2020) Thereby codes were used to subdivide and analyse the text. This coding system is thereby established in advance in which the rules are defined and supported with anchor examples. (ibid.) Even though, trough feedback loops, these rules can also be adapted and supplemented during the text analysis. Each code represents an aspect of the object of research, and they should be relevant to the research question. (Kuckartz, 2012) Thereby at the beginning, main categories are formed deductively, which were then assigned to the text. The deductive variant, I used my knowledge gained from the theoretical literature to form the main categories. This is followed by the inductive formation of intermediates and subcategories to expand the main categories. This inductive variant is characterized by the development of categories derived from the transcribed conversations and information. (Mayring and Fenzl in Baur & Blasius, 2014)

The described mixed-method approach and more precisely the triangulation of quantitative and qualitative research (method-triangulation) for the overarching methodology of the thesis in combination with the Mayring-method for analysing the interviews will therefore form the basis of this thesis. The next sub-chapter will fill this with the related sources of information.

2.3 Sources of information

For the analysis of definitions and concepts of Smart Cities, fundamental theoretical literature was used, mainly naming the theories of Rudolf Giffinger and Boyd Cohen, two important theoretical researchers in that field. Additionally, results of research institutes, such as the German *Zentrum für Technik und Gesellschaft* (ZTG) and other research institutes, such as the *German Institute for Urban Affairs* (DIfU), the *Bundesinstitut für Bau-, Stadt-, und Raumforschung* (BBSR) and more contributed with their research findings and contributions to the general goals and aims of a Smart City and Mobility. For understanding the handling of Smart Cities and Mobility on national level, guidelines, and strategies of the German government, especially of several ministries (*BMWSB, BMDV*) was embedded into the overarching theoretical findings.

For the definition of Smart and Sustainable (urban) Mobility theoretical literature of research institutes and think tanks in combination with case-study-oriented definitions of governments and political actors were considered. This helped to analyse a potential definition of the term and, as described earlier, deductively, and inductively at once. This methodology ensured considering interests, definitions, and concepts of the terms from an academic as well as practice-based point of view.

Thereby mainly literature from research organizations, such as the *ZTG* and *German Zukunftsinstitut* and *DIfU* was used. Additionally theoretical researchers of the field, such as the Glenn Lyons (for Smart Mobility) and Susan Brenner (for technologies and smartness) and Debra Lam & Peter Head (for Sustainable Mobility) helped identifying a theoretical understanding of the terms. These results helped shaping the self-created criteria of Smart and Sustainable (urban) Mobility.

For the specific case study, data analyses, reports, and guidelines of the city of Berlin as well the UK government and its Smart Mobility strategy have been used. Underlaying international and European guidelines and policies round-off this approach towards defining Smart and Sustainable (urban) Mobility. For the analysis of sustainability in mobility as well as in transportation, mainly quantitative research in from of statistics, graphs, and illustrations were used. The main sources were thereby the German *Umweltbundesamt* (UBA) for the analysis of tendencies, trends and phenomena in mobility and the *German Government* for analysing laws and regulations.

For a deeper understanding of Smart Mobility concepts and its potential clustering, theoretical literature, that analysed Smart and Sustainable Mobility concepts and potential clusters of Mauro Francini and Pandian Vasant built the basis of this chapter. Their quantitative approaches for a systematic literature review by using keywords and strings helped to grasp the bigger picture of current tendencies and research objectives within that field. This deductive method was then brought together with the case of Germany and more specifically the municipality of Berlin. Additional case studies and best practices of Smart Mobility projects from two different geographical locations (Rome, Berlin) were then used complementary. This procedure represents once more the method-triangulation of combining an inductive and deductive approach.

Results of these findings then formed the basis of the self-created framework. Thereby this framework was developed using the method-triangulation, using all beforehand mentioned quantitative and qualitative findings. The later presented case study of Berlin used policies and guidelines from all administrative levels, such as international, European, national, regional and local, with focus on European-, German- and Berlin-level. In conclusion this led to the mentioned policy recommendations for the example of Berlin as well as other cities with similar ambitions regarding Smart and Sustainable Mobility actions and projects.

3 Literature review

The following chapter aims in providing a holistic overview of frameworks, concepts and ideas of Smart Cities, Smart Mobility and Sustainable Mobility. The literature review thereby is mainly based upon theoretical literature, that strives for defining the underlaying concepts in a general way.

Thereby my literature review will be divided into two categories. Firstly, I will analyse existing theoretical literature regarding overarching concepts and frameworks to define, describe and explain the theories of Smart City, Smart Mobility, sustainable transport modes, new technologies and digitalization within urban planning systems. Goal is the explanation of a definition of these terms and concepts and their included criteria. Furthermore, it aims in giving a brief historical overview of the development of these terms.

Praxis-oriented literature about mobility shift in and traffic planning concepts at of Germany and Berlin will help to understand the given conditions. Best practices of smart mobility as well as several use cases and projects from other cities will allow to contextualize the researched patterns of Berlin in a European and International frame. Their guiding principles, regulations, laws, and funding programs are therefore presented. Aims and goals are grouped within a table.

This table will form the basis of the identified criteria, a Smart and Sustainable (urban) Mobility should contain. Each criterion is thereby directly linked to the explicit theoretical literature theorem, policy, or guideline. This ensures the linkages and deeper understanding for the reader, wherefrom each of these criteria derived from.

In the following section about Sustainable Mobility, the necessity of the so-called transport turnaround will be explained. Thereby, current mobility patterns, effects of climate change and its impacts in transportation will be presented. Furthermore, the description of the role of sustainable transport to meet international and national climate goals will help to understand problems and weaknesses of current transportation and to come up with new possible solutions.

3.1 Explaining Smart City and Smart Mobility

The following section will deep-dive into the terms, concepts, ideas, and frameworks of Smart Cities as well as Smart and Sustainable (urban) Mobility. It aims for providing a broad overview of the history of the terms, the related concepts and frameworks and its embeddedness in current urban and regional planning discourses.

Thereby the following section firstly explains the term of a Smart City and its related theoretical approach. It is followed by an explanation of smart and sustainable (urban) mobility, its standalone meaning as well as its combined meaning. Conclusively, the author presents his own characteristics of smart mobility. This will (in a later stage of this work) form the basis of clustering smart mobility solutions into a newly framework.

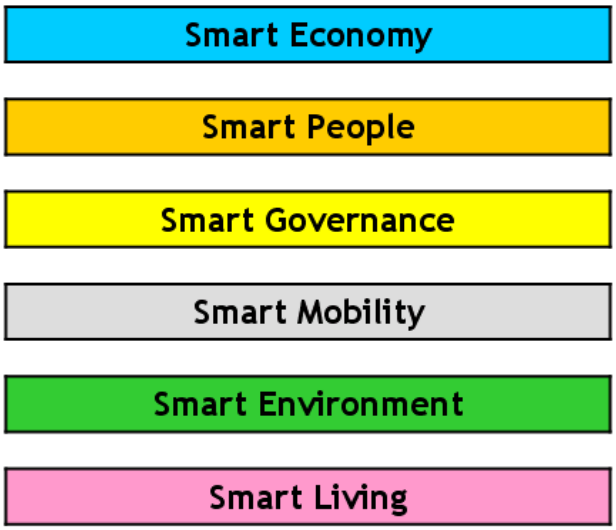
3.1.1 Smart City – a trending phenomena

The term of a Smart City is a trending phenomenon of urban planning. Many different research institutes, faculties of universities, think tanks, and private companies take up the term to describe the urban planning and urban design of the future. The kindly new trend of a Smart City is discussed since the 2000s, firstly introduced by the *State University of San Diego* in 1997. They were giving a first broad definition of Smart Communities and stated, that Smart Communities can be seen as a “geographic region, whose inhabitants, organisations, and administrations use ICT [information and communication technologies] for the transformation of its region” (Lindskog, 2004). Even though the term communities were used instead of cities, the direction of ‘smartness’ was already recognizable: Using information and communication technologies (ICT) to transform a region (or a city). That there is more about ‘smartness’ then just its technical approach will be discussed in a later

stage of this section.

Continuing with the timeline of the term, in 2007, Rudolf Giffinger attempted within his theoretical framework of the *European Smart City Model* to define a Smart City by categorizing it into six clusters. This definition is one of the most widely used one today for understanding the layers or facets of a Smart City. The six clusters derived from a transfer of urban themes, such as economy, civil society or people, governance, mobility, environment and living to the labelling of 'smartness'. He thereby describes 'smartness' as (but not only) the usage if information and communication technologies (ICT) to transform urban areas in six key areas: economy, people, governance, mobility, environment and living.

Figure 2: The six characteristics of Smart Cities according to the European Smart City Mode (2007)



Source: Giffinger et al., 2007, p.11

Thereby a *Smart Economy* "is used to describe a city with a 'smart' industry. That implies especially industries in the fields of information and communication technologies (ICT) as well as other industries implying ICT in their production processes" (Giffinger et al., 2007, p. 10). Within the cluster of *Smart People,* he refers to the education of its inhabitants, wherefor a Smart City has smart inhabitants in terms of their educational grade. The cluster of *Smart Governance* refers to the relation between the city government resp. administration and its citizen. Good governance as an aspect of a smart administration often also referred to the usage of new channels of communication for the citizens, e.g. 'e-governance' or 'e-democracy'. Within the category of *Smart Mobility* he describes a city as smart, if it includes the usage of ICT and modern transport technologies. Logistics as well as new transport systems can be considered smart systems if they improve the urban traffic' and its inhabitants' mobility. The category of *Smart Environment* strives for an improvement of a city's' security and safety of public spaces and green spaces as well as the reduction of greenhouse gas (GHG) emissions. Furthermore, it implies green, efficient, and sustainable energy consumption and usage. *Smart Living* includes ideas of e.g. Smart Homes, changing the way people live in their private environment using ICT. (Giffinger et al., 2007)

This technocratic approach of using ICT to transform urbanity and its inhabitants was specified by Orechhini in 2019, stating that "the digital component of the smart city collects and distributes tacit and explicit knowledge towards all channels of interest and actors revealing a new immaterial city dimension that is able to solve issues coming from the physical space" (Orecchini et al., 2019, p. 66).

But this also implies, that there is more to a Smart City than just its technical component. A Smart City is not solely about transforming urban areas with the use of technology. It is more about achieving broader goals with a holistic understanding of urban areas. Or as described in later in 2019 by Vasant: "In its full completion, the smart city treats urban territory as a complex mixture of networks, places, flows, and information, in which multiple relations and activities have the possibility to generate creative synergies and respond to contemporary urban demands" (Vasant et al., 2019, p. 67). Summarizing that a Smart City transform with (but not solely) urban areas with the use of technology and holistic approaches in a smart way.

A deep dive into these six categories

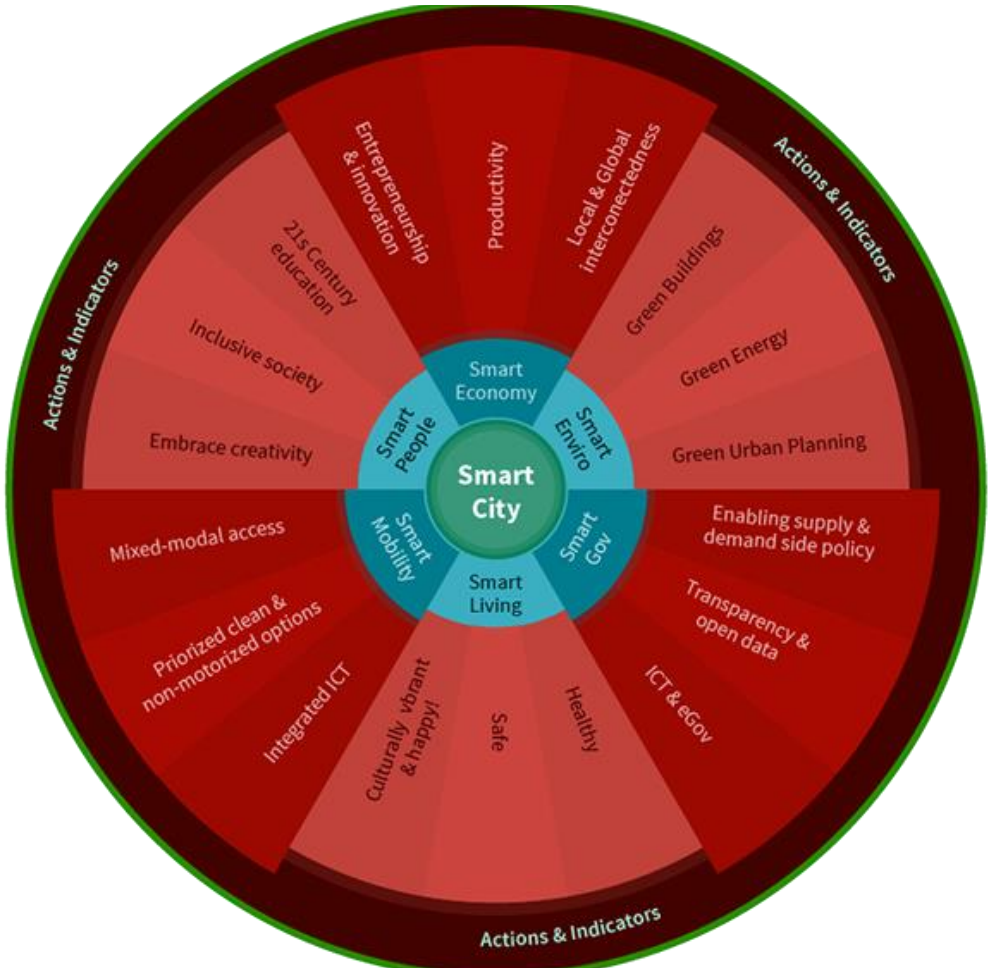
Giffingers' widely used definition and categorization of the term in 2007 was used by Cohen

in 2015 to identify three main generations of smart cities:

1. Smart Cities 1.0: “technology-driven cities, where technology companies providing solutions and services are the beneficiaries” (Cohen, 2015, p. 1).
2. Smart Cities 2.0: “Technology-enabled managed cities where authorities are increasingly focusing on technological solutions that help to improve the quality of life of the population” (ibid.).
3. Smart Cities 3.0: “Highly intelligent integrated cities that are characterized by a high degree of interaction between the government and the population and by civil participation in urban processes” (ibid.).

Each city, that call themselves a Smart City, is in one of these above-mentioned stages. Thereby most cities can be allocated in stage one or two, level three is nearly unachieved by any city, because of its complexity and high degree of interactions between all stakeholders within the urban context. Beside defining different generations of a Smart City, Cohen specified the six clusters of Giffinger and set them into relation to the generations. The outcome was the so-called *Smart City wheel*, which is displayed in the following:

Figure 3: The Smart City wheel by Cohen (2015)



Source: Cohen 2015, presentation.

Nowadays, this *Smart City wheel* is often used by municipalities or local authorities to identify their main fields of action for transforming their urban area. Thereby each of the six clusters contains three main sub-categories, setting the guidance for the aims and goals a city should strive for.

Thereby each of the six clusters will results in more specific categories. An example can be seen in the category of Smart Mobility. To achieve this within a Smart City context, the respective municipality should thrive for a mixed-modal access (of its transportation modes),

a prioritization of clean and non-prioritization of polluting transportation modes and the integration of ICT within the mobility sector. This will need specific actions & indicators of the respective municipality (e.g. in form of projects, guidelines etc.) to achieve these three sub-goals. These sub-goals will play an important role in a later stage of this work, where a specific framework for Smart Mobility solutions will be proposed.

Aims and goals a Smart City should strive for

While these categorizations help to grasp the big picture of what a Smart City contains, it still lacks clear aims and goals, a Smart City should strive for. Therefor one of the broadest definitions of a Smart City is being used: Loew & Rohde defined a Smart City as a city, that strives for a future perspective of its city by integrating and connecting several urban areas of actions (such as energy, mobility, urban planning, governance) to realize ecological and social enhancements. (Abraham et al., 2017; Rohde & Loew, 2011)

> *"One key realisation is that smart city concepts do not represent new development perspectives but complement existing guiding principles. Furthermore, technologies are smart when they serve the interests and needs of people and if they enable social and political participation and inclusion as well as fair and democratic social structures. In this way, smart cities can be created that are characterised by their high quality of life" (Abraham et al., 2017, p. 1).*

This perspective emphasises, that overarching goals and aims of urban development should be the basis of a Smart City. Within such a city, concepts of using technology in a holistic manner can help to achieve these goals. According to Paskaleva in 2011, all aims and goals of a Smart City can thereby be divided into three sub-categories:

- **Connected infrastructure:** Increase of economic and political efficiency and social as well as cultural urban development by using ICT-infrastructure and services to achieve a more connected (physical and informational) infrastructure system.
- **Visions and strategies for creation of competitive cites**: Usage of ICT to increase wealth and competitiveness of cities.
- **Approaches for sustainable and inclusive cities**: Smart Cities thrives for achieving a higher sustainability (from an ecological and social perspective) by using a higher participation rate of its inhabitants in urban decision-making processes. (Paskaleva, 2011)

These categories of aims and goals can be further achieved by using ICT (as described above). Thereby Kominos descried in 2013, intelligent (or smart) cities can be identified by the characteristics of:

- The usage of diverse electronic and digital technologies within cities.
- The usage of ICT for transforming living and working environments within a certain region.
- The embeddedness of these technologies within cities.
- The connection of ICT and humans for using potentials of innovation, learning, knowledge and problem solving. (Komninos, 2013)

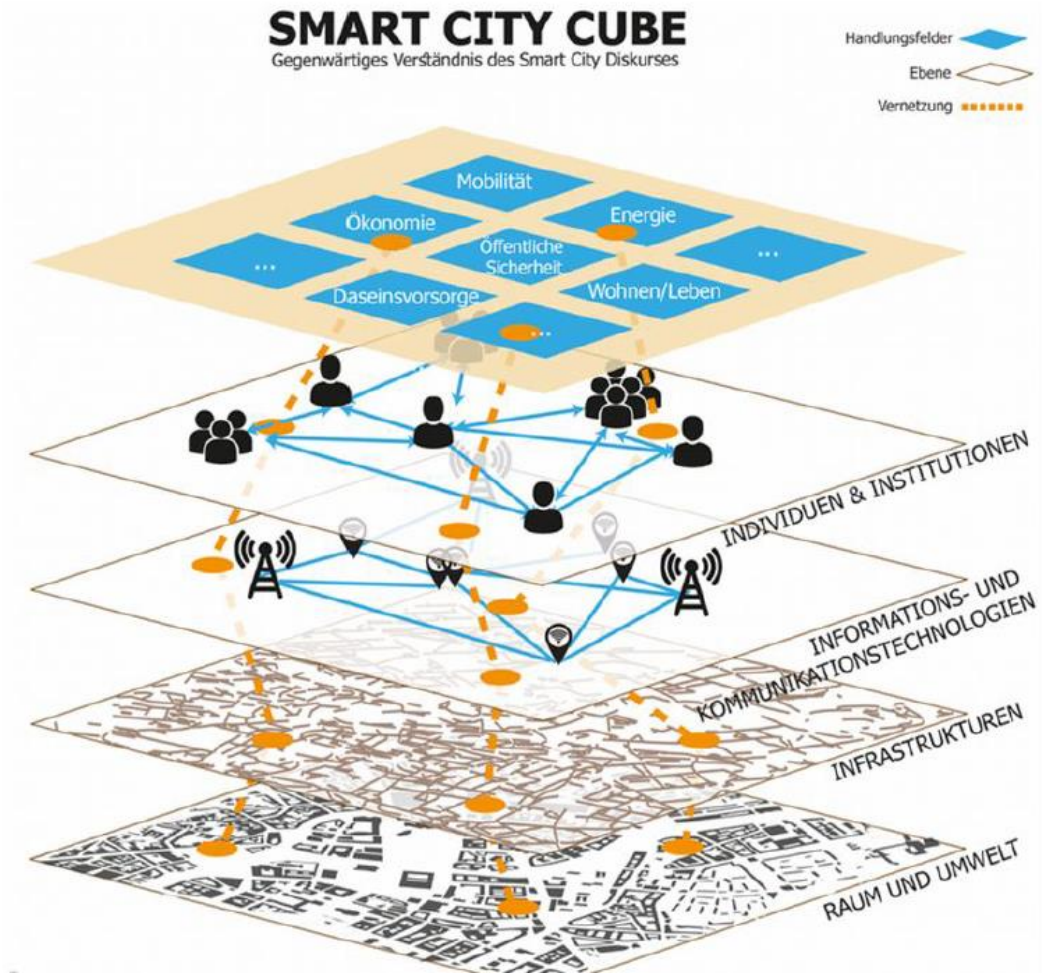
In a later stage, the clusters of Giffinger and the *Smart City wheel* of Cohen in relation with the mentioned categories of goals and aims can help us to group projects and ideas of a Smart City. In addition to these characteristics, Rhode and Loew identified in 2011 these additional characteristics of a smart city, which are going beyond its technical perspective:

- Connection of inhabitants, information, and urban infrastructure
- Utilisation of all possibilities of ICT for networking
- The targeted utilisation of the resulting networking and information flows, ecological, social, and economic sustainability at an urban level
- And lastly the utilisation of the potential of an integrated perspective on urban development. (Rohde & Loew, 2011)

Thereby the connection of inhabitants, information and (urban) infrastructure will be

analysed by various tools of ICT. The holistic usage of ICT helps to grasp different aspects of urbanity and their interrelation. A broader and more holistic view and picture of urban areas is possible. This analysis can be set into relation to its users, individuals, and institutions by connecting the different urban aspects with its needs. This can help to reshape urban areas in the field of mobility, energy, living, security, economy and many more. The following graphic will help to understand the lastly mentioned relation between urban areas (bottom), ICT (middle) and users and fields of action (top):

Figure 4: The smart city cube for identifying the interrelation of its levels



Source: Fathejalali & Rohde 2017 in Abraham et al. 2017

These categories, clusters and interrelations of a Smart City will be later used within the criteria catalogue for identifying a concrete definition of Smart and Sustainable (urban) Mobility.

As summarized by the German *Zentrum für Technik und Gesellschaft (ZTG)*, the aims and therefor characteristics of a Smart City can be summarized as:

1. A Smart City is characterized by a high quality of life.
2. Smartness is not a characteristic of technologies. Rather it refers to approaches conceived by people, strategies, and projects. Technology can be used as a tool to achieve a municipal guideline but is no end in itself.
3. Quality of life and the suitability of design approaches should be subject of social negotiation processes. (Abraham et al., 2017)

In the last years, the idea of concepts of a Smart City gained more and more popularity, specifically by solving urban issues related to increasing energy consumptions and carbon

dioxide emissions. (Abraham et al., 2017) The term Smart City stands for the attempt to find ways of coping these associated challenges and implement them. Thereby information and communication technologies (ICT) can play an important role in this. However, the term is often used more broadly. It then includes, for example, demands for an improved quality of life for citizens, which is only possible through an explicit focus on their needs. (Schweitzer, 2015)

Even though, most scientists agree, that concepts and ideas of Smart Cities can (but no only) use ICT to improve the quality of life and reduce carbon emissions in urban areas, "there is still no universally valid definition of Smart City" (Abraham et al., 2017).Thereby Hollands realized in his article *"Will the real smart city please stand up"* in 2008, that cities often describe themselves as 'smart', if they have a network-like infrastructure, a strong economic-based viewpoint of a city and emphasise the role of the creative- and high-tech-industry. They also often highlight their social and ecological sustainability. (Hollands, 2008, p. 315) He outlines, that cities can solely be called 'smart', if they foster investing in human capital, the overarching aim of social capital, traditional transport systems and modern ICT-infrastructure, which strives for economic growth and higher quality of life. This has to be done by a responsible handling of natural resources and participative governance. (Abraham et al., 2017, p. 8; Hollands, 2008)

Definitions vary depending on the specific city

Now that aims, goals, objectives, categories, and clusters of a Smart City are set, it is necessary to analyse the Smart City strategy of different cities. It is noticeable that cities have different approaches, using the above-mentioned aims, goals, and categories of a Smart City within their guidelines and policies. While some have their own Smart City guideline or framework, others use ideas of a Smart City within existing urban planning policies. An example for this can be seen in the city of Copenhagen, for which ecological issues are particularly important. Thereby Copenhagen subordinates its Smart City concept to this self-image. (The City of Copenhagen, 2020)

While Copenhagen implements ideas of a Smart City within existing plans, cities like Vienna have their own Smart City strategy. Thereby this strategy is its own guideline and not within existing urban planning frameworks. The adaption towards solving urban issues is done in a later stage (Stadt Wien, 2022) Thereby Vienna identified three categories of action:

- Resources (energy, mobility, building, infrastructure)
- Quality of life (social inclusion, health, environment)
- Innovation (research, technology, innovation, economy, education) (Magistrat der Stadt Wien, 2014)

These categories of action are later implemented within the overall Smart City strategy of the city. For the specific characteristics of German cities, the organization *Deutscher Städtetag* suggested in 2015 paying attention within digitalization, virtualisation, and connection of communication, mobility, technical infrastructures, building technologies and production of additionally using criteria of sustainability, efficiency (deceleration, disentanglement, decommercialization) and of the resilience (robustness, resilience, flexible adaptability). (Abraham et al., 2017; Städtetag, 2015)

Summarizing findings

After defining the term of a smart city in a broad way it can be summarized, that there is no unified definition of the term. Different categorizations and clusters in combination with the overarching aims and goals a Smart City can help to overview the different theoretical approaches towards defining the term.

Besides that, currently is a noticeable "tendency towards to equate ideas and concepts of a smart city with those of a sustainable city. This follows the logic, that self-controlling infrastructures and sensors can be easily adapt to individual needs [of its users] and therefore resources (such as energy and water) can be saved" (Abraham et al., 2017, p.

22). Actual examples of cities like Masdar in Abu Dhabi or Songdo in South Korea demonstrate, that smart technologies can have an impact on ecological sustainability, but nevertheless no smart city has been ever completed. Therefore, the holistic effects remain to be seen. (Abraham et al., 2017)

Within this thesis, I take up this point and state, that a Smart City should strive for a sustainable, economic growth and an support in increase in quality of life in harmony with a reasonable usage of natural resources and participatory governance, as stated by Caragliu in 2009. (Caragliu et al., 2009) The risk of both concepts (sustainable development as well as the Smart Cities) of being used inflationary or without content orientation or quality should be thereby avoided. It is a risk, as both concepts are not clearly defined and are multidimensional, which can ultimately lead to a conceptual conjuncture of both concepts. (Abraham et al., 2017)

“However, what is technically feasible is not necessarily what reflects the needs of society. […] Thereby the increasing unreflected transfer of the logic of private sector competition to cities must be viewed particularly critically” (Abraham et al., 2017, p. 39).

The *German Zentrum für Technik und Gesellschaft (ZTG)* summarizes very accurate, that “smart city concepts need to be primarily in harmony with socially negotiated expectations, needs and goals. Instead of asking what’s technically doable, it should be asked, which existing or expected ecological and social challenges should be addressed and with which existing alternative this can be achieved in the best possible way” (Abraham et al., 2017, pp. 39–40).

This viewpoint will form the basis of all further research within this thesis. The later created framework will be based upon these conditions.

3.1.2 Smart city in Germany

A broad definition, related concepts and frameworks of a Smart City are now set. The previous paragraph showed the diversity and versatility of the concepts of a Smart City within the theoretical and academical discussion. But how are the concepts dealt with within Germany? The following section will therefore provide an overview of the terms’ embeddedness in the national and municipal context and relate this to the beforehand mentioned theorems.

Within Germany, the federal government and its related federal ministries are responsible for setting guidelines and principles for the development of Smart Cities within the country. Specifically, the federal ministry of the interior (*BMI*), the federal ministry of housing, urban development, and construction (*BMWSB*) and the federal ministry of digital affairs and transport (*BMDV*) are particularly involved within this process. They are creating the needed national guidelines and frameworks for the national Smart-City-strategy weighing up globally and European interests with national aims and goals. They describe the overarching goal as “designing digitalization strategically and gear towards the common good in the spirit of sustainable and integrated urban development” (BMWSB, 2023b, p. 1).

To understand and support these different interests of the before-mentioned administrative levels, the federal ministry of housing, urban development and construction (*BMWSB*) created the so-called *Smart City dialogue*. (BMWSB, 2023b) According to the federal government, this dialogue “supports Smart Cities in Germany and worldwide in a dialogue between politics, administration, business, science and civil society” (BMWSB, 2023b, p. 1). This dialogue consists of different ‘operating levels’, such as:

- **National level:** At national level the dialogue called *Nationale Dialogplattform Smart Cities* helps to communicate interests of the stakeholders involved. Additionally the *Smart City Charta* sets guidance and goals of all Smart City projects within Germany and strives for “normative guidelines for a sustainable digital transformation of municipalities [and] the development of concrete recommendations for action for the implementation of these guidelines” (BBSR, 2021, p. 7). Furthermore, they promote model projects of a Smart City within the programme *Smart Cities Made in Germany*.
- **European level:** At European level, cooperation, networking, and informational

exchange happens within the programme *Enabling Smart Cities – Approaches for European Networking*.

- **International level:** At international level, a dialogue happens through the development of an *International Smart Cities Network* (ISCN). (BMWSB, 2023b)

Of particular interest within the research of achieving a Smart and Sustainable Mobility within Germany is the *Smart City Charta*, which sets the basic guideline for all Smart City projects and concepts and the national *Smart City dialogue*, which serves as a platform for the exchange of interests of the involved stakeholders. Interestingly, the Smart City Charta thereby refers to 'smartness' in the sense of digital transformation and not as stated by the academic literature as 'smartness' in the sense of a holistic understanding of urban areas, where digital tools are just one element of 'smartness'. They identified four pillars or guidelines for this digital transformation, wherefor a digital transformation needs:

1. Goals, strategies, and structures.
2. Transparency, participation, and co-creation.
3. Infrastructures, data, and services.
4. Resources, competences and cooperations. (BBSR, 2021)

They state that cities, communities, and municipalities need to have an openness to new technologies and "a strong focus on values and objectives" (BBSR, 2021, p. 8). Thereby the participants of the Smart City dialogue base their aims and objectives on "the normative image of an intelligent, future-oriented municipality" (ibid.). Within the *Charta* they are stating that a Smart City is therefore a city, that is "liveable and loveable; diverse and open, participatory and inclusive; climate-neutral and resource-efficient; competitive and flourishing; open-mined and innovative; responsive and sensitive and secure and space-giving" (BBSR, 2021, p. 8) .

This *Smart City Charta* evolved out of the *Smart City dialogue*, which is continuously being further developed. The *Charta* strives for combining overarching goals of urban development, such as participation, resilience, sustainability, and inclusion with the usage of innovation and technology-like approaches. However, care should be taken to ensure that 'smartness' is not solely being seen as a technology-oriented direction. As stated by the research institute *Zentrum für Technik und Gesellschaft (ZTG)* in the earlier paragraph, a Smart City should be characterized by a high quality of life, which should be subject of social negotiation processes. (Abraham et al., 2017)

The negotiation processes can be seen within the *Smart City dialogue*, where various stakeholders discuss together the overarching guidance of a Smart City within Germany. But the overarching goal of a high quality of life is only indirectly involved within the statements of the *Smart City Charta*. Other goals, such as innovation, competitiveness and flourish are given the same status as liveability and lovability. This can be seen as a confirmation of the previously outcome of Hollands article *"Will the real smart city please stand up"* from 2008 (Hollands, 2008), that often cities call themselves 'smart', if they have a strong economic-based viewpoint of a city (in the *Smart City Charta* described as competitiveness) and emphasises the role of the creative- and high-tech-industry (in the *Smart City Charta* described as innovation). The mentioned social and ecological sustainability was mentioned in the *Charta* by stating, that a Smart City should strive for climate-neutrality and resource-efficiency.

It can be summarized, that the national strategies of Germany, such as the *Smart City dialogue* and *Smart City Charta* should be seen as clear examples of theoretical approaches of what a Smart City should be and should strive for. But thereby it needs to be critiqued, that the strong economic viewpoint as well as the strive for innovation based on technology is given too much priority. Instead, the strive for improving the quality of life of everyone as well as the strive for climate-neutrality and resource-efficiency should be emphasised more strongly. Or as stated earlier by the organization *Deutscher Städtetag*, which is responsible to communicate and fosters interests of the local self-government: It should be paid attention to connect ideas of digitalization and virtualisation with criteria of sustainability, efficiency, and resilience. (Städtetag, 2015) Strengthening technological solutions as well as the economic growth should not be considered as an overarching goal

as it is the tool or method to achieve the overarching goals of an inclusive, participatory, resilient, and sustainable city.

Relation to Modellprojekte Smart Cities

Now that the straddling guidelines, aims and goals of the national Smart City strategy are understood, it is important to understand the promotion, development, and realisation of specific Smart City projects within Germany.

The underlying *Smart City Charta* and the *Smart City dialogue* form the basis of the so-called programme *Modellprojekte Smart Cities* (MPSC). These federally funded projects are experimental laboratories striving for an integrated urban development within the sense of a Smart City as defined by the *Smart City Charta*.

Since 2019, the federal government has been funding various 'Smart City model projects' in three phases. Thereby "municipal, interdisciplinary, and spatially-related Smart City strategies and their implementation as well as the necessary development skills are supported" (BMWSB, 2023b, p. 1). The goal is to test Smart City concepts and implementation measures in numerous German cities, districts, and municipalities of all sizes to "use the opportunities of information and networking technologies in the sense of sustainable and integrated urban development. The Federal Government is currently funding 73 Smart Cities model projects, which have been selected in three seasons since 2019, with a total of 820 million euros" (BMWSB, 2023b).

Profiteers of these fundings are independent think tanks, research institutes, and private companies as well as the municipalities and cities itself. These model projects can (after a successful implementation within the specific city or community) be later scaled upwards for other cities. This can help to transfer knowledge and technological developments.

To summarize the findings, it can be analysed that the German national Smart City strategy is partially in line with academic theorems about Smart Cities. Even though it emphasises goals, such as inclusivity, higher quality of life and sustainability, a tendency towards economic growth and the implementation of technological-based solutions can be seen. This partially reduces the importance of achieving a higher quality of life as suggested by academia in the sense of using technology as a tool and not an overarching aim. Nevertheless, especially the Smart City dialogue for communication of various stakeholders and the Smart City model projects can help to develop and realize specific Smart City project, that achieve a higher quality of life, resilience, and sustainability of urban areas of the future in the sense of the interests of its participants.

3.1.3 Smart and Sustainable (urban) Mobility

While concepts, frameworks and understanding of a Smart City and its embeddedness within the German context is now understood, a following analyses of academic approaches towards defining Smart and Sustainable (urban) Mobility is needed. This is needed, as Smart Mobility is part of the theorem of a Smart City, as described by Giffinger in 2007. (Giffinger et al., 2007)

Thereby defining the term of Smart (sustainable) Mobility is a complex task. As examined by Lyons in 2018 there exists "a lack of consensus in terms of smart cities and a paucity of literature seeking to make sense of smart urban mobility" (Lyons, 2018, p. 1). Thereby different organizations, research institutes and universities use diverging definitions, depending on individual projects or research purposes. An understanding of the existing scientific discourse will underpin the diverse approaches towards defining it.

The following section provides an overview of existing approaches. Therefor various theories and definition approaches will be combined with the current state of research. Based upon these findings, the author will lastly create an own definition, which will represent the fundamental basis for the upcoming evaluation matrix.

Defining the terms smart, sustainable and mobility

The *Cambridge Dictionary* defines the adjective ‘smart’ as a synonym of ‘intelligent’ with its meaning of something or someone having “the ability to think quickly or intelligently in difficult situations” (Cambridge Dictionary, 2023a, p. 1). This generic definition must now be set in relation to urban mobility. One of the most recognized authors in this field with various papers und publications about Smart Cities and Mobility is Glenn Lyons, who tried to approach the terms of Smart and Sustainable Mobility in his paper *Getting smart about urban mobility – Aligning the paradigms of smart and sustainable* in 2018 (Lyons, 2018). In this work, Lyons stated that “being technologically sophisticated may not always be smart” (Lyons, 2018, p. 9)

This approach is also being represented in various planning guidelines and frameworks of cities and municipalities, such as Berlin. Within its Smart City strategy, the so-called *Gemeinsam Digital: Berlin*, the authors are stating, that the term ‘smart’ goes beyond the term of making something just ‘digital’ (Stadt Berlin, 2022). Instead, ‘smartness’ should “aim at [answering] the question, how future challenges can be solved creatively, openly, expediently and participatory” (Stadt Berlin, 2022, p. 9). This results in the fact, that various theories, frameworks, and ideas should be considered while analysing the ’smartness’ of something or someone, not just the ‘digital’ aspect. Therefore, the following sections will go beyond the often-caused relationship of ‘smartness’ and ‘digitalization’. The later presented frameworks, projects and best practices will consider these basic assumptions.

While defining ‘smartness’ is certainly the most controversial and complex step, the definitions of ‘sustainability’ and ‘mobility’ are no less important in the context of this work. Thereby being ‘sustainable’ is often addressed of something being “able to continue at the same level for a period of time” (Cambridge Dictionary, 2023b, p. 1). Despite this generic definition, the author follows the idea, that ‘sustainability’ can be seen as something “causing […] little or no damage to the environment and [is] therefor able to continue for a long time” (Cambridge Dictionary, 2023b, p. 1). The term of ‘environment’ does not solely refer to an ecological dimension, rather to an economic, social, and environmental one. For a deeper understanding of Lyons’ call, that mobility systems need to be sustainable from these beforehand mentioned three dimensions, it is needed to deeply understand the meaning of what the term of ‘mobility’ stands for?

While Lyons describes mobility as an overall concept, that “concerns the freedom to, and ease of being able to connect between people, goods, services and opportunities” (Lyons, 2018, p. 9), the definition of the *German Zukunftsinstitut*, stating, that mobility “describes all possibilities and abilities for overcoming space, including their subjective perception and the evaluation of alternatives”. The difference between these meaning is the connection of the term ‘mobility’ towards a physical component. Within the following chapters, this work will not solely evaluate the overcome of physical space, but likewise the connection of services and information. This will be set into relation to transportation and its different modes. The meaning of this will be explained in a later section.

Relationship of smartness and sustainability to mobility

Now that all stand-alone terms are defined, the following section will relate these individual terms to each other. This will allow an intersecting understanding of ‘smartness’ and ‘sustainability’ in relation to mobility and will result in a fundamental basis for formulating an own interpretation. Firstly, a relation between ‘smart’ and ‘mobility’ will be drawn.

As described by Lyons in 2018 Smart (urban) Mobility can be seen as the “connectivity in towns and cities that is affordable, effective, attractive and sustainable” (Lyons, 2018, p. 1). Thereby, the separate words are described as following:

- **Connectivity** means to overcome a distance from point A to B with a certain mode. Connectivity should not only recognise the physical mobility of people and goods but also the reduction of distances for travelling and the finding of active travel alternatives. (Lyons, 2018) An example can be given by several digital devices, such

as laptops and smartphones, which indirectly have led to a decrease in travel distances (e.g., a book can now be read on a computer instead of 'travelling' to a library, which safes time, costs, and most important reduces the individual mobility).

- **Affordable and effective** relates to urban mobility system providers and their resources and means to have affordable and effective transportation modes for its users. (ibid.)
- **Attractiveness** means having a mobility system, that is attractive for its users (everyone). Being attractive includes to meet the needs of its users, considering its impact and effect on the experience of urban living and working, high maintenance and return of investment. (ibid.)
- **Sustainable** relates to the mobility system, which needs to be sustainable (under the given definition of it) from an economic, social, and environmental perspective. Thereby sustainability itself is the inclusion of the previously mentioned terms (connectivity, affordability and effectiveness, attractiveness)

The hereby used approach of Lyons for defining Smart Mobility is mainly based upon its criteria, that needs being fulfilled to be called 'smart (urban mobility)'. As mentioned beforehand by Lyons, a final definition of Smart urban Mobility is not solely about enhancing mobility systems by advanced technology, rather the connectivity of urban (and respectively rural) mobility systems, that are affordable, effective, attractive, and sustainable. But mobility is not solely about a spatial characteristic, but also about an immaterial one. This will ultimately lead towards the cognition:

> *"Technology has an important part to play, without question. However, technological possibility, driven by commercial attractiveness of innovation potential, may risk lessening the important attention that should be given to helping deliver connectivity in towns and cities that is affordable, effective, attractive, and sustainable. There is a need to ensure that the paradigms of smart urban mobility and sustainable urban mobility are aligned. To a significant extent, this is about bringing technological and social considerations closer together and ensuring due importance it attached to both"* (Lyons, 2018, p. 12).

Summarizing, that 'Smart urban Mobility' is not solely about moving people and goods around urban areas, but rather including the consideration of land use systems, transport systems, and telecommunication systems. (Lyons & Davidson, 2016)

While this definition will be used as the fundament of the upcoming, another definition of Melo in his paper *Guiding cities to pursue s smart mobility paradigm* from 2017 should be considered: "Smart mobility aims to improve the mobility of passenger and commercial vehicles, as well as to reduce environmental impacts and improve the social well-being" (Melo et al., 2017, p. 25). While this definition describes the overarching goal of 'Smart Mobility', it does not describe the practical tools, with which it can be achieved. Therefore, Brenner gave a possible intellectual approach, differentiating between 'smart' and 'dumb' technologies. She assumes, that "[a]n active human being uses passive, dumb technology (a simple tool or mechanical device)" (Brenner, 2007, p. 4). She suggests human beings are moving forward from using 'dumb technologies' (e.g. a telephone) to interacting with 'smart technology' (e.g. personalised journey planning apps) that "exist to help us, serve us, to make our lives easier and more interesting" (Brenner, 2007, p. 4).

This can lead us to the conclusion, that Smart Mobility is the connectivity in towns and cities, that fulfils the criteria of being affordable, effective, attractive and sustainable (Lyons, 2018) with the goal of reducing environmental impacts and improve social well-beings. This can (but not necessarily needs to) be achieved by using smart technology, such as "using technology to generate and share data, information and knowledge, that influences decisions but also using technology to enhance vehicles, infrastructure, and services" (Lyons, 2018, p. 7). But despite focussing exclusively on technological support, smart urban mobility should simultaneously aim for "improvements [of] transport system operators and users and for shareholders" (ibid.) to meet users' needs. "All of the aspects associated with

smart mobility, such as smart energy, people, environment etc. taken as a supportive system are a supportive environment for the implementation of sustainable, resource-efficient and climate-friendly modes of transport" (Abraham et al., 2017, p. 34). Concrete use cases can be seen in the usage of technologies for new ways of transportation, such as e-bikes, digital services in transportation and ridesharing and the optimization of existing transportation modes, such as multi-functional and multi-modal mobility services, integrated infrastructure service providers and participatory planning processes. Additionally, an analysis of social behaviour (behaviour analytics) of human mobility and the usage of geographical-informational systems (GIS) for this can play an important role in the future. (Abraham et al., 2017)

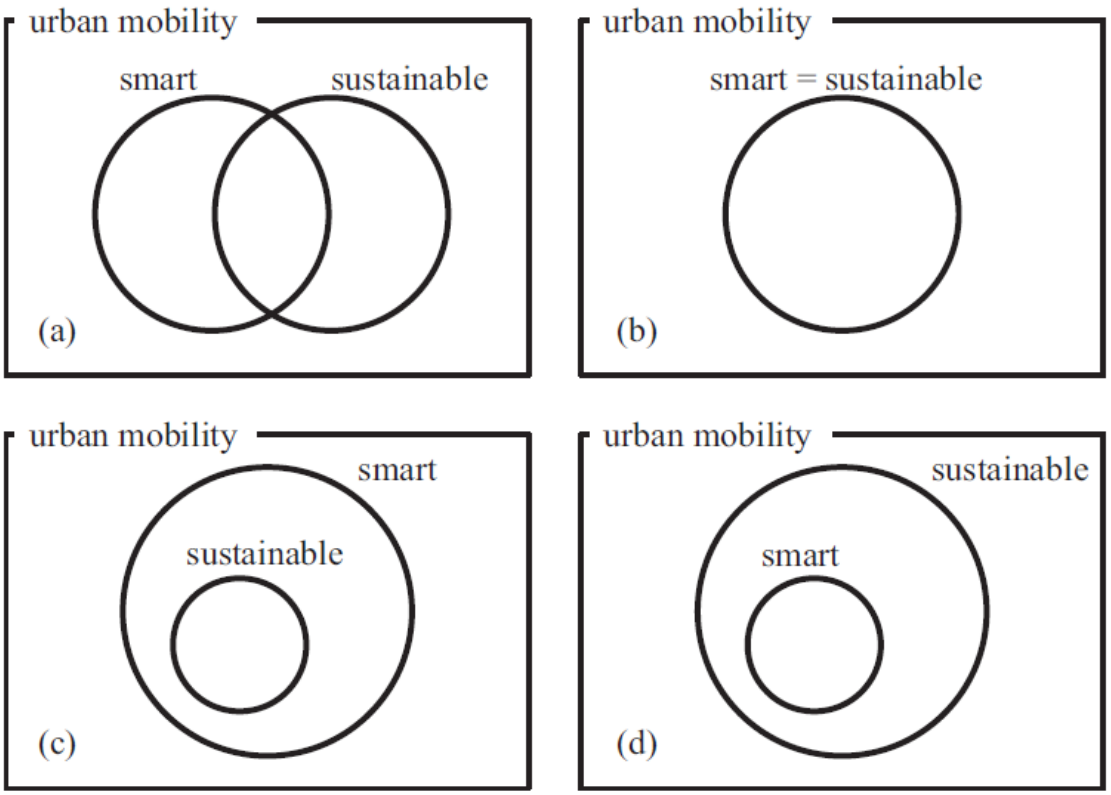
The above-mentioned approaches of Smart Mobility are complemented by considering the term of sustainability within it. Thereby "exists the risk in a one-sided idea of efficiency enhancement and efficiency and technical innovations, which smartness that neglects social innovations and more fundamental questions about sustainable lifestyles and economic styles" (Abraham et al., 2017, p. 36). For avoiding this existential risk, the following section will deep-dive into an analysis of sustainable approaches within mobility, resulting in a broader understanding of its connections.

Lam and Head described in their paper *Sustainable urban mobility* in 2012, that Sustainable urban Mobility is about "the ease, convenience, affordability of travelling to one's destination with minimal impact on the environment and others" (Lam & Head, 2012). This definition implies the environment itself (which can be seen as the ecological but also physical dimension), but also the impact on 'others', which implies the social dimension of sustainability. They are suggesting, that accessibility and convenience can be increased "with good urban design, behaviour change, advance in technology, supportive policies, economic incentives and city engagement and leadership" (Lam & Head, 2012, p. 359). As described before, the usage of digital tools is solely one possible aspect for achieving a more Sustainable (urban) Mobility. Other tools, such as policy making, providing governmental incentives, and fostering a behavioural change are also seen as potential solutions.

In his paper *The sustainable mobility paradigm* Banister sets out a sustainable (urban) mobility approach that "requires actions to reduce the need to travel (less trips, to encourage modal shift, to reduce trip lengths and to encourage greater efficiency in the transport system" (Banister, 2008, p. 75). He "highlights the need to make best use of technology, particularly in reducing the need to travel but also in addressing efficiency of mobility (in relation to energy use and emissions)" (Banister, 2008) (Lyons, 2018, p. 8). This seems to be partially contradictory to the mentioned definitions, that 'smartness' is not solely about 'digitalization' or using technology. But instead, it should be seen as technology supporting mobility changes towards a higher level of sustainability. Lyons illustrated in his paper in 2018 (Lyons, 2018) four different scenarios, how 'smart' and 'sustainable' can interrelate to each other. The following four diagrams reflects their interweaving, thereby the diagrams can be described as following:

- A) "[For some a] present reality, in which smart and sustainable are not opposing paradigms but are nevertheless not in all respects in harmony:
- B) [For some an] optimal reality in that all that is smart is sustainable and vice-versa as terminologies, or more importantly their meanings, converge:
- C) [For some a] dystopian reality in which the paradigm of smart has become dominant and has 'consumed' the diminished paradigm of sustainable […]
- D) [For some a stronger level of stewardship over urban futures] in which the smart paradigm is subservient to the sustainable paradigm, with the former 'confined' to contributing to the latter" (Lyons, 2018, p. 8).

Figure 5: Alternative Venn diagrams of urban mobility, explaining the relationship between 'smart' and 'sustainable' in the context of urban mobility



Source: *Lyons 2018*

Within this thesis, the focus lies on building a framework and approach toward Sustainable, Smart Mobility, that either fosters an urban future towards scenario A) or B). Thereby, sustainability and smartness should not be seen as opposing paradigms but rather mutually supportive paradigms (A). The second option is, that both terms are seen vice-versa terminologies, which means that by saying 'smart' someone automatically refers of something being 'sustainable'.

Applications of the terms in practice

All the discussed terms of (urban) mobility, smartness and sustainability are often used in practical urban and traffic planning, as well as research institutes, think tanks and municipal departments as underlying guidance for a 'smarter' urban future of the respective city. A good 'real-life' example, how governments define the term was already done in 2006 by the *UK Governments' Foresight Programme* under its title *Intelligent Infrastructure Futures*, that divides the term into four sub-aspects (thereby 'smart' could be substituted for 'intelligent'):

- *"Intelligent design, minimising the need to move, through urban design, efficient integration and management of public transport and local production.*
- *A system that can provide intelligence, with sensors and data mining providing information to support the decisions of individuals and service providers.*
- *Infrastructure that is intelligent, processing the mass of information we collect and adapting in real time to provide the most effective services.*
- *Intelligent use of the system where people modify their behaviour to use infrastructure in a sustainable way"* (Office of Science and Technology, Department of Trade and Industry, 2006, p. 10)"

Even though, this clustering of the terms happened (historically speaking) before the above-mentioned discussions, it revealed a first glimpse, how defining clusters and areas of action

could help cities and towns to further use and implement these ideas into practise. Thereby being smart or creating something smart is not mainly about the used tool or method (which nevertheless plays an important role), rather than its overall aim or goal. The goals are defined by users' needs (such as a better public transportation), systematic needs (such as a mobility change towards higher sustainability) and a behavioural change (such as the understanding of a mobility shift from motorized individual transport to a shared economy). Or by saying it with the words of Lyons: "The pursuit of smart urban mobility should […] be about improving the fulfilments of access needs, [which] concerns:

- Influencing how we connect
- Minimising the externalities of connection
- Supporting how we connect" (Lyons, 2018, p. 10).

Smart Mobility concepts can (if well done and equipped with a well-thought target) achieve a more sustainable future, e.g., by using "new forms of propulsion; new forms of vehicle control; changing business models of vehicle ownership and use; mobile technologies that equip and empower individuals; and opportunities to undertake activities without the need to travel" (Lyons, 2018, p. 5). In a later stage of my thesis, these categories, and clusters of developments of Smart, Sustainable Mobility concepts will be used for identifying different clusters of digital mobility concepts.

Developing an own definition of smart and sustainable mobility

The authors supports the statement, that "digital technologies are seen as an important tool for a sustainable and public welfare-oriented transformation of the city but not as an end in itself" (Stadt Berlin, 2022, p. 9). Nevertheless, as in above mentioned approximations of a definition, smart technologies are available funds for increasing sustainability (in regard to ecological, economic, and social aspects) in mobility. In the centre of attention of this own perception of a definition of Smart (urban) and Sustainable Mobility the basis of the later created framework will be the aims and goals of the mobility of the future. This mobility needs to be based upon users' needs in a sustainable way. Innovation and digitalization must serve as 'neutral' tools in favour of its users. The needs and demands of the civil society are the fundamental basis of its success.

Underlaying international, European and national guidelines, policies and frameworks, such as the *SDGs* by the *UN* (United Nations, 2023), the *Paris' climate agreement* (UNFCC, 2023), the *donut-economy model* (DIfU, 2022) or the *Urban Agenda* (UN-Habitat III, 2017) should be the underlying principles, that policy makers, politicians and planners in all fields should follow to create sustainable, common-goods oriented, cooperative, socially balanced and resilient cities of the future. These international frameworks are the guiding basis for the development and realization of smart and sustainable (urban) mobility concepts.

Summarizing, that the author defines Smart and Sustainable (urban) Mobility as the connectivity in urban areas, that are affordable, effective, attractive and sustainable (Lyons, 2018) to fulfil users' needs. Sustainable mobility thus identifies by the ease, convenience and affordability of travelling towards a destination with the minimal impact on the environment (Lam & Head, 2012), whereby environment is not solely defined by an ecological, but also an economic, and social dimension. Smartness and sustainability should be considered together by either being two different but not opposing paradigms or converging terminologies, that can be seen as one. Mobility cannot be considered smart, if its underlaying concepts do not strive for a higher ecological, economic, and social dimension.

The following chart was developed by the author, following the above-mentioned definitions and described the precise steps, cities and towns should strive for while implementing Smart and Sustainable (urban) Mobility-concepts. Basis of them were the mentioned definitions (for defining the categories) and international guidelines (for defining the description of the criteria). Thereby these criteria define all further work of this thesis. All upcoming frameworks, guidelines and projects will be evaluated accordingly to this chart of

criteria. This subsequently means, that every city project needs to fulfil at least one of the criteria (better more) to be called a ‘smart and sustainable mobility concept or project’:

Table 1: Table of parameters of smart and sustainable (urban) mobility

Criteria number	**Category**	**Description of criteria**
1.1	Sustainable mobility (as defined by Lam & Head; *German Zukunftsinstitut;* author)	Less emitted greenhouse gas emissions, such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) with constant mobility offers. (UNFCC, 2023; United Nations, 2023)
1.2		Less motorized individual transportation, such as cars, trucks, scooters, and more active mobility, such as walking and biking. (Lam & Head, 2012; Office of Science and Technology, Department of Trade and Industry, 2006)
1.3		Less long-distance travelling with transportation modes, such as airplanes and cars. (Lam & Head, 2012; Office of Science and Technology, Department of Trade and Industry, 2006)
1.4		Less used means of motorized, individual transport modes, such as cars, trucks, busses, airplanes, trains. (Banister, 2008; Lam & Head, 2012)
1.5		Reduced occurrence of congestions of motorized individual transportation. (Banister, 2008; Brenner, 2007)
1.6		Enhancement of micro-mobility supply to support last-mile transportation modes. (Lyons, 2018; Lyons & Davidson, 2016)
1.7		Support of digital devices for navigation within urban areas, such as displays and monitors. (Banister, 2008; Brenner, 2007)
2.1	Satisfaction of users’ needs (as defined by Lyons)	Less travel and commuting distances while fulfilling the same needs and satisfaction of its users. (Banister, 2008; Brenner, 2007)
2.2		Enhancement of user-friendly digital services for ticketing and navigation of public transportation modes. (Brenner, 2007)
2.3		Support of easy-to-use digital services in public transportation. (Brenner, 2007)
2.4		Optimization of demand-based public transportation to fulfil users’ needs and satisfaction.
2.5		Decrease of pricing for public transportation modes, such as trains, trams, busses, and subways while increasing the pricing for motorized individual transportation modes, such as cars, trucks, and scooters.

2.6		Good reachability of and easy access to public transport stations.
2.7		Increase in shared mobility offers of different transportation modes.
3.1	Smartness (as defined by the *ZTG*)	Using information and communication technology (ICT) to gain information about the built environment.
3.2		Usage of physical devices (such as sensors and cameras) to observe the built environment.
3.3		Intersection of different urban parameters and sectors by using software technologies for analysis, modelling and simulation.
3.4		Integration of obtained results from digital devices, models and simulations within existing municipal mobility guidelines and frameworks.
3.5		Usage of software-applications to increase the usage of public transportation and shared mobility offers.
3.6		Support of digital services and applications for sustainable transportation modes, such as electric cars, busses, trucks, bikes, autonomous vehicles, and SAVs.
3.7		Linkage of different transportation modes in one physical spot (e.g. with micro-mobility-stations)

Source: Elaborated by the author

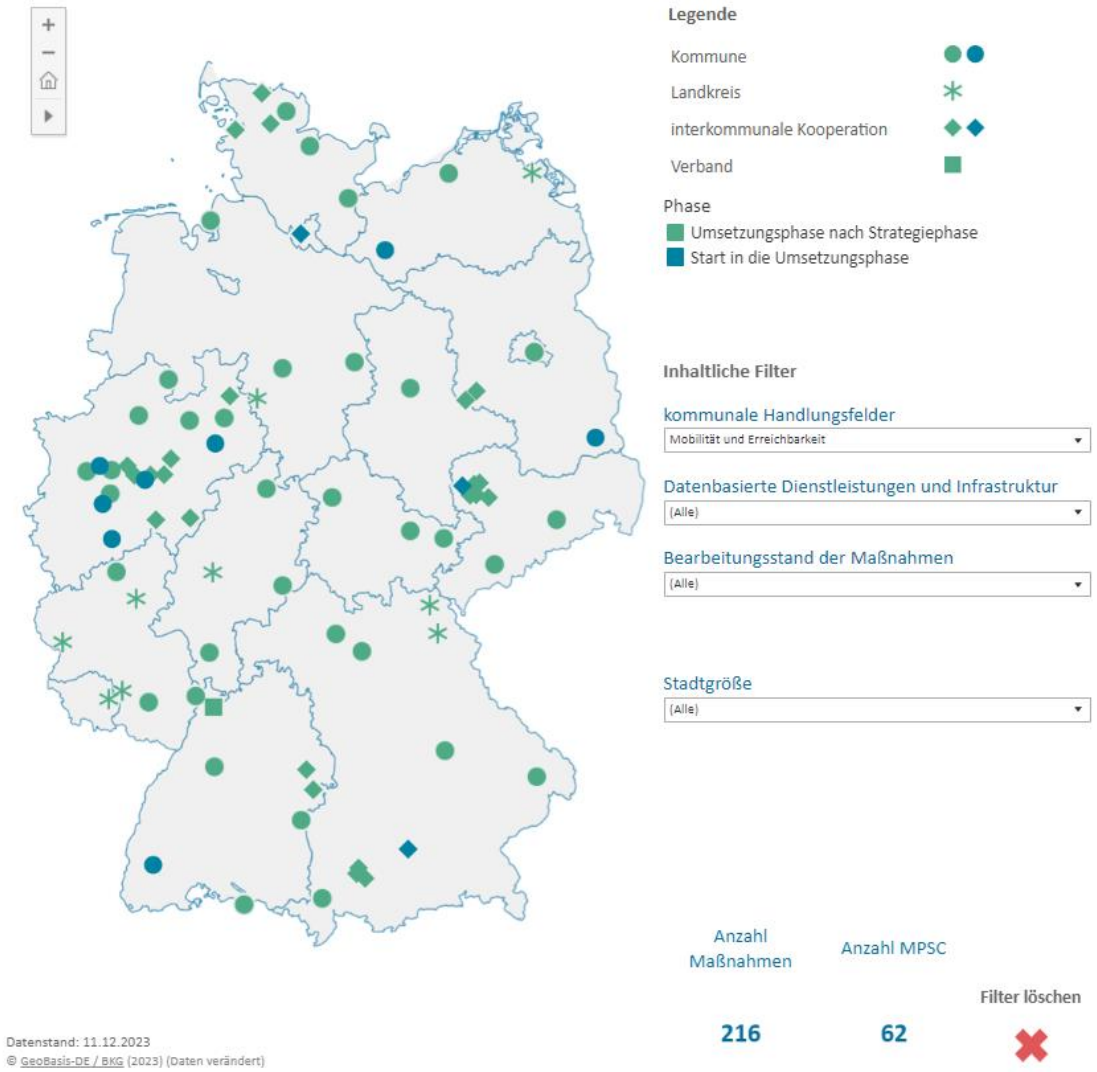
At least one of these criteria needs to be fulfilled within an urban planning guideline or a precise mobility project for calling the respective project a Smart Mobility-concept, that strives for sustainability. Smartness is thereby no inherent criteria, moreover it should be seen as the defining frame to achieve a sustainable, need-based mobility of the future.

3.1.4 Smart and Sustainable (urban) Mobility in Germany

As described in the section about Smart Cities in Germany, the federal government has spent about 820 million since 2019 to fund various ‘Smart City model projects’ in three phases. (BMWSB, 2023b) Thereby they identified 73 Smart City model projects (MPSC) with accumulated 659 actions. (BMWSB, 2023c)

An interactive website of the responsible federal ministry of housing, urban development and construction allows to navigate and filter these 659 accumulated actions. An analysis of all model projects undertaken in the mobility category revealed, that German-wide 62 administrative units, such as cities, municipalities, or counties with overall 216 local actions are dealing with Smart Mobility. The following map provides an overview of the geographical distributions of these projects within Germany (ibid.):

Figure 6: Smart Mobility projects under the MPSC-program within Germany



Source: *BMWSB 2023*

As described earlier, the total sum of all funded administrative units within the MPSC-funding-programs adds up to 73. As visualized in the map above, 62 administrative units (such as cities, municipalities, or unities) participate with at least one precise action in the field of mobility and accessibility. Therefore about 84% of all funded cities, municipalities and unities within Germany are operating within the field of Smart Mobility, about 1/3 of all precise actions and projects (216 actions/ projects out of 659 overall) are within the category of mobility and accessibility. (ibid.) This high percentage can not only be seen as an indicator of the importance of the topic, but beyond that as a confirmation of the relevance of ‘smart’ mobility planning and ‘smart’ accessibility.

Thereby the focus of the used tools and methods to achieve a Smart Mobility differs depending on the individual city or region. While some aim for the creation of a digital application, a data visualization, or a digital platform (e.g. for sharing data), others develop a whole digital twin of their city or region, use artificial intelligence or control traffic by means

of new management tools. Likewise new planning and modelling tools, sensors or *LoRaWAN*-Networks or approaches of Smart Meter or Smart Grid are used, as well as new ideas for network infrastructures, virtual and augmented reality, and gamification. Lastly, some actions or projects aim for an increase in cyber security, standardization, or data sovereignty. (ibid.) While a deeper analysis of all 216 precise actions and projects within the category of Smart Mobility would go beyond the scope of this work, a concrete analysis of the actions within the city of Berlin is needed.

Berlin as a city has five funded actions or projects within the MPSC-program. Thereby two precise projects aim in improving the cities mobility or accessibility. The first one is called *SMART SPACE Hardenbergplatz*, aiming in researching mobility patterns close to *Zoologischer Garten* in *Berlin-Charlottenburg*. The second one is Kiezbox 2.0 aiming in maintaining of communication and mobility in crisis situations. Both will be presented in chapter 6, describing the specific case study.

The previous paragraph illustrated, with which intensity cities and municipalities pushes in the direction of realizing model projects in the field of mobility and accessibility. The analysis of the MPSC-program revealed a strong tendency of developing various digital solutions for a better understanding and planning of mobility. Thereby Smart City-solutions are often closely interlinked with finding planning solutions (with the use of ICT) in the field of mobility as well as accessibility.

3.2 Sustainable mobility

Smart Mobility concepts needs to have a sustainable component. This derives out of the previously given definition by the author and in accordance with the given interrelation between smartness and sustainability of Lyons from the previous chapter.

Thereby something can solely be seen as smart as it is sustainable. Smartness and sustainability are not opposing paradigms, rather complementary theories. They are either two existing paradigms that exists both at the same time and complement each other or are vice-versa terminologies, whose interpretations overlap. (Lyons, 2018)

While smartness with its complexity was already explained before by using theorems about Smart Cities, the terminology of sustainability is not fully set into relation to mobility so far. Therefore, the following chapter will provide a summary of indicators and parameters, that define sustainable mobility. This will be set into relation to current mobility trends and patterns and are applied to the example of Germany and Berlin.

3.2.1 Sustainable mobility concepts and theories

Sustainability is one of the biggest trending words, both in academia as well as in practical applications. The term needs to be filled with life in accordance with its original meaning. As described by the Cambridge dictionary and already stated earlier within this work, sustainability is the “ability [of something] to continue at the same level for a period of time” (Cambridge Dictionary, 2023b, p. 1) and should cause little or no damage to the environment. (Cambridge Dictionary, 2023b) Beside that, the authors support the idea, that sustainability does not solely describe an ecological, rather an economic, social, and environmental one. This is the only way to do justice to the complexity of the term.

Mobility systems of all kinds needs to be adapted, planned, and executed in line with the definition of sustainability just given. Sustainable Mobility is about “the ease, convenience, affordability of travelling to one’s destination with minimal impact on the environment and others” (Lam & Head, 2012) as well as including social, economic and ecological interests of all participants. Beyond the physical dimension (in form of travelling to one’s destination) mobility can also have a non-physical dimension, e.g. in form of mobility of information or knowledge. This non-physical dimension needs to be included within the previous definition as well. Accessibility and convenience of Sustainable Mobility concepts can be increased using good urban design, behaviour change, advance in technology, supportive policies, economic incentives and city engagement and leadership” (Lam & Head, 2012, p. 359). As described before, the usage of digital tools is solely one possible aspect for achieving a

more sustainable (urban) mobility.

While we have now set the theoretical framework for sustainable transport concepts, we still need to identify its measurable and non-measurable parameters. Therefor the previously given parameters are now used. They can be summarized as following (elaborated by the author):

- **Environmental sustainability:** less GHG-emissions (carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)) of all transport modes, Less motorized individual transport modes and higher share of active mobility in model shift, less long-distance travelling, less carbon dioxide emissions in the construction process of infrastructure (highways, roads, rails, tunnels, bridges) including less usage of concrete and steel concrete as a construction material; strengthening of sustainable energy sources for transportation, such as electricity (from solar, photovoltaic, wind, water) instead of unsustainable energy for transport, such as petrol, gas and diesel.
- **Economic sustainability:** Better on-demand transportation adapted to users' needs and satisfaction; adapted prices of public transportation modes (subway, train, tram, busses) according to the economic situation of its population, fostering of public transportation over individual transportation including the therefore needed policies.
- **Social sustainability:** Improved supply-demand offer for users of public transportation, increased adaptation of public transportation towards users' needs, optimized routes for commuting, less commuting in general because of increased role of home-office, reduced occurrence of congestions higher punctuality of public transport, lower prices, and easier access to tickets for users (digital and print), Support of digital devices for navigation within urban areas, such as displays and monitors, easy-to-understand structures of tickets and prices, Enhancement of micro-mobility supply to support last-mile transportation modes and fulfil users' needs.

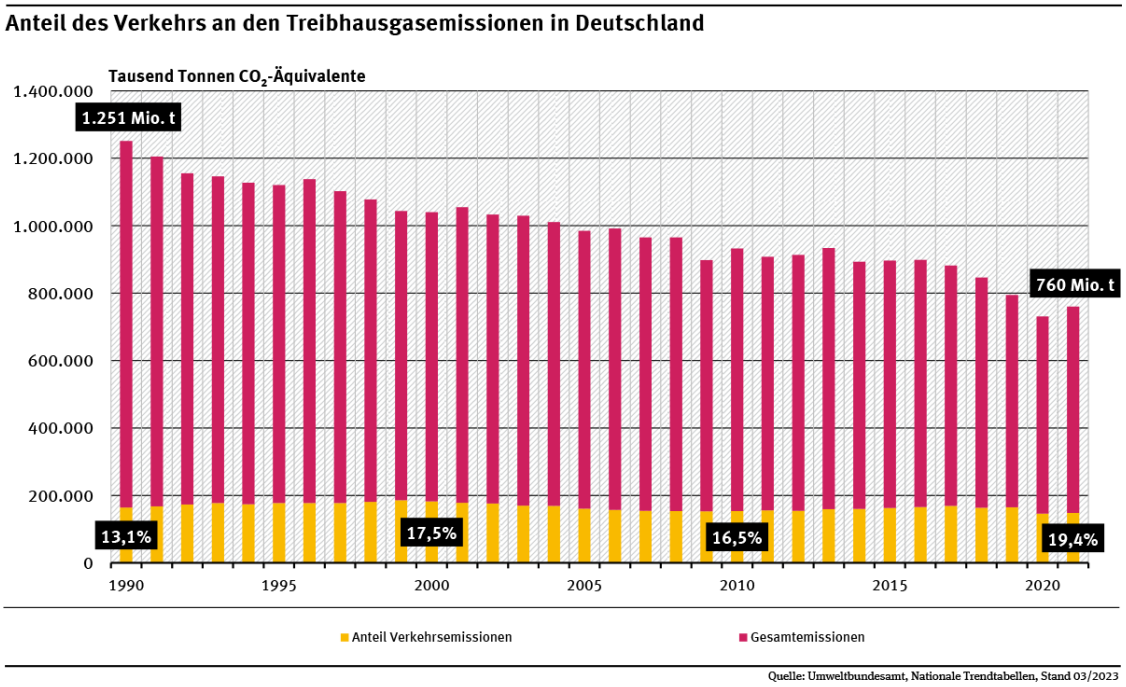
Or as summarized by Banister in 2008, Sustainable Mobility approaches "requires actions to reduce the need to travel (less trips, to encourage modal shift, to reduce trip lengths and to encourage greater efficiency in the transport system" (Banister, 2008, p. 75).

3.2.2 Current mobility trends and patterns in Germany

After the theoretical definition of sustainable mobility, these theorems need to be set into relation to a spatial context: in this case of Germany and more specifically Berlin. Thereby the following section provides a brief historical overview of mobility patterns and changes and the development of Sustainable Mobility (as defined before).

The GHG-emissions (carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)) in Germany have fallen rapidly since 1990 but there has been hardly any improvement in the transport sector. While the total amount of emissions is constant, the share of it in the total emissions increased from around 13% (in 1990) to 19,4% (in 2021), mainly due to a constant growing road freight transport, motorized private transport and increase in sales of diesel fuel. (Wilke, 2023a) The following graphic from the German *Umweltbundesamt (UBA)* displays this:

Figure 7: The share of the transportation sector in total greenhouse gas emissions over time in Germany according to the Umweltbundesamt (UBA) (2023)



Source: *Umweltbundesamt (UBA)* 2023

The graphic illustrates, that total greenhouse gas emissions of all sectors (displayed in red) have fallen from 1.251 million tonnes in 1990 to 760 million tonnes in 2021. While this is a slow but constant improvement of environmental policies on all administrative levels and technological enhancements, the transport sector shows no significant improvement. While in 1990 about 164 million tonnes of GHG-emission were emitted by the transport sector, in 2021 still round 147 million tonnes were emitted. And thereby the role of the COVID-pandemic on transport must also be considered. The small changes of the transport sector in the total number have a negative effect on the percentage share. While the share of the transport-sector of the total GHG-emissions added up to 13,1% in 1990, the share increased up to 19,4% in 2021. (Wilke, 2023a)

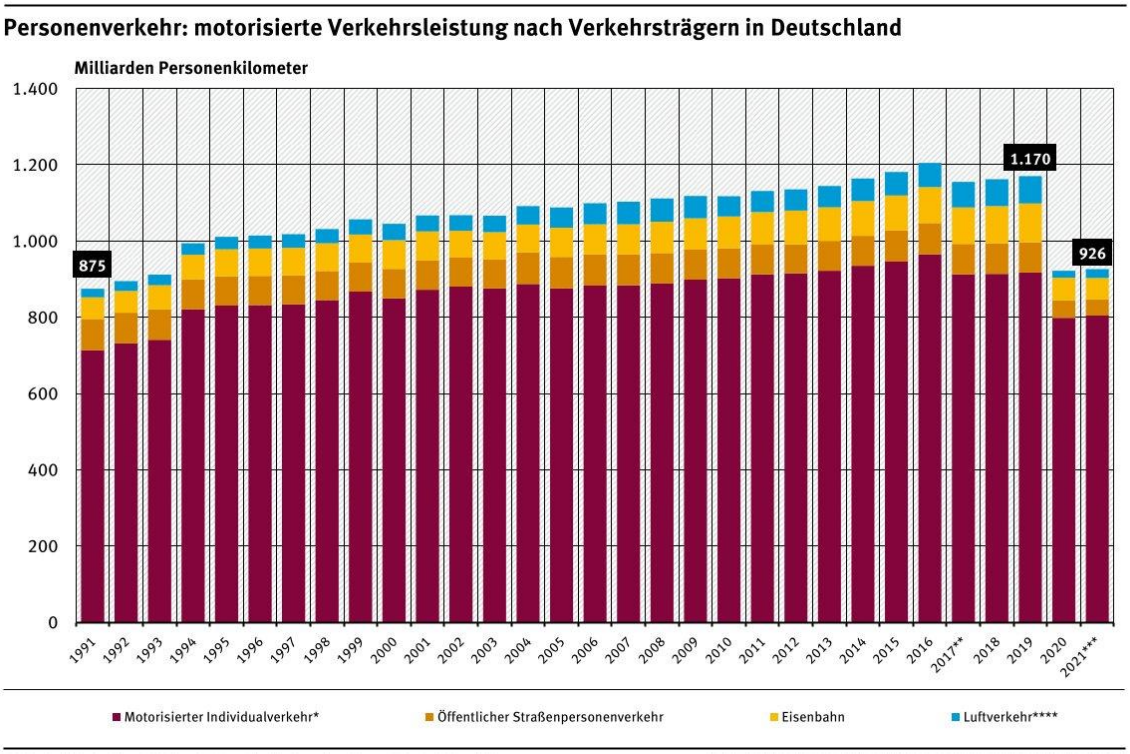
Traffic is thereby responsible for almost 37% of emission of nitrogen oxides in the air and 51% of total particle emissions in Germany due to motorized road traffic. (Wilke, 2023a) While we can see that GHG-emission of transportation stagnates since 1990 and its share in total emissions even increased, motorized individual transportation is more climate and environmentally friendly today. “On average, cars today pollute the environment per kilometre driven less than in the past” (Wilke, 2023a, p. 1). The two main reasons for this are:

1. The legislature has gradually tightened emissions regulations for newly registered cars. This resulted in an improvement from the car manufactures, providing improved engines and exhaust technology.
2. Regulations committed to improve the quality of fuels placed on the market.

But on the other hand, an increase in total traffic usage, especially of motorized individual transportation, can be seen. This results in the huge increase of cars used (+21% from 1995 to 2019) and almost 3% higher mileage in 2021 compared to 1995. (Wilke, 2023a) and leads to less kilometre-related CO_2 emissions in passenger car traffic but a higher total CO_2 emission. One reason for this is the increase in mileage, another one is the trend to larger and heavier vehicles.

The following graphic illustrates the importance to tackle especially the motorized individual passenger transport (illustrated in dark red). Its share of about 80% in the modal split of used transport modes was within Germany between 1991 and 2021 always the highest. Other modes of transport, such as public road passenger transport (ochre), railway (yellow) or air transport (blue) are merely secondary sources of pollutant-related environmental pollution from transport:

Figure 8: Modal split of motorized transport performance by mode of transport in Germany from 1991 to 2021 in billion kilometres

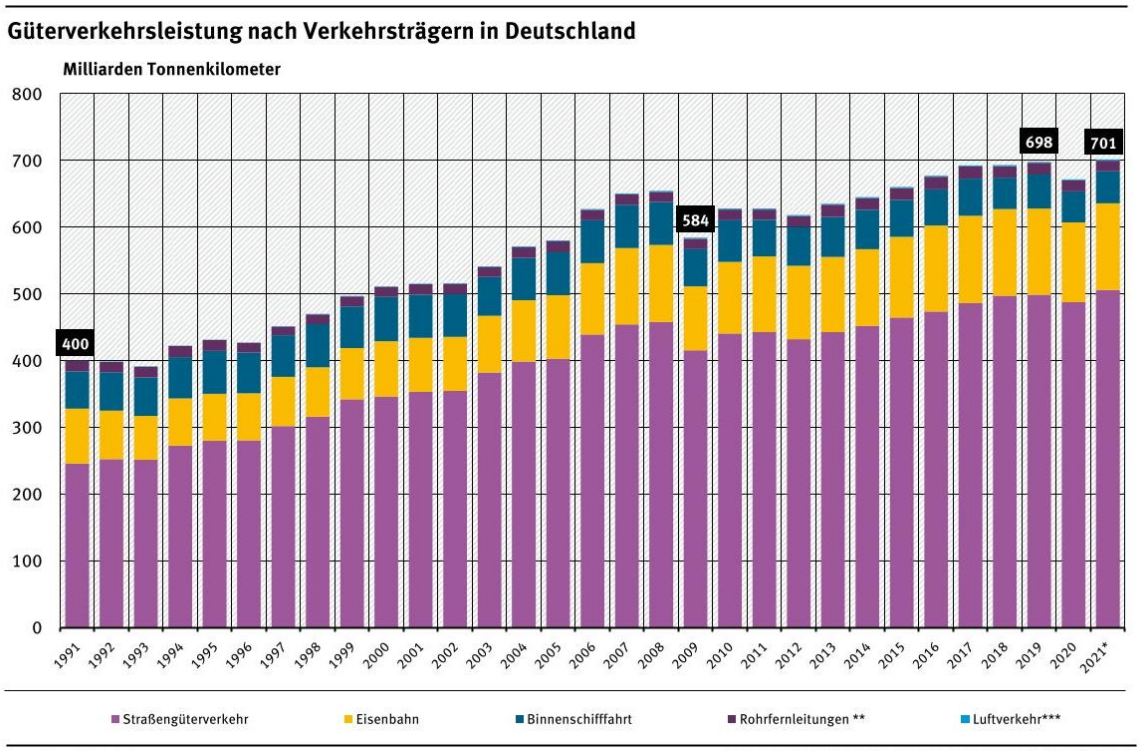


Source: *Umweltbundesamt (UBA)* 2023

This emphasises, that most actions, regulations, and policies should focus the role, handling, and planning of infrastructures for motorised individual transport. As cars, mini-busses, and trucks of all kinds are the most dominant mode of transport, they emit the highest amount of total GHG-emissions. But at the same time, they are under certain restrictions, one of the most convenient modes of transport and obviously are fulfilling (to some extend) the satisfaction of users' needs. Therefor a prudent and all-sided discourse should be sought in the future.

With the same importance, the discussion about climate-friendly or climate-neutral road freight transport should be carried out. The next graphic contours the same picture as the one for passenger transport, but this time in the light of freight transport:

Figure 9: Modal split of freight transport performance by mode of transport in Germany between 1991 and 2021

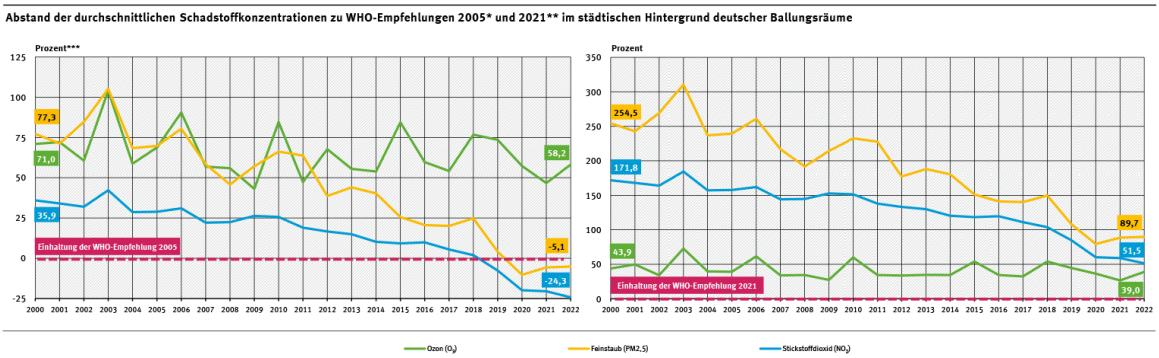


Source: *Umweltbundesamt (UBA)* 2023

Thereby road freight transport (illustrated in purple) has by far the biggest share of the modal split, followed by railway (yellow), ships operating within Germany (dark blue), pipeline-infrastructure (dark purple) and air transport (light blue). Again, this emphasises the need of all future projects to not solely but strongly focus on road transport modes (for passengers as well as for cargo).

Thereby another trend in road freight transport can be seen: A technical-related decline in emissions per kilometre was also partially offset by the increase in mileage. (Wilke, 2023a) Furthermore, the air pollution in metropolitan areas in Germany are heavily polluted and exceed the recommendations of the World Health Organization (WHO). A measurement between 2000 and 2022 shows how far the air quality in German metropolitan areas is dispresed from these recommendation for its parameters of fine dust, nitrogen dioxide and ozone. Even if a decrease of these emissions can be seen, the following graph shows the problematic and discrepancy to the strict WHO-recommendations: (Wilke, 2023b)

Figure 10: Distance of average air pollutants in German metropolitan areas to WHO-recommendations from 2000 to 2021



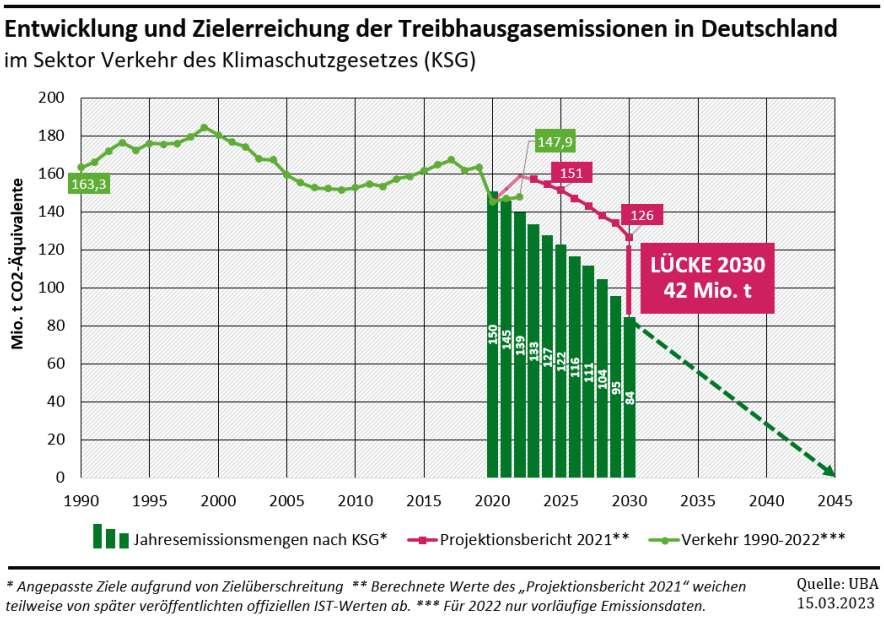
Source: *Umweltbundesamt (UBA)* 2023

Thereby all three indicators (fine dust, nitrogen dioxide and ozone) exceed the average concentration of WHO-recommendations for 2021. Thereby ozone shows even more than fine dust and nitrogen dioxide a very large interannual, weather-related fluctuation and even though, since 2000 pollution from nitrogen dioxide and particulate matter has decreased significantly, it is still way above the WHO-target (nitrogen dioxide: 52% over target; fine dust: 90%; ozone: 39%). (Wilke, 2023b)

The immense high percentage of 49% of all particles emitted within Germany are from the transportation sector. This percentage didn't change a lot since the reference of 1995, when its share was 51%. (Wilke, 2023a) All of them are health risks for human beings and must therefore be reduced drastically as soon as possible. Thereby the *Umweltbundesamt (UBA)* concludes, that "environmental and climate relief in passenger transport cannot be achieved solely through technical improvements to vehicles or alternative drives. This challenge can only be solved in combination with measures such as increasing transport efficiency, decreasing transport demand or changing the choice of means of transport" (Wilke, 2023a, p. 1).

The last graphic, that will be shown within this section, summarizes the previous specific findings perfectly. It indicates the development of GHG-emissions over time for Germany from 1990 to 2045 (projection) in million tonnes of carbon dioxide equivalent. A slow decrease of GHG-emissions from 1990 (about 163 Mio. Tonnes of CO^2) to 2020 (about 148 Mio. Tonnes CO^2) ca be seen. Even there, this small decrease gives a glimpse of hope for a climate-friendly transport sector, the aimed targets are far from reach. According to the federal climate protection act (in German: *Bundes-Klimaschutzgesetz* or *KSG*) the national goal is a decrease of GHG-emissions by 2030 to 84 Mio. Tonnes of CO^2 (-49% compared to 1990) and climate neutrality (-100& compared to 1990) of the transport sector by 2045. (Lambrecht, 2019) Because of the already existing gap between the therefor needed projection and the existing emitted GHG-emissions, the risk of failure is quite high. Even though, Germany will achieve its goals of the so-called *Projektionsbericht 2021*, which suggest a slow decrease of GHG-emissions over the years, there will still exist a huge gap between achieved and aimed goals by 2030. The needed 84 Mio. Tonnes of CO^2 by 2030 will be missed by 42 Mio. Tonnes CO^2. This will ultimately lead to a high chance of missing the target of climate-neutrality by 2045 as well. The following chart displays the current state of research for the measured as well as projected GHG-emissions of transport from 1990 to 2045 (ibid.):

Figure 11: Development and target achievement of GHG-emissions within the transport sector in Germany from 1990 to 2045 (projection)



Source: *Umweltbundesamt (UBA)* 2023

This last graphic clearly illustrates the need to act. All involved stakeholders, from administrations, such as national and state-levels governments, regional authorities to municipalities as well as private companies, think tanks and research organizations need to work closely together to achieve a more climate-friendly passenger and freight transportation. Even though, the actual chance of dismissing the aimed targets and goals is quite high, there is still time to tackle the above-mentioned climate issues.

While this section aimed in illustrating the current state of research about climate-related issues in regards of transportation, the following section will provide an overview of potential frameworks, ideas, and projects, who can help to improve a climate-friendly (urban) transportation. Thereby solely Smart Mobility projects were considered, which fulfil the beforehand mentioned criteria of Smart and Sustainable (urban) Mobility, as it was defined earlier.

The goal of Sustainable Mobility can (from a policy advising perspective) be divided into four pillars of action, according to the *German Environmental Ministry* (UBA):

1. "Avoid traffic.
2. Shift to more environmentally friendly modes of transport […].
3. Increase in energy efficiency.
4. Use post-fossil, greenhouse gas-neutral fuels and electricity" (Umweltbundesamt, 2020, p. 1).

These four pillars were summarized in the above-mentioned table of characteristics of Smart and Sustainable (urban) Mobility. Even if these are at a high level of thought and can be furtherly subdivided, they provide a good overview of the general goals of Sustainable Mobility and will be used in the following and as basis of the later created SASUM-framework.

4 Smart Mobility concepts

The following sections provides an overview of existing Smart Mobility concepts, project, and solutions, that strive to achieve a Sustainable Mobility. Within the section, existing frameworks, and solutions of Smart Mobility in academia are analysed and clustered.

Therefor the section will firstly provide an academic approach of clustering different solutions into groups by sifting through the academic literature using buzzwords. Secondly, three good-practice examples from other cities will help to understand potential solutions to achieve a Sustainable Mobility by using Smart Mobility approaches. Lastly, the findings of the clusters in combination with the good practices as well as the previously stated characteristics of Smart and Sustainable (urban) Mobility will be done.

Expected outcome is the fundamental basis of the authors self-created framework to cluster Smart Mobility solutions, which will be later exemplified and adapted to the case of Berlin.

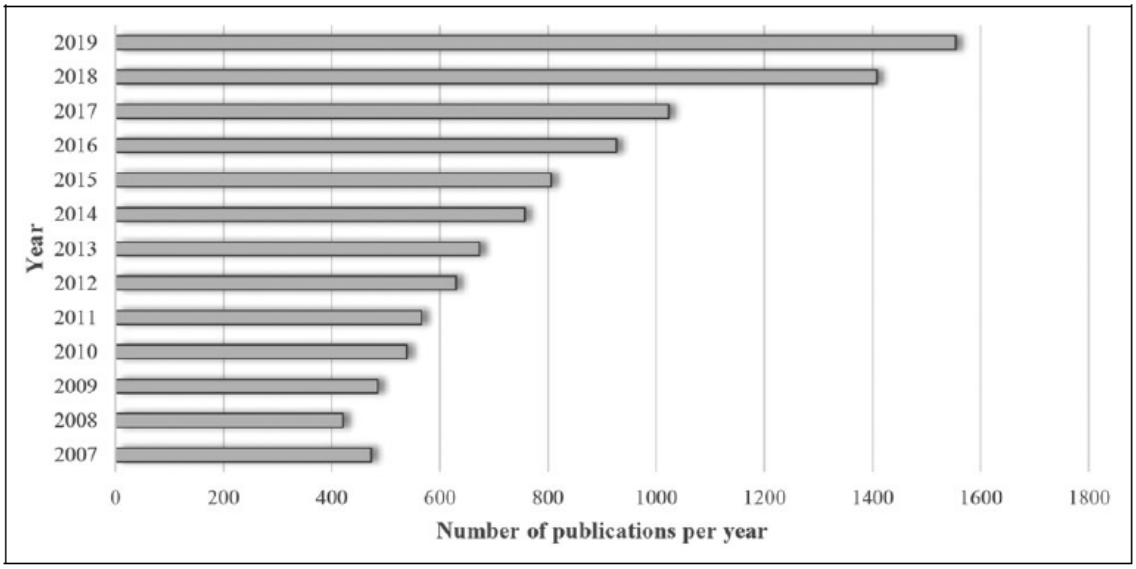
4.1 Clustering of Smart Mobility solutions

The first section aims in clustering existing Smart Mobility solutions into groups. Therefor tools and frameworks for analysing academic literature are firstly described and its applicability for the research purpose described. Secondly, these methods will be used to analyse existing literature and cluster them into different categories. These categories will later ‘filled with life’ by giving good practices for each of them.

Smart and Sustainable Mobility as trending subject in academia

The first step was to analyse the evolution of the term and concepts of Smart Mobility over time. Therefore, a publication by Mauro Francini, published in 2021 was used. Within his systematic literature review he tried to understand the evolution of Smart Sustainable Mobility and all related concepts, frameworks, and projects over time within academic literature. He used the *SLR-method* (*systematic literature review*), a methodology for finding and aggregating all revenant studies about a specific research question or topic. As a literature basis he used one of the biggest digital databases of academia, called *Scopus*. Thereby Francini et al. clustered the publications of Smart Sustainable Mobility into its distribution per year by using the keywords *smart mobility, smart mobility systems, smart transport, smart transport system, intelligent transportation system* in a Boolean query string. They figured out, that more research papers and documents got published in recent years. (Francini et al., 2021, pp. 285–286) The following chart will display the topics development in academia over time:

Figure 12: Evolution graph of the distribution of the number of publications of Smart and Sustainable Mobility per year from 2007 to 2019



Source: Francini et al. 2019 p. 286

They analysed the period between 2007 (first publication of Giffinger et al. about defining Smart City and its related sub-concepts, such as Smart Mobility) until 2019. Interestingly, since 2008 the number of academic publications constantly increased until its peak in 2019. Therefore, Francini et al. is stating, that “it is clear that the smart mobility topics are particularly widespread in Europe. Germany, Unit Kingdom, France, and Italy boast the largest number of publications” (Francini et al., 2021, p. 286). They also mention, that “the topic is [beside Europe] also widespread in the Asian (China), American (United States) and African continent (Egypt)” (ibid.). Thereby the authors state that the analysed research papers and articles mainly follow questions regarding the “particular conditions of urbanization, population density, and degree of computerization of the territories” (Francini et al., 2021, p. 286). Franicini et al. added, that “the most popular subjects covered by the publications are computer science, engineering, mathematics, and social science” (Francini et al., 2021, p. 286).

This systematic literature review indicates the gaining importance of the topic of Smart and Sustainable Mobility in academic literature and theorems in the world of urban planning. Of particular interest is, that between 2017 and 2019 about 47% of the sample (see figure 2) was published. (Francini et al., 2021) This indicates an increasing interest and importance of the topic in recent years. It furthermore allows the conclusion, that more and more research interest is given to the topic. While we understood Smart and Sustainable Mobility as a trending research topic in recent years, the next section will cluster Smart and Sustainable Mobility solutions into groups.

Clustering Smart and Sustainable Mobility into groups

“Smart Mobility is a multifaceted topic, involving all the smart city paradigms (digital city, knowledge city, green city etc.) and generated as set of heterogeneous benefits for all the smart city stakeholders” (Vasant et al., 2019, p. 68). While this definition describes methods and tools, Smart Mobility solutions, Vasant et al. furthermore identified briefly its aim: “The overall goal of [Smart Mobility] is the CO^2 emissions reduction” (Vasant et al., 2019, p. 68). This definition is in line with the authors previously given statement, that Smart Mobility needs necessarily to include sustainable approaches for being called smart. Additionally, Francini concluded, that “mobility cannot be considered smart if it is not sustainable” (Francini et al., 2021, p. 284).

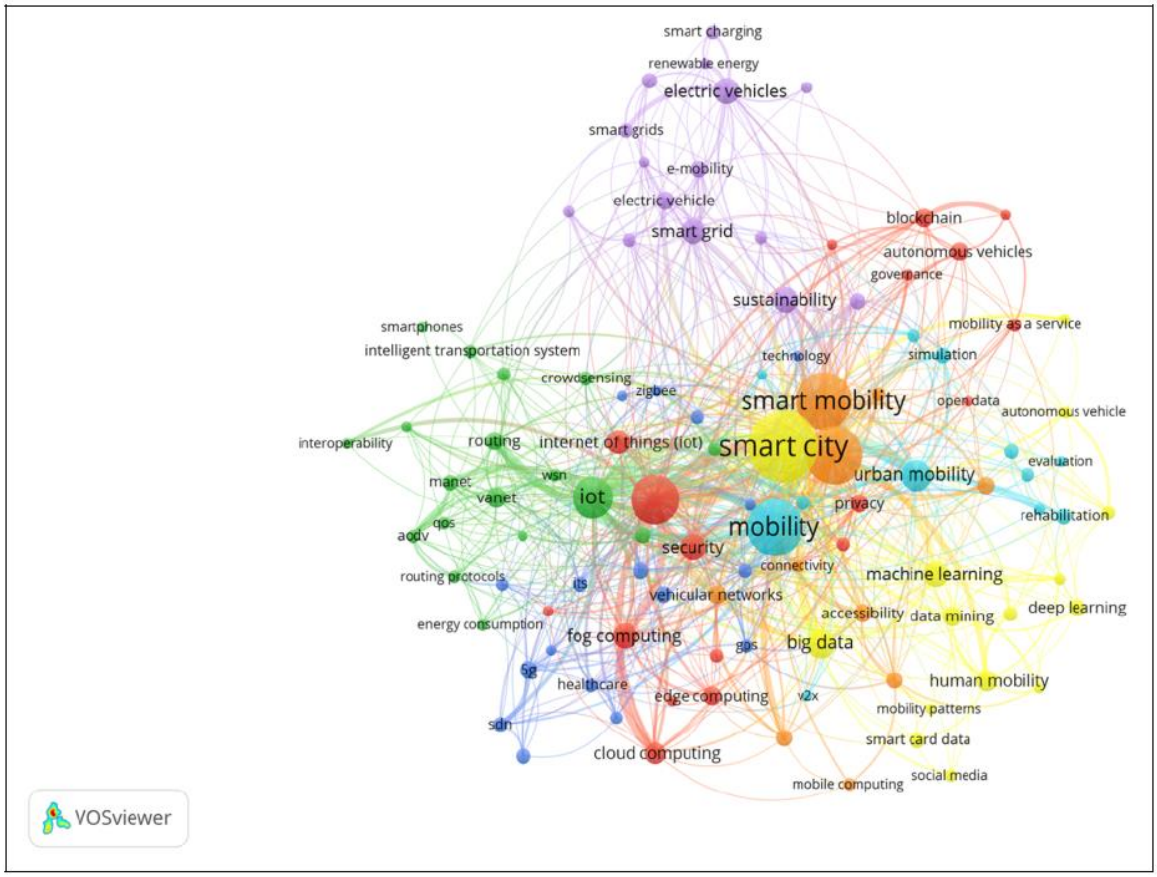
According to the previously analysed history of the term of Smart Mobility, he assumes, that “Smart Mobility plans to implement actions and reduce pollution and waste, while increasing transport efficiency. For this reason, Smart Mobility is deeply connected to the performance of sustainable mobility, contributing to improving the quality of life” (Francini et al., 2021, p. 284). Therefor it is using technology (ICT) to aim the optimization of saving time and costs.

While Francini and Vasant gave insights into the aim of academia for analysing Smart and Sustainable Mobility concepts, it is still unclear, how it can be categorized or clustered. The raising question is, in what categories, Smart Sustainable Mobility solutions can be divided. Therefor Francini et al. gave a first solution, using the CA-method. Thereby, the CA-method “allows […] the identification of a minimum number of groups so that the elements belonging to each of them are more like each other than those of other groups. The goal is essentially to bring together heterogeneous units [in this case out of 105 keywords] in several subsets [in this case clusters] in the most homogeneous and exhaustive form possible” (Francini et al., 2021, p. 285).

The researchers’ goal was thereby to find possible clusters of Smart Mobility within academic literature. Therefore, they identified 5.236 keywords, that are related to Smart Mobility. They filled the academic database called *Scopus* with these keywords to see their amount of occurrence and linkage to each other within academic papers. (Francini et al., 2021)

In a next step, they analysed these keywords with their co-occurrence. 105 keywords met the minimum threshold of at least seven co-occurrences. The connection of the resulted 105 keywords with their linkage and strength of occurrence in academic databases was then visualized in a map, using the software *VOSviewer*. This map, visualizing the connection and strength of these keywords is displayed in the following:

Figure 13: Map of research trends developed using the VOSviewer software



Source: Francini et al. 2021 p. 288

Thereby, the size of a keywords represents its amount of occurrence in academic papers (the bigger the size of the keyword, the more occurrences). The connecting lines represents the simultaneous occurrence of keywords in the same papers, the thicker a line is, the closer the linkage between one keyword and another is given.

The outcome displays clearly, that Smart Mobility is closely related to general mobility, urban mobility as well as the concepts of a Smart City. While the cluster of Smart City (yellow) is closely related to terms like machine learning, big data, deep learning and data mining, Smart Mobility (orange) is closely related to terms like mobility patterns, mobile computing, vehicular networks, urban mobility, and connectivity. The field of sustainability (purple) within Smart Mobility patterns mainly deals with e-mobility and electric vehicles as well as smart charging and smart grids. The other four categories, such as internet of things (green), computing (red), sensors (dark blue) and simulations (light blue) are existing technical components or concepts, that support the three main concepts of Smart Cities, Smart Mobility, and sustainability.

The displayed visual result of clustering the 105 keywords into linked groups allowed the researchers to identify these seven different clusters. Thereby, each cluster occurred out of the most linkages of words together, later displaying their connection towards each other in a specific definition. (Francini et al., 2021) The following table visualizes these seven clusters with their definition and related keywords:

Table 2: Visualization of Smart Mobility clusters according to Francini et al.s' systematic literature review on Smart Mobility from 2021

Cluster name	**Definition**	**Used keywords for identification (selection)**
Computing for urban safety and efficiency	Analysing, how applications of some technologies based on information technology in transport can guarantee higher levels of safety and efficiency of the overall mobility system. It aims to reduce potential accident rates, monitor traffic and improve the safety of mobility.	autonomous vehicles, blockchain, cloud computing, edge computing, governance, intelligent transport systems, security, privacy, internet of things […]
Solutions for reducing energy consumption and pollution	Strategies aiming to limit the negative impact of all modes of transport on the natural environment. The related literature explores benefits of low-emission transitions and analyses integrated mobility-energy systems for future modelling.	Crowdsourcing, crowdsensing, energy consumption, energy efficiency, routing, smart environments, interoperability, […]
Sensors and advanced digital technologies to support mobility management	It includes information systems for monitoring and controlling the territory to increase the abilities for strategic planning and sustainable management.	5G, Bluetooth, data collection, GPS, mobility management, sensors, authentication, wireless sensor networks, healthcare, ICT, […]
Sharing to meet the demand of human mobility	It has a double significance: Sharing data and information and sharing of transport in the provision of transport services. Its most present aim is to reduce the car dependency.	Autonomous vehicle, big data, data mining, deep learning, human mobility, machine learning, mobility patterns, public transportation, […]
Sustainable planning for quality services	This category refers to the concept of smart grids. Thereby its aim is achieving an efficient and sustainable urban mobility by connecting a set of information and electricity distribution networks (such as electric vehicles).	E-mobility, electric mobility, electric vehicles, enery management, modelling, optimization, renewable energy, smart charging, smart grid, sustainability, […]

Simulation and modelling to monitor mobility	Simulation and modelling of traffic and transport. This can play "a crucial role in planning processes by changing to direct the logistical and settlement choices of the territorial contexts" (Francini et al., 2021, p. 290). It helps to analyse the complex set of factors that influence mobility to construct assessment scenarios.	Artificial intelligence, assistive technology, cloud, evaluation, mobility, rehabilitation, simulation, smart parking, smart wheelchair, urban mobility, […]
Accessibility and connectivity of transport networks	It refers to the accessibility and connectivity of a transport network. Aim is to provide access for everyone and meeting the transport demand.	Accessibility, connectivity, intelligent transport systems, mobile computing, public transport, smart cities, smart mobility, vehicular networks, […}

Source: Elaborated by the author after Francini et al. (2021)

Thereby the colour of each cluster represents its colour in beforehand mentioned graphic of the *VOSviewer* software. Two clusters, *solutions for reducing energy consumption and pollution* as well as *sustainable planning for quality services* are directly connected to sustainability in mobility. While reducing energy consumption and pollution aims in limiting the negative impact of all modes of transport, sustainable planning for quality services refers to the concept of smart grids for achieving an efficient and sustainable urban mobility by connecting information and electricity distribution networks.

The clusters of *sensors and advanced digital technologies* and *simulation and modelling* are referring to the methods or tools to monitor, analyse and evaluate current mobility patterns. Within these clusters, the academic literature analyses, how Smart Mobility concepts can help to analyse a complex set of factors, that influence mobility to construct assessment scenarios or monitor and control the territory to increase the abilities for strategic planning and sustainable management.

The two clusters of *sharing to meet the demand of human mobility* and *accessibility and connectivity of transport networks* are referring to human needs in mobility. The first one describes the sharing of data and information as well as the sharing and provision of transport services with the aim to reduce the car dependency. The second describes the accessibility and connectivity of transport networks to provide access for everyone and meet the transport demands. Both are closely related to the previously described need to meet the human needs in mobility.

The last cluster of *computing for urban safety and efficiency* aims in developing applications of some technologies, that strive for a higher level of safety and efficiency of the overall mobility system. It aims in reducing potential accident rates, monitor traffic and improve the safety of mobility.

Because of these trends, Francini et al. summarizes that Smart Mobility is "the result of a planning process (cluster 5) which makes use of technological supports (cluster 3) in the simulation phases (cluster 6), use and monitoring of individual and shared transport systems to ensure safety standards (cluster 1), functionality (clusters 4 and 7) and sustainability (cluster 2)" (Francini et al., 2021, p. 290). Francini et al. summarizes, that "the global network [the internet] has changed the urban planning model by convincing traditional planners to look at the urban planning of the city" (ibid.).

All identified seven clusters refer to the previously stated characteristics of Smart and Sustainable (urban) Mobility. While all clusters directly or indirectly refer to the concepts of Smart Mobility as well as Sustainable Mobility, some are more related to specific characteristics. The two clusters about sustainability are clearly indicating the need to transform (urban) mobility systems in a sustainable way, whereby technologies can help to achieve this. The clusters of sensors, simulations and modelling are describing the tools, with which mobility can be analysed. This directly refers, to what was considered as 'smart'

before: Using digital tools and technologies to analyse mobility. They are not describing themselves an overarching goal (beside measuring existing mobility patterns), but they can contribute to achieve the goals of sustainability or meet the mobility demands. The clusters about meeting the demand of mobility and accessibility/ connectivity are referring to the stated need to meet the needs of its users, either in an informational or physical way. The last cluster of computing can be also seen as related to this characteristic, whether it is describing a combination of all previously given characteristics.

The analysis of these clusters revealed the main trends of Smart Cities, Smart Mobility, urban mobility, smart grid, and sustainability. The used technologies mainly lead towards using IoT (Internet of things), big data, security, fog and cloud computing, routing, machine learning, blockchain technology, and data mining. As mentioned beforehand, these are just the methods or tools, that can help to analyse (urban) mobility, they do not directly refer to its aim or purpose.

These trends need to be considered for analysing the further case study of the Smart City- and Smart Mobility-strategy of the city of Berlin. A classification of their projects into these categories helps to analyse the status and developing an overarching strategy, that takes the current trends into account.

4.2 Advantages and disadvantages of Smart Mobility concepts

The previous research paper revealed seven different clusters of Smart Mobility concepts and solutions. While this helps to grasp a bigger picture of potential categories of Smart Mobility solutions, it still lacks strengths and weaknesses, or in other words advantages and disadvantages of these concepts.

While hundreds of research papers analyse, how technology, or more precisely ICT, can transform urban mobility in favour of ecological, economic, or social sustainability and users' needs, just a few analyse strengths and weaknesses of Smart Mobility concepts. Even though, it is hard to define generic advantages and disadvantages of Smart Mobility concepts, because of their diverse approaches and aims, the following section tries to identify generic (dis)-advantages, that apply for most of the existing Smart Mobility approaches.

4.2.1 Advantages of Smart Mobility solutions

Advantages of Smart Mobility solutions, trying to improve urban mobility with the help of technology are widely spread.

1. Firstly, ICT can help to **act on the mobility demand**. Precisely this means an elimination of unnecessary travels with the overarching goal of making the travels easier and more accessible. (Francini et al., 2021)
2. Secondly, ICT can help to **manage mobility flows**. Precisely, reducing congestion, downtime, inefficiencies, and risks of mobility flows within urban areas. (ibid.)
3. Thirdly, ICT can help to create an innovative infrastructure design. Precisely, making them "more interactive and functional through the use of suitable technologies" (Francini et al., 2021, p. 284)

While these three objectives tackle general issues of todays' mobility, the following advantages are precisely focussing on specific areas of mobility, such as the theoretical planning, the physical infrastructure, and indicators, such as environment, economy and most importantly users' needs.

Planning

In urban and mobility planning, 'smart' technologies can help, with the support of ICT, to predict impacts of changes within a mobility system. Data from IoT can measure current mobility flows within a city in near-Realtime and predict possible impacts of changes towards the system itself. Sensors and cameras can thereby analyse mobility flows, the collected data can then later be analysed by urban and traffic planning administrations.

Data from service providers can assist urban planners to make mobility according to given evaluations of the built environment. Collected near-Realtime data sets can later be monitored, analysed, and evaluated according to the aimed vision of urban mobility. Especially for sharing mobility solutions, such as bikes, scooters and electric cars can help, to meet the needs of its users. A data intersection can predict optimised areas for the provisioning of shared mobility offers.

The expected impacts of realizing traffic planning solutions can be predicted by using digital models and simulations, that consider given traffic circumstances and intersect them with the planned traffic solution. An example, how this can be handled will be given later in the best practice of the *BeST-scenario project* in Berlin.

Infrastructure

Technologies and ICT cannot solely help to predict possible scenarios of planning interventions. It can help to react on real situations of current traffic flows, or as described by Vasant et al. in 2019, it can help for the “immediate detection of incidents on the road” (Vasant et al., 2019, p. 68). ICT can also help to “detect blockages, surveillance and realize remote controls” (ibid).

As described earlier, the terminus ‘smart’ thereby does not solely refer of using ‘smart’ technologies, ICT or IoT to transform the urban. Rather ‘smartness’ is a concept, that can use technologies but also use new ways of combining different urban indicators for a new creation of the city. An example can be seen in the infrastructural adaption of mobility services to the needs of its users. For instance, stations and platforms of public transport can be adapted to the needs of its users, structural obstacles can be removed, and stations can be designed to be barrier-free. Even if therefore, the usage of technologies is not necessarily needed, concepts that foster the mentioned physical interventions should be considered ‘smart’.

But Smart Mobility solutions can also be at the intersection of physical and digital information management and interaction. An example can be seen in ‘smart parking’ or ‘smart ticketing’, where digital devices in forms of apps or websites interact with its users to allow a faster, more efficient, and demand-oriented navigation and payment of car park fees. With “new services of the smart parking and smart ticketing, parking public spaces can be more efficiently managed by guiding drivers to the closest (proximity) parking place and [provide and on-demand system]” (Vasant et al., 2019, p. 73). Parking guidance systems can help the car owner to navigate within a city to the closest accessible and free parking place. It can also help to match supply with demand in near-Realtime and distribute the peak demand (of the certain transportation mode) more efficiently. (Vasant et al., 2019)

Even though, smart parking systems are used more often within cities, the usage and titling of them as a Smart Mobility solution should be enjoyed with a certain amount of caution. Because as beforehand mentioned and at least within this thesis, something can just be considered smart, as it is sustainable. If a smart parking system improves the efficiency and therefore reduces GHG-emissions of cars within cities, it can be considered smart. If it is just for the improved driving experience of car owners and their purposes, without having a noticeable impact on the environment, it should not be considered smart.

Environmental sustainability

Smart mobility concepts can help to measure and monitor GHG-emissions of various transportation modes, especially of the motorized individual transportation, such as trucks, cars, and scooters. Environmental sensors can analyse in near-Realtime the emissions of motorized vehicles in selected areas in the urban realm. These data can be collected, monitored, and displayed, e.g. as digital maps for policymakers to analyse traffic. In a later stage, this data can be used to regulate traffic flows and change according to its given circumstances, e.g. a road can be closed due to high GHG-emissions during a specific time.

Furthermore, demand-based interventions after a technology-based analysis in public transportation can help to regulate public transportation modes according to its needs. An example can be seen for a better fleet control of public transportation, such as subways,

after measuring the demand with cameras within the stations. Therefore, needs to be said, that Smart Mobility solutions should always meet the need of its users, but never cut back on privacy and data security. This will be later explained in the section about disadvantages of Smart Mobility solutions.

Another example can be seen in the monitoring of noise pollution. “[It] offers possibilities for a better quality of life and is, therefore, an important pillar in the city management” (Vasant et al., 2019, p. 68). An example for this can be seen in the city management of Berlin, where just recently a noise monitoring sensor was installed at the *Kaiser-Wilhelm-Gedächtniskirche* in the district of *Berlin-Charlottenburg*. Many more examples about measuring urban-heat-islands (UHIs) with sensors installed in various transportation modes, measuring the air pollution, temperature and rainfall with built-in sensors (MIT, 2018) on public service vehicles or predict environmental impacts of urban traffic interventions can be named. The list of these potential interventions and impacts seems endless, wherefore just the given examples are mentioned. The later section about the self-created evaluation matrix will thereby help, to logically cluster these potential Smart Mobility solutions into groups.

Economic sustainability

From an economic-sustainability perspective, technology and ICT can help to understand users’ needs and demand, especially in public transportation. This can help, reducing costs, safe trips and let the public transportation system sustain. Sensors and cameras can thereby help to identify the need of number of vehicles for handling the given transport demand in near-Realtime and subsequently react to it. This cannot solely fulfil users’ needs in a more demand-based way but also safe costs for the operating, often municipal, company. (Vasant et al., 2019)

With lower costs for the operating public transport companies, a subsequently reduction of the related prices for its usage and ticketing is likely to happen. This can ultimately lead to an improvement of customers’ satisfaction.

The development of user-friendly digital services, such as applications or websites can help to digitalize the ticketing system. This helps those people, who have access to digital devices, such as smartphones and laptops to gain a barrier-low access to tickets and information, regarding traffic flows, blockages, and alternative routes. Such devices are already publicly in use in different variations, such as digital maps, navigation systems and demand-based mobility apps. A currently trending and interesting phenomena are MaaS-applications (Mobility-as-a-Service), that combine and connect different transportation modes, such as public transportation and shared mobility in one digital application. These application as well as municipal or regional digital navigation apps can furthermore help to “create economic incentives to travel outside of peak hours or choose alternative routes” (Vasant et al., 2019, p. 73).

Another example, that could have benefits, for both the state/ administration as well as the user are simplified ticketing systems, that support an easier ticketing and pricing system across borders. For example, within Germany, the so-called *Deutschlandticket* was introduced in 2023 as the successor of the *9-Euro-Ticket*, which was tested for several months before. The *Deutschlandticket* helps to simplify the ticketing system across inner-state borders and makes travelling with public transportation easier within Germany. (BMDV, 2023c) If the price of 49€ is thereby appropriate needs to be seen in the near future.

Social sustainability

Social sustainability refers to the satisfaction of users’ needs as well as sustaining a society, that collectively profits of Smart Mobility solutions. Beside the given examples for a barrier-low ticketing system, a demand-based public transportation, and the availability of digital tools for using sharing offers and navigational systems, further advantages for society by using Smart Mobility approaches can be seen.

The beneficiaries for the users are widely spread. From being updated about transportation of each city in the world at any given time to seeing “route[s] and time of arrival in precision

of every transport mean [and having] the ability to plan the route and map online one's travel in the city" (Vasant et al., 2019, p. 68).

Citizens can also profit from better air quality, measured, monitored, and prevented with sensors and its resulting planning actions. The same appears for noise and its prevention in urban areas. The civil society can also profit from a demand-based public transportation and therefore a decrease in commuting time "in daily life mobility" (Vasant et al., 2019, p. 68). For operators, Smart Mobility solutions can have the "ability to create personalized mapping services to drivers" (Vasant et al., 2019, p. 68). This is already happening with various private companies, especially within the shared mobility.

But beside all these advantages, several disadvantages can be seen with evolving and emerging Smart Mobility solutions. The following section will therefor analyse potential threats, weaknesses of Smart Mobility solutions.

4.2.2 Disadvantages of Smart Mobility solutions

Besides its positive effects, Smart Mobility solutions can be used in a negative way or lead to misleading planning effects. While the advantages can be clearly assigned to the categories, the disadvantages are mainly overarching effects, which over span the previously mentioned subject areas. Probably one of the biggest weaknesses of using data and ICT for developing urban areas are issues related to privacy and security of the collected and analysed data. International and national regulations need to foster laws, that control the use of data in a manner, that protects personal data.

While the EU just announced and published the first international law on regulating artificial intelligence (European Parliament, 2023), on the national level of Germany, the so-called *Datenschutzgrundverordnung* (DSGVO) regulates, how data consumers have to protect the privacy of data providers. (BMJ, 2023) The *DSGVO* is quite strong in the sense of protecting privacy in data and regulates e.g. that no data can be publicly displayed or published, that contains personal data, such as name, birthday, contact information and so on. All personal data needs to be anonymised or pseudonymised, before using them for analysis. (BMJ, 2023) Because the country of Germany is divided into 16 states, most of them have additional laws that more precisely regulate the usage of data, e.g. the state and city of Berlin has the so-called *Berliner Datenschutzgesetz*, which protects the rights of its citizens, especially by using their data. (Berliner Beautragte für Datenschutz und Informationsfreiheit, 2022) Municipalities, think tanks, research institutes and private companies need to fulfil the mentioned legal regulations in regards of data privacy and data security to responsibly use the collected data. The benefits of data processing thereby should never outweigh the importance of data security and privacy.

Another disadvantage could be the overvaluation of quantitative methods for analysing the urban realm. As urban areas are still populated by humans and depends on their individual interactions, perception and feelings, quantitative data collected with technologies and ICT can help to understand some aspects of urbanity but do not replace qualitative methods. Urban analysis from an individual perception is still a valid tool for analysing cities, wherefore quantitative methods can additionally help to understand certain aspects. As mentioned beforehand, for some urban domains, such as mobility, environment, and economy, using quantitative methods can be more useful, than for domains, such as social interactions, development of urban designs and many more.

Resulting disadvantages are the overvaluation of quantitative data in general. Data do not replace mobility and traffic plans of cities. Overarching goals and aims of urban and traffic planning departments are still the basis of the cities' development in one or another direction. Hereby data can help analysing, monitoring, and overseeing outcomes of certain projects, actions, and implementations, but they do not create the overarching plans. The literature review and analysis of academic literature of Smart Mobility revealed a strong technocratic or technic-oriented focus of the research papers and books. Most papers analysed specific technical solutions, using ICT and IoT to analyse a certain urban area. The outcome of the papers was often strongly focussed on their technical solutions, instead of overarching goals and aims. This research gap needs to be closed soon.

4.3 Best practices

The analysis of clusters, categories, and advantages as well as disadvantages helped to understand the conceptual superstructure of Smart Mobility. But how are these theoretical ideas realised in concrete projects? And what are thereby good or so-called best-practices? Can the ideas, that emerge from this, be easily adapted to other geographical contexts? And how can we learn from them?

These questions will be answered in the following section. Thereby three best practices are introduced, analysed and their potential for scaling them to the case of Berlin will be evaluated. All the best-practices are chosen from a wide range of 'technical' projects within the academic field of Smart Mobility, where researchers from interdisciplinary fields tried to solve a specific mobility problem by using technology or ICT. All the following examples can thereby be seen as technological approaches towards modelling, restructuring, and planning of mobility in urban areas. Their aim is dependent of the regarding policymakers. Therefore, the beforehand mentioned criteria of Smart and Sustainable (urban) Mobility are taken to consider their potential outcome to achieve a more sustainable urban mobility with sustainable transportation modes.

4.3.1 The Sustainable Mobility Plan (SUMP) of Rome

The first best practice is in Rome, the Italian capital and biggest city of the nation. The municipality of Rome announced in 2012 the so-called *Sustainable Mobility Plan (SUMP)*. This plan works with three main objectives, which needs to be achieved:

1. Systematization of the transport system by expansion of two metro lines (B and C) and the subsequent amelioration of the tramline.
2. Creation and support of several e-mobility devices, car sharing and car-pooling for the city.
3. Usage of ICT, that could have the ability to control several of the traffic systems and allow citizens' participation. (Vasant et al., 2019)

The goal of the plan was to respond to challenges for safe, sustainable, and accessible transport. Furthermore, they wanted to reduce the use of private vehicles, such as cars and motorbikes, redistribute public space and improve environmental aspects. (ibid.)

All subprojects, that were realized within the Scope of the *SUMP* can thereby be classified into the three following categories, according to (Vasant et al., 2019, p. 71):

- **Technologically driven applications:** This includes applications, that transmit real-time information, such as mobile apps and websites. Its goal was to enhance the use of public transportation instead of private ones. Thereby the apps facilitated the transition between public transport and sharing transportation modes as well as fostered online tickets and parking.
- **Applications, that receive information:** From drivers, vehicles through technology and data for a better functioning of the city. It's a large and heterogenous set of applications, such as info mobility, sanctioning/ fining, monitoring, and controlling management.
- **Localization of services:** To support the smart mobility projects and provide a potential quantitative analysis of the built environment.

As a guideline or basis, they used an international framework (Kyoto Protocol) and made a city-specific environmental action plan for Rome. Thereby the expansion of the metro lines started its realization since 2000s, the other two objectives required more attention. Its realization was dependent with the focus on the ICT-sector.

The overarching goal was to measure mobility with several ICT devices, to analyse the actual mobility flows and their potentials. They analysed, that in all subprojects the used ICT devices acquire a physical dimension in urban space:

- Material/ physical use of existing space is transformed to host Hard- and Software (such as sensors, cameras etc.).

- Terminals to access public information, such as displays with traffic updates, LED-signals and data projected on responsive panels.
- Stalls and charging devices for electric mobility.
- All sharing vehicles and applications are represented with specific brand symbols (in this case with colours) (Vasant et al., 2019)

Result of SUMP was the creation of sharing services for automobiles, motorcycles and bikes supported using GPS, GIS and various numbers of sensors and satellite connected devices. Further results were the creation of 1200 new parking lots (authors note: not environmentally friendly), the replacement of traffic lights, access gates, checkpoints and release of new ecological, electrical auto buses (authors note: environmentally friendly).

Another result was the creation of a smart ecosystem, where all data is collected and displayed on a digital surface. In kind of augmented reality, the users can interfere with the physical environment in a digital space or as described by the authors: “In other words, the availability of these technologies of the municipality of Rome has given birth to a new interwoven image of the city, an augmented space that describes the city and is available to every user” (Vasant et al., 2019, p. 72). Thereby the developments of digital twins of cities or towns are also playing a key role. This describes the development of a digital ‘image’ in 3D of a city, which can be later used by planners, citizens, and policymakers to create the desired city, firstly in a digital space for analysing their potentials, and later in the physical real world. This can help to diminish unwished planning outcomes and predict impacts of certain planning interventions before their realization. This was also achieved by another outcome of the project: People can get connected in this digital space, rather than physical space. Therefore possible ‘What-if-scenarios’ can be created without interfering into the ‘real’ built environment.

Another interesting outcome was the behavioural change and management of mass flow during rush hours, which was achieved by analysing traffic flows in near-Realtime in Rome.

> *“In particular, changing human activity during rush hours at the physical space means also directing the critical mass towards new directions. This, in turn, might bring about ideas for neighbourhood’s intensification, the different relation between the city and the road system (including the pedestrian pathways), new ideas about relocating of activities that assist the drivers/ travellers in the city territory”* (Vasant et al., 2019, p. 73).

Of particular interest within the sustainability-scope of this master-thesis is, that “the sharing of bicycles, as well as the promotion of this activity on behalf of the commune, led to the creation of new cycle paths of about 241km in total” (Vasant et al., 2019, p. 70). The ‘smartness’ of the project can be seen in the usage of “numerous smart technologies for monitoring the different movement activities in the city” (Vasant et al., 2019, p. 70).

On basis of the SUMP, further, similar projects were developed and embedded within the city of Rome. They mainly supported the e-mobility diffusion and information about the decarbonization of the inner-city centre. Thereby all collected data of already existing or newly built measure and monitoring stations are transmitted and elaborated to Rome’s mobility centre. “It is called the Monitoring Centre for Road Safety [and it] regards the integration of new systems within the technological framework of the Mobility centre with adjustments of the Hardware and Software infrastructures” (Vasant et al., 2019, p. 70). Therefore, it can be concluded, that the “project consists of a number of city interventions using ICT and a web interface” (ibid.).

The results of the project and related subprojects was analysed within the study *Efficient cities Siemens 2012*, wherefore 54 Italian cities were examined towards their effectiveness in sustainability, performance in urban mobility and financial support for certain urban issues. “That study indicated surprisingly the popularity and effectiveness of the project: In 5 years’ time, the northern Italian cities [including Rome] showed remarkably improved performances in urban mobility and the southern ones were described as ‘having strong potentials for improvement’” (Vasant et al., 2019, p. 67).

Beside the project, Vasant concluded in 2019, that “most of the objectives attached to Smart

Mobility look at the implementation of ICT in the field of road transport, including infrastructure, vehicles, and users" (Vasant et al., 2019, p. 67). Thereby lots of sensors, installed across the city, study the urban traffic control system and track car locations in real time. They also adapt intelligent transportation systems, that allow administrators to manage instantly spontaneous traffic congestion issues. Collected real-time data are:

- Location
- Weather
- Traffic raw data

This data is generated constantly by "dynamic patterns of human behaviour as people navigate the city. In this way, personal smartphones or city sensors become a roaming source of information that allows transport operators to make immediate interventions and create additional capacity where it is needed in physical infrastructure" (Vasant et al., 2019, p. 68). He concluded:

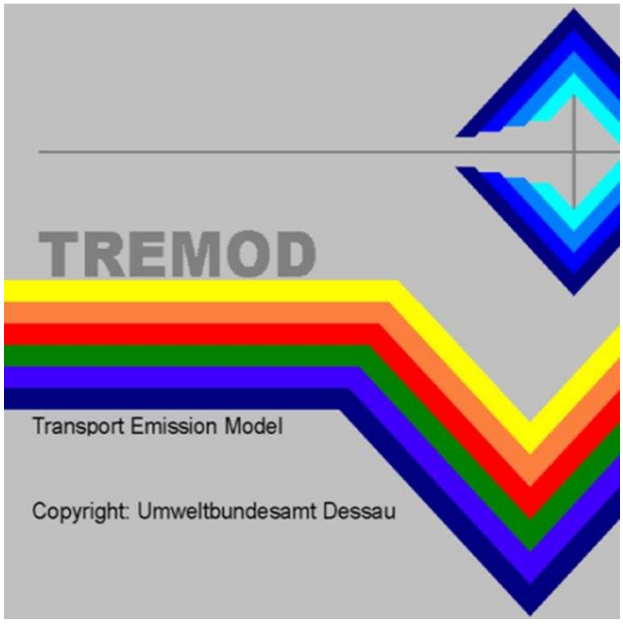
> *"The connection of smart mobility and urban planning is a complex and still challenging field of research and practice. The set of good practices and related planning actions, presented in the previous paragraphs, require more time for feedback and a considerable increase in the level of technical competencies that are among the pillars of planning disciplines"* (Vasant et al., 2019, p. 74).

The project of the SUMP in Rome indicates furthermore, how international, national, and municipal guidelines and principles can form the basis for formulating overarching aims and goals of Smart Mobility. The analysis of physical mobility patterns, results of interventions and outcomes of projects can then be analysed by using technology or ICT. This can help policymakers, majors, and planners to track mobility behaviour in near-Realtime make decisions-making based on these quantitative findings.

4.3.2 Measuring traffic emissions with TREMOD

An example for a Smart Mobility project, that analysis and evaluates emissions of certain transport modes is the TREMOD-model from Germany. TREMOD stands for *Transport Emission Model*. This German-wide used digital tool measures, monitors and displays air pollution and air quality in selected German cities. (Umweltbundesamt (UBA), 2023)

Figure 14: The TREMOD (Transport Emission Model) of Germany



Source: Institut für Energie- und Umweltforschung Heidelberg (Ifeu) gGmbH. 2019

Thereby the federal environment agency (so-called *Umweltbundesamt*) used the computer program TREMOD together with the federal ministries, the Association of the German Automotive Industry (*VDA*) and *Deutsche Bahn AG*. This program was developed to determine and process information from the transport sector to assess current emissions of certain urban areas.

Another functionality of the program allows to analyse trends of these developments of emissions and calculate scenarios for its reduction in the period from 1960 to 2050 (forecast). (Umweltbundesamt (UBA), 2023) With installed sensors in the built-environment in selected areas, air pollutants and GHG-emissions from motorized transport modes are measured. In the further process, these data are then collected and displayed visually. The measuring involves all kinds of types of passenger transport (cars, motorized two-wheelers,

buses, trains, airplanes) and freight transport (trucks, light commercial vehicles, trains, ships) operating in Germany. (ibid.)

The basic data ranges from driving and traffic performance to utilization levels to specific energy consumption and emission factors. The model also predicts future emissions per sector. “The emissions recorded include nitrogen oxides, hydrocarbons (differentiated into methane and non-methane hydrocarbons), benzene, carbon monoxide, particles, ammonia, nitrous oxide, carbon dioxide and sulphur-dioxide” (Umweltbundesamt (UBA), 2023, p. 1). It also calculates traffic and driving performance and the related energy consumption of motorized vehicles. This reveals the wide range of using a tool like TREMOD for diverse use cases.

The project can be seen as a perfect example of a Smart and Sustainable Mobility approach, but with a certain restriction. Even though, technology, ICT and IoT is used to collect data about emissions of traffic and monitor them regularly, the bigger aim of the collected data is what it defines it as ‘smart’. If the bigger goal is just a collection of data regarding traffic-emissions, it cannot be considered smart per se. But if the overarching goal is measuring emissions to overcome high emissions of motorized vehicles with resulting policies, planning actions and interventions, then it can be called so.

4.3.3 BeST Scenarios in Berlin

The last best practice that will be described here is a research project from Berlin in Germany called BeST Scenarios. Thereby a group of researchers from *TU Berlin*, *Frauenhofer FOKUS* and *Daimler Center for Automotive IT Innovations* conducted a funded research project, analysing the development of large-scale traffic scenarios for evaluating smart mobility applications in the case of Berlin. (Schrab et al., 2023)

The underlaying problem statement was, that the researchers wanted a holistic understanding of two specific sustainable urban transport systems, which were:

1. The electrification of vehicles
2. The development of novel mobility concepts, especially ideas and concepts of intelligent ride sharing, smart logistics and robotaxis (ibid.)

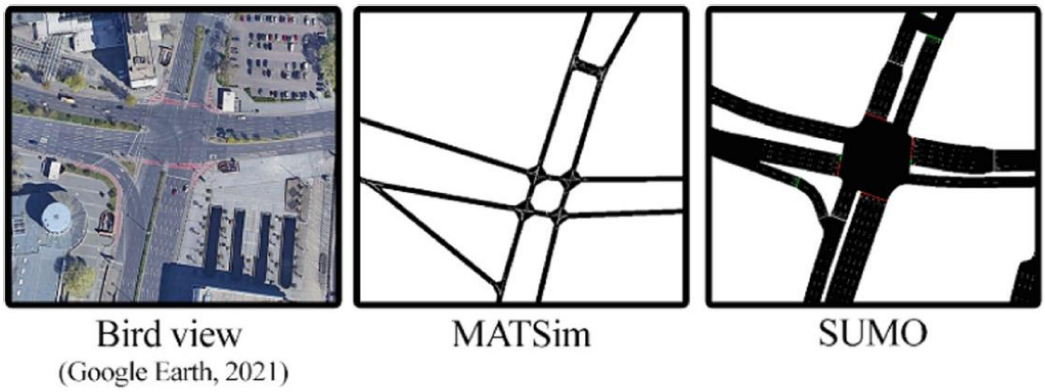
To analyse, monitor and implement these two streams of sustainable transport systems, a holistic understanding of a local or city-level traffic system is needed. This can be achieved by using digital simulations or models, that include the different sub-aspects of the before-mentioned streams. This holistic system simulation needs to model current “movements of individual vehicles, but also further aspects such as communication (e.g., ITS-G5 or LTE/5G), in-vehicle and server applications, electric mobility (battery, consumption, power grids), and more” (Schrab et al., 2023, p. 276).

Therefor huge models are required to simulate current transportation patterns in urban areas and come up with possible solutions. Smart mobility applications can thereby help to analyse the current situation and understand potential effects of structural interventions before its realization.

The projects’ goal was the conceptualization and development of a digital tool that simulates individual transport within Berlin as close to reality as possible and counted/ observed real time-data as possible (Schrab et al., 2023) for modelling road traffic (of individual transportation systems). They created a “large-scale simulation scenario depicting a full day of motorized private traffic […]” (Schrab et al., 2023, p. 276) that comes as close as possible to reality as possible.

For this, they used calibrated demand definition and a technological basis of an existing project, modelling traffic in Berlin (called M*ATSim*) “by extracting relevant car-based trips and re-calculating all routes” (Schrab et al., 2023, p. 284). The BeST-project was a rework and improved simulation of *MATSim*-Project, a simulation that generates calibrated traffic demand and supply. In comparison to the MATSim-Project, the BeST-project “concentrated in modelling basic vehicle movements on primary roads and highways rather than realistic inner-city patterns” (Schrab et al., 2023, pp. 277–278). They created the new simulation model, called SUMO. The following chart illustrates the differences in these models:

Figure 15: Different models of simulation and accuracy in the BeST-Project



Source: Schrab et. al 2023

Both models (MATSim and SUMO) can model multi-modal traffic scenarios based on real world data. “Agents (persons or vehicles) are modelled individually and as results one get macroscopic data such as traffic flows on roads and travel times of agents” (Schrab et al., 2023, p. 278).

The cartographical basis of both models was data from Open Street Map (OSM). This was manually adjusted to eliminate most of the modelling errors. For traffic assignment a “method of dynamic user assignment which iteratively runs route calculation and simulation until a user equilibrium is reached” was used (Schrab et al., 2023, p. 284).

In the next step, they transferred traffic demand from the MATSim-model to SUMO. The SUMO-scenario thereby provided a selected day plan for each agent, which contain all activities (duration and type - e.g., home, work, or leisure) and the trips between these activities (mode of transport, origin, destination, and departure time). “To extract the demand, [they] chose all trips which used car as transport mode” (Schrab et al., 2023, p. 280). They did 60 iterations and ultimately found a stable state representing a model close to Realtime-data.

After the model runs as close as possible to reality it can be used for the simulation of traffic and expected scenarios, that occur, e.g. if some streets are closed, the transport system for motorized vehicles becomes changed or similar events. “The scenario can serve as a baseline for analysing the effects and impacts novel of smart mobility applications can provide” (Schrab et al., 2023, pp. 281–282). Furthermore, this scenario technique and developed simulation tool can be used in urban- and traffic planning department and building department to model potential effects of changes within the traffic/ built environment.

5 Expert interviews

As now definitions of the used terms and potential model projects are understood, the next section aims in gaining knowledge from experts. Thereby, the following section will analyse the expert interviews, which contribute to understand Smart and Sustainable Mobility from the viewpoint of research institutes, administrations, and the private sector. These interviews, combined with the literature analysis (especially the academic literature clustering) will form the basis of the afterwards presented framework.

5.1 Methods

As described in chapter 2 about used methods and data triangulation, qualitative interviews were conducted. These interviews have thereby an explorative approach, which is especially well suited for topics that been rudimentarily researched. (Mayring, 2020)

The interviews have been collected in a semi-structured way with five guiding qualitative questions. This open survey method allowed the participants to answer free in choice by means of the medium they preferred. The questions were phrased open to leave room for their contributions. This ensures, that only the information, that the respondent takes from his or her knowledge or experience, are given.

In total, 21 people in their functions as experts from the fields of Smart City-context as well as Smart Mobility have been contacted. These experts are thereby working in different organisations, such as research institutes, think tanks, governmental organisations, and municipalities to private sector. In this context, the interviewees are to be understood as experts, since they function as knowledge mediators through their subjective perspectives, job positions, and qualifications. (Helfferich, 2022). While nearly all of them answered (in a positive or negative way), nine of them declared their willingness to contribute to this study, either directly within the questionnaire or indirectly by suggesting a short interview. These nine interviewees thereby work in the field of:

- Municipality of Berlin
- Think tank *CityLAB Berlin*
- *German Institute of Urban Affairs* (DIfU)
- *German Aerospace Center* (DLR), 2 participants
- *HafenCity University* Hamburg (HCU)
- *Frauenhofer Institute for experimental software engineering* (IESE)
- Private architectural office *Radbahn GmbH*
- Private engineering office (anonymised)

While six experts answered within the transmitted document in form of bullet points or sentences, three experts preferred digital interviews. All three interviews with the experts of the *German Institute of Urban Affairs* (DIfU), the *Frauenhofer Institute for experimental software engineering* and the private architectural office *Radbahn GmbH* were held digitally, the six filled-out forms of the questionnaires of the remaining organisations mentioned above were sent via Mail from the respective experts. Each interview was recorded acoustically (and two also visually) for later transcription. The transcription followed the rules as mentioned in chapter 2 and can be found in the appendix.

The applied Mayring-method

The interviews were analysed by using the Mayring-method as a qualitative content analysis. As described in chapter 2, this method was developed in 1988 by Philip A. E. Mayring and then regularly revised. (Mayring, 2020) Thereby findings of new editions were considered. The stated research question was stated within both in the cover letter of the e-mail and at the beginning of the conducted interviews. Due to the fact that there is not yet much research literature on the topic of smart and sustainable urban mobility, the categories

for analysing the interviews were formed using the inductive category development method by Mayring. (ibid.)

Codes were used to subdivide and analyse the text. Thereby the conducted interviews were combined with the questionnaires as this combination of different collection methods is a possible approach within the Mayring-method. (ibid.) The coding-system was established in advance in which rules are defined and supported with anchor examples. Each code represents an aspect of the object of research, and they should be relevant to the research question. (Kuckartz, 2012) At the beginning, main categories were formed deductively according to the presented theoretical literature, especially the two streams of aims and goals of Smart and Sustainable (urban) Mobility as presented in chapter 3.1 on one hand and potential technologies and tools on the other. For the formation of intermediate and subcategories to expand these main streams or categories, an inductive approach was chosen. This inductive variant is characterized by the development of categories derived from the transcribed conversations and information. (Mayring and Fenzl in Baur & Blasius, 2014)

The entire transcription and analysis were carried out using *MAXQDA*, one of the world's leading CAQDA-Software (Computer Assisted Qualitative Data Analysis) which is also recommended in the literature. (Kuckartz & Rädiker, 2020) The used version of the program was 24.1.0 Pro.

5.2 Posed questions

Each interviewee was asked five qualitative questions. These questions aimed in a deeper understanding of the terms of Smart City, Smart Mobility, the relationship between these two concepts, an analysis of

The posed questions can be subdivided into the following categories:

General questions regarding Smart City

- What Smart City approaches and concepts do you see?
- Which Smart City concepts can contribute to achieving a more sustainable urban transport in the future?
- How can aspects of a Smart City and Smart Mobility be thought together?

General questions regarding Smart Mobility/ Sustainable Mobility

- What is Smart Mobility for you and what characteristics does it have?
- What is Sustainable Mobility for you and what characteristics does it have?
- How can Smart Mobility approaches help to achieve a more Sustainable Mobility?
- What are strengths and weaknesses of Smart Mobility approaches?
- Which trends in Smart Mobility do you recognise?
- In which field of Smart Mobility (examples given) do you see the biggest potential of achieving a more Sustainable Mobility?

General questions regarding technologies and tools

- How can technologies and tools contribute achieving a more Sustainable Mobility?
- Which technical technologies and tools would you use to analyse the actual state of traffic situations and means of transport and why?
- What do you think digital control of the transport systems of the future could look like?
- Which technologies and tools of Smart Mobility do you consider most important in the future?
- Which kinds of technologies and tools within Smart Mobility do you already use?

General questions regarding network of stakeholders

- How can research/ private sector/ administrative institutions contribute to achieve a more Sustainable and Smart Mobility?

- How do you see the relationship between political institutions, administrations, think tanks, and the private sector within Sustainable, Smart Mobility?
- Who do you see as being primarily responsible for concrete implementation projects for Smart Mobility solutions?
- How can your specific institution/ organization contribute to achieve a Smart and Sustainable transportation of the future?

Specific questions regarding the case study of Berlin

- What steps do the city of Berlin needs to take in order to place more Sustainable Mobility projects in the city's context?
- What are your expectations for the development of Smart Mobility within Berlin?
- Which projects in Smart Mobility in Berlin do you consider the most relevant?
- How does the Smart City Unit of Berlin need to develop in the future in order to place a stronger focus on Smart Mobility concepts?

Additionally, specific questions in regard to the respective expert have been posed. These questions cannot be clearly assigned to one of the groups mentioned above:

- An assessment of the Smart City strategy of Berlin *Gemeinsam Digital: Berlin*.
- A statement about the applicability of Smart Mobility tools for rural areas.
- Is the creation of a Smart City approach to intelligent mobility more about the debate on breaking up data silos of existing data sets or the creation of new data sets (derived from sensors/ cameras in the built environment)?
- Is the Frauenhofer-society responsible for writing concepts or also developing the specific software?
- Current status of the projects of the *Radbahn GmbH*?
- What role does the *CityScience Lab* at *HafenCity University Hamburg* play in the network of research into smart city and smart mobility concepts?
- What opportunities do you see for electric mobility in Germany?
- Do these methods have an impact on the planning and management of electric mobility?

By using the Mayring-method, the answers of the respective experts have been codified using the CAQDA-Software (Computer Assisted Qualitative Data Analysis) *MAXQDA 24.1.0 Pro*. Because the objects of research is a fairly new phenomenon, the inductive categorisation according to Mayring was used. (Mayring, 2020) The interviews were analysed one after another and the categorisation took place within this process and in relation to the stated research question and sub-questions. If needed, a new category was created. In total, 8 categories were developed. Findings will be summarized in the following for each of these identified categories or codes.

5.3 Findings

The following section will deep-dive into the answers from the experts, categorised according to the codification of the inductive categorisation according to Mayring. (Mayring, 2020) Each of the 8 identified codes or categories are thereby presented and analysed. The findings will form the basis for the later created framework.

Understanding Smart City

The first category was the experts' approach towards defining and explaining the term of Smart City from their perspective. The category was sub-divided into strategy and projects, as some experts argued from a holistic point of view and some others from a project-perspective. From a holistic understanding, it was made clear, that "Smart City as a concepts needs to strive for sustainable urban development" (Dr. Jens Libbe, personal communication, December 7, 2023). He also underpins the before mentioned statement, that Smart City is not about digitalisation as an end in itself, "but ultimately about a serving function of digital tools and the use of data-based control for sustainable urban

development" (ibid.). He mentioned, that cities therefore take the Smart City Charta (BBSR, 2021) as a guiding basis of their implementations of this concepts in the specific cases. He stated that the cities and model projects are operating experimental within that field, as "no model project has the perfect strategy […] with the aims of sustainable urban development […] and testing technological capabilities" (Dr. Jens Libbe, personal communication, December 7, 2023). He continued: "In this respect, the whole thing has a very strong playful element and therefore I wouldn't say that every city measure automatically contributes to sustainable urban development" (ibid.) It was stated that it is strongly connected to the specific cases and projects. (ibid).

From the project-perspective and as added by the expert of the *Frauenhofer IESE,* the distribution of public funds for realizing these Smart City model projects is carried out by the *German Ministry of Living, Urban Development, and Construction* (*BMWSK*) called *Model-Projects Smart City* (*MPSC*). This statement is also consistent with findings in chapter 3, where these MPSC have been analysed for their contribution towards Smart and Sustainable Mobility projects. (BMWSB, 2023c) For the case study of Berlin, the expert from the private company *Radbahn GmbH* added, that Berlin is in subsidises status within this program since 1,5 years "and within the next 3 to 4 years we will be able to show something realisable from a concept" (Matthias Heßkamp, personal communication, November 17, 2023). He added the five projects, Berlin is currently realizing within the MPSC-program, the most important in regards of Smart Mobility is thereby the *Smart City Hardenbergplatz*. This statement is also consistent with the findings of chapter 3. (BMWSB, 2023c)

Understanding Sustainable Mobility

As presented within the literature review, Sustainable Mobility is about avoiding traffic, achieve the shift to more environmentally friendly modes of transport, increase the energy efficiency of these transportation modes and use greenhouse-gas neutral fuels and electricity. (Umweltbundesamt, 2020) When asked to what extent smart technologies can help to achieve this Sustainable Mobility, the experts' answers were very broad. An expert from the *German Aerospace Center* (DLR) added, that sustainable transportation modes contain the following characteristics:

- "Ridesharing
- Autonomous/ highly automated [transportation]
- Supplement to the public transportation system
- Locally emission-free" (Anonymised, personal communication, November 29, 2023a)

The expert added that this kind of transportation needs to be convenient and affordable for its users. (ibid.). The already mentioned Dr. Jens Libbe added that the relation of Smart and Sustainable Mobility highly depends "very much on the sense in which [the] digital tools [are used]" (Dr. Jens Libbe, personal communication, December 7, 2023). He gave the example, that if digital tools support motorized individual transportation modes, while policies should support cycling and walking within a certain city, it cannot be called sustainable. (ibid.) Instead, "the approach should be other way round and basically support walking and cycling with digital tools where it makes sense to do so" (ibid.). This statement will be considered within the following framework. From a technical perspective, Mr. Kohl from the *Frauenhofer-society* added, that especially in the past, mainly car-specific mobility data was collected, as it was the main mode of transportation. Therefore he suggested of generating new data about sustainable modes of transportation "to show what role other types of mobility have in public space and what effects they have […]" (Martin Kohl, personal communication, November 20, 2023). It can be summarized, that both statements from a research and technical-based viewpoint supports the idea of using digital tools to measure and analyse Sustainable Mobility in different ways. It is thereby important combining the aims and goals, a Sustainable Mobility should strive for with the respective technologies.

Understanding Smart Mobility

The next category referred to a deeper understanding of the experts' opinion about Smart Mobility. This category was within the process of coding and sub-divide into three streams: Useful trends, strategies, and projects. The experts agreed that Smart Mobility aims in understanding mobility movements, patterns, and flows with technical and tool-based methods, whereby the aims and goals derive from overarching policies and frameworks. Smart technologies are (as stated) just a method for a better understanding, but are no end in itself. (Anonymised, personal communication, November 21, 2023; Dr. Jens Libbe, personal communication, December 7, 2023; Martin Kohl, personal communication, November 20, 2023; Matthias Heßkamp, personal communication, November 17, 2023) Thereby an expert of an infrastructural company (hereby anonymised) summarised accurately, that "Smart Mobility combines the different types of mobility with technical solutions and innovations to enable efficient, clean and sustainable mobility" (Anonymised, personal communication, November 21, 2023). This is in relation with the statement of the literature review, that "the paradigms of smart urban mobility and sustainable urban mobility are aligned" (Lyons, 2018, p. 12) and if they are not, they need to do so.

As started a useful strategy combines paradigms of Smart Mobility with Sustainable Mobility. One expert added, that he "see[s] the danger from time to time of people claiming that everything should become smarter, that they should tell me everything, then I'll do it" (Matthias Heßkamp, personal communication, November 17, 2023). He believes that "we need to raise awareness of a different kind of mobility that doesn't hurt in terms of the fear of losing what I'm used to, but that opens up new paths […]" (ibid.). He suggests creating a mobility "that is healthier, which also gets you around quickly and then in turn frees up resources […]" (ibid.). With the example of cars as a great invention, but at the same time space- and resource-consuming mode of transport, he stated that "let's create a model, that's how the city needs to be distributed, then let smart technology help make this transformation possible" (ibid). He highlighted the advantages of shared cars within this and a potential combination of new technologies for ordering these vehicles easily. (ibid.) This statement about the advantages of the shared economy within Smart Mobility solutions coincide with the earlier statements, that Smart Mobility is also about ridesharing and sharing economy. (Anonymised, personal communication, November 29, 2023b) As stated within an example given by the author (measuring the traffic intensity on a given road with cameras (if two lanes fulfil the same criteria as three, then one can be taken aways) was slightly criticised by one expert. He stated, that within that scenario, the priority is given to the fluidity of car traffic instead of other modes of transportation, which also indicates potential problems of 'smart' technologies. (Matthias Heßkamp, personal communication, November 17, 2023) It can be summarized, that a useful Smart Mobility strategy combines aspects of Sustainable Mobility and prioritize sustainable modes of transportation. For the needed quantitative analysis, monitoring, and evaluation, technologies and tools can be used.

While one expert indicated, that useful trends of Smart Mobility are difficult to identify, as "[it] depends on what you ever want as a city […]" (Dr. Jens Libbe, personal communication, December 7, 2023) others gave examples of useful trends of Smart Mobility concepts, such as "Mobility-as-a-Service-applications, multimodal mobility platforms, one-step bookings or perhaps a mobility flat rate in the future, i.e. *Deutschland Ticket 2.0* […]" (Martin Kohl, personal communication, November 20, 2023). He added that a useful trend would be, if people pay, according on the travel route instead of the choice of mode of transportation. Therefore, someone needs to guarantee, that the person gets from point A to B with whatever mode of transportation and always pays a fixed price. He added that this would be "Mobility-as-a-Service, thought through to the end, really everything from a user-centred perspective […]" (ibid.). Prof. Dr.-Ing. Noennig added, "digital traffic modelling […] and integrated traffic concepts" (Prof. Dr. Ing. Jörg Rainer Noennig, personal communication, November 5, 2023) would be useful Smart Mobility tools of the future. While this statement is referring to monitor and measure traffic, the expert from the *German Aerospace Center* added the usefulness of electric mobility within the field of motorized individual transportation modes. (Anonymised, personal communication, November 29, 2023b) He

forecasts, that “electric vehicles will not completely replace combustion engines, but they will take a higher market share than combustion engines” (ibid.). It needs to be noticed, that his statement solely refers of replacing existing motorized transportation modes, not arguing, that electric vehicles are always sustainable in itself.

As useful projects of Smart Mobility, the experts identified different case studies and use cases. While some of them highlighted projects dealing with automated transport, sensor technologies and traffic flow control (Dr. Jens Libbe, personal communication, December 7, 2023) others highlighted the integration of smaller navigation systems (e.g. for bicycles) within the applications of big technology players, such as *Google* within Berlin (Martin Kohl, personal communication, November 20, 2023), which can, in turn, help to navigate easily within the respective city (hereby Berlin). Other useful projects will be explained in a later stage about specific useful projects for the case study of Berlin.

Strengths and Weaknesses

The next section summarizes the experts’ opinions on strengths and weaknesses of Smart Mobility solutions. This question was explicitly posed to experts from the private sector, as they often already implemented various Smart Mobility solutions and therefore are able to evaluate strengths and weaknesses from a practical perspective. One expert from a private infrastructural company replied to the questions about strengths, that it can be sub-divided into four categories: Increased efficiency, safety improvements, environmental friendliness, and better planning through simulation. (Anonymised, personal communication, November 21, 2023). He thereby stated, that:

- The increase in efficiency deals with “automated traffic monitoring and digital traffic control, [which] enable[s] real-time optimisation of traffic flow, leading to a reduction in congestion and improved efficiency” (ibid.)
- For safety improvements that “intelligent traffic monitoring systems can help reduce traffic accidents by reacting early to dangerous situations and automatically implementing safety measures” (ibid.)
- For environmental friendliness that “the reduction of traffic jams and optimised traffic flows through intelligent traffic control help to reduce emissions, which contributes to more environmentally friendly mobility” (ibid.)
- And for better planning through simulation that “simulation and modelling make it possible to analyse traffic scenarios in advance, which leads to improved urban infrastructure planning” (ibid.)

It can be summarized, that these stated advantages of automated traffic monitoring, safety improvements, environmental friendliness and better planning through simulation are noticeable and important features of Smart and Sustainable (urban) Mobility. Importance should be attached to achieving these characteristics also because they were mentioned not solely by the expert, rather the literature as well. The already analysed systematic literature review of Francini et al on Smart Mobility from 2021 (Francini et al., 2021) identified similar clusters of a ‘good’ Smart Mobility (see table 2 in chapter 4.1.).

While these characteristics are highlighted by the expert as particular desirable characteristics, he also mentioned weaknesses of Smart Mobility concepts. He thereby analysed five categories of weaknesses: data protection, costs, reliability on technology, non-uniform standards, and human behaviour. (Anonymised, personal communication, November 21, 2023) While concerns of users regarding data protection are quite obvious reasons, the concerns regarding the costs were described as a weakness, because “the implementation and maintenance of advanced Smart Mobility systems requires significant investment dependence on technology” (ibid.). It needs to be added, that in the long run, these investments can pay off due to an increase in efficiency of a certain transport system. As Smart Mobility systems are highly dependent on technology, its failure and malfunction can cause huge damage for the whole system. Another weakness as described by the expert is the lack of unified standards for Smart Mobility technologies, which can lead to difficulties of interoperability between different systems. (ibid.) The last critique aims at

human behaviour: “Smart mobility can only predict and respond to human behaviour and unpredictable events to a limited extent” (ibid.). As urban areas and also mobility systems are complex organisms, a full and holistic understanding of all related indicators is close to impossible, the reliability on technologies can give humans some certainty, but never predict the full causal chain of events. As added by Matthias Heßkamp, smart technologies should thereby always be set in relation of the overarching context. (Matthias Heßkamp, personal communication, November 17, 2023)

Useful technologies and tools

While the latest paragraph helped us to understand strengths and weaknesses of Smart Mobility solutions, it still lacks a clear understanding, what a potential Smart Mobility solution can be. Therefore, the experts got asked about their knowledge about technologies and tools, that are useful within this context. Together with findings of the literature review, these technologies will then be used to form one stream of the later created framework.

One potential technology is the usage of urban data platforms, that combines the collected static, dynamic, and synthetic data in one central space. (Martin Kohl, personal communication, November 20, 2023) Other useful technologies are sensors and cameras (especially thermal imaging cameras), that can observe the physical space in near-Realtime. They can collect data about counting of traffic and vehicles and display the gathered data in certain ways on a computer. (ibid.) LoRaWAN-networks have been identified as being useful to collect the data of installed sensors in a certain space. As mentioned by the expert from *Frauenhofer-IESE*, these technologies are especially useful in rural areas, as these networks require less energy and cover a large spatial area at the same time. (ibid.) He also mentioned that the use of technologies highly depends on each individual case and can therefore not generalised. (ibid). This is of particular importance for the later created framework.

The experts that answered within the questionnaires suggested using platforms to control traffic systems, that combines data of different stakeholders, sensors, and actuators. He added, that “this requires overarching interfaces (vehicles, traffic lights, […], satellites, weather forecasts, event management [and so on]” (Anonymised, personal communication, November 29, 2023b). This can be seen as a the already described plea for the consolidation of diverse data for optimised, holistic traffic planning. He added that especially methods of communications, such as Car2X and X2X communication are highly important for achieving a Smart Mobility system. This statement is in line with the assessment that IoT systems in particular could play a major role in transport planning in the future. (Francini et al., 2021) The former Chief Digital Officer of Berlin, Dr. Ralf Kleindiek pointed out that from his viewpoint, mainly “automatic traffic monitoring, intelligent traffic planning and digital traffic control are the absolutely essential tools of the future” (Dr. Ralf Kleindiek, personal communication, November 28, 2023). He concluded, that “flexible traffic light control for all road users, for example, is no longer a question of technology or money, but of will” (ibid.).

Sustainable transportation with technology

While the latest section aimed in understanding potential technologies and tools, that play a major role within Smart Mobility solutions, the next made-up category or code was identified as combining ideas of technologies with the aims of a sustainable transportation. Hereby the term transportation is used instead of mobility as it deals with the sustainability of modes of transportation and not of mobility patterns of its users. Thereby the experts gave different answers, how it can be achieved.

The expert from the *Frauenhofer-IESE* pointed out, that technology cannot achieve a sustainable transport if we continue looking at traffic from a car driver’s point of view. “If digitalisation is used to make it easier to find a parking space somewhere, then it goes in exactly the other direction” (Martin Kohl, personal communication, November 20, 2023). He criticised, that “other modes of transport are really only considered marginally” (ibid.). This

implies, that Smart Mobility solutions should strive for observing, analysing, and planning other modes of transportation, that are more sustainable. He suggests prioritizing other modes of transportation, such as bicycles, to fosters the city's ambition of creating a more sustainable (urban) transport.

Therefore, and as stated by the expert from the private infrastructural company, "new technologies and technological approaches are key drivers for the development of ecologically sustainable transport in the future" (Anonymised, personal communication, November 21, 2023). He generalised that "innovative technologies play a key role in making transport more environmentally sustainable by improving efficiency, reducing emissions and promoting the integration of different modes of transport" (ibid). This holistic answer was concretised by the expert of the *German Aerospace Center*, stating, that we should strive for a lower consumption of resources in production and operation of mobility, e.g. "lowering the weights/ person of individual vehicles and combine several micro-vehicles (such as scooters, bikes, etc.) into larger units" (Anonymised, personal communication, November 29, 2023b).

Prof. Dr.-Ing. Noennig from the *HafenCity University* in Hamburg pays particular attention to a "system networking and integration, synergies, and efficiency gains" (Prof. Dr. Ing. Jörg Rainer Noennig, personal communication, November 5, 2023) derived from the intersection of various data. He thereby points out the importance of "data value creation" (ibid.). Additionally, he sees the importance of a "digital management of urban air mobility" (ibid.), which could be of particular interest in the near future. Another interesting aspect was brought in by the Lead of the department for energy- and transportation systems of *DLR e.V.*, who points out, that "intelligent transport planning will have no influence on electro-mobility, but it will have an impact on the urgently needed shift away from private transport and towards public transport" (Anonymised, personal communication, November 29, 2023a). He added the useful technology of autonomous driving in public transportation, which can help to make these modes of transportation more affordable and convenient via driverless systems. This can, in turn, take over lot of capacity from private transport "and thus make transport fast, cheap, and more convenient for all participants" (ibid.). This is of particular notice, as the users' needs, and satisfaction should be a key element of reaching for a Smart and Sustainable (urban) Mobility of the future.

As summarized by Mr. Sperl from the *CityLAB Berlin* "intelligent traffic monitoring and control are initially flattering ideas and would very likely be able to control traffic flows more efficiently if implemented across the board" (Markus Sperl, personal communication, November 28, 2023). But he assumes, that "this would […] require the installation of a dense network of traffic measurement instruments, the capacity to analyse the resulting data, and the political will to take the following steps from these data analysis, which are not self-explanatory" (ibid.).

Contribution of research, private sector/ administration

The next question aimed in understanding the contributions, the selected organisations can contribute to achieve a Smart and Sustainable (urban) Mobility. This question was asked once to each organisation, representing one of the sectors: research institution/ think tank, private company, and administration. The code was thereby and within the process sub-divided into the three mentioned sub-categories as well as the stream of citizens, which play a crucial role within urban planning.

The **first category** are administrations. As stated by Prof.Dr.-Ing. Noennig, "municipal associations are the main actors for realizing Smart (and Sustainable) Mobility solutions" (Prof. Dr. Ing. Jörg Rainer Noennig, personal communication, November 5, 2023). They are the ones, which are stating the problems and trying to find potential solutions together with research institutes, think tanks, and the private sector. They are thereby responsible for formulating the overarching aims and goals of Smart and Sustainable (urban) Mobility according to already existing or newly developed knowledge. An example is hereby the strategy of Berlin, *Gemeinsam Digital: Berlin*, which combines aims and goals of a Smart

City and therefore Smart Mobility with potential technologies, tools, and precise projects. (Stadt Berlin, 2022) As described by Dr. Kleindiek, this can be achieved “through a holistic strategy and implementation across all sectors and the abolition of silo-thinking. The “consistent development and implementation of a data strategy for Berlin, the establishment of a data hub, a digital twin, and the consistent data sharing of public and private sector” is from his viewpoint thereby necessary to embed aspects of a Smart City as well as Smart Mobility within the city of Berlin (Dr. Ralf Kleindiek, personal communication, November 28, 2023). As stated by Dr. Kleindiek, the realization of Smart City and Smart Mobility approaches “won’t work without research and the private sector – politics and administrations cannot generate the foundations for innovation and digital transformation and their implementation themselves” (ibid.). He furtherly assumes, that the “public services of the future will be highly data-driven” and therefore an “intelligent and sustainable transport planning of the future will only succeed if the public and private sector share the available data with each other […]” (ibid.). This will be precisely analysed in the last category of the Use Case Berlin.

The **second category** are research institutes, organizations, and think tanks. Mr. Kohl as a representative of the technical research organisation *Frauenhofer-IESE* stated, that the *Frauenhofer-society* can contribute with analysing the specific problem, a certain city has with its Smart Mobility strategy and therefore not solely identifying the problem, rather finding solutions to overcome it. They can contribute with strategic consultation, conception, and specific software development of individual solutions. (Martin Kohl, personal communication, November 20, 2023) The *German Aerospace Center* can contribute with “advising the ministries to promote corresponding projects” and link or combine aspects of similar projects in one. (Anonymised, personal communication, November 29, 2023b) Thereby on one hand the “*DLR Project Management Agency* facilitates research funding in the transport sector on behalf of various federal ministries” and advise ministries about relevant topics and funding guidelines (Anonymised, personal communication, November 29, 2023a). On the other hand, the “*DLR Institutes* are actively researching future topics of society, e.g. green energy and new forms of mobility […]” (ibid.). They are “an important source of inspiration for politics and industry with the aim of strengthening Germany as a centre of knowledge and innovation” (ibid.). As stated by Markus Sperl from the *CityLAB Berlin* “research can begin to incentivise application-oriented research questions, interdisciplinary collaboration and solution orientation” (Markus Sperl, personal communication, November 28, 2023). While these research organizations focus on the precise realization of individual projects, the *German Institute of Urban Affairs* (DIfU) contributes with the scientific support of the *MPSC-program*, which allocated fundings for several Smart City model projects within Germany. They are thereby responsible for the scientific support of the *Coordination and Transfer Center* (*KTS*) within this funding program.

While these mentioned organizations contribute with their scientific support, the **third category** of the private sector is mainly responsible for developing and implementing the specific selected technologies and tools within urban and traffic planning approaches or as stated by Dr. Libbe: “The economic development agencies [of respective cities] hope to provide impetus for start-ups and for universities in general” (Dr. Jens Libbe, personal communication, December 7, 2023) as the market of Smart Cities and Smart Mobility grows. As stated by Markus Sperl, “the private sector naturally harbours great potential for innovation, especially in the area of innovation and in the broad sense of data-driven IT applications” (Markus Sperl, personal communication, November 28, 2023). But he also mentioned, that “at the same time, these players must also sometimes be reminded of the public welfare orientation of their solutions, which mobility solutions should at best considered” (ibid).

An example for a data-driven IT applications, developed by a private company is the asked private infrastructural company, which contributes with a created tool of roadwork-atlas to coordinate roadwork-constructions digitally. It thereby “reduces congestion and therefore resource consumption and contributes to reduce emissions” (Anonymised, personal communication, November 21, 2023). It contributes to sustainable transport by automating

routes planning for diversion and rail replacement transport and thereby increase its efficiencies. (ibid.) It needs to be noticed that this is just one example, how private companies can create technical solutions, that realise guidelines and policies of administrations and research institutions.

Think tanks, such as the public innovation laboratory *CityLAB Berlin* are contributing as a mediator. They "can place and translate topics from different social spheres on the agenda of political actors […] and support the senate and district administrations with expertise on technical issues relating to finding technical solutions in the transport sector, evaluate proposed solutions, stimulate and strengthen the exchange between civil society, science and administration in the mobility sector through networking formats, and help shape mobility in a way that is oriented towards the common good through various projects, including with the participation of the public" (Markus Sperl, personal communication, November 28, 2023). The *CityScience LAB* of the *HCU* in Hamburg can contribute with "basic and applied research, teaching, research transfer (spin-offs), tool development, and the provisioning of prototypes for digital urban planning and development" (Prof. Dr. Ing. Jörg Rainer Noennig, personal communication, November 5, 2023). These think tanks are thereby important actors as they combine the beforehand mentioned administrative guidelines and policies together with findings of research institutes and organizations and develop, together with the private sector, precise projects that help achieving a Smart and Sustainable (urban) Mobility.

The **fourth category**, which is often forgotten, are the citizens themselves. As described by Dr. Libbe from the *German Institute of Urban Affairs*, "Smart Cities should always have a strong participatory element, both in strategy development and ultimately even more so in implementation" (Dr. Jens Libbe, personal communication, December 7, 2023). Strategies, individual projects, and measures should be created in co-operation and co-productively with the citizens of the respective city. (ibid.) This approach helps to analyse the needs of the inhabitants of a certain area. It is thereby important to acknowledge the relevance of what citizens consider important. A "strong participatory momentum" is thereby needed, while creating the Smart City or Smart Mobility strategy of the future (ibid.). This bottom-up approach in Smart Cities and Mobility is needed, "because […] this is the only way to find out what is really needed [and] what actually makes sense" (ibid).

Use Case Berlin

For questions regarding the specific use case of Berlin, were mainly answered from the former Chief Digital Officer, Dr. Ralf Kleindiek. He was responsible for combing potential technologies and tools of a Smart City and Smart Mobility with overarching aims and goals of urban and traffic planning. He therefore published, together with the respective ministries, the Senate of Berlin and the former mayor of Berlin, the Smart City strategy called *Gemeinsam Digital: Berlin*, which will be analysed in a later stage. (Stadt Berlin, 2022) He is therefore the perfect expert with lots of insights in the city's precise development and gave answers about his suggestions regarding the overarching strategy on one hand and precise good practices on the other.

The category of the use case of Berlin is therefore divided into two streams: strategy and useful projects. Dr. Kleindiek identified as a useful Smart Mobility-strategy of Berlin the "consistent conversion of public transport to electric mobility, the coordinated expansion of private and public charging infrastructure and the intelligent transport planning and coordination based on digital twins and consistent data sharing" (Dr. Ralf Kleindiek, personal communication, November 28, 2023). He was also responsible lead of the Smart City strategy of Berlin *Gemeinsam Digital: Berlin*, which was assessed by Dr. Libbe, who stated, that "the strategy they have now written is actually a good one" (Dr. Jens Libbe, personal communication, December 7, 2023). He added that monitoring and evaluation of the conducted Smart City projects is an essential part of this document, which can help to evaluate the projects and its potential contributions within the sustainable guidelines of Berlin. (ibid.).

Mr. Heßkamp added, that learning of these projects and applications can be later scaled up for further use, whereby the Smart City network is of particular importance as they combine different actors and stakeholders. (Matthias Heßkamp, personal communication, November 17, 2023) Asked about potential combination of the Smart City strategy with criteria of Smart Mobility, Dr. Kleindiek answered, that "through a holistic strategy and implementation across all sectors and the abolition of silo trading" it can be achieved (Dr. Ralf Kleindiek, personal communication, November 28, 2023). He suggests "a consistent development and implementation of a data strategy for Berlin, the establishment of a data hub, a digital twin, and the consistent data sharing of public and private sector data" (ibid.). To focus within the Smart City strategy more on Smart Mobility, he suggests fostering "a stronger focus on concrete use cases and implementation projects, [as well as] a consistent and coordinated approach by all administrations and, in case of doubt, the right of the Smart City unit in the Senate Chancellery to intervene" (ibid.).

For a stronger focus on sustainability, the expert from the *German Aerospace Center* added, that "Smart Mobility concepts [need to] include all modes and [should] not just aimed at private transport" (Anonymised, personal communication, November 29, 2023a). With this approach, he sees "great opportunities to make transport in Berlin sustainable in the future" (ibid.). He analysed, that it is "already easier and more convenient to switch between different transport options in Berlin" (ibid.). And he therefore assumes, that the "easier/ more convenient this change is, the newer (and sustainable) offers will be accepted" (ibid.).

As a second question, the experts got asked, what Smart Mobility projects were assessed as successful. As mentioned by Dr. Kleindiek, many of these projects are carried out by the think tank *CityLAB Berlin*. (Dr. Ralf Kleindiek, personal communication, November 28, 2023) Therefore, the following list will shortly present them:

- **Shared Mobility flows**: simple visualisation of bike sharing data. This model allows sharing of data from different sharing models providers about transport behaviour of people with different vehicle types. It shows the "usage routines, [and] in combination with good public transport data [it indicates] weak points in public transport networks or possible expansion prioritisation" (Markus Sperl, personal communication, November 28, 2023)
- **Open traffic count**: Development of a "prototype for privacy-preserving, camera-based traffic counting" (ibid.). It is therefore a resource-saving, low-cost way to improve the poor mobility data situation and implement mobility data collection without privacy risks, as the camera does not store images. (ibid.)
- ***Freemove***: A project "working on the question of how movement data […] can be made available to the common good in a way that protects privacy" (ibid.). The data is generated within citizen science projects with e.g. GPS-tracking apps, data of shared mobility suppliers, and smartphones. (ibid.). It can help to "improve services (routing, intermodal offers), and make planning and expansion more demand-based" (ibid.).
- ***Radflow***: Part of the *Radbahn*-project, where smart traffic light circuits and signs help a convenient, easy, and efficient cycling experience. (Matthias Heßkamp, personal communication, November 17, 2023)

In addition, there are a few other projects, which also contribute to achieve a Smart and Sustainable urban Mobility within Berlin, but these mentioned ones were the highlights of the interviewed experts. They will strongly contribute to identify technologies and tools of the following framework.

It needs to be said, that all 9 experts (3 with interview, 6 by questionnaire) had a strong contribution to completing the previously analysed literature review. The coding-technique by Mayring (Mayring, 2020) thereby helped to identify 8 different codes/ categories within the analysis-process. Their results and findings have been presented. This will form the basis (together with the conducted literature review) of the following SASUM-framework.

6 The SASUM-framework

The theoretical and practical literature review revealed lots of different solutions to achieve a Smart Mobility. A first approach of clustering them was given by using the software *VOSViewer* to analyse a research data base (in the example *Scopus*) to identify seven different fields of action. Even though, this approach helps to identify the main research field of Smart Mobility, that most papers deal with, it still lacks a solution-oriented evaluation matrix, that describes different categories and groups of smart mobility solutions.

The remaining question is, how we can cluster the given Smart and Sustainable Mobility concepts in groups? How can an evaluation matrix be developed, that helps cities and municipalities to analyse their potential for achieving a Smart and Sustainable (urban) mobility? How can international, continental, national and regional guidelines be used for the needed mobility change and strive for a higher sustainability?

A recently published research paper of Mavlutova et al. in 2023 described the existing problem and research gap, that exists within the conceptual understanding of Smart Mobility concepts: They analysed, that:

> *"[…] it is worth considering that the huge number of concepts and their bride spectrum do not contribute to a sufficient level of understanding and system thinking. Therefore, there is an urgent necessity to provide a systematic overview resulting in a general concept allowing one to see the connections between the UN Sustainable Development Goals (including the sub-goals), theoretical concepts as elaborated above and practical applications (concepts or models) to be used as decision-making tools and KPI [Key Performance Indicator] to control the process of transformation towards sustainable development, it is valuable to rely on a KPI-based evaluation system covering the environment, energy, mobility, ICT, population, economy and governance in general"* (Mavlutova et al., 2023, p. 11).

They described the gap between existing guidelines regarding mobility and related technical and or 'smart' solutions. This bridge can be solved by using an evaluation system, that is based upon key performance indicators, covering domains of a city, such as environment, energy, mobility and many more. For the domain of mobility and urban transportation, they suggest, that "the urban transport system in Smart cities should focus not only on users but on all citizens, and should focus on developing citizen-friendly business models and innovations, […] while taking into account business, municipalities and universities which should support citizens by promoting them innovation activities towards sustainability" (Mavlutova et al., 2023, p. 11).

As described earlier, for achieving this complex task while fulfilling the best possible outcome for all citizens of an urban area, new methods and tools can be used. Therefore, Smart Mobility can provide solutions by intersecting and combining various urban indicators with the help of technology, or more specifically ICT, IoT, physical devices in the built environment and software analytics tools.

The following paragraph will provide a first approach, how such a holistic Smart Mobility framework could look like. It firstly provides the created indicators for the aims and goals, Smart and Sustainable Mobility solutions should strive before analysing the therefore applicable tools and technologies. Secondly, the described indicators will be used to create the final Smart and Sustainable Mobility framework (abbreviated as SASUM). Lastly, examples of its use and embeddedness will be given. Thereby the previously analysed literature and expert interviews were considered and marked within it.

6.1 The parameters of the framework

The following section will describe the parameters of the SASUM, that shape the evaluation matrix. It should be noted, that before the usage of this framework, all relevant stakeholders, and their relations within the field of Smart and Sustainable Mobility should be analysed.

The framework itself aims in providing a practical and usable matrix, that can be used to achieve a Smart and Sustainable (urban) Mobility. Hereby the word mobility is used within the framework of the SASUM instead of transportation. The reason for this is, that as explained earlier, transportation is the act of moving goods and people. It describes something, that someone or something does.

In comparison, mobility describes the ability to freely move or be moved. It is a condition, that something or someone has. While transportation systems in urban areas and their improvement can be analysed by using ICT, the overarching goal of Smart and Sustainable (urban) Mobility aims in changing the ability of moving for citizens and the users of transportation systems. Mobility is a condition, someone has, the term centres around the users' instead of the related system. As described in the introduction the framework will, beside other factors, improve users' ability to use a transportation system, wherefore this term is more suitable in the framework of the SASUM.

The following holistic framework is divided into two basic streams. These streams represent on one side the aims and goals, a Smart and Sustainable (urban) Mobility should strive for as well the technologies and tools, that can additionally help to achieve this. Therefore, the two streams are:

1. Aims and goals of Smart and Sustainable Mobility
2. Technologies and tools, that achieve a Smart and Sustainable Mobility

Thereby aims and goals of Smart and Sustainable Mobility should be derived from overarching transport and urban planning concepts on all administrative levels. This includes the international, continental, national, regional, and local or municipal level. Additionally, all other planning and governing levels and related authorities, that shape mobility in cities should be considered. At planning and governing levels, guidelines, and principles, regarding traffic planning, mobility, urban planning and especially regarding environmental topics should be analysed.

This includes international frameworks, such as, primarily but not exclusively, the Sustainable development goals (SDGs) of the United Nations (United Nations, 2023), the Paris' climate agreement (UNFCC, 2023), the Kyoto Protocol (Berger, 2013), the New Urban Agenda (UN-Habitat III, 2017), the IPCC-report (Tietz, 2023) and additionally the results of last climate action conferences, such as COP28 (UNFCC, 2023). Additionally, international guidelines like the *Guide of international good practices about mobility management* from UNECE, guidelines and principles about Mobility and transportation of UN-Habitat (UN-Habitat, 2023) as well as results of the last conferences on mobility and transportations, such as results from conferences like the International conference on Smart Mobility (IEEE, 2022), should be considered.

On a continental level (if existing and strongly influencing national guidelines regarding sustainability and transportation), guiding policies should be included. In example, at the European level, the Sustainable and Smart Mobility strategy (Sustainable and Smart Mobility Strategy, 2020), current guidelines of the European Commission on Mobility and transportation (European Commission, 2023) and further supplementary guidelines and specifications should be used.

On national and state-level the implemented regulations vary and depend on each specific case study. As this is (for now) a generic and holistic framework, that aims in being adaptable for various cases, national and state-level policies are not presented here. For the case of the city of Berlin, they will be presented in chapter 6.

6.2 Stream 1: Aims and goals of the framework

All the described plans on all levels should be analysed about their requirements, legal bindings as well as regulations and guidelines regarding Smart and Sustainable (urban) Mobility. These requirements of all affecting plans (for each specific case study) should then be categorized into one of the three categories (**Note**: In brackets can be found the reference to the analyse theoretical literature (if available), that was used to define the category):

1) Sustainable Mobility (as defined by Lam & Head; *German Zukunftsinstitut;* author)
2) Satisfaction of users' needs (as defined by Lyons)
3) Smartness (as defined by the *ZTG*)

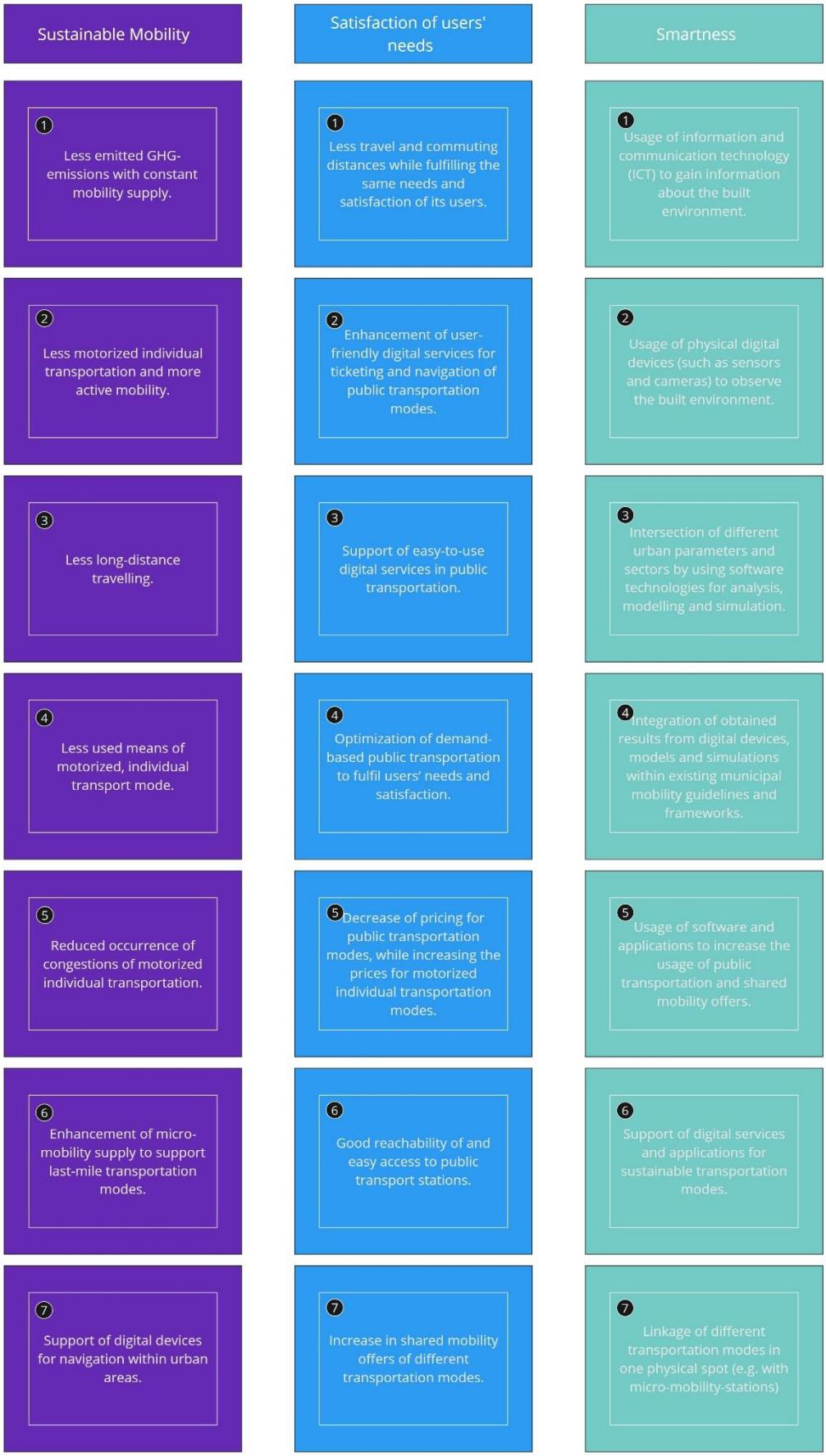
These categories derived from the *Table 3: Table of parameters of smart and sustainable (urban) mobility the beginning of this thesis* and describe the aims and goals, Smart and Sustainable Mobility concepts should strive for. All aims and goals can be clustered as:

1. Striving for Sustainable Mobility, including:
    1. Less emitted GHG-emissions with constant mobility offers. (UNFCC, 2023; United Nations, 2023)
    2. Less motorized individual transportation and more active mobility. (Lam & Head, 2012; Office of Science and Technology, Department of Trade and Industry, 2006)
    3. Less long-distance travelling. (Lam & Head, 2012; Office of Science and Technology, Department of Trade and Industry, 2006)
    4. Less used means of motorized, individual transport modes. (Banister, 2008; Lam & Head, 2012)
    5. Reduced occurrence of congestions of motorized individual transportation. (Banister, 2008; Brenner, 2007)
    6. Enhancement of micro-mobility supply to support last-mile transportation modes. (Lyons, 2018; Lyons & Davidson, 2016)
    7. Support of digital devices for navigation within urban areas. (Banister, 2008; Brenner, 2007)
2. Striving for satisfaction of users' needs:
    1. Less travel and commuting distances while fulfilling the same needs and satisfaction of its users. (Banister, 2008; Brenner, 2007)
    2. Enhancement of user-friendly digital services for ticketing and navigation of public transportation modes. (Brenner, 2007)
    3. Support of easy-to-use digital services in public transportation. (Brenner, 2007)
    4. Optimization of demand-based public transportation to fulfil users' needs and satisfaction. (Abraham et al., 2017)
    5. Decrease of pricing for public transportation modes, while increasing the prices for motorized individual transportation modes. (BMDV, 2023c)
    6. Good reachability of and easy access to public transport stations.
    7. Increase in shared mobility offers of different transportation modes. (Markus Sperl, personal communication, November 28, 2023)
3. Striving for a smart transportation system:
    1. Usage of information and communication technology (ICT) to gain information about the built environment. (Giffinger et al., 2007)
    2. Usage of physical digital devices (such as sensors and cameras) to observe the built environment. (Markus Sperl, personal communication, November 28, 2023; Martin Kohl, personal communication, November 20, 2023)
    3. Intersection of different urban parameters and sectors by using software technologies for analysis, modelling and simulation. (Dr. Ralf Kleindiek, personal communication, November 28, 2023)
    4. Integration of obtained results from digital devices, models and simulations within existing municipal mobility guidelines and frameworks. (Dr. Ralf Kleindiek, personal communication, November 28, 2023)

5. Usage of software-applications to increase the usage of public transportation and shared mobility offers. (Martin Kohl, personal communication, November 20, 2023)
6. Support of digital services and applications for sustainable transportation modes, such as electric cars (Anonymised, personal communication, November 29, 2023a), busses, trucks, bikes, autonomous vehicles, and SAVs.
7. Linkage of different transportation modes in one physical spot. (DIfU, 2019)

All objectives of Smart and Sustainable (urban) Mobility are thereby clustered in three categories: Sustainable Mobility, Satisfaction of users' needs and Smartness. Each of these categories contains several sub-goals, that shape and define the specific category. All objectives can be visualised as following:

Figure 16: Visualization of aims and goals of Smart and Sustainable (urban) Mobility



Source: Elaborated by the author

As explained earlier, the sub-categories came from theoretical literature about objectives of Smart and Sustainable Mobility approaches as well as the contributions within the expert interviews. Thereby the given list of aims and goals should not be seen as complete and fully conclusive, as there exist more approaches towards striving for a Smart and Sustainable Mobility. Nevertheless, this clustering can help identifying the main objectives in a first glance. A continuous supplementation of them is needed constantly, as sub-goals can slightly change over time.

All related goals of beforehand mentioned overarching guidelines and principles on all administrative levels (international, European, national, and regional/ local) should be grouped within one of these categories. Each of the guidelines should be analysed for their aims and goals related to Sustainable Mobility, satisfaction of users' needs and Smartness and its related sub-goals. For each individual case (or city), all relevant aims on all levels should be matched with one of the stated sub-goals. This will help, to cluster the goals into groups and intersect them later with the therefore suitable tool and technology.

6.3 Stream 2: Technologies and tools of the framework

The first step analysed the aims and goals a Smart and Sustainable (urban) Mobility should strive for. Within the next step, the methods are stated, that can be used to achieve these goals. Thereby a method is, within this context, understood as technology, technique, or tool, that is suitable to achieve one of beforehand mentioned goals.

The same approach of clustering was therefor used. The technologies and tools are firstly separated into three streams or clusters. (**Note**: In brackets can be found the reference to the analyse theoretical literature (if available), that was used to define the category) The three streams are:

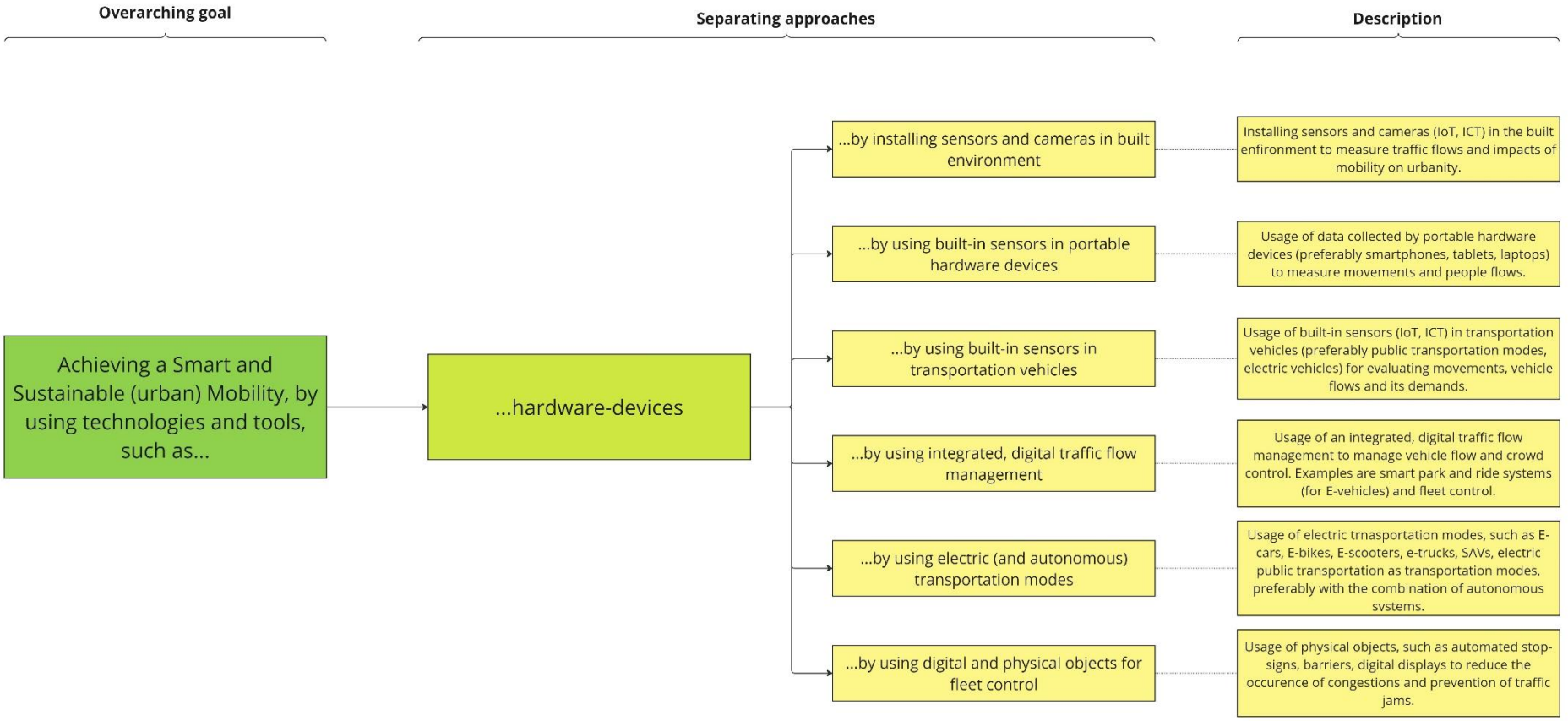
1) Usage of hardware-devices (as explained by Martin Kohl, personal communication, November 20, 2023)
2) Usage of software-tools (ibid.)
3) Usage of mixture of hard- and software (Middleware) (ibid.)

These three streams or clusters are defined by their technical components. Using hardware-devices thereby represents physical devices (e.g. sensors, cameras) to observe the built-environment regarding mobility. The second stream of software describes the usage of software tools of various kinds for analysing mobility patterns or predict possible scenarios, models, or simulations to achieve a pre-prediction of changes within the built environment. The third and last stream represents the interaction of hard- and software, also called middleware. Hereby, the physical objects of the built environment interact with software tools to monitor traffic and create insights regarding mobility.

Just as with the aims and goals of Smart and Sustainable (urban) Mobility, the three streams or clusters are now subdivided into smaller categories. Each stream contains the overarching goal (here simplified as 'Achieving Smart and Sustainable (urban) Mobility) as the basis. This overarching goal is thereby simplified and represents all mentioned aims and goals, that are mentioned beforehand. This overarching goal can be achieved by using the three mentioned streams (hardware, middleware, software), each of them is separated into sub-clusters, each cluster is then described in the following.

The next visualization will provide an overview of the first stream of hardware-devices, which can be used to achieve a Smart and Sustainable (urban) Mobility:

Figure 17: Visualization of hardware-devices within the framework



Source: Elaborated by the author

The stream of hardware-devices is thereby subdivided into six smaller clusters. The first cluster describes the installation of sensors and cameras in the built environment. This means the installation of physical objects within a network of ICT and IoT in physical urban space to measure traffic flows and impacts of mobility on urbanity. An example is the usage of a camera, that counts traffic flows (e.g. of vehicles/ hour) at a certain crossing in one main road of a city. (Anonymised, personal communication, November 21, 2023; Dr. Ralf Kleindiek, personal communication, November 28, 2023; Markus Sperl, personal communication, November 28, 2023; Martin Kohl, personal communication, November 20, 2023)

The second cluster describes the usage of built-in sensors in portable hardware-devices (preferably smartphones, tablets, laptops) (Markus Sperl, personal communication, November 28, 2023) to measure movements and flows of people. A common example is the usage of location-data, derived from smartphones, that tracks and analyses movements of people within a city.

The third cluster describes the same case of built-in sensors in certain transportation vehicles. The thereby collected data can help to track vehicles in a city and therefore predict vehicle flows and demands. A popular example is the usage of data derived from private cars, that collects data about air quality, rain, and temperature, that can be further used for analysing impacts of certain urban interventions. (DKSR, 2023)

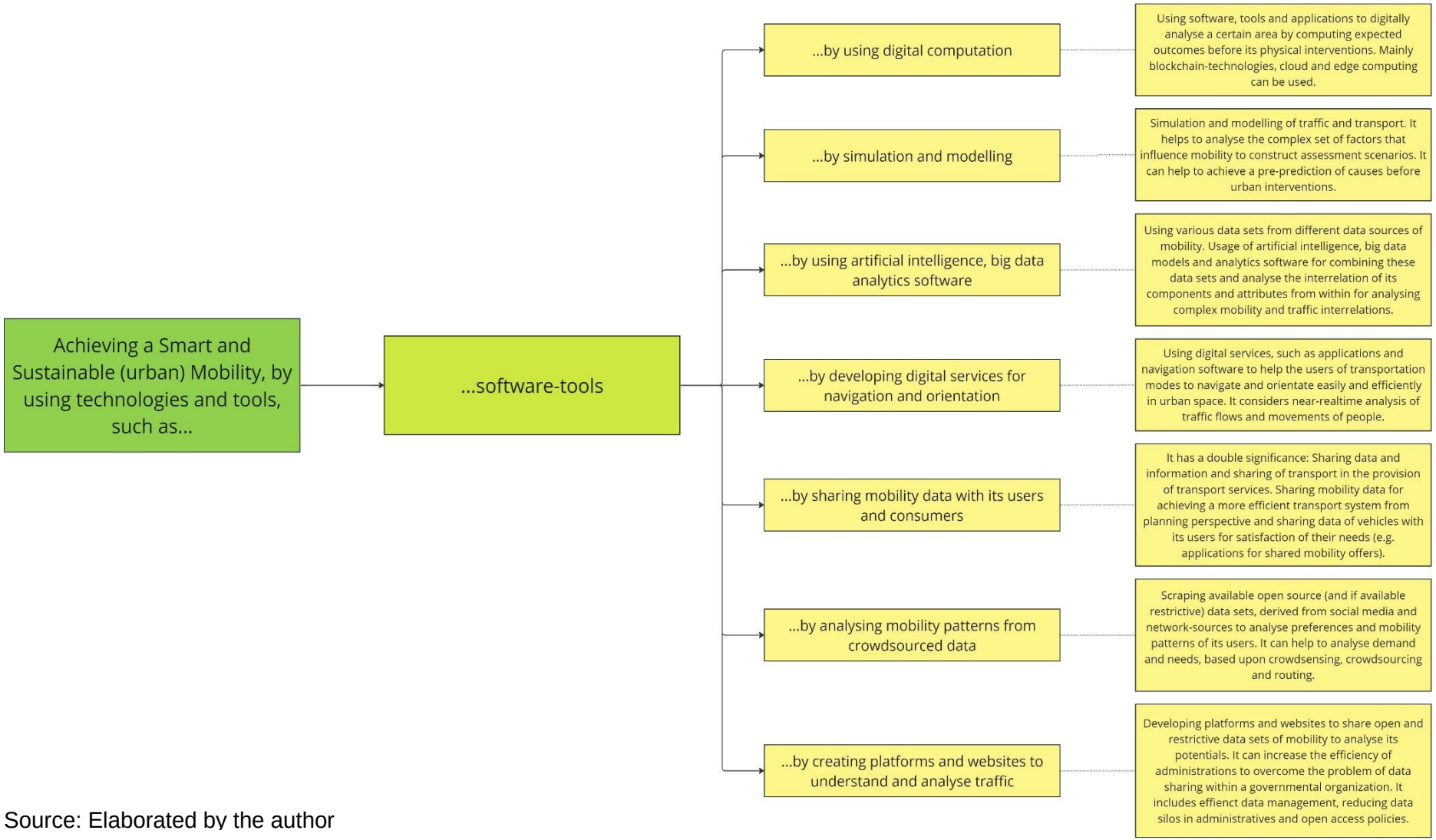
The fourth cluster describes the usage of an integrated, digital traffic flow management system, which can help to manage vehicle flows. Examples are smart park and ride systems (preferably for E-vehicles), and the inner-city fleet control, as well as bicycle-flow-systems. (Dr. Ralf Kleindiek, personal communication, November 28, 2023; Matthias Heßkamp, personal communication, November 17, 2023) Panels, signs, and digital display boards can thereby help car-drivers to efferently navigate within a city and use existing parking lots.

The fifth cluster describes usage of electric and autonomous transportation modes. While an electric vehicle cannot solely describe as sustainable, because of its engine, the trend of electric and autonomous vehicles, such as e-cars (Anonymised, personal communication, November 29, 2023a), e-bikes, e-scooters, and SAVs (shared autonomous vehicles) can help to strive for a higher ecological sustainability. The combination of electric vehicles with autonomous systems is thereby the preferred option.

The sixth and last cluster describes the usage of physical and digital objects for fleet control. These physical objects can vary from automated stop-signs, digital displays along roads and automated barriers, that are automatically regulating the traffic flow to avoid congestions and traffic jams. This is also closely related to using software to analyse traffic in near-Realtime and automatically regulate its flow. An example would be the automated closing of a certain road with a barrier in case of a measured high air pollution during rush hour. While sensors and cameras can provide the input-data, a software can analyse in near-Realtime the react by using physical objects for traffic regulation. (Dr. Ralf Kleindiek, personal communication, November 28, 2023; Martin Kohl, personal communication, November 20, 2023; Matthias Heßkamp, personal communication, November 17, 2023)

While all these technologies and tools have a physical component, Smart and Sustainable (urban) Mobility can also be achieved by using various digital software-tools. These will be visualized in the following:

Figure 18: Visualization of software-tools



Source: Elaborated by the author

The graphic illustrates, how Smart and Sustainable (urban) Mobility with its mentioned aims and goals can be achieved by using various software-tools. Thereby, seven different sub-categories are identified.

The first one describes the usage of digital computing for a digital analysis of urban space and a certain area. (Prof. Dr. Ing. Jörg Rainer Noennig, personal communication, November 5, 2023) This is characterized by analysing a potential outcome of an urban intervention before its physical realization. This can help to analyse expected outcomes of Smart and Sustainable Mobility interventions before its realization. Typical technologies, that can be used for this, are blockchain-technologies, cloud and edge computing, and big data analytics.

The second category describes the simulation and modelling of mobility patterns and traffic scenarios. It can help to analyse a complex set of indicators, that influence mobility, to construct assessment scenarios. (Prof. Dr. Ing. Jörg Rainer Noennig, personal communication, November 5, 2023) It helps to achieve a pre-prediction of causes before its physical urban intervention.

The third category is probably one of the most prominent one today. It describes using artificial intelligence and big data analytics for combining different, big data sets and parameters from various sources. (European Parliament, 2023; Stadt Berlin, 2022) New technologies and analytics software tools can help to analyse dependencies of indicators to analyse complex and mobility and traffic interrelations.

The fourth category describes the development of digital services and navigation software to help users of all different transportation modes to navigate and orientate easily and efficiently in urban space. It considers the near-Realtime analysis of traffic flows and movements of people. (Banister, 2008; Brenner, 2007; Vasant et al., 2019)

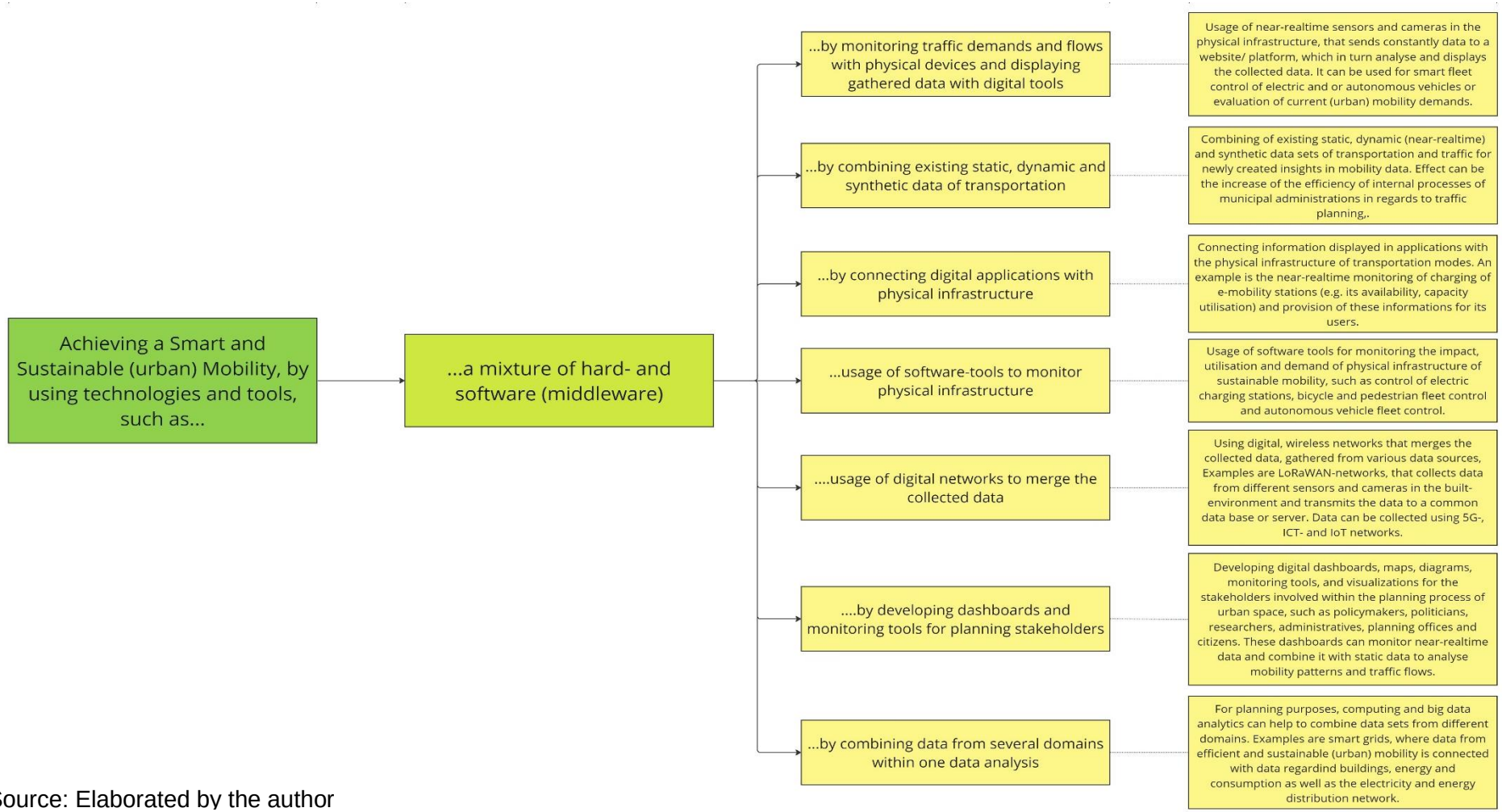
The fifth category describes the sharing of mobility data and offers. This has a double meaning, firstly describing the sharing of transportation modes (shared economy) as well as the sharing of data, that is directly or indirectly related to mobility. Sharing mobility data is specifically important to disseminate knowledge about current conditions of a mobility system across different stakeholders and participants. (Dr. Ralf Kleindiek, personal communication, November 28, 2023; Markus Sperl, personal communication, November 28, 2023)

The sixth category describes the analysis of analysing mobility patterns from crowdsourced data. This can specifically mean the usage of social media platforms and social networks to analyse preferences and mobility patterns of its users. (Markus Sperl, personal communication, November 28, 2023) This in turn can help to analyse demand and needs of users based upon crowdsensing, crowdsourcing and routing data. An example can be seen in the usage of data about preferences of users of transportation modes of all kinds.

The seventh and last category illustrates the development of platforms and websites to share mobility data and deeply understand and analyse traffic-scenarios. It is mainly about sharing open (and restrictive) data sets of mobility. This in turn can increase the efficiency of administrations to overcome problems of data sharing and plan complex transportation systems. (Berlin Mobility Data Hub, 2023; BMDV, 2023a)

While these seven categories all refer directly to the usage of software-tools, the third and last stream focuses on the intersection of hardware and software. For this mix of physical and digital tools the term ‘middleware’ is used, even though this term (in sense of informatics) describes a certain kind of software tool. Here, the term is used to describe the interrelation of hard- and software.

Figure 19: Visualization of 'middleware-tools'



Source: Elaborated by the author

The third stream represents a mix of hard- and software-tools to achieve a Smart and Sustainable (urban) Mobility. This, hereby called middleware represents the intersection of physical objects in urban space (hardware-devices) and digital software-tools. Whereby all beforehand mentioned components of hardware and software include (depending on the case) a component of middleware, this stream represents clearly identifiable middleware components, where a clear interrelation between both technologies can be seen.

The first category describes the monitoring of traffic demands and flows with physical devices and displaying these gathered data visually with a software-tool. (Anonymised, personal communication, November 29, 2023b; Dr. Ralf Kleindiek, personal communication, November 28, 2023; Markus Sperl, personal communication, November 28, 2023) An example can be seen in the assumption, that cameras and sensors observe the built environment and send the gathered data to a platform in near-Realtime. This platform allows interacting directly with the urban city life. It can be used for smart fleet control of electric and autonomous vehicles or an evaluation of current (urban) mobility demands.

The second category describes the combination of data sets from various sources, such as static data (often derived from administrations and government), dynamic data (derived from sensors and cameras) and synthetic data (data that is created on basis of the two beforehand mentioned and simulated or models traffic flows) and the collection in one digital space. (Berlin Mobility Data Hub, 2023; BMDV, 2023a)

The third category described the connection of digital applications with the physical infrastructure. For example, e-charging stations for electric vehicles can be monitored with sensors, a platform can gather and display these data and can tell municipalities or governments insights of its availability, capacity, and utilisation. (NOW GmbH, 2024)

The fourth category describes the usage of digital networks to collect data, derived from sensors and cameras. Examples are LoRaWAN-networks, that collects data from different sensors and cameras in the built environment and transmits the data to a commonly used data base or server. (Martin Kohl, personal communication, November 20, 2023; Smart City Berlin, n.d.) Beside LoRaWAN, technologies reaching from 5G to ICT and IoT networks and Bluetooth.

The fifth category illustrates the development of dashboards and monitoring platforms. These software-tools display gathered data from IoT-devices, sensors, and cameras. Dashboards, maps, and diagrams can be developed for various purposes of planning stakeholders and can provide valuable insights for stakeholders of the planning process, such as policymakers, politicians, researchers, municipalities, planning offices and citizens. It can help to analyse and understand mobility patterns and traffic flows. (Verkehrsinformationszentrale (VIZ) & Senatsverwaltung für Mobilität, Verkehr, Klimaschutz und Umwelt, 2024)

The sixth cluster describes the combination of data from several domains within one data analysis. As an example, smart grids can be seen, where data from efficient and sustainable (urban) mobility can be interrelated with data from buildings, energy, and electricity. (Jankowski, 2013)

All these cluster derived from the streams of hardware-devices, software-tools, and the combination of hard- and software can help to achieve a Smart and Sustainable (urban) Mobility with the beforehand mentioned goals. The next chapter will explain the potential use of the one example of the presented SASUM-framework with the use case of Germans' capital Berlin.

7 Case study of Berlin

The following chapter aims in checking the adaptability of the presented SASUM-framework. The usage of a specific case study (here Berlin) will help to evaluate the practicability and potential use of the framework. Therefore, the next chapter illustrates the step-by-step analysis of this process.

The first step is thereby a pre-processing analysis, that strives for illustrating and evaluating the existing direction the city is moving within the field of Smart Cities as well as the network of actors and projects within the field of Smart Cities and due to this Smart Mobility. This step needs to be done in advance of the usage and application of the SASUM-framework.

7.1 Smart city network in Berlin

Thereby the first step is an analysis of the underlaying direction, the city of Berlin is moving in regard to Smart City- and Smart Mobility solutions.

The reasons of Berlins' focus on Smart City solutions derived from the circumstances, that Berlin is German-wide the "fastest growing city […] with approximately 50.000 new citizens and appr. 13 million tourists per year" (Senate Department for Economic Affairs, Energy and Public Enterprises, 2023, p. 1). Therefore, Berlin needs functioning infrastructures and "networked, intelligent and holistic solutions that will enable the city to meet the challenges of the future, in particular climate neutrality" (ibid.). These reasons justifying the strong movement of the city of Berlin to become a Smart City.

Thereby the Berlin senate claims, they focus within the Smart City concept on the sectors of mobility, energy and living. Their conviction is, that "the digital transformation also enables ecological change" (Senate Department for Economic Affairs, Energy and Public Enterprises, 2023, p. 1). Special attention is thereby given to innovative economic and research locations (within Berlin mainly the ten future locations).

While these information of the senate department for economic affairs, energy and public enterprises give a broad overview of aims and goals of the Smart City strategy of Berlin, the next section will analyse the underlaying network of stakeholders, that are involved, to achieve the mentioned aims and goals.

7.1.1 Network of stakeholders

The firstly named group of actors is the so-called *Network Smart City Berlin*. It was founded in 2013 and is since supported by the *Berlin Partner for Economy and Technology GmbH,* a public-private partnership that supports Berlins promotion for Economy and Technology. (Berlin Partner GmbH, 2024) This network is thereby a "cross-sector association of more than 160 stakeholders from business, science, research and administration" (Smart City Berlin, 2024a, p. 1). It describes itself as "impulse generator, think tank and bridge builder for the further development of Berlin into an intelligent, innovative-oriented, citizen-focused and future-proof city" (ibid.).

Within this network, expert-groups discuss guidelines, projects, potentials but also weaknesses of underlaying ideas and concepts of a Smart City and its embeddedness within the case of Berlin. Therefore, "representatives of the expert groups, speakers of the network, the Smart City unit at *Berlin Partners for Business and Technology GmbH*, the Berlin Senate Chancellery as the central point of contact for the Berlin administration and the Senate Department for Economics, Energy and Operations" (Smart City Berlin, 2024a, p. 1) regularly meet and discuss the direction, the Smart City agenda of Berlin is aiming for.

This overarching agenda will result in the elaboration of various projects. These are then pitched in front of the secretaries of the state Berlin. (Senate Department for Economic Affairs, Energy and Public Enterprises, 2023)

After realization, the *Senate Department for Economics, Energy and Operations* of Berlin

enables citizens of Berlin to explore the conducted projects within their project, called *Discover Smart City Berlin*. (ibid.)

In 2015, the city of Berlin adopted the overarching strategy called *Smart City Strategy Berlin.* Additionally, the agenda *Gemeinsam Digital: Berlin* (Stadt Berlin, 2022) was developed in 2022. Both concepts form the basis of all projects within the Smart City-ecosystem since then. These strategies and further concepts are explained in a later stage of the thesis.

7.1.2 Portfolio overview

As described earlier, the Smart City network is supported by the public-private entity *Berlin Partner for Economy and Technology GmbH.* They enable the included research organizations, think tanks, private companies, and administrations to work collaboratively on the vision of a Smart City of Berlin.

This vision forms the basis of the developed projects. In the case of Berlin, these projects are widely spread and located within all fields of urbanity, such as environment, ecology, economy, infrastructure, construction, culture, arts, and digitalization.

Thereby all projects can be divided into two categories: so-called Model-projects, that are funded by the national government and are intended to be scaled up for other cities after successful realization; and municipal projects, that are not within the MPSC-funding program. “They are thus on par with the five implementation projects of the Smart City Berlin model projects […]” (Smart City Berlin, 2024b, p. 1).

An evaluation of the first category of the model-projects revealed two projects (SMART SPACE *Hardenbergplatz* and *Kiezbox 2.0*) that are precisely aiming in improving mobility in a smart way within Berlin. Their precise scope will be explained in the following section.

The number of municipal projects is higher. Within these projects, 12 projects are directly or indirectly related to mobility, traffic, or logistics. 14 projects are directly or indirectly related to sustainability and or environmental/ climate protection. Two projects (*Berlin TXL Schumacher District* and *Adlershof Combifuel station*) are cross-cutting projects, that contain both domains of mobility and sustainability. (Smart City Berlin, 2024b)

7.1.3 Explanation of current projects in smart mobility

The next section will deep-dive into selected projects of the previously presented portfolio overview. Projects of both categories (model projects as well as municipal projects) are analysed.

From the five projects, that are funded within the MPSC-funding program, two precise projects aim in improving the cities mobility or accessibility. The first one is called *SMART SPACE Hardenbergplatz*. Aim of the project is the development of “the area in front of Zoological Garden train station together with the Berlin city society from an ordinary station forecourt into a city square with increased quality of stay and smart mobility offerings by 2026” (BMWSB, 2023a, p. 1). Thereby they want to identify existing usage demands, flexible usability and efficient management of public spaces, transferable operator models, model use of smart technologies and creation of a prototypical negotiation platform and an improvement of the connecting mobility through a broader range of mobility options. (BMWSB, 2023a)

The second project, which is solely indirectly related to mobility and accessibility is called *Kiezbox 2.0*. Aim of this project is the improvement of communication between governmental institutions and citizens in the event of a widespread power outage. The research aims in solving communication problems between these stakeholders in case of a crisis. The therefore installed public Wifi-hotspots can in addition to maintaining the communication record urban sensor data such as temperature, air quality, noise and makes them available for public, civil society, and commercial use. (BMWSB, 2023a)

The category of municipal projects revealed 12 projects dealing with mobility and 14 projects dealing with sustainability. 2 are cross-cutting projects.

Focus of the 12 mobility projects is the creation of new, innovative city districts, such as

Berlin TXL with the *Schumacher district*, the *Urban tech Republic*, the *Campus Charlottenburg City West*, *EUREF-campus*, *Research- and technology-park Adlershof* and the *Technology-parc Humboldthain*. (Smart City Berlin, 2024b). Focus of these districts is the allocation of municipal space for research, testing and implementation of new forms of mobility. Another group are infrastructure projects, such as the creation of a bicycle-path under the U2 (project: *Radbahn*) and more. Additional projects with a wide range of aims, such as the creation of reusable and rechargeable batteries (project: *Greenpack Akku*), the development of an energy-efficient and hybrid inland waterway vessel (project: *ELEKTRAII*), and the analysis, planning and embedding of e-mobility solutions within the city (project: *Neue Mobilität Berlin*) round-off the portfolio. Lastly, projects that aim in improving the ICT and IoT-networks within the city, e.g. to analyse traffic data, are presented, such as the usage of a LoRaWan-Gateway at Berlin main station (project: *Berlin Hauptbahnhof LoRaWan-Gateway*), and projects in fostering standards for software development, e.g. to standardise data spaces, which collects mobility data of different sources (project: *Referenzarchitektur Offene Urbane Plattform*). (ibid.)

The projects of the category of sustainability and or environmental/ climate protection are mainly focussing on improving waste management by using digital tools, such as the projects like the *sewage treatment plant in Münchehofe*, the *waste-to-energy plant in Ruhleben* and a *hub for implementation of circular economy*. Interestingly and as stated earlier, just two of them (*Berlin TXL Schumacher District* and *Adlershof Combifuel station*) are directly cross-cutting of both domains. While within the *Berlin TXL-project*, where the Schumacher district is located, new smart and sustainable mobility solutions will be researched, the *Adlershof combifuel station* aims in researching alternative carbon-dioxide-neutral mobility solutions for refuelling vehicles. (ibid.)

As all projects are presented and its aims and goals understood, the next chapter analyses underlaying guidelines, policies, and frameworks, that were used to formulate the overarching guidance of these presented projects. All involved stakeholders, their interrelations and all relevant projects are presented by now, the pre-processing phase is thus completed.

7.2 Stream 1: Selecting aims and goals of underlying guidelines

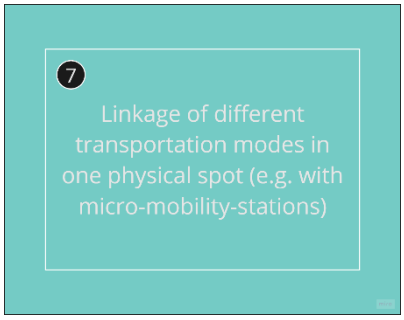
Several underlaying guidelines and policies shape the Smart City and more importantly the Sustainable Mobility strategy of Berlin. The following section will cluster them in categories. In the following, selected policies will be matched with the previously mentioned aims and goals of SASUM-framework. As described earlier, the hereby called ‘puzzle-piece’ of the framework will thereby help, to categorize and select requirements on different administrative levels into groups (here ‘puzzle-piece).

For the following example we consider that the city of Berlin wants to improve the following ‘puzzle-piece’ of aims and goals of Smart and Sustainable Mobility:

- Goal number 7 of the category of Smartness: Linkage of different transportation modes in one physical spot (e.g. with micro-mobility stations)

The pre-condition is, that a certain municipality (in this case Berlin) now takes this goal from the presented SASUM-framework and analyses related guidelines and policies on different administrative levels under with consideration of this goal.

Figure 20: Goal 7 - Linkage of transportation modes



Source: Elaborated by the author

As mentioned in chapter 3, this goal is sustainable, as it combines different transportation modes in one spot and allows changing from one mode of transportation to another easily and quickly. It is sustainable, as it allows to reduce the distances of travelling (and therefore could reduce GHG-emissions of transportation) and embeds new opportunities of transportation modes, such as e-bikes, scooters, and shared-electric

vehicles. It is smart, as it combines different transportation modes in one spot, increases the usability and accessibility with and to transportation modes for its users. Furthermore, it can be monitored by using ICT and IoT-sensors, which will be explained later in the section about the technologies and tools.

The assumption is, that the city of Berlin decided to work on this goal and now want to implement projects, that strive for achieving this goal. Therefore, the first needed step is to analyse existing guidelines and policies on different administrative levels, that directly or indirectly influence the mentioned goal. Thereby we now go from top (international level) to bottom (local level) in the administrative hierarchy and analyse the previously mentioned guidelines.

The international level

On international level, one example is the S*ustainable Development Goals* of the *United Nations*. Within goal number 11, target 2 is stated: “By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations” (United Nations, 2024, p. 1). It is noticeable that, the planners need to include public transportation (as one of the linked transport systems) and need to address especially the needs of vulnerable groups of users. An urban analysis of the respective area/ district or city can thereby help to identify vulnerable groups, discussions and workshops with local people, which can help to identify the specific needs. A second example of an international policy is the guideline *Mobility Management – A guide of international good practice* of UNECE. (UNECE, 2020) Within this guide is described, that sustainable mobility includes public transport, cycling, carpooling and electric mobility. (UNECE, 2020, pp. 21–22) This let us conclude, that at least some of these needs to be considered while intersecting the transportation modes. This explicitly means, that unsustainable transportation modes, such as fuel-based cars and trucks should be avoided to link within this goal. These two examples illustrated the usage of two selected international policies, that influence the chosen goal. Furthermore, all other previously mentioned international guidelines (such as Paris climate agreement, New Urban Agenda, IPCC-report, results of last international mobility conferences) should be analysed additionally.

The European level

Continuing with the Continental or in this case European level, the deep dive into exemplarily the *Sustainable and Smart Mobility Strategy* of the European Commission. (Sustainable and Smart Mobility Strategy, 2020) Within there is stated, that “European policies and financial support should also reflect the importance of urban mobility […], with provisions for first/ last mile solutions, that include multimodal mobility hubs, park-and-ride facilities, and safe infrastructure for walking and cycling” (Sustainable and Smart Mobility Strategy, 2020, no. 37). Even though this does not add additional information about the creation of the aimed transport-mode linkages it still emphasizes the importance of developing mobility hubs on European level. Beyond that, additional guidelines on European level should be included.

The national level

On national level, exemplarily the guideline and principles mainly of think tanks, such as *Agora Verkehrswende* (Agora Verkehrswende, 2021) , research publications of institutes, such as the *German Institute of Urban Affairs* (DifU, 2021) and the *Zentrum für Technik und Gesellschaft* (TU Berlin, n.d.) should be considered. Additionally, guidelines of ministries, especially the *Umweltbundesamt* regarding Sustainable Mobility (Umweltbundesamt, 2020) should be considered. Of particular interest within this case study are the results of *Mobilität in Deutschland* (MiD) (BMDV, 2023b) and the *Mobilithek* (BMDV, 2023a). The *Mobilithek* can help with the usage of existing mobility data within one data space, to identify potentials for the creation of physical spots for linked transport modes. (ibid.) Additionally, results of

the so-called *Mobilität in Deutschland* (*MiD)* can help to understand users' preferences and needs and therefore plan these physical spots according to the demand. (BMDV, 2023b)

The state- and municipal level

Lastly, guidelines and policies on state- and municipal levels needed to be analysed. As Berlin is a state and city at once, this level is hereby accumulated. Thereby, different plans need to be analysed comprehensively. The city of Berlin has on one hand, precise mobility plans, that evaluate, plan, and organise the mobility and traffic planning specifications of the future, and on the other 'technical' plans that form the basis for the overarching Smart City strategy of the city.

Mobility and traffic plans of Berlin

Particularly important are the *Stadtentwicklungsplan Mobilität 2030* (SteP MoVe) (Senatskanzlei Stadt Berlin, 2021) and the *Mobilitätsplan i2030* of the Berlin-wide *Verkehrsverbund Berlin-Brandenburg GmbH* (VBB - Verkehrsverbund Berlin Brandenburg GmbH, 2023). Thereby the *Stadtentwicklungsplan Mobilität 2030* identified the „expansion of mobility stations for the integration of public transport with pedestrian and bicycle traffic as well as sharing services" as one key scope of measures (Senatskanzlei Stadt Berlin, 2021, pp. 28–31). It thereby considers this component as particularly important in the geographical area of

1. The development of new residential areas and planning for the growing city.
2. The shape of connections with the surrounding region.

Furthermore, it declares these stations as a particular component of the sector of innovations, tourism, and communication. (ibid.) Even though the mentioned goal of linking different transportation modes in one physical spot does not solely refer to the construction of mobility hubs, the guideline of Berlin' *Stadtentwicklungsplan Mobilität 2030* can help to understand the areas, where such mobility hubs or stations should be developed.

The second important plan is the so-called *Mobilitätsplan i2030* (VBB - Verkehrsverbund Berlin Brandenburg GmbH, 2023). Within this, the construction or planning of mobility stations is not directly mentioned. But interestingly, the mobility plan states, that "space is a scarce resource. The traffic-congested capital Berlin needs to rethink the issue of cars and delivery traffic" (VBB - Verkehrsverbund Berlin Brandenburg GmbH, 2020, p. 12) They state, that "motorized individual transport is economically inefficient in terms of performance and space consumption. Other forms of mobility are significantly more efficient, allowing space for green areas, residential construction, and commercial development" (ibid.). This helps to understand the overarching direction, the city of Berlin is aiming for. As the aim is saving space, mobility hubs and stations and the connection of several transportation modes in one spot can help to diminish this problem partially.

While it can be summarized, that the urban mobility and traffic plans, as exemplified before, emphasises in different words the planning and construction of mobility hubs or stations, other plans are particularly focussing on the Smart City (and therefore Smart Mobility strategy) of the city. The next section analyses them shortly.

Smart City and Smart Mobility strategy in Berlin

The city and state of Berlin has its own smart city strategy, which is described in the so-called strategy-document *"Gemeinsam Digital: Berlin"*.(Stadt Berlin, 2022) This document provides a guidance for the overall strategy of the city of Berlin for achieving a digital and smart transformation of the city of Berlin. The overarching goal is thereby "a sustainable, common-good oriented, cooperative and resilient city" (Stadt Berlin, 2022, p. 4). Together with citizens, so-called silent groups (disadvantaged groups of people), administration, economy, science, and the organized civil society these groups developed this general strategy, which will be the basis for further smart and digital development of the city of Berlin.

Thereby this “unifying procedural model and the usage of modern tools and methods should achieve, that future plans and intends will be realized faster, more transparent and need-based.” (Stadt Berlin, 2022, p. 4) Within this strategy, it is described, how the city of Berlin wants to achieve these goals. Therefor they are describing the underlying principles and values, the field of actions, the actions itself, the underlying governance model, and its realization. The strategy-paper finishes with an impact assessment and an outlook for the future.

Within their concept of developing a sustainable city, they explain the overarching aim, of “reducing urban emissions, the consumption of resources [and] the acceleration transformation processes in the area of […] mobility” (Stadt Berlin, 2022, p. 13). They thereby foster the data-driven action and usage of artificial intelligence, which is an important strategical component. They also want to use data as one important source of information, to understand, plan, and therefore develop Berlin from a holistic perspective. They explicitly “applies […] to combine topics such as housing construction with mobility and urban […]” (Stadt Berlin, 2022, p. 17). In many fields of action, they want to use local test fields, but “in the case of smart infrastructures and climate adaption […] a city-wide approach makes sense in order to work towards a city for all” (ibid.). It is furtherly intended to increase the efficiency of natural and non-renewable resources at local level. They thereby explicitly mention mobility as one field of action and describe the beforehand mentioned projects of *Schumacher district* and *Urban Tech Republic* as parts of the *Berlin TXL-project*.

Within the description of central or decentral fields of action, the demand-driven expansion of the charging infrastructure, the mentioned *SMART SPACE Hardenbergplatz* to understand mobility demands and the network-like connection of city-actors to safe energy within the *Digital X Energy* action. (Stadt Berlin, 2022, p. 38ff.)

The strategy *Gemeinsam Digital: Berlin* is a combination of aims and goals of the city of Berlin with potential suitable technologies, an analysis of involved stakeholders, example projects. The strength of this strategy is the holistic understanding of a Smart City, that can be successfully integrated in all urban contexts and indicators. While precise fields of action are identified, these fields need now to be filled with content in form of precise projects. Some projects, and as analysed before, are already developed or are currently in the development phase. Others need to be researched, identified, and implemented over time and within the Smart City-strategy of Berlin.

Summarize findings

It can be summarized, that all different administrative levels set out guidelines, policies, and suggestions, how the mentioned goal: “Linkage of different transportation modes in one physical spot (e.g. with micro-mobility-stations)” can be characterized. Furthermore, the analysed policies made suggestions, how this could be adapted to practice.

The analysis can therefore help the respective urban planner, so implement and embed all needed ‘requirements’ or ‘characteristics’ of the chosen ‘puzzle-piece’. The following graphic will shortly summarize findings of this analysis. It is thereby divided into the level of administration. The main points of the needed characteristics on a linkage of transportation modes are thereby stated:

Figure 21: Summary of aims and goals of related guidelines and policies

Source: Elaborated by the author

Aims and goals of related policies and guidelines are now understood and connected to the mentioned ‘puzzle-piece’ of the SASUM-framework. As this is the first stream of the presented framework, the next step is an analysis of the second stream: Technologies and tools, that can be used to achieve these analysed aims.

7.3 Stream 2: Choosing technologies and tools

For the chosen ‘puzzle-piece’ of smartness-goal number 7: Linkage of different transportation modes in one physical spot, the aims and goals derived from guidelines and policies have been identified. The next step is matching these aims and goals of figure 21 with technologies and tools, that can help to achieve these goals.

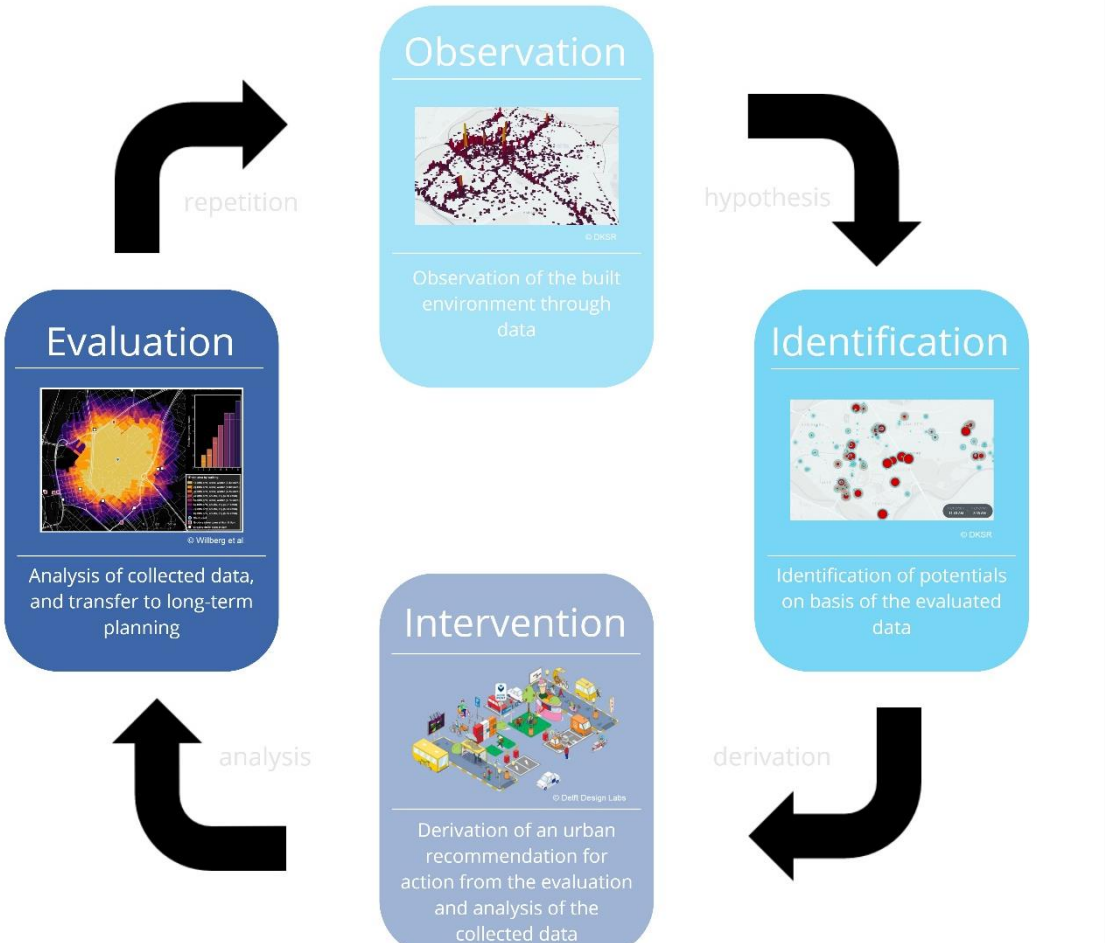
The chosen technologies and tools can thereby affect several aims simultaneously. While some technologies and tools are more suitable for analysing and planning interests, others are more appropriate for implementation and interaction with the built environment.

For each of the identified 7 aims, the best suitable technologies should be chosen. Thereby it is recommendable to choose different technologies for different purposes. Furthermore, it is recommended to choose for each aim at least two different methods:

1. One method for solving the problem (e.g. construction of mobility stations to link transportation modes)
2. One method for monitoring the impacts (e.g. a dashboard that monitors the number of users/ used vehicles from the specific mobility station)

Staying with the example of linking different transportation modes in one physical spot and assuming, that we want to create new mobility stations or hubs, that are linking these different modes. We can consider the following ‘planning cycle’:

Figure 22: Data-driven urban management



Source: Elaborated by the author with Lukas Koch for DKSR

This planning circle describes the main planning stages, where smart technologies and tools can be used. In the beginning the specific geographic area needs to be observed. This observation of the built environment can be done by intersecting existing data sets and related them to data derived from sensors and cameras in the specific area. The next step describes the identification of potentials on basis of the evaluated data. This will lead to recommendations, how the specific intervention could look like. After the implementation, the made changes of the built environment will be constantly analysed by using the collected data and made recommendations for long-term planning. This circle continues until the outcome of the physical changes within urban space are satisfying enough for the involved stakeholders. When it's finally satisfying for the users as well as planners, it can be scaled upwards, wherefore simulation and artificial intelligence tools can help to make pre-predictions about other geographical areas with similar conditions. This can help to evaluate planning decisions before their realizations.

For the presented case of goal number 7: Linkages of different transportation modes in one physical spot, the related technologies and tools should be chosen in accordance with the given aims and goals of overarching guidelines and policies. This can, but not necessarily need to be done by using the presented planning circle with its specific steps. Thereby the linkage of different transportation modes means the identification of already existing transportation hotspots but also the planning of new ones, that can combine different modes of transportation.

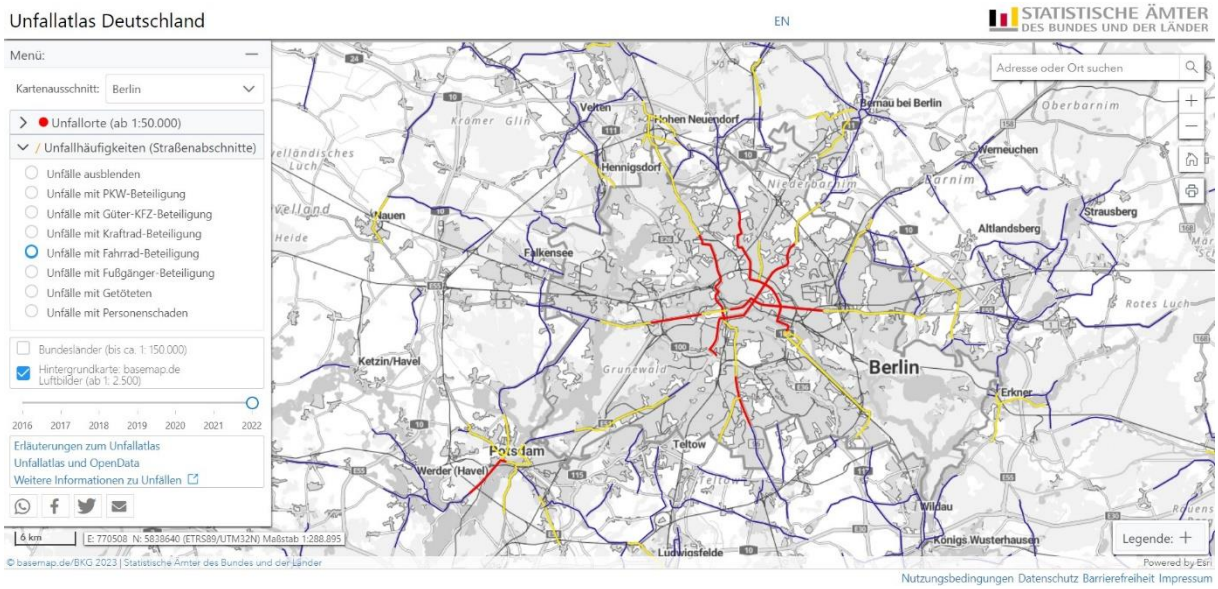
Observation

For the phase of the observation of the built environment, hardware-devices, especially sensors and cameras are useful. They can be installed in certain public spaces within the urban area within Berlin to detect the movement of vehicles, such as (e)-cars, e-bikes, e-scooters, and pedestrians. Additionally, data derived from built-in sensors in portable hardware devices can be analysed, e.g. data of mobile phones, laptops, and tablets of individuals and their movements within a city. Additional collected data by basic car navigation systems using GPS and speed cameras (Vasant et al., 2019) should be used. This needs to be done in relation with the existing regulations and laws about data protection and data privacy, e.g. the collected data needs to be collected in an anonymised or pseudonymised manner. Additionally, built-in sensors in transportation vehicles, such as (e)-cars and public transportation modes can help to analyse mobility patterns and preferences. Thereby the same regulations of data security and privacy must be considered.

Identification

In interaction with existing, mainly Geo-data of the municipality about routes and stops of public transportation modes, they can help to detect areas, where many different transportation modes are connected. Thereby the tool of digital computation can help to intersect and combine the different data sets. By combing existing static, dynamic, and synthetic data sets, the data can become a value for the planning stakeholders. The method of sharing of mobility data with its users and consumers can help to embed data sets of different sources. For the case of Berlin, the consideration of the local Geoportal with all related georeferenced data about urban planning themes (Senate Department for Urban Development, Construction and Living, 2024) should be scraped for potential useful data sets. An example, how these georeferenced data could look like will be shown by illustrating data of the so-called *Unfallatlas Deutschland*:

Figure 23: Accidents with bicycles involved within Berlin



Source: Unfallatlas Deutschland 2023

Additionally, the German-wide so-called *Mobilithek* of the *German Ministry for Digitalization and Transport* as an important source for all data regarding mobility needs to be searched for valuable data. (BMDV, 2023a) This *Mobilithek* thereby "offers access to open mobility data and enables the B2B exchange of data offers. [It is furthermore] a central point for access to all data that gets you moving" (BMDV, 2023a, p. 1). Even though, this data platform is for the whole of Germany, it still provides valuable data for the city of Berlin, as it offers data sets in many different categories. For the case study particularly interesting are data about road transportation, climate, weather, railway, infrastructure, real-time traffic data, public transportation, parking areas, car and bike sharing, freight and logistics, cycle networks, charging stations, and pedestrian network data. (BMDV, 2022)

Additionally, the *Berlin Mobility Data Hub* as an important source for mobility data, especially for Realtime data in the categories of movements, socio-demography, surveys, weather, infrastructure, simulations, and transportation statistics. (Berlin Mobility Data Hub, 2023) The data sets are thereby collected from various operators working in mobility and transportation, examples are: GPS mobility data for Berlin, bicycle traffic measure data, road network of Berlin, traffic detection, statistics rental cars, simulation scenarios for Berlin (general), freight transport volume according to GDP, -by mode, passenger transport by mode of transport and volume by GDP and many more. (Datasets - Berlin Mobility Data Hub, n.d.)

The analysis of all related data sets from the mentioned sources will lead to an identification of potentials of the urban space and where to build mobility hubs/ stations in relation with the results of the collected data sets.

Intervention

From the intersection of the specified data sets from various sources, urban recommendations should derive. Thereby existing mobility hubs/ stations, such as *Jelbi* (Jelbi GmbH, 2024) should be considered. It should be also analysed whether existing mobility stations or locations, where several means of transport come together, should be expanded. The intersection of the mentioned data can also help to identify potentially new geographical locations for the constructions of new mobility stations.

As this step is closely related to the interaction with the built environment, the suitable methods and tools are therefore mainly hardware-devices. The integration of electric (and autonomous) transportation modes is recommendable as well as the usage of the already

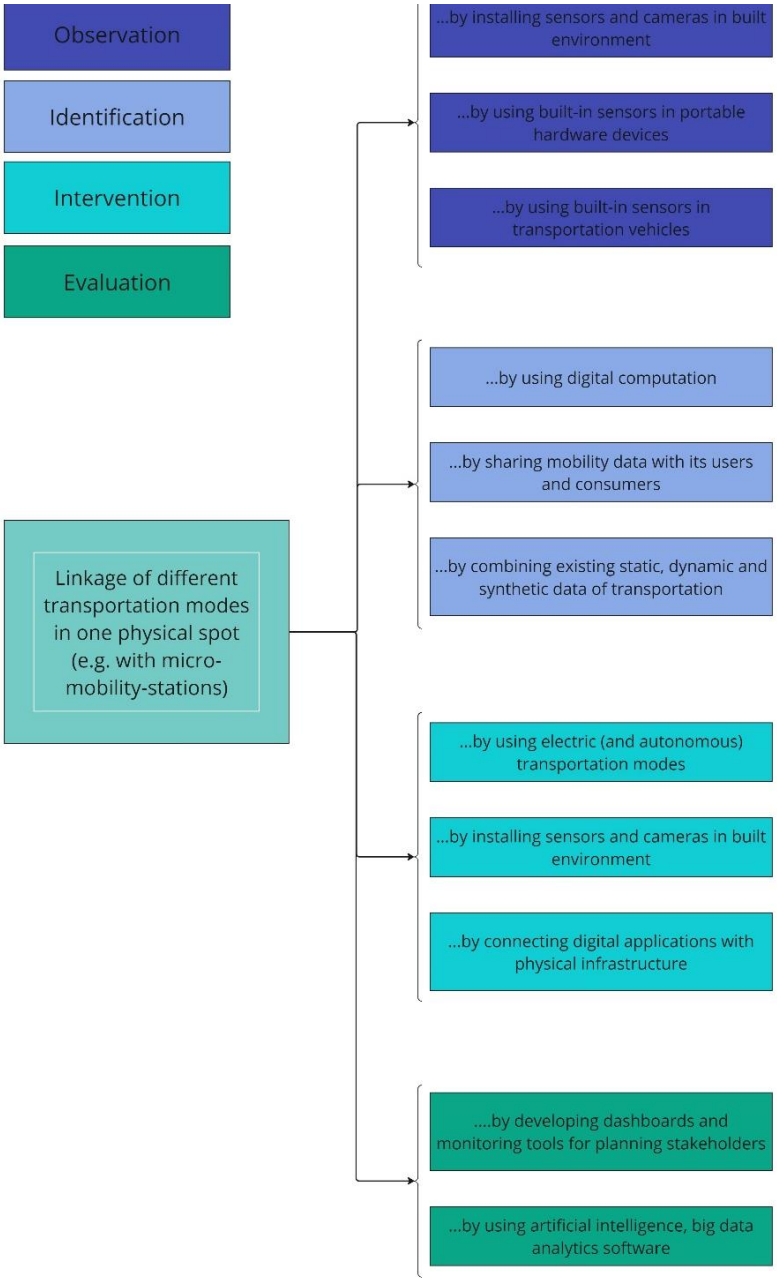
mentioned sensors, and cameras to further analyse results of the conducted intervention. Digital applications to interact with the physical infrastructure, such as the *Jelbi-App* (Jelbi GmbH, 2024) can help the users to consistently understand current transportation supply at these stations.

Evaluation

For the constant evaluation of the conducted urban intervention, different methods are suitable. The measurement of the results of the intervention with cameras and sensors helps to analyse users' utilisation, a dashboard, that displays these collected data, can help the municipality, and involved stakeholders to constantly monitor results of the intervention.

Additionally, after the successful intervention, tools such as artificial intelligence, big data analytics and further analytic software can help to simulate and model potential suitable areas in other cities or geographical areas and scale successes of the projects towards other cities. The summary of the potentially useful methods, including the technologies and tools are as following and in accordance with the SASUM-framework:

Figure 24: Technologies and tools for the case study of Berlin



Source: Elaborated by the author

Matching goals with technologies and tools

The last step is to relate the presented technologies and tools with the aims. It is thereby important, that not every aim or goal can be achieved by using just one technology or tool.

An example is thereby the goal, mentioned within the *Stadtentwicklungsplan Mobilität 2030* stating, that the „expansion of mobility stations for the integration of public transport with pedestrian and bicycle traffic as well as sharing services" (Senatskanzlei Stadt Berlin, 2021, pp. 28–31) is one key aspect of future mobility systems in Berlin. This aim can be solved by using various technologies and tools as stated previously: Sensors and cameras for measuring mobility demands, patterns, and preferences, data-intersection to identify geographical locations for the construction of mobility stations, and the development of a dashboard for the municipality after the urban intervention, to measure its impacts, advantages, and disadvantages:

Therefore, this matchmaking between aims/ goals with technologies and tools can be done cross-sectionized and for each individual purposes. The first overarching aim of the SASUM-framework is thereby just the identification of aims and goals of Smart and Sustainable (urban) Mobility on one hand and their corresponding characteristics within guidelines and policies of all administrative levels. The second overarching aim is the identification of technologies and tools, that can be used to achieve the chosen 'puzzle-piece'.

7.4 Summary of findings

The goal of this chapter was to check the applicability of the beforehand mentioned SASUM-framework with a specific case study. Therefore, the case of the city of Berlin was chosen.

The author selected goal number 7 (so-called 'puzzle-piece') of Smartness of the SASUM-framework: Linkage of different transportation modes in one physical spot (e.g. with micro-mobility stations). The author analysed the related guidelines and policies of all administrative levels to identify the statement in these, that fit directly or indirectly the aim of the 'puzzle-piece'. Subsequently, the related technologies and tools, that directly or indirectly strive to achieve these statements are presented. Thereby the self-created 'planning-circle' was used to identify different phases and the related technologies. Lastly the related technologies and tools were matched with these statements.

While it was recognizable, that the SASUM-framework is applicable for the reality of urban and regional planning and can be adapted in specific cases, some difficulties and weaknesses have been found. They will be presented in the last chapter, that does not solely relate back to the research question, rather presents a general discussion of the previous findings and limitations of that work as well as of the framework.

8 Conclusive words

The previous section illustrated, how the created SASUM-framework can be used to achieve a Smarter and more Sustainable (urban) Mobility. The policy recommendations for the case of Berlin will be kept short, as it was primarily the aim of checking the applicability of the created framework within a specific case, instead of analysing the case study of Berlin in detail.

For Berlin the author would recommend to extend the existing Smart City-strategy *Gemeinsam Digital: Berlin* (Stadt Berlin, 2022) with a separate guideline for its Smart and Sustainable Mobility-strategy. This new strategy should be in line with all previously mentioned guidelines and policies on all administrative levels, primarily with the regional mobility plans, especially the *Stadtentwicklungsplan Mobilität 2030* (SteP MoVe) (Senatskanzlei Stadt Berlin, 2021) and the *Mobilitätsplan i2030* of the Berlin-wide *Verkehrsverbund Berlin-Brandenburg GmbH* (VBB - Verkehrsverbund Berlin Brandenburg GmbH, 2023). It should thereby combine aspects of a Smart City with a Smart Mobility and its related technologies and tools combine with aims and goals of the mentioned strategies. Focus and priority should be given to Sustainable Mobility, especially under the criteria of users' needs and satisfaction and the priority to sustainable modes of transportation.

For the realization of the then developed strategy, all mentioned experts from the field of research, administrations, and the private sector should be included and develop together model projects, that foster Smart and Sustainable Mobility with its underlying criteria as mentioned within this thesis. The created SASUM-framework can thereby help to identify the aims and goals of Smart and Sustainable (urban) Mobility on one hand and combining it with existing technologies and goals on the other. The so-called 'puzzle-pieces' should be thereby forming the basis of each model project. They can be taken to evaluate the main goal, check the related guidelines and policies on all levels and combine it with the best suitable method (hereby technology or tool).

8.1 Relation to research question and hypothesis

The last section will analyse, how the stated research question with its related five sub-questions from the beginning as well as the hypothesis have been answered within this thesis. Therefore, a recap of the results will help to analyse the answers towards the research question and an evaluation of the plausibility of the hypothesis.

Reference to the research questions with its sub-questions

The stated research question from the beginning was: How can Smart City and Smart Mobility concepts and frameworks contribute to achieve a more sustainable urban mobility under consideration of the satisfaction of users' needs? This question was divided into five sub-questions, whose answer is examined in the following section.

Therefore, this thesis presented the concept of the Smart City with its underlaying six categories (whereby Smart Mobility is one), its related indicators and resulting actions, each of these categories have. The relation of Smart City and Smart Mobility was thereby given, explaining that both concepts take mainly (but not solely) information and communication technologies (ICT) and Internet-of-things-networks (IoT), to analyse, plan, and later improve urban areas. The concept of Smart Mobility was given by presenting the relationship of Smart City and Smart Mobility.

A summarizing table concluded the findings of characteristics of Smart Mobility and Sustainable Mobility, giving an own approach of a definition according to findings of the literature review. It was defined, that within this thesis, Smart Mobility concepts need to strive for an increase in Sustainability (from an environmental, economic, and social aspect) for being called smart. This resulted in Smart and Sustainable Mobility being used as one

term from this point onwards. This answered the first sub-question, what Smart City and Smart Mobility concepts stands for and how underlying concepts can be defined.

Within the next chapter, overarching concepts and ideas of Sustainable Mobility and its relation to Smart Mobility were given. It was stated, in what ways a Smart Mobility can help to achieve a Sustainable Mobility by presenting advantages (opportunities) and disadvantages (limitations) of Smart Mobility concepts. It was stated, what they can be used for and what not. Concluding best practices helped to grasp a deeper understanding of potentials from a practical perspective. This section helped to answer the second sub-question (opportunities and limitations of Smart Mobility concepts) as well as the third sub-question (explanation of Sustainable Mobility and how Smart Mobility concepts can help to achieve it). This chapter concluded with initial approaches of academia of clustering Smart Mobility concepts within a systematic literature approach into groups. This analysis helped to understand trends, research subjects, and perspectives of Smart and Sustainable (urban) Mobility.

The findings of these clusters were then used within the expert interviews. As the field of Smart and Sustainable (urban) Mobility is relatively new, it was important of including the perspectives of experts, working in the field. It was therefore chosen to ask experts from the fields of research institutions/ think tanks, administrations, and private companies as they have a broad understanding of the topic on one hand, as well as practical experience with precise model projects on the other. This helped to supplement the findings of the beforehand conducted literature review with personal perspectives and impressions. These findings in combination with existing literature formed the basis of the created framework.

This framework thereby brought together the aims and goals of Smart and Sustainable (urban) Mobility, that have already been stated before in accordance with the literature; and the technologies and tools, that can be used for achieving it, which mainly derived the conducted interviews. This helped to answer the fourth research question about potential clusters of Smart Mobility concepts and the development of a self-created framework that combines aims and goals with technologies and tools.

The last section of the thesis tested and evaluated this framework and its applicability using the case study of Berlin. As the created framework aims in providing a holistic and generic framework, that is suitable for similar cases as Berlin, solely one aim was tested within. Therefore, the author decided to check the applicability of one so-called ‘puzzle-piece’ (goal number 7 of stream Smartness) and analysed related guidelines and policies for the case of Berlin. This was then mixed with potential technologies and tools, that can achieve these goals. An example and outlook were given, how municipalities can use the SASUM-framework to create a Smart and Sustainable Mobility within their respective city. This partially answered the last sub-question, how the self-created framework can be used by municipalities to achieve a Smart and Sustainable (urban) Mobility.

The overarching research question is thereby answered partially. The SASUM-framework provided an approach for municipalities, authorities, and furtherly involved stakeholders, to achieve a Smart and Sustainable Mobility. It pointed out, how aims and goals of a Sustainable Mobility can be brought together with Smart Mobility concepts and therefore contribute to achieve a more Sustainable (urban) Mobility under consideration of the satisfaction of its users. It demonstrates, how the complex and elusive concept of a Smart City, and consequently Smart Mobility, can be broken down to derive simple, actionable, and practical steps. These steps enable the achievement of a Smart and Sustainable (urban) Mobility.

Reference to the hypothesis

The earlier stated, that *‘A shift towards a more Sustainable Mobility can solely be achieved by using Smart Mobility concepts, frameworks, and technologies’* is neither proven correct or incorrect. As argued and proven within this thesis, Smart Mobility concepts, frameworks, and ideas can help to achieve a more Sustainable Mobility. The self-developed SASUM-framework indicates, how this can be done and achieved by the network of involved

stakeholders. Therefore, and on basis of the displayed theoretical literature, best practices, and evaluations of already implemented Smart Mobility projects within cities, it has been shown, that these concepts can contribute partially to achieve a more Sustainable Mobility of the future.

On the other hand, the term *solely* within the hypothesis as such is not applicable, as there are other possibilities and opportunities of achieving a Sustainable Mobility. This can be exemplified with the case of active mobility, such as biking and walking. An increase in an inner-city share of active mobility in total travel distances can significantly reduce the GHG-emissions, increase the satisfaction of its users (if a well-structured infrastructure network for bikes and pedestrians is given) and increase the economic benefits of close-by shops, that profit from the new infrastructural opportunities. But this increase in active mobility is not necessarily a Smart Mobility concepts. It can be argued that ICT and IoT can contribute to plan, analyse, and later implement new bicycle- and pedestrian-lanes, but they are not necessities. It can be also argued that a well-connected bicycle- and pedestrian infrastructure is smart in itself, as long as “they enable social and political participation and inclusion as well as fair and democratic social structures” (Abraham et al., 2017, p. 1). If Smartness is seeing as a fixed term, that solely aims for transforming a city with the usage of ICT and IoT-networks, the stated hypothesis is proven right. If Smartness is understood as a term, that goes beyond the technical definition and furtherly describes the combination of different urban aspects together, the hypothesis is proven wrong. This will lead me to the conclusive discussion.

8.2 Limitations

Because of the generic and holistic nature of this thesis, this work is subject to certain limitations. Firstly, the aims and goals of the SASUM-framework are limited due to the complexity of Smart and Sustainable (urban) Mobility characteristics. As urban areas with their transportation networks are complex, interrelated, and interwoven structures, not all aims and goals of Sustainable Mobility, smartness, and users’ needs, and satisfaction could have been presented. Therefore, a constant rework of this framework is needed, to include new approaches of urban and traffic planning and constantly include findings of new research.

Furthermore, the three mentioned streams are not definite. Other streams could be added, the existing streams could be further categorized into sub-sections. An example is thereby the stream of Sustainable Mobility, which could be sub-divided into environmental, economic, and social sustainability within mobility. These sub-categories could then be ‘filled’ with more so-called ‘puzzle-pieces’ for further investigation. The same appears for the second stream of users’ needs, and satisfaction, which could be also subdivided into economic as well as social interests of users. The third stream of smartness could be further subdivided into the classifications of non-technical and technical smartness, as it is still object of research of a clear definition and characterization of the term smartness. As presented in the beginning it can be understood as transforming a city with the usage of ICT and IoT, but also as combining existing knowledge for a sustainable urban development of a city. Therefore, further investigation especially in the exchange with theoretical and practice-orientated research is needed.

Albeit the author aimed for a consistency of the mentioned so-called ‘puzzle-pieces’, not all indicators are on the same ‘level’. Some aims, such as goal 1 of stream: *Sustainable Mobility: Less GHG-emissions with constant mobility supply* could be considered as broader and more generic, other like goal 3 of stream: *Striving for satisfaction of users’ needs: Support of easy-to-use digital services in public transportation* could be seen as more specific. Therefore, a review of all indicators and characteristics in comparison with other transport planning objectives is needed.

Additionally, and as already mentioned, the created framework needs to be tested within cities and municipalities of all kinds. As stated, the framework was just tested with the case study of Berlin with one indicator, hereby goal 7 of stream Smartness: Linkage of different transportation modes in one physical spot. Other goals, especially regarding Sustainable

Mobility and Satisfaction of users' needs, should be constantly tested within different municipalities and cities. This will ensure the checking of the full applicability of the presented framework.

Each aim or goal therefore needs to be analysed by a municipality in regard to existing guidelines and policies on all administrative levels and needs to be combined with the mentioned technologies and tools. As technology is rapidly changing (e.g. with the occurrence of artificial intelligence, cognitive learning algorithms and large language models), the set of technologies and tools needs to be constantly reviewed and supplemented if necessary. This implies all three categories (hardware, middleware, software) of the presented technologies and tools. The presented technologies and tools should thereby not be seen as conclusive or fixed.

8.3 Discussion

The discussion about Smart Cities and Smart Mobility will be an ongoing topic in the field of urban and traffic planning. Further research is needed to precisely define the terms and derive precise guidelines, projects, and implementations out of it.

As described by Mavlutova et al. in her paper *'Urban Transportation Concept and Sustainable Urban Mobility in Smart Cities: A Review'*, there exists a research gap between the conceptual understanding of Smart Mobility concepts and technical solutions (mainly ICT and IoT-solutions). (Mavlutova et al., 2023) This research gap needs to be closed within the future to strive for a Smart and Sustainable (urban) Mobility.

As presented in the beginning of chapter 5, "it is worth considering that the huge number of concepts and their bride spectrum do not contribute to a sufficient level of understanding and system thinking" (Mavlutova et al., 2023, p. 11). She suggested to think theoretical concepts of administrations together with practical applications (concepts or models), that can be used in decision making. (Mavlutova et al., 2023) Therefore, this thesis partially contributed to close this gap by proving a potentially usable framework, that combines theoretical guidelines/ policies with practical implications in form of technologies and tools.

But this research gap needs to be further explored, by analysing deeply overarching guidelines and policies and relate them to potential technologies. Thereby, the methods need to be updated regularly, as technologies within the universe of Smart Cities and Smart Mobility rapidly change and deeply vary, depending on each specific case.

For a further development if this work, the author recommends of constantly checking the applicability of the created SASUM-framework with specific case studies. Thereby, different municipalities and local authorities can take this framework as the basis of their Smart and Sustainable Mobility guidelines and constantly develop municipal-lead projects, that takes the framework as a basis of their projects.

Albeit the potentials of Smart Mobility approaches for achieving a higher level of Sustainability are high, other factors, that are not labelled as 'smart' but still strive for the needed transport turnaround should not be forgotten. While Sustainable Mobility is a well-researched topic, the terms of Smart City and Smart Mobility needs to be analysed more detailed within urban and traffic planning. Open topics, such as a precise internationally recognised definition of Smart Mobility approaches and its potential contributions for Sustainable Mobility, needs to be researched and analysed within the future.

Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less.

Marie Curie

9 List of References

Abraham, M., Arndt, W.-H., Campos, R., Fathejalali, A., Jamerson, G., Keppler, D., Rohde, F., Schroeder, C., Süßbauer, E., & Wendorf, G. (2017). *Smart City: Zur Bedeutung des aktuellen Diskurses für die Arbeit am Zentrum Technik und Gesellschaft*. https://doi.org/10.13140/RG.2.2.31614.38721

Agora Verkehrswende. (2021, July 6). *Agora Verkehrswende*. https://www.agora-verkehrswende.de/veroeffentlichungen/mobilitaetswende-vor-ort/, https://www.agora-verkehrswende.de/veroeffentlichungen/mobilitaetswende-vor-ort/

Anonymised. (2023, November 21). *Qualitative questionnair with employee in infrastructural company* [Personal communication].

Anonymised. (2023a, November 29). *Qualitative questionnaire with Lead of department for energy- and transportation systems of DLR e.V.* [Personal communication].

Anonymised. (2023b, November 29). *Qualitative questionnaire with person from DLR e.V.* [Personal communication].

Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy*, *15*(2), 73–80. https://doi.org/10.1016/j.tranpol.2007.10.005

Baur, N., & Blasius, J. (2014). Methoden der empirischen Sozialforschung: Ein Überblick. *Handbuch Methoden Der Empirischen Sozialforschung*, 41–62.

BBSR. (2021). *Smart City Charta*. ifok GmbH. https://www.bmwsb.bund.de/SharedDocs/downloads/Webs/BMWSB/DE/veroeffentlichungen/wohnen/smart-city-charta-2021.pdf;jsessionid=5B673732F9B804C12DB8CEC0840A680A.live872?__blob=publicationFile&v=2

Berger, J. (2013, July 25). *Kyoto-Protokoll* [Text]. Umweltbundesamt; Umweltbundesamt. https://www.umweltbundesamt.de/themen/klima-energie/internationale-eu-klimapolitik/kyoto-protokoll

Berlin Mobility Data Hub. (2023). Berlin Mobility Data Hub. *Berlin Mobility Data Hub*.

https://mobilityhub.berlin/welcome/publications

Berlin Partner GmbH. (2024, January 18). *Berlin Partner: Das sind wir*. https://www.berlin-partner.de/das-sind-wir

Berliner Beautragte für Datenschutz und Informationsfreiheit (Ed.). (2022). *Berliner Datenschutzgesetz*.

BMDV. (2022, July 1). *Mobilithek – Deutschlands Plattform für Daten, die etwas bewegen*. https://www.bmdv.bund.de/SharedDocs/DE/Artikel/DG/mobilithek.html

BMDV. (2023a). *Mobilithek: Die Mobilitätsdaten Plattform*. https://mobilithek.info/

BMDV. (2023b, April). *BMDV - Mobilität in Deutschland (MiD)*. https://bmdv.bund.de/SharedDocs/DE/Artikel/G/mobilitaet-in-deutschland.html

BMDV. (2023c, July 31). *BMDV - Deutschlandticket*. https://bmdv.bund.de/DE/Themen/Mobilitaet/OEPNV/Deutschlandticket/deutschlandticket.html

BMJ. (2023, January 1). *Datenschutz-Grundverordnung*. Bundesministerium der Justiz. https://www.bmj.de/DE/themen/digitales/DSGVO/DSGVO_node.html

BMWSB. (2023a). *Berlin | Smart City Dialogue*. https://www.smart-city-dialog.de/mpsc/berlin

BMWSB. (2023b). *Smart Cities: Stadtentwicklung im digitalen Zeitalter*. Bundesministerium für Wohnen, Stadtentwicklung und Bauwesen. https://www.bmwsb.bund.de/Webs/BMWSB/DE/themen/stadt-wohnen/staedtebau/smart-cities/smart-cities-artikel.html;jsessionid=5B673732F9B804C12DB8CEC0840A680A.live872?nn=17169400

BMWSB. (2023c, December 11). *Modellprojekte Smart Cities | Smart City Dialog*. https://www.smart-city-dialog.de/programme-und-projekte/modellprojekte-smart-cities

Brenner, S. (2007). *Law in an era of smart technology*. Oxford University Press.

Cambridge Dictionary. (2023a, November 22). *Definition of “smart.”* https://dictionary.cambridge.org/dictionary/english/smart

Cambridge Dictionary. (2023b, November 22). *Definition of "sustainable."* https://dictionary.cambridge.org/dictionary/english/sustainable

Caragliu, A., Del Bo, C., & Nijkamp, P. (2009). Smart Cities in Europe. *VU University Amsterdam, Faculty of Economics, Business Administration and Econometrics, Serie Research Memoranda*, *18*. https://doi.org/10.1080/10630732.2011.601117

Cohen, B. (2015, August 10). *The 3 Generations Of Smart Cities*. Fast Company. https://www.fastcompany.com/3047795/the-3-generations-of-smart-cities

Datasets—Berlin Mobility Data Hub. (n.d.). Retrieved August 16, 2023, from https://app.mobilityhub.berlin/datasets/

DIfU. (2019, June 17). *Was ist eigentlich ... Mobilitätsstation?* [Text]. Deutsches Institut für Urbanistik. https://difu.de/nachrichten/was-ist-eigentlich-mobilitaetsstation

DifU. (2021, June 15). *Klimafreundliche Mobilität für Stadt und Land* [Text]. Deutsches Institut für Urbanistik. https://difu.de/publikationen/2021/klimafreundliche-mobilitaet-fuer-stadt-und-land

DIfU. (2022, September 23). *Was ist eigentlich ... Donut-Ökonomie?* [Text]. Deutsches Institut für Urbanistik. https://difu.de/nachrichten/was-ist-eigentlich-donut-oekonomie

DKSR. (2023). *Potenzialdetektor für nachhaltige Kommunen*. https://www.dksr.city/news/hitzemassnahmen-datenbasis/

Dr. Jens Libbe. (2023, December 7). *Interview German Institute of Urban Affairs* [MS Teams].

Dr. Ralf Kleindiek. (2023, November 28). *Qualitative questionnaire with former State Secretary for Digital and Administrative Modernisation in Berlin* [Personal communication].

Dresing, T., & Pehl, T. (2015). *Praxisbuch Interview, Transkription & Analyse: Anleitungen und Regelsysteme für qualitativ Forschende*. dr dresing & pehl GmbH.

European Commission. (2023, December 19). *Mobility and transport—European Commission*. https://transport.ec.europa.eu/index_en

European Parliament. (2023, June 8). *EU AI Act: First regulation on artificial intelligence* |

News | European Parliament. https://www.europarl.europa.eu/news/en/headlines/society/20230601STO93804/eu-ai-act-first-regulation-on-artificial-intelligence

Francini, M., Chieffallo, L., Palermo, A., & Viapiana, M. F. (2021). Systematic Literature Review on Smart Mobility: A Framework for Future "Quantitative" Developments. *Journal of Planning Literature*, *36*(3), 283–296. https://doi.org/10.1177/0885412221994246

Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Milanović, N., & Meijers, E. (2007). *Smart cities—Ranking of European medium-sized cities*.

Helfferich, C. (2022). Leitfaden-und experteninterviews. In *Handbuch Methoden der empirischen Sozialforschung* (pp. 875–892). Springer.

Hollands, R. (2008). Will the Real Smart City Please Stand Up? *City*, *12*, 303–320. https://doi.org/10.1080/13604810802479126

IEEE. (2022, September 4). *IEEE International Conference on Smart Mobility—IEEESM*. https://ieeesm.org/

Jankowski, S. (2013, August 3). *Was ist ein „Smart-Grid"?* [Text]. Umweltbundesamt; Umweltbundesamt. https://www.umweltbundesamt.de/service/uba-fragen/was-ist-ein-smart-grid

Jelbi GmbH. (2024, January 21). *Jelbi – Berlin's public transport and sharing services in one app*. Jelbi. https://www.jelbi.de/en/home/

Jonker, J., & Pennink, B. W. (2009). Qualitative Research. In J. Jonker & B. Pennink (Eds.), *The Essence of Research Methodology: A Concise Guide for Master and PhD Students in Management Science* (pp. 77–96). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-71659-4_5

Komninos, N. (2013). *Intelligent cities: Innovation, knowledge systems and digital spaces*. Routledge.

Kuckartz, U. (2012). *Qualitative inhaltsanalyse: Methoden, praxis, computerunterstützung*. Beltz Juventa.

Kuckartz, U., & Rädiker, S. (2020). *Fokussierte Interviewanalyse mit MAXQDA: Schritt für*

Schritt. Springer VS. https://doi.org/10.1007/978-3-658-31468-2

Lam, D., & Head, P. (2012). Sustainable Urban Mobility. In O. Inderwildi & S. D. King (Eds.), *Energy, Transport, & the Environment: Addressing the Sustainable Mobility Paradigm* (pp. 359–371). Springer London. https://doi.org/10.1007/978-1-4471-2717-8_19

Lambrecht, M. (2019, July 31). *Klimaschutz im Verkehr* [Text]. Umweltbundesamt; Umweltbundesamt. https://www.umweltbundesamt.de/themen/verkehr/klimaschutz-im-verkehr

Lindskog, H. (2004). *Smart communities initiatives*.

Lyons, G. (2018). Getting smart about urban mobility – Aligning the paradigms of smart and sustainable. *Transportation Research Part A: Policy and Practice*, *115*, 4–14. https://doi.org/10.1016/j.tra.2016.12.001

Lyons, G., & Davidson, C. (2016). Guidance for transport planning and policymaking in the face of an uncertain future. *Transportation Research Part A: Policy and Practice*, *88*, 104–116. https://doi.org/10.1016/j.tra.2016.03.012

Magistrat der Stadt Wien. (2014). *Smart City Wien: Rahmenstrategie*. Magistrat der Stadt Wien.

Markus Sperl. (2023, November 28). *Qualitative questionnaire with a projectmanger research at freemove & CityLAB Berlin* [Personal communication].

Martin Kohl. (2023, November 20). *Interview Frauenhofer IESE* [MS Teams].

Matthias Heßkamp. (2023, November 17). *Interview Radbahn GmbH* [Mobile phone].

Mavlutova, I., Atstaja, D., Grasis, J., Kuzmina, J., Uvarova, I., & Roga, D. (2023). Urban Transportation Concept and Sustainable Urban Mobility in Smart Cities: A Review. *Energies*, *16*(8). https://doi.org/10.3390/en16083585

Mayring, P. (2020). Qualitative Forschungsdesigns. In G. Mey & K. Mruck (Eds.), *Handbuch Qualitative Forschung in der Psychologie: Band 2: Designs und Verfahren* (pp. 3–17). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-26887-9_18

Melo, S., Macedo, J., & Baptista, P. (2017). Guiding cities to pursue a smart mobility

paradigm: An example from vehicle routing guidance and its traffic and operational effects. *Research in Transportation Economics*, *65*, 24–33. https://doi.org/10.1016/j.retrec.2017.09.007

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. sage.

MIT. (2018). *City Scanner*. https://senseable.mit.edu/cityscanner/

NOW GmbH. (2024, January 24). *Nationale Leitstelle Ladeinfrastruktur | für E-Mobilität in Deutschland*. https://nationale-leitstelle.de/en/

Nuttavuthisit, K., Nuttavuthisit, K., & Achauer. (2019). *Qualitative Consumer and Marketing Research*. Springer.

Office of Science and Technology, Department of Trade and Industry (Ed.). (2006). *Intelligent Infrastructure Futures Project Overview*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/300334/06-522-intelligent-infrastructure-overview.pdf

Orecchini, F., Santiangeli, A., Zuccari, F., Pieroni, A., & Suppa, T. (2019). Blockchain Technology in Smart City: A New Opportunity for Smart Environment and Smart Mobility. In P. Vasant, I. Zelinka, & G.-W. Weber (Eds.), *Intelligent Computing & Optimization* (pp. 346–354). Springer International Publishing.

Paskaleva, K. A. (2011). The smart city: A nexus for open innovation? *Intelligent Buildings International*, *3*(3), 153–171. https://doi.org/10.1080/17508975.2011.586672

Prof. Dr. Ing. Jörg Rainer Noennig. (2023, November 5). *Qualitative questionnaire with HafenCity University Hamburg* [Personal communication].

Rohde & Loew. (2011). Smart City: Begriff, Charakteristika und Beispiele. *Materialien Der Wiener Stadtwerke Zur Nachhaltigen Entwicklung*, *7*.

Schrab, K., Protzmann, R., & Radusch, I. (2023). A Large-Scale Traffic Scenario of Berlin for Evaluating Smart Mobility Applications. In *Smart Energy for Smart Transport* (pp. 276–287). Springer Nature Switzerland. https://link.springer.com/chapter/10.1007/978-3-031-23721-8_24

Schweitzer, E. (2015). *Smart cities international: Strategien, Strukturen und Pilotvorhaben*.

Bundesinstitut für Bau-, Stadt- und Raumforschung.

Senate Department for Economic Affairs, Energy and Public Enterprises. (2023, January 6). *Smart City Berlin*. https://www.berlin.de/sen/wirtschaft/technologiezentren-zukunftsorte-smart-city/smart-city/

Senate Department for Urban Development, Construction and Living. (2024, January 9). *Geoportal – Daten und Dienste*. https://www.berlin.de/sen/sbw/stadtdaten/geoportal/geoportal-daten-und-dienste/

Senatskanzlei Stadt Berlin. (2021, March 2). *Stadtentwicklungsplan Mobilität und Verkehr 2030*. https://www.berlin.de/rbmskzl/aktuelles/pressemitteilungen/2021/pressemitteilung.1058932.php

Smart City Berlin. (n.d.). *Berliner Hauptbahnhof LoRaWAN-Gateway*. Smart City Berlin. Retrieved July 17, 2023, from https://smart-city-berlin.de/kompetenzen-loesungen/projekte/detail-projekte/berliner-hauptbahnhof-lorawan-gateway

Smart City Berlin. (2024a, January 18). *Network*. https://smart-city-berlin.de/en/network

Smart City Berlin. (2024b, January 18). *Smart City Berlin—Projects*. https://smart-city-berlin.de/en/competencies-solutions/projects

Stadt Berlin (Ed.). (2022). *Strategie Gemeinsam Digital Berlin*. https://gemeinsamdigital.berlin.de/documents/82/Strategie_Gemeinsam_Digital_Berlin.pdf

Stadt Wien. (2022). *Smart City Strategie Wien*. Smart City Wien. https://smartcity.wien.gv.at/strategie/

Städtetag, D. (2015). Integrierte Stadtentwicklungsplanung und Stadtentwicklungsmanagement. *Positionspapier Des Deutschen Städtetages. Berlin/Köln*.

Sustainable and Smart Mobility Strategy, (2020). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0789

The City of Copenhagen. (2020). *Climate Plan 2025*. https://kk.sites.itera.dk/apps/kk_pub2/index.asp?mode=detalje&id=2062

Tietz, C. (2023, May 12). *Sechster Sachstandsbericht des Weltklimarates IPCC* [Text]. Umweltbundesamt; Umweltbundesamt. https://www.umweltbundesamt.de/themen/klima-energie/grundlagen-des-klimawandels/weltklimarat-ipcc/sechster-sachstandsbericht-des-weltklimarates-ipcc

TU Berlin. (n.d.). *Kompetenzen des Bereichs Mobilität und Raum des ZTG*. Retrieved January 6, 2024, from https://www.tu.berlin/ztg/forschung/forschungsbereiche/mobilitaet-und-raum/kompetenzen

Umweltbundesamt. (2020, September 11). *Nachhaltige Mobilität* [Text]. Umweltbundesamt; Umweltbundesamt. https://www.umweltbundesamt.de/themen/verkehr/nachhaltige-mobilitaet

Umweltbundesamt (UBA). (2023, 18). *Emissionsdaten* [Text]. Umweltbundesamt; Umweltbundesamt. https://www.umweltbundesamt.de/themen/verkehr/emissionsdaten

UNECE. (2020, March). *Mobility Management—A guide of international good practices | UNECE*. https://unece.org/sites/default/files/2023-06/Informal%20document%2009%20Mobility%20Management%20%281%29.pdf

UNFCC. (2023). *The Paris Agreement | UNFCCC*. https://unfccc.int/process-and-meetings/the-paris-agreement

UN-Habitat. (2023). *Mobility and Transport | UN-Habitat*. https://unhabitat.org/topic/mobility-and-transport

UN-Habitat III (Ed.). (2017). *New Urban Agenda*. https://unhabitat.org/about-us/new-urban-agenda

United Nations. (2023). *THE 17 GOALS | Sustainable Development*. https://sdgs.un.org/goals

United Nations. (2024, January 19). *Goal 11 | Department of Economic and Social Affairs*. https://sdgs.un.org/goals/goal11#targets_and_indicators

Vasant, P., Zelinka, I., & Weber, G. W. (2019). *Intelligent Computing and Optimization:*

Proceedings of the 2nd International Conference on Intelligent Computing and Optimization 2019 (ICO 2019). Springer International Publishing. https://books.google.de/books?id=SEa5DwAAQBAJ

VBB - Verkehrsverbund Berlin Brandenburg GmbH. (2020). *Mobilität in der wachsenden Hauptstadtregion – Chancen und Herausforderungen*. https://www.i2030.de/wp-content/uploads/2020/02/i2030-Metropolbroschuere.pdf

VBB - Verkehrsverbund Berlin Brandenburg GmbH. (2023). *Berlin i2030*. i2030. https://www.i2030.de/

Verkehrsinformationszentrale (VIZ) & Senatsverwaltung für Mobilität, Verkehr, Klimaschutz und Umwelt. (2024, January 24). *Verkehr in Berlin—Verkehrsinformationszentrale*. VIZ Verkehrsinformationszentrale. https://viz.berlin.de/verkehr-in-berlin/

Walton, D. (2014). *Abductive reasoning*. University of Alabama Press.

Wilke, S. (2023a, 28). *Emissionen des Verkehrs* [Text]. Umweltbundesamt; Umweltbundesamt. https://www.umweltbundesamt.de/daten/verkehr/emissionen-des-verkehrs

Wilke, S. (2023b, 26). *Luftbelastung in Ballungsräumen* [Text]. Umweltbundesamt; Umweltbundesamt. https://www.umweltbundesamt.de/daten/luft/luftbelastung-in-ballungsraeumen

Wilson, V. (2014). *Research methods: Triangulation*.

Appendix

1) Questionnaires

Questionnaire 1/ 5.11.2023/ via Mail

Role of responder: Professor for Digital City Science of *HafenCity University Hamburg*

Sehr geehrter Herr Prof. Dr. Ing. Noennig,

Die folgenden Fragen beziehen sich auf Ihre Rolle als Professor für Digital City Science der HafenCity Universität Hamburg:

1. Welchen Trends smarter Mobilität (Monitoring der verkehrstechnischen Umgebung mittels Kameras/ Sensoren, Modellierung von Verkehrsaufkommen mittels digitaler Modelle, aktive Verkehrssteuerung durch digitale Bedarfsanalysen, etc.) messen Sie die größte Bedeutung für die Zukunft bei?
   - Digitale Verkehrs-Modellierung, integrierte Verkehrkonzepte

2. Sehen Sie weitere Themen der smarten Mobilität, welche einen nachhaltigen Verkehr der Zukunft zur Auswirkung haben können? Wenn ja, welche?
   - digitales Management urbaner Luftmobilität

3. Wie können Ihrer Meinung nach smarte Mobilitätsangebote dazu beitragen, einen nachhaltigen Verkehr der Zukunft zu erzielen?
   - System-Vernetzung und -integration, Synergien und Effizienzgewinne, Datenwertschöpfung

4. Welche Aufgabe im Geflecht der Forschung zu Smart City und Smart Mobility Konzepten übernimmt das Digital City Science der HafenCity Universität Hamburg?
   - Grundlagen- und Anwendungsforschung, Lehre, Forschungstransfer (Ausgründungen), Toolentwicklung, Bereitstellung von Prototypen für die digitale Stadtplanung und -entwicklung

5. In Bezug auf Ihre Teilnahme in der *54. Sitzung des Deutschen Bundestags zur Anhörung zu Smart Cities*: Welcher Gruppe von Beteiligten (Administration/ Verwaltung, Forschung und Think Tanks, Privatwirtschaft) messen Sie die größte Bedeutung bei der Umsetzung von smarter Mobilität bei?
   - Kommunale Verbände

Questionnaire 2/ 21.11.2023/ via Mail

Role of responder: Employee in infrastructure company (anonymised)

Sehr geehrter Herr (anonymisiert),

Die folgenden Fragen beziehen sich auf Ihre Rolle als (anonymisiert):

1. Was ist für Sie Smart Mobility?
   - Smart Mobility verknüpft die verschiedenen Arten der Mobilität mit technischen Lösungen und Neuerungen, um effiziente, saubere und nachhaltige Mobilität zu

ermöglichen. Darunter fallen auch neue Mobilitätskonzepte und -ideen für urbane und auch nicht-urbane Räume.

2. Wie können neue Technologien und technologische Ansätze dabei helfen, einen ökologisch nachhaltigen Verkehr der Zukunft zu entwickeln?
   - Neue Technologien und technologische Ansätze sind wesentliche Treiber für die Entwicklung eines ökologisch nachhaltigen Verkehrs der Zukunft. Innovative Technologien spielen eine zentrale Rolle dabei, den Verkehr ökologisch nachhaltiger zu gestalten, indem sie Effizienz verbessern, Emissionen reduzieren und die Integration verschiedener Verkehrsmittel fördern.

3. Was sind Stärken aber auch Schwächen und Grenzen von Smart Mobility, wie automatisierte Verkehrsüberwachung, intelligentes Verkehrsmonitoring, Simulation und Modellierung sowie digitaler Verkehrssteuerung?
   - Stärken:
     - **Effizienzsteigerung**: Die automatisierte Verkehrsüberwachung und digitale Verkehrssteuerung ermöglichen eine Echtzeitoptimierung des Verkehrsflusses, was zu einer Reduzierung von Staus und einer verbesserten Effizienz führt.
     - **Sicherheitsverbesserungen**: Intelligente Verkehrsüberwachungssysteme können dazu beitragen, Verkehrsunfälle zu reduzieren, indem sie frühzeitig auf Gefahrensituationen reagieren und automatisch Sicherheitsmaßnahmen implementieren.
     - **Umweltfreundlichkeit**: Die Reduzierung von Staus und optimierte Verkehrsströme durch intelligente Verkehrssteuerung tragen zur Verringerung von Emissionen bei, was zu einer umweltfreundlicheren Mobilität beiträgt.
     - **Bessere Planung durch Simulation**: Simulation und Modellierung ermöglichen es, Verkehrsszenarien vorab zu analysieren, was zu einer verbesserten städtischen Infrastrukturplanung führt.
   - Schwächen und Grenzen:
     - **Datenschutzbedenken**
     - **Kosten**: Die Implementierung und Wartung fortschrittlicher Smart-Mobility-Systeme erfordert erhebliche Investitionen
     - **Abhängigkeit von Technologie**: Die Zuverlässigkeit von Smart-Mobility-Systemen hängt stark von der Technologie ab, was zu Ausfällen oder Störungen führen kann.
     - **Nicht einheitliche Standards**: Es gibt derzeit keine einheitlichen Standards für Smart-Mobility-Technologien, was die Interoperabilität zwischen verschiedenen Systemen erschweren kann.
     - **Menschliches Verhalten**: Smart Mobility kann menschliches Verhalten und unvorhersehbare Ereignisse nur begrenzt vorhersagen und darauf reagieren.

4. Wie kann (anonymisiert) dazu beitragen, einen ökologisch nachhaltigen Verkehr zu erwirken?
   - Durch die digitale Baustellenkoordinierung mit dem Baustellenatlas trägt (anonymisert) dazu bei, Störungen im Verkehr zu minimieren, reduziert Staus und somit Ressourcenverbräuche und trägt zur Reduzierung von Emissionen bei.
   - Verknüpfung des Baustellenatlas mit automatisierter Routenplanung für Umleitungen und Schienenersatzverkehre kann weitere Effizienzen heben und zum nachhaltigen Verkehr beitragen.

5. Was sind Ihre Wünsche für die Entwicklung der Verkehrsplanung, -überwachung, -monitoring und -steuerung der Mobilität in Berlin?
   - Digitalisierung und Automatisierung: Die kontinuierliche Entwicklung und Implementierung fortschrittlicher digitaler Technologien für die Verkehrsüberwachung, -planung und -steuerung, um den Verkehrsfluss zu optimieren und Staus zu minimieren.
   - Nachhaltigkeit und Umweltschutz: Eine verstärkte Berücksichtigung von Umweltaspekten in der Verkehrsplanung, mit dem Ziel, den Einsatz umweltfreundlicher Verkehrsmittel zu fördern und Emissionen zu reduzieren.
   - Echtzeitinformationen für Bürger: Die Bereitstellung von Echtzeitverkehrsinformationen für Bürger, um ihnen zu ermöglichen, informierte Entscheidungen über ihre Mobilität zu treffen und alternative Routen zu wählen.
   - Partnerschaften und Zusammenarbeit: Eine verstärkte Zusammenarbeit zwischen öffentlichen Institutionen, privaten Unternehmen und der Forschung, um innovative Lösungen voranzutreiben und die Mobilität in Berlin kontinuierlich zu verbessern.

Questionnaire 3/ 28.11.2023/ via Mail

Role of responder: former State Secretary for Digital and Administrative Modernisation within the municipality of Berlin

Sehr geehrter Herr Dr. Kleindiek,

die folgenden Fragen beziehen sich auf ihre Rolle als ehemaliger Staatssekretär für Digitales und Verwaltungsmodernisierung (CDO) des Landes Berlin.

1. Wie können Aspekte der Smart City und smarten Mobilität zusammengebracht werden?
   - Durch eine ganzheitliche und alle Sektoren übergreifende Strategie und Umsetzung und die Abschaffung des Silohandelns. Dier konsequente Entwicklung und Umsetzung einer Datenstrategie für Berlin, der Aufbau des Datahub, eines digitalen Zwillings und das konsequente Datasharing öffentlicher und privatwirtschaftlicher Daten.

2. Welche drei Projekte smarter und digitaler Verkehrsplanung der Stadt Berlin waren und oder sind aus Ihrer Sicht besonders relevant?
   - Konsequente Umrüstung des ÖPNV auf E-Mobilität
   - der koordinierte Ausbau privater und öffentlicher Ladeinfrastruktur
   - eine intelligente Verkehrsplanung und -koordinierung auf Basis eines digitalen Zwillings und konsequentem Datasharing – Rollout des Projektes im CityLab (gemeinsam mit Friedrichshain-Kreuzberg), mit dem auf smarte Weise Baustellen und Schulwege koordiniert werden.

3. Wie sollte die intelligente Verkehrsplanung der Zukunft aussehen? Welche Mittel (automatische Verkehrsüberwachung, intelligente Verkehrsplanung und digitale Verkehrssteuerung) sind dabei von besonderer Relevanz?
   - Automatische Verkehrsüberwachung, intelligente Verkehrsplanung und digitale Verkehrssteuerung sind die absolut notwendigen Tools der Zukunft; eine flexible Ampelschaltung für alle Verkehrsteilnehmer:innen z. B. ist ja keine Frage mehr der Technik oder des Geldes, sondern des Willens.

4. Wie muss die Smart-City-Einheit der Stadt Berlin sich zukünftig entwickeln, um einen verstärkten Fokus auf smarte Mobilitätskonzepte zu legen?
   - Es muss eine stärkere Fokussierung auf konkrete Usecases und Umsetzungsprojekte erfolgen (Vieles in der Smart City-Strategie ist noch zu abstrakt). Es braucht eine konsequente und abgestimmte Vorgehensweise aller Verwaltungen und im Zweifel ein Durchgriffsrecht der Smart-City-Einheit in der Senatskanzlei.

5. Welchen Beitrag kann Forschung und Privatwirtschaft leisten, eine intelligente und nachhaltige Verkehrsplanung der Zukunft zu erzielen?
   - Ohne Forschung und Privatwirtschaft geht es nicht – Politik und Verwaltung können die Grundlagen für Innovation und Digitale Transformation sowie deren Umsetzung nicht selbst generieren. Denn: Die öffentliche Daseinsvorsorge der Zukunft wird in hohem Maße datengetrieben sein. Und: Eine intelligente und nachhaltige Verkehrsplanung der Zukunft wird aber nur gelingen, wenn Public Sector und Privatwirtschaft in einer neuen und ganz anderen Form die jeweils vorhandenen Daten miteinander teilen.

Questionnaire 4/ 28.11.2023/ via Mail

Role of responder: Project Manager research at *freemove* & *CityLAB Berlin*

Sehr geehrter Herr Sperl,

die folgenden Fragen beziehen sich auf Ihre Rolle als Projektmanager Forschung bei freemove & CityLAB Berlin:

1. Wie kann intelligente Verkehrsüberwachung und -steuerung dazu beitragen, eine nachhaltige Verkehrsplanung zu erzielen?
   - Intelligente Verkehrsüberwachung und -steuerung sind erstmal schmeichelhafte Ideen und würden mit großer Wahrscheinlichkeit bei flächendeckender Umsetzung Verkehrsflüsse effizienter steuern können. Zunächst müsste aber hierfür ein engmaschiges Netz an Verkehrsmessungsinstrumentarium installiert werden, Kapazitäten zur Analyse der entstehenden Daten vorhanden sein und dann auch der politische Wille vorhanden sein, aus diesen Datenanalysen die folgenden Schritte zu ziehen, die ja auch nicht selbsterklärend sind. Legt man den Steuerungsfokus darauf, bestimmte Verkehrsmodi (bspw. den Umweltverbund) zu bevorteilen, oder versucht man die jetzige Verteilung in der gegenwärtigen Form zu optimieren? Adaptive Systeme zur Verkehrssteuerung können durch Ampelphasen den Verkehr flüssiger gestalten, ändern aber an der in vielen Städte zu großen Menge an Verkehrsteilnehmenden im motorisierten Individualverkehr von sich aus wenig. Bestimmte Messmethoden gehen darüber hinaus auch mit Privatsphäre-Bedenken einher. Städte sind historisch gewachsene Strukturen, und genau so sind auch die Straßennetze und Bewegungsmuster der Individuen historisch gewachsen und entziehen sich einer simplen Steuerungslogik, die die intelligente Verkehrsüberwachung und -steuerung implizieren. Nichtsdestotrotz sind diese beiden Bereiche wichtige Teile einer Strategie hin zu nachhaltigerer Verkehrsplanung. Ich sehe aber einen klaren politischen Willen und Bereitschaft in ÖPNV zu investieren (Ausbau und Bepreisung) ebenso entscheidend, sowie einen klar erkennbaren Aufwand Bürger:innen aufzuklären und einzubeziehen.

2. Wen sehen Sie bei der Umsetzung von nachhaltigen Mobilitätskonzepten auf Basis von Daten am stärksten in der Verantwortung (öffentliche Verwaltung, Forschung, Think Tanks oder die Privatwirtschaft)?
   - Im Anbetracht des großen Handlungsdrucks, sind alle im Sinne eines kollektiven Unterfangens ein Stück weit in der Verantwortung. Es gibt aber Synergie-Opportunitäten, die sich hier anführen lassen, die das Verantwortungsgefüge etwas klarer ordnen. Die öffentlichen Verwaltungen haben, zumindest hier in Berlin, eine solche Vielzahl an Aufgaben und Verantwortungsbereichen bei recht knappen Ressourcen, dass man ihnen nicht realistisch alle Facetten der Umsetzung von Mobilitätskonzepten zumuten kann – was sie aber können, ist Experimentierfreudigkeit an den Tag legen und Lösungen aus Zivilgesellschaft, Wissenschaft und ggf. auch Privatwirtschaft ernsthaft in Erwägung ziehen, und ggf. mittels Reallabor-Klauseln zu testen. „Die“ Forschung wiederum kann beginnen, anwendungsorientierte Forschungsfragen, interdisziplinäre Zusammenarbeit und Lösungsorientierung zu incentivieren – teils sind die Fachdiskurse noch sehr selbst-referenziell, und junge Forschende werden dazu ermutigt sich sehr zu spezialisieren, was ich auch nicht problematisieren möchte, aber den Weg Richtung stärkerer Praxisanbindung zu wählen, darf zumindest nicht sanktioniert werden.
   - Die Privatwirtschaft birgt natürlich gerade im Innovationsbereich und im weiten Sinne datengetriebenen IT-Anwendungen großes Innovationspotenzial – gleichzeitig muss auch diesen Akteur:innen die Gemeinwohlorientierung ihrer Lösungen manchmal auch in Erinnerung gerufen werden, die Mobilitätslösungen bestenfalls berücksichtigen sollten – wozu wiederum saubere Vergabepraktiken auf Seiten der öffentlichen Verwaltungen und klare Anforderungsformulierung wieder in das Spiel kommen, aber eben auch Kooperationsbereitschaft von Shared Mobility-Anbietern. Think Tanks können Themen aus den unterschiedlichen gesellschaftlichen Sphären auf der Agenda politischer Akteur:innen platzieren und übersetzen.

3. Welchen Beitrag kann das CityLAB Berlin leisten, eine intelligente und nachhaltige Verkehrsplanung der Zukunft in Berlin zu erzielen (allgemein)?
   - Das CityLAB Berlin als öffentliches Innovationslabor der Stadt Berlin ist im Mobilitätsbereich eher in einer Vermittlerrolle. Es kann die Senats- und Bezirksverwaltungen bei fachlichen Fragen zur technischen Lösungsfindung im Verkehrsbereich mit Expertise unterstützen, Lösungsvorschläge, die im Raum stehen evaluieren, kann mittels Vernetzungsformaten den Austausch zwischen Zivilgesellschaft, Wissenschaft und Verwaltung im Mobilitätsbereich anregen und stärken, und mittels unterschiedlicher Projekte, auch unter Beteiligung der Öffentlichkeit, Mobilität gemeinwohlorientiert mitgestalten. Als Experten in Sachen Bürger:innenbeteiligung können wir auch Ort sein, an dem dieses spannungsgeladene Thema diskutiert wird. In diesem Jahr sind wir mit dem Kiezlabor, einem umgebauten Schiffscontainer auch in Kiezen unterwegs gewesen, in denen unterschiedliche Maßnahmen zur nachhaltigen Mobilitätsforderung umgesetzt werden, und haben dort vor Ort politischen Akteur:innen die Möglichkeit gegeben mit der Bürger:innenschaft in Kontakt zu treten, Fragen zu beantworten und Maßnahmen zu erklären.

4. Welche drei Projekte (wie bspw. das digitale Tool für die Radwegeplanung, Clair Berlin oder Shared Mobility Flows) sehen Sie als besonders relevant für die Umsetzung einer nachhaltigen Mobilität (spezifisch)?
   - Shared Mobility Flows, eine einfache Visualisierung des CityLAB Berlins von Bike Sharing-Daten, ist zwar für sich genommen eher ein kleiner Demonstrator, zeigt aber trotzdem, und dieses Urteil teilen die meisten Vorzeigestädte im Verkehrsbereich, welches Wissen in solchen Daten liegt. Gute Daten unterschiedlicher Sharing-Modelle bergen sowohl Wissen über Verkehrsverhalten von Menschen mit unterschiedlichen Fahrzeugtypen, über Nutzungsroutinen, in Kombination mit guten ÖPNV-Daten über Schwachstellen des ÖPNV-Netzes oder

mögliche Ausbaupriorisierungen – und darüber hinaus lassen sich potenziell hierdurch auch Möglichkeiten erkennen, wie man Menschen dazu motivieren kann, stärker auf diese Modi umzusteigen, intermodal unterwegs zu sein und das eigene Auto stehenzulassen.

- Open Traffic Count beschäftigte sich mit einem Prototypen zur Privatsphäre-schonenden, kamera-basierten Verkehrszählung. Darin steckten zwei Grundideen – erstens, eine ressourcenschonende, günstige Möglichkeit zu ergründen, die schlechte Mobilitätsdatenlage zu bessern, und zweitens die Mobilitätsdatenerhebung ohne Privatsphäre-Risiken umzusetzen. Beides ist zumindest prinzipiell mit der Open Traffic Cam möglich – die Kamera speichert keine Bilder sondern berechnet auf dem Gerät, welcher Verkehrsteilnehmer detektiert wurde, ergo entstehen anstelle personenbezogener Daten nur Zählungsstatistiken, sie ist kostengünstig, aber leider unter schlechten Wetterbedingungen und bei Dunkelheit nur begrenzt nutzbar. Nichtsdestotrotz ist das ein wichtiger Beitrag zur Debatte gewesen wir brauchen Daten, aber nicht um den Preis, dass wir unsere Städte mit Kameras gänzlich abdecken, sondern es muss hier nach Kompromissen gesucht werden, die Privatsphäre wahren und Datenlücken schließen. LiDAR-Sensorik und Radarsysteme machen ähnliche Versprechnungen, sind aber deutlich kostspieliger.
- Freemove beschäftigt sich in einem größeren Forschungskonsortium mit unterschiedlichen Berliner Universitäten mit der Frage, wie Bewegungsdaten (also Trajektorien von Individuen) dem Gemeinwohl Privatsphäre-schützend verfügbar gemacht werden können. Diese Daten entstehen bspw. bei Citizen-Science-Projekten mit GPS-Tracking-Apps, als Nebenprodukt bei der Abrechnung von Shared Mobility-Apps, beim Einwählen von Smartphones in Mobilfunknetze oder Wi-Fi-Points und dergleichen mehr. Mit ihnen können Verkehrsmodelle optimiert, Services verbessert (Routing, intermodale Angebote), und Planungen und Ausbau bedarfsorientierter ablaufen. freemove erprobte Anonymisierungstechnologien (Differential Privacy, Data Syntheticization) um deren Personenbezug auf ein vernachlässigbares Niveau zu senken und diese Daten öffentlich teilbar zu machen, was nur bedingt möglich ist. Bei dem Projekt sind trotzdem wichtige Erkenntnisse offenbar geworden, nämlich, dass sich Projekte, Verwaltungen und Firmen zunächst im Klaren darüber sein müssen, was sie denn in Erfahrung bringen wollen, was genau ihr Anwendungsproblem ist, um die richtigen Anonymisierungsmethoden zu wählen und vorgelagert die richtigen Daten zu erheben.

5. In welchem Bereich der Verkehrsplanung (Überwachung, Simulation, Monitoring oder Steuerung) sehen Sie das größte Potenzial für eine nachhaltige Mobilität?
    - Ich glaube, dass hier nur alle der genannten Komponenten gemeinsam funktionieren können. Überwachung würde ich mal außenvor lassen, weil der Bereich mit anderen Grundwerten kollidiert, die wir nicht bereit sind zu opfern vor dem ungewissen Besserungspotenzial bezüglich Verkehr. Wenn es um Verkehrsüberwachung im Sinne von stärkerer Kontrolle der Regeleinhaltung geht – sicher nicht irrelevant, gerade im Bereich Gefahrenvermeidung (Parken auf Radwegen etc.). Aber Monitoring im Sinne eines Wissens und Beobachtens um aktuelle Verkehrssituation, Simulationen, die sich aus guten und möglichst unverzerrten Datenbasen speisen und entsprechend realistisch sind (gute Verkehrsmodelle zur Berechnung von Auswirkungen von Anpassungen an Stelle x), sowie Steuerungselemente, soweit sie für die öffentliche Hand erschwinglich und funktionsfähig sind, sind sinnvoll und unterstützenswert.
    - Das dickste Brett in puncto nachhaltiger Mobilität ist meines Erachtens nach aber trotz aller aussichtsreicher Lösungsansätze das individuelle Verhalten der Verkehrsteilnehmenden. Darauf können Steuerungselemente natürlich indirekt einwirken, aber ja auch nur in demokratisch tragbarem Sinne, und das wird die Gesetzgeber:innen in jedem Fall noch langfristig beschäftigen – Nachhaltigkeit lässt sich nur schwerlich technologisch erzwingen.

Questionnaire 5/ 29.11.2023/ via Mail

Role of responder: Lead of department for energy- and transportation systems of DLR e.V.

Sehr geehrter Herr (anonymised),
Die folgenden Fragen beziehen sich auf Ihre Rolle als Abteilungsleiter Energie- und Verkehrssysteme des Deutschen Zentrums für Luft- und Raumfahrt e.V.:

1. Wie kann Ihrer Meinung nach eine digitale Steuerung der Verkehrssysteme der Zukunft aussehen? Welche (digitalen Werkzeuge) werden dafür benötigt?
    - Die Steuerung der Verkehrssysteme kann über Plattformen erfolgen, die unterschiedliche Stakeholder, Sensoren und Aktoren miteinander vernetzt. Dazu werden übergreifende Schnittstellen benötigt (Fahrzeug, Ampeln, RSU, Satelliten, Wettervorhersagen, Veranstaltungsmanagement, …)

2. Welche Methode smarter Mobilität (Monitoring der verkehrstechnischen Umgebung mittels Kameras/ Sensoren, Modellierung von Verkehrsaufkommen mittels digitaler Modelle, aktive Verkehrssteuerung durch digitale Bedarfsanalysen, etc.) messen Sie die größte Bedeutung für die Zukunft bei?
    - Car2X und X2X Kommunikation

3. Was bedeutet, ökologisch nachhaltiger Verkehr für Sie? Welche Charakteristiken muss ein solcher aufweisen?
    - Ridesharing
    - Autonom/hochautomatisiert
    - Ergänzung zum ÖPNV
    - Lokal Emissionsfrei
    - Bequem und bezahlbar für Nutzer Tür-zu-Tür-Mobilität

4. Wie können Konzepte und Ideen der smarten Mobilität dazu beitragen, einen nachhaltigeren Verkehr (nachhaltig im Sinne von ökologischer Nachhaltigkeit) der Zukunft zu entwickeln?
    - Weniger Ressourcenverbrauch bei Herstellung und Betrieb der Mobilität
        - Geringes Gewicht/Person der Fahrzeuge
        - Ggf. Sammeln mehrerer Mikrofahrzeuge zu größeren Einheiten

5. Welchen Beitrag kann das DLR leisten, nachhaltige Verkehrssysteme zu entwickeln?
    - Beratung der Ministerien um entsprechende Projekte zu fördern
    - Vernetzung von Projekten

Questionnaire 6/ 29.11.2023/ via Mail

Role of responder: (anonymised)

Sehr geehrter Herr (anonymisiert),

Die folgenden Fragen beziehen sich auf Ihre Rolle als (anonymisiert) des (anonymisiert):

1. Welche Chancen räumen sie der Elektromobilität in Deutschland ein?

- Ich sehe für die Elektromobilität auf jeden Fall im PKW-Bereich hohe Chancen. Die Zulassungskurve wird deutlich steigen, da viele PKW Nutzer lernen, dass Elektroautos im Alltag funktionieren. E-Fahrzeuge werden die Verbrenner nicht vollständig verdrängen, aber einen höheren Marktanteil als Verbrenner einnehmen. Die Herausforderung bleibt die Lademöglichkeit im Geschoßwohnungsbau in größeren Städten.
- Bei den Nutzfahrzeugen gibt es wegen der Reichweite und der üblichen Fahrleistung von Nutzfahrzeugen noch eine größere Herausforderung, aber auch hier wird der Marktanteil deutlich wachsen, da die TCO für viele Anwendungen/Bedarfe besser sein wird als bei Dieselfahrzeugen.

2. Welche Rolle kann Ihrer Meinung nach intelligente Verkehrsplanung (Monitoring der verkehrlichen Umgebung mit Sensoren/ Kameras, Simulation mittels Modellen, aktive Verkehrssteuerung durch Bedarfsanalysen) für die Mobilität der Zukunft haben?
   - Auf die Elektromobilität wird die intelligente Verkehrsplanung keinen Einfluss haben, aber bei der dringend notwendigen Verkehrswende, weg vom Individualverkehr hin zum öffentlichen Verkehr. Sensoren/Kameras werden für das autonome Fahren eine Rolle spielen. Autonomes Fahren wiederum kann helfen, den ÖPNV über fahrerlose Systeme günstig und bequem zu machen. Bei guter Planung und Steuerung können wenige Peoplemover viel Kapazität vom Individualverkehr übernehmen und so den Verkehr für alle Teilnehmer schnell, günstig und angenehm ermöglichen.

3. Wirken sich diese genannten Methoden auf die Planung und Steuerung von Elektromobilität aus? Wenn ja, inwieweit?
   - Nein, ein E-Auto bleibt in der Regel ein individuelles Auto und würde weiterhin die Straßen verstopfen. Eine intelligente Routenplanung/Vorhersage würde nur kurzfristige Effekte erzielen.

4. Welche Chancen sehen Sie für Berlin, mittels smarten Mobilitätskonzepten einen nachhaltigen Verkehr der Zukunft zu erschaffen?
   - Wenn smarte Mobilitätskonzepte alle Modale beinhalten und nicht nur auf den Individualverkehr zielen sehe ich große Chancen, den Verkehr in Berlin in der Zukunft nachhaltig zu gestalten. Auch heute schon ist es in Berlin bequemer und einfacher, zwischen verschiedenen Verkehrsangeboten zu wechseln. Je einfacher/bequemer dieser Wechsel ist, desto mehr werden neuartige (und nachhaltige) Angebote auch angenommen. In Städten ist der Druck grundsätzlich höher, den Verkehr fließend zu halten. In ländlichen Regionen wären smarte Verkehrsangebote zwar auch wünschenswert, aber dort gibt es außerhalb des Individualverkehrs kaum wirtschaftliche Alternativen.

5. Welchen Beitrag kann das DLR leisten, eine nachhaltige Verkehrsplanung und -steuerung zu erzielen? Wie verorten Sie die Rolle des DLR innerhalb dieses Geflechts?
   - Hier gibt es zwei Perspektiven:
   - Der DLR Projektträger ermöglicht als Projektträger im Auftrag für verschiedene Bundesministerien Forschungsförderung im Verkehrsbereich. Wir identifizieren relevante Themen und beraten Ministerien zu neuen Förderrichtlinien.
   - Die DLR Institute (z.B. Institut für Verkehrssystemtechnik, Institut für Verkehrsforschung) forschen aktiv an Zukunftsthemen unserer Gesellschaft, z.B. von grüner Energie über neue Formen der Mobilität bis hin zur künstlichen Intelligenz. Hier sind sie wichtiger Impulsgeber für Politik und Wirtschaft mit dem Ziel der Stärkung des Wissens- und Innovationsstandorts Deutschland.

2) Interviews

Transcript 1/ 20.11.2023/ via MS Teams

Role of responder: Martin Kohl, Smart City Engineer Frauenhofer IESE

0:0:38.168 --> 0:1:19.778
Jonas Merbeth
Perfekt, super ganz vielen Dank für den Hinweis und dann würde ich jetzt einmal zu den Fragen kommen genau also die Fragen beziehen sich eben auf die Rolle des Fraunhofer Instituts im Bereich experimentelles Software Engineering, wo du ja auch dazu gehörst und die erste Frage ist, welche Trends von Smart Mobility erkennst du und liegt der Fokus dabei aus deiner Sicht eher auf der Analyse des Verkehrs, also dem IST-Zustand mittels Sensoren und Kameras, also der Erhebung und Auswertung, oder der Simulation und Modellierung von Verkehrsströmen oder dem digitalen Eingriff in die bebaute Umgebung also konkrete Steuerung, wenn man so die 3 Kapitel nimmt genau.

0:1:20.528 --> 0:1:44.338
Martin Kohl
Genau ja, dann würde ich auf jeden Fall sagen, dass ersteres ist, also dass die Projekte, die wir begleiten, die ich auch betreue sind, dann viele aus dem Reich Modellprojekte Smart City Made in Germany, natürlich aber auch andere jetzt auch die Bundesländer, ja auch gerade im Bereich, Urbane Datenplattform irgendwie auch sehr viele bisschen dezentrale Förderprogramme dann haben aber da es eigentlich wirklich bezogen, überlegen ich sogar fast ausschließlich sagen würde, dass die Beispiele, die ich betreue, dann noch bei bei Schritt 1 sozusagen noch in Anführungsstrichen sind, weil erstmal die Infrastrukturen, die dort vorhanden ist, also für für Datenmanagement in den Kommunen natürlich bescheiden ist erstmal und so dann quasi erstmal die Idee ist, wie können wir eigentlich die Daten, die wir irgendwie vielleicht analog erheben, wie können wir das irgendwie sinnvoll machen? Also Zählungen, an Kreuzungen mit Kameras oder machen wir, was auch ein Klassiker, irgendwie Parkraummanagement und diese ganzen Sachen also es sind wirklich für den Anwendungsfällen her finde ich sehr, sehr basic-Sachen, das ist irgendwie die Tasten sich halt mal ran und auch nicht immer mit, wie ich finde, richtig guten Use Cases ehrlich gesagt, aber das sind eigentlich so die Dinge wie wir brauchen erstmal Sensoren wollen erstmal erheben und wollen das auf eine Datenplattform bringen und die Probleme, die am Anfang stehen sollten sind zwar da, aber die sind dann so okay, es gibt Parkraum, Suchverkehr ist relativ generisch. Wir wollen den reduzieren mit Maßnahmen XY als Beispiel.

0:2:58.528 --> 0:2:58.788
Jonas Merbeth
Ja.

0:2:59.928 --> 0:3:15.28
Martin Kohl
Genau, und das ist eigentlich primär dann in Schritt 1 verhaftet und das natürlich dann die die Simulation irgendwann da eine Rolle spielen kann, das steht in vielen Ideen mit drinne wird aber sich zeigen. Im Verlauf, wenn die Projekte laufen, noch ein paar Jahre, ob das dann wirklich dann halt gemacht wird oder ob es in 3/4 Jahren immer noch als als notwendig empfunden wird, ja also, das ist so die die grundlegende Frage auch im Bereich nachhaltige Mobilität, was dann für Potential denn auch drinne steckt ja genau.

0:3:34.228 --> 0:4:3.958
Jonas Merbeth
Ja, ja, die die Simulation und Modellierung kommt ja dann sozusagen auch erst im

nächsten Schritt ne erstmal wäre die Erhebung des IST-Zustandes also ich ermittel wieviel Verkehr haben wir, was haben wir für eine Verkehrs stärke und daraus ableiten kann ich ja dann zum Beispiel ein Python Skript schreiben, was mir dann den Verkehr modelliert für die Zukunft.

0:4:18.648 --> 0:4:19.108
Martin Kohl
Ja.

0:4:3.968 --> 0:4:20.848
Jonas Merbeth

Okay super, ja, erstmal danke dafür, dass es schon mal schon mal richtig auch in meine Richtung wie kann, das ist eine allgemeine Frage, wie können dann aus deiner Sicht digitale Werkzeuge insgesamt dazu beitragen, einen ökologisch nachhaltigeren Verkehr zu erzielen, also genau auch weitergedacht als jetzt sozusagen mal das Beispiel Parkraumsuchverkehr, sondern schon noch ein bisschen Richtung Nachhaltigkeit gedacht?

0:4:21.58 --> 0:4:35.338
Martin Kohl
Genau würde ich glaube ich so anfangen mit der Antwort, wie Sie das nicht kann und das ist nämlich zum Beispiel der Use Case, der halt sehr, sehr häufig gemacht wird, das halt quasi alles immer noch durch die Autobrille durchgesehen wird und das ist halt ein Problem, wenn Digitalisierung dafür verwendet wird, um es einfacher zu machen, den Stellplatz zu finden, irgendwo, dann geht es halt genau in die andere Richtung.

0:4:43.648 --> 0:4:43.918
Jonas Merbeth
Ja.

0:4:44.208 --> 0:4:51.158
Martin Kohl
Ja also das ist halt seh ich da seh ich spontan sogar eher Gefahren als Potenziale so in den ersten Blick, tatsächlich war dann irgendwie sehr viele Auto Lösungen von den Verkehrsämtern halt forciert werden, die dann dazu führen, dass ich halt genau weiß, wann ich wohin fahren kann und das ist alles easy für mich und ich nehme doch nicht den Bus, weil jetzt kann ich dir noch viel geiler im Auto dahin fahren, so als negatives übertriebenes Szenario und da sind wir klar bei der ganzen Parkplätzen und Durchflussgeschwindigkeit etc. Wo es aber auch sehr wohl eine Möglichkeit gibt ist, wenn man wirklich auch mal hingehen würde, verschiedene Verkehrsträger zu priorisieren. Also das ganz klassische Bereich, da brauch man jetzt keine großen Datenmodelle, als ich in der Schweiz war im Studium war in Bern in der Fahrradstraße und ich fahr über 2 Bodenschleifen drüber, und die Ampel hinten, die über die Straße über die Autostraße wird für mich grün. Autos müssen anhalten, ich kann durchfahren und das theoretisch sagt: Ich, will Fahrräder priorisieren, könnte ich genausogut quasi eine Ampelschaltung und Verkehrsfluss so simulieren das auch quasi der Durchsatz oder der Weg mit dem Fahrrad sehr viel schneller zurück liegt bei ist wie mit PKW also auch wirklich eine Priorisierung reinzubringen.

0:6:1.738 --> 0:6:2.78
Jonas Merbeth
Mhm.

0:6:1.718 --> 0:6:8.968
Martin Kohl
Ja, das ist weil im Endeffekt finde ich, ist der Diskurs, der geführt wird, es geht immer Mobilität und nachhaltig.

0:6:12.678 --> 0:6:12.948
Jonas Merbeth
Ja.

0:6:8.978 --> 0:6:13.548
Martin Kohl
Eigentlich denken alle an Autos, Autos wie komme ich am schnellsten durch andere Verkehrsträger sind da wirklich, wenn überhaupt nur am Rande betrachtet.

0:6:16.248 --> 0:6:26.338
Jonas Merbeth
Ja ja, es geht eher um die Optimierung vom Autoverkehr in vielen Projekten, ja mit den mit den mit den Fahrradschleifen, da gibt es auch ein spannendes Beispiel, aber das ist bestimmt bekannt, dass Fietsflow-Projekt…

0:6:29.588 --> 0:6:30.698
Martin Kohl
Ja.

0:6:28.148 --> 0:6:40.728
Jonas Merbeth
…aus den aus den Niederlanden, wo es um den darum geht und flüssiger Verkehr, Fahrradverkehr zu schaffen, das ist auch ein spannendes Projekt, finde ich ja also sowas kann auch sozusagen helfen deiner Meinung nach.

0:6:41.428 --> 0:7:1.688
Martin Kohl
Ja, würde ich schon sagen, also das ist im Endeffekt man was Verkehrsmittelwahl irgendwie Kosten, Bequemlichkeit und Zeit, wenn man die Sachen runter bricht das wir standardmäßig dann ist halt Bequemlichkeit und Zeit mach ich halt, wenn ich schnell von A nach B komme und halt dann wähle ich vielleicht das was am schnellsten geht und dass wenn das Fahrrad ist es Wahrscheinlichkeit höher, als wenns das Auto generell ist einfach ja.

0:7:5.608 --> 0:7:7.278
Jonas Merbeth
Ja, ja, ja.

0:7:7.378 --> 0:7:10.58
Martin Kohl
Genau ja, und ich meine die ganzen anderen Sachen, wie multimodale Mobilitätsplattformen, Ein-Schritt-Buchungen oder als zukunftsmäßig vielleicht ne Mobilität Flat, also Deutschland Ticket 2.0 oder wahrscheinlich 8.0 irgendwann das quasi egal ist mit was ich fahre.

0:7:41.548 --> 0:7:41.828
Jonas Merbeth
Ja.

0:7:22.238 --> 0:7:44.788
Martin Kohl
Ich hab einfach einen festen Betrag und es ist also ich zahl quasi es ist mir egal wie ich von A nach B komme, sondern einfach jemand bietet mir die Garantie ich komm von A nach B und ist mir egal, ob ich meinen Weg, wenn es jetzt gutes Wetter ist mit dem Fahrrad fahren muss, wenn du eigentlich den Präferenzen das zulassen ich mit dem Taxi abgeholt werde der Busfahrer, das wäre mir dann eigentlich egal, also das wäre ein bisschen Vision quasi so dieses Mobility-as-a-Service halt zu Ende gedacht wirklich alles aus User-zentrierter-Perspektive sag ich mal ja.

0:7:52.718 --> 0:8:4.628
Jonas Merbeth
Ja und wahrscheinlich auch sozusagen, also ein Verschnitt verschiedener Verkehrsmittel und einen einen Preis beziehungsweise ein Ticketing System, was ja auch das nutzerfreundlicher machen würde ja.

0:8:3.258 --> 0:8:23.38
Martin Kohl

Ja genau also sogar wenn man also theoretisch jetzt in guten Luxemburg ist, ja der ÖPNV, aber wenn man sich vorstellt, wenn wir jetzt, wenn ich nix bezahlen, durchs ich zahl halt quasi egal wo ich einsteigen also ich brauch nicht die Gedanken zu machen brauch ich jetzt ne Fahrkarte brauche ich hier und da sondern entweder wenn es eine genaue Abrechnung ist, trackt dass mein Smartphone vielleicht oder ich hab sowieso die Mobilitätsflat, die vielleicht von Arbeitgebern unterstützt wird (oder wem auch immer), und dann nutze ich einfach ist mir egal weil das wird automatisch im Hintergrund verrechnet und ich hätte einfach eine Abrechnung oder weiß alles ist abgedeckt.

0:8:37.688 --> 0:8:38.838
Jonas Merbeth
Ja ja.

0:8:38.968 --> 0:8:44.228
Martin Kohl
Genau das wäre auch noch also quasi datengetriebene Möglichkeit, das also sehr komfortabel zu machen.

0:8:44.648 --> 0:8:51.688
Jonas Merbeth
Bei da muss ich nochmal kurz nachfragen bei Mobility-as-a-Service was sind so die also die Projekte, die du als Vorreiterprojekte siehst? Ich weiß, es gibt ein zum Beispiel in Potsdam ein Forschungsprojekt mit stattfindet. Was das so aus Deiner Sicht die Priorität?

0:8:58.98 --> 0:9:1.338
Martin Kohl
Also eigentlich finde ich, gibt es sehr viele, ich weiß gar nicht, ob es irgendwie best practice gibt.

0:9:13.308 --> 0:9:13.578
Jonas Merbeth
Ja.

0:9:5.48 --> 0:9:16.228
Martin Kohl
Weil so Mobilitätsplattformen an sich sag ich mal, als sehr technisch sind die Probleme nicht eher auf der technischen Seite, sondern eher wie kriege ich alle meine Anbietenden drauf? Wieso sollen jetzt die Leute irgendwie die siebte Mobilitätsplattform irgendwie nutzen?

0:9:20.988 --> 0:9:21.278
Jonas Merbeth
Ja.

0:9:20.248 --> 0:9:23.628
Martin Kohl
Und warum nutzen Sie in der Stadt eine andere wie woanders?

0:9:24.228 --> 0:9:24.468
Jonas Merbeth
Ja.

0:9:24.798 --> 0:9:25.838
Martin Kohl
Also ich glaub, es gibt sehr viele, die das schon ganz gut machen, aber es hat die Frage ich mein muss jetzt Google sein? Keine Ahnung, aber irgendwie das Big Player irgendwie alle mal integrieren kann, dass wollen die Verkehrsverbünden wahrscheinlich irgendwie nicht. Aber ich glaube, der braucht irgendwie regulatorische Eingriffe, um das zu machen, weil sonst ist zu viel Klein-Klein meiner Meinung nach.

0:9:45.218 --> 0:9:51.58
Jonas Merbeth
Ja, ja ja, schreib ich das mal kurz auf, regulatorische ja, ähm genau das ist für mich auch

so eine große Grundfrage sollte man die großen Big Player der Tech Industrie auch aus den USA dort mit zu Rate ziehen? Sie können halt viele Daten sehr gut bereitstellen, gerade was zum Beispiel Verkehrsströme betrifft einfach, weil sie die meisten Daten haben, aber es ist auch immer die Frage, wie man wie man lokale oder kommunale Plattformen schaffen kann, wie die BVG App unmöglich ist, ja.

0:10:18.428 --> 0:10:30.518
Martin Kohl
Ist ja Berlin hat doch auch glaub ich sogar das Fahrradnavi der Fahrradplaner jetzt über Google Maps irgendwie abgebildet als Beta oder hab ich genau die haben sehr viel entschieden, doch irgendwie den mal zu nutzen, was ich einen ganz spannenden Ansatz finde. Ich mein ist natürlich irgendwie schon Google klar, es hat viele Gefahren, irgendwo auch einfach mal sagen gut, wir versuchen es halt mal nicht in Klein-Klein sowie einer großen Lösung ist immer spannend, was da rauskommt.

0:10:41.488 --> 0:10:55.908
Jonas Merbeth
Ja, und und was man da auch mit reinbringen kann, weil wenn es eben auf einer großen Plattform mit angeboten wird, vielleicht doch Regula genutzt ja, ne finde ich auch sehr spannend, welche technischen Werkzeuge die Frage hatten wir oben schon in eine ähnliche Richtung. Welche technischen Werkzeuge, also Monitoring Kameras, Sensoren von der Hardware, die jetzt quasi in der echten Umgebung genutzt wird würdest du für die Analyse des IST-Zustandes von Verkehrssituationen und Verkehrsmitteln heranziehen und warum? Das gibt bestimmt keine generische Antwort, sondern es wird bestimmt abhängig sein vom Projekt aber so ne Tendenz.

0:11:16.758 --> 0:11:21.338
Martin Kohl
Ja, also nicht ganz charmant finde gibt es auch pro und Cons kann ich auch noch mal erläutern danach sind die also Kamera, Erfassung von Gefäßen, also von von PKW'S Bussen, Lkws, whatever das sieht mittlerweile quasi die Filmen, ist allerdings nicht mit einer Video, sondern mit Wärmebild zum Beispiel, so dass quasi auch ausgeschlossen ist, dass personenbezogene Daten erhoben werden und quasi das System darüber läuft, erkennt das ist ein Lkw, das ist ein Fahrrad, das Motorrad, das ist ein Auto und quasi später kann ich auf der Kreuzung Linien ziehen und sagen ich hätte gerne von da nach da: Wie viele Gefäße XY waren das denn?

0:11:57.68 --> 0:11:57.298
Jonas Merbeth
Ja.

0:11:57.338 --> 0:12:2.418
Martin Kohl
Das finde ich ne ganz charmante Lösung, weil man da relativ variabel, sehr viele Daten irgendwie erheben kann.

0:12:3.128 --> 0:12:3.348
Jonas Merbeth
Ja.

0:12:4.738 --> 0:12:11.908
Martin Kohl
Hab aber auch schon Rückmeldungen gehört, dass wenn man irgendwo eine Kamera aufhängt und sagt es geht darum, irgendwas zu erzählen, dann sind die Vorbehalte relativ schnell recht hoch und die Informationen sagte ist eine Wärmebildkamera, die kriegt natürlich lange nicht jeder mit, das heißt viele daran stören der Kamera, die stören sich daran, egal was für ein Spektrum da aufgenommen wird, ja, aber man sieht sie nicht direkt.

0:12:27.958 --> 0:12:28.228
Jonas Merbeth
Ja.

0:12:28.638 --> 0:12:30.578
Martin Kohl
Das ist halt so vor Nachteile ein bisschen. Und Na ja, die Frage jetzt in der Stadt ist es ja wahrscheinlich relativ egal, weil dort gibt es also Netzwerk und Datenverbindungen ja genug. Aber gerade im ländlichen Raum auch sind irgendwie alle Sachen mit LoRaWAN irgendwie ganz, ganz nett, weil oftmals sehr viel dezentral ist halt auch am Start ist irgendwie Akkulaufzeit irgendwie hoch das ist halt glaub ich gerade für die Fläche zu bringen auch noch ein wichtiger Punkt ja also möglichst pflege, pflegarm und halt auch klar öffentlicher Hand sie günstiger desto besser bisschen gewissen Grad spielt auch immer eine Rolle.

0:13:4.268 --> 0:13:8.588
Jonas Merbeth
Ja, ja LoRaWAN-Netze gibt es in urbanen Gebieten schon sehr viel. Also ich glaub hier in Berlin gibt es zum Beispiel eins auf dem Hauptbahnhof was was du einst der größten ist. Du wirst aber auch sagen das ist Grad von ländlichem Raum, ne gute Eignung ist?

Martin Kohl
Also da sind auch ein paar MPSCs, die doch aufbauen wirklich sagen, OK mit der Technologie können wir etwas anfangen. Wir werden in der nächsten Zeit als nächsten Jahre auf jeden Fall einige entstehen.

0:13:30.658 --> 0:13:36.958
Jonas Merbeth
Ja, das wird dann quasi auch gehört zum Modellprojekt Smart City und wird auch wahrscheinlich vom MFund mit gefördert, schätz ich mal.

0:13:38.298 --> 0:13:41.198
Martin Kohl
Über das BMWSK läuft das quasi das große, genau MPSC Made in Germany des 870.000.000€-Millionen-Großprojekt, das auch jetzt ein paar Jahre schon läuft?

0:13:50.28 --> 0:14:7.58
Jonas Merbeth
Ja okay, okay, super gleich die nächste Frage geht es bei der Schaffung einer Smart City mit Ansätzen einer intelligenten Mobilität eher um die Debatte des Aufbrechens von Datensilos bestehender Datensätze, der Verwaltung oder um die Schaffung neuer Datensätze, zum Beispiel mittels IoT -Netzwerken?

0:14:7.988 --> 0:14:8.258
Martin Kohl
Ja.

0:14:7.68 --> 0:14:17.118
Jonas Merbeth
Also geht es eher ums Kreieren neuer Daten oder geht es eher um den Nutzen bestehender Daten, die bei den Verwaltungen schon leben, aber eben noch ein Silos gefangen sind?

0:14:17.808 --> 0:14:18.438
Martin Kohl
Ja.

0:14:20.428 --> 0:14:36.918
Martin Kohl
Ist denke ich Anwendungsfallbezogen, wenn ich jetzt Einzel Beispiel überlege muss sagen ok vergleichsweise ganz ja die Daten sag ich mal digitalisiert überhaupt das würde erste Schritte also wenn ich Zeitreihen-Analyse oder wie machen will, merke ich, wenn es gut läuft das seit 2019 digitale Daten da sind und sonst gibt es irgendwo keine Ahnung Disketten oder Lochkarten übertrieben gesagt jetzt aber das ist halt eine Möglichkeit dann wäre es halt erstmal die Zusammenbringung von Daten. Das war ein riesengroßer Schritt.

0:15:1.138 --> 0:15:1.378

Jonas Merbeth
Ja.

0:14:52.48 --> 0:15:1.978
Martin Kohl
Aber dann sind wir natürlich wieder die Sache, wenn das über die im Bereich nachhaltige Mobilität sehen, sind die Daten die zurückliegend, da sind in der Regel ja auch PKW-spezifisch. Ja also in der Vergangenheit wurde noch weniger drauf geschaut, was irgendwie andere machen. Und für Bereich nachhaltige Mobilität ist halt denke ich wichtig, auch neue Daten zu generieren, um zu zeigen was hat denn andere Mobilitätsarten überhaupt für eine für eine Rolle im öffentlichen Raum und was für Auswirkungen vor allen Dingen also gerade, wenn wir viel Stau, Versiegelungen oder halt Platzbelegung sich sich das anschauen, dass der Dinge, die wurden so und nie systematisch erhoben, ja also, dass man da Erkenntnis schaffen kann und na ja, vielleicht auch neue Argumentation empfindet, weil ja die Argumentation jetzt in der Stadt oder sagen wir, der Verkehrsplanung sind ja sehr sehr, sag ich mal 60er Jahre autogerechte Stadt angelehnt noch mit Verkehrszählung wir denken so viele Autos kommen deswegen wird Straße so breit, dass wenn ich sagte, wir haben eigentlich vor, dass der Verkehr so und so aussehen sollte, was müssen wir tun, damit es denn so wird? Da kann man sich Erkenntnisse auch gewinnen, wenn wir neue Datensätze erhebt.

0:15:58.328 --> 0:16:6.878
Jonas Merbeth
Ja ja, das heißt doch gerade für quasi die aktive Mobilität nicht mal also Fußgängerverkehr Fahrradverkehr und auch für den ÖPNV sicherlich wäre es gut, neue Daten zu erheben.

0:16:10.198 --> 0:16:10.428
Martin Kohl
Ja.

0:16:9.818 --> 0:16:11.958
Jonas Merbeth
Für den Autoverkehr liegen sie halt teilweise schon da. Okay super, das ist auch eine großartige Antwort. Es gibt mir nämlich gut Argumentationsbasis genau dann schon tatsächlich die letzte Frage wie siehst du die Rolle des Fraunhofer IESE innerhalb des Netzwerkes an Akteuren der Smart City? Welchen Beitrag kann das Fraunhofer leisten, um einige intelligente Verkehrsplanung zu erzielen?

0:16:37.698 --> 0:16:50.168
Martin Kohl
Sehr breiten würd‘ ich sagen, also wenn ich so überlegt was unser Portfolio ist also wir sind halt sowohl in der wirklich in der aller ersten Problem-Konkretisierung also Leute, wir haben irgendwie ein Problem, wollte irgendwas machen. Wir können den den Städten halt wirklich auch schon helfen oder Unternehmen zu verstehen, was eigentlich das Problem ist, weil erstmal das, was vielleicht auf den ersten Blick gesagt wird, gar nicht als Problembeschreibung ausreicht oder gar nicht ausreichend, wirklich irgendwann am Ende des Prozesses eine gute digitale Lösungen dafür zu haben hat, das dann quasi in dem Bereich ganz klar sind wir, ohne dass wir das nicht gut gemacht ist, wird der Rest sowieso halt nichts und dann sind wir eigentlich von Strategieberatung bis Konzeption von digitalen Lösungen, sogar mit den Schwesterabteilung darin, gut auch die Lösung zu bauen.

0:17:37.988 --> 0:17:38.248
Jonas Merbeth
Ja.

0:17:23.208 --> 0:17:41.568
Martin Kohl
Also wir sehen jetzt eigentlich als als begleitende Instanz im gesamten Prozess und da wir halt auch jetzt viele Kontakte auch schon zu Kommunen und Firmen haben, mit

Sicherheit auch gewisse Art Vernetzung, die wir leisten können, weil wir jetzt sowohl als viele Angebote auch kennen, aber auch schon viele Probleme und Bedarfe.

0:17:43.448 --> 0:17:48.308
Jonas Merbeth
Das heißt, es gibt viele Kontakte zu Akteuren, Kommunen, aber auch der Privatwirtschaft.

0:17:48.318 --> 0:17:50.448
Martin Kohl
Ja, ja, ja, auf jeden Fall genau.

0:17:49.658 --> 0:17:53.778
Jonas Merbeth
Ja, ja und du hast gesagt Strategieberatung und unterstützende Beratung, aber auch die Softwareentwicklung als solches oder übernimmt das dann andere auch das ja?

0:17:58.168 --> 0:18:9.178
Martin Kohl
Ja genau nee, das machen wir auch, also das ist quasi jetzt sagen dieser USP von der IESE quasi in diesem ganzen Prozess, das wirklich von A bis Z durchspielen können und dann auch quasi dann halt gewährleisten, dass wir eigentlich keine Wissensverlust haben, ja, und das war sie eine einheitliche Sprache sprechen von Beginn bis Ende und das ist halt für das Produkt, was hinten rauskommt, eigentlich auch ziemlich gut in der Regel.

0:18:19.688 --> 0:18:26.828
Jonas Merbeth
Ja ja Softwareentwicklung übernimmt auch das IESE mit oder machen das andere?

0:18:24.188 --> 0:18:37.508
Martin Kohl
Ja ne, das machen auch wir also wir haben auch hier zum Beispiel ich bin jetzt im Smart City Design also eher quasi ein Problem und Konzeption und Smart City Engineering, die Schwesterabteilung die ist dann sozusagen auch in Entwicklung tätig.

0:18:37.68 --> 0:18:41.568
Jonas Merbeth
Ja, ok ja also macht auch die technische Konzeption mit.

0:18:42.308 --> 0:18:42.528
Martin Kohl
Ja.

0:18:45.148 --> 0:18:45.488
Jonas Merbeth
Super. Tatsächlich sind die Fragen schon durch, wir waren super schnell.

0:18:50.468 --> 0:18:51.908
Martin Kohl
Ja gar kein Problem.

0:18:52.378 --> 0:18:54.368
Jonas Merbeth
Ja, es ist großartig.

0:18:54.398 --> 0:18:59.28
Jonas Merbeth
Mir werden die Fragen, glaube ich, sehr weiterhelfen, auch um es zu konkretisieren.

0:18:59.38 --> 0:19:6.198
Jonas Merbeth
Ich würde gleich jetzt abschließend anbieten, meine Arbeit einfach ganz unverbindlich, wenn sie fertig ist mit rumzuschicken.

0:19:6.488 --> 0:19:8.128
Martin Kohl

Ja, sehr gern.

0:19:6.228 --> 0:19:18.338
Jonas Merbeth
Vielleicht kann es, kann es mit was bringen ich würde sie einfach dann als als PDF Anhang sozusagen mit hier an die E-Mail Rand schicken, noch eine kleine bitte oder frage? Ich hatte in meiner erste E-Mail eine Datenschutzbestimmung von unserer Uni mitgeschickt, eine Einverständniserklärung.

0:19:21.928 --> 0:19:28.848
Martin Kohl
Ah ja stimmt, Ach klar dachte die hätte ich schon tatsächlich mitgekriegt, aber mach ich sofort.

0:19:29.538 --> 0:19:38.108
Jonas Merbeth
Da sind so 8 kleine Fragen mit drin und dann muss man einfach nur kleine 8 Kreuzchen setzen, wenn man damit einverstanden ist und unterschreiben, geht auch digital.

0:19:38.368 --> 0:19:47.838
Martin Kohl
Gerne Ach ja, super, mach ich dir fertig.

Jonas Merbeth
Dann danke fürs Gespräch.

Transcript 2/ 7.12.2023/ via MS Teams

Role of responder: Dr. Jens Libbe, Head of Research Department Infrastructure, Economy, and Finance at the German Institute of Urban Affairs (DIfU):

Jonas Merbeth 0:00
Genau in diesem Sinne würde ich einfach mal gleich mit meinen Fragen anfangen, wenn sie erstmal zu meiner Forschungsfrage keine Fragen haben genau alle Fragen beziehen sich auf Ihre Rolle als Forschungsbereichsleiter Infrastruktur, Wirtschaft und Finanzen beim Deutschen Institut für Urbanistik und meine erste Frage wäre, welche Smart City Ansätze und Konzepte sehen sie und welche können dazu beitragen, einen nachhaltigen urbanen Verkehr der Zukunft zu erzielen aus ihrer wissenschaftlichen Sicht?

Dr. Jens Libbe 0:53
Welche Smart City Ansätze sehe ich und möchte Mobilität befördern okay also was heißt das? Ist eine sehr allgemeine Frage, wenn sie von Ansätzen sprechen.

Jonas Merbeth 1:03
Ja.

Dr. Jens Libbe 1:05
Grundsätzlich ist es so, dass die deutschen Kommunen nach meiner Beobachtung mehrheitlich eben folgendes auch in der Smart City Charta steht, nämlich Smart City als ein Konzept zu begreifen was nachhaltige Stadtentwicklung unterstützen kann. Es geht

also es nicht um Digitalisierung als Selbstzweck, sondern es geht um letztlich eine dienende Funktion von digitalen Tools und die Nutzung von Daten basierter Steuerung für die nachhaltige Stadtentwicklung. Und auch in den Modellprojekten, die wir beobachten, und deren Strategien wir so kennen, steht das mehr oder weniger auch so drin.

Jonas Merbeth 1:46
Ja.

Dr. Jens Libbe 1:50
Damit beantwortet sich eigentlich auch schon ein Stück weit Stück weit die zweite Frage nämlich was macht überhaupt nachhaltige Mobilität aus beziehungsweise wie weit kann die Smart City zur Nachhaltigkeit beitragen? Das hängt natürlich ganz stark davon ab, in welchem Sinne ich digitale Tools verwendet. Ob die sozusagen bestimmte verkehrspolitische Zielstellungen unterstützen oder nicht?
Also wenn ich beispielsweise eine klare Präferenz für Rad- und Fußverkehr in meiner Stadt habe, dann macht es wenig Sinn, mit digitalen Tools Individualverkehr noch weiter zu verflüssigen, sondern der Umgang ist umgekehrt, muss im Grunde der Weg sein und Fuß- und Radverkehr da, wo sinnvoll, mit digitalen Tools zu unterstützen.

Jonas Merbeth 2:41
Ja.

Dr. Jens Libbe 2:42
Dazu muss man allerdings sagen. Die ganzen Modellprojekte so Moment unterwegs sind, sind natürlich noch sehr experimentell unterwegs, also kein kein Modellprojekt hat jetzt die perfekte Strategie und man sagen kann, sämtliche Smart City Maßnahmen sind klar auf ein Ziel hin orientiert, sondern es geht immer um zweierlei, nämlich einerseits nachhaltige Stadtentwicklung, andererseits auch erstmal Erprobung von technologischen Möglichkeiten und insofern hat das Ganze ein ganz stark spielerisches Element und deshalb würde ich auch nicht sagen, dass jedes Mal City Maßnahme automatisch zur nachhaltigen Stadtentwicklung beiträgt. Selbst wenn die Kommunen sich das strategisch erstmal auf die Fahne geschrieben habe, dann muss man im Einzelfall etwas genauer hingucken.

Jonas Merbeth 3:23
Ja, das bedeutet auch aus deren Sicht das ist sehr, sehr projektspezifisch und projektabhängig.

Dr. Jens Libbe 3:24
Genau genau genau.

Jonas Merbeth 3:29
Ja, ja, okay meine zweite Frage geht in ähnliche Richtung, und zwar in welchem der folgenden Bereiche von intelligenter Verkehrsplanung, also Smarte

Verkehrsüberwachung, Monitoring von Verkehrsbestand, Simulation von Verkehrsszenarien oder die aktive digitaler Verkehrssteuerung oder auch Verkehrsleitsysteme sehen sie das größte Potenzial? Ich denke mal darauf gibt es keine allgemeine Antwort, sondern das hängt wahrscheinlich auch wieder, ich will nicht so weit vorgreifen, aber vom Spezifischen ab.

Dr. Jens Libbe 3:58
Genau genau das hängt man von dem ab, was man jemals will als Stadt also kann ich, kann ich Ihnen überhaupt nicht eindeutig beantworten.

Jonas Merbeth 4:06
Ja, okay.
Sehr gut, die dritte Frage ist eine sehr spezifische, und zwar Sie sind ja für die Begleitung der Koordinations- und Transferstelle der KTS für die Modellprojekte Smart City des Bundesministeriums zuständig. Welche der daraus hervorgegangenen Projekte sind denn aus ihrer Sicht besonders hilfreich einen nachhaltigen urbanen Verkehr der Zukunft zu erzielen, können Sie 1,2,3 nennen, die besonders ins Augenlicht gerückt sind? Und wenn ja, warum?

Dr. Jens Libbe 4:40
Direkt nicht, weil ich hab zwar die Projektleitung, aber ich steck aber nicht so im operativen Geschäft drin, also jetzt müsst ich richtig rein gucken in die Projekte, richtig tief rein gucken, welche davon wirklich gut im Mobilitätsberatung betreiben, da würde ich Ihnen raten, im Zweifel nochmal bei den Kollegen selbst anzurufen, (anonymisiert), (anonymisiert), die bei uns im KTS Team sitzen und die Projekte begleiten, die haben da vielleicht eine Antwort, braucht vielleicht können Sie mich da flankieren?

Jonas Merbeth 5:04
Ja.
Ja, okay, sehr gut.

Dr. Jens Libbe 5:11
Wenn das jetzt ihr ihr methodisches Vorgehen nicht völlig durcheinanderwirft?

Jonas Merbeth 5:15
Nein, nein, nein, nein, da werde ich mich entweder dort nochmal melden oder genau ich bin auch selber das vielleicht noch vorweggenommen. Ich arbeite selber für eine Privatfirma, die auch in den Modellprojekte Smart City mit tätig ist.

Dr. Jens Libbe 5:28
Ja, also ich weiß früher war Wolfsburg, der natürlich sehr aktiv, überhaupt die Städte mit Automobilstandorten, die waren am Anfang sehr, sehr aktiv, aber es gibt sicherlich inzwischen ganz andere.

Jonas Merbeth 5:39
Ja, die haben dann aber vorwiegend wahrscheinlich Projekte begleitet, die auf den Individualverkehr abzielen, oder auch.

Dr. Jens Libbe 5:40
Jeder.
Ja, die haben doch die haben auch alles Mögliche gemacht, da ging ging, natürlich ging es auch im automatisierten Verkehr. Aber ich glaub die haben das halt auch erstmal so als Reallabor genommen, um da überhaupt zu verstehen, worum es geht.
Viele beschäftigen sich meines Erachtens mit Fragen von Sensorik und Verkehrsflußsteuerung, gibt aber auch so Sachen wie smarte Ampeln in Mönchengladbach und solche Geschichten. Ja, alles Mögliche, aber wie gesagt, fragen Sie die beiden ruhig nochmal.

Jonas Merbeth 6:17
Ja.

Dr. Jens Libbe 6:20
Ob die noch gute Tipps haben? Ja, die Verkehrsflußsteuerung zielten aber auch wahrscheinlich vorwiegend auf den Individualverkehr ab oder auch auf die aktive Mobilität wie Fußverkehr sein also etwa indem die Sensorik geschaut, wie schnell bewegen sich die Menschen über die Straße? Und wenn der jetzt, was weiß ich ältere Leute, die nicht gut zu Fuß sind oder jemand, der mit einer mit dem Handicap, der länger braucht, die länger braucht, um über die Straße zu kommen, dann wird entsprechend die Grünphase verlängert.

Jonas Merbeth 6:51
Okay, ich kenn auch ein Projekt, aber das kennen Sie sicherlich auch aus den Niederlanden Fietsflow, wo es darum geht, den den Fahrradverkehr flüssig zu machen, indem man die Geschwindigkeit der Radfahrerin misst.

Dr. Jens Libbe 7:00
Ja.
Ja, das kenn ich nicht so im Detail, aber das könnten da könnten ihn jetzt meine Kollegen aus dem Mobilitätsabteilung viel zu sagen die der bei denen ist Fahrradverkehr, das Leib und Magenthema.

Jonas Merbeth 7:11
Okay, alles klar?
Ja, sehr gut, sehr gut okay, dann wieder eine übergeordnete Frage wie sehen Sie denn die Rolle von Staat und Administration, aber auch Forschungseinrichtungen, Think Tanks und der freien Wirtschaft als Geflecht zueinander. Meine Frage zielt vorwiegend auf die Aufgabenverteilungen zwischen diesen einzelnen Bereichen ab? Wie sehen Sie das im

Geflecht der nachhaltigen Smarten Mobilität.

Dr. Jens Libbe 7:45
Sehr allgemeine Frage also grundsätzlich in den Smart City Modellprojekten ist die Wissenschaft regelmäßig vertreten? Warum? Weil sich natürlich die sowohl die lokale Wissenschaft als auch die Kommunen Wirtschaftsförderung davon natürlich gewisse Effekte erhoffen, also Kommunen engagieren die Wissenschaft, um sich fachliche Unterstützung zu holen. Die Wissenschaft selber ist froh, wenn sie den Kommunen das ein oder andere experimentell erproben kann. Die Wirtschaftsförderung erhofft sich und Impulse für Startups oder für die Hochschulen allgemein. Also das ist ein Prozess des Gebens und Nehmens. Das Gleiche gilt im Grunde für die Wirtschaft auf viele Smart in den Projekten sind häufig auch lokale kleine, größere Unternehmen unterwegs je nach Standort. Hochschulstandorten fällt in der Regel leichter, weil die natürlich mir ein kreatives Milieu haben und entsprechend dann eben auch Ausgründungen, Startups was, was auch immer von Smart City Maßnahmen profitieren und Zivilgesellschaft halt ich ganz generell für insofern für wichtig, als das ganze Thema Smart City hm?
Sowohl in der Strategiebildung, aber letztlich noch mehr in der Umsetzung eigentlich immer auch ein starkes partizipatives Moment haben sollte. Das ist auch die zweite Leitlinie der Smart City Charta. Und das ist auch eine Auflage letztlich annehmen, die an die Modellprojekte immer wieder gerichtet wird. Das heißt, ihre Strategien und letztlich auch ihre Einzelmaßnahmen im Zusammenspiel und letztlich auch Co--produktiv mit ihren Bürgerinnen und Bürgern zu entwickeln. Warum? Weil man natürlich nur so raus bekommen kann, was denn eigentlich wirklich gebraucht wird, was eigentlich Sinn macht, weil frühe Smart City Projekte in Deutschland etwa die von der EU gefördert waren, das waren immer so Technologie Förderprojekte.
Da mussten die Kommunen sich schon vor der oder Zuschlagserteilung committen, mit welchem Industriepartner sie zusammen ging und dann ist man in einem Bezirk gegangen, und plötzlich fielen dort Elektroroller vom Himmel oder so, die niemand bestellt hatte. Ne, also das fand ohne jeden Beteiligungsprozess Stadt und daraus hat Deutschland gelernt und deshalb sagen wir heute bei dem Modellprojekte Smart Cities bitte starkes partizipatives Moment und das gilt generell das hat also nicht nur mit Mobilität zu tun, sondern das ist ein ganz ganz genereller Sachverhalt.

Jonas Merbeth 10:20
Ja, davon bin ich jetzt auch ausgegangen, dass sich auf alle Arten der Smart City Projekte bezieht, also wenn Smart City in diese 6 Teilbereiche vielleicht unterteilt, dies da auch gibt, dass es sich sozusagen auf alle Bereiche bezieht, dass man eher vielleicht einen stärkeren Bottom-up Ansatz oder auch partizipativen Ansatz der Zivilbevölkerung forciert, ja.

Dr. Jens Libbe 10:30
Ja, ja und und auch hier gilt jede Stadt hat sozusagen unterschiedliche Druck Punkte also, bei dem einen in der einen Stadt brennt das Thema Verkehr aus unterschiedlichsten Gründen und in der anderen Stadt mag es das Thema Verwaltungsmodernisierung sein also sozusagen die, die Relevanz dessen, was die Bürgerinnen und Bürger für wichtige

achten. Das kann eben auch sehr stark von den lokalen Gegebenheiten hier abhängig sein und damit variieren.

Jonas Merbeth 11:10
Das heißt, die Relevanz kommt dann immer von von der Kommunalverwaltung oder von der Stadtverwaltung sozusagen selber.

Dr. Jens Libbe 11:16
Ja, oder eben von den Bürgerinnen und Bürgern, die letztlich sagen so dass das damit würden wir uns gerne beschäftigen. Das finden wir das interessant eben mit im Sinne Smart City auszuprobieren, ja bestimmte Maßnahmen, Portfolio und andere Maßnahmen sagen die Bürger dann vielleicht nö haben wir eigentlich, sehen wir nicht so den Sinn drin. Also gute Smart City Strategien sind stark bottom-up auch getrieben das heißt die Stadt macht macht es auch, sagt Wir haben hier 16.000.000€ zur Verfügung. Wir haben uns mit der und der Leitidee beworben. Und die wollen wir jetzt mit Leben füllen und dann mit Leben füllen, das muss dann eben mit den Menschen vor Ort passieren.

Jonas Merbeth 11:59
Ja, ja können dürfen Sie eine Einschätzung zur Smart City Strategie Gemeinsam Digital: Berlin treffen?

Dr. Jens Libbe 12:14
Na ja, möchte ich möchte da kein Werturteil abgeben also ich sag mal die die das was wir vor 5 Jahren oder so mal in Berlin vor hatten, das fand ich damals so, dass ich gedacht habe um Gott, also als man 400 Projekte im Grunde in einen Topf geworfen hat und kann irgendwie Smart City drüber geschrieben hat. Da hat man für jedes Projekt genommen, was gerade in der Stadt unterwegs war und hat das irgendwie darein gewürfelt. Ich finde die Strategie, die sie jetzt geschrieben haben, eigentlich gut.

Jonas Merbeth 12:38
Ja.

Dr. Jens Libbe 12:41
Ich hab die eigentlich mit Interesse gelesen, ich fand das hatte war gut durch strukturiert war, war gut durchdachten das hin glaub ich auch ganz stark damit zusammen, dass da paar Kolleg*Innen mit unterwegs waren wie etwa die (anonymisiert) oder etwa (anonymisiert) die da einfach viel Gehirnschmalz in die dies entwickelnde Strategie gesteckt haben, so und das hat man da den Produkt angemerkt, jetzt im Konkreten in den Projekten vermag ich mir wirklich kein Urteil zu bilden, weil ich die nicht im Einzelnen beobachte. Ich hab ein bisschen mit Start Smart kürzlich zu tun gehabt, finde dass da eigentlich ganz spannend da geht es eben auch um die Umsetzung der wassersensiblen Stadt und mit digitalen Tools bestimmte planerische Maßnahmen darzulegen. Das finde ich erstmal ganz interessanten Ansatz, und ich weiß auch, dass sie sich das Thema Monitoring und Evaluation sehr stark auf die Fahnen geschrieben haben also genau

anzugucken, welche Wirkung ihre Smart City Strategie oder die Maßnahmen dann im Hinblick auf die Nachhaltigkeit Ziele des Landes Berlin bedeuten.

Jonas Merbeth 13:46
Ja.

Dr. Jens Libbe 13:47
Also insofern finde ich das für ein Berliner Projekt gar nicht mal so schlecht.

Jonas Merbeth 13:51
Ja, sehr gut, ja, ich hab sie auch mit Begeisterung gelesen und war erstaunt, auf welcher hohen Flughöhe sie auch war. Die Strategie als solche und…

Dr. Jens Libbe 13:58
…Ja.
Die Probleme in Berlin liegen ganz woanders. Die Probleme in Berlin liegen in der starken Zersplitterung von Senat und Bezirken. Und den vielen Akteuren, die unterwegs sind, sozusagen in der in dem Geflecht von Verwaltung, da kann man dann glaub ich schon verzweifeln.

Jonas Merbeth 14:14
Ja.
Ja, okay.
Guter guter Hinweis.

Dr. Jens Libbe 14:24
Aber das zitieren Sie jetzt bitte nicht wirklich.

Jonas Merbeth 14:26
Nein, Nein Gottes willen, da kommen wir dann ganz zum Abschluss sowieso noch kurz dazu. Genau meine letzte Frage schon wenn sie sehen Sie denn hauptsächlich in der Verantwortung von konkreten Umsetzungsprojekten für Smart Mobilitätslösungen? Ich glaube, die Antwort haben wir auch schon implizit mit drin, aber nochmal nochmal ganz konkret gefragt.

Dr. Jens Libbe 14:46
Naja, konkret sozusagen die zuständigen Fachdezernate die zuständigen Fachressorts.

Jonas Merbeth 14:52
Ja.

Dr. Jens Libbe 14:55

Die darauf achten müssen, dass das, was sie da machen und zu ihren sonstigen Zielstellungen passt, so und das kann man mit öffentlichen Partnern machen, das kann man mit privaten Partnern machen, da kann man ganz unterschiedliche Wege gehen, aber letztlich muss das Ganze sozusagen immer wieder an die öffentlichen Interessen der Kommune rückgekoppelt werden und ist damit Aufgabe von Verwaltung und auch Politik.

Jonas Merbeth 15:01
Ja ja.
Ja, okay.
Okay, das muss ich noch kurz aufschreiben.
Perfekt vielen Dank, das wäre jetzt schon meine 5 Fragen gewesen, ich will sie auch gar nicht lange aufhalten. Noch eine ganz kleine bitte ich hab in der ersten E-Mail an sie auch eine Einverständnis Genehmigung mitgeschickt. Sie können auswählen darf Ihr Name genannt werden? Darf nur die Organisation genannt werden?

Dr. Jens Libbe 15:47
Hatte ich Ihnen nicht zurückgeschickt?

Jonas Merbeth 15:49
Ich hatte noch nichts von von ihnen jetzt bekommen.

Dr. Jens Libbe 15:52
Können Sie mir gefallen, schicken Sie mir einfach nochmal.

Jonas Merbeth 15:54
Die schick ich jetzt gleich nochmal als E-Mail rum, genau da können Sie alles auswählen, wie sie genannt werden wolle super, dann ganz, ganz vielen Dank.

Dr. Jens Libbe 15:58
Ja, alles klar.
Gut gerne.

Jonas Merbeth 16:02
Ich würde meine Arbeit wird 1. Februar fertig, Ende Februar ist sie dann wahrscheinlich so, dass sie auch ordentlich aussieht. Ich würde Ihnen natürlich an, falls Sie Interesse haben, gerne Exemplar als PDF einfach zukommen lassen.

Dr. Jens Libbe 16:16
Sehr gerne sehr gerne.

Jonas Merbeth 16:17
Genau es wird auch eins an die an die Smart City Abteilungen der Stadt Berlin gehen und anderen Beteiligten genau mit denen ich gesprochen habe. Aber ja, vielleicht bringt es ja

was.

Dr. Jens Libbe 16:26
Ja ja, okay, ja, sehr gerne viel Erfolg wünsche ich.

Jonas Merbeth 16:31
Ja, dann ganz ganz vielen Dank und einen schönen Tag.

Dr. Jens Libbe 16:33
Ja, ebenso.

Transcript 3/ 17.11.2023/ via mobile phone

Role of responder: Matthias Heßkamp, CEO of *Radbahn GmbH*

00:00:00 Jonas Merbeth

Ganz kurze Frage. Ich würde das Gespräch aufzeichnen. Ist das ist das in Ordnung?

00:00:01 Matthias Heßkamp

Aha, ja, ja, natürlich, ja, ja, ja.

00:00:07 Jonas Merbeth

Super vielen Dank. Genau, ganz kurz zur Einordnung. Also ich schreibe eine Masterarbeit zum Thema Smart Mobility und ich beschäftige mich damit, wie quasi Smart Mobility Konzepte und Ideen dazu beitragen können, nachhaltigeren Verkehr zu erzeugen und das Ganze mache ich am Beispiel der Stadt Berlin. Ja, genau, und ich habe Smart Mobility für mich selber definiert, weil es gibt keine allgemeinen Definitionen als quasi nachhaltiger Verkehr erzielen, also sprich mehr Fußgänger und Radfahrverkehr, also mehr, sozusagen Verkehr der aktiven Mobilität und weniger Autoverkehr, weniger motorisierten Individualverkehr. Und ich untersuche sozusagen, mit welchen Innovationen und Technologien wir das ganze messen können. Und genau da hätte ich ein paar Fragen an sie in Ihrer Position als Geschäftsführer von der *Radbahn GmbH*. Und ja, wenn sie erstmal dazu keine Fragen haben?

00:01:06 Matthias Heßkamp

Vielleicht auch noch mal zwischen Nachhaltigkeit und Smart. Also ich verstehe, dass, dass man jetzt über smarte Technologien etwas misst. So hattest du gesagt, oder sprichst du einfach von smarten Technologien innerhalb einer, einer neuen Mobilität.

00:01:22 Jonas Merbeth

Genau richtig.

00:01:24 Matthias Heßkamp

Ja, OK, ja.

00:01:26 Jonas Merbeth

Genau, mir geht es vorwiegend um die Analyse und des Monitoring von Verkehr, also von Verkehrsflüssen und und dass wir daraus ableiten können, was man anders machen kann und ganz, ganz konkretes Beispiel, man hat eine dreispurige Autostraße, man stellt eine

Kamera auf die Kamera, misst den Verkehr und und man zählt die Autos, also die Verkehrsstärke, und man ermittelt okay so und so viel Autos fahren dadurch: Könnten wir eine dieser 3 Spuren wegnehmen und die zum Beispiel zum Fahrradverkehr ummodeln?

00:01:31 Matthias Heßkamp

Ah, ich verstehe ja.

00:01:56 Jonas Merbeth

Und wenn ja, könnte die Verkehrssteuer immer noch bedient werden. Das ist so die Idee. Genau jetzt, als ein Beispiel von von ganz vielen.

00:02:05 Matthias Heßkamp

Von ganz vielen, kann ich mir vorstellen. Ja, ja, wir fliegen seit 50 Jahren zum Mond, nicht auf der Straße sind wir sowas von Neandertaler.

00:02:13 Jonas Merbeth

Genau. Was ich recht spannend finde: Ich werde quasi diese verschiedenen Konzepte und Ideen clustern. Also ich gucke mir quasi auch die Smart City Strategie der Stadt Berlin an und ich versuche eine Clusterung zu machen und sozusagen eine Art Evaluationsmatrix als Outcome meiner Arbeit zu machen, in der alle Ansätze, die es im Bereich Smart Mobility gibt, zu Clustern und zu gucken, wie können die sich auf Nachhaltigkeit auswirken. Und dann nehme ich diese Matrix und leg die sozusagen als Überkonzept über die Stadt Berlin und gucke mir an, was davon erfüllt die Stadt Berlin bereits und was erfüllt sie nicht und das, was sie nicht erfüllt, da werden quasi meine Police recommendations was könnte man dementsprechend besser machen, das ist so die Idee dahinter.

00:02:56 Matthias Heßkamp

Bist du mit dem Smart City Netzwerk in Kontakt?

00:02:59 Jonas Merbeth

Genau, also ich. Ich arbeite auch für ne für ne Firma aktuell schon, die DKSR heißt, genau die machen, die beschäftigen sich auch damit, wie quasi urbane Daten nutzbar gemacht werden können für Städte und ich bin auch dann im Austausch mit der Smart City Unit der Stadt Berlin, dem City Lab Berlin und ähnlichen Organisationen.

00:03:21 Matthias Heßkamp

Mit wem sprichst du da vom Smart City Netzwerk.

00:03:24 Jonas Merbeth

Vom City Lab, muss ich mal kurz in meine….

00:03:27 Matthias Heßkamp

Vom Smart City Netzwerk meine ich.

00:03:30 Jonas Merbeth

Vom Smart City Netzwerk ich habe einige Leute vom Fraunhofer-Institut.

00:03:35 Matthias Heßkamp

Ah ja, OK, mhm.

00:03:36 Jonas Merbeth

Ich hab gerade meine Liste eine Sekunde, dann muss ich einmal kurz reinschauen.

00:03:43 Matthias Heßkamp

Hallo, ich dachte, ob du jetzt so direkt so weil also dieses Smart City Netzwerk tja ja, man rühmt sich ja jetzt nicht nach 10 Jahren Gründung oder so. Damit das jetzt seit anderthalb Jahren tatsächlich Berlin da. In unserem Förderstatus gekommen ist und innerhalb von

den nächsten 3/4 Jahren dann quasi aus einem Konzept auch etwas Umsetzbares vorzeigen können nicht. Und ich würde eines dieser 5 Projekte meines Wissens ist Smart City Hardenbergplatz. Das ist dir wahrscheinlich alles ein Begriff, oder?

00:04:16 Jonas Merbeth

Genau das habe ich alles angeschaut und das auch als quasi als Good-Practice-Beispiele rausgenommen. Aber das Good ist noch in Frage.

00:04:25 Matthias Heßkamp

Ja, also ich kenn da so n paar Leute möchte ich nur sagen und das ist wahnsinnig hilfreich was du da glaub ich machst fürs Smart City Netzwerk, denn wenn du treiben die etwas an, aber die die Applikation das Learning aus dem um das wiederum weiter zu skalieren auf das was hier in Berlin braucht und das was man idealerweise auf der Expo 35 zeigen kann in Berlin, da gibt es andere Treiber, gerade ganz gesunde Kräfte, die genau solche Technologien ganz schnell applizieren, ausprobieren wollen, in den nächsten 11 Jahren, um damit Berlin weltweit zu zeigen, ist nur ein Hinweis ja.

00:05:04 Jonas Merbeth

Ja, ja, super, super, vielen Dank. Ich habe gerade noch mal reingeschaut, also ich spreche zum Beispiel mit (anonymisiert), ich weiß nicht, ob der ein Begriff ist vom City Lab Berlin.

00:05:05 Matthias Heßkamp

OK.

00:05:14 Jonas Merbeth

Genau dann. (anonymisiert), die ist Koordinatorin von der Smart City-Unit.

00:05:17 Matthias Heßkamp

OK.

00:05:22 Jonas Merbeth

Genau dann habe ich zum Beispiel (anonymisert). Ich weiß nicht, ob der ein Begriff ist vom DIfU, der ist Bereichsleiter für Infrastruktur und Finanzen. Dann habe ich DLR noch 2 Leute, die quasi mehr die technische Seite beleuchten und dann sagt bestimmt (anonymisert) und (anonymisiert) was die sind an der HCU in Hamburg und sind dort in Smart City als Bereich.

00:05:45 Matthias Heßkamp

Ja, genau. (Anonymisiert) doch mal zusammen denken mit (anonymisiert), die das da leitet.

00:05:55 Jonas Merbeth

(anonymisiert) ja.

00:05:57 Matthias Heßkamp

Ja, die koordiniert das ganze Netzwerk und ja, und dann würde ich dir so im Nebensatz noch (anonymisiert) irgendwie nahelegen, sondern auch ein ein Startup, der gerade Technologien smarter Art, quasi ein Inkubator für andere Firmen, Förderprojekte und das Wissen um ein smartes quasi weiterzutreiben, ist ein großartiger Gesprächspartner. Ich, ich sag's immer nebenbei, wenn du da noch richtig guten Input haben möchtest. Aber wenn du doch keine Zeit, der ist von Urban Impact.

00:06:36 Jonas Merbeth

Ja OK super, ganz vielen Dank. Ich hab mir die beiden Namen mal aufgeschrieben, (anonymisiert) und (anonymisiert).

00:06:42 Matthias Heßkamp

Das ist quasi nicht die gleiche Richtung, ja.

00:06:47 Jonas Merbeth

Die gleiche Richtung. Ja, das ist perfekt, weil ich hätte gern genau diese Perspektive auch gerne mit in meiner Arbeit drin.

00:06:53 Matthias Heßkamp

Ja, nee, also die, die machen eigentlich das gleiche, nur dass (anonymisiert) ist da aus dem anderen mit ihr unterwegs, gut.

00:07:01 Jonas Merbeth

Ja, was bestimmt auch noch ganz spannend ist. Ich hab nur einmal noch (anonymisiert) von von *Jelbi* mit in meiner Liste und (anonymisiert) von der Berliner Agentur für Elektromobilität.

00:07:14 Matthias Heßkamp

Ja, natürlich auch n richtiger Kontakt. Ja ja, super perfekt.

00:07:19 Jonas Merbeth

Genau dann würde ich gleich mal kurz mit den Fragen starten. Ich habe nur 5 Stück.Und die erste ist ne ganz allgemeine. Welche erstmal darf ich du sagen ist das, ist das in Ordnung?

00:07:30 Jonas Merbeth

Ja, okay welche Eigenschaften und Charakteristiken siehst du, die einen ökologisch nachhaltigen Verkehr oder Mobilität der Zukunft ausmachen und wie können wir Sie erreichen? Ganz allgemein.

00:07:45 Matthias Heßkamp

Und die Frage war Eigenschaften einer ökologischen, sagen wir mal, wiederholen. Bitte, ja.

00:07:49 Jonas Merbeth

Genau. Eigenschaften, und Charakteristika von ökologisch nachhaltigem Verkehr.

00:07:58 Matthias Heßkamp

Ja, ja, ja, da möchte ich gerade. In etwas gehen ich. Ich glaube nicht, dass es nur um smarte Technologien geht, nicht nur, ja, ich möchte das wirklich nicht nur sagen, ich sehe sogar ab und zu die Gefahr darin, dass man sich beruft, auch das möge alles smarter werden, man möge mir das alles sagen, dann mach ich das schon. Ich glaube, dass wir insbesondere und das macht auch unser *Paper Plane*, insbesondere das Bewusstsein schärfen für eine andere Art von Mobilität, die nicht weh tut im Sinne des der Verlustängste zu dem, was ich gewohnt bin, sondern die neue Wege eröffnet, wenn eine gewisse Entschleunigung reinbringen, die auf andere Ebenen dann mit einem Beschleunigung bedeutet im Sinne des wie trete ich mit Menschen in Kontakt, wie teil ich den Raum, wie nehme ich Raum wahr und wir werden uns alle womöglich ein andere Art der Mobilität, die gesünder ist, mit der man ebenfalls schnell voran kommt und dann wiederum Ressourcen frei macht auf der Straße und Autos, die dann weniger fahren, denn das ist erwiesen, dass die Autofahrenden nicht die Glücklicheren sind, ja, als die Idee mit anderen unterwegs sind und diese Bewusstseinsschärfen der vielen Möglichkeiten der alternativen Mobilität finde ich insbesondere durch und durch einen nachhaltigen Ansatz, denn smarte Technologien nehmen immer wenn wir uns so darauf stützen, dass eine Stadt lebenswerter, wirklich smart ist, dann hat man womöglich etwas verpasst. Es gibt Beispiele auch in Asien, da rühmt man sich osmatisch, aber das Leben ist nicht auf die Straße gekommen, weil das Leben zwischen den Menschen dort im Grunde im außer Acht gelassen wird. Dann haben wir wieder das Essentielle vergessen.

00:09:57 Jonas Merbeth

Ich, ich bin gerade sehr froh, dass Sie das genauso sagen, weil das ist schon der erste Erkenntnispunkt auch in meiner Arbeit gewesen. Smart im Begriff von wir verwenden nur Technologien und Innovationen ist nicht smart. Das ist eine Verwendung von neuen Formen, wie wir etwas messen oder erheben können, aber es schafft nach keinem kein anderes Denken. Es ist erstmal nur ein Erhebungstool und es kann für was gutes und es kann für was Schlechtes genommen werden.

00:10:26 Matthias Heßkamp

Ja ich möchte da noch eins draufsetzen ich behaupte also mir fällt es sogar schwer zu sagen das ist eine smarte Technologie ich behaupte ja das ist mein Begriff von von Smart Time ist ein Mensch nur ein Mensch glaube ich, Tiere kann ich jetzt gerade gar nicht so richtig sagen, hat die Eigenschaft etwas smartes zu entwickeln und es liegt einfach daran dass wir als Menschen Emotionen mit Wissen verquicken können ja um Emotionen kommen aus der Erfahrung, ja. Das heißt, dass wir entwickeln aus dem, wie ich mich fühle, wie ich denke, habe aus der Erfahrung etwas was besser und sein kann und da ist das Gehirn ein ein wahnsinnig gutes Tool in Verbindung mit unserer Emotion und das was dadurch entwickelt ist, ist womöglich smart, aber die Technologie selber ist programmiert. Jetzt kann man natürlich sagen, die Selbstlernenden oder so schaffen das irgendwie, aber sie werden nimmer diesen Aspekt dessen, was der Mensch eigentlich braucht, und es ist Liebe und Zuneigung, begreifen können. So, und deswegen das es uns wahnsinnig helfen, die Unterstützung durch Smart Technologie. Dein Beispiel war wunderbar, das erkennen, dass hier was Unlogisch ist.Um dann genau Räume zu öffnen, die uns Menschen in der Mobilität, aber auch in vielem anderen wieder Räume öffnen, ja.

00:11:45 Jonas Merbeth

Ja, würde ich, würde ich absolut zustimmen.Bringt mich auch gleich schon zu meiner zweiten Frage. Die ist etwas etwas konkret auf die Stadt Berlin bezogen, und zwar welche Schritte muss die Stadt Berlin gehen, um mehr nachhaltige Verkehrsangebote in der Stadt zu platzieren natürlich. Sicherlich ist die Radbahn GMBH da auch ein Beispiel, aber vielleicht haben sie eh du auch noch weitere weitere Ideen.

00:12:10 Matthias Heßkamp

Ja, ich glaube, es muss tatsächlich erst mal ein ein radikaler Shift durch die Einstellung zu Berlin was ist Berlin eigentlich? Ist Berlin eine Stadt, die zwar ständig in Metamorphose ist, aber ich möchte behaupten, bisschen kopflos in ganz viele Richtungen hinein agiert und vieles auch einfach mal laufen lässt und sich dann wiederum in der Verwaltung, und ich mache keinen Vorwurf an einzelne Verwaltungsbehörden sich selbst wieder im Wege steht, um, ja, smart ist immer synergetisch, es wird smart und genau das, genau das geschieht einfach nicht und man schaut nicht auf die Teller der anderen. Die Senatsverwaltung ein Beispiel, nur ja der Stadtentwicklung wurde Ich glaube, vor 30 Jahren separiert oder vor weniger Jahren in Richtung Verkehr ja, und und und Stadtentwicklung und es gehört alles so zusammen und es wird alles, das heißt, keiner weiß so Recht, was der andere macht. Vielleicht weiß man es auch man versucht sich da eher abzugrenzen und Pründe in die eigene Senatsbank zu schieben, das haben die bitter spüren müssen. Also A) meine Kritik ist, dass tatsächlich, synergetisches Denken ein Projekt bedarf. Fast alle Verwaltungen, vom sozialen bis hin zum verkehrlichen, um Projekte voranzutreiben, sind immer wieder diskutiert, auch gerade im Rahmen unserer, geförderten Projekte ob es dort Schnittstellen gibt, kann es über die Senatskanzlei gehen usw., da hagelt es ganz bitter und ein anderes ist: Ich wünschte mir so sehr ja, dass Berlin für mehr stünde als die Entwicklung eines Potsdamer Platzes, ja, für den man uns gefeiert hat. Man kommt nach Berlin, weil Berlin alternativ und cool ist. Wo ist denn da wirklich ein radikal neuer Ansatz, der all diese Signale hört und sagt, wir rennen da einfach mal schneller voran, wir haben sie, die Leute in Berlin stehen alle, wir sind alle so fast schon sehr sozial denkende Stadt. Hier fahren sowieso schon weniger Autos. Warum schlägt man daraus kein radikales Kapital? (anonymisiert) vielleicht mal schauen, das ist jetzt ich hab das im Ansatz mal angedeutet, da ist eine wunderbare Initiative entstanden, die die Expo 35 nach Berlin holen will. Und die will genau das, sie will Berlin reformieren als eine schnellere Stadt als eine, die dieses Verfahren, wo quasi per Bypass ermöglicht, um in 11

Jahren etwas zu zeigen, was die Welt braucht. Und das finde ich cool. Und ich kann auch den Geschäftsführer des ganzen der das vorantreibt, den ehemaligen Geschäftsführer der Handwerkskammer, da mal reingucken. Das finde ich wichtig. Ja, und es wird wie es wird gerade wieder höher, ausgebremst durch eine Olympia.

00:15:05 Jonas Merbeth

Die Olympiabewerbung, die auch wieder aussteht.

00:15:07 Matthias Heßkamp

Ja, ja, die an sich schon beschlossen ist und beides geht dann nicht. Ja, was soll ich sagen, ich hab nichts gegen das eine, nichts gegen das andere, aber ich unterstütze natürlich viel stärker, aber wie gesagt, meine Kritik, dass wir, wenn ich jetzt noch mal, ich will es nicht zu lange machen, nicht zurückblicke in den letzten 4 Jahren, wo wir von konzeptionellen Denken Lobbyarbeit in die Ausführung gegangen sind. Und ich möchte dir jetzt nicht unbedingt in die Feder diktieren, was alles nicht funktioniert. Ja, und es funktioniert so viele nicht und wenn man da drin verharrt, ist Berlin als eine Signalstadt irgendwie abgehängt, ja weltweit, und das kann ich nicht verstehen, ja, ich würde mir gerne einen Slogan für Berlin wünschen und das in diese Richtung des ganz anderen Miteinanderlebens einhergeht. Ja, mir fällt es gerade nicht ein.

00:16:03 Jonas Merbeth

Ja, das das das fehlt. Und Berlin hat aber eigentlich das Potenzial, also gerade was auch Stadtgestaltung betrifft, es gibt wenige Städte, wo so viele Leute in in Planungsbereich im Architekturbereich Kunst und Kulturschaffenden-Bereich tätig sind, die eigentlich damit das Potenzial bieten könnten okay danke erstmal für die Antwort, das ist auch großartig. Was sind denn deiner Meinung nach Stärken und Schwächen von Smart-Mobility-Ansätzen? Ich glaub die haben wir vorhin schon so n bisschen aufgedröselt, aber vielleicht noch mal so en Detail: Ich habe hier mal so n paar Beispiele, automatisierte Verkehrsüberwachung, intelligentes Verkehrsmonitoring, Simulation und Modellierung, das sind jetzt eher so die Erhebungsmethoden und ganz konkrete Tools und Werkzeuge, vielleicht aber auch noch mal gerne auch auf der Metaebene, was stärker ist.

00:16:54 Matthias Heßkamp

Ja, ich finde, wenn smarte Technologien, ist kein Vorwurf, aber häufig, wenn, wenn sie wieder nicht in den größeren Kontext gebracht werden, sondern per se irgendwie smart sind, aber das Ziel nicht genau definiert ist. Ne, also es gibt so schöne Beispiele eines was du genannt: Dass man da sagt, da ist gar nicht so viel Verkehr, wir brauchen keine 3 Fahrbahnen, man kann es auch reduzieren auf 2, aber da geht man ja auch schon wieder davon aus, dass wir erst mal schauen, was steht in der StVO der Verkehr muss rollen. Ja, wunderbar, dann kommen wir ja eins abzwacken. Aber wenn er nicht rollt, dann brauchen wir wieder 3. Ja, und dann ist diese smarte Technologie eigentlich wieder ein Hilfsmittel, um einem Problem entgegenzukommen, ne? Das heißt: Du weißt was ich meine. Das ist dann die Kritik aber, dass wir tatsächlich ja die Zahlen hinlänglich bekannt, da irgendwie das Auto 23,2[h] steht und von diesen 40 Minuten die es fährt, steht es 20 Minuten im Stau und die anderen 20 Minuten sucht man verzweifelt einen Parkplatz und haben dann noch 20 [Minuten] über. Und warum suchen wir dann und fahren wir denn wie die Berserker da um Blocks und suchen, das ist natürlich alles absurd in diesem Jahrhundert und jeder weiß, was ich jetzt gerade mache, dass ich jetzt hier Hin und Hergehe und das beobachte und dass man das nicht zusammenführt und sagt: Es muss nicht mehr sein. Also die Gefahr ist grundsätzlich, dass wir uns nicht verlieren. Das sorgt dafür Monitoring und dann bleibt noch was über wunderbar für den. Es muss noch stärker also angewährt werden, um radikal diesen Shift der gerechten, sozialen Umverteilung zu genügen und nicht nur als Mittel zum ‚Was-bleibt-da-über' Zweck. Das hab ich jetzt gerade so spontan erfunden, aber das glaube ich, wäre meine Kritik. Und da smart ist nur dann, wenn man ganz viele verquickt und nicht nur das Monitoring des Verkehrs, das zusammen denken mit naja, diese Leute haben gerade auf der Straße ein Problem. Hinzugehen? Warum kann denn das nicht irgendwie besser beobachtet werden? Wer bewegt sich durch die ganze Stadt. Und hakelt an jeder Stelle und manchmal gibt es Interviews und das war es

dann auch schon. Dass wünschte ich mir viel stärker zu evidenzieren.

00:19:27 Jonas Merbeth

Das ist, das ist quasi auch der Punkt, sozusagen, wo es, wo es am meisten hakt, ne, weil wir, weil wir sind immer in dem Modus, dass wir, wenn ich das jetzt richtig verstanden hab, nur aktuelle Probleme sozusagen anzugehen, indem wir es Monitoren, Analysieren, anstatt noch proaktiver in den radikalen Shift zu erzwecken.

00:19:49 Matthias Heßkamp

Ich denke, ich will ja, dass die Stadt so sich umstrukturiert, dass sie den Bedarfen der Menschen (Sozialwissen ist ja ein weiter Begriff) wirklich entspricht und ich sage das Auto per se ist nicht schlecht, es gibt Fälle, ja, na ja, so ne Feuerwehr wünsch ich mir auch ne Überholspur. Und möge nicht an in so nem Handkarren durch die Gegend fahren. Find ich nicht richtig. Es gibt auch Personen, die, na ja, die, die tatsächlich in so n Bus hochsteigen und lange können sie dann auch irgendwie nicht, außer ja, da gibt's so viele Fälle. Und für diese Menschen, also das Auto ist ne großartige Erfindung. Das Automobil. Welch ein Traum, ja, aber das wir uns das nicht leisten können, wissen wir seit 2000 1960 ja, *Club of Rome*: Ressourcen sind endlich und wissen wir alles, haben wir alles im Kopf. Wollen wir aber nicht wissen. Und weil und so weiter… Aber jetzt: Wenn wir sagen, dass diese Ressourcen hat die Erde und den Leuten können wir diesen Luxus gewähren, oder Luxus Können wir im öffentlichen Raum nur so lange gewähren, dass es anderen Leuten nicht etwas wegnimmt. Dass eine eine, eine, eine Prämisse die über allem steht aber einfach so weggelogen wird.Ja, so, und wenn wir sagen: Das muss her, machen wir ein Modell, so muss die Stadt verteilt werden, dann möge die smarte Technologie helfen, diese Transformation zu ermöglichen und ich geb zu, ich rutsche mich auch gerne mal auf so ein Mietauto, wenn ich wirklich mal dringend hab und dann steht es direkt von meiner Tür. Wie wunderbar über das Telefon ist ja wirklich ne nach dem Internet die neue Revolution da. Plötzlich geht es ja in die shared economy und das ist gut. Es gab in den Flohmärkten damals auch schon. Nur das ich jetzt tatsächlich jedes mögliche Angebot mit einem der sucht, verbinden kann ne, weswegen ich das per se nicht schlecht [finde]. Zumindest da auch nicht zu große Monopole entstehen dabei, und das ist der erste Ansatz, um gerechter zu verteilen, das muss man schon auch steuern, muss ich sagen, muss man so steuern, dass tatsächlich die im Grundgesetz steht? Ja, jeder hat irgendwie das gleiche Recht auf… Ja, und darüber müsste man smarte Technologien nehmen, um das möglich zu machen. Ja und auch schmackhaft zu machen.

00:22:10 Jonas Merbeth

Ja, ja, da, da gebe ich absolut recht.

00:22:13 Matthias Heßkamp

Und nicht, dass man sagt: Ich wiederhole ich jetzt denen, die StVO ist ja sowieso gesetzt, ja und dann gucken wir mal, was überbleibt. Ja, im Grunde und dann dann nicht, wähnen wir uns in einem großen Fortschritt, der aber ein Hinterherlaufen ist. Das ist eine Problemlage, in die wir uns hinein navigiert haben.

00:22:34 Jonas Merbeth

Ja, ja, es geht ja auch nicht um das generelle Verbieten von von motorisiertem Individualverkehr, sondern zu überlegen, wie man die Ressourcen besser verteilen kann, eben durch shared economy, durch Last-mile-Ansätze, dass man vielleicht auch andere Mobilitätsformen für, für den letzten Kilometer oder die letzte Meile nutzt, anstatt die bisherigen, ja okay sehr sehr gut vorletzte Frage, sind wir schon, welche Art von Technologien und Innovation nutzt das *Radbahn Reallabor*, haben sie was?

00:23:04 Jonas Merbeth

Und ich hab dann später noch ne persönliche Frage, wie der aktuelle Stand ist. Aber das kommt später dann noch.

00:23:09 Matthias Heßkamp

Ja, schau in unserem Buch damals: Das haben wir 2017 glaub ich veröffentlicht und 2015 sind wir gestartet, sind wir die Strecke entlang gefahren derer 9 Kilometer, und haben erstmal geschaut, Ja, wer lebt hier eigentlich, wer wohnt hier eigentlich und wieviel Platz ist vorhanden und haben dann quasi für jeden Abschnitt dann eine, eine Geschichte erzählt, so wie es in unserem Ermessen ohne große Recherche besser funktioniert. Und natürlich ist uns bewusst, ja, das auf dieser Strecke es A) gefährliche ist und ja, B) wenn wir etwas sicherer machen, auch Licht benötigen. Und woher kommt denn der Strom? Der kommt natürlich dann nicht aus dem Kraftwerk und so weiter und dann haben wir gesagt, natürlich kommt das aus ganz vielen Quellen und überall ist Energie ja, überall reibt es aber es kommt von der Sonne. Natürlich, es kommt, über die die Kräfte des Windes es kann aber auch über ein Auto, was ohnehin über die Kreuzung rollt, Impulsmatte hinlegen und schon ist, dass es das Auto ohnehin produziert und womöglich wird es durch die Impulsmatte, finde ich jetzt gerade, womöglich ausgebremst leicht und die Energie kommt den anderen zugute. Da gibt es ganz viele synergetische Ansätze, um sich die Energie aus gewissen Quellen zu holen, wir haben das durchgespielt im Park Gleisdreieck, weil da hat man kein Dach gibt und kein Dach deswegen ist die Sonne da, ja das heißt an X-beliebigen Stellen gibt es unterschiedliche Quellen, wo wir Energie anzapfen können, so ein anderes Beispiel möchte ich nennen, das haben wir damals auch schon genannt, mittlerweile ist man da schon weiter. Das erste Mal auf den Tisch gebracht. Ich glaube ja, jetzt möchte ich das Pferd aufzäumen über: Wwarum verhalten sich Menschen wie, warum werden sich in Autos anders, in einer Kapsel und wenn ich exponiert auf der Straße stehe, ja, das ist so, diese Psychologie, die dahintersteckt, darum will ich aber nicht hinaus, ich will darauf hinaus, dass uns mir es oft so geht, ich verstehe nicht, Ich verstehe nicht, was die Anzeigen mit mir machen, die sind irgendwo programmiert worden aus irgendeinem Grund ist nämlich bei der Ampel warum weiß ich denn nicht, wann die Ampel umspringt? Nein, die springt irgendwie um und manchmal kennen wir doch alle, ja, man wartet die erst in 15 Sekunden und nicht nächsten ist man nervös und nach 45 Sekunden ist erwiesen 40 sag mal ich: Du kannst mich mal, ich geh jetzt d rüber. Aber was in dir passiert ist in diesen 40 Sekunden ist ist eine gefühlsmäßig ist so dermaßen viel passiert von: Jetzt reichts mir aber, Stress, und dann renn ich da rüber und guck nicht mal nach links und rechts und da passiert es schon und der ganze Tag ist anders und die Gesundheit und ähnliches. Worauf ich hinaus will, ist, dass Menschen das ja immer so? Ja, brauchen wir keine Technologie, wenn man informiert wurde. Ich werde heute das und so und verstehst du und dann, dann fühle ich mich sicher, ich fühle mich gehört und wer an einem kleinen Beispiel exerzieren wir durch, als wäre es denn, zumindest wenn die Ampel dir nicht an der Ampel sagt, wie lange es noch dauert, dann warte ich ja schon aber vorher schon mal sagt: Hold on, Hold on, fahren wir langsamer: Kommst du völlig entspannt an und hast aber diesen Stress nicht gehabt. Es führt irgendwie dazu, dass du an Ampeln miteinander sprichst statt irgendwie auch auf blödes, großes Licht zu schauen. Also wir haben da ein eine kleine Technologie, die wir da entwickelt haben mit der TU zusammen. Die weiß einfach wann die Ampel umspringt, kleine Sender und schickt diese Daten dann an einen Signalgeber, aber dann im schnell 30 Meter, bevor man die Kreuzung oder 60 Meter vor und sagt schonmal: Jetzt nicht in Sekunden, wie es früher mal so gedacht habe, wie man sich verhalten möge, das macht man intuitiv spät. Intuitiv. Das wünsche ich mir ja, ist das nicht alles, das möge man machen, ohne viel nachzudenken, es führt aber dazu, dass man tatsächlich end-stresster also befreiter durch die Stadt geht es ist nur ein kleines Beispiel.

00:27:07 Jonas Merbeth

Da da, ja, da gibt es, da fällt mir direkt Fiets-flow aus den Niederlanden ein.

00:27:25 Matthias Heßkamp

Die nennen das Fiets-flow, ja.

00:27:26 Jonas Merbeth

Ja, was mit mit? Ich glaube Hase, Schnecke und…

00:27:30 Matthias Heßkamp

Genau. Das hab‘ ich auch mal gesehen ne wir nennen es jetzt Radflow in unserem Fall? Ja, das ist alles irgendwie das gleiche, ne.

00:27:36 Jonas Merbeth

Genau geht es geht in die gleiche Richtung und sorgt eigentlich dafür, dass man sich als als als Radfahrer oder Radfahrerin etwas befreiter durch den Verkehr bewegen kann. Nicht immer anhalten und und warten muss.

00:27:47 Matthias Heßkamp

Da gibt es auch sowas wie was weiß ich in dem Moment wo es regnet oder was haben dann haben die Radfahrer wieder mehr Prioritäten, bin ich auch wieder skeptisch, warum denn nur wenn es regnet ist. Ja warum sind die Radfahrer, eigentlich in ihrer Programmierung immer eher die weniger egal. Aber das ist so eine kleine Technologie, aber ich auch eine andere finde ich smart, ohne dass sie mit viel Computertechnologie auskommen muss. Wir haben viel Wasser oberhalb des Viaduktes. Darum regnet es hier rein und unten drunter ist nichts und dann kann man nichts wachsen. Unser Projekt ist übrigens, er hat ein Shift bekommen, es viel weniger Radweg geworden ist vielmehr ein ein genau ein Projekt was den Boden entsiegelt, auflockern, begrünen, um dieser ganzen Thematik, die schon hinlänglich bekannt ist, Städte nicht versiegeln, sondern entsiegelt, um das Klima und so weiter und das testen wir in unterschiedlichsten Varianten gar nicht so sehr, dass das Wasser in die Erde, sondern, lass es gleich kurz in die Erde, sperre es aber, damit es dann über die Verdunstung wieder ein Mikroklima erzeugt, ja.

00:28:56 Jonas Merbeth

Ja, verstehe ich.

00:28:58 Matthias Heßkamp

Und das testen wir in 6 unterschiedlichen Varianten, wir wollen es dann wirklich später auch überprüfen. Wem hat es gutgetan? Welchem Tier? Ist es wirklich messbar? Ist es dort besser geworden, aber wir sorgen auch dafür, das Wasser was von oben in die Kanalisation gerät, muss irgendwie übers Dreckswasser, weil es Abwasser ist. Wir haben es abgezapft. Jetzt wurde er jetzt analysiert, auf Schadstoffe ist heftig, wie beschädigt das Wasser, aber wir denken, dass die Natur da smart genug ist. Schickt man das mal durch gewisse Schilfbeete und andere Pflanzen. Und nicht alles smarte liegt überhaupt in der Natur vor, kommen wir nie hin, ja, und die sorgt schon dafür, dass das Wasser soweit vollgefiltert wäre., dass es dann den anderen normalen Pflanzen Genüge tun würde. So und das finde ich smart.

00:29:47 Jonas Merbeth

Smart? Ja, das ist auch genau dann der smarte Ansatz und der geht es gar nicht nur um die reine Verwendung von einer Technologie, sondern eher um die zum Beispiel Nutzung von Ressourcen, in dem Fall Wasser für mehrere verschiedene Zwecke.

00:30:01 Matthias Heßkamp

Die Menschen können dann entdecken, dass diese Pflanzen da diese Kapazität haben und das bringt man zusammen mit einem Problem und dann ist es smart. Das wir da von der Natur lernen können, das muss ich jetzt auch nicht, glaub‘ ich, zweimal sagen, das ist ja so dermaßen offensichtlich, die sich ja immer so lange reparieren kann, solange der Mensch da nicht reinfummelt.

00:30:19 Jonas Merbeth

Genau, es wird echt meistens echt immer schlimm, wenn wenn der Mensch reinkommt.

00:30:24 Jonas Merbeth

Genau, weil es, weil du es gerade auch angesprochen hast, der der aktuelle Stand von der *Radbahn GmbH*, also ich hab‘ mir die Website lange durchgeschaut hab gesehen was hier insgesamt die Zielsetzung ist. Hab aber auch mitbekommen, dass jetzt mit der neuen Wahl leider, ich glaube von 17 Radausbauprojekten, Radinfrastrukturprojekten in Berlin

ein Großteil durch die CDU-Regierung gekippt wurde, da eher so die Frage, wie ist der aktuelle Stand?

00:30:56 Matthias Heßkamp

Na ja, das betrifft uns jetzt erstmal nicht, das ist n befördertes, gesichertes Projekt, aber wir wollen ja jetzt keine keinen Radwege, das möcht ich jetzt einmal so sagen, wir wollen ja hier im Testfeld kann man auf 200 Meter, was jetzt ganz andere Thematiken adressiert, natürlich vorgesehen war, um Schlüsse zu ziehen und dann die Empfehlung zu geben, um dort weiterzubauen. Ich glaube, realistisch betrachtet, in nächster Zeit gerade nicht so viel passieren, aber wir werden ein baldiger Kürze ein anderes Konzept, ein Weitergehendes auch präsentieren, was nochmal viel radikaler, irgendwie auf 9 Kilometern den Stadtraum umdenken würde ja. Warum? Weil im Laufe der Zeit sind viele Studien gemacht worden und die eine Studie sagt das, was du eingangs gesagt hast von 3 Spuren brauchen wir gar nicht so viele, also zum Beispiel gab eine Studie, die hatte herausgefunden, dass von diesen 4 Spuren, die wir da gerade haben, 2 gebraucht werden, um den gleichen Fluss an Autos ja, sicherzustellen. Alles andere denkt man nur im Kopf. Ich brauch sie, aber wir sind ja zu doof, wenn ein Auto in 2. Reihe steht, dann bremst man, dann schert man aus und bremst ja hinter dem Ausscherenden, der bremst so dass der andere nochmal bremst und steht alles ja, Ameisen die sind da klüger. Und deswegen ist das alles Quatsch mit den 2 Spuren. Und das ist auch schonmal, das hat mal schonmal herausgekriegt, das glaubt aber so eine Regierung jetzt vielleicht glaubt die das aber sagt, das wäre zu krass und dann wären wir. So, ja, ja. Wir reduzieren alle Spuren auf die Hälfte und fahren genauso schnell, glaubt keiner. Und deswegen gehen die da so sehr schonhaft mit den WählerInnen an, mit denen man gesprochen hat, dass man auch deren Aspekte begründet, obwohl gar nicht so viele sind, aber das hat funktioniert. Ja die Ängste und da muss ich sagen, wir bauen unser Testfeld also seit vorgestern sind die Baumaschinen unterwegs. Auf der Website ist das noch nicht präzise genug, sondern wenn man den paar Unterlagen geben mit einer Öffnung am 11. April nächsten Jahres. Nur dann können wir das auch nutzen. Ne, und das ist ein öffentliches Feld. Wir laden auch gerade ein, dort ja Veranstaltungen zu machen, kommt her, wir unterstützen euch, lasst es knallen in alle Richtungen. Und ja, da wird auch einer stehen, der wird dann zur smarten Ampel. Was sagen das Absurde ist, dass wir diese Technologie haben, die die Kreuzung, an der wir jetzt 3 Jahre arbeiten, das ist wunderbar, aber mittlerweile ist die Kreuzung gestorben, aus welche Gründen, dass möchte ich es gar nicht ausführen, das heißt, wir haben eine Anzeige, wie man über die Kreuzung kommt, ohne dass man eine Kreuzung hat. Das heißt jetzt auch gleich die Dame, die mit uns dieses Radfloader entwickelt und wir versuchen dennoch, in diesem Testfeldmodus halt nur das zu simulieren: Was wäre denn wenn, ja. Vielleicht, sagt uns diese Anzeige auch wie nett das Wetter gerade irgendwie, den Kanaren ist. Wir müssen irgendwie reagieren, aber es wird gebaut. Ja, wir bauen da was und das Probierfeld.

00:34:04 Jonas Merbeth

Ja, 200 Meter Strecke war das insgesamt ne auf dem und ich hab auch gelesen es ist ich mein es geht ja auch weit über diese Idee einer einer Radinfrastruktur hinaus, also es werden ja auch, korrigiere mich gerne, aber auch auch Stadtmöbiliar gebaut. Es wird Begrünung angedacht, es wird überlegt wie die Nutzung von Menschen da auch einwirken kann, also das ist geht ja weit über diesen ursprünglichen Gedankengang…

00:34:25 Matthias Heßkamp

Haben wir alles zusammen mit Bürgern entwickelt? Ganz zu Beginn war das eigentlich immer der der Ansatz aus hat sich da in, deswegen nenne ich es auch Feld und nicht Strecke. Strecke ist jetzt irgendwie zu linear. Wie gesagt, auch in den zukünftigen Szenarien werden wir da viel raumgreifender werden und diesen Raum der polyfunktional. Also wir denken ja einen Raum und einer polyfunktionalen Nutzung.

00:34:49 Jonas Merbeth

Ja, super gut, das waren meine Fragen eigentlich schon.

00:34:56 Jonas Merbeth

Mit den Fragen wir mal durch.