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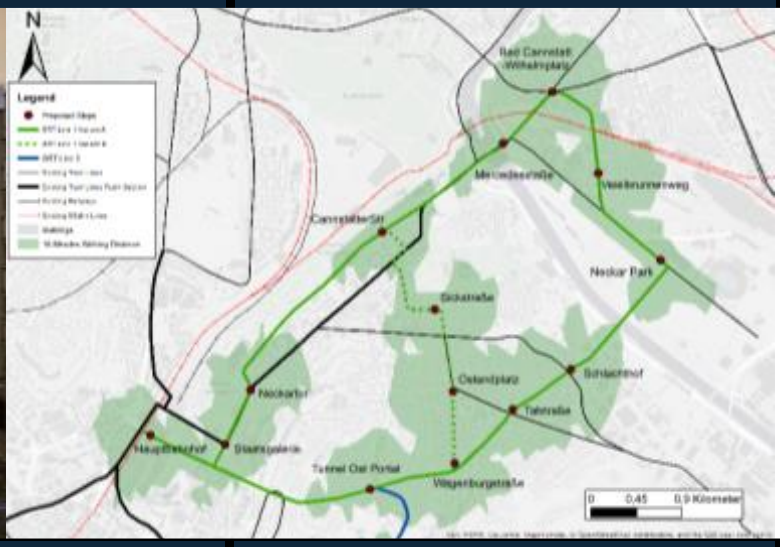
An Extensive Analysis of the Bus Rapid Transit Potentials in the City of Stuttgart



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An Extensive Analysis of the Bus Rapid Transit Potentials in the City of Stuttgart

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Abstract

The City of Stuttgart in Germany suffers from heavy air pollution and regular road congestion and resembles problems common to many major (developed) cities. These issues challenge the overall sustainability performance of the city and particularly the sustainability of the urban transportation sector. The main contributor to these problems is the high volume of car traffic in and around the city, together with a well-developed yet insufficient public transportation network. This report has assessed the potentials of Bus Rapid Transit as an alternative to the currently discussed driving bans to improve the situation in Stuttgart. The findings show that despite technical limitations, a BRT system can be a significant step towards more sustainability if intelligent measures, adapted to the urban context are applied. The main challenge is to get the numerous actors involved that are needed to bring such a project on the way, by establishing a framework that not only makes BRT a considerable alternative but also can also change negative perceptions towards the approach among these actors.

Keywords: Stuttgart**,** Bus Rapid Transit**,** sustainability, urban transport, sustainable city

Deutsche Zusammenfassung

Stuttgart ist mit seiner hohen Luftverschmutzung und regelmäßigen Staus, beispielhaft für die typischen Probleme vieler Großstädte. Diese Probleme wirken sich negativ auf die Nachhaltigkeit einer Stadt und im speziellen auf die Nachhaltigkeit im Bereich der urbanen Mobilität aus. Die Hauptauslöser für derartige Probleme ist das hohe Verkehrsaufkommen gepaart mit einem zwar gut entwickelten, aber dennoch unzureichenden Nahverkehrsnetz.
Diese Thesis hat die Potenziale von Bus Rapid Transit als Alternative zu den derzeit diskutierten Fahrverboten für Dieselfahrzeuge analysiert. Die Ergebnisse zeigen, dass BRT trotz technischer Beschränkungen, signifikant zu einer nachhaltigeren Stadt beitragen kann, sofern intelligente Maßnahmen an den urbanen Kontext angepasst werden. Die schwierigste Aufgabe besteht darin alle nötigen Akteure in ein solches Projekt zu involvieren. Dazu müssen Rahmenbedingungen geschaffen werden, die BRT nicht nur zu einer ernsthaft diskutierten Alternative machen, sondern zusätzlich Gegner des Konzeptes überzeugen können.

Stichwörter: Stuttgart, Bus Rapid Transit, Nachhaltigkeit, urbane Mobilität, nachhaltige Stadt

List of Figures & Tables

List of Abbreviations & Acronyms

ANT	Actor Network Theory
BRT	Bus Rapid Transit
BHLS	Buses with High Level of Service
BHNS	Bus á Haute Niveau de Service
BVWP	Bundesverkehrswegeplan
EU	European Union
LRT	Light Rail Transit
LUBW	Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg
NOx	Nitrous Oxides
NVP	Nahverkehrsplan
PM	Particulate Matter
RPS	Regierungspräsidium Stuttgart
RPT	Regierungspräsidium Tübingen
SSB	Stuttgarter Straßenbahnen AG
STS	Socio-Technical-System
S 21	Stuttgart 21
VRS	Verband Region Stuttgart
VVS	Verkehrs- und Tarifverbund Stuttgart

1. Introduction

The city of Stuttgart is exemplary of common problems of many large (European) developed cities (Solvang Jensen, 2014). One “regular” issue under which the population of big cities suffers, is road congestion. Stuttgart is often referred to as the “German capital of congestion”, which is proven by data stating that commuters must expect more than 50% additional time loss for their trip into and out of the city, due to congestion (Leibbrand, 2017). The city finds itself in good company among cities with similar traffic problems such as London, Barcelona, Paris, Rome, Munich and many more (Moya-Gómez/García Palomares, 2016).

Cities suffering from high car traffic and congestion face various issues. Most importantly the worsening of negative environmental, social, economic and health impacts in the form of for instance rising air and noise pollution, carbon emissions and urban sprawl all of which are considered as largely unsustainable (Newman/Kenworthy, 2015). Congestion needs to be conquered by transport solutions that can induce change in the existing system and changes in individual behavior of car users (Moya-Gómez/García Palomares, 2016). This entails that common solutions which are often based on an increase of network capacity, e.g. by adding new lanes or roads, are not sufficient and can upscale the problem to even create new issues (Litman, 2014). New and efficient approaches need to be developed and implemented to start fighting the unsustainability in the transport sector.

The second significant problem Stuttgart has in common with many other cities and that is directly linked to transportation, is air pollution. Stuttgart regularly exceeds the EU air quality limit/target values, particularly for nitrous oxides (NOx) and particulate matter (PM). The main contributor to air pollution in the city is the local traffic (RPS, 2017). Just as congestion, these air pollution issues and their sources are common to many other big cities worldwide and almost all major cities in Germany (Solvang Jensen, 2014).

A third group of common problems derives from planning mistakes for transportation infrastructure projects. These include the global principle of planning cities for cars in the 1960’s (Kühne, 1996; Newman/Kenworthy 2015), as well as short-comings in large infrastructure projects and public transportation planning, transport modelling and traffic forecast (Flyvbjerg, 2007) as they happened or happen in Stuttgart and many other cities.

A detailed analysis of the mentioned issues is provided within this report.

Despite Stuttgart’s wide network of public transportation with an extensive urban rail system, the issues are proof that the whole system does not perform in a way to induce change,

especially in individual behavior of car users, and therefore leads to unsustainable outcomes. New systematic and sustainable approaches in a city's supporting systems seem to be essential to significantly improve the situation.

Recent discussions about potential solutions have now led to the development of a concept that aims to ban the majority of diesel cars from the central city basin within the next one to three years (RPS, 2017). The improvement potentials of this approach are highly doubtable as it appears to be fighting the causes rather than the symptoms. Despite expectable difficulties with the legal transposition and other entailed issues of such a solution (Beck, personal interview) it is essential to further extend and improve public transport in the city.

With implementing a Bus Rapid Transit system in Stuttgart, a systematic and sustainable approach could be undertaken thereof.

2. Problem Area

This introductory chapter will frame the problem area around the topic of this thesis and the research questions.

The first part defines the terms sustainability, sustainable transport and sustainable city within the context of this project, before the role and potentials of public transport in planning sustainable cities is addressed. Afterwards it will be directly related to the aims of this thesis by a summary of potential effects of BRT on the overall sustainability performance of the city. Finally, the research questions and the general project approach are presented.

2.1 Defining Sustainability, Sustainable Transport and Sustainable City

The number of definitions for the above-mentioned terms is big, but in general they all go into the same direction and differences within the various definitions are minor. The aim of the following paragraphs is not to start a discussion about the numerous definitions, as this is beyond the scope of this project. Instead, the main target is to set the baseline for the use of the terms within this report.

2.1.1 Sustainability

Seen from a historical perspective the term "sustainability" derives from the agricultural/forestry sector but is now a widely-used term with an almost endless number of definitions that can be found throughout literature. Sustainability spans over a wide, interdisciplinary field of research with diverse theories and approaches, however most definitions have similar key ideas. Nonetheless it is important to point out how the term is used and defined within the framework of this thesis (The World Conservation Union, 2006).

One of the most common and most used definitions of sustainability respectively sustainable development derives from the UN Brundtland Commission (1987), defining "Sustainable *development [as a] development that meets the needs of the present [generations] without compromising the ability of future generations to meet their own needs".* This definition builds the basis for many other definitions of sustainability that can be found today. Moreover, this definition is also the starting point of more specific research fields, most importantly in this context: sustainable transport and sustainable cities.

In recent years, the rather broad Brundtland definition was concretized through a three-bottom-line framework built up on three pillars: social, environmental and economic sustainability (Litman, 2016). Describing sustainability with these three pillars has become common practice. Hence in this project, when discussing the role of BRT for improving the sustainability performance of Stuttgart's transportation infrastructure and the overall sustainability of the city, the Brundtland definition including the three pillars of sustainability will provide the baseline.

2.1.2 Sustainable Transport

This thesis specifically addresses transportation issues and the potentials to improve the sustainability performance of Stuttgart's public transport with the help of BRT. It is therefore necessary to clarify how "sustainable transport" is defined here.

Black (2010) provided a definition for sustainable transportation systems, which is an adaptation of the Brundtland definition of sustainable development by proposing that "*[sustainable transportation] satisfies the current transportation and mobility needs without compromising the ability of future generations to meet those needs".* Again, this has a rather broad perspective and for the use in this project a more specific definition seems reasonable. Hence, the definition by the European Commission gives a more detailed overview of what

sustainable urban transportation should include. According to the EC, sustainable urban transport…

- Is accessible for all users and meets their basic mobility needs
- Guides a balanced development and prevents sprawl
- Limits inequality in access to transportation for the poor
- Integrates other modes of transport into the network
- Optimizes cost effectiveness and efficiency
- Enhances attractiveness of urban environment, quality of life and health
- Improves traffic safety
- Reduces pollution and energy consumption

(European Commission, 2013)

The above-mentioned definition acts as the baseline for the evaluation of sustainable transportation and the case of BRT in Stuttgart. It is further enhanced by the Centre for Sustainable Transportation's definition which considers the three pillars of sustainability by outlining the following key elements of sustainable transportation:

- It allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations (social sustainability)
- It is affordable, operates efficiently, offers choice of transportation mode, and supports a vibrant economy (economic sustainability)
- It limits emissions and waste within the planet's ability to absorb them, minimizes consumption of nonrenewable resources, limits consumption of renewable resources, reuses and recycles its components, minimizes the use of land and the production of noise (environmental sustainability)

(The Centre for Sustainable Transportation, 2002)

Aspects of both approaches will be used, to analyze and evaluate the current transportation infrastructure as well as the sustainability improvements that could derive from a BRT system in Stuttgart.

2.1.3 Sustainable City

Finally, it needs to be clarified what defines a sustainable city. According to the UN Habitat (2009) sustainable cities should be environmentally safe, socially inclusive and economically

productive. For achieving these targets, it is essential to cover environmental management objectives and human or built environment objectives which ensure that basic human needs can be met. Again, this definition leaves room for various interpretations, but also builds upon the common definitions with the three-pillar approach and provides a good first insight in the concept and definition of sustainable cities. A commonly used definition within the M.Sc. Sustainable Cities studies describes that planning for sustainable cities means “creating cities and societies that make it possible to live within the limits of nature and ecosystems and at the same time provide for fair, equal/just and “liveable” living conditions for all people – now and in the future” (Haunstrup Christensen, 2015). In contrast to the UN definition the latter includes the important aspect of maintaining liveable conditions for future generations.

However, both definitions leave room for interpretation and it is difficult to decide on one common definition for the sustainable city. One could argument that a truly sustainably needs to perform well in all three pillars and all aspects of sustainability, but still there is no existing rule on where to draw the line at which point a city can be labelled as (truly) sustainable. In some cities the situation can be so bad, that the main task is not making them a sustainable city, but take a starting point in trying to reduce the unsustainability. Taking this into account it is important to focus on the context of the individual cases respectively cities.

With regard to Stuttgart, it has to be clarified that the mere installation of BRT will not make Stuttgart an overall sustainable city. Nonetheless, it can improve or initiate certain aspects that are crucial for sustainable cities, in this case particularly related to transportation issues, and contribute to a more sustainable development within the framework of other entailed measures in different sectors.

2.2 The Role of Public Transport in Planning Sustainable Cities

When naming key components of planning and building sustainable cities, transportation in general and public transportation in specific often appears as such a key component. This entails that the environmental, social and economic impacts of urban transport are seen as critical and challenging issues to the sustainability of cities (Miller et al., 2016). Transport can equally have positive and negative impacts for the sustainability performance of urban areas, which can also be seen in the case of Stuttgart. Accordingly, an effective and sustainable transportation network is essential for developing and planning sustainable cities. Recent definitions and interpretations of sustainable urban planning and development mostly include

the requirement of reducing private car use and the associated improvement of public transport service quality (Susnienė, 2012).

From an environmental perspective, the most sustainable modes of urban transportation are walking and cycling. However, public transportation should be the backbone of a developed city's transportation system and is essential for the quality of urban life. Efficient public transportation systems can contribute towards sustainability in many ways. They can for instance contribute to reduction of emissions, air pollution and energy use, less congestion, decrease of urban sprawl, travel time savings, increased accessibility for a broad range of inhabitants, money savings, promotion of economic development or boost of land values. (European Commission, 2013).

The analysis of a city's current (public) transportation infrastructure can help identifying issues and inefficiencies and discover improvement potentials (Susnienė, 2012). For bringing forward potential improvements it is significant to sensibly select technologies and appropriate ways to deal with the current and future problems and to tailor a system to the urban context and transportation needs (Hensher, 2006).

2.3 What can BRT do to make Stuttgart more Sustainable?

Stuttgart's public transport needs to be further strengthened and new approaches are necessary to create a more sustainable city and overcome the current issues. The driving bans mentioned in the introduction appear to be a despairing reaction to the recent developments and it is highly doubtable whether this solution can really improve the situation. With fast solutions being required and further extensions of the urban rail network seen as unrealistic, a systematic approach to improve bus-based public transport seems appropriate (Sautter, personal interview). Improved bus systems could enhance public transport use, generate a modal shift, close the gap between the current city buses and urban rail, lower the pressure on both the Stadtbahn and the s-trains as well as the pressure on high-demanded roads and as a consequence have positive impacts on the traffic itself, the cities livability and the environmental quality.

A systematic approach towards bus-based public transportation is now undertaken with the development of Bus Rapid Transit (BRT). Bus Rapid Transit is a relatively new public transport solution for cities, trying to transfer the major advantages of rail-based transportation to the bus. Originally being a solution for cities in Latin America, BRT-systems are now becoming

increasingly popular in cities throughout Europe, Asia and North America. Nevertheless, especially in Germany BRT is often an unknown concept when discussing alternatives to improve the local public transport (Mejía-Dugand et al., 2013). More relevant information on BRT is provided in Chapter 4 (pp. 23 - 27).

For Stuttgart BRT can be a fast and cost-efficient solution and act as a starting point towards a more sustainable transportation infrastructure and a more sustainable city overall. In this context, it is important to mention that a BRT system cannot and should not be a substitution for Stuttgart's urban rail system, but it should meet the requirements and achieve the quality to be a real supplement to it (see Chapter 8 and 9, pp. 59 – 72 for details).

2.4 Research Questions

The aim of this project is to assess how a BRT can contribute to a more sustainable city of Stuttgart by answering the following **research questions**:

Are there potentials for BRT in Stuttgart and how can it improve the city's sustainability performance?

Sub-questions:

What needs to be done and who needs to be involved in the project?

How could a potential BRT for Stuttgart look like?

After explaining the methodology and use of theory in this thesis, an introduction to the city itself and the concept of BRT will follow. A two-part analysis will then be conducted. With the Actor-Network-Theory (ANT) as theoretical background it will be assessed what needs to be done and who needs to be involved in a potential BRT project. An extensive analysis of the current transportation infrastructure will then outline the potentials and problems in detail. As a final step, a rough BRT concept for Stuttgart will give an outlook on how such a system could look like under consideration of the local urban context and moreover build a solid base for further development of an in-detail BRT concept.

3. Methodology and Theories

This chapter aims to give an overview of the general project design, the methodology and the theoretical background. First the overall structure and the project design will be explained, before the various methods of data collection are presented. Finally, the use of geographic information systems (GIS) within this thesis will be addressed and the Actor-Network-Theory as theoretical background discussed.

3.1 Project Layout

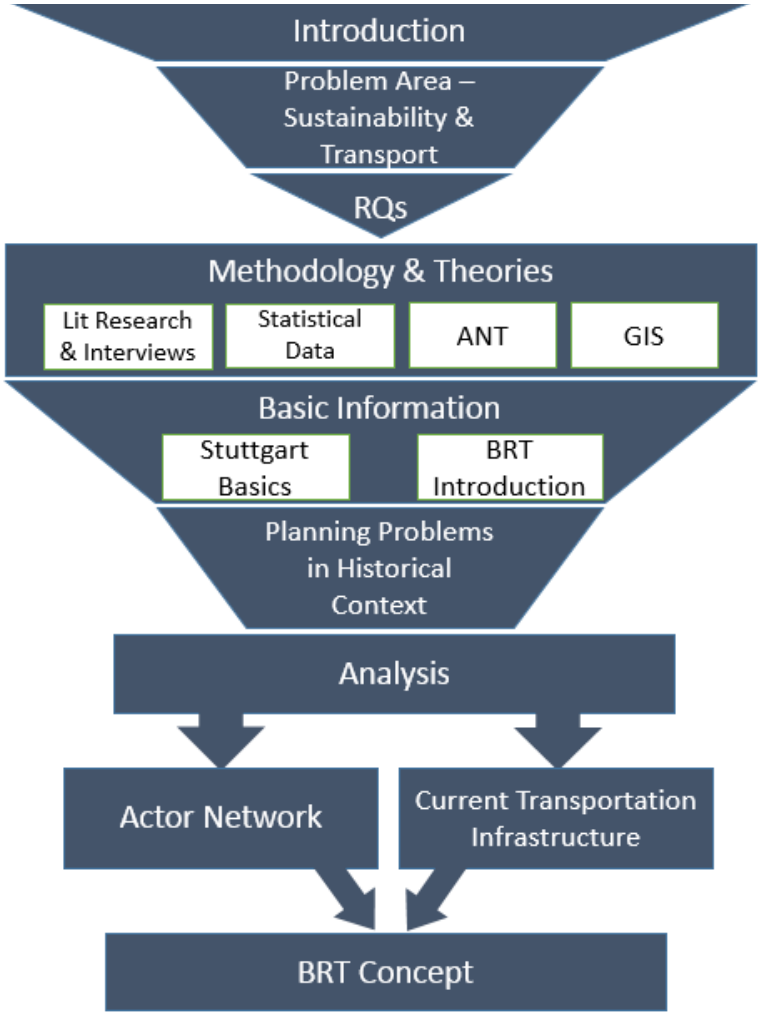

Figure 1: Project design

In the project layout above, it is illustrated that a two-way approach is chosen for the analysis and in addition to that a rough BRT concept for Stuttgart is developed. All three approaches can inform each other. The concept is the most practical approach within this thesis, but is

also an important factor in the ANT Analysis. The current transportation infrastructure analysis is the foundation for the conceptualization, highlights the benefits or improvements that can come with a BRT and puts light on the current (infrastructural) problems. The ANT Analysis is conducted to understand the situation, its complexities and the different perceptions among the actors in Stuttgart towards a BRT and can help to determine what needs to be done to have a BRT planned, built and operating in Stuttgart.

3.2 Mixed Method Research Design

In the first place the decision to conduct a study about Stuttgart was made, because the case of Stuttgart is a relevant, current and interesting example for a city with big problems due to its unsustainable transportation infrastructure, as it is presented in the introductory parts to this paper. The general research design of this thesis can be categorized as a mixed method research design which includes both qualitative and quantitative methods and both theoretical and practical approaches. It is crucial to mix both methods for this project as especially the two distinct parts of analysis demand different ways of research and data collection. Whereas the actor network needs a more qualitative approach, the status quo analysis also needs a solid base built up on quantitative data. All in all, conventional approaches from case studies are merged with a more action-based concept (Hesse-Biber, 2010).

Case studies enable the researcher to explore a certain case and get in depth information on the specific issues (Baxter & Jack, 2008). Case studies can be conducted on individuals, organizations, communities, events, cities and many others. Therefore, they allow to collect comprehensible data from different sources and examine the case in detail, but also to identify significant challenges and reveal complexities which can then be used to propose potential solutions (Neale et al., 2006). All of this will be beneficial for examining the situation in Stuttgart, because comprehensive, specified data is needed to inform the analysis and the BRT concept. Nonetheless a case study also has its limitations, especially because of its descriptive character and its lack of generalizability (Yin, 2003).

In the last chapters, this thesis will go beyond the descriptive nature of a case study, especially by analyzing the actor network and by developing a BRT rough concept for the city. This will add a more practical part to the project with the main aim to improve the situation and induce

change. Theory and practice is connected. Both of which are defining characteristics for an action research approach (Costello, 2011).

Generalizability of the results of this project is only partly given, mainly because such a project can be very dependent on the respective (urban) context. Therefore, it is not the main aim to achieve generalizability, however it will not be precluded that findings of this project can be adapted to other areas with similar structures and problems (see Chapter 2.3, pp. 11 - 12).

3.3 Literature Research and Data Collection

This section describes the methods and sources of data collection used within this report. As previously described both quantitative and qualitative data is used within this project. This data is derived from different sources, the three most important being scientific literature in the form of books and journal articles, official statistics and own interviews (see 3.4, pp. 19-20). Available data is filtered to match the scope and context of the project. Most of the general literature was discovered by searching specific topics such as “Bus Rapid Transit”, “sustainability of public transport” or “Actor Network Theory in transportation planning” in the common databanks like Scopus, or the university library. Statistics and planning documents where specifically searched at the official websites of planning departments and statistical institutions in Stuttgart and Baden-Württemberg.

Most of the information gathered from literature research is used to form the background of this project and feed the introductory parts, the theoretical and methodological approach, the basic information chapters on Stuttgart and BRT, as well as the “Role of Public Transport for Sustainable Cities” chapter. All sources of data used for the report were selected, while considering the criteria of information validity and quality. Thus, in this thesis scientific articles and books written by professionals in relevant domains or official reports, plans and analyses e.g. of governmental institutions or public transport providers were used.

To get an insight in recent discussions and the political sentiment around relevant transportation topics in Stuttgart, local newspapers and news websites can be a helpful source of information. Although they are not a valid source of scientific information in the usual sense, those sources will be used with care in an appropriate manner as they allow to get insight in current topics that can hardly be found elsewhere.

Besides literature research, the collection of statistical data is crucial to meet the scope of this project and is the main source of quantitative data. Traffic data for example commutes, traffic

counts or public transport demand is mostly obtained from official statistics. The most common sources are statistical bureaus on national, federal, regional or municipal level. All of them can be expected to be as valid and reliable as possible. Other potential sources are local planning authorities or public transport operators. Information that could play a role for a potential BRT concept for example road widths etc., is either obtained through observations in the field or with the help of GIS (see Chapters 3.5 & 3.6)

Additionally, internal information of the EvoBus GmbH on past approaches on bus-based transportation in Stuttgart is used for different purposes, among others to get an overview over the operational landscape of public transport in Stuttgart and to detect potential contact persons or institutions. Own expertise regarding potential routing of BRT lanes and design of stations further backs up the project.

All in all, credibility and validity is reached by cross-checking (data) sources where possible. The use of interviews is addressed in the following section.

3.4 Interviews

In interviews conducted for scientific research, knowledge is generated through the interaction between the interviewer and the interviewee(s). Interviews enable the researcher to get in-depth insight in certain topics that for instance literature research cannot provide to that degree. When researching recent developments, it can often be difficult to find literature for this exact context, whereas interviews can help gathering this information. Furthermore, local experts have more expertise and knowledge about the studied case than a researcher from "outside". "Informal" or off-record information can be gathered – even the way a person talks can give insights regarding their perception towards a specific topic. Another advantage is that spontaneous answers as they often occur in face-to-face interviews, are generally more honest (Kvale/Brinkmann, 2009).

Despite the advantages, face-to-face interviews also have their limitations. Especially in unstructured or semi-structured interviews the interviewer needs to formulate questions in direct conversation, as a reaction to the interviewees answers. If not done right this can lead to a loss of important information, which also occurs when the interviewer does not intervene when it becomes necessary. Credibility can be an issue; may it be because the interviewee is biased or because the interviewer tries to guide the interview in a certain direction to support

his own assumptions or perceptions. Hence, a certain amount of training is necessary on side of the interviewer to ensure good quality interviews and to gather helpful and relevant information. Last but not least, interviews are very time consuming. Possible interviewees need to be searched and contacted, appointments made and trips conducted to get to them. After the interview the process of listening to the record as well as summarizing/transcribing, if indispensable translating and analyzing the interview again takes considerable time (Opendakker, 2006).

Within the project several interviews have been conducted with two main overarching aims. Firstly, the interviews should form a solid base of primary data for the empirical research and analysis. Secondly, the interviews are the primary source for the analysis of an actor-network formed for a potential BRT system in Stuttgart. In context of the ANT Analysis (Chapter 6) interviews can be great help for determining different perceptions and misalignment between the actors. It has been tried to reach an understanding of the complexity of challenges associated with the problem formulation.

The interviews have been conducted with local experts mainly involved in transportation planning or public transport operation. As the baseline a semi-structured interview design was used and the interview guides were created accordingly (see Appendix B). The comparably open design of a semi-structured interview was chosen to enable the interviewees to paint a picture of their own without too much external influence from the questions or the interviewer himself. Nonetheless, interview guides had to be prepared in order to appear structured and trustworthy and to ensure that the most important questions are asked (Kvale/Brinkmann, 2009). Interviewees were also asked for their own perceptions on possible solutions to the problem, which is also framed in the context of the theoretical background.

The interview guides for each interview were adapted to the respective interviewee and their professional backgrounds. However, it was important to pose the same or similar questions to different people as contrast between different sources is the main methodological strategy in Actor Network Theory. For this reasons, it has been tried to keep the adaptations and changes to the interviews as small as possible. In addition to that, field notes from “informal conversation” and small talk complemented the questions to better spot divergence. None of the informants knew the questions in advance, which gave the opportunity to get the immediate reactions on the subject (Kvale/Brinkmann, 2009).

Within one or two days after each interview, the interviews were carefully summarized from the recorded audio files as well as from the "off-record" notes to ensure that a valid scientific source is produced and no important information is missing. As all interviews have been conducted in German language, the summary writing included the translation to English.

Interviews were conducted with Mr. Nicolas Leyva and Mr. Wolfgang Forderer from the City of Stuttgart's Transportation Planning Department (see Appendix B. I), Mr. Peter Sautter from IGV Stuttgart, a private transportation planning bureau based in Stuttgart (see Appendix B. II), Mr. Christian Beck, head of transport division at the VRS (Verband Region Stuttgart) and specialist for bus-based public transport (see Appendix B. III) as well as with Mrs. Corinna Reik and Mr. Hans-Peter Benzing from the department of strategic planning at Stuttgart's main public transport operator Stuttgarter Straßenbahnen AG (SSB) (see Appendix B. IV).

3.5 On-site Observation

Due to the physical proximity to Stuttgart and because all interviews were carried out in the city, on-site visits and observations were made with two overarching aims. Firstly, to understand and get a personal impression of Stuttgart's infrastructure problems, secondly to obtain relevant data or pictures, especially about the local (public) transport infrastructure that could later be helpful for the conceptualization of the BRT system. For this project, Stuttgart was visited multiple times and whenever possible the traffic and public transport situation was observed.

Observations can be a good method for gathering up-to-date data and information. An own impression can be created without the need to rely on other sources and the observation situation is less "artificial" than for example an interview situation. Additionally, observations can help to verify information retrieved from other sources (Diekmann, 2007).

Nonetheless, site visits and observations also have certain limitations. Depending on the context, it might become necessary to carry out observations over a longer time period, with standardized processes and continuity – otherwise they could paint a wrong picture because they are just a snapshot and do not represent the "normal" situation. Another disadvantage is the emergence of complex situations with almost endless possibilities on what to observe. Therefore, it is crucial to structure and focus the observations in a way, that they can truly inform the research (Diekmann, 2007; Meier Kruker/Rauh, 2005).

3.6 Use of ArcGIS

For parts of the analysis and the development of the BRT concept a geographic information system (GIS) software was used. Geographic information systems are a set of integrated software tools for handling, analyzing and visualizing spatial data (Castree et al., 2016). In detail, the utilized software within this project was ESRI ArcGIS with its central application "Arcmap" and the add-on "Network Analyst". The Network Analyst is an add-on tool for ESRI ArcGIS, which enables the user to do in-detail analyses of transportation networks, vehicle routing etc. and must not be confused with the Actor-Network-Theory analysis, also conducted for this project.

The main objective to use GIS was the creation of maps to visualize the current public transport infrastructure respectively the proposed BRT concept as well as to analyze the accessibility of the proposed BRT stations and stops by calculating the walking distances to the stops from the surrounding areas (see Chapter 8 and Appendix D). The visualization of the concept is particularly important for presenting the results to local stakeholders as well as to help readers understand the project who are not familiar with the city of Stuttgart. Moreover, it was used to measure certain distances and road widths where it was necessary, to determine which infrastructure option could be feasible. All the required spatial data was either directly obtained from ESRI or from reliable open sources, such as the Geofabrik GmbH (www.geofabrik.de), a renowned provider of regularly updated open street map data converted for direct use in GIS software. For the use in this project and the main purpose of visualizing it was sufficient to focus on basic features of GIS for the rough BRT concept.

ArcGIS has a vast toolbox of more than 30.000 thousand tools for analyzing spatial data and the analysis possibilities of the software go far beyond of what it has been used for here. However, the huge capabilities can also be a limitation, because consequently the software becomes highly complex and even simple task are dependent on many parameters that need to be aligned. This is not only time consuming, but also opens room for mistakes.

3.7 Actor Network Theory

The Actor-Network-Theory (ANT) forms the theoretical background for one of the fundamental analysis sections within this project. The theory is used to help answer the question on what needs to be done to install a BRT system in Stuttgart. It should help to determine which actors are or need to be involved and in what way, who is in favor or against such a project and why, who is championing the project, who could be in the lead of putting it forward and where conflicts or misalignment can be detected. ANT gives a good framework for understanding these dynamics, and will help analyzing the situation in Stuttgart, the local issues and the chances of a possible BRT system. Moreover, ANT can provide the theoretical background for better understanding the complex, multidimensional and adaptable nature of a city (Ruming et al., 2016).

ANT is a socio-scientific resp. sociological approach developed and advanced by the French sociologists Michel Callon and Bruno Latour as well as the British scientist John Law. The theory finds its roots in the "Science and Technology Studies" from the early 1980's (Kneer, 2009). In "The Sociology of an Actor Network", Callon (1986a) introduces how heterogeneous actors can form and break relations and explains coevolution between technology and social relations through the main concepts of ANT: Actor Networks and Translation. The main difference of this relatively new approach compared to all other sociological theories is the heterogeneity of actors. Society, nature and technology are not defined as single entities and besides human beings, natural or artificial objects like animals, plants, roads, cars etc. can be actors too. Human actors as well as artifacts can possibly have the same level of influence (Callon, 1986a). However, this does include that all entities get allocated the same discretions to act or that humans are converted into objects or the other way round. Rather it should provide an alternative to the usual diversion of objects and subjects (Kneer, 2009). There is also no pre-given hierarchy of the actors, but the differences in influence between actors comes through the process of translation, which will be explained later in this chapter (Callon, 1986a). In ANT an actor is defined as a unit which is provoked to act by many others (Latour, 2007). With regard to the context of urban and transportation planning, ANT allows to examine the complexity of interactions between the actors and the outcomes of those interactions which can often be a kind of compromise of intended and desired or unintended and undesired plans, solutions and outcomes (Rydin, 2010).

Planners, in this context practicing in urban and transportation planning, are often limited in carrying out their work. They have to deal with a number of constraints deriving from institutional, social and urban contexts, a combination of (differing) interests, personal and professional connections and many more. ANT can help to understand these obstacles and various suggestions to overcome these, can be deduced thereby (Rydin, 2013).

3.7.1 Socio-Technical-Systems

In the introductory part above it hast been disclosed that ANT finds its roots in the so-called "Science and Technology Studies". A common concept of these studies is the "Socio-Technical-System". This concept is directly connected to ANT and for that reason needs to be briefly explained beforehand.

As the name indicates, socio-technical systems are the combination of physical/technical and social elements. They are inter-related combinations of one or more technologies, legislative and market frameworks, institutional foundations and human as well as non-human actors or actants (Ruming et al., 2016). This also indicates that on one hand technologies are mostly socially constructed where on the other hand technology as well influences social relations, culture, routines etc. Technology and society are in co-evolution (Sismondo, 2010). For this project, the concept of STS together with ANT will be used to analyze and understand how the potential BRT system for Stuttgart can come into shape.

3.7.2 Actor Network(s)

As mentioned earlier the two main concepts of ANT, also for the purpose of ANT-use within this thesis are the actual "*Actor Network(s)*" and the process of "*Translation"*. The term *Actor Network* is used to describe interplay between actors, as actors do not act all own their own. Actor Network therefore serves as the theoretical definition to unite the various relations and connections between the entities or actors (Latour, 2007). Interactions and discussions create the networks and the actors are assigned to different roles, characteristics and competencies. Therefore, the process of creating an Actor-Network focuses on the composition and transformation of the relations between the actors as well as on the composition and transformation of the actors themselves. This underlines that the single actors, according to the ANT perspective, depend on all other actors and hardly have autonomous opportunities

of action, which also means that an actor cannot exist without the network. An Actor-Network can also be an actor in another network (Callon, 1986a).

3.7.3 The Process of Translation

The second crucial part of ANT is the concept of *Translation*. An ANT approach takes its point of departure in an intervention. Keeping this in mind, Translation is the process of creating, negotiating and changing the Actor-Network with all its identities, relations and interactions. Furthermore, it is the process of allowing a single entity to represent the whole network and to define the roles of all actors in the network. This is not a simple or logical process, but a struggle of distinct interests and a battle of power (Callon, 1986b). Within the context of the project this means that the questions of who needs to be involved in a potential BRT for Stuttgart and in what way can be reworded into: "Who needs to be translated into the project"? According to Callon (1986b) the process of translation constitutes of four phases, namely: *Problematization, Interessement, Enrolment* and *Mobilization.* All four phases build upon the assumption that actor-networks are unstable, perhaps because of conflicting ideas or differing interests.

Problematization is the process of defining the nature of the problem in a specific situation by a single actor (a group or an individual), the definition of potential actors involved or affected by the problem and the consequential establishment of identities and links between the actors. In other words, problematization means pointing out a problem that is either shared, where there is a shared concern for or to simply create a "common enemy". With the help of this process, alliances among the actors can be formed. Even if there will be different understanding of translated roles and conflicting interests in an actor-network, a certain degree of agreement needs to exist (Callon, 1986b).

Interessement describes the phase of mobilizing allies, gain their attention and seed interest for the specification or potential redefinition of the problem as well as for a proposed problem-solving approach. A certain entity tries to stabilize an actor-network and the roles of the actors and its alliances that have been defined through the problematization. It remains open how this is tried to be achieved (Callon, 1986b).

The third phase of *Enrolment* is decisive on whether the actors accept their proposed and assigned roles or not. The main method for enrolling the actors are multilateral negotiations with the task to lower resistance and raise acceptance (Callon, 1986b).

Mobilization is the final stage of the translation process. Through mobilization it is ensured that the actor(s) who represent and speak for the collective are properly representative. Moreover, does it mean that if the process of translation was successful, the assigned roles of actors within the network are accepted and that active support for the proposed programme of action is provided. The result should be a stable actor-network. However, this result is not always final – to ensure a long-term realization it might become necessary to extend the network through recruitment of new entities or formation of different alliances (Callon, 1986b; Kneer, 2009).

3.7.4 Summary

It is important to mention, that the Actor-Network-Theory goes far beyond this rather brief description above. However, due to constraints in time and size of this thesis and the two-way approach chosen for the analysis, the focus is on the most important points of the theory and those theoretical aspects that are considered most helpful for answering the research questions. In fact, that means that the ANT is adapted to the context of this project and narrowed down to its central aspects. Particularly the process of translation with its four phases will form the theoretical background for part one of the analysis (see Chapter 6, pp. 31-47) It also becomes indispensable to keep the number of potential actors on a bearable amount to perform a good quality analysis. The terminology of Callon (problematization, enrollment etc.) is used where deemed necessary, but not all over the analysis as it was developed for assessing projects after they were carried out, which for the BRT in Stuttgart is not the case.

4. The European BRT Approach

This chapter has the purpose to present relevant information on BRT Systems. The typical characteristics of BRT-systems will be explained and the historical development briefly outlined. A distinction is made between BRT and standard bus based public transport systems. To fit into the context of this project the “European BRT Approach” will be explained. (Following parts 4.1 & 4.2 were already prepared in the framework of my M.Sc. Sustainable Cities 3rd semester project on BRT systems in medium-sized cities in Europe and are reused and adapted in the context of this project.)

4.1 Characteristics of BRT-systems

BRT is a mass transit concept, which tries to combine the advantages and performance of rail-transit and translate them into a bus-based system. Often a distinction is made between "Full BRT" encompassing all the characteristics listed below and BRT-systems comprising only a share of those characteristics, often referred as "BRT Lite" (Pojani/Stead, 2015). Within this thesis this differentiation will not be made, because it cannot be clearly distinguished and could therefore be misleading. As a definition in this context, systems with separate infrastructure over the majority of the total system length and at minimum two other basic BRT characteristics will be defined as BRT. *Figure 2* shows five of the basic characteristics.

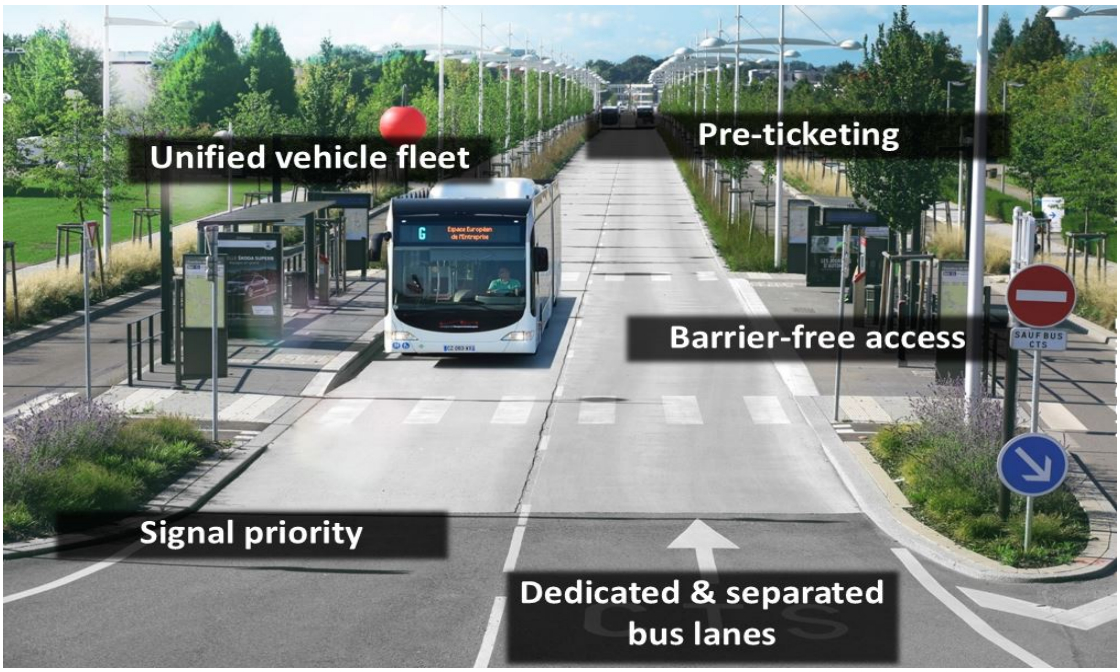

Figure 2: Basic BRT-elements (Picture source: Daimler – BRT Strasbourg)

Supplementary to the characteristics depicted above the following characteristics are exemplary for BRT-systems (based on IDTP, 2007):

- Metro-quality services (high frequency, speed etc.) through:
- Location of busways in median position (rather than on the curbside)
- Integrated network of routes and fares
- Intermodal linkage with other means of transport (Park + Ride, bike sharing etc.)
- Specially designed (closed) high quality stations that provide level access
- Modern and uniquely designed vehicles
- Marketing identity (catching name, unique logos)

- "Closed system" approach: Entry to system restricted to predetermined number of vehicles and prescribed operators
- Real time traffic and operation information; clear route maps and signage
- Special customer service
- Clean vehicle technology

4.2 BRT Systems in Europe

BRT systems are becoming increasingly popular throughout the globe. Firstly, planned and built in Latin America they have made their way to Europe in recent years (see *Figure* 3).

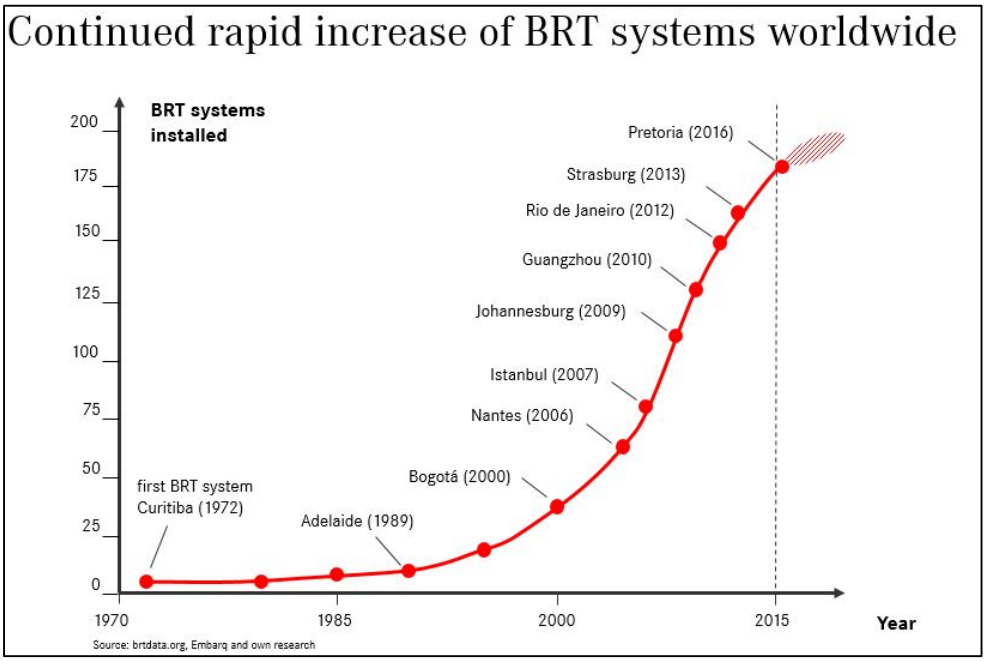

Figure 3: Increase of BRT systems worldwide (Source: Daimler AG)

The European approach towards BRT is inspired by the American approach, but adapted to the European urban context. Whereas American BRT systems offer a high-capacity metro-like service with 100 percent of separate infrastructure and feeder systems carrying passengers in smaller vehicles to the main BRT trunk line, the European approach to BRT differs. Until this day, France is the only European country covered by a "nation-wide" network of BRT systems which is why the French approach can be considered representative for the overall European development (COST, 2011).

Even though American-style BRT-systems can be found in Europe as well (e.g. in Istanbul), high-capacity configurations are generally not suitable for most dense and historically grown European cities with narrow, winding streets and a lower overall public transport demand.

Therefore, the concept of “Buses with high level of service” (BHLS) / “Bus à Haute Niveau de Service” (BHNS) emerged in Europe. BHLS combines typical components and advantages of BRT and customizes them for European needs to fill in the gap between regular bus-service and urban rail, regarding capacity, costs and demand. The focus is on delivering a fast, accessible, comfortable, convenient and overall improved bus service. Exclusive bus lanes for the BHLS vehicles are still favored, but if it is necessary for example due to space limitations, the lanes offer a certain permeability allowing regular buses, taxis or deliveries to go onto the route if the circumstances demand it. The BRT buses can also operate in mixed-traffic for shorter distances. This offers the flexibility of such systems to be installed even in dense city centers (COST, 2011). In this paper, the terms BRT and BHLS/BHNS will be used synonymous, as both system types share the same core characteristics.

4.3 The Stuttgart Approach

With regard to space limitations, the urban structure, topography and to ensure technical feasibility, the above described European approach allowing a certain degree of flexibility, for instance through mixed traffic sections, can also expected to be the guideline for a potential BRT system in Stuttgart. Dedicated infrastructure is still a significant factor for BRT to achieve its potential, yet especially in the city center but also in the metropolitan area the technology should not be the determining factor (Hensher, 2006). For European cities, around 70 percent of dedicated infrastructure is seen as feasible, while still ensuring the provision of efficient transport. (Mejía et al., 2012). Moreover, is it important to develop and offer integrated approaches that are able to provide a high level of service, with a connected network, efficient service and a certain visibility aspect (Hensher, 2006). Nonetheless is it crucial to make a clear distinction between the BRT approach conceptualized in chapter 8 (pp. 59 – 69) and standard bus-service as it is now to be found in the city and which will be analyzed in chapter 7 (pp. 47 - 58) of this thesis. This distinction is a part of the “concept section” of this project and will therefore be addressed later.

5. Basic Information about Stuttgart

In this chapter, relevant information about the urban, regional, industrial and demographic structure of the Stuttgart area is presented, together with an overview of the topographic and climatic environment. The information will not only act as an introduction to the city itself but is also directly connected to the city's infrastructure and the related problems.

5.1 Demographics, Urban and Regional Structure

The City of Stuttgart is the capital of the federal state Baden-Württemberg, located in south-west Germany (see *figure 4*) around the shores of the river Neckar. The City consists of 23 urban districts that cover an area of 207.35 km² with an overall population of 609.000 inhabitants. With a population density of 3008 inh./km² Stuttgart is ranked on position three among German cities with more than 200.000 inhabitants. With more than 66.600 inhabitants and a density of 4.440 inh./km² the urban district Bad Cannstatt is the most populous within the city area, followed by Stuttgart West and Stuttgart Ost. For the next 10 years a population growth is predicted (see also *figure 6*, p. 29) (Statistisches Bundesamt, 2016).

Figure 4: Geographic location of Stuttgart (Source: Statistisches Amt Stuttgart (n.d.); own adaptation)

The Stuttgart region, or Stuttgart Metropolitan Area consists of the City of Stuttgart and five surrounding districts with 179 communities, covering an area of 3654 km² with a population of ca. 2.7 million and a density of 750 inh./km² (*see Figure 5*). Besides the City of Stuttgart, the districts Ludwigsburg with 526.000 inhabitants and Esslingen with 516.000 inhabitants are the most populous. Furthermore 25% of the population of Baden-Württemberg live in the Stuttgart Region with an area covering only 10% of the whole federal state, proving its trans-regional significance. As for the city itself, the region expects a considerable growth of population within the next ten years (Statistisches Landesamt Baden-Württemberg, 2016).

Figure 5: Stuttgart Metropolitan Area (Source: http://www.emta.com/spip.php?article33&lang=en)

Within this project, the focus lies on the City of Stuttgart itself, however it is important to keep the regional structure in mind as it has a strong influence for instance on traffic volumes and commutes.

5.2 Topography and Climate

The geographical and climatic peculiarities are important factors for the shape of Stuttgart's infrastructure and the related problems. The core city lies in a basin with the lowest point at 207 meters above sea level, surrounded by hills with an elevation of up to 549 meters above sea level (see *figure 6*, p. 29). This elevation difference of more than 300 meters is very unusual for German major cities and entails certain problems.

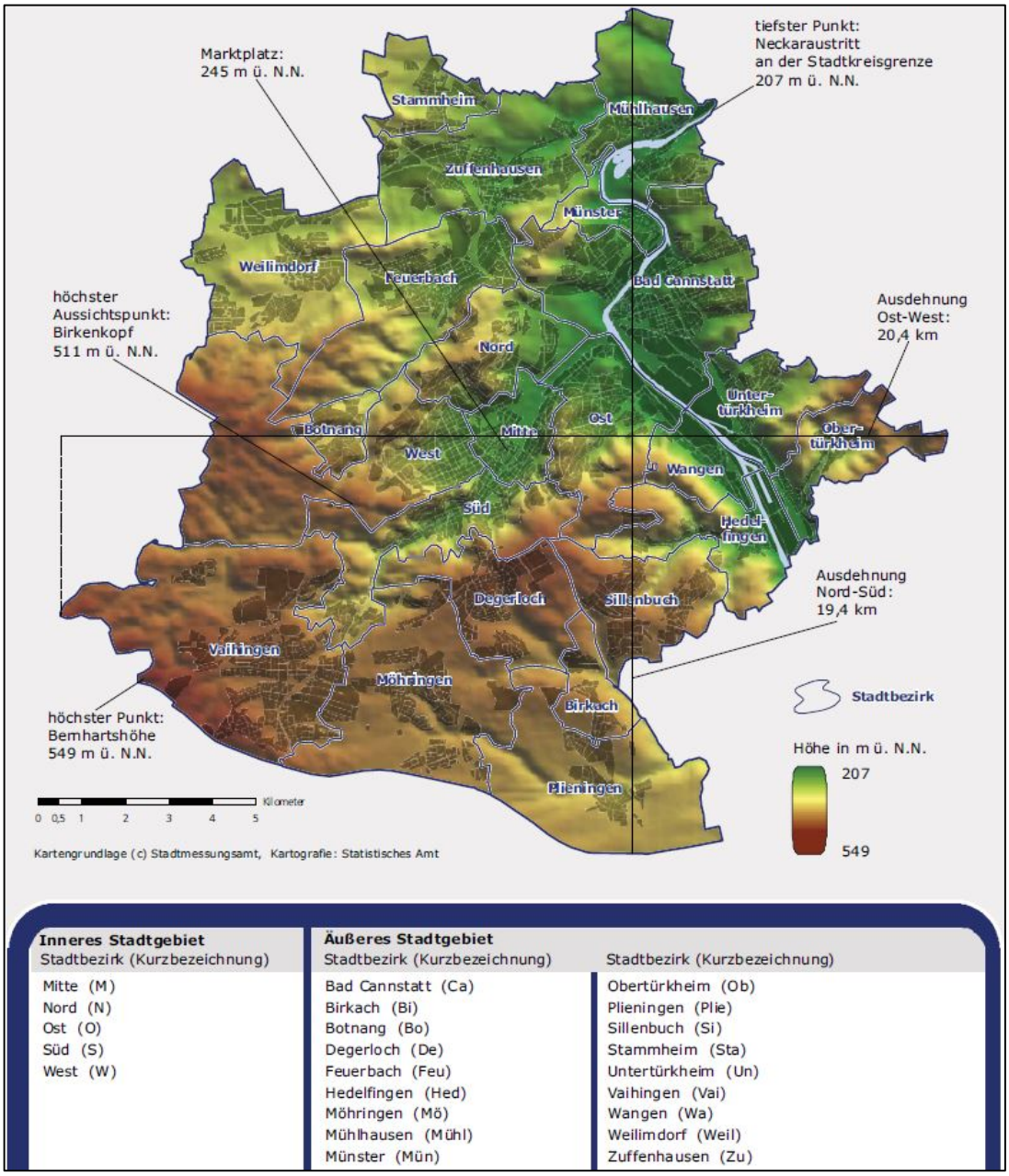

Figure 6: Topography and urban districts (Source: Statistisches Amt Stuttgart (n.d))

Above all the location in a basin means that certain spatial restrictions are given. The construction of urban infrastructure of all forms is easier on a flat surface, which in the case of Stuttgart results in a particularly strong concentration of urban and even regional infrastructure including roads and railways in the dense city center (Sautter, personal interview).

Compared to the German average, the climatic conditions in Stuttgart are warm and dry with a yearly median temperature of around 10° C and a cumulated rainfall of 680 mm. Extra high temperatures in the city center are favoured by the basin location and a dense built infrastructure, whereas temperatures can vary significantly between the inner and the hilly

outer districts (Amt für Umweltschutz, 2017). More importantly, Stuttgart is often exposed to the meteorological phenomenon of atmospheric inversion. This phenomenon commonly occurs in anticyclones at wintertime where the ground and air in low height can cool down during the long, cloudless nights which then leads to a temperature inversion – cold on the ground and increasingly warm with higher elevation. The thicker cold air constantly stays below the thinner warm air and the exchange of air masses is hindered. As a consequence, the pollutants produced in the city cannot escape into higher atmospheric regions, the concentration of pollutants rises and becomes visible in form of smog (**Deutscher Wetterdienst, 2015)**. Especially on those days the "Feinstaubalarm" is called out in Stuttgart.

5.3 Industry and Economy

The city of Stuttgart as well as the metropolitan region are renowned for their industrial and economic strength, which together with the regional structure has massive effects from the infrastructure and transportation point of view, for example on the number of daily commutes (see Chapter 7.3.2, p. 52 - 53). In 2016, almost 400.000 people were employed in the city and more than 1.15 m in the Stuttgart Region (Statistisches Landesamt Baden-Württemberg, 2017). Stuttgart is the home of global players such as Daimler, Porsche, Bosch, Stihl and Kärcher, some of them also forming important actors for planning processes within the city Those relations also need to be considered when developing a BRT concept for the area.

5.4 Summary

Concerning the analysis and the BRT concept many of the above-mentioned characteristics are relevant. The topography shapes the current transportation infrastructure, has effects particularly on the comfort of bus-based public transport and limits the establishment of a BRT system to certain areas. The regional and urban structure together with the economic power of both the region and the city, on the one hand lead to a high traffic volume and a lot of commutes which again is import for analyzing the current situation. On the other hand, with respect to the ANT analysis, the number of actors involved in a BRT project is undoubtedly higher due to the regional structure and powerful companies based in Stuttgart.

6. Analyzing a Potential BRT Project for Stuttgart by Using Actor-Network-Theory

This first analysis part of this thesis fulfills the purpose to understand, inform and analyze the potential BRT project for Stuttgart from an actor-network perspective with its complex combination of identities, institutions, plans and various interests. The theoretical background is formed by ANT and in particular ANT's concept of translation.

The choice of ANT as theoretical background for this analysis is appropriate because the current transport network as well as the BRT system for Stuttgart can be clearly defined as socio-technical systems. Both networks/systems are socially influenced mainly by the included human actors, such as public transport operators, municipal institutions and others, whereas the system itself also strongly influences the social processes, for instance by changing people's transportation habits. ANT is closely linked to the science and technology studies and the concept of STS and therefore a suitable theory for this analysis (Kneer, 2009).

6.1 Actor overview

The implementation of a BRT system in Stuttgart is a highly complex process, not only because of technical restraints and such but also because a high number of actors is or needs to be involved, assuming that projects like that always having fans and detractors, which makes it even more difficult. Therefore, the first task performed as part of this analysis is to map the field. With mapping the field, an overview of actors is provided, which also includes their perception towards the BRT project. Questions that are answered include: Who is in favor of BRT and on what arguments? Who is against BRT and on what arguments? The focus in this part of the ANT analysis will be on the human-actors and on determining their level of involvement or resistance, whereas the non-human actors will come into play into the second part of the ANT analysis.

An ANT approach takes point of departure in an intervention. The second part of this analysis is carried out to understand what needs to be done to have a BRT system designed, built and operating in Stuttgart. At this point non-human actors such as the BRT concept, the current infrastructure, planning documents etc. are added to the network. The overarching aim of part three is to explore a strategy on how to get a BRT project on the way by involving all important actors and by overcoming potential resistance.

6.1.1 Overview of Human Actors and Institutions

The following overview of human actors and institutions that are or need to be involved in a BRT project in Stuttgart and their perceptions towards this approach is mainly acquired with the information gathered through interviews with local experts. Some of the actors are pooled into actor groups as sometimes a distinction of competencies and perceptions was not possible to determine. This is compounded by the fact that this analysis is conducted for a project that is neither planned, nor has been implemented. The listing of actors below is in no special order and no claim is made that the list is complete.

Urban Planning Department:

The Urban Planning Department's main task are the preparation of development plans and the drawing of legal baselines for the realization of important construction projects, which also includes infrastructure projects. It further acts as an intermediary between other involved actors such as investors, citizens, architects or other further departments (Landeshauptstadt Stuttgart, n.d. a). In accordance with their competencies they will definitely be involved in a BRT project for Stuttgart.

Past approaches of the local public transport operator have proven that is has been difficult to put forward bus prioritization measures in the city, because the urban planning department was often opposed. Previous BRT plans around Stuttgart's central station have been directly abandoned. Besides the fear of taking away space from cars (and therefore worsening congestion) the common concern is the land-use of BRT and its compatibility with the current built infrastructure. One of the main arguments against BRT infrastructure is, that buses can just use normal roads and with the existing space limitations dedicated bus infrastructure is therefore not necessary. Moreover, in recent years, bicycle and pedestrian infrastructure was in the focus than improvement of bus based public transport (SSB, personal interview).

Road and Civil Construction Department:

The Road and Civil Construction Department is in charge for construction and maintenance of roads and urban rail lines within the urban area. Furthermore, they are responsible for the overall traffic management (Landeshauptstadt Stuttgart, n.d. b).

Although not directly included in pre-construction and planning processes, the department still influences the processes, for example by helping to decide whether a solution is feasible

or not from a technical viewpoint. Currently it appears that the right people are at the right place in the right time, meaning that decision makers in the department are acting in favor of public transport, which for instance enabled the SSB to push through their prioritization measures for the new X1 express bus service on the Cannstatter Straße (see Chapter 7.4.3, p. 58 for more details) (SSB, personal interview). A positive perception towards BRT can be expected from this actor.

City of Stuttgart Mobility Department:

The Mobility Department is directly subordinated to the mayor of Stuttgart. The department can be described as a strategic unit that coordinates different (international) mobility projects in which the city is involved and promotes sustainable or innovative forms of mobility (Leyva/Forderer, personal interview).

The department is not directly involved in transportation or infrastructure planning, however as part of their daily work, they evaluate different forms of urban mobility, including BRT. BRT projects are not their focus and they are no experts in the field, meaning that at this point no reliable statements regarding the potentials of this solution can be made. It became clear that the mobility department is not opposed to the idea of a BRT system for Stuttgart, nonetheless they have numerous concerns. First of all, the biggest concern is the technical feasibility with relation to the space that would be needed to install dedicated bus infrastructure. Furthermore, the actor's perception that bus-based public transport in the city is already very efficient has to be seen critical for putting forward the idea of BRT (Leyva/Forderer, personal interview).

Political Leaders:

Political decision makers in Stuttgart and the region are formed into this group. They make final decisions on the realization and budgeting of infrastructure projects (in accordance with the different departments, operators etc.) and have the power to push certain approaches. All of this makes politicians to a very important actor (group) that certainly needs to be involved in the BRT project (SSB, personal interview).

A common issue with involving the politicians, is their lack of BRT knowledge and expertise Mejía-Dugand et al., 2013; Sautter, personal interview). Political decisions for a certain infrastructure concept are often made because certain concepts are familiar and operators

and cities in general have experience with it. Important factors for finding the most suitable solution such as the actual demand, financial possibilities or the urban context are often forgotten (Flyvbjerg, 2007; Sautter, personal interview). Changing the way of planning and considering new concepts is a slowly moving and complex process, especially in Stuttgart and Baden-Württemberg where politicians are rather conservative. They share the "common fear" of taking away space from cars and rather promote solutions in favor of cars than pushing public transport (Schwarz, 2017; Sautter, personal interview). From the political leaders in Stuttgart, with the mayor being member of the green party, it could be expected that there is a strong willingness to push a wide range of sustainable transport solutions. Yet, the focus is on well-known urban rail concepts, despite their high-costs and long realization times. Ancient thinking can be detected, instead of considering out-of-box approaches providing fast and efficient solutions (Sautter, personal interview).

Regardless of the critical perception on new public transport solutions, city government officials have recently given positive feedback on systematic approaches to improve city bus service. Under the pressure of the current problems and endless discussions about environmental badges and driving bans a positive development towards open mindedness for new bus solutions can be detected (SSB, personal interview). A further sign of growing awareness is demonstrated by the fact that Baden-Württemberg is the only federal state in Germany with the legal framework to subsidize bus systems (internal document).

Public Transport Operator SSB:

The Stuttgarter Straßenbahnen AG (SSB) is the main local public transport operator and is in charge for both, the operation of urban rail as well as operation of city buses (Stuttgarter Straßenbahnen AG, 2014). The SSB is a municipally owned company and can be seen as the final instance of decision making together with the City of Stuttgart with regard to all public transport developments (Leyva/Forderer, personal interview).

In the past, the main strategic interest of the SSB was to develop, improve and extend the "Stadtbahn" network. Systematic bus planning was therefore often left behind and the topic BRT did not play a role so far (**SSB, personal interview; Leyva/Forderer, personal interview**). Now, under the pressure of air pollution, congestion and exceeding capacities in public transport the SSB seeks for improvements and tries to push and promote bus systems. It is not usual to be radical in that respect but new suggestions are brought up carefully. The

company's CEO is also taking a lot of effort in presenting possible solutions and improvements, especially in discussions with political decision makers (SSB, personal interview). A lot of capacities are now put into bus transportation planning, also because further extensions of the urban rail system after 2020 are unlikely (Sautter, personal interview).

Even though different perceptions towards BRT and some misalignment can be detected within the SSB (Sautter, personal interview), many people clearly see the benefits of BRT and in general it is considered as an approach worth to be dealt with. The SSB as the expertise to do so, but the infrastructure and financing thereof is crucial for the success of BRT in Stuttgart (SSB, personal interview).

All in all, it can be summarized that the willingness to go new ways with a more systematic approach towards bus based transport including BRT and knowledge about the benefits and chances is existent within the SSB. Radical approaches or exertion of pressure cannot be expected, yet the SSB will play a fundamental role in the future development of the city's public transportation network and a potential BRT system.

***Private Planners**:*

This actor consists of private (non-municipal) planning bureaus, engineers, consultancies etc. that are often asked for their professional feedback on municipal (transportation) projects or given the tasks to conduct feasibility or cost-benefit analyses. This entails that they would conceivably be included in a BRT project. Only one interview has been conducted with an experienced private transportation planner based in Stuttgart, so the information from this interview is the main source used for painting a picture of the potential perception this actor group has towards the BRT approach.

Regarding the installment of BRT in Stuttgart, the actor is aware of the difficulties that come with it. Technical limitations are one of the issues, yet it is also considered very complicated to discuss and suggest new ideas and progressive approaches with political decision makers in Stuttgart and on a nationwide level. Another problem is the insufficient legal framework in Germany, especially because in contrast to rail systems, BRT systems are not included in the "Standardisierte Bewertung" (Note: The main legal framework to evaluate the economic feasibility of infrastructure projects in Germany) (Sautter, personal interview).

Nonetheless, since a considerable time an effort is taken to promote BRT and a more systematic approach to overcome the bad perception of buses in public. It is seen as a crucial

step to take away space from cars and build separate bus infrastructure in order to ensure fast, comfortable and efficient service and to generate a significant visibility effect. An effect the urban rail lacks in many central parts of the city because it is underground or out of sight. The latter might change the behavior of car users, if they actually see that buses are the faster solution. Thus, only if public transport is planned in a way that it becomes a visible and a serious alternative to the car, taking away space from cars can be justified.
It appears that private planners are aware of the benefits (and limitations) of BRT and willing to suggest the best possible solutions and a systematic change in public transport.

Automotive Industry:

The automotive industry in Stuttgart has a long history and can potentially be a very influential actor in many decision-making processes in the city. Within the context of this analysis it was complicated to find out the perception of this actor towards a BRT for Stuttgart.
The interviews have shown that there is misalignment regarding the role of the car industry in such projects. Whereas some of the interviewees assumed that the car industry has a negative influence on the overall public transport development in Stuttgart because of their own interest of selling cars, others assumed that with facing possible driving/diesel bans in Stuttgart (and other cities following that example) a strong public transportation network is the preferable option (Sautter; Leyva/Forderer; Beck, personal interviews). With recent developments in the VW-scandal, the car industry fears a further image loss of diesel cars if driving bans become reality. This would hurt them, as a significant proportion of diesel cars is the precondition for being able to stay within the EU-limits for CO2 emissions, due to their lower fuel consumption compared to petrol engines (Reuters, 2017).
The only reliable statement over the automotive industry's perception towards BRT to be made at this point, is that it is ambiguous. Still, they are an actor that needs to be involved in the project.

Public Transport Users:

The actor "public transport users" is defined as persons that are using public transport regularly, e.g. for the daily commute to work. Supposedly, people already using public transport would welcome further network improvements, supplements and alternatives, such as more direct connections, especially in the bus sector. However, in general there is often a

rail-bonus also on the side of public transport users, which is mainly based on the perception that rail bases solutions are faster and more comfortable than buses (Hensher, 2016). Accordingly, it is important to highlight the benefits of BRT also in front of this actor group.

Private Car Users:

Private car users, their feedback and their mindset plays an important role for transportation planning, as they are a huge and strong actor group. As previously outlined, decision makers often fear the reaction of car users when it comes to implementing solutions that might entail disadvantages for them.

Stuttgart and the whole regional area is characterized by a strong car related mentality. It appears to be a "cultural problem", most certainly deriving from the automobile manufacturing history of the region and potentially further influenced by the vast amount of jobs, the economic benefit and level of wealth connected to it (Leyva/Forderer, personal interview). Moreover, the "ability to suffer" among car users in Stuttgart appears to be very high. Even if there is no chance to get through the traffic jams in a bearable amount of time, they do not switch to public transport. On the one hand this roots from a general unwillingness, on the other hand they might come from areas with a bad connection to the city's public transport (SSB, personal interview).

The general perception towards a BRT which will take away space from cars will be critical. A recent case where one car lane was removed and cycling infrastructure was installed (on Cannstatter Straße) was entailed by many complaints and strong opposition (Leyva/Forderer, personal interview). A lot of this opposition roots in the fact, that car lanes are taken away without providing a serious alternative (Sautter, personal interview).

Despite the critical views and the expected opposition, there is also a low acceptance for the currently discussed solutions around driving/diesel bans. This is the chance to present BRT as the better alternative.

Verband Region Stuttgart (VRS)*:*

The VRS is the political entity for the Stuttgart Region. Important responsibilities of the organization are spatial planning, economic development, and public transportation. In the latter, the VRS is responsible for i.e. the suburban railway system, the new regional express

bus services (Relex Bus), Park & Ride systems and regional traffic management (Beck, personal interview).

Regarding the BRT for Stuttgart, the VRS would not be directly involved in planning tasks, but could be in an observatory and coordinating position. BRT is percepted as a solution with good potentials for tangential connections in the region as well as for the city center of Stuttgart. However, until now there were neither approaches made to promote BRT nor serious BRT planning considerations from the VRS in this direction (Beck, personal interview).

The question that remains is, whether there is a serious interest to be involved in new projects that are not directly under the VRS's responsibility, also when considering that their main task is coordinating the rail transport in the region (Sautter, personal interview).

EvoBus GmbH:

The EvoBus GmbH is the European bus branch of the Daimler GmbH and was a partner in developing this thesis. The company has a dedicated BRT team which tries to promote BRT solutions globally and consults operators and cities concerning the implementation of BRT systems (internal document).

EvoBus has a special interest to implement a "showcase" BRT system in Germany to enhance the overall BRT development in the country. In the context of Stuttgart, BRT is seen as a sustainable urban mobility solution that can induce a system change in the city and help to overcome some of the current infrastructure issues. EvoBus can provide expertise in form of BRT consulting services and rough concept development as well as vehicles with the right configuration for BRT. The actor is willing to push a BRT solution for Stuttgart as well as to offer help for planning and implementing it (internal document).

Verkehrs- und Tarifverbund Stuttgart (VVS):

The VVS is the roof organization for public transport operators and authorities in the Stuttgart region. It is mainly responsible for developing the tariffs etc. and not directly included in the planning of infrastructural measures. It is not possible to make a statement regarding the position towards BRT, but the VVS could possibly be in a coordinating role as it incorporates all important public transport operators in the region (Leyva/Forderer, personal interview).

6.1.2 Non-human Actors

One of the main concepts of ANT is to include non-human actors or entities in an actor-network. In this context, for instance technological features or planning documents can play a significant role in the planning process, as they can define the relationships between actors and can act as intermediaries to bring them together (Rydin, 2013).

The current infrastructure and transportation network:

The current infrastructure and transportation network in Stuttgart (detailed analysis thereof in chapter 7, pp. 47 – 60) is an essential actor for the development of a BRT system.

Firstly, it is a contributor to the unsustainability of the city and the main reason for the necessity of new systematic approaches. Secondly, it considerably influences and shapes new transportation systems and future planning approaches. On the one hand, it sets limitations and restraints for the BRT system, i.e. space limitations determined by the existing built infrastructure or demand-related limitations because of the existing public transport network with the extensive urban rail system. On the other hand, the current infrastructure offers possibilities and potentials for BRT development and shapes the conceptualization. The wide multilane roads in certain areas allow separate infrastructure, inefficient bus lines (e.g. due to congested roads) justify it.

Topography:

The topography of the area sets limitations (spatial) to the BRT concept in the same way the current urban infrastructure does and therefore also influences the project.

BRT Concept:

The BRT concept developed in chapter 8 (pp. 59 - 69) of this report can be another crucial actor in the shaping of the system. It is directly linked to the existing infrastructure and planning documents and takes limitations and potentials into account. The conceptualization and visualization of a proposed BRT system for Stuttgart as well as the provision of information on its benefits and expected improvements do not only have informative character for the other actors, but can be helpful for enrolling and aligning them.

Nahverkehrsplan (NVP):

The NVP is a strategic instrument in Germany to formulate targets for the overall public transportation development of a city and is termed for 5 years. The latest version for Stuttgart has been published in 2015 (NVP, 2015).

The plan suggests public transport improvements based on the status-quo and expected future developments in demographics etc. The are several aims set for the improvement of the city's bus based public transport to ensure a more attractive and efficient service. However, prioritization measures for buses are limited to signaling and sectional bus lanes. A BRT solution is not explicitly mentioned in the NVP and the plan misses detailed policies and targets for the bus sector. Nonetheless, the NVP has informative character for all actors included in public transportation planning and can furthermore help aligning them by setting common targets.

Luftreinhalteplan:

The „Luftreinhalteplan" is a legally mandatory planning document, which should include obligatory measures to reduce air pollution and improve air quality, enabling a city to stay within the air pollution limit values set by the EU. It analyzes the current air pollution situation, examines measures against it and deduces effective measures from that *(RPS, 2017).*

Besides the driving bans already discussed in the introduction to this thesis, the plan briefly tackles public transport improvements as a valid measure to reduce air pollution. Besides an already decided extension of one tram line and the new express bus line X1 (see Chapter 7.3.2, p. 57) it does include various proposals for short-distance sectional bus lanes. Yet, the proposals are under the premise that car traffic will not be disrupted due to the bus lanes. BRT is not discussed as a potential solution to improve Stuttgart's air quality and just as the NVP, the "Luftreinhalteplan" lacks in-detail measures to improve public transport, particularly when it comes to buses. Nevertheless, the planning document outlines issues that most actors similarly mentioned and defines common targets.

6.1.3 Summary

The actor overview, which does not claim to be exhaustive, proofs that a big number of actors is or needs to be involved in the transportation planning process of a BRT system in Stuttgart. Despite the overview having a rather illustrative character, the included description of perceptions towards the potentials of BRT for Stuttgart shows both: Common views and similar interests on certain topics as well as different perceptions to BRT, misalignment and differing interests (**Rydin, 2013**). All in all, a distinct level of involvement among the actors can be detected. The questions that now need to be answered are: How can all actors be involved into the BRT project and how can misalignments and different perceptions be aligned and the actor network be stabilized?

6.2 Exploring a Strategy to Implement BRT in Stuttgart

In the following chapter a strategy to implement BRT in Stuttgart is developed, with the focus on exploring how actors can be involved and aligned in the project. Different steps are presented that potentially can help to build a stable network of actors to push the idea of a BRT system for Stuttgart. The strategy is limited to this and does not include economic or detailed legal considerations, as this would go beyond the scope of the project.

6.2.1 Problematization

The process of problematization is explained in Chapter 3.7.3 and can be described as the "creation of a common enemy" of all actors. In the case of Stuttgart this process can help to align actors and make them work together (**Callon, 1986b**).

All conducted interviews have proven that there is a common awareness among all actors regarding the clearly visible main issues in Stuttgart: air pollution and congestion. Particularly the air pollution problems and partly also the congestion problems are now approached by the strategies which aim to ban "old" diesel cars from certain areas in the city centers (RPS, 2017). Despite vivid debates on the feasibility and impacts of this measure (Reuters, 2017), it suggests that diesel cars are seen as the common enemy of many decision-makers, as otherwise such a solution would not have been developed to this extent. Yet, just narrowing down the problematization to these issues is not sufficient to have a BRT developed for Stuttgart. The common problem should go beyond this and include the apparently insufficient

and partly inefficient public transportation network as well as a lack of alternatives for car use. Only if this is considered, a consent regarding new approaches seems possible. Especially in the light of the fact that further extensions of the Stadtbahn network are very unrealistic, a system change could be necessary with BRT being a suitable solution.

Many actors shared concerns about taking away space from cars to install separate bus lanes for a BRT system and those concerns are even written down in the planning documents, by stating that bus lanes can only be implemented if car traffic is not negatively affected. This perception is rather surprising, as these concerns overweigh the concerns the actors have regarding driving bans for cars. The latter clearly is a more radical approach, disrupts car traffic more than giving space to public transportation and not only has negative effects for car users, but also for the industry (Reuters, 2017), the public transportation network which has already reached its capacity limits and the public perception towards the local politicians who develop those unpopular strategies (Sautter, personal interview).

Only if all the considerations above are deliberated when problematizing the current situation in Stuttgart, a BRT project has a chance to be commonly seen as a feasible and sustainable solution for the problems in the city.

6.2.2 Promoting BRT

During the interviews and the development of the actor overview it was detected that many of the actors that need to be involved in a BRT project for Stuttgart have a wrong perception on how such a system for Stuttgart would look like. On the one hand this misperception can be attributed to the low degree of familiarity with BRT concepts in Germany overall (Mejía-Dugand et al., 2013). On the other hand, it became clear that if there is basic knowledge about BRT, many actors have the high-capacity Latin American systems in mind that are not suitable for the urban context of Stuttgart and sometimes appear to be badly integrated into the cityscape.

These misperceptions can be corrected by actively promoting the European BRT approach as a cost-efficient solution for Stuttgart, with all its characteristics and benefits. Relevant information can be provided for example by sharing best-practice solutions of European cities that have successfully implemented, efficient and well-integrated BRT systems, such as Rouen, Strasbourg or Nantes (COST, 2011). Furthermore, the BRT concept presented in Chapter 8 (pp. 59-69) can act as an intermediary to get the misperception straight and enroll actors, by

presenting a feasible way of implementing BRT in Stuttgart that is adapted to the urban context with its limitations. Additionally, the stronger promotion of BRT and its benefits can help to overcome the bad perception of bus-based transport in public (car users and public transport users) as well as the rail-bonus that is inherent in transportation planning processes in Germany and in political decision-making processes thereof (Hensher, 2016).

To overcome resistance of car users and the car industry, BRT needs to be promoted as a better alternative to the discussed driving bans and a time-saving option that could potentially be installed not only in the city center, but also on commuting routes with a bad connection to public transport. The industry can push public transport in general and BRT in specific by handing out job-tickets to their employees.

Another important aspect to make car users shift to public transportation is visibility. Car users need to actually see the time benefits of public transport in form of busses passing by the cars stuck in traffic jams. Such a visibility effect can only be achieved through separate infrastructure over a considerable line length (Sautter, personal interview).

The urban planning department in Stuttgart has previously been lined out as an essential actor involved in a potential BRT project who has so far been opposed to the idea of BRT. One of the main concerns of the department is the land-use of separate BRT infrastructure and the integration in the cityscape (SSB, personal interview). This can be overcome with presenting a wall-to-wall approach as it is typical for French BRT systems. Wall-to-wall means that not only the BRT infrastructure is built, but that the implementation of BRT encompasses an urban renewal process. This includes good integration of cycling and pedestrian paths as well as integration into the existing urban context (COST, 2011). The concept will take this into account, by proposing mixed-traffic sections or single bus lanes where space limitations are given.

To sum up it can be said, that it is crucial to acquaint all involved actors about the benefits, possibilities and adaptability BRT can offer, as well as to relate this to their specific concerns or misperceptions in order to get them involved into the project. Moreover, the implementation of a first real “showcase BRT system” in Germany can be expected to be the initial spark for BRT development in Germany and could massively help to raise awareness over the advantages among all actors in Stuttgart.

6.2.3 Defining the Leaders

Chapter 6.2.2 has outlined the significance of promoting BRT in Stuttgart, to get important actors enrolled and aligned. The question that remains is, who should push forward the idea in Stuttgart. Whereas this thesis and the developed concept can be the first step towards the BRT development in the city, local actors with the power and reputation to take the lead and to persuade other actors with different perceptions to be involved in the project. They need to convey the concept of BRT as a sustainable and efficient solution for Stuttgart's transportation problems.

The analysis permits the conclusion that two of the actors in the network qualify for this position. The first actor group with the potential to lead such a project in Stuttgart could be the political leaders, as they have the final decision-making power over big infrastructure projects as well as the power to enroll all the necessary actors. Furthermore, they have a strong interest in providing solutions to improve the overall unsustainable situation in Stuttgart. However, it has been detected that the politicians are lacking the expertise and knowledge regarding BRT solutions and are generally not known for pushing entirely new concepts (Sautter, personal interview). Hence, it is rather unrealistic to expect this actor to take the lead in a BRT project.

The second actor that qualifies for a leading role is the local transport operator SSB. The SSB is one of the biggest public transport operators in Germany and by far the main public transport operator in the Stuttgart region. Besides the manpower and influence to push such a project, they also have the expertise and competencies to do so. Moreover, does the SSB have an own interest in improving their bus-based public transport with a more systematic approach and is already using considerable resources on that (SSB, personal interview). Further opportunities are given through the organizational structure of the company. The SSB is a municipally owned company. The close connection of the public transport operator and the municipality as the building authority - at least in theory - simplifies the public transport decision-making and planning process in Stuttgart (Beck, personal interview).

Yet, besides the positive basic framework, the SSB must take the lead with a more radical policy than they followed in the past to successfully advance the idea of BRT in Stuttgart and to align the other actors. They also need to overcome disagreements within the organization, regarding the potentials of BRT and policy of promoting the idea (SSB, personal interview). Active support for such an approach by the SSB can be expected from other actors with BRT

expertise and interest in developing a system for Stuttgart, such as the EvoBus GmbH and private planners.

6.2.4 Establishing the Legal Framework

An in-detail analysis of the legal framework around a potential BRT system for Stuttgart is not subject of this thesis. This chapter focuses on the planning documents mentioned in the overview of non-human actors (see chapter 6.1.2) which are setting guiding principles and general policies for the development of transportation infrastructure in the city. Planning documents can be important intermediaries between actors and can help to overcome misalignment of actors and stabilize the network through detailed planning policies and common targets (Rydin, 2013).

As previously mentioned, neither the "Nahverkehrsplan" nor the "Luftreinehalteplan" include the possibility or proposal of establishing a BRT system to improve public transport and to reduce air pollution. Proposals for the improvement of bus-based public transport are generally not detailed enough and are limited to inefficient measures such as short sectoral bus lanes in front of crossings or signal priority. These acceleration measures have already been installed on an area covering scale and show little effects as the roads are just too congested (Sautter, personal interview). A systematic approach, with clear targets and more detailed policies to reach those targets is compulsive, as only then these documents can help to reach planning consent among the actors (Rydin, 2013). The premise that bus acceleration measures should only be implemented if car traffic is not negatively affected is inherent to both documents and resembles the ancient way of thinking of several decision-makers in the city. Less restrictions and "if's" when planning public transport and preparing respective documents is favorable.

Yet, Baden-Württemberg is the only federal state in Germany where it is possible to get subsidies for BRT projects (internal document). The question that remains is, why the authorities in charge for the preparation of those planning documents, do not take this into account when discussing improvements and extensions of the network and mention BRT as a potential solution. One reason could be that an equal treatment of transportation systems in pre-planning processes is currently not given in Germany. The "Standardisierte Bewertung" is the legal framework for cost-benefit-evaluations of public transport projects in Germany and therefore one of the decisive planning instruments. Currently it only includes rail systems, but

no bus systems (Sautter, personal interview). Getting this straight and including bus systems into the framework is crucial for a positive BRT development in Stuttgart and Germany overall. This is not within the responsibility of the local actors in Stuttgart, but of the actors in charge for the development of the "Standarsierte Bewertung". Nevertheless influential (political) actors from Stuttgart (e.g. the mayor) could help rising awareness for this issue, by promoting BRT and clearly pointing out these legal shortcomings.

6.2.5 Introducing a New Actor

The introduction of new actors to an actor network, can help to involve actors and build a stable network (Callon, 1986b). In this case, it is the emergence of new technologies in the bus sector that are expected to change the perception of bus based public transportation among the actors.

When discussing public transportation solutions for cities like Stuttgart, a "rail bonus" is often inherent. Besides the higher comfort and reliability of rail transport (which both can be equally achieved by a well-planned BRT), such discussions are often narrowed to the environmental aspects of the different means of public transport (Hensher, 2016). Although the energy mix of a country is generally left out in such discussions, urban rail has an advantage because it runs on electricity, whereas diesel buses are often percepted as "dirty" (SSB, personal interview). The emergence of buses with alternative drivetrains (electric, hybrid etc.) will make them more competitive in this respect and for political decision makers it becomes easier to find convincing arguments for the bus which can change their overall perception. The same can be expected for (semi-)autonomous driven buses currently gaining momentum. They have the potential to close the final gap of comfort between urban rail and BRT (internal document).

For operators, BRT is the perfect opportunity to introduce electric (and later autonomous) buses to their fleet, as the systems provide a high planning reliability and the new technologies are generally easier to adapt when buses run on separate infrastructure. Segregated BRT lanes are the most suitable "playground" for using autonomous driven buses in real operation (internal document). This will make it worth to promote BRT systems and push its implementation.

Both new technologies have the power to enhance involvement and achieve alignment among important actors and for bringing a BRT system for Stuttgart on the way.

6.3 Summary

The ANT Analysis has unfolded the complexities of bringing a BRT project for Stuttgart on the way. A high number of actors, with different interests, varying perceptions towards the potentials of BRT paired with a (partial) lack of expertise need to be involved and aligned. Outlining this has helped to explore a strategy on how to achieve this goal.

The strategy has provided some relevant guidelines to help getting all necessary actors involved and aligned to a degree where it becomes realistic that a BRT system is seen as a serious alternative to the currently discussed solutions for the traffic problems and a beneficial supplement to the city's public transportation. Yet, the strategy only scratches the surface and "pressure" and involvement from the outside only helps to a limited degree, for example by constantly promoting BRT and make the concept known. The local actors themselves need to be willing to carry out key tasks in bringing the project on the way**.** Actor groups such as private car users can only be convinced to a certain degree**,** but their engagement is crucial for the success of new approaches. Facts like that proof, that it will be difficult to induce a system change in Stuttgart, but it could be possible if approached with the right strategy and the right actors in the right places.

7. Status Quo Analysis

This chapter aims to give fundamental insight in the backgrounds that lead to the city's unsustainable transportation infrastructure and to analyze the current transportation network with the focus put on the entailed problems.

At first, an overview of historical planning problems is presented, to point out how the infrastructure was established and what mistakes have been made. After that, the air pollution problems as well as the road and public transport infrastructure will be analyzed by describing the present status, main issues and mid-term development plans. This will help to understand where the main challenges are and how a BRT system can improve the situation.

7.1 Historical Planning Problems

The first elemental problem in Stuttgart's transportation planning history is directly connected to World War II. Because of the city's industrial and economic significance for Germany, more than 60% of the urban area were destroyed in WW II. During the war the population shrank to 266.000 inhabitants in 1945. But already in the 1950's the population hit the 600.000 inhabitant mark, peaking in 644.000 inhabits at the beginning of the 1960's. In connection with this rapid and massive population growth the main target in this period was the fast rebuilding of the city focused on housing development and the creation of a car-friendly city (Stadtarchiv Stuttgart, n.d.). The paradigm of an integrated urban and transport development was more or less given up and a significant share of urban space was dedicated to build up car infrastructure (Monheim, 1990). The planning mistakes made in this period are almost irreversible and can still be seen today, among others in form of the very wide, multilane roads around the city center in Stuttgart, for instance Hauptstätter Straße or Rothebühlstraße (see red boxes, *Fig. 7* below) (Kühne, 1996).

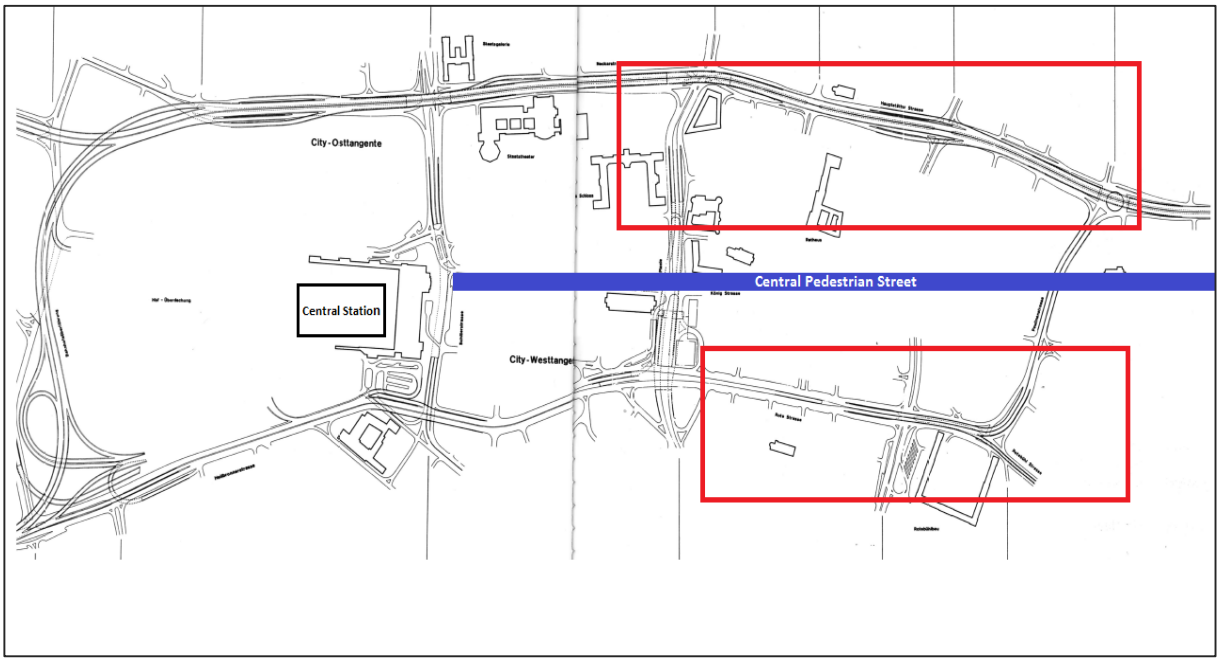

Figure 7: City Ring plan 1962 (based on Kühne, 1996; own adaptation)

The second major problem that almost all cities in the Western world have in common is the rapid motorization and mobilization that started in the late 1950's and continues until today. Especially in the early phases the dimension and consequences of the motorization process were underestimated. Even though many cities were actually planned for cars, they still were planned for a lower number of cars and less overall personal mobility. The massively growing volume of freight traffic was also heavily underestimated at that time. As a consequence, even

cities planned for cars, such as Stuttgart, cannot handle todays flowing traffic volumes. A systematic planning approach for bicycles was not realized until the 1990's and appears to be neglected up to this day (Kühne, 1996).

Another issue in Stuttgart is the public transport and organizational structure. The Stuttgarter Straßenbahnen AG (SSB) which is still the main public transport operator in the city was already founded in 1889 and since then the focus of public transportation planning has been on urban rail which is the major mean of public transport in the city (Kühne, 1996). The current urban rail network consists of the "Stadtbahn" which is a tram-subway mix and the commuter rail, also known as s-trains in Germany. Especially the Stadtbahn has been continuously extended since the 1960's and big investments were made. Both systems offer an efficient and high-quality service and cover wide areas of the agglomeration. Nonetheless, both rail types have now reached or are close to reaching their capacity limits on many lines and especially the commuter rail suffers from unpunctuality (Sautter, personal interview). Further extensions cannot be expected in the nearer future, mainly because the network is already area covering and space as well as financial resources are limited (Beck, personal interview). While connecting areas of the city that are poorly or not connected to the urban rail network, bus-based public transport acts more as a supplement to urban rail and plays a subordinate role for the city's public transportation, especially in the central basin (Leyva/Forderer, personal interview). It appears that bus planning was left behind, which led to a big gap between the urban rail and the rest of the public transport. Due to the high traffic volume, the buses are often stuck in traffic jams and are neither reliable nor comfortable. A more systematic approach for the buses might be necessary to release pressure from the urban rail network and to make them a more attractive option, especially compared to private car use (Sautter, personal interview).

7.2 Air Pollution

Air pollution is Stuttgart's most discussed topic and fighting it is one of the city's major sustainability challenges. Air pollution seriously affects human health and urban life in Stuttgart (RPS, 2017). It has become common practice that a so-called "Feinstaubalarm" (Smog Alarm) is called out, when the limit values of particulate matter – a fine dust material which can lead to respiratory diseases and others – are exceeded. This happens on a regular basis in Stuttgart. An even bigger problem in Stuttgart, however discussed with less publicity than PM, is the emission of NOx. Just as PM, nitrous oxides can cause respiratory and cardiovascular diseases and furthermore contribute to global warming (Leyva/Forderer, personal interview).

Table 1 and *2* show yearly CO2, particulate matter and NOx emissions, categorized by emitter groups. The data proofs that the local traffic is responsible for 40% of the overall CO2 emissions, and for more than 50% of the particulate matter and NOx emissions in the city. Traffic is therefore by far the strongest emitter of harmful air pollutants. The high emission volumes of diesel engines are the main reason for the discussed driving bans, however it can be expected that petrol fueled cars are only marginally cleaner (Sautter, personal interview).

Year	Cumulated CO2 Emissions	Proportion					
		Industry and Public Power Plants		Private Households, Businesses & Trade, Services and others		Traffic	
	1000 t		%	1000 t	%	1000 t	%
1995	3 160	891	28,2	1 183	37,4	1 086	34,4
2010	2 681	825	30,8	846	31,6	1 011	37,7
2014	2 709	682	25,2	945	34,9	1 083	40,0

Table 1: CO2 emissions by emitter group (Source: Landeshauptstadt Stuttgart, 2016; own adaptation)

	Traffic	Power Plants	Industry & Businesses	Biogenic Systems	Other technical facilities	Sum
Particles in total	429	103	30	5	21	588
Particulate Matter (PM10)	168	100	16	4	19	308
NOx	1504	431	410	18	370	2734

Table 2: Air pollution emissions in Stuttgart 2014 in t/a (Source: RPS, 2017; own adaptation)

Figure 8 below depicts the average yearly NOx immissions in microgram per cubic meter air, measured on numerous roads in the city area of Stuttgart. Yellow, orange, red and purple lines indicate that the limit value of 40 microgram/cubic meter is exceeded. This is the case on all highways around Stuttgart, on main roads leading into and out of the city as well as in the city center itself, proving that air pollution problems deriving from traffic cover the whole urban area.

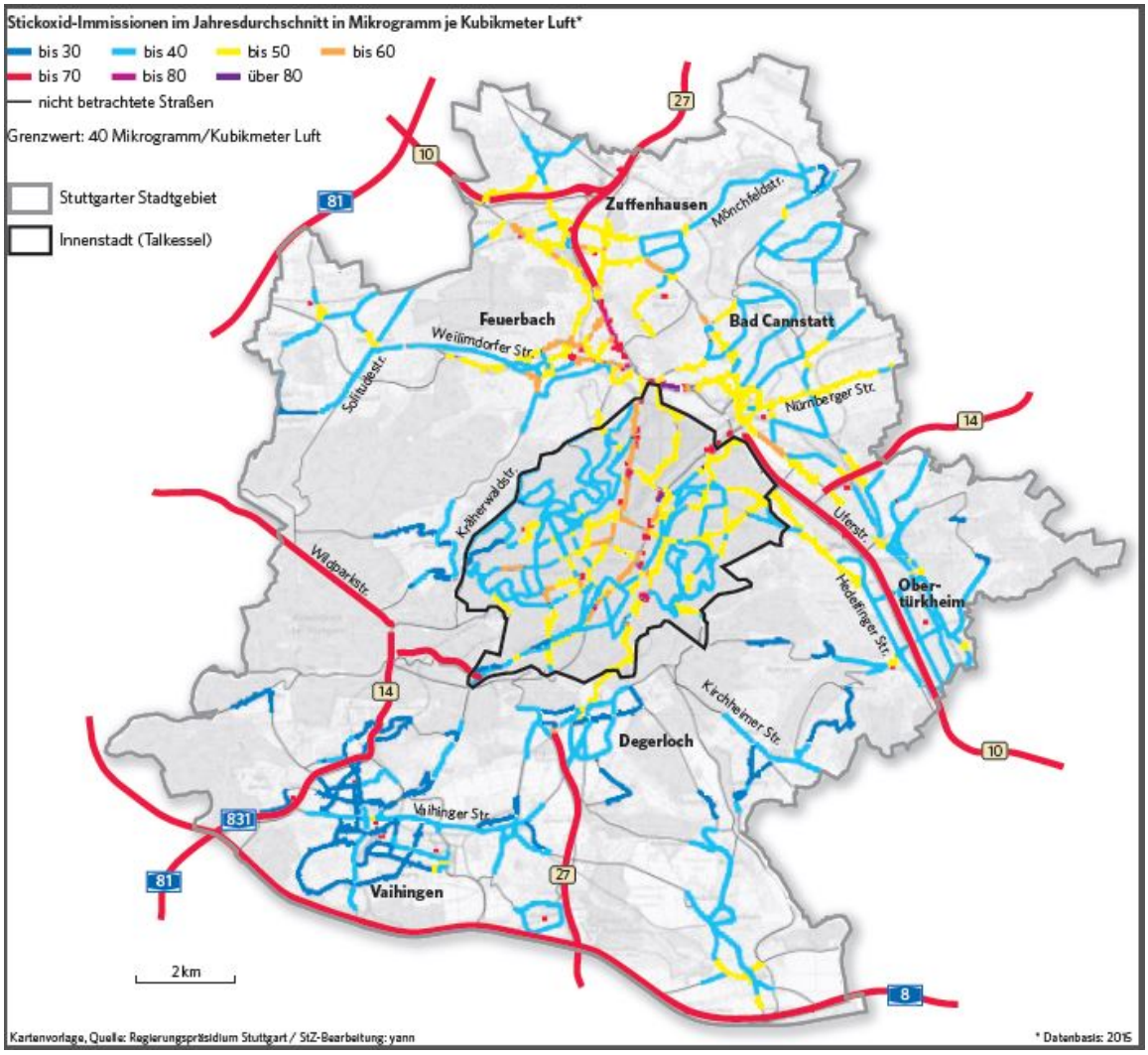

Figure 8: NOx emissions on roads (Source: RPS, 2017)

7.3. Road Network, Traffic Counts and Car Ownership

This chapter examines the local road network and car use. Relevant data is analyzed to discover the main reasons for the heavy congestion and other transportation issues in the city.

7.3.1 Road Network

Stuttgart is surrounded by highways A8 and A81 which connect the city to many important economic centers in Germany. This interregional road network is supplemented by the federal roads B10, B14, B27 and B295 with highway-like road conditions (RPS, 2017). In this regard, Stuttgart with its topography is a special case, as in contrast to many other major cities, all four roads with regional or over-regional relevance go directly through the basin in the city center. For an overview of the road network see *Appendix C: II* and *figure 8* in chapter 7.2.

The consequence is an unusually high transit-traffic through the core of the city, worsened by the fact that the connections between the highways and the well-developed federal roads in the east of Stuttgart are inefficient (Leyva/Forderer, personal interview). All the mentioned main roads in or around Stuttgart, including the highways A8 and A81 suffer from heavy congestion, particularly in peak hours in the morning and the evening. This claim is backed up by official traffic counts (LUBW, 2012). The Bad Cannstatter Straße (see title picture), connecting the densely-populated city district Bad Cannstatt with the inner city of Stuttgart counts an average of more than 75.000 cars per day (both directions) which makes it one of the busiest and most polluted inner city roads in Germany (LUBW, 2012). Other roads in the eastern center such as the Talstraße and Wagenburgstraße count around 15.000 cars per day, whereas the number of cars and the traffic jams are rising. The Wildparkstraße in the west of Stuttgart is connecting highway A81 with federal road B14 and has an average traffic count of 33.000 cars per day (RPT, 2016).

7.3.2 Commutes

As mentioned before, the specific regional structure of Stuttgart has a major influence on commutes and therefore the overall traffic volume the city needs to handle. Stuttgart is the center of the region, with more than 600.000 inhabitants, a strong economy and a very high number of jobs, but it is also surrounded by numerous important sub centers. Cities like Esslingen or Ludwigsburg have a considerable population with more than 80.000 inhabitants, and are home to big companies offering a significant number of workplaces. This entails a lot of commutes between all the sub centers and Stuttgart itself and is one of the main reasons for the regular congestions (Beck, personal interview).

Figure 9 below depicts the daily number of vehicles crossing the (inner) city border (in both directions). In both directions, a vast and rising number of more than 800.000 cars/day cross

the city border and more than 400.000 cars/day the central basin border. With the given infrastructure and the spatial restraints, this number of cars cannot be handled sustainably.

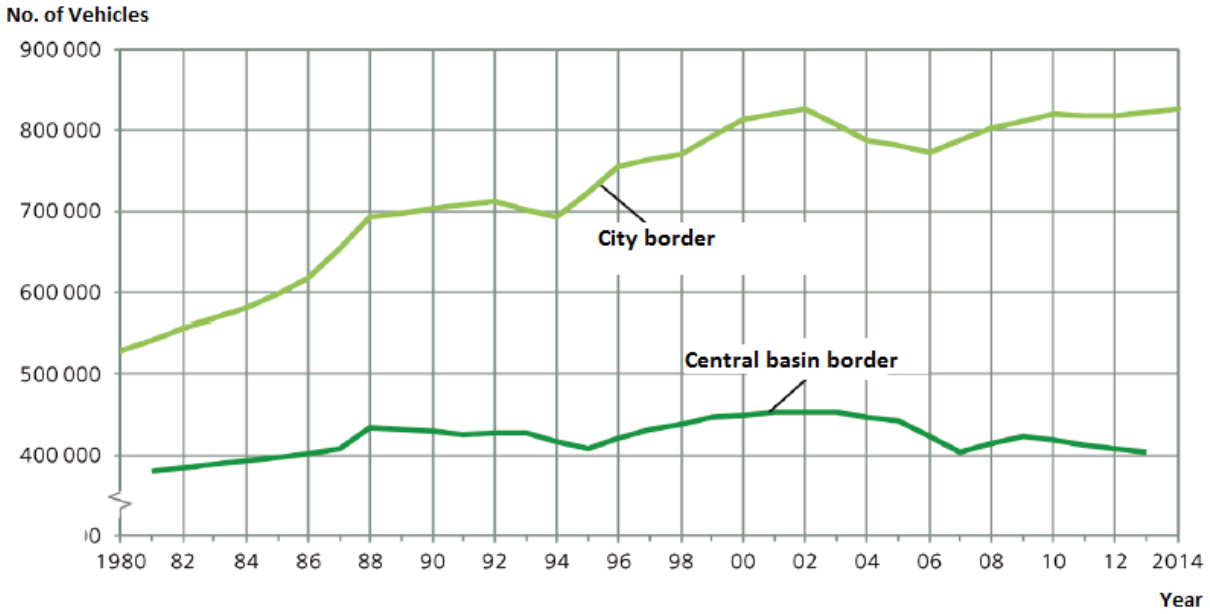

Figure 9: Daily commutes into and out of the city (Source: Landeshauptstadt Stuttgart, 2016; own adaptation)

7.3.3 Car ownership & Modal Split

It has been described earlier that Stuttgart was and still is heavily influenced by the automotive industry and a high level of car ownership. Reasons among others are the history of car manufacturing and the high level of wealth in region**.** *Figure 10* shows the number of cars per 1000 inhabitants. Car ownership in Stuttgart has been on a high level since many years. Although according to the data the level of motorization languishes in the last 10 years, the total number of cars in the city is rising, as Stuttgart still has a considerable population growth (Landeshauptstadt Stuttgart, 2016).

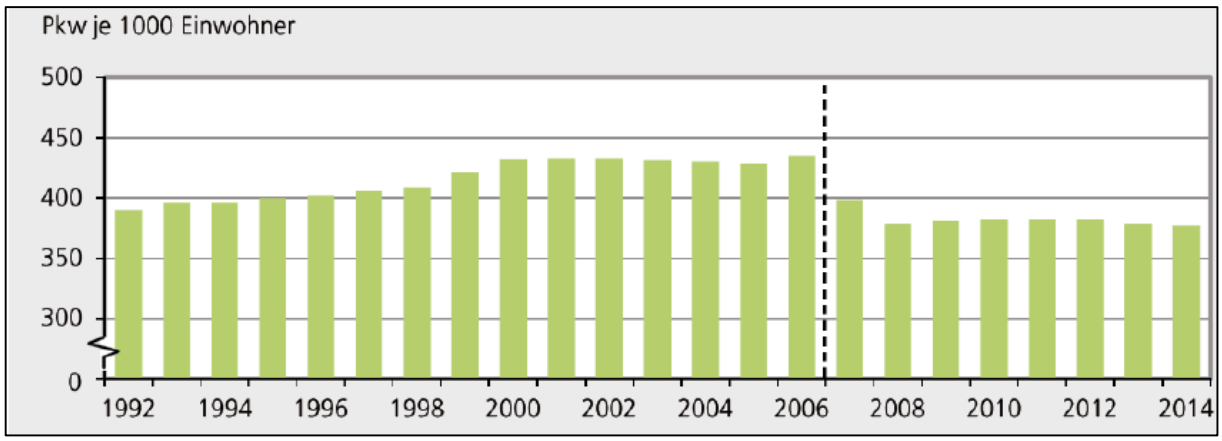

Figure 10: Level of motorization (Source: Landeshauptstadt Stuttgart, 2016)

Figure 11 illustrates the modal split of Stuttgart's resident population. 45% (blue) of the total population use the car and only 24% (yellow) percent use public transportation. Only 5% (dark green) are using the bicycle, which is in the light of recent extensions of bike infrastructure presumambly attributed to the hilly topography (SSB, personal interview). The share of cars in the modal split is 15% higher compared to Zurich, a city of similar size and with similar topographic conditions and still 8% higher than in Munich a city with a comparable (over-) regional significance and economic structure (EPOMM, n.d.).

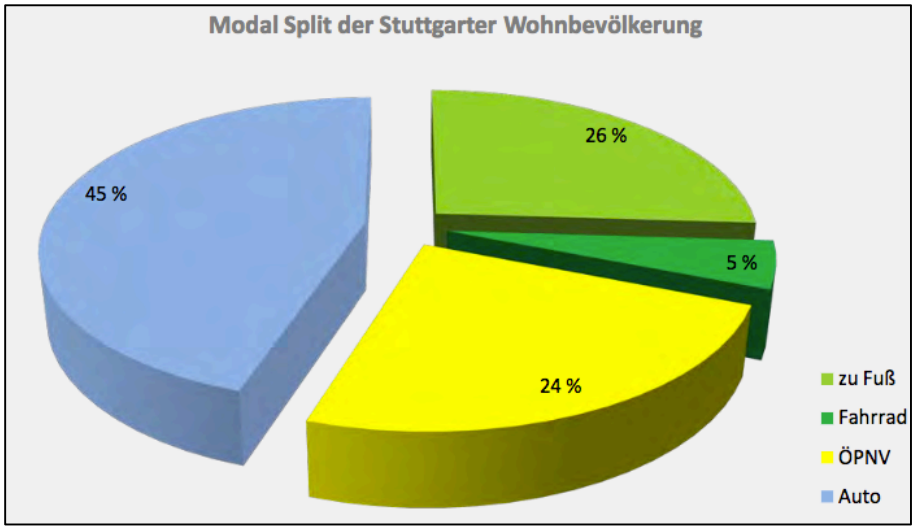

Figure 11: Modal Split in Stuttgart (Source: Landeshauptstadt Stuttgart, 2016)

7.3.4 Medium-term Plans

To give insight in the mid-term future development, several (planned) measures affecting the local road infrastructure and traffic are worth to be mentioned.

Within the framework of the "Luftreinhaltekonzept" passed in May 2017, the City of Stuttgart has recently presented their diesel-ban strategy for reducing air pollution. Two alternative elaborations are provided. The first strategy aims to ban all diesel cars with an engine configuration lower than EURO IV from all streets in the central basin area and other selected routes by 2020 and by 2018 on all days where the PM limits are exceeded. However, this measure cannot be executed by Stuttgart alone because the national legal framework in Germany needs an adaption thereof, which at this point seems highly doubtable. The second strategy is provided, for the case that the national legal laws will not allow such a measure. It provides the possibility to ban below-Euro IV diesel cars from selected roads in the inner-city basin without locking them out of the whole central basin area. Roads affected thereof are for instance the Bad Cannstatter Straße, Wagenburger Straße and Talstraße which have already

been mentioned in chapter 7.3.1 (p. 52) because of their high average traffic counts. Delivery traffic is exempt from both bans (RPS, 2017).

If the measures are implemented as planned, this will pose significant challenges to the roadwork outside of the central basin as well as to the public transportation infrastructure. The measure can be expected to lead to a massive transfer of traffic from the city center to the road network around the borders of the central basin, which has already been categorized as incapable of accommodating the current traffic volumes. Public transport in the described areas is already at its capacity limit as well (see chapter 7.4.2, pp. 56-57).

National infrastructure plans foresee an extension in form of additional lanes on the federal road B10 in east and west of the city center, to lower congestion in these areas (BVWP, 2016). An expectable outcome of this infrastructure measure is even more transit traffic through the inner city.

In the framework of the heavily discussed rail megaproject “Stuttgart 21” (S21) also some road infrastructure measures are implicit. The most influential measure will be the tunneling of the Rosensteinpark (B10) to get a more direct transit east-west connection in this central city area (Stadt Stuttgart, 2017).

It can be concluded that all mentioned measures will not contribute to a more sustainable transportation situation as they either aim to accommodate even more cars in the city or will lead to a transfer of problems to other parts of the city.

7.4 Public Transport Network and Ridership

Chapter 7.4 analyzes the local public transport infrastructure. First a general overview of the network is presented, before the ridership and capacities are thematised. As a final step mid-term plans to extend the public infrastructure are presented. Again, the focus will be on outlining the main problems to discover improvement potentials.

7.4.1 Public Transportation Network

Stuttgart has a well-developed and area covering public transportation network. The total network includes 72 lines and 830 stops. The main mean of public transport is the “Stadtbahn” with a total of 15 lines and 190 trains, with two of the lines running only on events such as football matches. The urban rail network is supplemented by 55 bus lines with 250 buses, a rack railway and a cable car. Additionally, seven S-Bahn (commuter rail) lines connect Stuttgart

with the surrounding areas. For an overview of the urban rail network in the city, see map in *Appendix C. 1* (RPS, 2017).

Just as the car infrastructure, most of the public transportation infrastructure is concentrated in the dense city center, entailing certain space limitations (**SSB, personal interview**). Generally, radial connections into the city center are numerous and efficient, whereas missing or insufficient tangential connections are perceived as problematic (**Beck, personal interview**). Especially, highly demanded bus lines are currently using some of the roads with the highest traffic counts in Stuttgart (e.g. Wagenburgstraße, Talstraße and Ostendstraße) (Sautter, personal interview). Despite prioritization measures in form of signal pre-emption and sectoral bus lanes in certain areas, the buses cannot escape the congestion and are lacking reliability and comfort. As an example, one of the most demanded bus lines in the city – line 42 – was accelerated through many prioritization measures over its complete length, yet it cannot keep within its desired five-minute headway and jams at bus stops of three or more vehicles arriving at the same time can be observed (own observation; SSB, personal interview). This inefficiency does neither enhance the use of buses as a serious alternative to urban rail, nor improve the bad public perception of buses. The only way to deal with this is separate infrastructure (Sautter, personal interview).

The S-Bahn suffers from unreliability and unpunctuality as the capacity of the central S-Bahn tunnel is exceeded and construction works in the frame of S21 heavily affect the commuter rail network (Beck, personal interview).

7.4.2 Ridership and Capacities

Figure 12 (next page) depicts the development of the yearly public transport ridership in Stuttgart. The data proofs a high demand for public transport with a positive development in form of growing passenger numbers. In 2014, the Stadtbahn (light green) was used by almost 130 million passengers yearly whereas city bus service (dark green) counted around 65 million passengers. Despite the positive development, a big gap between urban rail and city bus can be spotted, which can potentially be closed through the implementation of BRT.

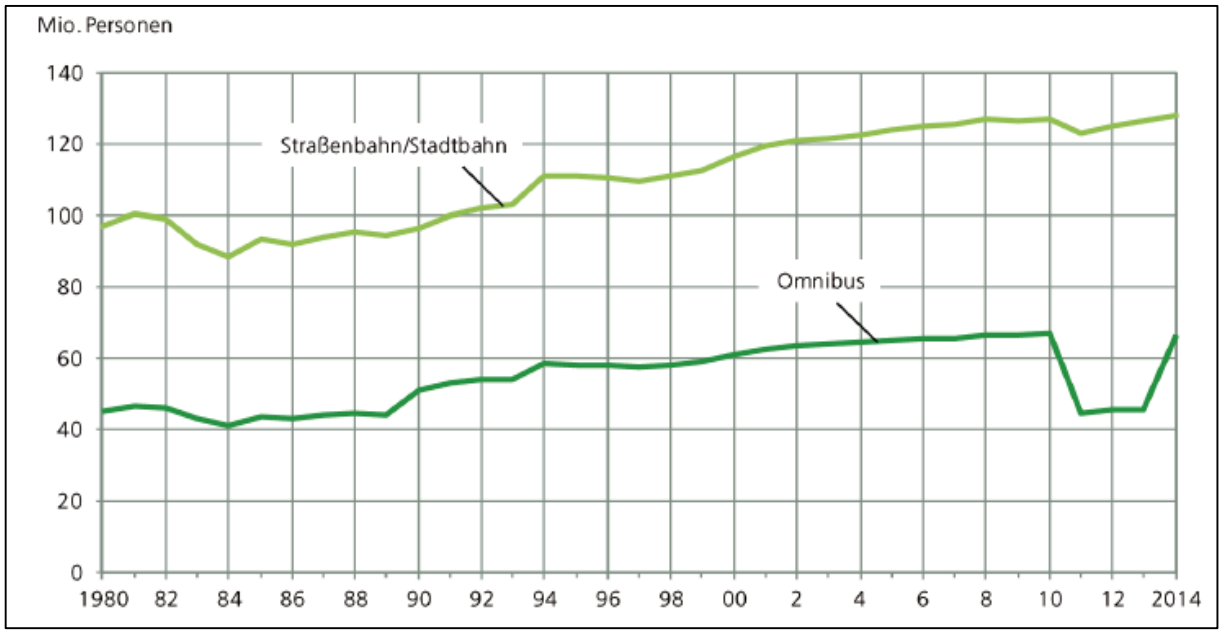

Figure 12: Yearly public transport ridership since 1980 (Source: Landeshauptstadt Stuttgart, 2016).

Various sources have confirmed that the local public transport has reached its capacity limits on many lines. For the Stadtbahn this is the case especially in north-south/south-north connections and on all lines between Bad Cannstatt and the city center. Currently the former 40 meter stations are extended to 80 meters on line U1 to accommodate longer trains (SSB, personal interview). Yet, this solution fights the causes rather than the symptoms, is expensive and needs construction works which affect the normal operation of the urban rail lines over a considerable time.

For the buses the situation is similar. Line 42 is the most demanded line with a passenger volume of more than 30.000 passengers per working day and already runs in five minute headways. Other high-demand lines are the lines 40, 41 and 45, all in the city center (SSB, personal interview).

The capacity of S-trains is by far exceeded in peak hours on working days, which does not allow more commuters to use them. Longer trains or shorter headways are not possible, as the s-train tunnel in the center cannot accommodate more trains (Beck, personal interview).

7.4.3 Medium-term Plans

Major investments in the extension of the urban rail network cannot be expected within the next years. Besides the construction of 80m stations for line U1, two minor extensions of the Stadtbahn are currently planned or under construction. The first one will extend line U6 to Stuttgart airport and the second will extend line U19 to the Daimler factory in Untertürkheim

(NVP, 2015; SSB, personal interview). Both extensions close important gaps in the network, but will not have a recognizable influence on the general capacity problems.

For the city bus service the further expansion of prioritization measures is examined. This will be in the same style as before with signaling solutions and sectoral bus lanes, under the premise that car traffic is not affected (RPS, 2017). The only major development in this respect is the new express bus line "X 1" connecting Bad Cannstatt Wilhelmsplatz with the inner city of Stuttgart (*see Appendix C: III*). The line runs parallel to the tram and is installed to take pressure of it as well as to enhance a shift from motorized individual traffic to public transport (RPS, 2017). The line will run in a 5-minute headway and to achieve an attractive and punctual bus service, certain BRT elements are installed. Besides signal prioritization, one car lane in inner city direction will partly be reserved as a dedicated bus lane, specially equipped buses with clean technologies (hybrid) will be used and the whole line gets an own marketing identity (SSB, personal interview).

7.5 Summary

The status-quo analysis has backed up the claim of Stuttgart's unsustainability, especially in the transport sector. Planning policies in the 1960's have led to a strong dependency on cars which is still existent and leads to significant air pollution problems and congestion. These problems are worsened by the specific topography and regional structure with a high number of commutes. Despite a constant development of urban rail and an area covering network, the public transportation is inefficient or at its capacity limits on many lines. Bus-based transportation planning was apparently left behind in the last decades. The congested roads in the city center, as well as missing efficient tangential lines make an efficient bus service without separate infrastructure almost impossible, what further proofs the justifiability and necessity of BRT. Whereas most planned improvement measures need to be seen critical, the development of the express bus line X1 with BRT elements parallel to the Stadtbahn is a sign of awareness among actors and could be a door opener for a real BRT approach.

The outlined problems and causes help to inform the development of a rough BRT concept for the city.

8. BRT Concept

The final part of the analysis consists of a self-developed BRT rough concept for Stuttgart. The concept can help to inform relevant actors about the benefits and possibilities of BRT in the context of the city. A clear distinction between the regular city bus service and the BRT is drawn and three potential BRT lines are presented, under consideration of the city's transportation problems and unsustainability. The target is to improve the overall public transport infrastructure, to release pressure form the urban rail network as well as to generate a modal shift from car to public transport, all of which can enhance the sustainability performance of the city.

For each line, it is explained how it could improve the situation. Furthermore best-practice examples are given on how to deal with space (limitations) and how to integrate the BRT system in the urban landscape.

8.1 Distinction between Regular Bus Service and BRT

To begin with, it is important to establish the baseline of the BRT system for Stuttgart by drawing a clear distinction between the BRT approach and regular bus service.

In contrast to the current bus service, the most significant difference concerns the proportion of separate infrastructure. The current approach to install short-distance sectional bus lanes and signal prioritization has proven to be not efficient enough to accelerate the buses on the congested roads in Stuttgart, which makes buses not a thoroughly convincing alternative to private car use (Sautter, personal interview). With separated and dedicated bus lanes, the buses can achieve travel time savings and a higher comfort. Another important benefit of the separate infrastructure is a visibility effect of the time savings, with the potential to convince car users to switch to public transport (Sautter, personal interview).

Beyond that, the BRT needs to be clearly marked as a new approach and a different system in comparison to the conventional bus service. This can be realized by giving the BRT lines and own marketing identity, with a modern bus design and recognizable line names (IDTP, 2007).

For the vehicles it can be expected, that clean technologies are the only option for a city like Stuttgart (SSB, personal interview) and BRT offers a good possibility to introduce fully-electric buses. Due to the separate infrastructure, a more consistent operation is possible, as it is less prone to traffic jams or other disruptions. Silent electric buses with a smooth acceleration can

also have a positive impact on the overall riding experience for passengers (internal document).

BRT stops and stations should be designed modern, barrier-free and well-equipped with roofs, seating places, passenger information systems and pre-ticketing (IDTP, 2007).

8.2 Line Concept

The BRT rough concept for Stuttgart is based on three potential routings. The lines have been chosen in accordance with the findings from the interviews and the previous analysis sections. The aim of the conceptualization is to visualize the BRT potentials and to explain how the system could help to improve the current situation.

All maps were developed with the help of ArcGIS. Overview maps with the three route proposals are attached in *Appendix D: I*.

8.2.1 BRT Line 1

A detailed view on the proposed BRT Line 1 is attached in *Appendix D: II*.

The BRT Line 1 is designed as an inner-city circle line with the idea to have a full BRT service in both directions. Variant A starts/ends at Stuttgart Central Station and counterclockwise runs through the Wagenburgtunnel, on Wagenburgstraße, Talstraße, Daimlerstraße, Wilhelmsplatz, Cannstatter Straße and Konrad-Adenauer-Straße. It therefore runs on some of the most used roads in the city and connects important areas such as the central station, main residential areas, the Mercedes Benz Arena, the SWR headquarters and the Ministry of Environment of Baden-Württemberg. Intermodal connections to the s-train and urban rail network are established at the important transport hub “Bad Cannstatt Wilhelmsplatz”, with further connections to the national train service at the main station and urban rail at Neckartor.

Variant B is a shorter version of the circle line, connecting Wagenburgstraße and Cannstatter Straße through the Ostendstraße, with connection to the urban rail network at Ostendplatz. This variant also connects the main station with important residential areas and the work locations around Cannstatter Straße.

A big proportion of BRT Line 1 serves areas that are currently served by the bus lines with the highest demand in Stuttgart (40 + 42). Both are currently inefficient as they mostly drive in

mixed traffic and are exposed to road congestion (SSB, personal interview). At the same time the connection from the areas around the south-eastern part of the BRT line to Bad Cannstatt is improved.

The connection from Staatsgalerie to Bad Cannstatt Wilhelmsplatz runs along Stuttgart's busiest, most polluted road, where the X-1 express bus service starting in 2018 is already a first measure to take pressure of the parallel running Stadtbahn-lines, that have already reached their maximum capacity in peak hours (RPS, 2017).

The choice of BRT stops was informed by existing bus stops on the routes and expanded by new stops at Cannstatter Straße (and Sickstraße for variant B) under the premise that most stops can be reached within 10 minutes of walking from the surrounding areas while keeping the number of stops low, to ensure fast service and less stop and go.

The planned driving bans on the exact same roads as well as the high level of congestion make improved public transportation service on these routes inevitable. Having the BRT circle line installed will significantly improve the existing bus service, establish new time-saving connections and relieve pressure from the roads and urban rail. Infrastructure, prioritization and acceleration measures for this line are presented in chapter 8.3 (pp. 62 – 68).

8.2.2 BRT Line 2

For a detailed map of BRT Line 2 see *Appendix D: III*.

The BRT Line 2 is designed as a vertical connection from the district Degerloch in the south of Stuttgart to the city center. In the south, the line terminates at the urban rail stop in Stuttgart-Degerloch and runs on Jahnstraße, Pischekstraße, Planckstraße, Schwarenbergstraße and Wagenburgstraße. In the north, a direct connection to BRT Line 1 can be created, providing a fast trip from the south to the north-east of central Stuttgart without the need to directly go through the city center. Again, the stops have been chosen to cover the biggest potential area within 10 minutes of walking time.

This route choice is justified by the fact that vertical connections to the central basin of Stuttgart are characterized by a high number of commutes with insufficient capacities, both on roads and urban rail. Recent approaches have shown that parallel service to urban rail is generally considered as a supplement to the system. The lane can potentially lower the commutes by car into the center from the south, especially if a good intermodal connection is assured, for example through park and ride close to the southern stations. In addition to that, pressure is relieved from the highly-demanded urban rail lines U12 and U15 (SSB, personal

interview; see map in *Appendix C: I*), if the BRT line can achieve comparable travel times through acceleration measures. For potential acceleration measures see chapter 8.3 (pp. 62 – 68).

8.2.3 BRT Line 3

BRT Line 3 (see map in *Appendix D: IV*) is an approach for a new public transport connection, established through a tangential route in the west of Stuttgart, connecting the cities Leonberg and Gerlingen with Stuttgart University and the city district Vaihingen with more than 45.000 inhabitants and a considerable amount of work places (Statistisches Bundesamt, 2016). The BRT line starts/terminates at the urban rail station "Gerlingen" and Vaihingen train station. It further runs on Panoramastraße, Wildparkstraße, B14, Büsnauer Straße, Katzenbachstraße and Robert-Koch-Straße with a potential extension into the important industrial areas around Möhringen (SSB, personal interview). As before, within the populated areas the 10-minute walking premise was applied.

Efficient tangential public transport lines are generally missing around Stuttgart (Beck, personal interview). BRT Line 3 has the potential to offer efficient service in the outskirts of the city between highly populated areas, the university and work locations. The recently introduced regional express bus service "RelEx" is already using the route (Leonberg - Stuttgart airport) in mixed traffic, indicating that there is demand (Beck, personal interview). The main aim of the express bus line is the airport connection which is why it drives in a 30-minute headway and only has few stops between Leonberg and the airport. This limits its capability for regular public transport use, for instance daily commuting. Running in mixed traffic on the busy roads (average traffic count on Wildparkstraße of almost 40.000 vehicles per day; LUBW, 2012) makes it prone do delays. To justify an investment in BRT infrastructure, the lanes could be used by RelEx and BRT buses as well as a high-occupancy lane for cars. An attractive and fast connection has the potential to enhance car users commuting between these areas to consider switching to public transport.

8.3 Dealing with Space Limitations

Due to existing space limitations, 100% of separate BRT infrastructure is not feasible for the context of Stuttgart. Separate infrastructure should be built where possible, elsewhere other prioritization solutions need to be applied. The following chapters give an overview of

different infrastructure measures with explanations on where they could be applied within the proposed BRT lines. The BRT infrastructure needs to be attractively and well integrated in the urban landscape.

8.3.1 Separate Bus Lanes for Both Directions

Separate bus lanes in both directions are the favorable choice of infrastructure measure, as they have the strongest positive effect on travel time savings, riding comfort and environmental improvements (IDTP, 2007).

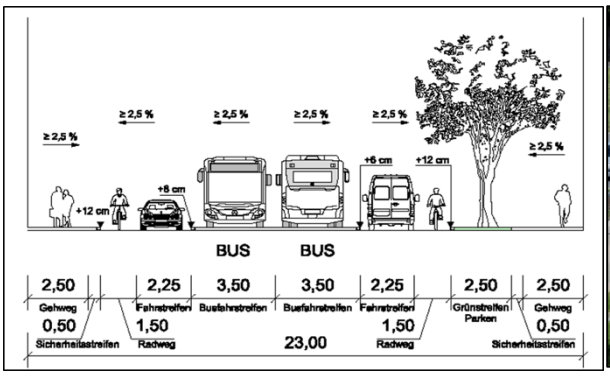

Figure 13: BRT road cross-section (Source: Möhring, 2014) *Figure 14: Separate bus lane – BRT Nantes (Source: Daimler)*

However, separate buslanes for both directions have a rather high use of space. *Figure 13* above shows that at least 23 meters of street width are necessary to accommodate buslanes, car lanes, cycling paths, sidewalks for both directions as well as a green strip. Although this space use can for instance be reduced by relinquishing green strips, it is not possible to install separate infrastructure throughout the whole line length. *Figure 14* depicts a well-integrated separate bus lane of the BRT system in Nantes that also entailed urban renewal processes along the line. Approaches like this have to be the general guiding principle for the integration of BRT infrastructure in Stuttgart.

8.3.1.1 Dedicated Bus Lanes on BRT Line 1

BRT Line 1 offers the possibility to install dedicated bus lanes for both directions over a majority of the total line length (see map in *Appendix D: V* – green boxes).

Figure 15: Wagenburgstraße (Source: own picture)

Figure 16: Cannstatter Straße (Source: own picture)

The Wagenburgstraße (*Fig. 15*), the Cannstatter Straße (*Fig. 16*) and the Talstraße provide adequate street widths for those infrastructure measures. On Wagenburgstraße it is possible to convert the green strip alley in the middle into median bus lanes. Another measure, that was already considered by the SSB in connection with potential bus lanes on that road, can be to take away the parking spots on each side of the street (SSB, personal interview). On Talstraße it is necessary to take away one or two car lanes and extend the existing sectoral buslanes over the full length to achieve a more efficient service. An approach to partially convert a car lane to a dedicated bus lane is already undertaken on the Cannstatter Straße in the framework of the new express bus X 1 (SSB, personal interview).

8.3.1.2 Dedicated Bus Lanes BRT Line 2

Exisiting space limitations make it difficult to install dedicated bus lanes for both directions on this BRT line. As this route runs parallel to urban rail, the acceleration measures implemented need to allow the buses to reach comparable travel times to the trains of U12/U15, which means buses need to have an average speed of 25-30 km/h over the whole line length. This can potentially achieved with single or electronic bus lanes (see chapters 8.3.2.2 & 8.3.3.2)

8.3.1.3 Dedicated Bus Lanes BRT Line 3

Similarly to BRT Line 1, BRT Line 3 offers the possibility to have separate infrastructure over a majority of the total route length (see map in Appendix D: VII – green box).

Figure 17: Wildparkstraße (Source: Google Street View)

The Wildparkstraße (*Fig. 17*) has two lanes per direction and addional free space on each side of the road and the median strip. Moreover, there is no need to install BRT stops, as the road goes straight through aforrested areas. This allows to install separate bus lanes with little effort. The national road B 14 leading to Stuttgart University has three to four lanes per direction, which also would allow converting two lanes to dedicated bus infrastructure. However, this could legally be difficult because of its status as a national road.

8.3.2 Single Bus Lane for Both Directions

For areas with space limitations and no possibility to install dedicated bus lanes for each direction, alternating single bus lanes in median position can be an efficient acceleration measure (*Fig. 18*). Paired with smart signaling systems, the single bus lane can be used by buses in both directions. *Figure 19* (next page) schematically depicts the operating principle. An alternating bus lane can only be installed if the headway of the bus service leaves enough margin (internal document).

Figure 18: Single bus lane – BRT Rouen (Source: Daimler; internal document)

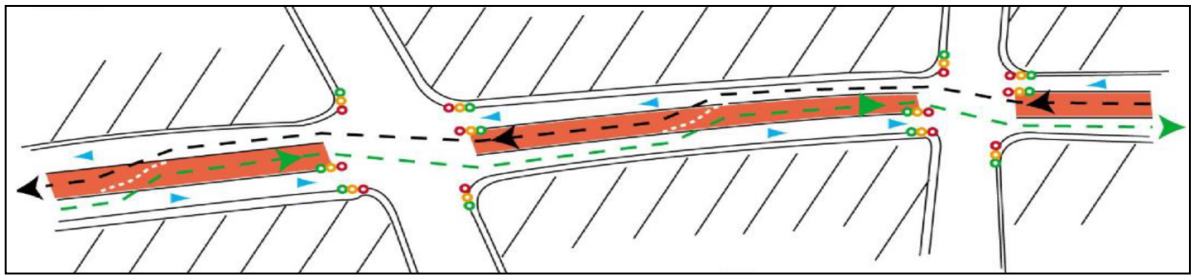

Figure 19: Scheme single bus lane (Source: Daimler; internal document)

8.3.2.1 Single Bus Lane BRT Line 1

As a supplement to the dedicated bus lanes, a single bus lane on Daimlerstraße can further accelerate the overall operation (see map in Appendix D: V – purple box & *Fig. 20*)

Figure 20: Daimlerstraße (Source: own picture)

The traffic volumes on Daimlerstraße are not as high as on the other roads on BRT Line 1, yet traffic jams are also likely to occur (NVP, 2015). A single bus lane for both directions is an economic option, adapted to the existing space limitations and seen as sufficient to ensure the efficiency of the system.

8.3.2.2 Single Bus Lane BRT Line 2

As stated before, infrastructural acceleration measures are difficult to implement on BRT Line 2. Nonetheless, a single bus lane can be a feasible solution for the central part of the line (Appendix D: VI – purple box). Space limitations are given through the topography and the existent rail infrastructure. An alternating bus lane is problematic due to the long distance, especially in peak hours with shorter headways. Nonetheless, to achieve a reliable service and to ensure a comfortable ride, especially on the hilly and winding sections of the road, separate infrastructure is crucial. The potential solution could be the conversion of one car lane to a

single bus lane, that is used by buses driving in direction of the main traffic flow in peak hours. In hours with a lower overall demand and longer headways the buses can use the lane in alternating directions. To make this work and to avoid any dangers through the varying driving directions, intelligent and reliable signal controls together with clear signage need to be installed.

8.3.3 Electronic Bus Lane

Electronic Bus Lanes allow buses to avoid congestion in areas with limited space, without the necessity to build separate infrastructure (SVI, 2015). The main principle is schematized in *Figure 21.*

Figure 21: Electronic bus lane (Source: SVI, 2015)

GPS signal steering allows the buses to use the counter flow lane as a temporary dedicated lane, by stopping the counter flow traffic with a red light. At the same time, the traffic in the same direction is also stopped by a traffic light, giving the bus the chance to overtake numerous vehicles and drive on as a group leader after getting back in its initial lane. Buses can avoid traffic jams and achieve a travel time savings and a high level of reliability. However, it is important to consider the safety aspect, as the majority of road users is not used to such measures (SVI, 2015).

8.3.3.1 Electronic Bus Lane BRT Line 1

For the service reliability of BRT Line 1, it is critical to find a solution for the bottleneck at Wagenburgtunnel (see *Appendix V* - yellow box). The tunnel connects the inner-city area around the main train station with the eastern parts of the central basin. The passage through the tunnel is limited to one lane per direction, yet has high average traffic volumes which lead to regular traffic jams on each side of the tunnel. For economic reasons, it is not feasible to extend the tunnel or build a second tunnel just for public transport, making it impossible to install separate bus infrastructure in this area (SSB, personal interview).

An electronic bus lane through the tunnel can ensure timekeeping and desirable travel times. Signaling solutions in front of both tunnel entrances need to allow the bus to stop the counter flow traffic and to decelerate traffic in the same direction, before entering the tunnel. The buses can then overtake the cars going in their direction on the counter flow lane and enter the tunnel as group leaders. This measure can work for both directions and accelerate the BRT buses. Additionally, it will significantly slow down car traffic, making the advantages of using the bus visible to car users.

8.3.3.2 Electronic Bus Lane BRT Line 2

To achieve the desired average speed of BRT buses on BRT Line 2, prioritization measures at potential bottlenecks need to be installed. Again, space is scarce on this route, making the installation of separate built infrastructure comparably complex. The buses meet those bottlenecks when entering the urban district Degerloch (*Fig. 22*) in the north and the densely-populated areas of the inner basin of Stuttgart in the south (see Appendix VI – yellow boxes).

Figure 22: Bottleneck Degerloch (Source: Google Street View)

The installation of electronic bus lanes at junctions at the entrance of those more densely populated areas on the line, can be highly beneficial for the average speed and travel times of the BRT buses.

8.4 Summary

The three BRT lines proposed within the development of the BRT concept have visualized the potentials of BRT in Stuttgart and provided a baseline for further planning approaches and in-detail investigations. Further possibilities or different solutions are easily conceivable, but could not be researched within the limited timeframe of this project.

The described acceleration and prioritization measures are crucial for achieving an efficient BRT service in Stuttgart. With separate infrastructure not being possible everywhere, intelligent solutions can help to reach a high service level on bus based public transport.

Whereas a significant share of separate bus infrastructure is feasible for BRT Line 1 and BRT Line 3, BRT line 2 is more a BRT-Lite approach because of the topographic conditions and existing space limitations. Nonetheless it can still be an improvement and justifiable supplement to the existing network, particularly together with BRT Line 1.

9. Discussion and Conclusion

The research has proven, that the main problems of Stuttgart derive from the high number of cars that drive into, out of or across the city every day. Together with a public transportation network that is either at its capacity limit or for various reasons not attractive enough to act as a real alternative, this significantly challenges the overall sustainability of the city. Problems that are similarly inherent to many other major cities across the globe.

In the analysis sections, together with the BRT conceptualization it was outlined, that BRT can be a potential solution for tackling the unsustainability of Stuttgart by improving the urban transportation sector. Despite space limitations and topographic restraints, it is technically possible to achieve a high service quality if intelligent solutions are implemented and buses are constantly prioritized. Depending on how or where the BRT system is implemented, it can have a positive effect by releasing pressure from the urban rail network, providing fast and more direct connections to certain urban areas that are worthy of improvement, positively influencing the service quality of high-demanded bus routes or lowering the number of commutes by car. At the same time, with taking away space from cars and using it for public transport it becomes even less attractive to use the car within the city. An alternative is provided while at the same time the causes are fought, which can be considered as a more desirable approach than just banning certain car types from driving into the city.

Besides the potentials of BRT for Stuttgart, it will not be a simple task to get such a project on the way. One of the most crucial steps to implement BRT in Stuttgart, is to get all necessary actors involved and the different perceptions, especially those of the detractors, aligned. This needs to happen up to a degree, where BRT is established as a seriously considered alternative among the decisive actors. The overview of actors and their roles and perceptions has paved the way for exploring a strategy to align them and advance the idea of BRT in Stuttgart. Promoting the concept of BRT by outlining its potentials is one of the key tasks that can help to convince actors. In connection with this, the perception of metro-like Latin American BRT systems needs to be changed and the systems need to be seen in the European context, not for substituting the urban rail systems, but for supplementing them and closing the gap between rail and bus. Additionally, a strong leading actor is needed for bringing such a project on the way. With the local public transport operator SSB such an actor is generally existent in Stuttgart, despite being not thoroughly convinced of the idea of a BRT system for Stuttgart. Above that, BRT approaches in Germany need to be supported by a legal framework that creates equal evaluation frameworks for all public transport system types which is currently not the case.

More dedication to give space to public transportation and consequently invest in the necessary infrastructure to make it an attractive option is crucial. The target needs to be to fight the causes not the symptoms. The latter is currently done with proposing driving bans for cars, without providing new alternatives. A real strategy on how to get this in the mind of decision-makers could not be provided within this research. The main reason for that, were a certain fear or stubbornness when it came to the topic of taking away space for cars that almost all actors shared. Therefore, the topic was not discussed to the desired extent. Furthermore, the role of the strong automobile industry could not be evaluated to a degree that would have been necessary to inform improvement strategies. This can be expected to have the extent of a project of its own.

Nonetheless, new technologies, such as electric and autonomous driven buses can further improve the attractiveness of bus based public transport and initiate a new wave of public transport solutions including BRT. Signs of rising interest among actors have been discovered within the research, which can be built upon.

The mere implementation of a BRT system will neither make Stuttgart nor any other city a thoroughly sustainable city. More improvement measures across all sectors of urban life need to be implemented. Yet, it can it can fight unsustainability and induce an urgently needed and cost-efficient system change in one of the most important urban subsystems to have less cars, less air pollution, less congestion and a higher quality of life. This can be concluded for Stuttgart as for any other city with similar problems and the potentials to have a BRT system implemented. The flexibility of BRT or BRT-like systems allow adaptations to the respective urban context. New approaches are necessary, while proving that they work can entail other new approaches and more courage among the local actors to promote and try them.

The findings of this report are not cast in stone. There might be even more actors involved and the analyzed perceptions of actors or actor groups can be subject to change, or differ even within an actor group. Also, the balance of power between the actors can play a significant role, but was hard to explore as information on this was scarcely provided and complex to explore from the outside. The nature of this report with analyzing a potential project, that is neither implemented nor definitively planned was the main reason for those limitations. The results of the actor analysis can inform similar types of analyses for other cities, but cannot be entirely generalized. Actor structures vary widely across projects, cities and countries.
Data availability limited the depth of the BRT concept, as in-detail data especially on the public transport ridership or traffic models were not accessible. It remains a rough concept where further work needs to be carried out to proof its feasibility. Still, visualizing and explaining the benefits and possibilities BRT offers to Stuttgart, can help to align the actors.

It can be concluded that Stuttgart suffers from a high degree of unsustainability in the transport sector and the planned measures for reducing car traffic as well as for improvements of the public transportation infrastructure appear to not have the potential to seriously improve the situation. A BRT for Stuttgart has the characteristics to mark the start to an urgently necessary system change. Potentials for BRT are clearly given, however the process of implementing it will be a highly difficult one. All necessary actors need to be involved, which will need a lot of effort, persuasion and above all local driving forces. In addition to that, a stronger willingness to take more radical steps, especially when it comes to taking away car infrastructure for improving public transport, is crucial for advancing the BRT project. If a BRT project would be realized in a major city in Germany, it could push the nationwide

development of the concept as a sustainable and efficient public transportation option for urban areas.

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Appendix

Appendix A: Internal Document

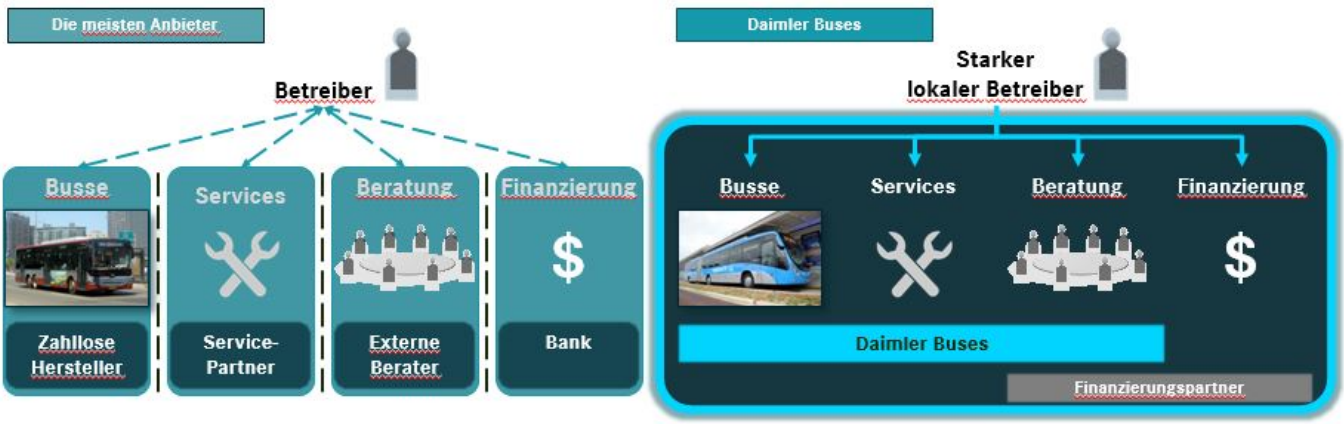
This document contains relevant information and data of the EvoBus GmbH/Daimler Buses as well as notes from own work experience (cited in text as “internal document”).

Förderung

Maßnahme	Baden-Württemberg Förderquote: 50%
Verkehrswege Bussystem (BRT bzw. BHLS)	✓
Omnibusspur	✓
LSA-Priorisierung	✓
Telematiksysteme	✓
Haltestelleneinrichtungen	✓
Betriebshöfe, zentrale Werkst.	✓
Omnibusse	✓
Barrierefreie Infrastruktur	✓

- Förderung von BHLS-Systemen grundsätzlich möglich (analog zu Frankreich)
- Seit Ende 2015 werden explizit BHLS-artige Systeme vom Land gefördert
- Deutliche Entlastung der kommunalen Haushalte gegenüber Schienenprojekten

Daimler Buses bietet ein Komplettpaket mit Fahrzeugen, Dienstleistungen, Beratung und Finanzierung an



I.5: Information on electric and autonomous driven buses:

- Mercedes-Benz starts producing their first fully electric city bus in 2018; other manufacturers are already pushing into the market (BYD, Volvo)
- BRT systems currently discussed in Germany will potentially be the first fully electric BRT systems worldwide
- The (semi-) autonomous city bus "Future Bus" was presented in spring 2016 and is running successfully on a BRT lane in Amsterdam to the present day. Such developments are expected to come to the production stage within the next 10 years.

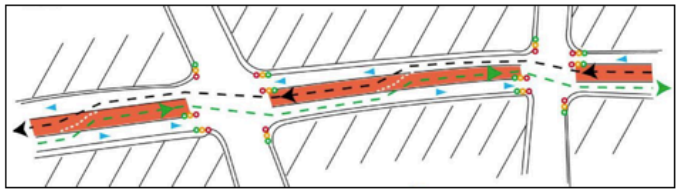
Einstreifige Busspur

Busspuren in Bereichen mit Platzmangel

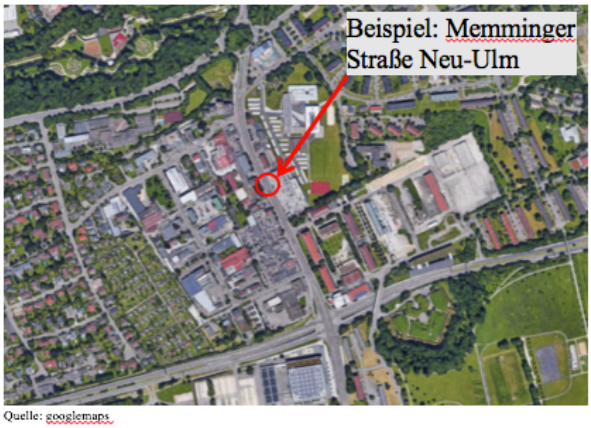
Bild: BRT in Rouen (Frankreich)

- **Eine einstreifige Busfahrspur in mittlerer Position kann für beide Richtungen benutzt werden, wenn intelligente Priorisierungslösungen implementiert werden**

- Ziel der Maßnahme:
  - Alternierende Busspur als Maßnahme, um die Reisegeschwindigkeit zu erhöhen
  - Eine einstreifige Busspur kann für beide Richtungen genutzt werden



Separate Busspur



Quelle: googlemaps

- Ziel der Maßnahme:
  - Verhinderung von Staus durch Trennung vom übrigen Verkehr
  - Gewährleistung hoher Fahrplantreue
  - Attraktive Reisezeiten

BRT-Korridor Nantes

Appendix B: Interview Guides & Summaries

I. Interviewleitfaden & Summary: Hr. Wolfgang Forderer, Hr. Dr. Nicolas Leyva

(Interviewguide: Mr. Wolfgang Forderer, Dr. Nicolas Leyva)

Qualitatives Interview mit den Herren Wolfgang Forderer (Leiter Abteilung Mobilität bei Stadt Stuttgart) und Dr. Nicolas Leyva (Abteilung Mobilität bei Stadt Stuttgart) über die Verkehrssituation, Öffentlichen Nahverkehr und BRT-Potenziale in Stuttgart.

(Qualitative interview with Mr. Wolfgang Forderer (Head of City of Stuttgart Mobility Department) and Dr. Nicolas Leyva (City of Stuttgart Mobility Department) about the traffic situation, public transport and BRT potentials in Stuttgart.)

Das Interview wird halb-strukturiert sein. Beide Personen werden als lokale Experten für Mobilität und Verkehr in Stuttgart interviewed.

The interview will be semi-structured. Both persons will be interviewed as local experts for mobility and transport in Stuttgart.

Intro:

- **Vorstellung meinerseits, der Firma, der Thesis und meiner Ziele**
  (Introduce myself, the company, the thesis topic and what I aim for with my thesis)
- **Fragen ob ich das Interview aufnehmen kann und die Namen als Quellen nennen (kann auch anonymisiert werden)**
  (Ask if it is okay to record the interview and to cite the names in the thesis (If not I will make it anonymous)
- **Ich schlage vor wir beginnen mit einer kurzen Vorstellung von Ihnen und Ihrer Arbeit.**
  (I suggest we begin with a short introduction of you and your workfield)
- **Einstieg mit aktuellen Diskussionen in der Presse (Fahrverbote, Klage, Blaue Plakette)**
  (Start with some buzzwords from press articles, blue stickers, driving ban and lawsuits)

Fragen (Questions):

1. **Könnten sie mir zum Einstieg einen groben Überblick zur aktuellen Situation und politischen Lage rund um Luftverschmutzung, Feinstaub und Verkehrsprobleme in Stuttgart geben?**
   (To begin with, could you give me an overview of the current (political) situation around air pollution, smog and traffic problems in Stuttgart?)

2. **Wo sehen sie die größten Probleme hinsichtlich der aktuellen Verkehrssituation in Stuttgart?**
   (Where do you see the biggest problems with regard the current traffic situation and transport infrastructure in Stuttgart?)

3. **Gibt es Ihrer Ansicht nach (offensichtliche) Probleme oder Verbesserungs-möglichkeiten speziell im ÖPNV?**
   (Do you see any obvious problems or necessary improvements particularly in the city's public transport?)

4. **Ist nach Ihrer Meinung grundsätzlich BRT-Potenzial in Stuttgart vorhanden?**
   - Falls ja, können Sie sich einige spezielle Linien/Straßen/Bereiche vorstellen wo dies besonders sinnvoll oder die besonders geeignet wären?
   - Falls nein, warum?

   (In your opinion is there a potential for BRT in Stuttgart? If yes, can you imagine any routes/streets/areas where this could be especially useful? If not, why?)

5. **Wo sehen sie die größten Hindernisse in Bezug auf die Planung bzw. Umsetzung eines solchen BRT-Systems in der Stadt Stuttgart?**
   - Technisch, politisch, finanziell, rechtlich, betreiberseitig?

   (What are the major hindrances with regard to the implementation of a BRT-System in Stuttgart? Technical/Political/Economical/Operational?)

6. **Welche sind die wichtigsten Akteure die in solch einem Projekt involviert sein müssen? Welche wären eher für, welche eher gegen ein solches Projekt?**

   (Who are the main actors that need to be involved in such a project in Stuttgart? Which ones would be in favor of such a project and which ones might be opposed?)

Background notes for myself:

Q. 1: Discussion about blue environmental badge, ban for diesel cars built earlier than 2016….

Q.2: Many of the important connections go through the city center respectively the basin; lack of tangential connections or a ring road?

Q.3: Gap between urban rail and conventional bus-service, buses are constantly in traffic jams, capacity of urban rail is already exceeded at peak hours

Q.4: In my opinion it is; Potential streets for separate buslanes are mentioned in the NVP; It has been in discussion already

Q.5: Lack of space? Taking away space from cars? Strength of the city's car industry? Concerns at side of the SSB (public transport operator)?

Summary/Notes: Mr. Leyva & Mr. Forderer

Q.1: Do you see any obvious problems or necessary improvements particularly in the city's public transport?)

- Overall the public transportation infrastructure is very good, the quality of buses and urban rail are on a high level (personal remark: I do not totally agree with that, personal experiences as well as research has shown that buses and even the rail are often stuck in traffic jams and overcrowded on the main routes – the rail has capacity problems)

- Even the commuter trains are of high quality, despite their obvious punctuality problems

- There are just a lot of jobs connected to the car and jobs where people depend on their cars

- Even the reduction of public transport ticket prices (-50%) on "Feinstaubalarm" days did not have a significant impact on the use of cars

Q.2: In your opinion is there a potential for BRT in Stuttgart? If yes, can you imagine any routes/streets/areas where this could be especially useful? If not, why?

&

Q.3: What are the major hindrances with regard to the implementation of a BRT-System in Stuttgart? Technical/Political/Economical/Operational?

- Buses are only one of the public transportation modes in Stuttgart, whereas the focus is strongly on the urban rail (Stadtbahn), which has been continuously extended since the 1960's

- Especially in the „Stuttgarter Kessel" (basin) bus transport is subordinate for the city's public transportation and acts more as a supplement to urban rail while connecting areas of the city that are poorly or not connected to the urban rail

- The city has already installed buslanes where it is possible (personal remark: that is most definitely not true)

- Busses and trains have signal priority where it is possible (personal remark: that doesn't help if they are stuck in traffic jams)

- A problem regarding BRT is, that there not many main roads that are wide enough for BRT, and if so they are often rather short. Moreover if people think about BRT in Germany, they have the big Latin American systems in mind which are normally not adaptable to the European urban context (personal remark: I agree with this, which is why if we think of BRT in Stuttgart the French BHLS systems should be the paragon)

- Nevertheless, besides the technical issues (space etc.), it is a political question and especially a question of willingness on sides of the SSB (main public transport provider in Stuttgart) to offer or to try implementing a BRT system. In the end it is not the City of Stuttgart who decides but other actors, mainly the SSB

- The SSB is developing its own systems and is investing a lot of money, especially in its rail infrastructure which is why there might be little interest there to try something new . However this does not mean that there is no BRT potential in Stuttgart

- It is a political and strategic question that we in this department cannot answer right now

- Technically there are a lot of possibilities as also shown by your company, what is missing so far is the direct connection to the circumstances in Stuttgart

- Potential routes could be Wagenburg- and Talstraße, Cannstatter Straße or areas not connected to the urban rail, but this needs to be further examined

Q.4: Who are the main actors that need to be involved in such a project in Stuttgart? Which ones would be in favor of such a project and which ones might be opposed?

- The planning departments of the city of Stuttgart, including the mobility department with all its employees is definitely not opposed to the idea of a BRT, but the evaluation of suchs systems is only one part of our daily work, which is why it also does only get a part of our attention

- Even the car industry might not be opposed to public transportation or BRT. There is rising awareness that everybody needs to act more sustainable which is why Daimler and Porsche (personal remark: Daimler and Porsche are based in Stuttgart) have done a lot of things to promote the use of public transportation among their employees but also their customers (e.g. job tickets and other benefits) and they also support the City of Stuttgart and promote sustainable mobility

- What really hurts the car industry way more than public transportation projects are the driving bans that are heavily discussed right now

- But again, in a potential BRT project for Stuttgart it is not the mobility and planning departments of the City that make final decisions but the public transport operators

- The SSB has its own interests and a strategy where the topic BRT did not play a role so far. The backgrounds for this development are hard to evaluate from our viewpoint. Maybe it is because of their strong rail focus….furthermore they are at moment very busy with modernizing their bus fleet and get rid of the old Euro 3 Diesel buses and change to Euro 6 Diesel or Hybrid vehicles

- Another important actor is the VVS (Verkehrs- und Tarifverbund der Region Stuttgart – linked transport system authority for the whole region) who is an important partner when it comes to transportation and infrastructure topics and incorporates all of the important public transport operators in the region. From this point it is hard to hard to make a statement regarding their position

- Definitely problematic in Stuttgart are the car users themselves. It seems like a cultural problem, maybe deriving from the car manufacturing history of the region and potentially influenced by the powerful car industry and the huge amount of jobs they offer in the region, that people in Stuttgart just like to use and own a car even if they do not necessarily depend on them and would probably even be faster by using public transport (at least in the city center)

- A recent case where one car lane was removed and cycling infrastructure was installed (on Cannstatter Straße) has shown that there is a strong opposition on sides of the users when it comes to taking away space from cars, as the City received a big amount of complaints by angry car users

Q.5: Could you give me an overview of the current (political) situation around air pollution, smog and traffic problems in Stuttgart?

- Smog ("Feinstaub") and overall air pollution are the most important topics, whereas nitrous oxides are a much bigger problem than the "Feinstaub"; The latter is more or less under control and is also a spotty problem with a positive tendency. The term "Feinstaubalarm" is more of a working title, standing for the overall air pollution and especially nitrous oxides which are harder to reduce than "Feinstaub" → the City is trying hard to fight this

- The problem will exist as long as the car industry cannot handle it

- The city of Stuttgart has requested a catalogue of measures and an impact analysis on potential solutions, with the outcome that a blue environmental badge is the most efficient solution (personal remark: this badge is a blue sticker for the windscreen, that a car can only get if it has the latest EURO 6 engines → we already have that systems with green, yellow and red badges…depending on the city, cars are not allowed to enter the city if they do not have a badge in the requested color). But neither

the federal state (Baden-Württemberg) nor the city has the legal competencies to introduce this badge and the German government is strongly opposed to this idea

- The strong car industry and their lobby has a big influence and own interests in these processes

- As the blue badge is off the table, the City of Stuttgart is now planning to ban polluting cars (< EURO 6) on certain roads or sections in the City if smog-alarm is called out. As it is not covering the whole area, the city has the compentencies to do so and is now in the process of developing a concept

- Hopefully these discussions will lead car users as well as public transport operators to switch to alternative drivetrains

Q.6: Where do you see the biggest problems with regard the current traffic situation and transport infrastructure in Stuttgart?

- A minor problem is that most important connections go directly through the central basin

- The major problem is the structure of the region with many dispersed small- to medium-sized cities around Stuttgart in connection with the huge amount of jobs in Stuttgart itself. More than 400.000 cars commute in and out of the city on a daily basis, which is a huge number compared to other german cities

- Commuting is a given process that cannot and should not be stopped, but alternatives to the polluting car transport need to be determined and provided, e.g. public transport or cycling

- Regarding the statistics about the congestion in Stuttgart and the city's reputation as the congestion capital of Germany one needs to be careful because a lot of the traffic jams are measured on the "Autobahn" around Stuttgart and not in the city itself (personal remark: As is could see myself and hear from my many colleagues who live in Stuttgart, congestion is definitely also a huge problem in the city center, also for public transport)

II. Interviewleitfaden & Summary: Hr. Dipl. Ing. Peter Sautter

(Interviewguide: Mr. Peter Sautter)

Qualitatives Interview mit Herr Dipl. Ing. Peter Sautter (Verkehrsplaner in Stuttgart) über die Verkehrssituation, Öffentlichen Nahverkehr und BRT-Potenziale in Stuttgart.

(Qualitative interview Mr. Peter Sautter (Stuttgart based transportation engineer) about the traffic situation, public transport and BRT potentials in Stuttgart.)

Das Interview wird halb-strukturiert sein. Herr Sautter wird als lokaler Experte für Mobilität und Verkehr in Stuttgart interviewed.

The interview will be semi-structured. Mr. Sautter will be interviewed as a local expert for mobility and transport in Stuttgart.

Intro:

- **Vorstellung meinerseits, der Firma, der Thesis und meiner Ziele**
  (Introduce myself, the company, the thesis topic and what I aim for with my thesis)
- **Fragen ob ich das Interview aufnehmen kann und die Namen als Quellen nennen (kann auch anonymisiert werden)**
  (Ask if it is okay to record the interview and to cite the names in the thesis (If not I will make it anonymous)
- **Ich schlage vor wir beginnen mit einer kurzen Vorstellung von Ihnen und Ihrer Arbeit.**
  (I suggest we begin with a short introduction of you and your workfield)
- **Einstieg mit aktuellen Diskussionen in der Presse (Fahrverbote, Klage, Blaue Plakette)**
  (Start with some buzzwords from press articles, blue stickers, driving ban and lawsuits)

Fragen (Questions):

1. **Wo sehen sie die größten Probleme hinsichtlich der aktuellen Verkehrssituation in Stuttgart?**
   (Where do you see the biggest problems with regard the current traffic situation and transport infrastructure in Stuttgart?)

2. **Gibt es Ihrer Ansicht nach (offensichtliche) Probleme oder Verbesserungs-möglichkeiten speziell im ÖPNV?**
   (Do you see any obvious problems or necessary improvements particularly in the city's public transport?)

3. **Wo würden sie als Erstes ansetzen um die Verkehrssituation in Stuttgart zu verbessern, falls ihnen unbegrenzte Mittel zur Verfügung stünden?**

   (Where would you put the lever to improve the traffic situation in Stuttgart, if you would have unlimited resources?)

4. **Ist nach Ihrer Meinung grundsätzlich BRT-Potenzial in Stuttgart vorhanden?**
   - Falls ja, können Sie sich einige spezielle Linien/Straßen/Bereiche vorstellen wo dies besonders sinnvoll oder die besonders geeignet wären?
   - Falls nein, warum?

(In your opinion is there a potential for BRT in Stuttgart? If yes, can you imagine any routes/streets/areas where this could be especially useful? If not, why?)

5. **Wo sehen sie die größten Hindernisse in Bezug auf die Planung bzw. Umsetzung eines solchen BRT-Systems in der Stadt Stuttgart?**
   - Technisch, politisch, finanziell, rechtlich, betreiberseitig?

   (What are the major hindrances with regard to the implementation of a BRT-System in Stuttgart? Technical/Political/Economical/Operational?)

6. **Welche sind die wichtigsten Akteure die in solch einem Projekt involviert sein müssen? Welche wären eher für, welche eher gegen ein solches Projekt? Wer müssen die treibenden Kräfte sein?**
   (Who are the main actors that need to be involved in such a project in Stuttgart? Which ones would be in favor of such a project and which ones might be opposed?)

7. **Welche Einstellung hat die politische Führung der Stadt zu solch einem Konzept?**
   (Regarding the political decision-makers in Stuttgart, which attitude do you think they have towards such a concept?)

Summary/Notes: Mr. Sautter

Legend – Information for ANT use:
Blue = politicians/policies
Pink = public/users
Orange = Verband Region Stuttgart (VRS)
Red = SSB
Green = (Car-)industry

General Information about the status quo, recent discussions and political decisions:

- *Not particulate matter but nitrous oxides are the biggest problem and most harmful*
- *Driving bans will punish the wrong people – not the big expensive SUV's but the people with older cars that have to rely on it*
- *Political decisions like that do not find acceptance among the public*
- *Banning Diesel but allowing petrol is a bad solution and the wrong approach*
- *But the quality of electric cars at this point is also not sufficient – especially with regard to the range*

Information regarding the traffic and public transport situation in the city:

- *The biggest problem is definitely the vast number of cars and in connection with this the insufficient capacity of public transport*

- *Urban rail is good, but the capacity is maxed out and hard to further extend; commuter rail is not reliable, so there are improvements needed; the most useful step now would be to improve bus transport*
- *The commuter rail is very unreliable, especially recently with the construction works for S21 it is prone to disorders*
- *S21 will not help to improve and increase the public transport performance*
- *Too many cars, too many pollutants and no real alternatives; serious improvements of public transport are not recognizable; the commuter rail is stuck to the current level even if it needs renovation in many areas; overall, the mid-term perspective is missing*
- *The alternative route for the s-trains in case of disorders will be dropped after the finishing of S21 which will make it even more disorder-prone*

Information with focus on bus-based PT:

- *The bus-based public transport in Stuttgart is hindered by car traffic*
- *Rethinking is crucial – just normal signal priority is not sufficient, the bus needs full priority which is only possible if the buses can drive separate from the normal traffic, e.g. through BRT/separate bus lanes or at least "Busschleusen"*
- *Installing BRT in city centers in Germany is difficult, because the streets are often not wide enough (e.g. compared to the boulevards/alleys in france)*
- *Besides the technical issues, it is also politically difficult in Germany – in France they decide and do things without taking much care about the needs of car users which is not happening in Germany*
- *The car users need to SEE and realize that buses are faster – as long as the buses are as vulnerable to congestion as the cars there is no time benefit by using the bus – if the car drivers are clever they can even use the signal priority of buses to drive through junctions behind them*
- *Stadtbahn is faster than cars, but also lacks the visibility effect in the congested parts, because its often underground or out of sight*
- *Bus has a bad perception in public – slow, dirty, uncomfortable, with a more systematic approach most of these problems could be solved though*
- *Another problem: BRT is not a well-known concept among the German public, e.g. perception that standard city buses cannot use the BRT lanes; if it is argued that all buses can potentially drive on a BRT lane, then people tend to think "well, than its just a normal slow, dirty, uncomfortable bus"*

Information with focus on BRT, new concepts and actors :

- *Politicians are not ready to try a new concept for Germany, which would also be important as a showcase. They rather stick with the proven urban rail concepts, they have certain experience with, even though it often takes more than 10-15 years to realize those*
- *Decisions for a certain concept are often made without considering things like the actual demand, the financial possibilities, the urban landscape and what would be the most suitable solution with the best effects, both short- and long term just because another*

concept is well known, operators and cities have experience with it etc. --- this is a very political problem as well

- *the german "Standardisierte Bewertung" (note which is used to evaluate infrastructure projects) does not include bus-/BRT-systems, but only rail projects*
- *For Stuttgart: Instead of extending the Stadtbahn e.g. to the airport, the money could better be used to improve the bus transport in the city center, where the positive effects would be much stronger and much more visible, especially if the buses are then running on alternative drivetrains*
- *It is difficult in Stuttgart because of space limitations, consequently taking away space from cars has to be part of the solution*
- *German legal regulations also state, a separate bus lane has to be implemented if more than 20 buses an hour are running on it, which is unrealistic in the context of most german cities, especially those that have urban rail and the bus transport acts as a supplement to it*
- *Crucial in the process of rethinking the current way planning in the city is to plan public transport and also cycling in a way that it becomes a real alternative to the car, and then it becomes placeable to take away lanes for cars etc. – a lot of opposition of the public comes from the fact that car lanes are taken away without providing serious alternative – then it just leads to more congestion and pollution*
- *Changing the way of planning is a moving process, whereas especially the politicians in BaWü are very conservative and often a bit sluggish who tend to promote car traffic more than any other means – they are often stuck to ancient thinking…even for the green leader in Stuttgart the urban rail is by far the best means of transportation which is why they are also not thinking about other concepts and solutions. Even with a policy that is promoting public transport a question that often remains unanswered is how to reach the best possible outcomes keeping in mind all important indicators…Out of box thinking and efficient "short-term solutions" can rarely be detected*
- *It is crucial to ask the question for the BEST and most suitable possible solution, which in certain cases could definitely be BRT (demand, financing etc, implementation time etc.)*
- *Commuting is a big problem in Stuttgart, a lot of high-paid jobs in the city which means that people come from all over Germany to work in the city and are also able to afford cars*
- *Electric driven cars are seen as one of the main factors to improve and air pollution situation in Stuttgart but they won't improve the congestion and space problems – parking is already rare which means that charging points are difficult to implement*
- *There was the planning paradigm in the 1960's that no connections (by bus) should be implemented parallel to the s-train network, which made sense 40 years ago but might need rethinking now; the s-trains do not have the necessary capacity to take more passengers which becomes a big problem if driving bans are realized, because there are no alternatives to the car to get into the city; a higher capacity is needed to get people from the outskirts to the city but neither the regional transit nor the s-trains can carry it; an alternative could possibly be express buses, but not in areas with no capacity problems as done recently (Relex busse) but in areas where there are serious problems and ones that drive INTO the city, buses not only to the s-train stations and the citys edge but into the center – however it is difficult from an economic perspective as this might only be necessary in peak hours*

- *Also the VRS (Verband Region Stuttgart) is stuck to his old ways of thinking and the political framework doesn't allow necessary changes (the current system is at the edge of collapsing no matter where you look – rush hours are not 1 hour in the morning and 1 hour at the evening anymore, but more like 3 hours in the morning and 3 hours in the afternoon) they also seem to be not too interested in promoting bus, as their main task is coordinating rail transport*
- *The question where there is the will to be involved in new approaches that are not necessarily directly their responsibility*
- *SSB also tends to prefer extending the Stadtbahn before anything else, because they can get more subsidies there – cross-system thinking is also not very common at the SSB as well as on the political level*
- *Different perceptions within the SSB AG towards BRT can be detected – some are more open for such ideas, some are clearly opposed*
- *However, the SSB has put a lot of capacities into planning their bus transportation, so they show signs of wanting to improve – especially because the possibilities to extend the Stadtbahn are rare, there might be a glimpse of rethinking – they also think about shared bicycle/buslanes – redefine definitons in order to get permits etc…*
- *There is also another wrong approach connected to the whole Feinstaubthematik: The situation needs to be improved and alternatives to the car have to be provided every single day of the year, not just on days where the limits of the air pollution values are exceeded – just focusing on the limit values only is totally wrong – you need to provide quality alternatives that are widely recognized as such – but there seems to be a lack of consequence in the way politicians in the city think when it comes to these topics*
- *Mr. Sautter is trying since 20 years to promote BRT put the will to think different is hardly there and this could be the most difficult thing for traffic planners to start new things*
- *Regarding the economics, there is enough money, but it is spend wrong*
- *Especially in Stuttgart the car industry is very influential*
- *One would expect that driving bans hurt the industry more than taking away space for cars in city, even if a driving ban might have a short-term positive effect – in the long-term they will suffer from that*
- *The dedication of the car industry to improve their overall concepts also seems to be very small – even if it should be clear that the car industry will suffer in the mid- or long-term view if they continue as they do now, a lot of jobs will get lost and with the jobs also the customers…so one should expect that the willingness to not only improve the cars but also to help finding more sustainable infrastructure solutions should be bigger than the opposition towards it*
- *A serious outlook into the future "How will our world look like in 25 years" also seems to be missing in the industry*
- *Regarding the politics it needs to be said, that Baden-Württemberg is the only federal state in Germany that subsidizes bus lanes, so despite the whole old-thinking thing, there is also a glimpse of change*
- *It is very difficult for planners to find other people to discuss new and progressive approaches and new ideas with you and are willing to put them forward*

Technical information/Potential routes:

- *Potential routes: Wagenburgstraße/Talstraße, Stadtbahnen on the western axles leading into the city (like Pitschekstraße/Weinsteige) so there is a low potential, tangential connections possible, Rothebühlstraße, Birkenwaldstraße (Killesberg), Kriegsbergstraße (KH – Naturkunde Museum) – there are definitely areas where it is possible, maybe not area covering on separate infrastructure but in parts where it could be done with the necessary consequence*
- *Many knots are not capable to carry the traffic, existing bus lanes often end 30-40 meters before the actual junction, again a lack of consequence here and also a reason for the lack of capability*

III. Interviewleitfaden & Summary: Hr. Christian Beck (VRS)

(Interviewguide: Mr. Christian Beck)

Qualitatives Interview mit Herr Christian Beck (Verkehrsreferent, Verband Region Stuttgart) über die Verkehrssituation, Öffentlichen Nahverkehr und BRT-Potenziale in Stuttgart.

(Qualitative interview with Mr. Christian Beck (Verkehrsreferent, Verband Region Stuttgart) about the traffic situation, public transport and BRT potentials in Stuttgart.)

Das Interview wird halb-strukturiert sein. Herr Beck wird als lokaler Experte für Mobilität und Verkehr in Stuttgart interviewed.

The interview will be semi-structured. Mr. Beck will be interviewed as a local expert for mobility and transport in Stuttgart.

Intro:

- **Vorstellung meinerseits, der Firma, der Thesis und meiner Ziele**
  (Introduce myself, the company, the thesis topic and what I aim for with my thesis)
- **Fragen ob ich das Interview aufnehmen kann und die Namen als Quellen nennen (kann auch anonymisiert werden)**
  (Ask if it is okay to record the interview and to cite the names in the thesis (If not I will make it anonymous)
- **Ich schlage vor wir beginnen mit einer kurzen Vorstellung von Ihnen und Ihrer Arbeit.**
  (I suggest we begin with a short introduction of you and your workfield)
- **Einstieg mit aktuellen Diskussionen in der Presse (Fahrverbote, Klage, Blaue Plakette)**
  (Start with some buzzwords from press articles, blue stickers, driving ban and lawsuits)

Fragen (Questions):

1. **Gab oder gibt es in der Region Stuttgart irgendeine Art von BRT-Bestrebungen (außer LB)?**
   (Where do you see the biggest problems with regard the current traffic situation and transport infrastructure in Stuttgart?)

2. **Ist nach Ihrer Meinung grundsätzlich BRT-Potenzial in der Region Stuttgart vorhanden?**
   - Falls ja, können Sie sich einige spezielle Linien/Straßen/Bereiche vorstellen wo dies besonders sinnvoll oder die besonders geeignet wären?
   - Falls nein, warum?

   (In your opinion is there a potential for BRT in the Stuttgart area? If yes, can you imagine any routes/streets/areas where this could be especially useful? If not, why?)

3. **Wo sehen sie die größten Hindernisse in Bezug auf die Planung bzw. Umsetzung eines solchen BRT-Systems in der Region Stuttgart?**
   - Technisch, politisch, finanziell, rechtlich, betreiberseitig?

   (What are the major hindrances with regard to the implementation of a BRT-System in the Stuttgart area? Technical/Political/Economical/Operational?)

4. **Welche sind die wichtigsten Akteure die in solch einem Projekt involviert sein müssen? Welche wären eher für, welche eher gegen ein solches Projekt? Wer müssen die treibenden Kräfte sein?**

(Who are the main actors that need to be involved in such a project in Stuttgart? Which ones would be in favor of such a project and which ones might be opposed?)

5. **Können sie mir etwas über die historische Entwicklung des ÖPNV in der Region Stuttgart und eventuelle Leitbilder (seit der Nachkriegszeit) erzählen?**
   (Could you tell me a little bit more about the historic development of public transport and transport policies in the area (after WW II)

6. **Ist die S-Bahn überlastet? Wenn ja auf welchen Abschnitten?**
   (Does the commuter rail have capacity problems? If yes, where exactly?)

7. **Gibt es Pläne zum Ausbau der S-Bahn? Dabei weiterhin eine Konzentration auf das Zentrum oder eher ein Ansatz der Verkehrsströme verteilt?**
   (Are there plans to extend the commuter rail network in the near future?)

8. **Wird es als Möglichkeit gesehen, entgegen des ursprünglichen Leitbildes den ÖPNV z.B. in Form von Bussen parallel zu S-Bahn Linien zu fördern um dadurch mehr Pendlern eine Alternative zu bieten?**
   (Is there a possibility to install public transport routes parallel to the existing s-train lines, to give commuters an alternative)

9. **Warum waren wirkliche BRT-Elemente (eigene Spuren o.ä.) nie ein Thema für die Relex-Busse? Und warum diese Linienwahl?**
   (Why were "real" BRT-elements (separate lanes etc.) never in discussion for the Relexbuses? And what were the most important points for choosing the actual routes?)

10. **Gibt/Gab es Diskussionen bezüglich einer möglichen Nutzung des Pannenstreifens für den Busverkehrs**?
    (Are/were there any discussions regarding the use of service lanes for buses driving on the Autobahn?)

11. **Wie bewerten sie den Erfolg der Relexbusse seit ihrer Einführung/Sind sie zuverlässig und pünktlich? (Blog: Schleichwege)**
    (Would you say the Relexbuses are successful since their implementation? Are they reliable and punctual?)

12. **Wie sieht es bezüglich der prognostizierten und tatsächlichen Nachfrage aus?**
    (Is there a gap between the forecasted and the actual demand?)

13. **Gibt es Pläne zu einer Erweiterung des Netzes?**
    (Are there any plans to extend the network?)

Summary/Notes: Mr. Beck

1. **Gab oder gibt es in der Region Stuttgart irgendeine Art von BRT-Bestrebungen (außer LB)?**
   (Are there any BRT considerations within the Stuttgart region?)

   - *BRT is a new topic in the region, that has not been present until recently (because of Ludwigsburg)*
   - *Guided buses have been in the mind of some people years ago, f.ex. in Esslingen*
   - *But the policy in the region is to have normal buses or urban rail*
   - *LB – Esslingen, Böblingen-Sifi do have a very dense citybus network*
   - *Bus lanes have been installed in many areas, but not separate buslanes in BRT-style*
   - *For the future it looks like the conventional approach to bus services with bus-only lanes in certain areas – i.e. in front of crossings/knots - will be continued*
   - *But BRT is not really playing a role in the planning considerations*
   -

2. **Ist nach Ihrer Meinung grundsätzlich BRT-Potenzial in der Region Stuttgart vorhanden?**
   - Falls ja, können Sie sich einige spezielle Linien/Straßen/Bereiche vorstellen wo dies besonders sinnvoll oder die besonders geeignet wären?
   - Falls nein, warum?

   (In your opinion is there a potential for BRT in the Stuttgart area? If yes, can you imagine any routes/streets/areas where this could be especially useful? If not, why?)

   - *High use of land of real BRT systems which is why the rail solutions are preferable in Stuttgart*
   - *Difficult in city centers because of the existing built infrastructure*
   - *Nonetheless, we definitely the BRT potentials in the area, especially for tangential connections*
   - *We had the idea to implement BRT or BRT elements on highly occupied axles, f.ex. on the route Ludwigsburg – Waiblingen…so it is a possibility to focus not only on the cities itself but also install separate lanes on regional level (Überland)*
   - *Perhaps at the side of conventional Landstraßen were space limitations are normally not given and Feldwege etc. already exists at the sides of the road*
   - *But for regional routes the BRT approach is definitely interesting and also for the city centers, as long as there is a possibility to have more different bus lines running on the BRT tracks*
   - *Because no extension of the s-bahn can be expected for a considerable time period I think that the potential for new bus-based concepts will be rising within the next years*
   - *Within the ÖPNV-Pakt it was mentioned that new buses should run on own infrastructure as far as possible*
   - *Big chances for BRT on regional tangential lines, where there cycling paths etc. right next to the main roads and where there is enough space – might be easier than in the city centers*

3. **Wo sehen sie die größten Hindernisse in Bezug auf die Planung bzw. Umsetzung eines solchen BRT-Systems in der Region Stuttgart?**
   - Technisch, politisch, finanziell, rechtlich, betreiberseitig?

   (What are the major hindrances with regard to the implementation of a BRT-System in the Stuttgart area? Technical/Political/Economical/Operational?)

- ***A lot of different players/actors in the region, VRS is allowed to plan and order bus lines in consent with the Landkreisen which have their own bus systems, as well as Gemeinden who can also influence the whole process → the VRS has to fight for the simplest forms of bus priority measures***
- ***So many different scenes including landscape protection etc.***
- *Often they face a low level of acceptance from the smaller municipalities because they are afraid that Public transport priority measures lead to more car congestion → so in their perspective private transport needs to be prioritized (e.g. because of noise etc.)*
- *Planning authorities, municipalities are afraid of doing some that is "negative" for private transport mainly because they fear that all those measure will lead to even more congestion etc.*
- *Just installing "normal" bus lanes in certain areas leads to more congestion, because those measures do not promote changing from private car to public transport*
- *It is less a problem of financing than a problem of who wants to build such an infrastructure – somebody needs to be content to build it, because we could pay it if we wanted to*
- *A big problem is the mentality that if I adversely affect car traffic, the problems with noise/congestion etc. just grow – it is not easy but also partly understandable because traffic is often simply relocated without offering real alternatives and without having real modal-splits effect towards PT*
- *Space is not the problem, not even in the city center – I see possibilities there, if you consider to also using the (green) median strips*

4. **Welche sind die wichtigsten Akteure die in solch einem Projekt involviert sein müssen? Welche wären eher für, welche eher gegen ein solches Projekt? Wer müssen die treibenden Kräfte sein?**
   (Who are the main actors that need to be involved in such a project in Stuttgart? Which ones would be in favor of such a project and which ones might be opposed?)

   - *VRS could be in a coordinating role but also as a funding unit – but normally only in an observatory position*
   - *From construction side it is the responsibility of the cities or the districts, depending on where the BRT would be, as well when it comes to the detailed planning*
   - *In the city of Stuttgart the situation is positive with the city as the building authority and the SSB, a municipal company, as the operator – So in theory it is rather easy, also it might be more difficult in practice*
   - *Even in the car industry and the ADAC it seems like they are starting to understand that private car use doesn't solve all the problems, that they are big problems connected to pollution (VW) and that public transport is an important alternative*
   - *Political decisions, such as driving bans cannot be the solution as long as no real alternatives are provided*
   - *Intermodal connections are very important*

5. **Ist die S-Bahn überlastet? Wenn ja auf welchen Abschnitten?**
   (Does the commuter rail have capacity problems? If yes, where exactly?)

   - *Yes, in the rush-hours the capacity of the s-trains is exceeded*

- *All S-trains meet in the S-Bahn-Tunnel in Stuttgart, where in the main hours there is a train every 2 ½ minutes*
- *The tunnel is full, the s-trains are not reliable/punctual*

6. **Gibt es Pläne zum Ausbau der S-Bahn? Dabei weiterhin eine Konzentration auf das Zentrum oder eher ein Ansatz der Verkehrsströme verteilt?**
   (Are there plans to extend the commuter rail network in the near future?)

   - *As there is no space for any more trains especially in the tunnel, the only extension plan is to use longer trains (+1 wagon) where it is possible, which is why 10 new wagons have already been ordered*
   - *It is really difficult to construct new rail lines – there is one extension planned within the next 5 years and in our perception this is last big extension for a longer period of time*
   - *A shift from the centralized star-shaped s-bahn network towards a network with tangential connections is a heavily discussed topic, as well as the centralized road infrastructure with 3 Bundesstraßen (B10, B14, B27) going through the city center of Stuttgart*
   - *Connection of old rail lines is also a possibility (f.ex. Korntal – Zuffenhausen – Markgröningen)*

7. **Wird es als Möglichkeit gesehen, entgegen des ursprünglichen Leitbildes den ÖPNV z.B. in Form von Bussen parallel zu S-Bahn Linien zu fördern um dadurch mehr Pendlern eine Alternative zu bieten?**
   (Is there a possibility to install public transport routes parallel to the existing s-train lines, to give commuters an alternative)

   - *Buses are not fast enough to be an alternative to S-trains on the same routes, but the situation is different if you compare buses with the trams; If done right buses could be a serious alternative*

8. **Warum waren wirkliche BRT-Elemente (eigene Spuren o.ä.) nie ein Thema für die Relex-Busse? Und warum diese Linienwahl?**
   (Why were "real" BRT-elements (separate lanes etc.) never in discussion for the Relexbuses? And what were the most important points for choosing the actual routes?)

   - *Mainly because it is very hard to implement separate buslanes on the desired routes*
   - *We tried to focus on higher comfort and better equipped buses, so that people can use the travel time to work etc. rather than to promote a fast connection*

9. **Gibt/Gab es Diskussionen bezüglich einer möglichen Nutzung des Pannenstreifens für den Busverkehrs**?
   (Are/were there any discussions regarding the use of service lanes for buses driving on the Autobahn?)

- *It was a discussion especially for the very congested areas on the Autobahn, but a big problem and the actual knockdown for the idea was the huge amount of construction works going on there currently because of Stuttgart 21 and Autobahn extensions*
- *Whenever it appears that such measures could be bad for private transport you usually have a strong opposition against them*

10. **Wie bewerten sie den Erfolg der Relexbusse seit ihrer Einführung/Sind sie zuverlässig und pünktlich? (Blog: Schleichwege)**

    (Would you say the Relexbuses are successful since their implementation? Are they reliable and punctual?)

    - *They have a good number of passengers, of course they are sometimes late because of traffic jams but we are constantly looking for alternatives to the existing routes, e.g. small parallel roads to the big roads*
    - *On problematic parts we have alternative routes in our plans, to make the buses less exposed to traffic jams and other problems*

11. **Wie sieht es bezüglich der prognostizierten und tatsächlichen Nachfrage aus?**

    - *We don't have official counts but it appears as if the demand is positive*
    - *We have mainly positive feedback from the operator*
    - *But it does not have the publicity/level of awareness we would like it to have*
    - *But we get feedback from bus users as well, who are very happy with the offer and the equipment of buses*

12. **Gibt es Pläne zu einer Erweiterung des Netzes?**
    (Are there any plans to extend the network?)

    - *The usual plan was to install 5 lines, which was an agreement between the federal state of BaWü, the Landkreise of the VRS and the city of Stuttgart*
    - *It is part of the so-called "ÖPNV-Pakt"*
    - *It is insecure whether the remaining 2 lines will be installed in the near future*

Own notes added during the conversation

- *It appears that even though Mr. Beck likes the idea of BRT concepts and sees/understands the potentials, he was very careful when it came to the discussion of taking away space from cars, which appears to be a common problem throughout all instances*

IV. Interviewleitfaden & Summary: SSB

(Interviewguide: SSB)

Qualitatives Interview mit Frau Corinna Reik und Herr Hans-Peter Benzing von der Stuttgarter Straßenbahnen AG (SSB) über die Verkehrssituation, Öffentlichen Nahverkehr und BRT-Potenziale in Stuttgart.

(Qualitative interview with Mrs. Reik and Mr. Benzing about public transport and BRT potentials in Stuttgart.)

Das Interview wird halb-strukturiert sein.

The interview will be semi-structured.

Intro:

- **Vorstellung meinerseits, der Firma, der Thesis und meiner Ziele**
  (Introduce myself, the company, the thesis topic and what I aim for with my thesis)
- **Fragen ob ich das Interview aufnehmen kann und die Namen als Quellen nennen (kann auch anonymisiert werden)**
  (Ask if it is okay to record the interview and to cite the names in the thesis (If not I will make it anonymous)
- **Ich schlage vor wir beginnen mit einer kurzen Vorstellung von Ihnen und Ihrer Arbeit.**
  (I suggest we begin with a short introduction of you and your workfield)
- **Einstieg mit aktuellen Diskussionen in der Presse (Fahrverbote, Klage, Blaue Plakette)**
  (Start with some buzzwords from press articles, blue stickers, driving ban and lawsuits)

Fragen (Questions):

1. **Wo sehen sie die größten Probleme hinsichtlich der aktuellen Verkehrssituation in Stuttgart?**
   (Where do you see the biggest problems with regard the current traffic situation and transport infrastructure in Stuttgart?)

2. **Gibt es Ihrer Ansicht nach (offensichtliche) Probleme oder Verbesserungs-möglichkeiten speziell im ÖPNV?**
   (Do you see any obvious problems or necessary improvements particularly in the city's public transport?)

3. **Wo würden sie als Erstes ansetzen um die Verkehrssituation in Stuttgart zu verbessern, falls ihnen unbegrenzte Mittel zur Verfügung stünden?**

   (Where would you put the lever to improve the traffic situation in Stuttgart, if you would have unlimited resources?)

4. **Ist nach Ihrer Meinung grundsätzlich BRT-Potenzial in Stuttgart vorhanden?**

   - Falls ja, können Sie sich einige spezielle Linien/Straßen/Bereiche vorstellen wo dies besonders sinnvoll oder die besonders geeignet wären (tangential? Innerstädtisch?) (Anm.: Nicht unbedingt von bestehenden Linien und bestehender Nachfrage ausgehen (Zwangsmobilität) sondern davon wo Leute vielleicht hin möchten) Wo ist es sinnvoll ein NEUES Angebot zu schaffen?

- Falls nein, warum?

(In your opinion is there a potential for BRT in Stuttgart? If yes, can you imagine any routes/streets/areas where this could be especially useful? If not, why?)

5. **Wo sehen sie die größten Hindernisse in Bezug auf die Planung bzw. Umsetzung eines solchen BRT-Systems in der Stadt Stuttgart?**
   - Technisch, politisch, finanziell, rechtlich, betreiberseitig?

(What are the major hindrances with regard to the implementation of a BRT-System in Stuttgart? Technical/Political/Economical/Operational?)

6. **Welche Einstellung hat die SSB und die politische Führung der Stadt zu solch einem Konzept?** (Regarding the political decision-makers in Stuttgart and the SSB in general, which attitude do you think they have towards such a concept?)

7. **Welche sind die wichtigsten Akteure die in solch einem Projekt involviert sein müssen? Welche wären eher für, welche eher gegen ein solches Projekt? Wer müssen die treibenden Kräfte sein?**

   (Who are the main actors that need to be involved in such a project in Stuttgart? Which ones would be in favor of such a project and which ones might be opposed?)

8. **Abschließend noch einige operative und technische Fragen:**

   (To conclude a number of operational and technical questions)

   - Welche Buslinien in Stuttgart haben eine besonders hohe Nachfrage, sind unter Umständen schon an ihrer Kapazitätsgrenze?
     (Anm: Linie 42 die stark priorisiert ist – Bei einer Begehung hat sich allerdings gezeigt dass sich Kolonnenstaus bilden – mehrere Fahrzeuge direkt hintereinander – Kann das ein Indikator dafür sein dass vereinzelte Busspuren und Ampelpriorisierung nicht ausreichen? Müsste Mischverkehr nicht die Ausnahme sein und separate Busspuren die Regel?)

   - Wäre es möglich mir Zugang zu einigen Daten, z.B. Passagierzahlen zu gewähren? Werden in Stuttgart noch viele Tickets direkt beim Fahrer gekauft? Gibt es Analysen bzgl. der Einstiegsprozesse (Zeiten etc.)?

   - Können Sie mir sagen wie hoch der Anteil an Ampeln mit ÖPNV-Priorisierung im Stadtgebiet ist? (58% in MUC) Wie viele km Busspuren gibt es im Vergleich zum Gesamtnetz?

Summary SSB:

Mr. Hans-Peter Benzing and Mrs. Corinna Reik from the strategic planning department of Stuttgart's main public transport operator Stuttgarter Straßenbahnen AG (SSB).

An interview guide was designed for the semi-structured interview **(see Appendix XX)**, however it turned out to be a more open interview than initially expected, which is why the summary is not entirely aligned with the interview guide. The focus is on most important points with regard to the aims of the project.

Information about potentials, BRT routes and system design:

- *It is important to have separate infrastructure, be independent from the rest of the traffic, as only then a rail like quality and efficiency can be achieved*
- *Historically it was a problem that no subsidies could be received for bus lanes / BRT*
- *In many European cities rail systems are implemented, BRT often is perceived as an entirely new concept, often cities do not decide to take on the new approach, also because of the rail "bonus"*
- *Interesting connection would be Wagenburgstraße – Ostendplatz, also the Cannstatter Straße as a higly congested route where buses are stuck in traffic jams regularly*
- *At the Wagenburgstraße the solution could be to take away parking space, rather than removing the trees/alley in the middle – these could also be a way to ensure an urban revaluation and not only have a wide strip of tarmac with both, bus and car infrastructure*
- *For the Wagenburgtunnel signaling solution would be necessary, to keep the costs at a bearable level, as it is too narrow for dedicated buslanes*
- *Talstraße to Neckarpark is questionable regarding the demand, however it is important to mention that due to a lack of alternative routes into the city, connected with a Rückbau of infrastructure in the 70's, the talstraße is often highly congested*
- *We also thought about a BRT system close to the central station, but those plans have been directly abandoned by the Stadtplanungsamt etc. – whenever we need a certain street width for dedicated bus infrastructure it is blocked by saying that buses can use normal roads and the width is not needed*
- *It is easier to build dedicated rail infrastructure while dedicated bus infrastructure is always questioned*
- *We at the SSB are taking an effort in pushing those solutions but it is very difficult to overcome the opposed groups, no matter whether its people wanting to keep their parking space, keep the trees in the middle of the road or others*
- *The line 42 urgently needs a systematic approach (bus or urban rail)*
- *A sufficient demand for BRT would definitely be there*
- *Tangential: It is planned to construct a big car park close to Möhringen Freibad, to enable car users coming from direction Tübingen/Reutlingen to leave their cars and switch to the stadtbahn to the city center → but then there is a connection missing between this and "Wallgraben" (Nord-Süd-Straße) where big companies are developing new buildings with a lot of workplaces*
- *The S-bahn can carry people coming from the city center, but there is no real public transport alternative in this area for people coming from the B 27 (Reutlingen/Tübingen)*

- *In this area there is always congestion, a park & ride solution in this area and then a BRT connection on separate infrastructure could be a solution – however it is questionable whether this "late" switch from the car to public transport will generate enough demand…there needs to be an incentive – but in general the s-train park and rides and car park Degerloch are highly demanded so there is definitely a chance*
- *Regarding the new x1-line (Cannstatter Straße) it was not able to force or push through a real system/BRT approach which is why the current solution with signaling solutions and 1 buslane for both directions on the normal road was developed to accelerate the buses and reach the same or better travel times than the Stadtbahn*
- *X1 should take pressure of the highly congested Cannstatter Straße as well as from the Stadtbahn in this area which has reached the capacity limits*
- *For the X1 we chose new vehicles with alternative drivetrains, own marketing identity and a high level of equipment driving in 5 minutes headway*
- *Charlottenplatz & Rothebühlplatz are now also in the focus for prioritization measures…but it is not definitive in what way they will be implemented*
- *A lot of those discussions in Stuttgart need to be on the highest level, meaning our CEO has to talk to the city's mayor etc.*
- *Again: We want to put forward BRT solutions and we think we have the expertise, but we need the infrastructure and the financing thereof, we are now trying to sell the "system bus" after strongly concentrating on urban rail for many years*
- *We at the SSB are however not known for radical solutions, but rather for peacable solutions*
- *There is also a strong car mentality across the population of the region, even if there is no chance to get through the traffic jams in a bearable amount of time they do not switch to public transport…maybe because they don't want to, maybe because they come from areas where there is no real public transport alternative*

Information about actors included in Stuttgart and their perception towards BRT:

- *With the political structure in Stuttgart it is sometimes difficult to make decisions, not only the city is involved but also the region and the federal state – you always have a lot of actors involved*
- *The political willingness to build and pay separate infrastructure needs to be there – also willingness to bear the consequences of taking away space from cars*
- *The "Wagenburg BRT solution" was a topic within the SSB, but was considered to "futuristic" mainly because they knew that important actors (e.g. Stadtplanungsamt) in the city of Stuttgart would be opposed to such ideas*
- *There is fear of taking away space from cars but also concerns regarding the compatibility of the BRT infrastructure with the current built infrastructure*
- *We at the SSB are taking an effort in pushing those solutions, especially our CEO Mr. Arnold is very active in this respect*
  → but it is very difficult to overcome the opposed groups, no matter whether its people wanting to keep their parking space, keep the trees in the middle of the road or others
- *We also thought about a BRT system close to the central station, but those plans have been directly abandoned by the Stadtplanungsamt etc. – whenever we need a certain street width*

for dedicated bus infrastructure it is blocked by saying that buses can use normal roads and the width is not needed

- *It is generally not popular to compare Stuttgart with other cities, also in the BRT case*
- *Systematic approaches sometimes receive a good feedback also from city government officials, nonetheless in the end the question on the influence this has on the car traffic is always asked*
- *Generally there are two parties, the ones who want to make public transport as compatible with private car transportation is possible and the ones with a more radical approach, the latter for now having not the power assert themselves*
- *It was very difficult to put forward any bus-based solutions (prioritization etc.) in the last years, often because of concerns or different focus on side of the Stadtplanungsamt (urban planning department) → in the recent years this has been cycling and pedestrian infrastructure which sometimes lead to dismantling of bus prioritization measures*
- *It often depends on having the right people or decisionmakers in the right place at the right time – we are lucky now that Mr. Hertkorn (Head of Traffic Management, City of Stuttgart) and Dr. Unkhoff (Signaling) are acting in favor of public transport, which more or less enabled us to push through the solutions on Cannstatter Straße*
- *Also under the pressure of current problems with air pollution, blue badge and driving bans the SSB makes a lot of suggestions for improvements and on the political side there seems to be a slow development towards more willingness and open mindedness for new approaches regarding bus based public transport*

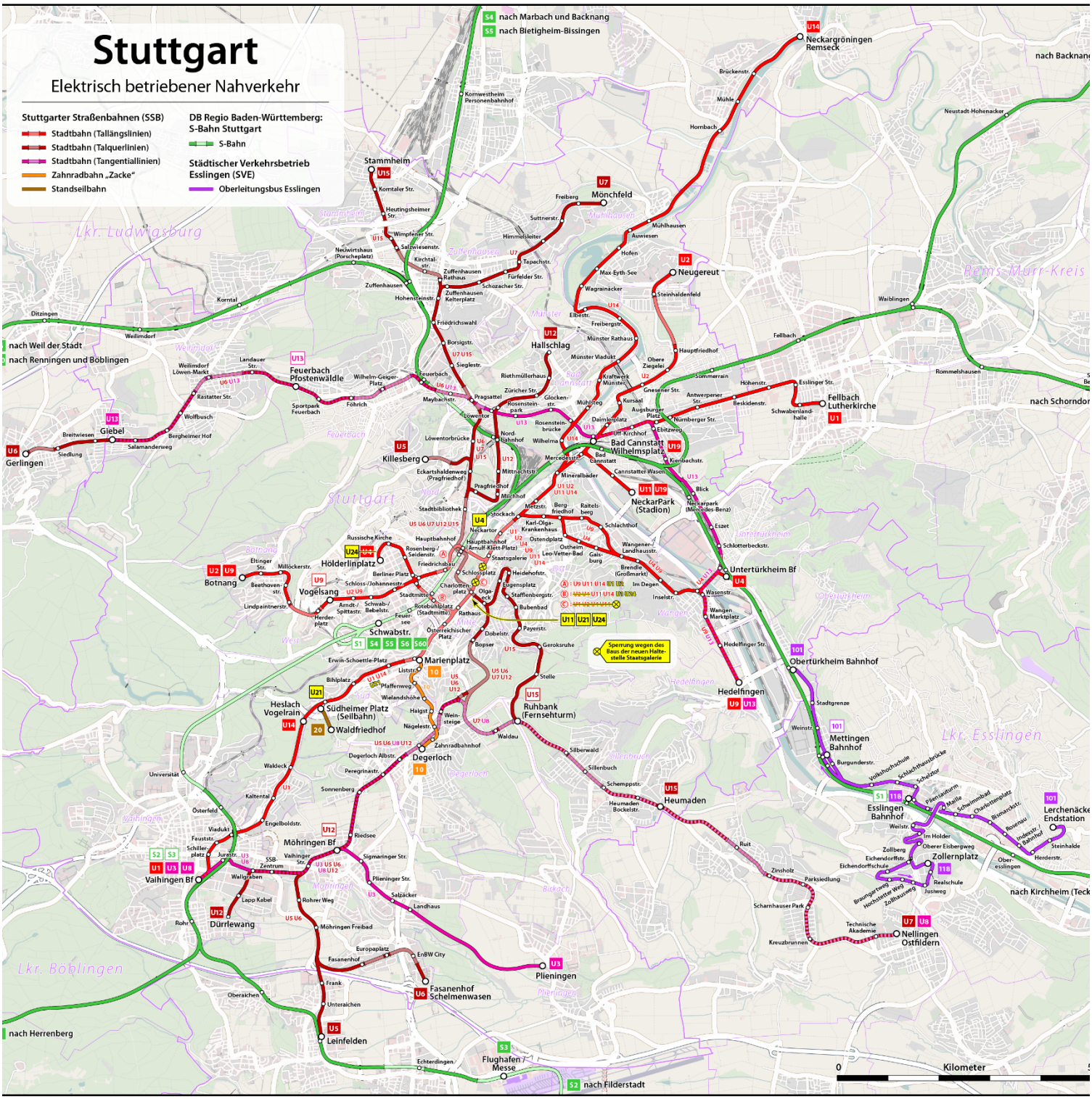
Technical information and data on public transport:

- *Strongest line (demand) is 42 (up to 40.000 passengers per day), especially between the main train station and Lindenmuseum (Lines 40 and 42), Particularly high demand also Line 42 (Ostendplatz/Wagenburgstraße), less but still highly demanded in the city center are lines 41 and 45.*

- *Line 42 is driving in 5-minutes headway but still at its capacity limits, buses run into each other because of the high traffic and all the old problems return, system is urgently needed*

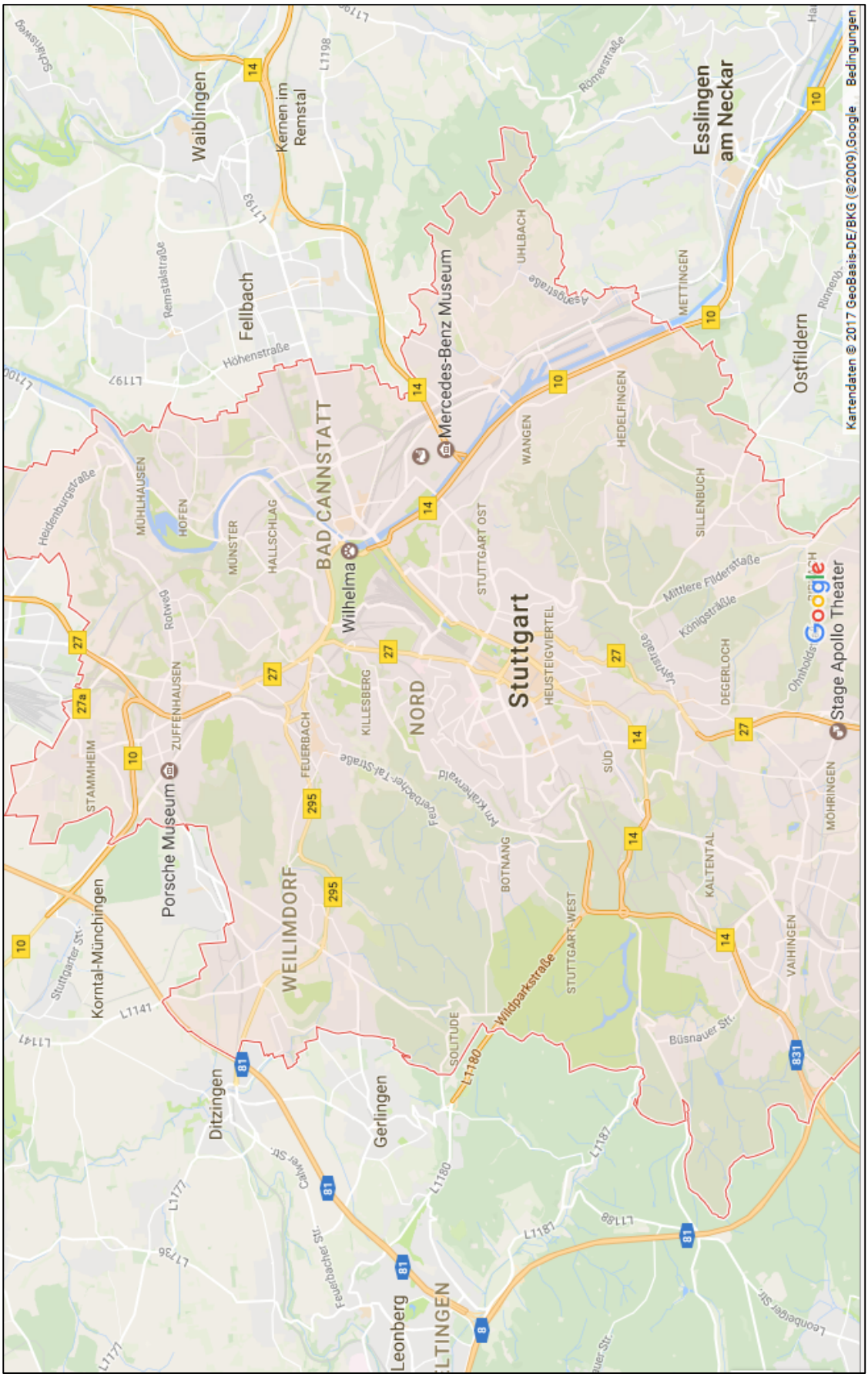
Appendix C: Maps for Analysis

I. Urban Rail Network



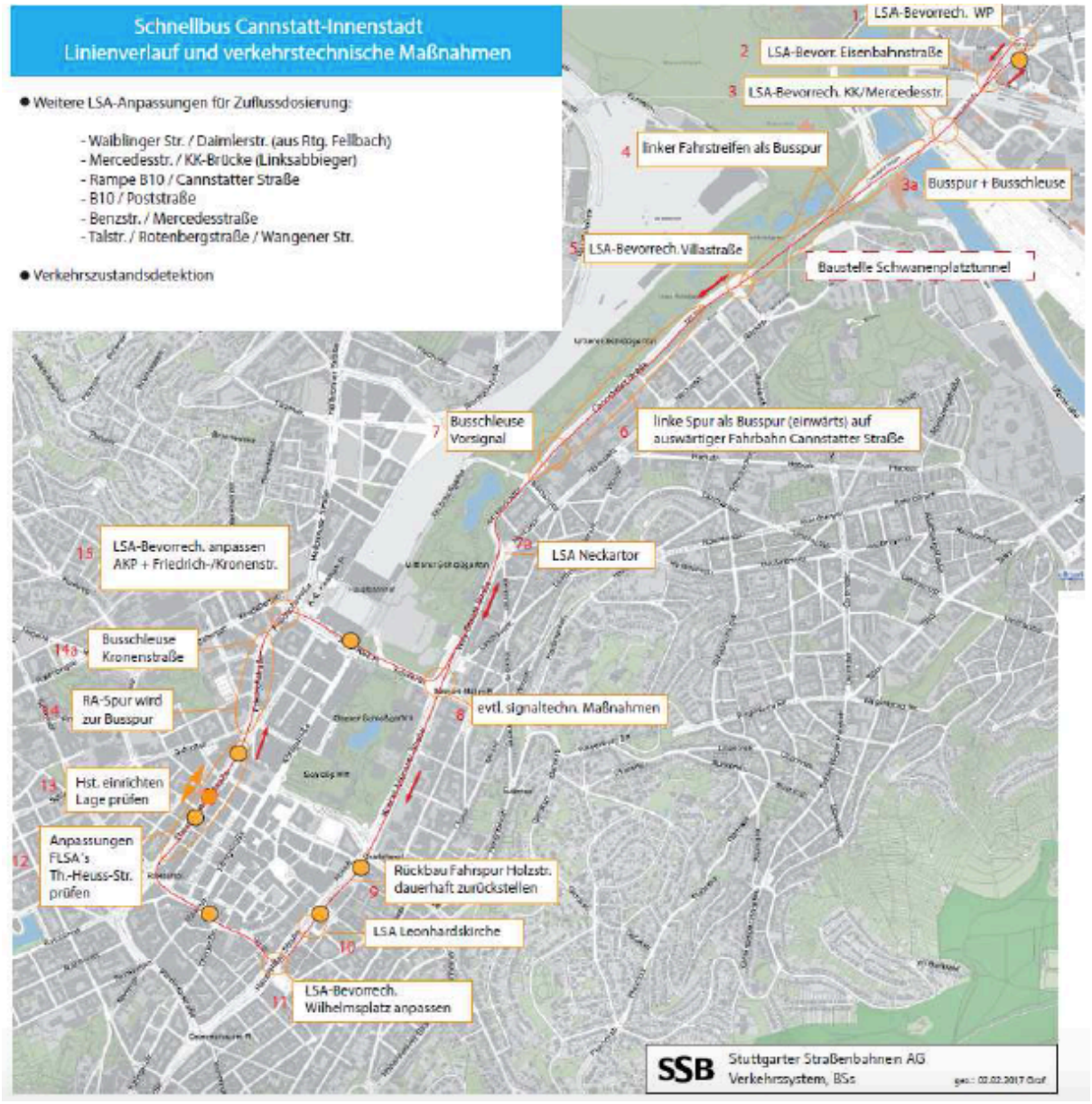
Source: https://upload.wikimedia.org/wikipedia/commons/2/2d/Karte_der_Stadtbahn_Stuttgart_und_des_O-Bus_Esslingen.png, Last download: 31.05.2017

II. Road Network



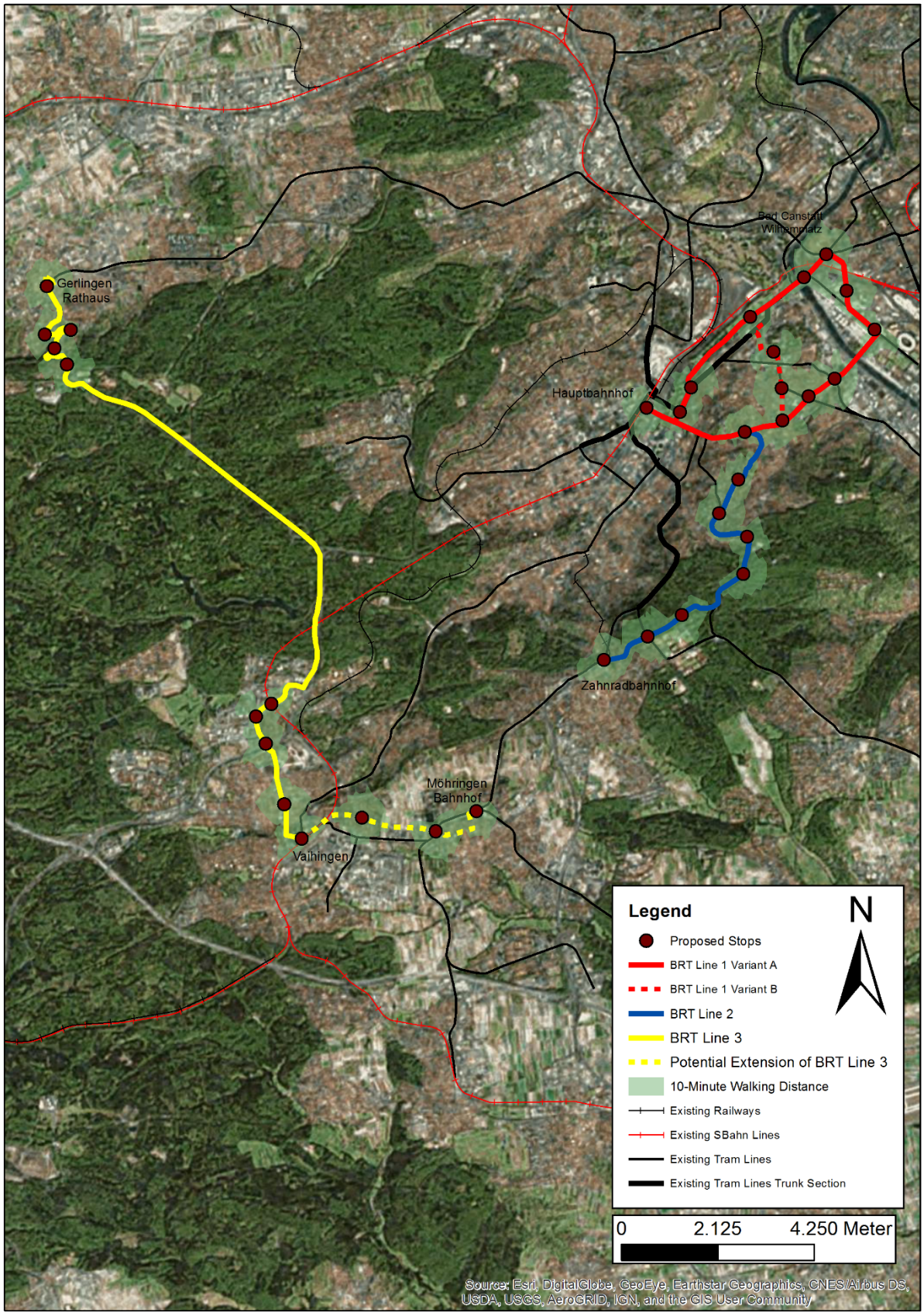
Source: Google Maps – Stuttgart

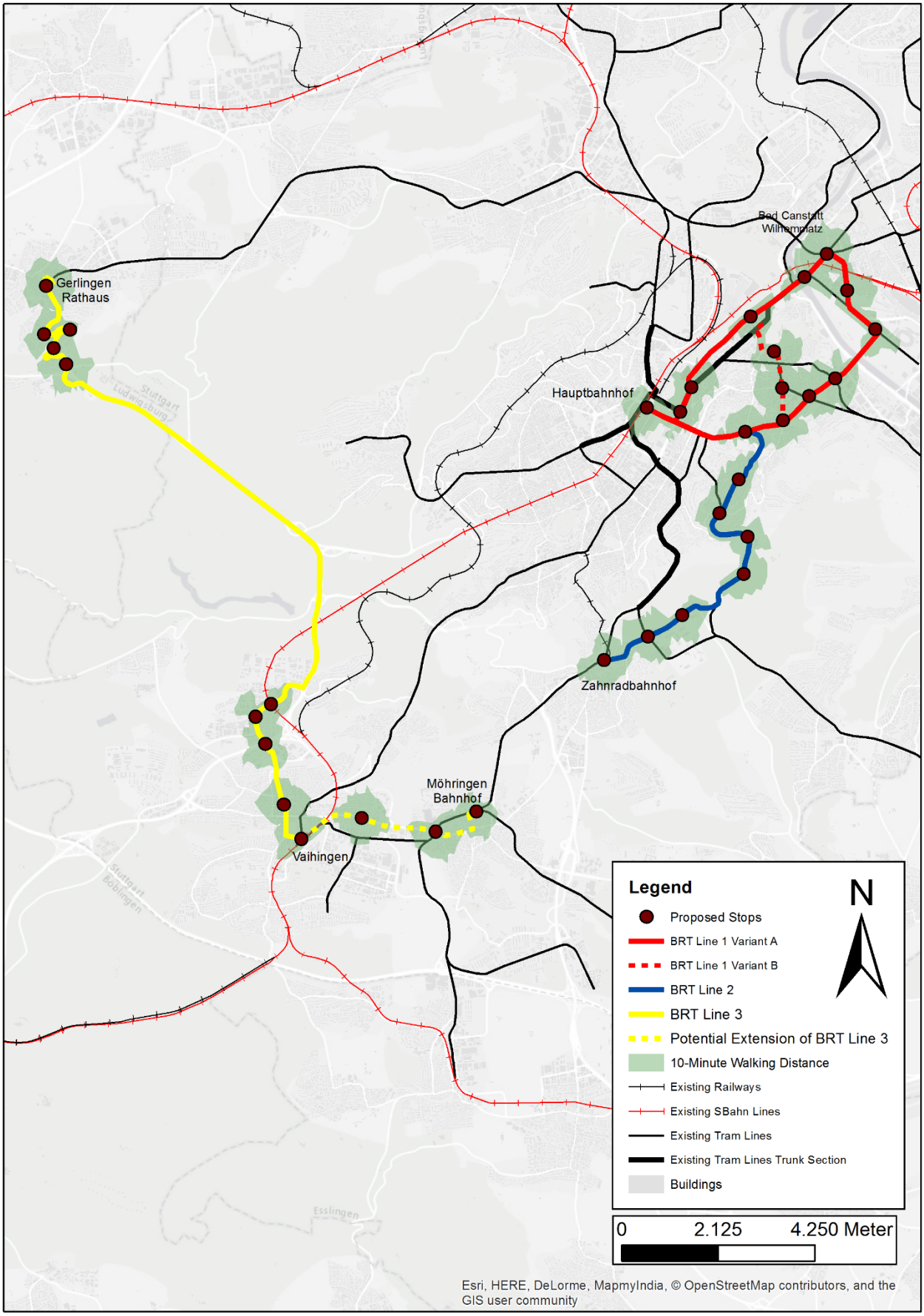
III. Expressbus X1



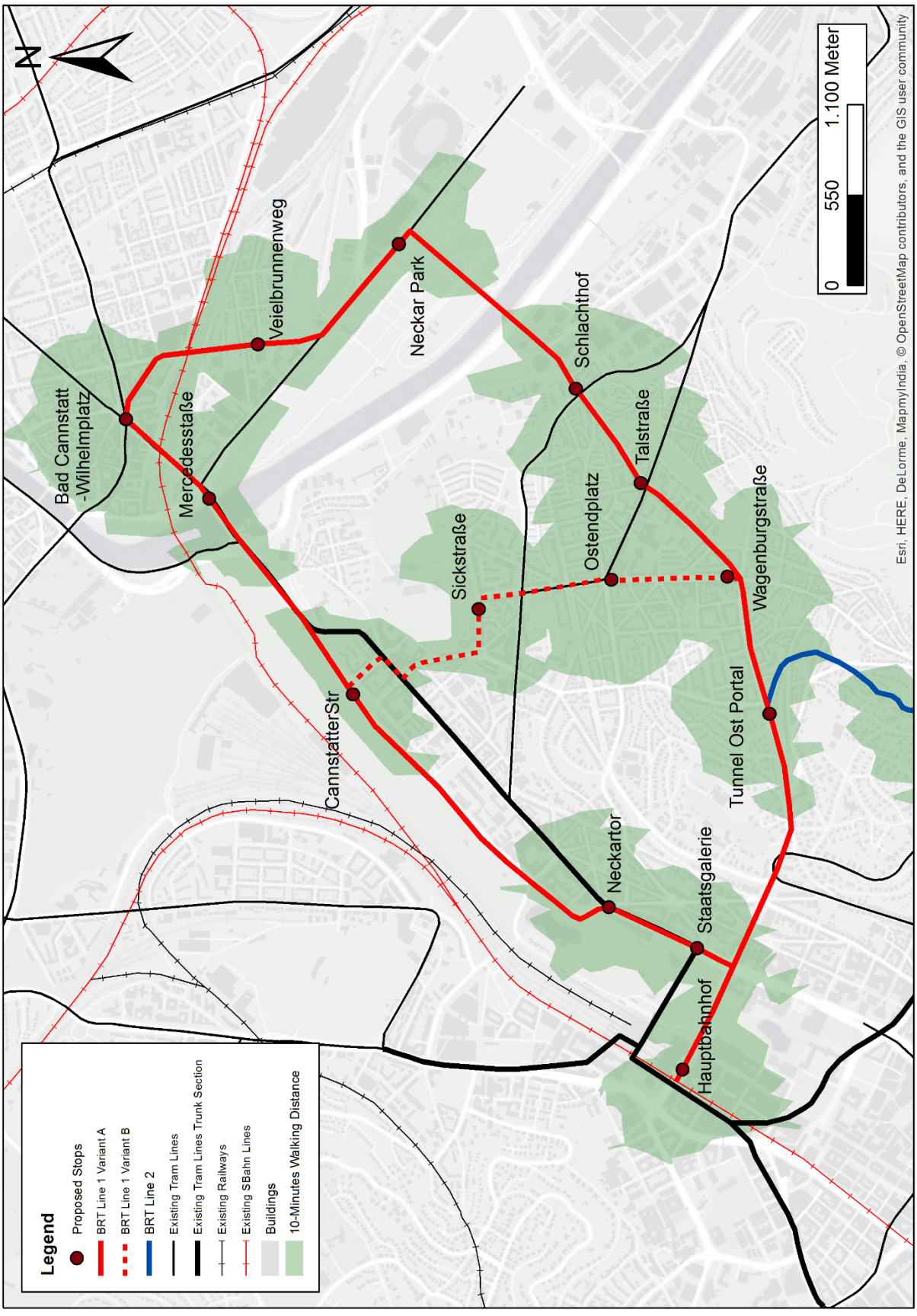
Appendix D: Maps BRT Concept

I. Overviews (incl. 3 BRT line proposals)




Gerlingen
Rathaus
Bad Canstatt
Wilhelmplatz
Hauptbahnhof
Zahnradbahnhof
Möhringen
Bahnhof
Vaihingen
Stuttgart
Ludwigsburg
Stuttgart
Böblingen
Esslingen
Legend
N
Proposed Stops
BRT Line 1 Variant A
BRT Line 1 Variant B
BRT Line 2
BRT Line 3
Potential Extension of BRT Line 3
10-Minute Walking Distance
Existing Railways
Existing SBahn Lines
Existing Tram Lines
Existing Tram Lines Trunk Section
Buildings
0
2.125
4.250 Meter
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

II. BRT Line 1


Legend
Proposed Stops
BRT Line 1 Variant A
BRT Line 1 Variant B
BRT Line 2
Existing Tram Lines
Existing Tram Lines Trunk Section
Existing Railways
Existing SBahn Lines
Buildings
10-Minutes Walking Distance
N
0
550
1.100 Meter
Bad Cannstatt -Wilhelmplatz
Mercedesstaße
Veielbrunnenweg
Neckar Park
Schlachthof
Talstraße
Ostendplatz
Sickstraße
CannstatterStr
Neckartor
Staatsgalerie
Hauptbahnhof
Tunnel Ost Portal
Wagenburgstraße
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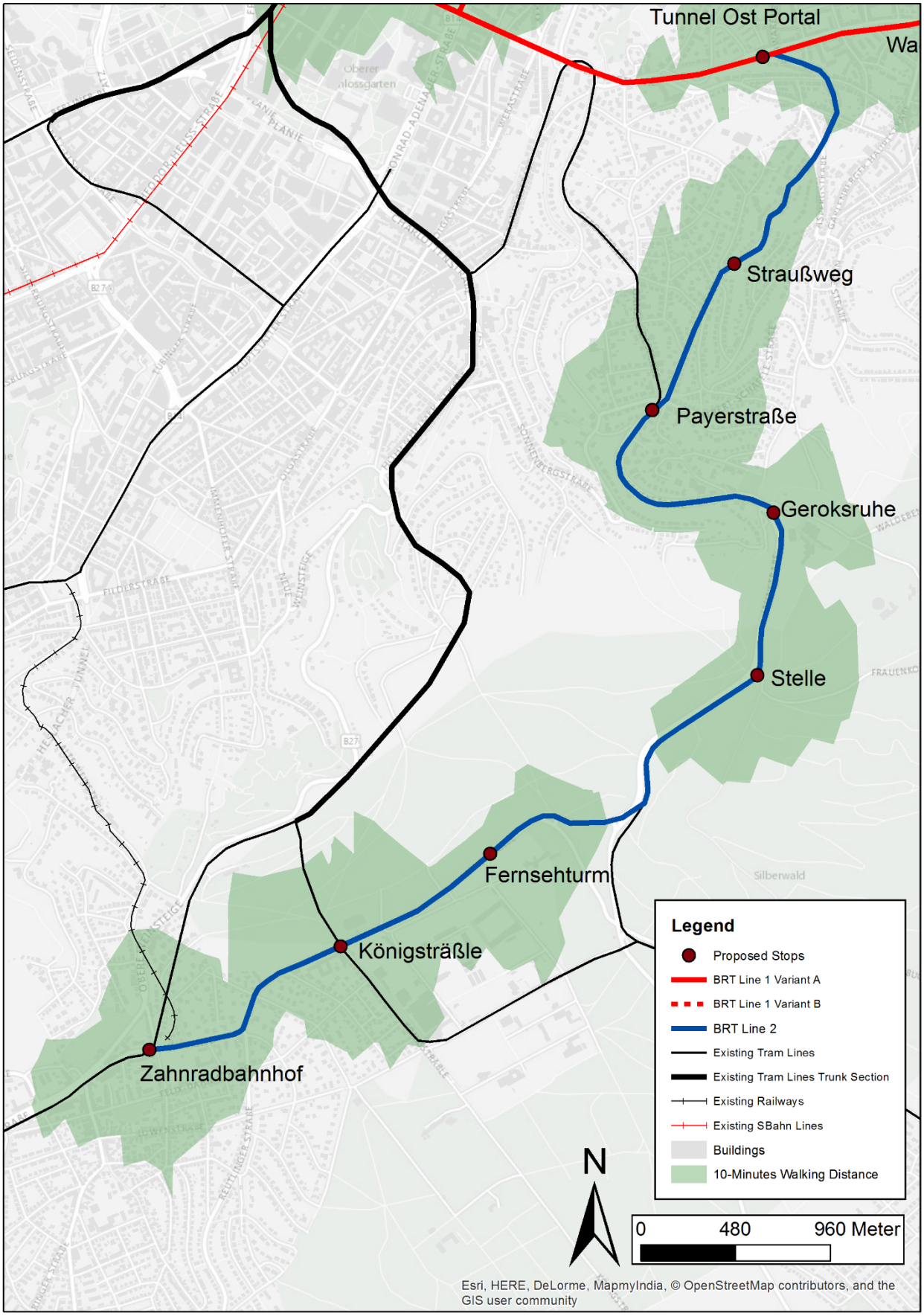
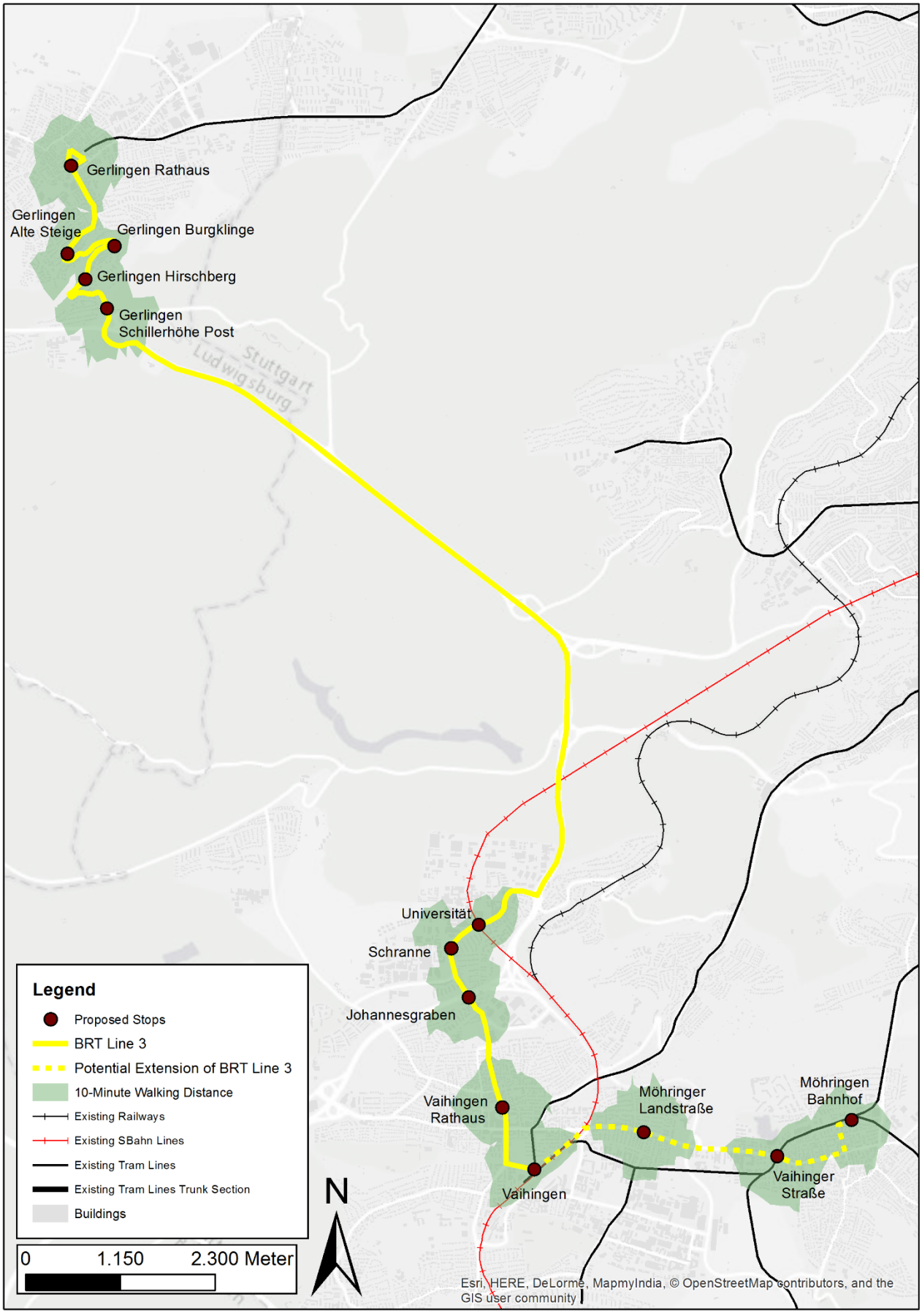
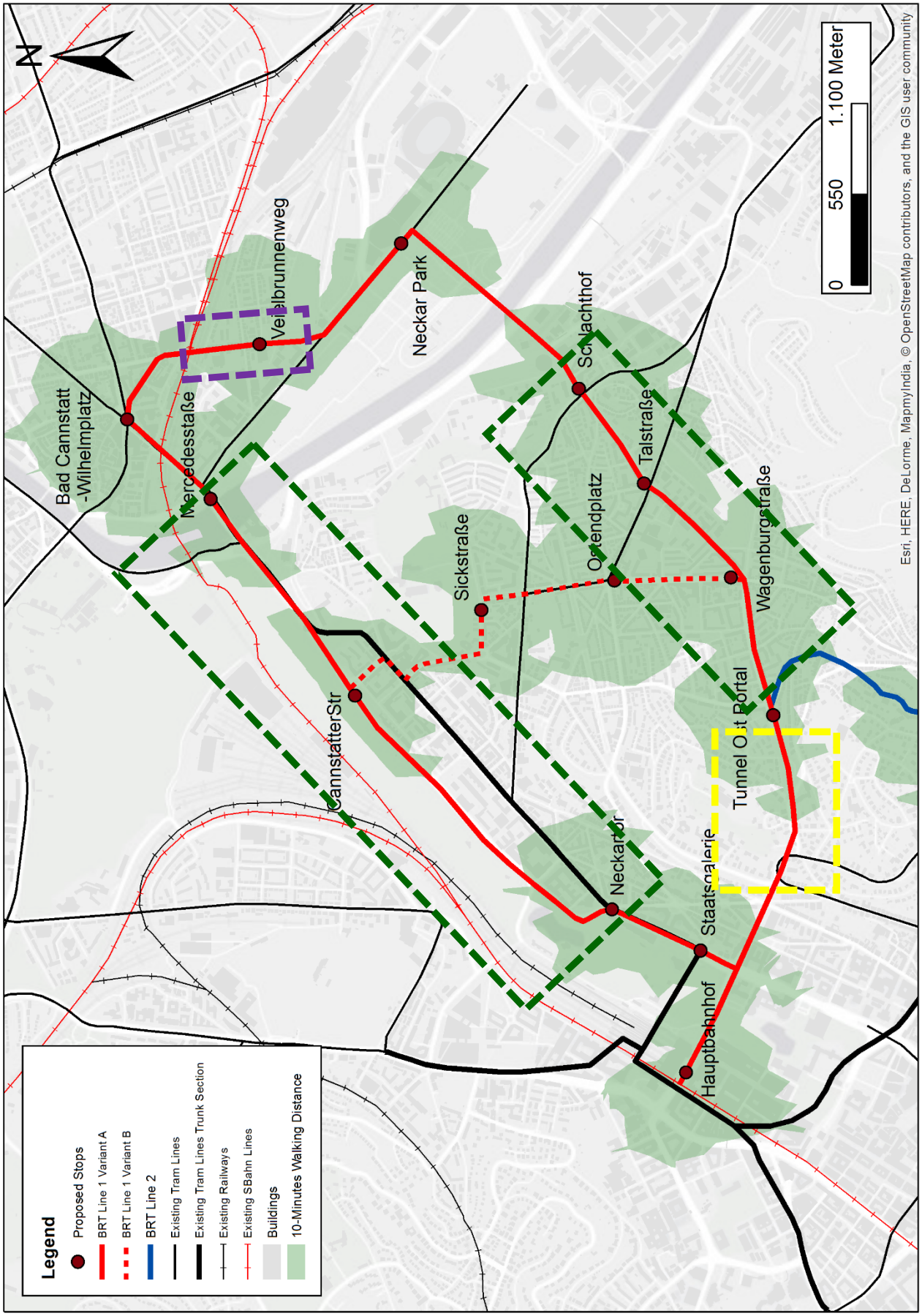
III. BRT Line 2



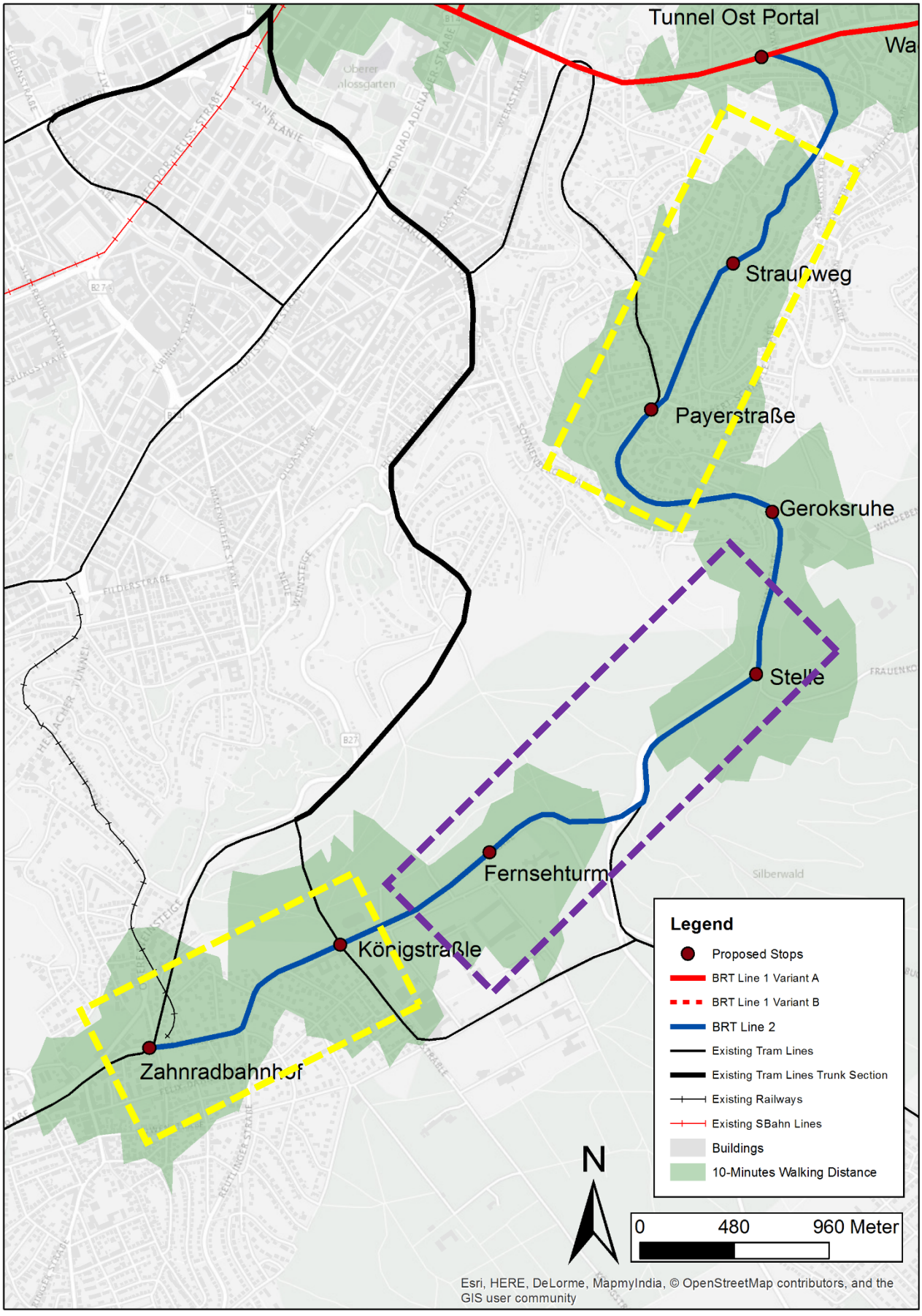
IV. BRT Line 3


Gerlingen Rathaus
Gerlingen Alte Steige
Gerlingen Burgklinge
Gerlingen Hirschberg
Gerlingen Schillerhöhe Post
Stuttgart
Ludwigsburg
Universität
Schranne
Johannesgraben
Vaihingen Rathaus
Vaihingen
Möhringer Landstraße
Möhringen Bahnhof
Vaihinger Straße
Legend
Proposed Stops
BRT Line 3
Potential Extension of BRT Line 3
10-Minute Walking Distance
Existing Railways
Existing SBahn Lines
Existing Tram Lines
Existing Tram Lines Trunk Section
Buildings
0
1.150
2.300 Meter
N
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

V. Detail BRT Line 1



VI. Detail BRT Line 2



VII. Detail BRT Line 3