TU Delft & Arcadis

Public transport nodes at airports

A method to clarify the challenges of public transport nodes at airports

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By

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An electronic version of this thesis is available at http://repository.tudelft.nl/.

Preface - Acknowledgements

During my Bachelor and Master education at the Delft University of Technology, I focussed on subjects of public transport in combination with air transport. Through my time in Delft, I learned that public transport and airports is a complex combination. Therefore, I wanted to investigate this topic in more detail.

Almost everybody uses air travel nowadays. Since nobody lives at the airport itself, the trip towards the airport is almost as important as the air trip itself. Making this so called "land-side" trip as easy and comfortable as possible, the responsible companies need to offer suitable means of transport. From my own experience, it became clear that what I think is comfortable, is for another person not comfortable at all. This was my inspiration to start my thesis research on the subject "public transport towards airports".

There are multiple ways of looking at public transport. A technical approach which focusses on the transport network itself and, an actor approach focussing on the interaction between responsible parties and the customers. Both approaches are part of the complex airport puzzle that need to be analysed to get a clear view why offering public transport is as complex as it is. For the public transport access to airports, the transport network, users of the system and the involved stakeholders will be analysed. This will be done from the available theory, as well as a case study concerning Schiphol Airport. This thesis report will clarify the challenging issues around public transport nodes at airports.

This document contains the report of my master thesis of the TU Delft Master programme Transport, Infrastructure and Logistics. This project is executed at Arcadis NL in Amersfoort in cooperation with TU Delft. Within this report, a study on the landside accessibility of Schiphol Airport is conducted. The aim of this report is to inform the reader on the subject accessibility and the adaptation of several concepts at Schiphol Airport. Next to informing the reader, this report will clarify the challenges of public transport nodes at airports.

Via this way, I would like to thank my committee:

- Bart van Arem, for his constructive feedback and time in his busy schedule
- Rob van Nes, for his eye for detail and enthusiasm for this research
- Jan Anne Annema, for his enthusiasm and helicopter view on this research

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Marieke Sulkers
Amersfoort, 5/10/2017

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Summary

Introduction

A well accessible airport is of significant importance for the functioning of the airport. Without a good access infrastructure, no passengers, employees or resources can get to the airport. Part of this access infrastructure is the public transport network towards the airport. A public transport station at an airport is not the same as a regular station. There are three main subjects that differ for airports compared to regular public transport: 1) different network levels, 2) multiple user classes and 3) multiple stakeholders. These subjects are researched separately in current literature. Within the literature, no or only limited attention is paid to the relation between these three subjects and the airport system, let alone the interaction between these subjects. Therefore, this research will clarify the subjects in relation to the airport and each other.

It is important to understand the public transport system around airports because airports keep on growing in terms of passengers transported. To verify the challenging issues that arise from the literature study, a case study will be performed. The airport chosen for this case study is Schiphol Airport. This specific airport is known for its good public transport. Although there are many strengths, more weaknesses arise over time.

The aim of this research is to clarify the challenging issues regarding the public transport access of airports. This clarification will result in a "airport public transport analysis method". Following this method enables researchers, policy makers and other interested parties to clarify the complexity of one specific airport. The method can be used for all airports.

The main research question is therefore:

"What are the challenges concerning public transport nodes at airports and what challenges should be researched in the future?"

To answer and structure this problem, this thesis research will answer the following questions:
- Which factors influence the accessibility of locations?
- What network levels are connected to airports and what function does the airport take within the transport network?
- How do user classes differ in case of their preferences and wishes for a transport service to an airport?
- Which stakeholders are involved in the airport public transport access issue?
- What are the complex issues around Schiphol Airport considering the public transport access of the airport?

The research consists of two parts, 1) a theoretical literature study and 2) a case study. Within both parts the three subjects of networks, user classes and stakeholders will be clarified. The data for the case study will be retrieved from online-web based research and interviews with the involved stakeholders.

Airport public transport access challenges

Through the analyses done in this research, the following challenges within the airport public transport nodes can be identified:

Firstly, the network approach was used to analyse the network characteristics. The challenges found from this analysis are as follows.

Network approach

1. Location of the airport station within the network is a determining factor for the available access possibilities through public transport. Location can often not be chosen. The location within the public transport network depends on the growth and orientation of the network. When an airport is not located near train infrastructure, it cannot be integrated in the network unless new infrastructure is constructed.
2. Airport differs in operational time during the day compared to other locations. PT systems are sometimes not available during the operations of the airport. For passengers that need to catch a very early flight or arrive very late in the evening this might be a problem. They often cannot use public transport any more. Including night services to important locations around the airport can be a solution for this complexity.
3. An airport operator has the wish to attract as many passengers as possible to the airport. Therefore, they prefer a many-to-one network structure. An airport operator does not have the objective to transport other passengers than airport passengers. Therefore, they want as many direct connections to their airport station.
4. PT organisations need to transport as many passengers as possible. Therefore, they prefer a many-to-many network structure. They have the objective to transport as many passengers as possible through their complete network.
5. The surrounding of the airport station. Is the station located on ground floor or in a tunnel? This influences the ways in which the infrastructure can be expanded. A station that is located in a tunnel cannot be expanded easily. In concentrated urban areas, expansion of infrastructure is also a problem.
6. An airport that is well accessible through public transport attracts more passengers to public transport. Therefore, the public transport is a returning loop of three parts: 1) improving PT, 2) attracting more passengers and 3) crowded PT/ PT problems. This loop makes from the strength of a well accessible airport by public transport a weakness.

Secondly, the users of public transport around airports were analysed. The user classes that are distinguished are business airport passengers, leisure airport passengers, airport employees, commuting non-airport passengers, other non-airport passengers. The challenges concerning these different user classes are as follows.

User classes approach

7. User classes mainly differ in the aspects of pieces of luggage, tight departure time and importance of user friendliness. Within a public transport structure in which the airport is integrated in the public transport network, multiple user classes are using the services. Airport passengers have more pieces of luggage and therefore require more space in the vehicles. Airport passengers do have a set time at which they need to check-in for their departing flight. Therefore, they have a higher preference towards a reliable system.
8. Airport users consist of both national passengers and international tourists. Tourists are assumed to be less familiar with the PT system of a country. Since the airport passengers are both national and international individuals, the information provision needs to be adjusted compared to information on regular stations.

9. Public transport companies need to offer public transport that will be used by all user classes and not only airport passengers. Since all user classes will use the public transport (in case of an integrated airport station), the preferences of all user classes need to be incorporated in the services offered. For public transport companies, it is difficult to operate vehicles for airport passengers specifically.
10. Airport passengers do not use the airport station for transferring between network levels, while non-airport passengers may use the airport station for transferring between network levels. Therefore, the function of the airport station is different between user classes.
11. Some user classes can change network levels more easily as others. This is dependent on the design of the stations and the amount of luggage passengers carry with them.

Thirdly, the different stakeholders are analysed on their objectives, preferences and wishes. The user classes that are analysed are national, regional and local governmental bodies, airport owner and operator, public transport infrastructure owner and public transport service operator and the travellers. The challenges on this subject are:

Stakeholder approach

12. Airport operator is dependent on the public transport companies for the public transport access of the airport. The airport operator does not have much power over the operations of the public transport companies around the airport.
13. Local governmental bodies have the least power, though they have very high interest.
14. National governmental bodies consider the airport as an employing company that needs to be well connected to the public transport network.

Analysis method

The analysis method is set up to analyse specific airports and clarify the challenges. To get a clear overview of the challenges at the specific airport, the following questions should be asked:

Network approach:

- What is the location of the airport public transport station within the public transport network?
- What network levels are connected to the airport station?
- What are the most important cities where passengers travel from to the airport?
- What are the corresponding speeds, frequency, transfers needed, costs, reliability, comfort, user friendliness and travel experience between those cities and the airport station?
- From what time is the transport network available?
- How high is the robustness of the network?
- Does the service that is provided on a network level match the theoretical standards?

User classes approach:

- Which user classes can be identified?
- What are their preferences in case of public transport on the attributes speed, cost, reliability, comfort, user friendliness and travel experience?
- Which user classes do differ the most?

Stakeholder approach:
- Which stakeholders are involved in the public transport access system around the airport?
- What are their objectives?
- What are their interests and wishes for the public transport access?
- Which actors have conflicting interests?

Within the method, relations and interactions between the network, user classes and stakeholders and the airport system are most important. This focus makes the method useful since no literature studies these subjects in this way. By using this method, new the information can be structured in a presentable way.

How to solve the challenges

Some of the challenges that arise from the analyses are present and are difficult to solve. They need to be taken into consideration when changes are made in the public transport system around the airport. For some other complexities, some solutions are suggested. To make sure that the network capacity can be adapted easily, the configuration of the airport station should be organized as flexible as possible.

For the differences in user classes multiple solutions can be found. For example, the luggage of airport passengers could be checked-in at the train stations before passengers will board their train to the airport. In this way, the differences between airport and non-airport passengers become smaller. Because the airport passengers are both national and international passengers, the information provision at the airport station should be different to the information at regular stations. A balanced number of directional signs and communication at the airport station could help achieving this goal. To accommodate all passenger types, the airport station should be able to function as a transport hub for non-airport passengers and a station for airport passengers. In the design phase of the airport station, this should be considered.

The complexities around stakeholders involved in the public transport access of airports are difficult to change. This depends on the attitude and power of the stakeholders itself. One way of decreasing the complexity is to make the stakeholders aware of the problems and their contribution to these problems. Establishing a committee with members from all stakeholders that will work together with the same goal is a way of minimizing the bureaucratic and hierarchical problems between the stakeholders.

Schiphol Airport public transport access challenges and recommendation

For Schiphol Airport, the biggest strength concerning their public transport train station underneath the terminal, is now becoming more of a weakness. There are lots of disruptions in the tunnel, international passengers cannot find the train station and the bus platform in front of the terminal is too complex. Because of this configuration, expanding the capacity is difficult and expensive. Within the network analysis, the international connection towards Eastern Europe is missing. This link could be interesting for Schiphol Airport to be able to compete with the airports of Germany. On the local level, some improvements can be made towards the central business district (CBD) Zuid-As and the city centre of Amsterdam. Within the near future, capacity problems will arise on this part of the network. One possible solution could be to establish a high-frequency and high-speed rail service from Schiphol-Airport through CBD Zuid-As to the city centre. With the soon-to-be opened "Noord-Zuid metro" in Amsterdam, extending this metro line towards Schiphol might solve this problem.

Further research

From this research, it is clear that more attention should be paid to the interaction between user classes, network levels and stakeholders around the airport. Because of little available research on this interaction, some educated guesses are made in this research. These can function as a starting point for further research on this topic. Subjects that should be researched in more detail are:

- Standard to measure reliability of public transport
- Preferences of different user classes in combination with the airport
- Interactions between network levels, user classes, stakeholders and the airport system

The questions from the proposed method that need to be analysed in more detail are thus:

- What are the corresponding speeds, frequency, transfers needed, costs, reliability, comfort, user friendliness and travel experience between those cities and the airport station?
- How high is the robustness of the network?
- Which user classes can be identified?
- What are their preferences in case of public transport on the attributes speed, cost, reliability, comfort, user friendliness and travel experience?
- Which user classes do differ the most?

Reflection and limitations of this research

Within this thesis research, the main objective was to clarify the concept of accessibility and the access of airports by public transport. The methods used to reach this objective were mostly literature research, interviews and small sample surveys. The literature study on topics of accessibility, airport access structures, network levels and user class preferences revealed many sources on generic public transport usage. Only few sources made some explicit differences in airport access by public transport. Therefore, some assumptions in this research are based on generic public transport literature. This might have influenced the conclusions and recommendations stated in this research.

The user classes as specified in this research are set up from regular public transport users as from airport passengers. Not all information that was available for regular public transport users was also available for airport passengers. Therefore, some educated guesses and small responses from the interviewees were used to come to conclusions. Some effects and preferences might therefore be over- or underestimated. From these educated guesses, it is clear that there are significant differences in user classes preferences. This research makes it clear that more research needs to be done in this subject.

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List of abbreviations

AAS	Amsterdam Airport Schiphol
AMS	Amsterdam Schiphol
CBD	Central business district
GDP	Gross domestic product
LOS	Level of service
MKS	Multimodal transport node Schiphol (multimodale knoop Schiphol)
NMCA	National Market and Capacity Analysis (Dutch research)
O&D	Origin and destination passengers
PT	Public transport
RTH	Rotterdam The-Hague Airport
VoT	Value of Time
VTTS	Value of Travel Time Savings

1. Introduction

"Last Thursday, Schiphol Airport was not accessible by train for hours due to disruptions as was the case on Friday. This weekend, Schiphol was hardly accessible by train due to construction work, and today the airport is barely accessible due to failing of that construction work." (Spithorst, 2015)

This quote taken from a column published on OVPro.nl describes a situation that is not exceptional for the accessibility by public transport of Schiphol Airport. The airport can be inaccessible due to planned or unplanned construction works, disruptions in the infrastructure or rolling stock, or even external factors such as weather or strikes. Accessibility of airports is of significant importance to both the airport itself, the airlines, the passengers and the employees. For the operations of the airport, a good landside accessibility is a critical issue.

The location of an airport is desirably far removed from urban areas to minimize disturbances for people (Vespermann & Wald, 2011). On the other hand, people living within the catchment area of the airport need to use the airport. Therefore, good landside accessibility of airports is essential to make people use the airport. The landside accessibility of an airport is not only important for the functioning of the airport as a transport hub itself, but also the regional and national economy (Hakfoort, Poot, & Rietveld, 2001). Next to the public transport network, the users of the network are important as are the involved stakeholders.

At public transport nodes where multiple network levels and multiple modalities come together, several challenges arise. When multiple network levels need to be connected with each other, the transfer facilities need to be arranged appropriately. On different network levels, services are offered with different specifications concerning speed, frequency and vehicle types. The different modalities are offered and supervised by different stakeholders with all different goals and interests. Next to these challenges, the services are used by different user classes with different preferences. For regular public transport nodes, these challenges are evident. When looking at public transport nodes that are located at an airport, even more challenges arise. There are more different user classes that need to make use of the public transport services, more stakeholders are involved with different goals and interests. Within current literature, not much attention is paid to the interaction between public transport nodes and airports. Therefore, this thesis has the aim to construct a method to make the challenges of public transport nodes at airports visible.

To come to a complete research approach, multiple challenges around the accessibility of an airport through public transport will be analyzed in more detail. First, the issues that are present in this problem will be described. Secondly, the multiple user classes of the airport's landside access structure will be analyzed. Because most airports serve passengers on multiple transport levels, the interaction between those levels will be described next. Fourthly, the challenges around the involved stakeholders will be made explicit. From these analyses, the research relevance will be stated and the research questions for this thesis research will be formulated.

1.1   Problem analysis

Challenges of public transport nodes at airports

Accessibility is a complex and an abstract subject and can be measured in multiple ways. In most cases, accessibility measures relate to indicators such as travel costs, travel time and the robustness of the network towards a specific location. These indicators are relatively easy to implement, while subjective indicators such as user friendliness, comfort and travel experience are more difficult to measure. These subjective measures are actor specific and different within diverse cultures.

Landside accessibility of an airport may be divided in two categories; access through the road network or through public transport. From this subject, the first issue arises which can be formulated as "negative external effects vs. regional economic benefits" (Hakfoort et al., 2001). Because of congestion on the road network around the airport and environmental pressure problems, the preferred access mode from a social point of view would be public transport. On the other hand, airport operators would prefer a car as an access mode because this generates revenue out of parking tariffs (Vespermann & Wald, 2011). Looking at public transport systems some issues can be identified. Bus networks are relatively easy and flexible to implement, while the level of service (LOS) of these bus services are perceived lower compared to rail services in terms of comfort and travel speed (flexibility vs. LOS). For rail services, the investment costs are much higher and less flexible, while the LOS is perceived better (investment costs vs. LOS). Another decision for rail services is what network level they should cover. Should the services be local, regional, national or even international? (Vespermann & Wald, 2011). While making decisions on the landside accessibility of airports these issues and the user classes that will be using these services should be considered. The services need to be sufficient, efficient and need to serve the user's needs. Another issue for public transport nodes at airports is the limitations in space around the airport to use for public transport facilities. The space available around airports is often limited and expensive. Within this thesis research, only the access through the public transport network will be researched. From this point forward, all subjects will reflect on public transport access of airports.

Three pieces of the challenges around airport public transport nodes

Within the challenges of public transport nodes at airports, three fields are identified (see Figure 1). Multiple user classes, different network levels and the multiple involved stakeholders. Those fields all interact with each other and have influence on the access of the airport. Through this research, all three fields will be discussed on a general level in chapter 3, and in a Schiphol specific case study in chapter 4.
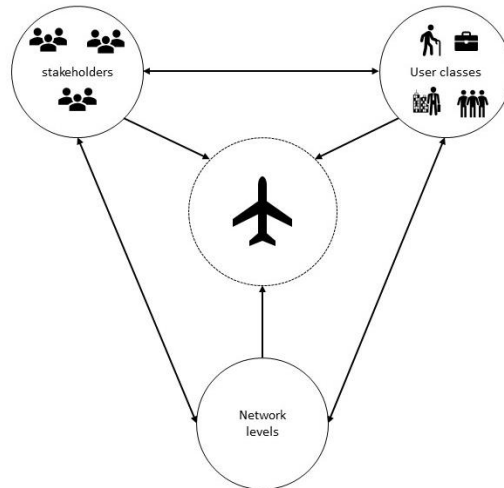
Figure 1- Three pieces of the complex airport puzzle

Different network levels

The most important function of a transport network is serving the demand between origin and destination locations. These locations may be on the same network level or at another level. The distinctive network levels are connected at a transport hub. The transport network levels differ in characteristics such as speed, vehicle type, frequency and trip length. Therefore, the various levels can serve different user classes with unique needs. An airport public transport station can have a hub function or it can be a regular station within the network. If the airport is a regular stop within the network, the station will handle public transport passengers that need to access the airport. Transfers will be made in a limited amount at a regular airport station. When the airport has a public transport hub function, multiple network levels are connected to the airport station. The function of this station will be to facilitate both public transport passengers that need to access the airports and public transport passengers that want to transfer to another network level. The position in the network and therefore the function of the airport public transport station determines the complexity of the airport station. The challenges will be discussed in chapter 3.1.

In the case of Schiphol Airport, it is not only a transport hub for aircraft but also for other public transport. At the station of Schiphol, multiple modalities are connected on multiple network levels. As Schiphol wants to maintain and strengthen its position within the competing field of airports, a top connectivity needs to be guaranteed. Schiphol wants to offer good transport services on both regional, national and international level (SchipholGroup, 2017d). Over 60% of the arriving passengers with a business travel motive have their destination with the region of Amsterdam. In particular, the Amsterdam business district "Zuid As" is important for business passengers (SchipholGroup, 2017b). This subject will be analyzed in more detail in chapter 4.2.

Multiple user classes

Airports are commonly considered as transport nodes where multiple airport user classes interact. Since this thesis will investigate the challenges for public transport nodes at airports both airport and non-airport public transport users will be incorporated. The user classes that will be distinguished here are: 1) business airport passengers, 2) leisure airport passengers, 3) airport employees, 4) commuting non-airport passengers and 5) other non-airport passengers (Hess, Adler, & Polak, 2007; SchipholGroup, 2017d). All these different user classes have distinctive characteristics, values and wishes. Therefore, offering services to these different classes is a complex subject. Looking at this complex subject, some issues can

be identified. The first issue relates to the costs of the services offered versus the level of service for the passengers. Where business passengers often receive refunds for their expenses by their employer and therefore have a higher willingness to pay, a holiday passenger might have a smaller budget and thus a lower willingness to pay. Both passenger types need to access the airport with a suitable means of transport within their travel budget. Another issue is the differences in passenger characteristics. Passengers carrying a lot of luggage are less flexible and need more space, while a non-airport commuter is more flexible and is less space consuming. When mixing multiple users within the same transport system, all characteristics need to be incorporated. The differences in wishes, characteristics and needs for all passenger types makes the accessibility problem complex without a 'one size fits all' solution. For all different user classes, the characteristics and specific wishes will be analyzed. An overview will be made with the differences among these user classes. This will be done in more detail in chapter 3.3.

Multiple involved stakeholders

On and around an airport, multiple stakeholders are involved for operating all services. The national, regional and local governments, airport operator, public transport operator and infrastructure owners are all involved with the public transport access of airports. Those stakeholders all have their own interest and economic reasons for working on the airport grounds. Those interest can conflict and hinder the decision-making process for solutions. Having a clear overview of which actors are involved in the public transport access of airports is therefore important to make sure plans become reality. The involved actors will be discussed in 3.4.

1.2 Relevance of this thesis research

Societal relevance of the Schiphol Airport case study

Amsterdam Airport Schiphol is the ultimate example of an airport that is integrated within the national public transport network. The airport is connected to multiple public transport modes and the station for public transport services is in front and bellow Schiphol Plaza (SchipholGroup, 2017g). The share of public transport increases over time while the drop-off by car decreases (see

Table 1). This concept is very convenient for the passengers wanting to access and egress the terminal building, as for non-airport passengers that want to transfer to another mode of transport. Schiphol station has developed itself as one of the most important transport hubs within the region (MRA, 2015) and Schiphol Group wants to strengthen this position (SchipholGroup, 2017h). With this development, some benefits have evolved to dis-benefits. During peak moments, Schiphol station must operate above its capacity (Ministry-of-Infrastructure-and-Environment, 2016) which leads to overcrowded platforms and vehicles. From the recently performed NMCA (Nationale Markt- en Capaciteitsanalyse) it is evident that there are problems within the public transport capacity around Schiphol Airport (Ministry-of-Infrastructure-and-Environment, 2017). Because the train station is located in a tunnel underneath Schiphol Plaza, and the limited area available around Schiphol Plaza, the expansion possibilities are limited. The choice to let all public transport services run through the bottleneck Schiphol station is now one of the major problems, but this is also the biggest advantage for passengers because of the ease of transferring. Combining the existing issues with the predictions in origin-destination passengers (being passengers arriving at and departing from Schiphol Airport that will use the landside access network) for Schiphol Airport (see Figure 2) makes it evident that, over time while doing nothing, this concept will go down from its own success.

Because Schiphol is an airport with an important public transport function, this case will be used to identify problems and learning goals for the integrated concept.

Academical relevance of this research

All the above-mentioned challenges and differences make it difficult for the involved stakeholders to choose what type of services they want and need to offer. This problem differs in every airport within different regions in the world. There is no guideline or solution to make the airport accessibility as good as possible. Obtaining information and knowledge about the challenges of this system and stakeholder perspectives is valuable to optimize the airport accessibility problem. Within current literature, not much attention is paid to the interaction between public transport nodes and airports. Since more challenges and interactions arise when adding airports to the challenges of regular public transport nodes, it is important to gain insights in this interaction. This will be done by constructing a method for analysing the challenges for public transport nodes at airports. This method will be set up using current literature and interviews with professionals in these subjects. The knowledge that is not yet available within current literature will be made visible and some research recommendations will be given.

The aim of this research is to structure these challenging problems from an actor perspective as well as from a technical perspective. The technical perspective will go in detail on the theory of transport network levels. The actor perspective will specify the needs, wishes and objectives of the involved stakeholders. Combining both research fields results in a wider and more complete view on the problem.

Table 1- Mode share Schiphol Airport (SchipholGroup, 2017e) & (SchipholGroup, 2017d)

Transport mode	2013	2014	2015	2016
Public transport	39.2	39.1	40.4	42.4
Drop-off by car	26.6	26.2	23.8	22.5
Parked car	13.0	13.0	13.6	12.3
Taxi	9.9	9.3	10.8	11.7
Shared transport	8.0	8.4	8.2	7.4
Other	3.3	3.3	3.2	3.7
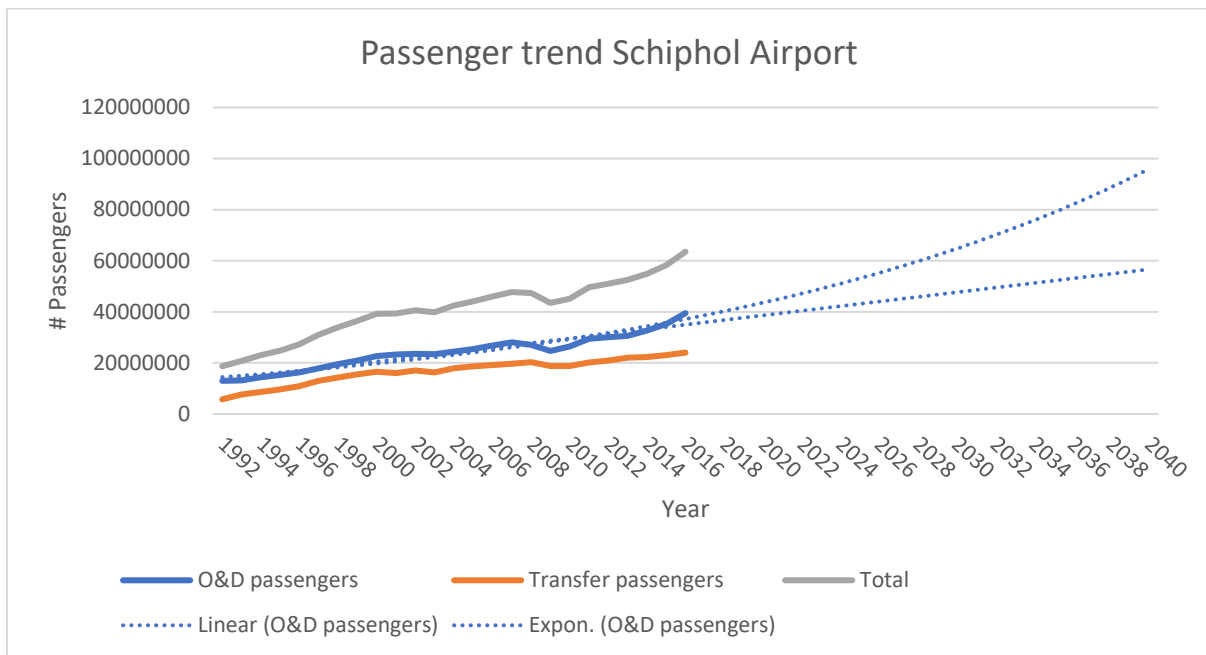
Figure 2- Passenger prediction 2040 (SchipholGroup, 2017f)

1.3   Problem statement

As mentioned before, the concept of airport accessibility is complex and concerns multiple stakeholders with different interests. The public transport operator needs to make multiple choices on complex issues concerning airport accessibility by public transport. On the other hand, multiple user classes need to access the airport. With different preferences and wishes, each of these user classes need to be identified. Thirdly, airports want to be connected to the public transport network on local, regional and (inter)national level. If the airport public transport station has a hub function, all these transport network levels must interconnect with each other on the airport grounds. The location of the airport in a transport network cannot always be chosen and sometimes grows historically into the network. Next to that, the available space around airports is often limited and expensive. Combining all these issues, offering transport services that fit all user classes seems almost impossible. Therefore, it is necessary to obtain insights in these challenges by analysing all separate elements of the problem. Within current literature not much attention is paid to the interaction between public transport nodes and airports. Therefore, there is a lack of knowledge on this interaction. This so-called knowledge gap can lead to problems for policy and infrastructure investments. This research will fill in this knowledge gap where possible and will give recommendations on how to fill in the remaining knowledge gap.

1.4   Aims and research questions

The aim of this research is to gain insights in the challenging issues of airport public transport nodes as described above. Issues that will be addressed are the different network levels, the differences in passenger characteristics and the involved stakeholder preferences. From the literature study, a method will be constructed that can be used to analyse the challenges around public transport nodes at airports. This method will be generic and can be used for all airports that are connected to a public transport node. To test this method, a case study will be done by investigating the common practices at Schiphol Airport. The current situation at Schiphol Airport will be assessed for all public transport network levels, user classes and

involved stakeholders. This case study will be performed to test if the proposed method works and what research is needed to complete this method. This method has the aim to clarify challenging problems at specific airports. The method can be used to analyse all airports in the worlds. From the theoretical research and practical research, a recommendation will be made on how to improve the proposed method and how to research the knowledge gaps in the future.

In this research, the main research question is:

"What are the challenges concerning public transport nodes at airports and what challenges should be researched in the future?"

To answer and structure this problem, this thesis research will answer the following questions:

1. Which factors influence the accessibility of locations? (Chapter 2)
2. What network levels are connected to airports and what function does the airport take within the transport network? (Chapter 3.1)
3. How do user classes differ in case of their preferences and wishes for a transport service to an airport? (Chapter 3.3)
4. Which stakeholders are involved in the airport public transport access issue? (Chapter 3.4)
5. What are the challenges around Schiphol Airport considering the public transport access of the airport? (Chapter 4)

1.5   Structure of the research

Methodology

Every question stated in this research is specified to gain knowledge about the public transport access problem around airports. The knowledge will contribute in making technical and policy decisions about public transport provision at airports. It is important to know that there will not be a 'one size fits all' solution that can be applied at all airports around the world. Using techniques for actor analysis and system analysis this problem can be structured and made insightful. Figure 3 visualizes the structure of this research. This research is separated in a theoretical part, and a case study part. The information about network levels, user classes and stakeholders obtained from the theoretical research will be used to construct a method to analyse the public transport nodes at airports. To test this method, the case study on Schiphol Airport will be used.

The research questions, as formulated above, are indicated with their corresponding number in Figure 3. This is done to indicate in which part of the research which question is answered. Within the theory, a distinction is made between the subject 'public transport' in general and 'airport public transport'. Within the concept of airport public transport, several attributes need to be added to get to a complete overview. From conducted research, conclusions and recommendations for the current scientific knowledge on airport public transport access are given. From the case study on Schiphol Airport, case specific complexity issues are stated and solutions for these issues are given.

The theoretical research is conducted using literature research. This literature research is performed using online databases of Google Scholar, Science Direct and Scopus using the TU Delft license. To gather relevant literature the following terms are used to search the mentioned databases (see Table 2). The found literature is checked on relevance and quality by reading the content of the documents. The literature that is found relevant and of sufficient quality is used to conduct the thesis research. The information from the literature is not

presented in a separate literature research section, but it is mentioned by referencing important documents through this report. For a detailed list of all referenced documents can be found in the reference list in the back of this report.

Table 2- Search terms

Accessibility	Airport user classes	Schiphol bus
Airport actors	Multimodal transport hub	Schiphol passenger types
Airport ground access	Preferences user classes	Schiphol public transport
Airport network levels	Public transport	Schiphol public transport problems
Airport passengers	Public transport network hierarchy	Schiphol train
Airport public transport	Public transport network levels	Schiphol user classes
Airport public transport accessibility	Public transport stakeholders	Transport hub
Airport stakeholders public transport	Public transport user classes	

Data collection case study Schiphol Airport

The case study is performed using online literature research and doing interviews with involved stakeholders. The web research is performed in the same way as the literature research as described above. The interviews were scheduled with experts from the involved stakeholders. The experts are selected by the team of Arcadis. All experts have specific knowledge about the Schiphol case. The experts that were invited are:

- National railway operator (NS) – Wim Oosterwijk, Account manager region Randstad Noord
- National rail owner (ProRail)- Alexandra Vanhoutte, Process manager Noord-Holland and Douwe Westervaarder, Process- and relation manager Noord-Holland
- Vervoerregio Amsterdam- Arnoud Mouwen, Senior researcher Municipality Amsterdam and Jan Smit, manager decision making MKS Schiphol

Schiphol Group was invited for these interviews. However, they did not respond to multiple ways of contact and were therefore excluded from the interviewees. The actor analysis for Schiphol Group is performed based on online research.

The municipality of Haarlemmermeer was contacted through Erik van der Peet, an Arcadis colleague who is also working for the municipality council of Haarlemmermeer. He could not participate in the interviews but was able to send the necessary documents. These documents are used as all other literature in this research.

The interviews are performed by asking open questions to the interviewees. The list of questions send to the interviewees can be reviewed in appendix A. The questions are formulated by doing literature research before the interviews. The interviews were recorded (if allowed by the interviewee) to prevent false interpretation during the interview. To verify the statements made during the interview, a document was send back to the interviewee. All interviewees confirmed the summarized interviews and allowed to use the interviews for this research. The interviews are not mentioned in a separate section of this report, but are being referred to by the last name of the interviewees throughout this report. A summary of the performed interviews can also be reviewed in appendix A.
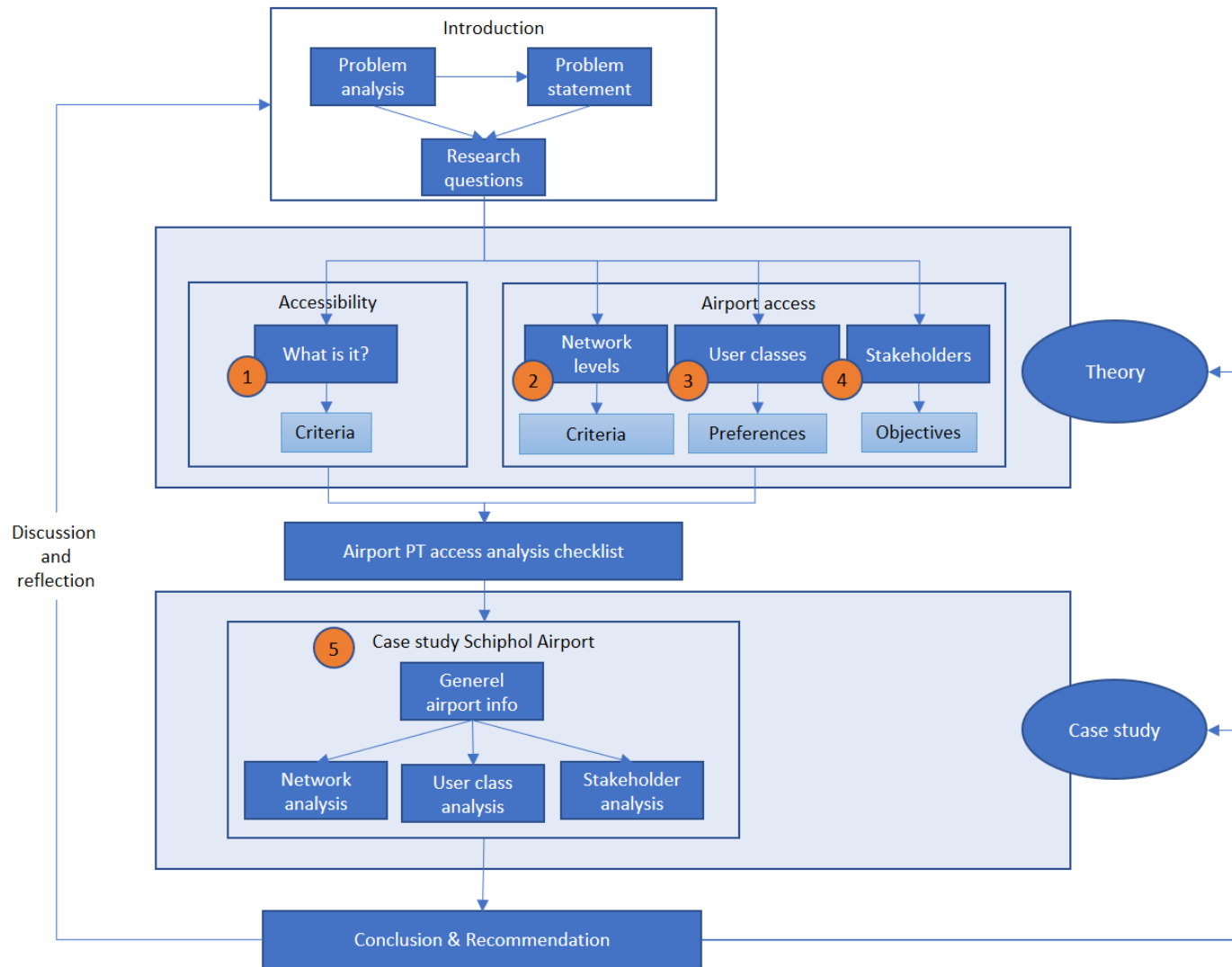
Figure 3- Research approach

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2. Accessibility of public transport nodes

Within this chapter, the concept of accessibility will be addressed. This will be done to construct a method on how to assess public transport access in general. No relation with airports will be made in this chapter. The research question that will be discussed in this chapter is "which factors influence the accessibility of locations". To obtain a complete overview of airport accessibility, the term "accessibility" needs to be understood and well defined. First, an overview of various definitions of accessibility will be laid out. Secondly, a description of accessibility will be given based on multiple references. Thirdly, an overview will be given about the common measurement attributes of accessibility.

2.1   Debate about accessibility definitions

Accessibility is a complex subject. The term accessibility is explained by many scientists in numerous ways. A few definitions are:

"The freedom of individuals to decide whether or not to participate in different activities" (Burns, 1979)

"The benefits provided by a transport land-use system" (Ben-Akiva & Lerman, 1979)

"The potential of opportunities for interaction" (Hansen, 1959)'

"The ease and convenience of access to spatially distributed opportunities with a choice of travel" (Dong, Ben-Avika, Bowman, & Walker, 2006)

"The ease with which any land-use activity can be reached from a location, using a particular transport system" (Koenig, 1980) & (Dalvi & Martin, 1976)

"Accessibility refers to the ability to reach desired goods, services, activities and destinations (collectively called opportunities)"(Litman, 2011)

"Accessibility … is the capacity of a location to be reached from other locations, or to provide access to other locations, and it is inversely related to the generalized costs associated with this access"(Reynolds-Feighan & McLay, 2006)

"Accessibility is the ease of reaching meaningful destinations from a particular location within a particular time or cost threshold" (McCahill & Ebeling, 2015)

From these definitions, it can be concluded that the term accessibility should be explained as 'the ease of traveling from the origin A to destination B'. Where location A is the current location of a person and location B the preferred location because the opportunities at location B are better than those at location A. Opportunities can be seen as shops, jobs and activities.

To determine how accessible a location is, the first aspect can be defined as the ease with which a location can be reached. The ease of travelling from one location to another is mostly associated with the effort or costs related to a trip. This depends on the services offered on the route from location A to B.

The second aspect of accessibility is the diversity of cities from where a location can be accessed. When a destination can be reached from more origins, the better the overall accessibility will be. The directness is one related aspect. Directness can be defined as a trip that can be made towards the desired destination without needing to transfer within that trip. The more direct connections are offered between the origin and destination, the better the accessibility of a location (Oosterwijk, 2017).

Thirdly, a time component should be added to describe accessibility. This relates to the time of day on which the transport system is available. Specifically, during very early morning or very late evening trips, this temporal component might cause some issues.

Fourthly, the personal components of passengers that make a trip should be incorporated. This relates to personal characteristics, preferences and wishes that people have (Geurs & van Wee, 2004).

2.2   What does accessibility include

To further understand the term accessibility the key components should be described. These components can be retrieved from the various definitions and theories on measuring accessibility. The four components that are identified are: "land-use, transport, temporal and individual" (Geurs & van Wee, 2004). For all four components, a brief explanation will be given:

- Land-use component: This component relates to the distribution in space of meaningful opportunities that people want to reach. The more meaningful these opportunities are, the more demand will be generated for these destinations at the origin.
- Transport component: This component describes the transport system itself. This transport component gives people the possibility to reach certain locations with meaningful opportunities. Without this transport component, no trips will be made by people.
- Temporal component: The transport component, as described above, is not always available. An example of this restriction is that for most public transport services, no or few services are available over night. For the road system, this temporal component is of less importance, though roads might be closed because of construction work.
- Individual component: Within this component, the needs, wishes and personal restrictions from which the need to travel to opportunities is covered. Individuals have different objectives to travel to a destination.

The transport component is assumed to be one of the key factors that enables people to travel from one place to another to reach meaningful opportunities. The transport system can be analyzed by the layer system (Schoemaker, 2002). This layered system is visualized in Figure 4.
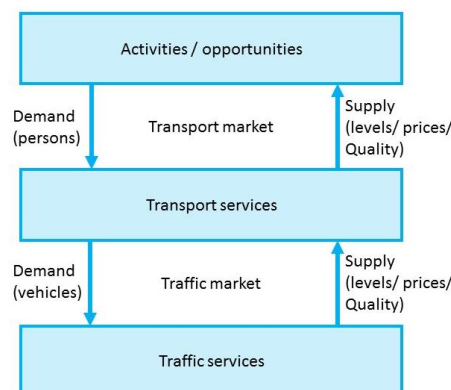

Figure 4- Transport layer system (Schoemaker, 2002)

The top layer consists of the activities and meaningful opportunities that are distributed in space. This can be linked to the land-use component, mentioned earlier. The second level is represented by the transport services. These are the services available to people that wish to

travel to activities and opportunities. Both private transport modes and public transport modes fall in this layer. The transport layer determines the utility, or disutility, of a trip from the origin to the destination. The temporal component relates to this layer. The third layer consists of the traffic services. The traffic service provides infrastructure to the transport services to operate on (Schoemaker, 2002).

The markets between those layers are driven by demand and supply of persons and vehicles. These markets are evolving over time. Both the economic environment in which the transport system is located as the technological developments in transport and traffic services change demand and supply over time. For example, with a fixed travel budget, when income increases, the mobility increases proportionally (Schafer & Victor, 2000). Therefore, the demand on the transport market will rise when the economy strengthens. Due to technological developments, the supply on the traffic market can change in case of quality of services.

2.3   How to measure accessibility

In the paragraphs above, the concept of accessibility is explained and described. Within this part the commonly used attributes that indicate the accessibility of a location are described.

Attributes

Throughout the proceeding paragraphs, some attributes are mentioned. The most intuitive attribute of accessibility is the out of pocket costs for users. To structure all accessibility associated attributes a classification is made (Kamruzzaman, Baker, Washington, & Turrell, 2013):

- Location characteristics: mode availability, type of location.
- Trip characteristics: trip time, distance, time of day, purpose of the trip and costs
- Individual characteristics: such as age, gender, physical abilities and car availability
- Individual preferences: such as attitudes towards travel modes and social factors

An additional category for externalities can be added for policy evaluation purposes. This category should take into account environmental effects, safety and land-use effects of mode choice policies (Koenig, 1980).

Other attributes that should be incorporated when considering accessibility measurements are (Beirão & Cabral, 2007):

- User friendliness: this attribute relates to the ease of use of the system for the passengers. This includes ticketing, travel information and the different directions that can be taken. More different directions may cause passengers to take the wrong train.
- Comfort: this aspect relates to the physical aspects of making a trip. Aspects that are incorporated in this comfort attribute are level changes on stations, level changes in trains, train environment, platform environment etc.
- Reliability: the reliability of a system is related to the percentage of trains that are operated on time. "On time" is specified differently in every country. In the Netherlands, a train is on time when it arrives at the station within a 5 minute interval (NS, 2016).
- Robustness: additional to the reliability (on time) performance of a transport network, the robustness of a network is important. The robustness can be defined as "The extent to which, under pre- specified circumstances, a network is able to maintain the function for which it was originally designed" (Snelder, Immers, & van Zuylen, 2012). An addition to this definition is "The robustness of a public transport system is the

ability to withstand or quickly recover from disturbances such as infrastructural and vehicular malfunctions and planned maintenance without significant reduction in the performance of the system" (Cats & Jenelius, 2015).

- Level of service (LOS): this attribute relates to the trip itself. Aspects that relate to this attribute are frequency, waiting time, transfers needed and trip time.

These attributes all relate to the preferences of the passenger group that is using the transport network. All attributes will have different importance to different user classes. This will be described later in this report.

2.4   Conclusion

The objective of this chapter was to clarify the concept of accessibility. The research question that is answered in this chapter is 'which factors influence the accessibility of locations'?

Through literature study as described in previous sections, accessibility is the ease of reaching a meaningful opportunity with an associated utility. The ease can be defined as the travel time or the effort it takes to reach a location. On the other hand, the accessibility of a location can be defined by the number of direct locations connected to the specific location. Accessibility of a location is dependent on the transport system which gives individual users the opportunity to travel towards the preferred location. Another component of accessibility of a location are the access rate on a specific time of day. To enrich the measurement, aspects such as individual characteristics, preferences, trip characteristics and location characteristics can be added. To summarize, the components of accessibility are:

- Land-use component
- Transport component
- Temporal component
- Individual component

Most important attributes to measure these components are:

- Distance
- Travel time, travel costs, waiting time, transfers needed, frequency, reliability, robustness
- Comfort, user friendliness

This chapter discussed accessibility in general. This will serve as a base for the airport accessibility study that will be done in the next chapters. The attributes that are important to assess public transport access of a node, as mentioned here, will be used to assess public transport nodes at airports as well. Now that for regular public transport nodes the assessment attributes are known, the additive attributes to assess public transport nodes at airports will be discussed in the next chapter.
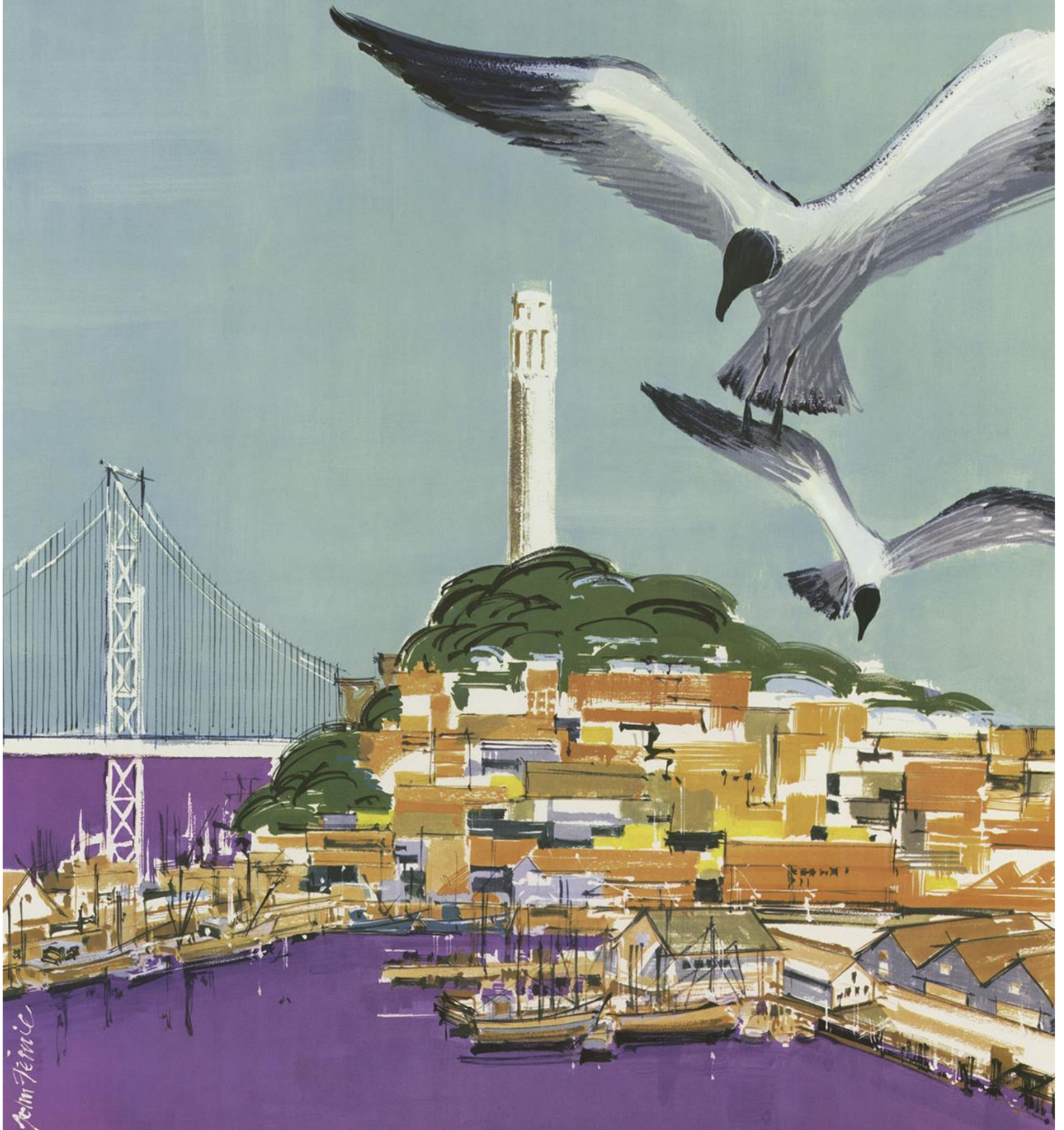
3. Public transport nodes at airports

Within this chapter, the issues around public transport nodes at airports will be discussed. Within this chapter three research questions will be discussed. In section 3.1 the question "what network levels are connected to airports and what function does the airport take within the transport network" will be treated. Secondly, the travel behaviour and mode choice will be discussed. This will be done to get a better understanding on how passengers choose a transport mode. The information will be used to answer the second research question in section 3.3 "How do user classes differ in case of their preferences and wishes for a transport service to an airport. In section 3.4, an overview will be given on the involved stakeholders in the airport access problem. This will answer the fourth research question "Which stakeholders are involved in the airport public transport issue". The knowledge from this chapter will be used to define an overview of the challenges around airports in case of public transport. Also, a method will be set-up to use on case specific airports. This will be done in section 3.5.

3.1 The airport within the public transport network

Within chapter 2, the transport layer system of (Schoemaker, 2002) is discussed. Within this layered system, the transport service component illustrates the transport services that are available to people needing transport. When looking at a single-modal transport system, only one transport service will be provided. Only one public transport service provider needs to operate a service. When talking about multimodality within the public transport network, more public transport service providers offer their services within the transport services component. The more transport services are offered, the more competition between parties resulting in more involved stakeholders. This has benefits for competition, but does not always make the services better or more user friendly. Think about different ticket services that can make the transfer more inconvenient. The public transport companies often offer services on different network levels. For example, bus companies offer their services on an urban level where train companies do offer their services on an inter-urban level. Therefore, there is only a limited competition effect between the public transport service providers. Their services have a more additive effect than a complementary effect.

For an airport, some of the components as described in section 2.2 have differences compared to other locations. Airports are important locations for employees, airport passengers and visitors of the airport. Because airports are sometimes also developed as an important transport hub in the transport network, the importance of this location becomes even bigger. The temporal component is very important when considering airports. Work shifts at airports often start very early and end very late on the day, the public transport services should preferably run on those times as well. Accessing the airport even for the first or after the last flight should be possible. The individual characteristics differ as well from regular public transport stations. At the airport, passengers carry more baggage and will be less familiar with the transport system compared to regular commuters. Those differences need to be considered when looking at the access of airports.

The future multi-modal transport network should be a combined network of multiple hierarchy levels of several distinctive transport services, all coming together in a transport hub (Hoogendoorn-Lanser, Hoogendoorn, & Bovy, 1998). When airport landside road access networks get more congested, the need to change these congested airports into multimodal public transport hubs is growing. This could be done by integrating the airport into the regional, national and international public transport networks (Janic, 2011). Another reason to make airports multimodal hubs in the national public transport network refers to the benefits of a

central location in a network. When more direct services are offered to cities within the regional, national and international network, more passengers will find it easy to access the airport. Directness (defined as trips from origin to the destination without a transfer within the trip) of services is therefore an important incentive to develop the airport station as a hub station (Oosterwijk, 2017). The location of airports within the public transport network cannot always be chosen. It depends on the geographical location in relation to other cities how the airport can be connected to public transport. When looking at Figure 5, the location of Rotterdam The Hague Airport (RTH) is removed from the national rail network (in orange), while the location of Schiphol Airport (AMS) is right on top of the national rail network. This determines the access possibilities by public transport. Through the historical development of airports, more attention is paid to public transport. For Schiphol Airport, no public transport was available when the airport first started operating commercial flights in 1920 (SchipholGroup, 2017a). If airport become bigger and attract more passengers, the public transport access possibilities will grow as well.
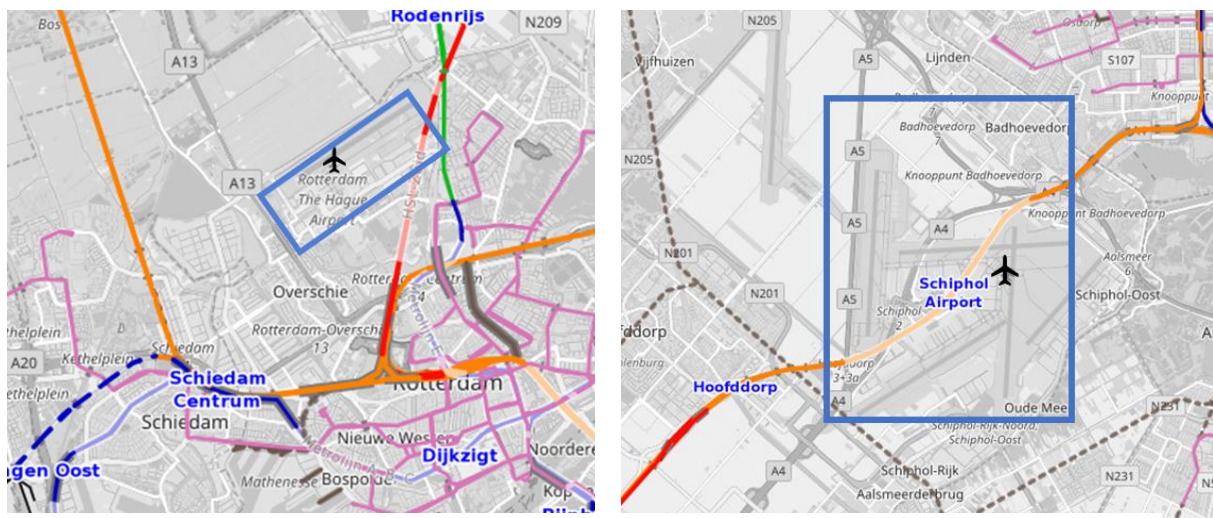
Figure 5- Location RTH (Left) and AMS (Right)

To give passengers the opportunity to change to another mode of transport, a transfer must be made. This can preferably be done on multiple locations in the transport network. On the transfer locations, multiple transport services with distinctive characteristics are connected. Multiple service levels such as, regional, national and international transport services are connected to these transfer locations.

Since making a transfer implies more inconvenience for the passengers (Hoogendoorn-Lanser, 2005), this transfer should be as effortless as possible in order for people to make the transfer attractive. Especially for airport passengers carrying baggage, the amount of transfers should be minimized within one trip. This can be done by designing the station in such a way that vertical movements are minimized and the connecting times for transfers are sufficient.

There is no guideline or rule on how many network levels an airport station should be connected to. Though most airports do have connections to local, regional and national transport services, not all airports have international connections (see Table 3). The public transport network maps of all airports mentioned in Table 3 can be retrieved in appendix B.

Within that table, only European airports are being displayed. This is done because public transport is used more compared to American airports (ACRP, 2008). It can be concluded that airports that can be characterized as a hub airport such as Amsterdam Schiphol, Frankfurt and Brussels, are connected to international locations via public transport.

However, this is not the case for London Heathrow. Passenger need an extra transfer at a national train station to use international train connections.

From the investigated airports in Table 3, the stations of Amsterdam and Frankfurt can be classified as airport stations with a public transport hub function. The stations of London Heathrow and Vienna are regular public transport stations within the network and do not have the hub function. The public transport network maps of all airports mentioned in Table 3 can be retrieved in appendix B.

Table 3- Available levels of transport at airports

Airport	Local transport	Regional transport	National transport	International transport
London Gatwick (GatwickAirport, 2017)	✓	✓	✓	
London Heathrow (Heathrow, 2017)	✓	✓		
Oslo Gardermoen Airport (Avinor, 2017)		✓	✓	
Arlanda Stockholm (SwedaviaAirports, 2017)	✓	✓	✓	
Vienna (ViennaInternationalAirport, 2017)		✓		
Amsterdam (SchipholGroup, 2017g)	✓	✓	✓	✓
Dusseldorf (DUS, 2017)	✓	✓	✓	✓
Frankfurt (FrankfurtAirport, 2017)	✓	✓	✓	✓
Brussels (BrusselsAirport, 2017)	✓	✓	✓	✓

To assess airports on the access structure, four network levels will be analysed: local, regional, national and international. This will be done because these network levels have distinctive characteristics and are offered at almost all major airports.

3.2 Travel behaviour on airport access mode choices

The transport services that are offered to access the airport are determining for the attractiveness of the airport. When the transport services that are offered have sufficient quality, more people will choose to use that airport to start their air trip. Especially in a region with close competing airports, the landside access by public transport is important the ensure a good position in the competing market (Tsamboulas & Nikoleris, 2008).

To offer a good transport service, there needs to be knowledge about the diverse characteristics of the customers which use the service. These characteristics differ between different user segments of the market. Different public transport customers might think different about certain service aspects than other customers (Beirão & Cabral, 2007). There are often different modes of transport available to access an airport. Customers that need to access the airport therefore need to choose which mode of transport they want to use. Because there are multiple services available around the airport, often from different public transport operators, these public transport companies compete when they offer the same services. When services are offered at another network level, the companies offer additive services and do not compete. They want to offer services that fit their passengers' needs as good as possible. In order to serve the passengers, the public transport operators need to know how passengers choose and what their objectives are (Tsamboulas & Nikoleris, 2008).

Within this research, passengers will be grouped by travel motive to analyse their preferences. Next to that, the focus will be laid upon arriving passengers for which the airport is the destination of their landside trip (see Figure 6). This group of arriving passengers consist of people that live in the country of the airport and the tourist that visited the country. This is done because this group of passengers is dependent on the departing flight on the airside of the airport. Therefore, this group has a higher interest in being on time at the airport to catch their flight. Departing passengers from the airport that have the airport as a starting point of their landside trip do not have that time constraint and are assumed to have lower priority in a punctual transport service (Tsamboulas & Nikoleris, 2008) & (M.-L. Tam, Lam, & Lo, 2011). An important note to make here is that for a small piece of this departing airport passenger, some time restrictions are in order. This group will mainly be part of the business travellers that have important meeting in the nearby business district. For this group, it is assumed that they have the same preferences and characteristics as an arriving airport passenger.
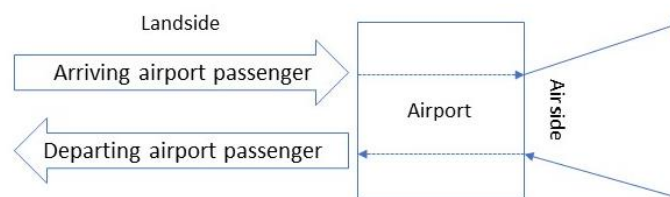
Figure 6- Arriving and departing airport passengers

Airport passengers arriving at the airport to go to the airside take some additional travel time into account to incorporate some delay in the landside part of their trip (Koster, Kroes, & Verhoef, 2011) & (M. L. Tam, Lam, & Lo, 2008). Incorporating this additional travel time, the departure time from home can be retrieved (see Figure 7).
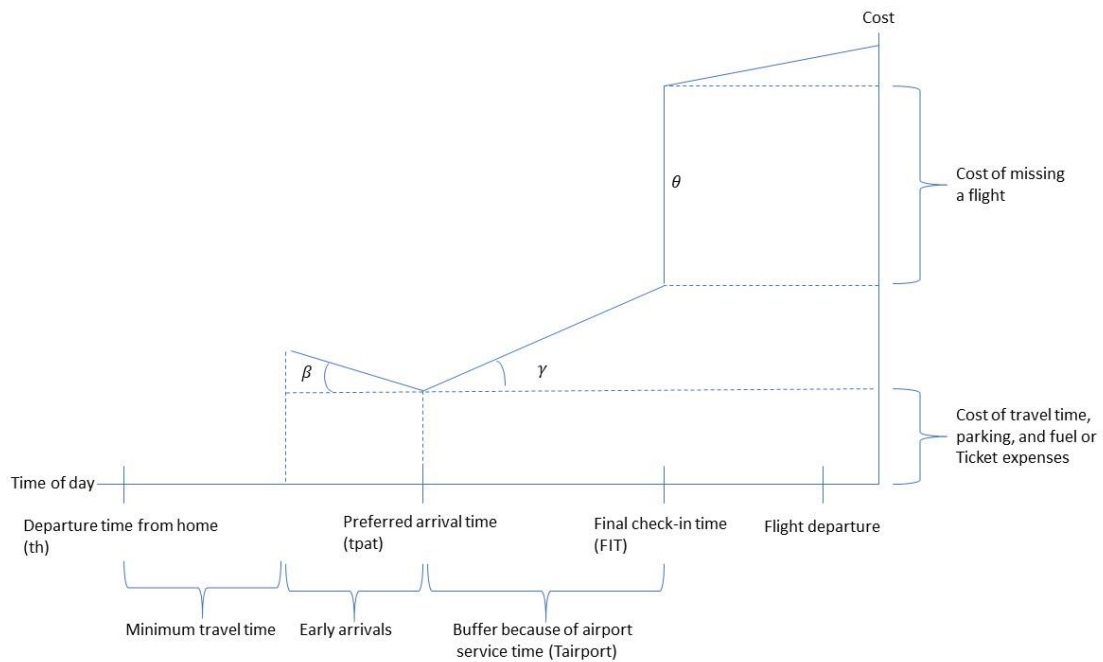
Figure 7- Landside trip travel time to airport and corresponding costs (Koster et al., 2011)

Looking at Figure 7, it can be deducted that passengers need to arrive before the final check-in time to catch their departing flight. Some buffer time at the airport is included for the check-in process and airport service time. Including this time, the preferred arrival time is stated. This is the most optimal arrival time for passengers, they are not too late and not too early. The travel time between home and the airport is included by taking the minimum travel time. The costs for being too early are associated with long waiting at the airport. The costs for being too late are associated with less time than desired at the airport and with higher chance of missing the flight. When missing the flight, the costs rise with value θ (Koster et al., 2011).

Next to the travel time aspects, the comfort aspects are also important in the choice of a travel alternative. These aspects can be incorporated by setting up multipliers for several comfort aspects (KiM, 2016). These multipliers are generic for all passengers within the transport network (not specified for airport passengers). It is assumed that these multipliers have a higher value when considering airport passengers since these passengers are limited by their departing aircraft and thus have a higher preference to arrive on time at the airport. The values for the multipliers can be seen in Table 4. When designing a new public transport service, these aspects should be considered and the effects should be minimized to make sure the public transport service will have sufficient comfort.

Table 4- Comfort multipliers (KiM, 2016)

Comfort aspect	Multiplier
Arriving too late	3.0-5.0
Walking with high effort	4.0
Walking in busy environment	2.5-4.0
Walking and waiting in regular circumstances	1.75-2.0
Standing in busy vehicle	1.50-2.0
Follow-up time vehicle	0.5-0.8
Deviation from desired arrival time	0.4-0.6
Transfer penalty	5-15 travel minutes

3.3 Identifying user classes

This section will discuss the specific user class preferences. The user classes that will be considered are: business airport passengers, leisure airport passengers, airport employees, commuting non-airport passengers and other non-airport passengers. These distinct categories of passengers will be compared based on their preferences in travel time, travel costs, reliability of the system, comfort, ease of use and travel experience. The chosen attributes to compare the user classes with are based on the customer preference pyramid as displayed in Figure 8 (van Hagen, 2014). It is stated that these aspects are the most important to customers and are likely to stay important over time for all users of the public transport system.
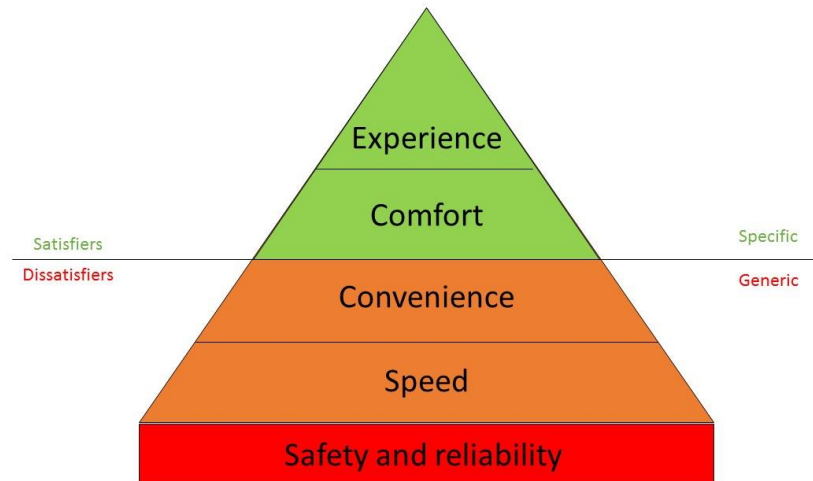
Figure 8- Customer preference pyramid (van Hagen, 2014)

Safety and reliability aspects relate to the transport service offered. Is the vehicle safe for the passengers and is the service reliable in terms of delays? Speed is of course the operational speed at which the vehicle operates. Within this research, the speed will be associated with the total trip. Therefore, the speed will be lower the operational due to intermediate stops. Convenience relates to the ease of use of the service. These aspects are classified as dissatisfiers. This means that if the transport service does not operate under these predefined characteristics, the passengers will be dissatisfied and are likely not to use this transport service. Because the safety criterion is assumed to be equally important to all user classes, this criterion will not be considered for the further analysis.

More passenger specific satisfying aspects are comfort and experience. These aspects relate to the tidiness of the vehicle, in-vehicle services such as Wi-Fi and the environment of the vehicle. When a transport service scores good on these aspects, the passengers are satisfied and are likely to use the transport service (van Hagen, 2014).

The dissatisfiers need to have sufficient quality to make passengers use the service. How high the scores on the satisfying aspects may be, these positives do not cancel out the negatives.

The final list of assessment criteria on which the different user classes will be compared are:

- Travel Time
  This criterion relates to the total time a passenger needs to travel from its origin to the airport. It includes the waiting time and transfers needed in the trip. This criterion is related to the speed of the total trip.
- Travel costs
  Within travel costs, the average fares for the trip will be considered.
- Reliability
  Within this criterion, the punctuality of the service will be classified
- Comfort
  This relates to the physical aspects of making a trip. For airport passengers, it is common they carry one or multiple pieces of baggage. With this assumption, it becomes clear that level changes and long walking distances will have an impact on the comfort of the passenger. The more pieces of baggage a passenger needs to carry, the less comfortable the trip will be.
- Ease of use
  This criterion considers the mental aspects of the trip. It includes the natural way finding at the station, ticketing, available traffic information, number of destinations and considering the chance of taking the wrong direction.
- Travel experience
  The travel experience of a passenger is influenced by the environment in which the trip takes place. This is the most subjective criterion within this analysis which makes it difficult to measure.

For every criterion, a qualitative priority will be given compared to the other user classes. Every assessment of user classes is done relative to the other user classes. The criteria are scored on a scale from 1-5, with 1 being very unimportant and 5 being very important. The values given to these criteria are based on research performed on ground access mode choice of airports (Jou, Hensher, & Hsu, 2011), (Harvey, 1986) and the interviews that are carried out for this research (Mouwen, 2017; Oosterwijk, 2017; Smit, 2017; Vanhoutte & Westervaarder, 2017). The preferences as will be presented in the next part cannot always be justified by the available literature or the interviews. Therefore, the statements must be considered as hypotheses based on personal considerations and educated guesses. The hypotheses need to be verified with future research.

Business airport passengers

Passengers in this group are travelling for business purposes such as meetings and conferences. These passengers may live in the country or are visiting the country. Business airport travellers have a relative high VTTS compared to the regular airport passengers. This is because business travellers often get refunded by their employer for travel costs (Harvey, 1986). This means that one hour is equal to approximately €20 (KiM, 2016).This measurement is specified for regular business passengers not airport related. It is assumed that this value will be higher for airport business passengers. Because business airport passengers often travel under time constraining limitations, they are willing to pay more to reduce their travel time. Therefore, travel costs are rated as not important. One note that should be made here is that since the economic crisis, more organisations want to decrease their travel expenses (Telegraph, 2008).

Since business airport travellers have such a high value of time (VoT), they often have higher expectations of the transport service compared to other passengers. Having a seat available in the vehicle makes it possible to use the travel time to work (Harvey, 1986). Because of the high VoT for business airport passengers, the reliability and travel time criteria are rated as most important.

Business airport passengers mostly make more trips per year compared to leisure airport passengers. Therefore, it can be said that they have more knowledge on the airport system and its access possibilities. The ease of use is rated important because of the higher knowledge of the system compared to leisure passengers. The physical comfort of a trip is rated as important. However, compared to a leisure airport passenger, the airport business traveller has less baggage to carry. Therefore, it is assumed that airport business travellers have a lower priority on the comfort aspect.

Since the airport business traveller makes the trip more times a year and arrives on a tighter schedule at the airport, it is assumed that the travel experience is rated neutral. It is not important if there are lots of shops with souvenirs on the station of an airport, the business traveller just wants to catch his flight. Business travellers that originate from the country in which the airport is located are assumed to have a higher knowledge of the public transport system compared to business travellers that are visiting the country of the airport.

Leisure airport passengers

This group of passengers need to access the airport to take a flight in their personal time. This could be a holiday trip or a trip to visit family or friends abroad. Passengers within this group may originate from the country in which the airport is located, or visit the country. These flights are usually operated by charter airlines. The value of time of this group of passengers is assumed to be lower compared to the regular commuter passengers. They are not refunded for their travel expenses. Because leisure airport passengers take much more time before their departing flight, the reliability aspect is of lower importance compared to the business airport traveller. The leisure airport passenger sees the complete trip from home towards the destination as a trip and wants to spend more time at the airport. Therefore, it is assumed that the travel time is of average importance to this group of passengers. The travel costs are considered important because of the low budget. Because this group takes more time before departure, the reliability of the public transport network is of less importance compared to the business airport traveller. However, missing a flight might cause missing a long-planned holiday. Therefore, a reliable service is still important.

This user class travelling for holiday purposes is likely to carry a lot of luggage. Therefore, a convenient and spacious vehicle is preferred. Also, stations with few level changes and short walking distances are preferred. In the interview with ProRail, it is stated that from personal

experience, transferring on a station with lots of level changes while carrying baggage will not be chosen by leisure passengers (Vanhoutte & Westervaarder, 2017). Therefore, this criterion is rated as very important.

Because this group does travel less compared to the business airport traveller, the leisure airport passenger is likely to be less familiar with the airport system and the access possibilities. Passengers that are visiting the country do have less knowledge compared to passengers that live in the country where the airport is located. The ease of use of the system is therefore very important.

Airport employees

This user class can be compared with non-airport commuters. The only difference is that this group of airport employees do use the terminal space of the airport. This group arrives at the airport whenever their work day starts. Probably just in time before the start of their shift. This group consists of both employees that will stay at the airport grounds, and employees that work for airlines. The employees working for airlines have time restrictions and have therefore a higher value of time compared to the airport ground employees. On the other hand, ground personnel also need to be on time for their shifts otherwise the process at the airport might be delayed. The travel time is therefore rated as important. It is assumed that the VoT of this group of airport employees ranges between the VoT of commuters and airport business passengers. Because of these time limitations, the reliability is of very high importance. This group will sometimes get (partly) refunded for their travel costs. This criterion is therefore rated as important. Since this group of passengers travel with relative few pieces of baggage compared to the business and leisure airport passenger, the comfort criterion is rated neutral. Lots of level changes are not preferable although it is of less importance compared to leisure passengers. This group of passengers makes the trip to the airport multiple times a week, and therefore the ease of use is less important since their knowledge is optimal. The knowledge of the airport system is high and the information to reach the airport is close to perfect. The travel experience is rated as totally not important since this group visits the station almost every day and is not interested in souvenir shopping.

Commuting Non-airport passengers

The non-airport passengers are not making use of the airport facilities. This user class only should be considered when looking at an airport with an integrated access structure. They only use the airport as a public transport station for travelling through to another destination. These passengers are regular commuter passengers for either work or study related purposes. The remaining part will consider attribute values for commuter passengers that make use of the infrastructure around the airport. This group does not have the restrictions of the departing flight. Therefore, the value of time is lower compared to the business airport travellers. This can be explained by the fact that this group is able to participate in their activity at the destination independent of their arrival time. However, the commuter travelling towards their job has a specified time to start their work activities and meetings. They do have some time restrictions, but lower compared to the business airport passenger. Therefore, the reliability of the network is of neutral importance. Travel time and travel costs are assumed to be the same as for airport employees.

The physical comfort of a trip is of average importance because of the same reasons for airport employees. Ease of use is not important since the information available to this group of travellers is assumed to be close to perfect. Also, the travel experience is totally not important because this group does not use the shops on the station.

Other non-airport passengers
This group consists of all other non-airport related traffic going through the airport station. This could be people visiting the nearby city or family. They do not have time restrictions for when their tasks will start at their destination. Therefore, travel time is rated as not important. Consequently, the reliability of the service is rated as neutral. This group is assumed to have an equal value of time compared to the leisure airport passenger. Therefore, the travel costs are also rated as important. The comfort is rated equal to the commuting (non-airport) passengers. For non-airport passengers, the travel experience is rated higher compared to commuting non-airport passengers because the commuting non-airport passenger is more likely to work or read on the way to work while other non-airport passengers can enjoy a new environment. This group also does not want to change levels too often and this group will make minimal use of the shops in the airport station. The ease of use does differ from the commuter group. This category does not travel often and the information available to them is much lower compared to the commuter group. Therefore, the ease of use is of high importance.

Table 5- Attribute values all user classes

Attribute	**Importance [1-5]**					
Travel motive	Business	Leisure	Airport employees	Commuting non-airport	Other non-airport	Average score
Travel time	5	3	4	4	2	3,6
Travel costs	2	4	4	4	5	3,8
Reliability	5	4	5	4	3	4,2
Comfort	4	5	3	3	3	3,6
Ease of use	4	5	2	2	4	3,4
Travel experience	3	4	1	1	2	2,2

Now that all the user class preferences are known, the values are summarized and displayed in Table 5. The average score is calculated for all attributes. This is done to show the difference in importance of the attributes for all users of public transport nodes at airports.

From the analysis, it can be concluded that overall reliability is the most important criterion. When looking for access solutions, the services that will be offered should have high reliability. Travel experience is the least important criteria. However, the environment of travelling should at least be pleasant and safe for people to travel in. The ease of use is only important for passengers that do not use the system daily. There should be attention paid to this aspect for the specific passenger type. It should be noted that there is a difference for business passengers that live in the country of the airport compared to visiting business passengers. This same difference is present in the leisure user class. When offering services at airports, this difference should be considered.

3.4   Stakeholders of public transport nodes at airports

As described before, multiple stakeholders are involved when it concerns airport access by public transport. For all airports, the following involved stakeholders can be identified.

National government

In the first place, the National government of a country has the obligation to ensure the safety of all inhabitants and visitors of the country. Therefore, the airport and its operations fall within this obligation. Furthermore, an airport is a facility that generates jobs and contributes to the national economy. Within Europe, most of the airports (53%) are fully owned by the national government and almost 30% is partially owned by the national government (ACI, 2016b). In case of a full publicly owned airport, the landside infrastructure and the airport facilities are owned by the national government. For partial ownership by the state, the landside infrastructure is owned by the national government (ACI, 2016b).

Regional government

The regional governments are concerned with the accessibility of the complete region in which the airport is located. Their objective is based on the complete region, not specifically for the airport. Regional governments have the obligation to define the development of grounds in their region such as the land use planning and development of infrastructure. Therefore, the development of the airport is important to them.

Local government

The local governments have the obligation to make land-use plans for the surrounding of the airport and the rest of the local grounds.

Airport owner

As mentioned earlier, the ownership of the airport facilities and infrastructure depends on the ownership structure. This can be fully public, private or a mix of public and private. In Europe, most airports are owned fully or partially by the state. The owner of the airport has the obligation to maintain and develop their part of the airport. In most cases, the landside infrastructure is owned by the state, where the terminal facilities and airside infrastructure is owned by the airport.

Airport operator

The airport operator wants the best accessibility of the airport. Depending on the location and country of the airport, this may be more public transport oriented or more private road transport oriented. Depending on the ownership structure, the airport operator rents the airport facilities from the owner. The airport operator wants to attract as many passengers as possible. They prefer a network structure that can be classified as many-to-one (being from many origins to on destination, the airport).

Public transport infrastructure owner

Since 2012, the European Parliament stated in a directive that the ownership of the rail infrastructure and the operation of the services on the infrastructure need to be done by separate companies (European-Parliament & The-Council-Of-The-European-Union, 2012). Within part of Europe, this is already the case, as for some countries the infrastructure and service provider is still the same company. The infrastructure owner has the obligation to ensure safety and availability of the infrastructure for service operators to use. In some countries, the infrastructure owner is a publicly owned company. Therefore, the national government also plays a role in this.

Public transport service operators

Public transport service operators want to offer their services to the passengers and users of the airport system. These companies pay charges to the infrastructure owner to be able to use the infrastructure. At airports with public transport services, one or multiple public transport service operators are present. When multiple service operators are present, those companies offer services additional to or competing with other public transport companies. The public transport service operators have the objective to operate in a network of services to serve as many passengers as they can. This network can be classified as many-to-many (being from many origins, to many destinations).

Travellers

The travellers that use public transport around the airport want transport services that fit their needs and preferences as good as possible. The travellers do not have a substantial influence on the decision-making process. However, they are often represented by traveller interest groups that make sure the voice of the travellers is considered.
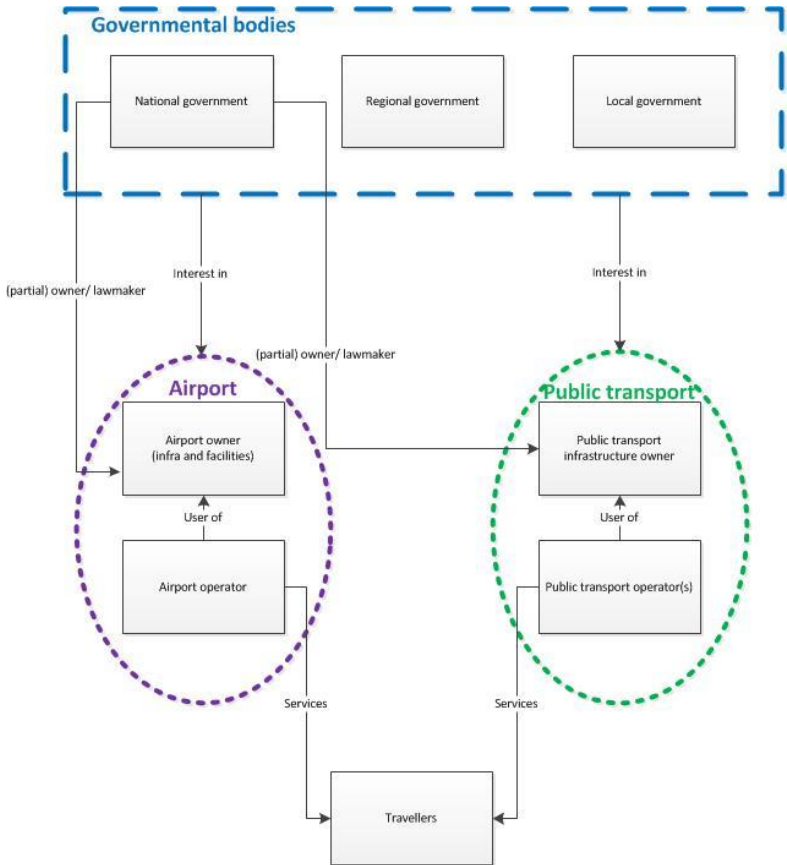
Figure 9- Generic airport public transport stakeholder relationship diagram

In this field of stakeholders, the overall objective is mostly the same "ensure good accessibility of the airport". Although the objective might be the same, the economic objective from the public and private stakeholders are different, as well as the objectives between all private stakeholders. Within companies, multiple divisions are present that all need to work together. In a project, this complexity can cause time consuming debates on what to do with the access of an airport. The structure of stakeholders as shown in Figure 9 can be used to identify case specific stakeholders and will therefore be used in the case study of Schiphol Airport in chapter 4.

3.5   Conclusion and analysis method

This chapter gives answers to three research questions. Firstly, "what network levels are connected to airports and what function does the airport take within the transport network". Most airports do have connections to multiple transport network levels. Local and regional levels are the most commonly connected levels. For some bigger airports, connections to the national and international transport level are given. The transport function of the airport depends on the network levels connected to the airport. In case of big airports, the station is often a hub within the big national transport network. For smaller airports, the station is not more than a stop within the network.

The second research question that is answered in this chapter is "How do user classes differ in case of their preferences and wishes for a transport service to an airport". User classes that are making an air trip differ compared to passengers that only use the airport station as a public transport hub. Air passengers do carry luggage and have more time restrictions. Also, air passengers do travel less by public transport compared to commuting non-airport passengers and are therefore considered to have less knowledge of the public transport system.

Now that the most important preferences for passengers are described for all passenger types, some notes should be made on what is most important for implementing new public transport services. In most public transport improvement programs, a modality or solution is chosen without considering the preferences of passengers beforehand. This often results in low usage of the public transport solution and not obtaining the preferred results. Therefore, this overview of passenger type preferences can be of added value for policy making and solution design. When looking at a solution to increase the access of airports by public transport these preferences should be considered. This research question could not be fully answered with current available literature. Therefore, statements that are made on this topic should be seen as hypotheses that can function as a starting point for future research.

The third question in this chapter "Which stakeholders are involved in the airport public transport access issue" can now be answered. Governmental bodies on national, regional and local level are part of this airport public transport access issue. Also, the airport operator and owner are present in the field of stakeholders. Public transport service operators and the infrastructure owner need to be considered. In the end, all stakeholders need to work together to serve the travellers and their preferences.

Challenges for public transport nodes at airports

Through the analyses done in chapter 2 and 3, the following challenges within the airport public transport access network can be identified:

Network approach

1. Location of the airport station within the network is a determining factor for the available access possibilities through public transport. Location can often not be chosen.
2. Airport differs in operational time during the day compared to other locations. Public transport systems are sometimes not available during the operations of the airport.
3. An airport operator has the wish to attract as many passengers as possible to the airport. Therefore, they prefer a many-to-1 network structure.
4. Public transport organisations need to transport as many passengers as possible. Therefore, they prefer a many-to-may network structure.

User classes approach

5. User classes mainly differ in the aspects of pieces of luggage, tight departure time and importance of user friendliness
6. Airport users consist of both national passengers as tourists. Tourists are assumed to be less familiar with the public transport system of a country
7. Public transport companies need to offer public transport that will be used by all user classes and not only airport passengers
8. Some user classes can change network levels more easily as others. This is dependent on the design of the stations and the amount of luggage passengers carry with them.

Stakeholder approach

9. Airport operator is dependent on the public transport companies for the public transport access of the airport. They do not have much power over the operations of the public transport companies around the airport.
10. Local governmental bodies have the least power, though they have high interest
11. National governmental bodies see the airport as an employing company that needs to be well connected to the public transport network
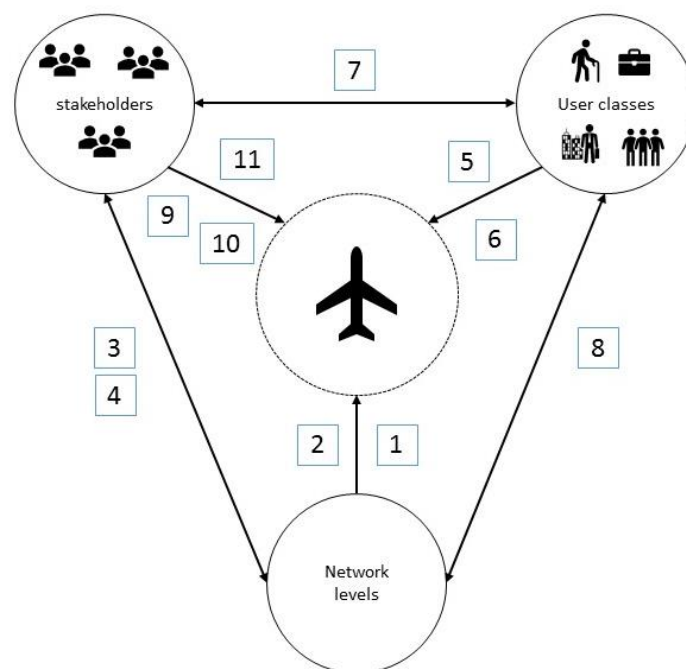
Figure 10- Challenges for public transport nodes at airports

Airport public transport access analysis method

To gain insights in the challenges of the airport public transport nodes, a method should be followed for a complete and structured overview. From the performed analyses, it is clear that three subjects must be analysed 1) public transport network around the airport, 2) user classes of the public transport at the airport and 3) involved stakeholders in the public transport at airports. To make sure all challenges will be made visible within a case study, the following questions must be asked:

Network approach:
- What is the location of the airport station within the public transport network?
- What network levels are connected to the airport station?
- What are the most important cities where passengers travel from to the airport?
- What are the corresponding speeds, frequency, transfers needed, costs, reliability, comfort, user friendliness and travel experience between those cities and the airport station?
- From what time is the transport network available?
- How high is the robustness of the network?

User classes approach:
- Which user classes can be identified?
- What are their preferences in case of public transport on the attributes speed, cost, reliability, comfort, user friendliness and travel experience?
- Which user classes do differ the most?

Stakeholder approach:
- Which stakeholders are involved in the public transport access system around the airport?
- What are their objectives?
- What are their interests and wishes for the public transport access?
- Which actors have conflicting interests?

This airport public transport access analysis method can be used to analyse all airports on their public transport structure. To test if this checklist is useful and complete, a case study on Schiphol Airport will be performed in the next chapter. From this case study, additional checks and challenges can rise (if any) and may be added to the final method.

4. Case study of Schiphol Airport

To check of the proposed method is complete and useful, a case study will be performed. Within this chapter, the public transport access of Schiphol airport will be studied. First, a general description will be given about the airport. Next, the network will be analyzed on international, national, regional and local network level. For all levels, the strengths and weaknesses in the network will be made visible. Thirdly, the user classes that travel around Schiphol Airport will be analysed. Fourthly, the stakeholders that are of influence on the public transport access are discussed. Fifthly, some plans that are carried out will be discussed and assessed. These analyses will answer the 5th sub question "What are the complex issues around Schiphol Airport considering the public transport access of the airport?"

4.1   General airport information

Schiphol airport is the largest airport located in the Netherlands and has a top 20 notation on the world's largest airport (ACI, 2016a). In 2016, Schiphol Airport transported over 63 million passengers. The airport is operating within one terminal for both arriving and departing international passengers. While airports transporting the same passenger volume as Schiphol such as Shanghai, JFK New York and Singapore operate multiple terminals to transport their passengers. The terminal configuration is based on one central arrival and departure hall connected to seven piers for parking aircraft. This configuration ensures that once passengers enter the terminal building, they do not need to transfer to another terminal building using inter-terminal transport.

Since 1920, Schiphol Airport is operating commercial flights. From that moment, the airport grew into the airport it is today. It was not until 1978 that the airport was connected with train infrastructure to Amsterdam Zuid. The tunnel in which the train station is located initially had only two platforms and in total three tracks. The tunnel was expanded to three platforms and six tracks (InfoSchiphol, n.d.).

The public transport access of the airport is provided in front and underneath the terminal building. The train station is located underneath the terminal and can be accessed through Schiphol Plaza by using the moving stairways or elevators. The Dutch railways provides train services to and from Schiphol. International railway services are provided by NS international, Thalys, ICE and in the future Eurostar. Bus services are provided in front of Schiphol Plaza on the Jan Delleartplein. Multiple Dutch bus operators offer services on Schiphol. Schiphol station is a central and important station within the national rail network.

Schiphol is the fourth busiest station next to Amsterdam CS, Rotterdam CS and Utrecht CS. When looking at the platform and rail capacity of those stations, Schiphol has much less space to transport all passengers. Schiphol station is not only a destination for airport passengers, but also a transport hub for passengers travelling to and from the Amsterdam region. Because the train station is located in a tunnel underneath the terminal, expanding capacity is very difficult and expensive. The bus station is surrounded by expensive real-estate and commercial buildings which makes expanding on ground level also difficult. These mentioned aspects make transporting passengers at Schiphol station complex (Mouwen, 2017; Oosterwijk, 2017; Smit, 2017; Vanhoutte & Westervaarder, 2017).

4.2   Network analysis

Within this section, the public transport network around Schiphol Airport will be analysed. The network analysis is performed to check if the network approach part of the proposed method is useful and complete. This analysis will be done on four network levels; international, national, regional and local level. The levels will be described by measuring the travel time towards cities within the search area, distance covered, speed of the vehicle, travel costs, travel costs per kilometre and frequency of the service. The network levels are represented in Figure 11. Furthermore, the ticketing principles will be analysed. This will be done to incorporate the complexity of ticketing systems for both national and international travellers. Within this part of the case study, the following questions from the method will be answered:

- What is the location of the airport station within the public transport network?
- What network levels are connected to the airport station?
- What are the most important cities where passengers travel from to the airport?
- What are the corresponding speeds, frequency, transfers needed, costs, reliability, comfort, user friendliness and travel experience between those cities and the airport station?
- From what time is the transport network available?
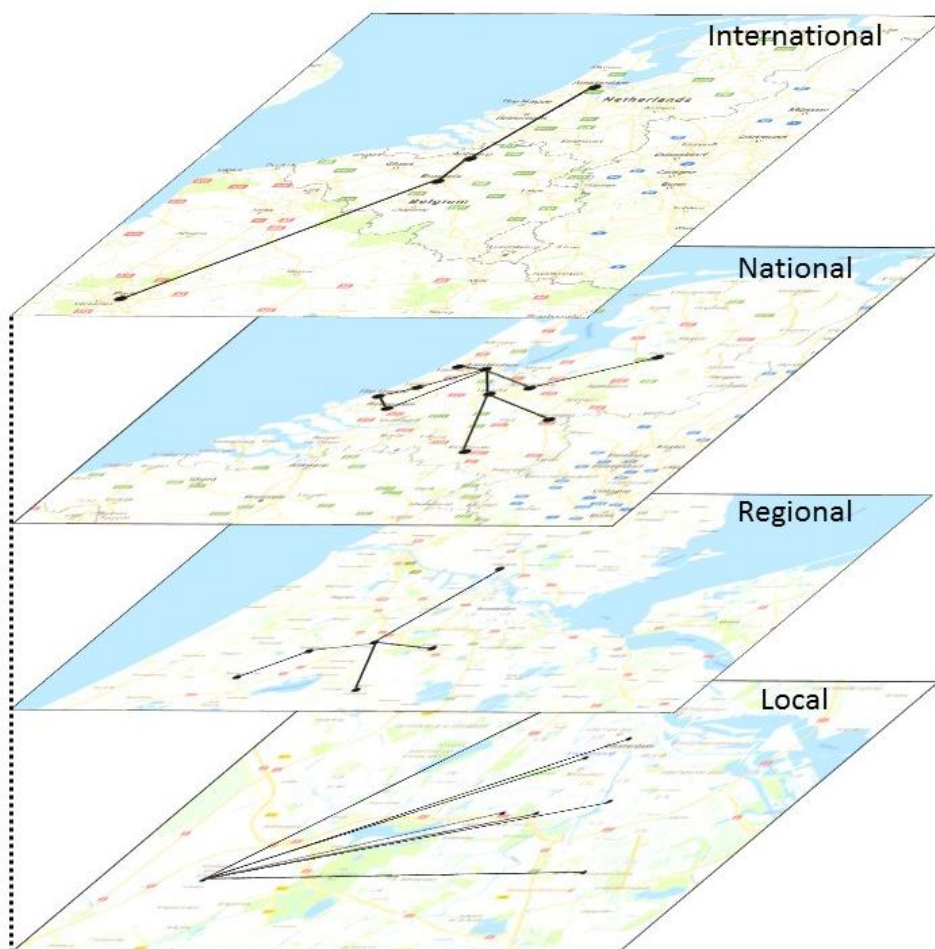- How high is the robustness of the network?

Figure 11- Network levels

Public transport companies operating at Schiphol Airport

At Schiphol station, multiple public transport providers are operating. As already mentioned in the previous section, services provided by NS, Connexxion, Arriva and GVB come together at the transport node of Schiphol. NS International covers the international train services towards the airport and NS operates the national trains on national and regional level. Connexxion has won the new concession for the area of Amstelland-Meerlanden and will be covering the regional and local transport services. Arriva offers multiple regional bus services in the area around Schiphol (Q-liner). GVB, the public transport operator of Amsterdam covers one bus line towards Amsterdam. These operators need to use the area around Schiphol Airport to provide their services to the passengers. To make Schiphol Airport good accessible and a well-functioning transport hub, these services need to connect in a convenient way for the passengers. The higher the frequency of the services, the less waiting time will be for the passengers and thus having a better connection between services.

International level

The services that are currently offered at Schiphol Airport are the NS International IC train to Brussels Zuid-Midi and the Thalys towards Paris Gare du Nord. These services are analyzed. The travel times that are displayed within the analysis is the shortest travel time with the fewest transfers. The distance towards the cities are measured using Google Maps base on the trajectory of the train services as displayed in the route planner (Google, 2017). Speed is derived from the travel time and distance and is therefore the average speed of the complete trip including stops. Travel costs are derived from the service providers online ticketing services (NSInternational, 2017). For the Thalys services, the costs are depending on how far in advance the trip is booked. Within this analysis the minimum cost is taken. Costs may be higher when booking on another day. Travel costs per kilometre is derived from the travel costs and distance. The frequency of the service is also derived from the online ticketing service. The frequencies are taken from a weekday. It is investigated if there is any difference in frequencies between peak-hours and non-peak-hours. For the train services, this is not the case. All frequencies of the investigated services are the same during the weekday. The results of the analysis can be find in Table 6. The results are visualized in **Error! Reference source not found.**. No international connections are offered on approximately the same radius distance as specified in the figure. Therefore, no comparisons can be made for other cities with the same distances to the airport.

The services that are offered on the international level are operated on the high-speed track between Amsterdam and Paris and on the regular intercity tracks between Amsterdam and Brussels. The Thalys makes use of the high-speed track. For passengers between Schiphol Airport and Antwerp and Brussels, there are multiple travel options available. In case of disruptions on either the high-speed track or the regular IC track, the passengers may be able to take the other trains. For the Thalys services there need to be a reservation made before the passengers may use the services. The trains towards Paris Gare du Nord cannot transfer to another train in case of disruptions. Therefore, the international network level is not considered as robust. The reliability of this network is difficult to define. The reliability (or punctuality of the services) depends on the time of the day. Another difficulty is the fact that punctuality is defined and measured differently in the Netherlands, Belgium and France. Therefore, comparing the punctuality data is not useful.

Within all trips between Schiphol Airport and Antwerp, Brussels and Paris, no transfers are needed. For the Thalys services, a passenger needs to make a reservation which ensures a seat in the trains. Therefore, the comfort aspects of the international level are considered as sufficient. All international train tickets can be booked within one ticket service from NS

International. This ticket service is clear and well structured. Therefore, the user friendliness of this aspect is considered as sufficient. This statement is made from a personal perspective, for international passengers this statement could be different.

The services to Belgium do not arrive at Schiphol Airport before 08:24, from Paris the services arrive not before 09:24. The last departure towards Belgium is at 20:34 (IC) and for Paris around 19:34. This makes early flight arrivals and late departures difficult.

On the international transport level, it can be said that only connections towards the South are offered from Schiphol Airport. For passengers that want to travel to Germany, they need to travel towards Utrecht CS and then transfer on to the ICE train. Travelers towards London need to travel to Brussels Zuid-Midi by either NS International or Thalys and then transfer to the Eurostar to London St-Pancras International station.

Another remarkable result is the low speed of the IC service to Brussels Zuid-Midi. This can be explained by the (relative) long stopping times at the intermediate stations and the low speed between station Brussels Airport Zaventem and Brussels Zuid-Midi.

The maximum speed allowed at the high-speed tracks between Schiphol Airport and Paris is 300 km/h, with an exception of the tracks around and between Antwerp and Brussels where the maximum speed is 160 km/h. The maximum speed at the regular IC track is 160 km/h. The speeds as displayed in Table 6 are much lower than the maximum speed. This can be explained due to the long duration of the stops at intermediate stations. The speeds appropriate for the international network level (van Nes, 2002).
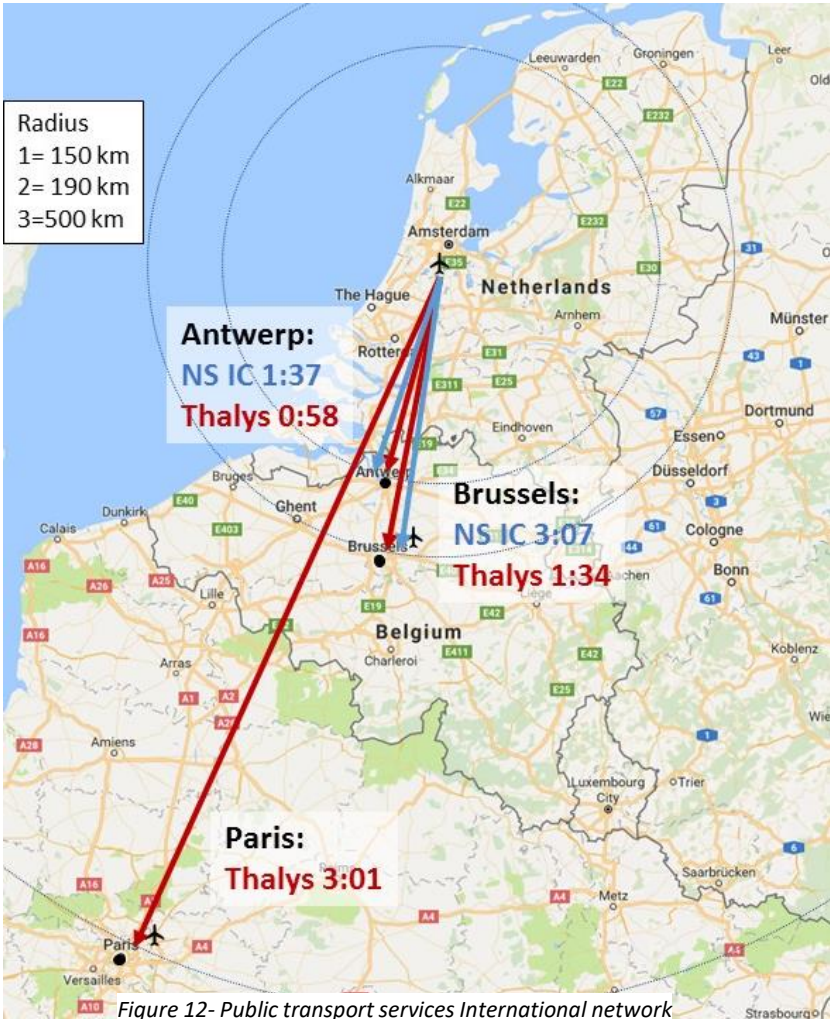
Figure 12- Public transport services International network

Table 6- Public transport services International network

Schiphol to	Travel time [Hours: min]	Distance [km]	Speed [km/hour]	Travel costs [Euro]	Travel costs/ km	Frequency	Average waiting time [min]	Transfers needed	First arrival at AAS	Last departure from AAS
Antwerp CS [Thalys]	0:58	145	150	From 29	0,19	1/hour	30	0	08:24	20:34
Antwerp CS [NS IC]	1:37	160	100	32,20	0,21	1/hour	30	0	08:21	21:08
Brussels Zuid-Midi [Thalys]	1:34	195	125	From 29	0,15	1/hour	30	0	08:24	20:34
Brussels Zuid-Midi [NS IC]	3:07	215	70	42,60	0,22	1/hour	30	0	08:21	21:08
Paris Gare du Nord [Thalys]	3:01	500	165	From 71	0,24	1/hour	30	0	09:24	19:34

National level

On the national level, multiple services are operated. NS operates the IC direct train between Amsterdam CS- Schiphol- Rotterdam CS, the regular IC trains and Sprinter trains. The data for this analysis is obtained by using the NS online trip planner (NS, 2017c), national trip planner of OV9292 (OV9292, 2017) and Google Maps (Google, 2017). This is done in the same way as for the international analysis. When in the NS planner, both IC trains and Sprinter trains were viable travel alternatives, both services are incorporated in the analysis. The frequency of the service is also derived from the online ticketing service. The frequencies are taken from a weekday. It is investigated if there is any difference in frequencies between peak-hours and non-peak-hours. For the train services, this is not the case. All frequencies of the investigated services are the same during the weekday. For bus services, there is a difference in frequencies. Arriva offers bus connections to Leiden CS with a frequency of 2/hour during the day. After 19.00 p.m., the frequency is 1/hour. Therefore, this service is incorporated in the national network analysis. Connexxion offers bus services to Haarlem (Zuidtangent). The fares for all services are fixed and not depending on the date of booking. A * in the table indicates that there is a night service available from this station to the airport and vice versa. This night service has other values than the regular day time services. Table 7 and Figure 13 give the outcomes of the analysis.

From the NS trip planner, it can be concluded that the reliability of the national train services can be increased. On most trajects, the punctuality (defined as arrival at the platform between 5 minutes from the schedule) lies between 80-100% of the trains that run on time. For some, specifically long distance trajects, the punctuality is between 70-80%. The punctuality fluctuates during the day depending on disruptions and peak-hours. The national network is considered as robust. This statement is made because there are multiple routes through which the airport is accessible. If a disruption occurs on one route, the passengers can make a detour and still arrive at the airport. However, because the rail station of Schiphol Airport is located in a tunnel, the airport becomes inaccessible during disruptions in the tunnel. Recent innovations and maintenance work has decreased the chance of disruptions in the tunnel, but the long-term effects of these works still need to be assessed (Oosterwijk, 2017). Within this analysis, there are few trajects on which passengers need to transfer. There often is a travel alternative without the necessity to transfer. During peak-hours, the trains can be really crowded. Therefore, the comfort of the PT on national level is considered as sufficient. However, some improvements can be made for the seat availability. At some stations within the national rail network, access gates are in place. These gates make the station inaccessible for people that did not buy a ticket for a train trip. For national citizens, this system is sometimes difficult to understand, let alone the difficulty for foreign passengers. Therefore, the user friendliness of this system can be improved. By providing more awareness and information about the gates at the stations, the user friendliness can be improved. When looking at the earliest arriving trains and latest departing trains, the national PT network is considerably well available during the day. Especially because there is a sufficient night service available between Schiphol Airport and big cities that operates at a frequency of 1 per hour. One remarkable omission from the night services is The Hague CS. The city of The Hague is however connected to the night service through The Hague HS station.

By looking at the outcomes some remarkable results can be seen. The travel time to Haarlem CS by NS sprinter train, is almost double compared to the travel time by Sprinter towards Amsterdam CS. Therefore, this connection has a much lower speed although having an equal number of stops (3 stops). This extra travel time is caused by a transfer that needs to be made at Amsterdam Sloterdijk station and a large detour on the trajectory of the train. The travel time to Haarlem is almost equal to the travel time towards Utrecht CS covering almost double distance. The speeds that are derived from this analysis are sufficient according to the network level (van Nes, 2002).

Figure 13- Public transport services National network

*Table 7- Public transport service National network * Night service available*

Radius	Schiphol to [mode]	Travel time [Hours:minutes]	Distance [km]	Speed [km/hour]	Travel costs [Euro]	Travel costs/ km	Frequency	Average waiting time [min]	Transfers needed	First arrival at AAS	Last departure from AAS
1	Amsterdam CS [NS Sprinter]	0:17	17	60	4,20	0,25	4/hour	8	0	05:32 *	01:11 *
1	Amsterdam CS [NS IC Direct]	0:14	17	73	4,20	0,25	4/hour	8	0	06:21	00:07
2	Haarlem CS [Connexxion Bus]	0:41	20	34	5	0,25	6/hour	5	0	05:27	01:11
2	Haarlem CS [NS sprinter]	0:35	27	46	6	0,22	7/hour	4	1 (at Amsterdam Sloterdijk)	06:14	00:41
3	Leiden CS [NS IC train]	0:16	25	94	5,80	0,23	4/hour	8	0	06:32 *	00:57 *
3	Leiden CS [NS Sprinter]	0:22	25	69	5,80	0,23	4/hour	8	0	05:54 *	00:30 *
3	Leiden CS [Arriva Bus]	0:46	30	33	6,38	0,21	2/hour	15	0	05:53	22:08
3	Utrecht CS [NS train]	0:32	45	83	8,70	0,20	4/hour	8	0	06:59 *	23:48 *
4	The Hague CS [NS IC train]	0:29	43	89	8,30	0,19	4/hour	8	0/1 (at Leiden CS)	06:02	00:27
4	The Hague CS [NS Sprinter]	0:50	43	52	8,30	0,19	2/hour	15	0	06:29	00:01
4	Rotterdam CS [NS IC Direct]	0:24	52	120	14,70	0,28	4/hour	8	0	06:53	23:23
4	Rotterdam CS [NS IC train]	0:51	65	76	12,30	0,19	4/hour	8	0/1 (at Leiden CS)	06:02 *	00:27 *
4	Amersfoort CS [NS IC train]	0:43	54	72	10,20	0,19	2/hour	15	0	06:53	23:06
4	Amersfoort CS [NS IC + IC Direct train]	0:55	54	60	10,20	0,19	2/hour	15	1 (at Amsterdam CS)	07:21	23:07
5	Nijmegen CS [NS IC train]	1:30	120	80	19,60	0,16	4/hour	8	0/1 (at Utrecht CS)	07:11	23:18
5	Zwolle CS [NS train]	1:09 / 1:33	115	100 /75	19,40	0,17	4/hour	15	0	06:55	23:34
5	Eindhoven CS [NS train]	1:26	125	88	19,80	0,16	4/hour	8	0/1 (at Utrecht CS)	06:59	23:18

Regional level

For this level, a difference was obtained in frequencies of bus services. During the peak hours (between 7:00 a.m. and 19:000 p.m.) the frequency for the bus services to Uithoorn and Amstelveen are 10/hour. During the other moments during the day the frequencies drop to 8/hour. The output of the regional transport level analysis is displayed in Figure 14 and Table 9. On a regional level, it can be concluded that some cities, located at the same distance from Schiphol Airport do have significant differences in travel time. Another remarkable finding is the travel time to Amstelveen. This city is located next to Schiphol (right hand side), has three times the number of inhabitants of Nieuw Vennep, while the travel time to Amstelveen is almost double compared to Nieuw Vennep. This can be explained by the detour made in the trip to Amstelveen and the fact that Amstelveen does not have a NS station.

From the NS trip planner, not all punctuality rates are available. For the information that is available, it can be concluded that the punctuality on the regional network level is good because the rates range between 77%-100% punctuality. Furthermore, the PT-customer analysis shows that the punctuality within the region of Amsterdam does not differ significantly from the average in the Netherlands (see Table 8). For all trips as displayed in this analysis, more trips are available with more transfers or a longer travel time. These alternatives can still be chosen if the first travel option is not available for passengers. Therefore, the regional network is considered to be robust. Within this regional level, not much transfers need to be made in a trip. The comfort level is therefore high.

Recently, the Amsterdam travel ticket is introduced for international passengers that need to travel between the airport and Amsterdam, or the region around the airport. This ticket makes it easier for international passengers since one ticket ensures access to all travel modes within the region. The user friendliness is therefore high. For Amstelveen, there is a night service available which enables passengers to reach the airport during the night. For all other destinations, the airport is inaccessible during the night.

Table 8- Punctuality OV-klantenbarometer (CROW-KpVV, 2016)

Criteria	Bus- city of Amsterdam	Bus- Amstelland-Meerlanden	Bus- Average Netherlands	Train- Average Netherlands
Punctuality	7.2	7.1	7.2	7.7

Figure 14- Public transport services Regional network

*Table 9- Public transport services Regional network * Night service available*

Schiphol to [mode]	Travel time [Hours: minutes]	Distance [km]	Speed [km/hour]	Travel costs [Euro]	Travel costs/ km	Frequency	Average waiting time [min]	Transfers needed	First arrival at AAS	Last departure from AAS
Zaandam CS [NS Sprinter train]	0:20	20	60	4,50	0,23	4/hour	8	0/1 (at Amsterdam Sloterdijk)	05:53	00:11
Amstelveen [Connexxion Bus]	0:15	12	48	2,46	0,21	10/hour	4	0	05:29 *	00:59 *
Uithoorn [Connexxion bus]	0:35	20	35	4	0,2	10/hour	4	1 (at Amstelveen)	05:29	00:59
Hoofddorp [NS Sprinter train]	0:04	5	75	2,30	0,46	10/hour	3	0	05:28	01:06
Nieuw Vennep [NS Sprinter train]	0:09	10	67	2,70	0,27	4/hour	8	0	05:54	00:30

Local level

On the local network level, Schiphol Airport is connected by the "Ster-net" bus services of Connexxion and GVB. Connexxion offers 14 bus line services connecting cities Amstelveen, Haarlem, Hoofddorp, Uithoorn and Amsterdam to the airport by bus. Within the new concession, these services will be intensified and have more capacity on the lines by extended buses (Connexxion, 2017a). These services have high frequencies of at least 2 times per hour to 8 times per hour. The Ster-net busses are free accessible for employees of Schiphol Airport and affiliated companies. The locations displayed in this analysis are based on the thesis of van den Brink (van den Brink, 2013) in which the most important locations within the agglomeration of Amsterdam are stated based on inhabitants, work places and event locations. The frequency of the bus service to Leidseplein has a frequency of 6/hour during peak hours (between 7:00 a.m. and 20:00 p.m.), outside this timeframe the frequency is 4/hour. The investigated train services have the same frequency during the day.

As mentioned earlier, the reliability of this region is good and in line with the average in the Netherlands. The local network is robust because of the many transport options available during disruptions. The speed of the services is in some cases low. Passengers that need to access the city centre of Amsterdam to stations of de Dam, Leidseplein or Amsterdam Amstel, the travel time is very high compared to the other destinations.

When looking at the user friendliness of this level, the bus platform at Schiphol Airport is the biggest problem. Lots of people do have difficulty with finding the right bus. For international passengers, this becomes an even bigger problem. The availability of services during the day are good. There are some night services available, and de latest departures are all around 01.00 A.M. This is later compared to the other network levels.

When looking at the results in Table 10, the distances, speed and services do not match. The Intercity trains normally run on longer distances. Because of the good connection by train, the local bus services are competed out of the attractive travel options by the train.
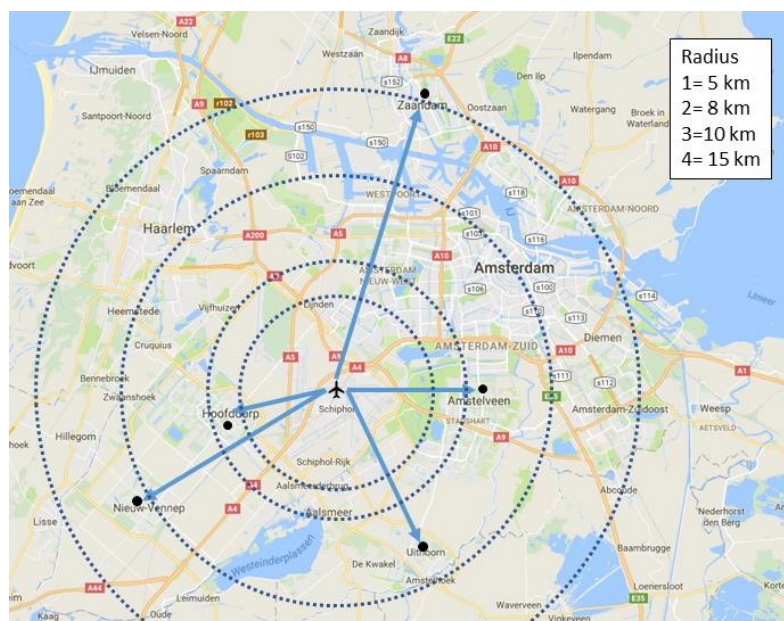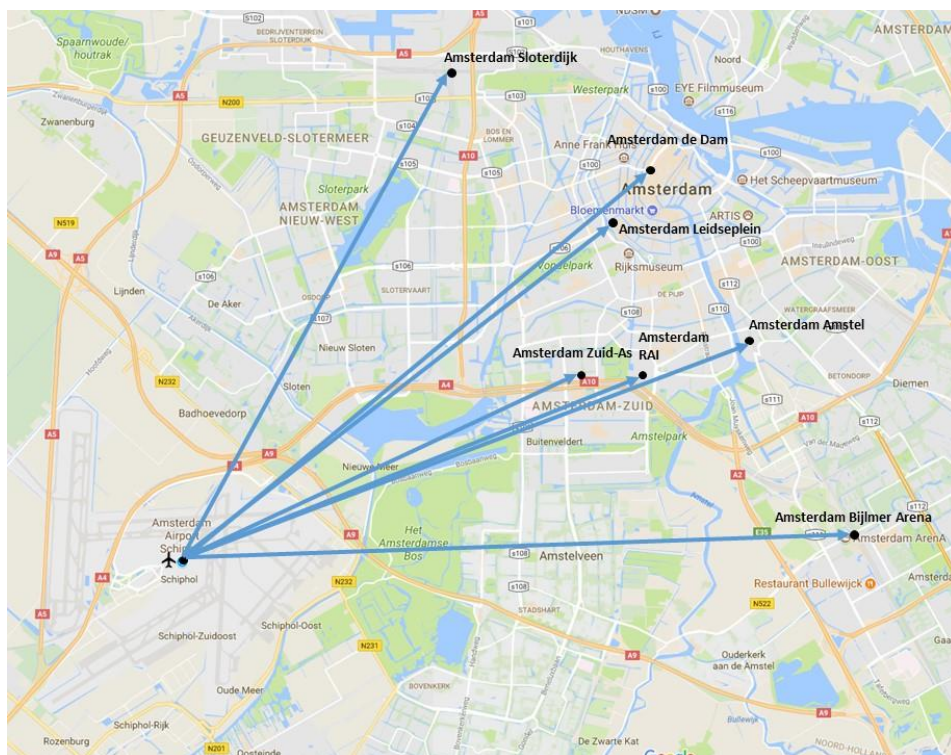

Figure 15- Public transport services Local network

*Table 10- Public transport services Local network *Night service available*

Schiphol to [mode]	Travel time [Hours: minutes]	Distance [km]	Speed [km/hour]	Travel costs [Euro]	Travel costs/ km	Frequency	Average waiting time [min]	Transfers needed	First arrival at AAS	Last departure from AAS
Amsterdam Sloterdijk [NS Sprinter train]	0:10	12	72	3,50	0,29	6/hour	5	0	05:32	01:11
Amsterdam Zuid-As [NS IC/ Sprinter train]	0:06	10	100	2,80	0,28	12/hour	3	0	05:43	00:24
Amsterdam Amstel [NS IC/ Sprinter train]	0:30	17	34	3,80	0,22	6/ hour	5	1 (at Duivendrecht)	06:17	00:41
Amsterdam Bijlmer Arena [NS IC train]	0:13	15	70	3,80	0,25	4/hour	8	0	06:29	0:41
Amsterdam de Dam [GVB/ NS train]	0:28	18	40	5,00	0,28	12/hour	3	1 (at Amsterdam CS)	06:18 *	01:11 *
Amsterdam Leidseplein [Connexxion Bus]	0:30	15	30	3,16	0,21	6/hour	8	0	05:02 *	00:28 *
Amsterdam RAI [NS Sprinter train]	0:10	10	60	3,00	0,30	4/hour	8	0	05:43	00:24

Ticketing

As described in the previous parts, the public transport services are often provided by multiple companies with other ticketing principles. For the Dutch national travellers, the OV-chipcard can be used to travel with all public transport modalities (if activated on the card) and serves as a general ticketing service. However, for international passengers, this system is not always known and easy to use. Therefore, the NS and region of Amsterdam now offer tickets for tourists that combine all public transport modes into one ticket. These tickets are available at ticket counters and vending machines at Schiphol Airport station. For NS, the Holland travel ticket is a day ticket with which passengers can travel unlimited with train, bus and metro through the Netherlands. The ticket price ranges from 39 Euro during off-peak periods, to 59 Euro during peak periods (NS, 2017a).

For the region of Amsterdam, there are two tickets that can be chosen. First, the Amsterdam region travel ticket. This ticket can be used to travel unlimited within Amsterdam and the region. Travel modes that can be used are bus, tram, metro and ferry from all public transport providers can be used for €18,50 per day. No train is incorporated in this ticket. The Amsterdam travel ticket does offer train and shuttle services between Amsterdam central and Schiphol Airport. Bus, tram, metro and ferry services offered by GVB can be used with this ticket. This ticket only costs €16 per day. This ticket is cheaper compared to the region ticket however, it has more limitations for the public transport providers that can be used (Discover-Holland, 2017).

With these general tickets, it is much easier for international passengers to use the public transport. Maps of the networks are provided when buying these tickets. There is also a discount offer when travelling more than one day.

Strengths and weaknesses in public transport network

Now that the network levels are analysed, some conclusions can be drawn on the strengths and weaknesses of the public transport network around Schiphol. The location of the airport is central in the national, regional and local network. On an international level, the station can be seen as a start- and terminating station.

On international level, the services are oriented towards the South of Europe. No direct connections are being offered towards East or West Europe. This could be a point of improvement.

On national level, there are a lot of direct connections to big cities over the Netherlands. However, Haarlem is very close by Schiphol Airport but not good accessible. This orientation towards the North region could be better to increase accessibility.

On the regional level, more attention should be paid to cities located around Schiphol such as Amstelveen and Zaandam. Compared to cities on a bigger distance to the airport, the travel times are much higher.

On local level, the connection between Schiphol Airport and the central business district (CBD) Amsterdam Zuid-As is very important. Because a lot of business passengers of Schiphol Airport have their destination in the CBD Zuid-As, this connection will become even more important in the future. The connection with the city centre of Amsterdam is another point where some improvements could be made. One possible solution is to connect Schiphol Airport with the soon-to-be opened Noord-Zuidlijn metro line that will connect Amsterdam CS with Amsterdam Zuid-As (GemeenteAmsterdam, 2017). This high speed and frequency service can strengthen the accessibility of Schiphol Airport towards the city of Amsterdam.

For Schiphol Airport, an increase in PT access can be concluded. This is caused by an attracting effect of a good PT system around the airport. If an airport is well accessible, more passengers will choose to use PT to access the airport, which in the end will result in a crowded

PT. With increasing the service of the PT system, more passengers will be attracted. This will result in a returning effect. For Schiphol Airport, the use of PT increased over the years (SchipholGroup, 2017d). If this trend keeps increasing combined with the evident capacity problems (Ministry-of-Infrastructure-and-Environment, 2017), more improvements have to be made to the PT infrastructure and services.

Furthermore, the location of the station in a tunnel is now a growing concern. The user friendliness of the easy transfer from train station to the airport terminal is one of the biggest advantages of this airport. However, expanding the capacity of a tunnel is much more difficult compared to constructing train infrastructure on ground level. This advantage is now a big concern of public transport operators and Schiphol Group.

Checking the method

Within this network analysis, the network approach part of the method is tested. When looking at this analysis some valuable information is retrieved from the case study. Looking at the services in more detail gives insights in how the network is used. However, it is difficult to retrieve information about the reliability of services. This is caused by the different measurement techniques between national public transport providers and the transparency of those measurement techniques. If the reliability cannot be measured and compared between countries, looking at this attribute on an international level is not useful.

Through the analysis, it became clear that some services as provided at Schiphol station, are being used that is not in accordance with the theory. Some services that are meant to serve passengers over long distances, are transporting passengers over very short distances. By looking at the services in this way, this mismatch is made visible. This mismatch is not specifically related to public transport nodes at airport but might occur at regular stations as well. This can be used in future changes in the planning of public transport services. Therefore, an additional question needs to be asked in the network approach part of the method:

- Does the service that is provided on a network level match the theoretical standards?

4.3   User classes

Within this part of the case study, the user classes of the public transport at Schiphol Airport will be analysed. This is done to validate the user classes approach part of the proposed method on its functionality and completeness. The questions that need to be answered by this analysis are:

- Which user classes can be identified?
- What are their preferences in case of public transport on the attributes speed, cost, reliability, comfort, user friendliness and travel experience?
- Which user classes do differ the most?

The travellers of the PT system want to use the services that are provided. They want to reach their destination in a comfortable, fast and affordable way. Therefore, a good accessibility of Schiphol Airport is preferred. This group does not have much influence on the other stakeholders in this field. However, they are represented by multiple traveller organizations such as Rover and "Maatschappij voor Beter OV". Those organizations represent the voice of national public transport passengers in processes concerning PT.

The airport passengers travelling from Schiphol Airport have different nationalities. 33% of the passengers live within the Netherlands, 37% within the EU and 7% in European countries not part of the EU. 23% of the passengers are intercontinental (SchipholGroup, 2017e). This is displayed in Figure 16. There are no publications about the travel motives of the public transport travellers. A rough estimation is that 50% of the passengers in the trains at Schiphol station are airport passengers and employees of the airport (Oosterwijk, 2017). The other 50% has its destination in Amsterdam or cities around Amsterdam and can thus be classified as non-airport passengers. 31% of the airport passengers are business related, 49% of them have leisure as travel motive to access the airport. This is displayed in Figure 17. The detailed calculation of these statistics is displayed in appendix C.

Residence Schiphol airport passengers
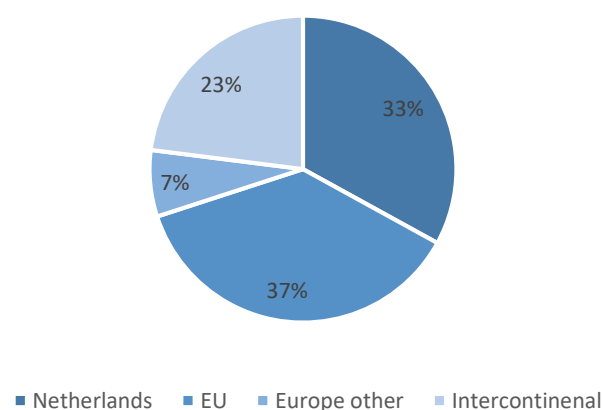

Netherlands ■ EU ■ Europe other ■ Intercontinenal

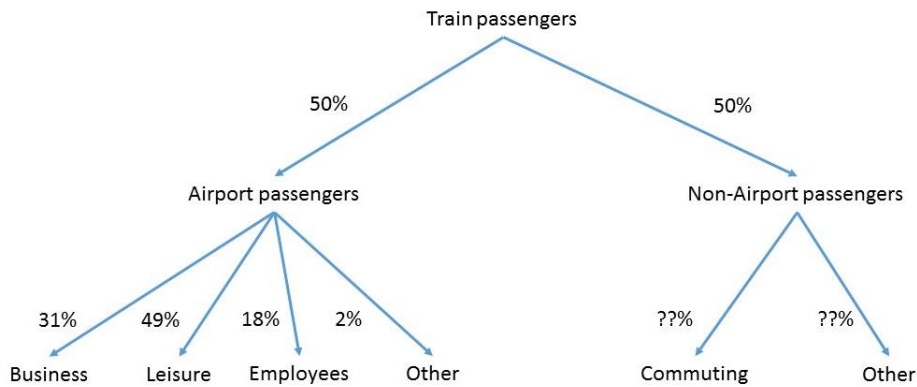*Figure 16- Residence airport passengers Schiphol (SchipholGroup, 2017c)*

Figure 17- Travel motive train passengers

Because only 33% percent of the airport passengers at Schiphol lives within the Netherlands, the information provision about public transport at Schiphol Airport needs to be adjusted to the information given on other stations in the Dutch network. As mentioned in chapter 3.3, different passenger classes have different preferences. For Schiphol Airport, almost 50% of their passengers have a leisure travel motive. It is therefore important to consider their preferences when looking for public transport solutions around Schiphol Airport.

To get more insight on the preferences of the passengers at Schiphol station that use public transport, more information needs to be available. There are passenger surveys held by NS, but the results are not publicly available (Oosterwijk, 2017).

Checking the method

Within this user class analysis, the user classes approach of the method is tested. It can be concluded that due to the lack of available data and information only a small part of the method can be followed. To make this part of the method work, detailed data needs to be available about the preferences of different user classes. It is important to realise that knowing all preferences of all user classes is useful information. However, since public transport services need to fit all passenger types, not all preferences can be considered as much as the passengers want to.

Through further research, more insights need to be obtained on the preferences of different passenger types. This part of the method as proposed here should be revised when more information is available.

4.4   Stakeholder analysis

Within this section, stakeholders that can influence the public transport provision on Schiphol Airport will be discussed. This is done to validate the stakeholder approach part of the proposed method. The questions that will be answered by this analysis are:

- Which stakeholders are involved in the public transport access system around the airport?
- What are their objectives?
- What are their interests and wishes for the public transport access?
- Which actors have conflicting interests?

The actors that are taken into consideration are: Dutch government (Ministry of Infrastructure and Environment, Ministry of Finance and Ministry of Safety and Justice), Province of Noord-Holland, Municipality of Haarlemmermeer, Schiphol Group, ProRail, NS, Vervoerregio Amsterdam, International public transport providers, national public transport providers and the travellers of the public transport system.

For these actors their objective, goals and viewpoints on the Schiphol area will be discussed. Within appendix D, an overview will be given on the stakeholder analysis performed. The relationship between all actors will also be discussed.

Dutch national government, Ministry of Infrastructure and Environment

The ministry of I&E is concerned with the liveability and accessibility of the Netherlands. They are the lawmaker and responsible party for civil air transport within the Netherlands. Within their list of priorities, the growth of airports Schiphol and Lelystad are mentioned (Rijksoverheid, 2017c). Therefore, the objective of this ministry is to ensure good accessibility to the Schiphol as well as the entire metropolitan region of Amsterdam. The airport need to be well accessible for all people that need to use the airport. Therefore, integrating the airport in the national network to ensure a so called many-to-many transport is preferred. From environmental and economic perspective, the landside access of the airport by public transport should be efficient and effective. This to reduce the road congestion around the airport.

Last year (2016), the ministry made a budget available to improve the accessibility of the public transport hub of Schiphol Station (FD, 2016).

Dutch national government, Ministry of Finance

The ministry of Finance has to ensure a financially healthy economy within the Netherlands (Rijksoverheid, 2017a). The ministry is for almost 70% shareholder of Schiphol and is therefore a stakeholder that cannot be ignored. Since the airport ensures jobs and revenue for the GDP, the ministry needs to make sure that the airport also stays financially healthy. This ministry is also shareholder of the NS (NS, 2016). Apart from the shareholder position of this ministry, no other tasks or objectives are linked to this ministry.

Dutch national government, Ministry of Safety and Justice

The ministry of safety and justice is concerned with the safety of all Dutch citizens and visitors. They ensure a safe and justified environment within the Netherlands. This ministry is the lawmaker for all safety and security aspects that are concerned with Schiphol airport (Rijksoverheid, 2017b). Because this ministry does not involve mobility or transport related aspects, this actor will not further be analysed.

Province of Noord-Holland

This province has the objective to transport her inhabitants in a safe and fast way through the province (Province-Noord-Holland, 2017b).

In case of Schiphol Airport, the province will ensure a good balance between the economy and the liveability and work environment in the metropolitan area of Amsterdam (Province-Noord-Holland, 2017a).

The province of Noord-Holland is the major party in defining the geographical surroundings of Schiphol. A lot of research is done for the accessibility around Schiphol and the city of Amsterdam. The province is always a big party within these projects.

Municipality of Haarlemmermeer

The airport is located within the ground area of Haarlemmermeer. Therefore, this municipality is an important stakeholder.

The municipality states several goals with respect to the airport and its environment. The main goal is to be the best airport region on sustainability aspects. To reach this goal, the sub goals are:

1) "Improving quality and vitality of living environment,
2) Ensure enough space and capacity for the airport to maintain its mainport function and network qualities in the future,
3) Finding a solution for the long-term air transport development in the region."

The limits for air transport movement at Schiphol is defined until 2020. It is not yet known what the limits will be after that date. The municipality and all other involved stakeholders are currently discussing what will happen after 2020. It is assumed that the municipality is of lower importance compared to the Province of Noord-Holland and the ministries because of their lower power of influence (Gemeente-Haarlemmermeer, 2017).

Schiphol Group

Schiphol Group is the owner of Schiphol Airport and therefore an important stakeholder in this problem. Schiphol Group has the objective of developing the Schiphol Airport to "Europe's most preferred airport" (SchipholGroup, 2017h). One part of this objective is a good accessible airport for people to travel towards. Therefore, the airport prefers a network structure that is oriented towards the airport from as many places as possible. Many direct point-to-point trips are preferred to let passengers travel to and from the airport in a direct way. Part of the revenues at the airport is generated by parking facilities around the airport. When passengers choose to use the public transport services to access the airport, fewer parking revenues will be generated, which will have a negative impact on the overall revenue. On the other hand, Schiphol Airport has only limited space to improve the landside access for cars. Therefore, a good public transport system is necessary. Another reason for a well-functioning public transport system is to improve the image of the airport. Within big projects, Schiphol Group is one of the bigger parties. However, they do not have major influence on the decision-making process. Schiphol Group can only speak out its wishes and preferences. Rather or not those wishes are interpreted into the concrete output is up to the executing parties of the Dutch national government, ProRail, NS and the Vervoerregio.

ProRail

ProRail is the Dutch national rail network operator. This stakeholder is owned by the Dutch national government and has the ownership of the rail network of the Netherlands. ProRail constructs and maintains the railways and let rail service companies use their network to offer a train product to the customers. ProRail strives to offer a reliable train product, by raising the capacity of the Schiphol tunnel and the robustness of the infrastructure. Another objective is to maximize the usage of Schiphol station. Through crowd-management at peak moments they try to maximize the capacity of the platforms. On a more structural level, ProRail conducts research for maximizing the usage of the rail infrastructure. With these objectives, they try to ensure a good accessible station for all passengers (Vanhoutte & Westervaarder, 2017). According to ProRail, the tunnel underneath Schiphol is a bottleneck in the network. Another problem is the usage of the rolling stock by NS. Some intercity trains are running empty through the tunnel. Therefore, the rail capacity is being occupied by services that only a few passengers use. They state that by changing the services and configuration of the services, a more specific train product can be offered and some capacity can be gained at the rail infrastructure.

Dutch Railways (NS)

NS is the principle train service operators in the Netherlands. They operate on main part of the Dutch rail network that is owned by ProRail. NS wants to promote public transport usage in the Netherlands to transport more passengers. NS is responsible for construction and maintenance of stations, operating trains and maintaining rolling stock and the transport of passengers. For the passenger transport part of their operations, they want to offer a fast, user friendly, safe and affordable train product to ensure a sustainable accessibility of stations. To reach those goals, NS wants to offer a punctual train product, ensure sufficient and comfortable rolling stock, valuable information management and offer alternatives in case of disruptions. For station development, the environment is a big focal point. The experiences of passengers at the station influence the total value of the trips people make (NS, 2017b).

From the interview conducted at NS, the main focus lies on offering sufficient capacity on the train services around Schiphol. It is stated that within 10 years, the capacity will be reached and there needs to be a good plan to cope with this problem. To do so, investments must be made. Although, the NS considers the user class preferences, it offers public transport that will be used by all different user classes. Offering one specific service for one specific user class is not preferred by NS (Oosterwijk, 2017).

Part of the NS, NS International, offers international train services outside of the Netherlands. These connections are often part of the high-speed trains. International services that are offered at Schiphol station are Thalys and IC Brussels. Within the next section, the network will be analysed in more detail.

Vervoerregio Amsterdam

The Vervoerregio Amsterdam is the responsible party for regional and urban public transport. The Vervoerregio grants concessions to the national public transport provides for the modalities metro, tram and bus (VervoerregioAmsterdam, 2017). The Vervoerregio has three main tasks in the region of Amsterdam: 1) granting concessions in the four concession areas, 2) observing and ensuring quality of PT and 3) improving PT on aspects as sustainability, safety, infrastructure management and maintenance and information management. To improve the PT services within the region, the Vervoerregio is participating in big research programmes. Currently, a MIRT- research is being conducted around the multimodal transport

node Schiphol (MKS). They are also conducting a research on the behaviour of passengers at the station of Schiphol (Smit, 2017). According to the Vervoerregio, the major problems at Schiphol are the Schiphol tunnel and the bus platform in front of the terminal. Both stations have capacity and issues in the logical wayfinding. At the station, the capacity problem is specifically visible at platform 1 and 2 in the tunnel. These platforms have the smallest capacity and are overcrowded during peak hours.

Regional and Urban public transport providers

Within the concession area of Schiphol (Amstelland-Meerlanden), multiple public transport providers are operating (Connexxion, 2017b). Connexxion has won the new concession for 2018-2027. From then on, Connexxion will expand its bus fleet with bigger electric busses and will offer more services to more destinations. Within their new plans, the complete Amstelland-Meerlanden region will benefit with a higher accessibility (Connexxion, 2017a). Next to that, Connexxion also provides services on the local Sternet of Schiphol Airport. The Sternet connects important locations around Schiphol Airport. This service is free available for employees of Schiphol Airport and affiliated businesses (Connexxion, 2017c).

Arriva also offers bus services at Schiphol Airport, although Arriva does not have the concession to operate in this region. They offer three long distance busses between Schiphol and Alphen aan den Rijn, Sassenheim and Leiden.

As GVB is the urban and regional public transport provider it also serves Schiphol. Its mission is to improve the accessibility and mobility of the inhabitants of Amsterdam and its surroundings (GVB, 2017). GVB only serves Schiphol with one bus service towards station Sloterdijk covering the west part of Amsterdam.

These regional and urban public transport providers operate on and around Schiphol and Amsterdam. They provide bus services for the passengers and want to improve the accessibility of the station at Schiphol. According to the Vervoerregio, the capacity as for the natural wayfinding, the bus station is close to its limits. When the PT providers decide to operate another or a bigger fleet of busses, there will not be sufficient space at Schiphol station to do so.

Conflicting stakeholders

From the analysis, it can be concluded that there are stakeholders that do not have the same objective. Schiphol has the preference to be connected to a public transport network in a way that as many people as possible can travel towards the airport directly without transfers needed. Therefore, they do not prefer an integration within a network but a point-to-point network layout. Although Schiphol Group does not have direct influence on transport policies, they managed to attract more direct train services towards the airport. There is no obvious reason why this development took place. The public transport providers and NS want to operate on a network that is not only oriented to the airport but to all important locations.

On national and regional network level, the services provided by NS and PT providers are additive while in a local level here is competition in place. This confuses the interests on some PT lines. Furthermore, conflicting interest between NS and Schiphol Group limit the NS. This conflicting interest is based on the exploitation of space. Schiphol Plaza is owned by Schiphol Group, while the train station of NS is located underneath Schiphol Plaza. NS cannot use Schiphol Plaza for commercial shops and services since they do not own that space.
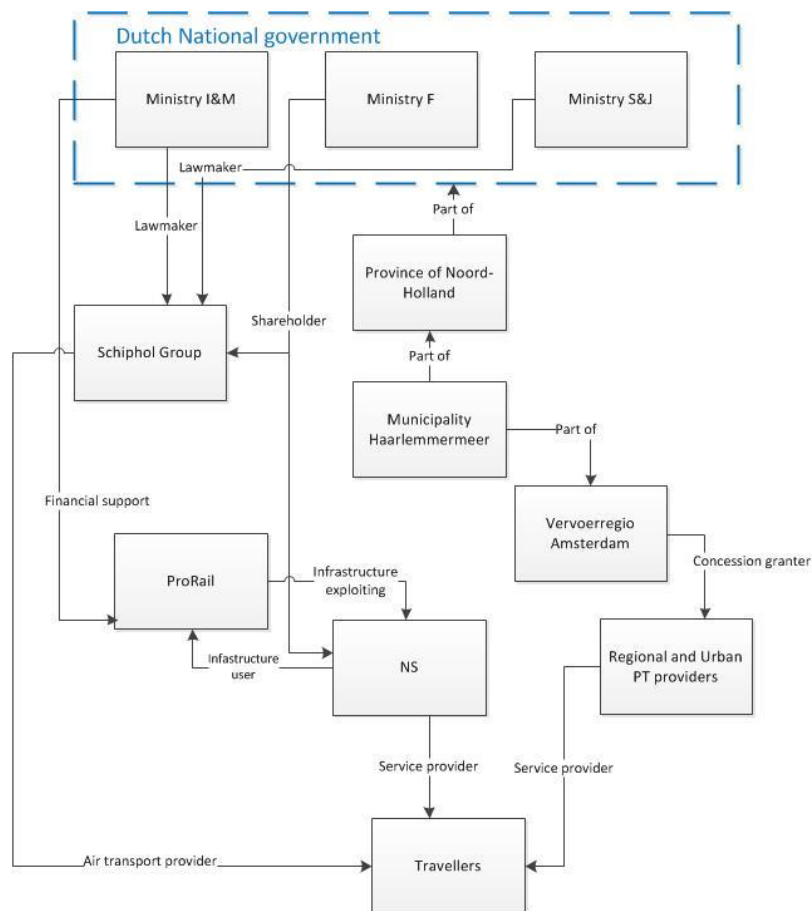
Relationships between stakeholders

Figure 18- Relations between involved stakeholders

In this diagram (Figure 18), the relationships between the involved actors are displayed. The actors are ranked from high power to lower power. The Dutch national government does have the highest power and is therefore placed in the top of this diagram. The arrows between the actors reflect on the type of relationship between the connected actors. The diagram is based on the performed actor analysis as described in previous sections.

The Dutch national government is concerned in the Schiphol case with the ministries of Infrastructure and Environment, Finance, Safety and Justice. The province of Noord-Holland and municipality Haarlemmermeer are part of the Dutch national government, but on a lower level. Schiphol Group is influenced by all ministries from the Dutch national government through law making and shareholder ship. ProRail gets financial support from the ministry of Infrastructure and Environment. ProRail exploits its infrastructure to NS for them to operate their trains on. On the right-hand side of this diagram the Vervoerregio is placed between the municipality and the national PT providers. The Vervoerregio is, as described, an organisation in which multiple municipalities are concentrated. Therefore, the municipality of Haarlemmermeer is part of the Vervoerregio. The travellers are served with transport services by Schiphol, NS and the national PT providers.

Within big projects, the most important stakeholders that are presents are Schiphol Group, NS, ProRail and the Vervoerregio. The ministries, province and municipalities take the role of financier and supervisors of the projects. Although the four important actors do have the same objective, making Schiphol accessible, their economic objective is different and conflicts with other stakeholders. This is the biggest issue during projects (Oosterwijk, 2017).

Checking the method

Within this part, the actor approach of the proposed method is checked on its usefulness and completeness. By following the proposed method, a clear overview of the involved stakeholders can be made. All relevant information can be retrieved. Throughout the case study, no additional challenges were found.

4.5 Planned innovations

To increase the accessibility of Schiphol Airport by public transport, multiple measures are being implemented (Vanhoutte & Westervaarder, 2017). On short term, there are multiple measures already in place. On train platform 1 and 2 in the Schiphol tunnel, additional entry-and-exit points are constructed. This is done to increase the in- and outflow of people on the platforms. Within Schiphol Plaza, crowd management is being implemented in peak periods to ensure the safety of people on the platforms. For the medium-long-term period, another additional entry-and-exit point will be constructed that will be placed in front of Schiphol Plaza next to the bus station. On long-term period, a MIRT- exploration study is being conducted. Within this study, multiple plans are assessed on how to increase capacity at public transport station. On constructional level, there are plans to lift the bus platform to level +1 for better transfer movements. This would give bus services more space to operate and increase their fleet and reconstructing the platform would give an opportunity to use modern technology for wayfinding.

Another plan is to homogenize the train services in the Schiphol tunnel from Amsterdam. Therefore, intercity trains would no longer impede on sprinter trains. Within this plan, the long-distance intercity trains would be relocated to Amsterdam Zuid and let the short-distance trains in the Schiphol tunnel. With this relocation, Schiphol could be connected to cities on a much higher frequency and Amsterdam Zuid would become more dominant in the network.

More innovative solutions can be incorporated in the long-term perspective.

4.6 Conclusion

With this analysis, the question "what are the challenges around Schiphol Airport considering the public transport access of the airport?" is answered.

The same complexities arise in reality, compared to the list of complexities specified in chapter 3.5. Some additional issues arise. Firstly, the tunnel in which the train station is located is a problem. With this choice, expanding the capacity is more difficult and expensive. Another issue that became clear from this case study is the attraction effect of a well accessible airport by public transport. If an airport is well accessible, more passengers will choose to use PT to access the airport, which in the end will result in a crowded PT. With increasing the service of the PT system, more passengers will be attracted. This will result in a returning effect.

Schiphol Airport is well connected to public transport modes train and bus. When looking at the different network levels, some differences are visible. On local level, no changes should be made since the frequency of the Ster-net busses is already high and the bus services are revised for the new concession period. There can be some improvements made towards the city centre of Amsterdam. On regional level, improvements should be made by connecting Amstelveen and Zaandam to more high frequency services being either bus or train. On national level, the city of Haarlem should be better connected to the airport. On international level, it could be argued to implement more services to diverse locations in Europe. When looking at the statements made in the interview with ProRail, it is not wise to advise more international trains within the Schiphol tunnel. When connecting more international trains to Amsterdam Zuid and an additional fast service between Zuid and Schiphol Airport, this could

be an opportunity for both international and national rail services. With the development of CBD Amsterdam Zuid-As the new international gateway of the Netherlands, more capacity can be offered for national and regional trains in the Schiphol tunnel, and more international business travellers can be transported to the central business district of the CBD Amsterdam Zuid-As.

Checking the method

The aim of the research is to construct a method that can help clarify the challenges around public transport nodes at airports. One way to check the usefulness and completeness of this method is to use it in a case study. This chapter did not only answer to the questions of the method for Schiphol Airport, but also checked the proposed method.

Through the case study it became clear that for the network approach part of the method, an additional question must be asked to get a complete view on the challenges. Furthermore, for the user classes approach, a lack of information made executing the analysis difficult. The method can only be applied when all necessary information about the user classes is available. Applying the method on a case study revealed useful information that can be used for planning public transport around airports. Because this method incorporates the interaction between the network levels, user classes, stakeholders in relation with each other and the airport, all challenges can be identified in a clear and complete way. Incorporating this method into the decision-making process concerning public transport nodes at airports is therefore useful and important.
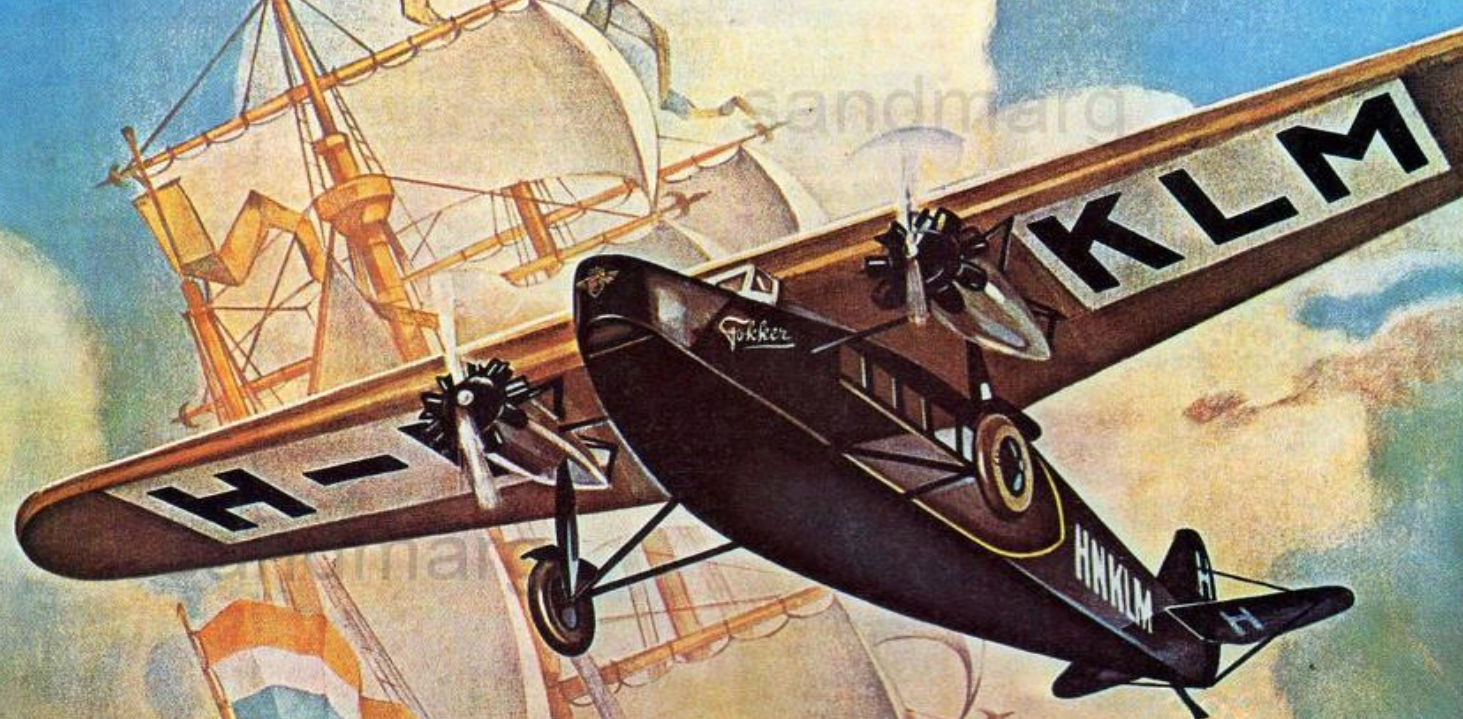
5. Conclusion and recommendations

The aim of this thesis is to obtain knowledge on the challenges regarding the public transport nodes at airports. This is done because there currently is no insightful overview of this interaction. The public transport access of airports is important for the functioning of an airport. Therefore, it is important to understand how the public transport at airports works and how it differs from regular public transport stations. Therefore, the main question in this thesis research was: **"What are the challenges concerning public transport nodes at airports and what challenges should be researched in the future?"**

To structure the analysis, a method is constructed. This method will help clarify the challenges that rise when considering a public transport node at an airport. Within the method, three perspectives are incorporated, 1) network levels, 2) user classes and 3) stakeholders. Those three perspectives were analysed based on literature study and a case study of Schiphol Airport. This case study was done to validate the method on its completeness and functionality.

5.1 Airport public transport challenges

Firstly, the network approach was used to analyse the network characteristics. The complexities found from this analysis are as follows.

Network approach

1. Location of the airport station within the network is a determining factor for the available access possibilities through public transport. Location can often not be chosen.
2. Airport differs in operational time during the day compared to other locations. PT systems are sometimes not available during the operations of the airport.
3. An airport operator has the wish to attract as many passengers as possible to the airport. Therefore, they prefer a many-to-one network structure.
4. PT organisations need to transport as many passengers as possible. Therefore, they prefer a many-to-may network structure.
5. The surrounding of the airport station. Is the station located on ground floor or in a tunnel? This influences the ways in which the infrastructure can be expanded.
6. An airport that is well accessible through public transport attracts more passengers to public transport. Therefore, the public transport is a returning loop of three parts: 1) improving PT, 2) attracting more passengers and 3) crowded PT/ PT problems.

Secondly, the users of public transport around airports were analysed. The user classes that are distinguished are business airport passengers, leisure airport passengers, airport employees, commuting non-airport passengers, other non-airport passengers. The complexities concerning these different user classes are as follows.

User classes approach

7. User classes mainly differ in the aspects of pieces of luggage, tight departure time and importance of user friendliness
8. Airport users consist of both national passengers as tourists. Tourists are assumed to be less familiar with the PT system of a country
9. PT companies need to offer public transport that will be used by all user classes and not only airport passengers
10. Airport passengers do not use the airport station for transferring between network levels, while non-airport passengers may use the airport station for transferring between network levels. Therefore, the function of the airport station is different between user classes.

11. Some user classes can change network levels more easily as others. This is dependent on the design of the stations and the amount of luggage passengers carry with them.

Thirdly, the different stakeholders are analysed on their objectives, preferences and wishes. The complexities on this subject are:

Stakeholder approach

12. Airport operator is dependent on the PT companies for the PT access of the airport. They do not have much power over the operations of the PT companies around the airport.
13. Local governmental bodies have the least power, though they have high interest
14. National governmental bodies see the airport as an employing company that needs to be well connected to the PT network

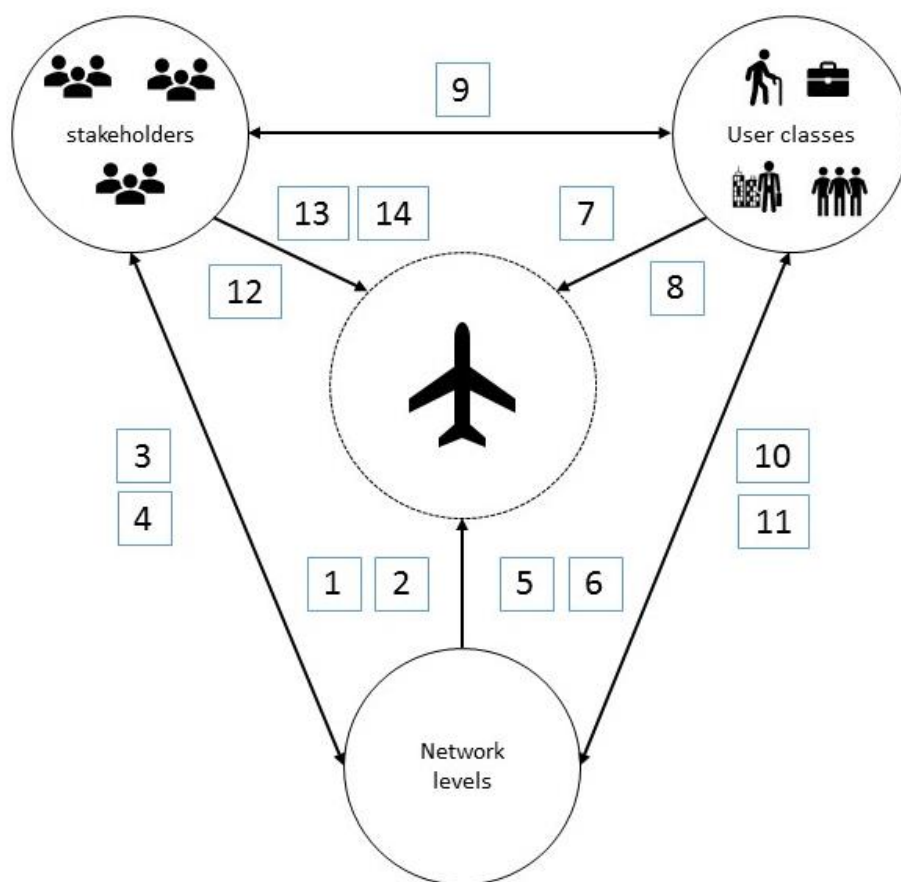All the above-mentioned complexities are visualized in Figure 19.

Figure 19- Challenges between the airport PT system, network levels, user classes and stakeholders

5.2   Analysis method

To analyse these challenges in airport specific cases, the following analyses and questions should be asked.

Network approach:

- What is the location of the airport PT station within the PT network?
- What network levels are connected to the airport station?
- What are the most important cities where passengers travel from to the airport?
- What are the corresponding speeds, frequency, transfers needed, costs, reliability, comfort, user friendliness and travel experience between those cities and the airport station?
- From what time is the transport network available?
- How high is the robustness of the network?
- Does the service that is provided on a network level match the theoretical standards?

User classes approach:

- Which user classes can be identified?
- What are their preferences in case of PT on the attributes speed, cost, reliability, comfort, user friendliness and travel experience?
- Which user classes do differ the most?

Stakeholder approach:

- Which stakeholders are involved in the PT access system around the airport?
- What are their objectives?
- What are their interests and wishes for the PT access?
- Which actors have conflicting interests?

Executing this analysis checklist enables the researcher to gain all necessary insights in the complexity of the public transport access of the airport studied.

Within the method, relations and interactions between the network, user classes and stakeholders and the airport system is most important. This focus makes the method useful since no literature studies these subjects in this way. By using this method, new the information can be structured in a presentable way.

5.3   Further research directions

The combination between the three investigated subjects and the airport system is not a common combination in current literature. All subjects are being researched upon separately but they are not commonly combined. Because combining the subjects gives useful information, it is recommended that in future research, this combination is made more often.

Through this thesis research, some knowledge gaps could not be filled. First, the measuring of reliability of networks should be analysed in more detail to enrich this method. The measuring of reliability is done in different ways between countries. To make this method useful and insightful, one standard should be constructed for all countries to measure reliability. This will make answering the reliability question from the network approach part of the method easier and insightful.

Secondly, the preferences of the user classes need to be investigated in more detail. Not much information is available on this subject in combination with airports. Public transport providers do passenger surveys but they are not publicly available. Because of this fragmentation, no generic view can be formulated about the preferences of all user classes that use the airport station. Therefore, it is necessary to do passenger surveys among both airport and non-airport

passengers that use the airport station. These surveys can answer the questions within the user classes approach part of the method. These surveys should focus on the preferences and their perceived importance towards the attributes since there are satisfaction rates known from passengers. Within this research, a start is given for a more detailed analysis. It is of significant importance that this subject will be analysed in more detail in the future to make sure that the airport public transport system can be used by all passengers that need to use it.

The network approach of the method does mention robustness of the network. To enhance the method, some additional research should be done in measuring the robustness and add this to the network analysis. The question on "How high is the robustness of the network?" will be answered with this. Reaching the airport through an alternative travel option within a time frame is important to the passengers and has impact on the accessibility of an airport.

From this research, it can be concluded that the proposed method gives useful information to people using this method. With additional information from future research, this method can clarify the challenging issues of public transport nodes at airports. Next to making the challenges insightful, this method gives a clear example on how these challenges can be made presentable. By placing the challenges on the interactions between the four subjects network levels, user classes, stakeholders and the airport system, it becomes clear what subjects are related to the challenges.

5.4   How to solve these challenges?

Some of these complex issues cannot be solved. They exist and need to be considered when changes are made in the public transport system around airports. To ensure a good accessibility of the airport during the night, more night services could be implemented from important origins towards the airport. To make sure that the network capacity can be adapted easily, the configuration of the airport station should be organized as flexible as possible.

For the differences in user classes multiple solutions can be found. For example, the luggage of airport passengers could be checked-in at the train stations before passengers will board their train to the airport. In this way, the differences between airport and non-airport passengers become smaller. Because the airport passengers are both national and international passengers, the information provision at the airport station should be different to the information at regular stations. A balanced number of directional signs and communication at the airport station could help achieving this goal. To accommodate all passenger types, the airport station should be able to function as a transport hub for non-airport passengers and a station for airport passengers. In the design phase of the airport station, this should be considered.

The complexities around stakeholders involved in the public transport access of airports are difficult to change. This depends on the attitude and power of the stakeholders itself. One way of decreasing the complexity is to make the stakeholders aware of the problems and their contribution to these problems. Establishing a committee with members from all stakeholders that will work together with the same goal is a way of minimizing the bureaucratic and hierarchical problems between the stakeholders.

5.5   Recommendation Schiphol Airport

From the case study of Schiphol Airport, it became clear that the main problem is the capacity of the train tunnel underneath the airport. Because of this configuration, expanding the capacity is difficult and expensive. Within the network analysis, the international connection towards Eastern Europe is missing. This link could be interesting for Schiphol Airport to be able to compete with the airports of Germany. On the local level, some improvements can be made towards the CBD Zuid-As and the city centre of Amsterdam. Within the near future, capacity problems will arise on this part of the network. One possible solution could be to establish a high-frequency and high-speed rail service from Schiphol-Airport through CBD Zuid-As to the city centre. With the soon-to-be opened "Noord-Zuid metro" in Amsterdam, extending this metro line towards Schiphol might solve this problem.

6. Discussion, research limits, further research and reflection

6.1 Discussion

Within this thesis research, the main objective was to clarify the concept of accessibility and the access of airports by public transport. The methods used to reach this objective were mostly literature research, interviews and small sample surveys. The literature study on topics of accessibility, airport access structures, network levels and user class preferences revealed many sources on generic public transport usage. Only few sources made some explicit differences in airport access by public transport. Therefore, some assumptions in this research are based on generic public transport literature. This might have influenced the conclusions and recommendations stated in the previous chapter.

6.2 Limitations

Due to the scope of this research, some choices are made that can limit the outcome. Within this thesis research, the landside access structure of airports is analysed by looking at the public transport systems. The road network is not considered. To analyse the landside access of an airport, the road network should also be considered because these two systems interact with each other.

The user classes as specified in this research are set up from regular public transport users as from airport passengers. Not all information that was available for regular public transport users was also available for airport passengers. Therefore, some educated guesses and small responses from the interviewees were used to come to conclusions. Some effects and preferences might therefore be over- or underestimated. From these educated guesses, it is clear that there are significant differences in user classes preferences. This research makes it clear that more research needs to be done in this subject.

Within the network analysis of Schiphol Airport, a choice is made in which cities to select for the analysis. This is done based on the size of the city. Other cities, that are not included in the analysis, might also be important to include. Because of the scope and time limits of this thesis research, not all cities could be incorporated.

From the interviews performed for this research, it became evident that a lot of plans and studies are being performed at the moment of this thesis. Some of them are publicly available, while most them are still on-going studies and therefore not yet available. The stakeholders that are interviewed for this thesis is only a selection. The main stakeholder Schiphol Group was not available for this research. To get a better understanding of their statements and preferences in this topic, they should be interviewed as well.

6.3   Reflection

Q1: Which factors influence the accessibility of locations?

To answer this question, some of the available literature was used. Because of the size of the available literature it was difficult to get a sharp vision on the concept of accessibility. This part of the research was very time consuming. There are numerous factors that influence the accessibility of locations and those factors do interact. However, this interaction is not taken into consideration in this research.

Q2: What network levels are connected to airports and what function does the airport take within the transport network?

Within this part of the research, a selection of airports was chosen to determine which network levels are commonly connected to airports. The information available was not always clear and well-structured for all airports. The information and the quality of this information was the most difficult part of this sub-research question.

Q3: How do user classes differ in case of their preferences and wishes for a transport service to an airport?

To answer this question, some assumptions needed to be made. These assumptions were based on a small sample of interviewees and a small amount of available scientific literature. The most difficult part was to make specific airport related preferences for passengers from generic public transport literature studies. When starting this thesis, it was assumed that more literature studies would have been performed. This was not the case.

Q4: Which stakeholders are involved in the airport public transport access issue?

The stakeholder analysis that is performed to answer this question is based online-study on this topic. Since there are many stakeholders involved in this problem, this part of the research was perceived as time consuming and intensive. For all countries, the public transport network is managed in another way. Therefore, it was difficult to achieve a general overview. However, within this research this general overview is achieved.

Q5: What are the complex issues around Schiphol Airport considering the public transport access of the airport?

Because of the literature research performed before the case study of Schiphol Airport, a lot of knowledge of the complex issues was already known. The case study had the aim to verify these complexities and check if more complexities exist.

What are the challenges concerning public transport nodes at airports and what challenges should be researched in the future?

The literature and case study made answering this question possible. The complexities are identified and transformed into a method for analysts to use for case studies on airports.

6.4   Personal reflection

Through this master thesis, I learned a lot of skills and personal characteristics. From the beginning, it was sometimes hard to keep an academic view on the thesis. This became an issue due to the practical environment in which I worked. Therefore, it took a while before I had a clear visual on what my thesis needed to do.

Due to the individual form of a master thesis, I got a lot of self-confidence when reporting something of excellent quality, while I also learned to cope with feedback when reporting something of lower quality. Also managing and structuring my own graduation process made me feel confident about these skills.

Because of the method I used to do this research, I had the opportunity to do interviews with professionals in the field. I learned a lot from doing those interviews.

Doing this research was sometimes hard due to the lack of information, but because of my interests in this field I managed to keep going.

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Appendices

Appendix A: Interviews

Interview method

To get a better understanding about the problems in public transport services around Schiphol airport the main affiliated actors are invited for an interview. Within these interviews the main objectives of the actors and their plans for the future are discussed. The interviews were constructed in a semi-structured way and consist of open questions. These questions were send in advance to the interviewees. The questions were constructed after doing literature research. The interviewees that were invited are Vervoerregio Amsterdam, ProRail, NS, Schiphol Group, Gemeente Haarlemmermeer. Unfortunately, Schiphol Group did not respond to the invitation. The municipality of Haarlemmermeer send reports with their information on the Schiphol area case. These reports are used in the actor analysis. Not all interviewees were in liberty to let the interview be recorded. Therefore, all interviews are summarized. The summaries are send back to the interviewees to confirm the conclusions made from the interview. After confirmation, the interviews were used in the actor analysis.

The questions that were sent to the interviewees are as follows:
• Wat speelt er volgens u een rol bij een goede bereikbaarheid van een luchthaven?
• Wat zijn volgens u de belangrijkste afwegingen in de bereikbaarheid van een luchthaven?
• Hoe functioneert het openbaar vervoer systeem rondom luchthaven Schiphol volgens u?
• Zijn er aspecten die zeker verbeterd moeten worden in het OV systeem?
• In hoeverre denkt u dat er nog uitbreidingsmogelijkheden zijn rondom het OV netwerk rondom Schiphol?
• Wat doet uw organisatie om de bereikbaarheid van de luchthaven te verbeteren?
• Zijn er concrete plannen om de bereikbaarheid van de luchthaven te verbeteren?
• Zijn er innovatieve veranderingen gaande op het gebied van OV naar de luchthaven die de gehele visie op OV kunnen veranderen?
• Wat zijn uw persoonlijke ervaringen met de bereikbaarheid van de luchthaven met het OV?
• Wat zijn uw persoonlijke overwegingen wanneer u met het OV naar de luchthaven reist?

Within this appendix, all interviews are summarized.

Interview Vervoerregio Amsterdam 1- Arnoud Mouwen- 21/06/2017

- Wat speelt er volgens u een rol bij een goede bereikbaarheid van een luchthaven?

Met name veiligheid, kwaliteit en capaciteit speelt een belangrijke rol.

- Wat zijn volgens u de belangrijkste afwegingen in de bereikbaarheid van een luchthaven?

Afwegingen die gemaakt worden bij besluiten rondom verbetering van de capaciteit hebben betrekking tot de kosten, technische inpasbaarheid, ruimtelijke inpasbaarheid, bereikbaarheidsbaten (reistijdwinsten) voor de reiziger op het traject waar de verbeteringen worden toegepast maar ook de gehele regio moet baat hebben bij de verbeteringen.

- Hoe functioneert het openbaar vervoer systeem rondom luchthaven Schiphol volgens u?

Op dit moment functioneert het matig, in de nabije toekomst zullen al problemen voordoen op het trace Amsterdam Schiphol. Daarbij is de tunnel de echte bottleneck. Maximaal 32 treinen per uur door de tunnel. Uit de NMCA blijkt dat met het OV er in 2040 problemen gaan ontstaan in de capaciteit. De vervoervraag stijgt meer dan het aanbod.

De vervlechting van alle modaliteiten en verschillende gebruikersgroepen maken het een zeer complex vraagstuk. Er wordt nu nog weinig gekeken naar verschillende soorten reizigers die toch verschillende karakteristieken hebben.

- Zijn er aspecten die zeker verbeterd moeten worden in het OV systeem?

De capaciteit van de tunnel moet verhoogd worden om in de toekomst alle reizigers te kunnen vervoeren.

- In hoeverre denkt u dat er nog uitbreidingsmogelijkheden zijn in het OV netwerk rondom Schiphol?

In de tunnel zit weinig rek meer. Ook bij de bus verbindingen is een tekort aan opstelplaatsen. De aanbieders willen wel met meer materieel rijden maar er is simpelweg geen plek op Schiphol Plaza om al dat materieel kwijt te kunnen.

- Heeft uw organisatie doelen gesteld om de bereikbaarheid van de luchthaven te verbeteren?

De bereikbaarheid van de gehele regio Amsterdam moet verbeterd worden om de toekomst aan te kunnen. De verbinding tussen Amsterdam Centrum en Schiphol moet verbeterd worden. Nu is het zo dat reizigers op centraal aankomen maar dan vaak nog verder moeten reizen met ander vervoer. Door ze meer gericht richting de bestemmingen te vervoeren wordt het makkelijker voor de reizigers. Met name de vakantie reiziger die hier niet bekend is loopt nog al eens tegen problemen aan.

- Wat doet uw organisatie om de bereikbaarheid van de luchthaven te verbeteren?
- Zijn er concrete plannen om de bereikbaarheid van de luchthaven te verbeteren?

Nog geen concrete plannen, enkel veel verkennende studies die nog in volle gang zijn.

- Zijn er innovaties op het gebied van OV naar de luchthaven die de gehele visie op OV kunnen veranderen?

Op dit moment wordt niet rekening gehouden met innovaties. Het is veel toekomstkijken maar dan op de manier waarop we het nu gewend zijn. Het besef is er dat meer met innovaties gedaan moet worden, maar concrete invulling in onderzoeken wordt niet gedaan.

- Wat zijn uw persoonlijke ervaringen met de bereikbaarheid van de luchthaven met het OV?

Goede verbinding met Amstelveen. Kies altijd voor OV om naar de luchthaven te reizen.

- Wat zijn uw persoonlijke overwegingen wanneer u met het OV naar de luchthaven reist?

Met name het gemak van vervoer en de parkeerkosten zijn overwegingen. Vanuit Amstelveen binnen 15 minuten op de luchthaven per bus. Met de auto zou ik en duurder uit zijn en vaak langer door files. Ook in de nachten is Amstelveen goed aangesloten op de luchthaven.

Interview Vervoerregio Amsterdam 2- Jan Smit- 23/06/2017

- Wat speelt er volgens u een rol bij een goede bereikbaarheid van een luchthaven?

De thema's die wij voor de MIRT verkenning multimodale knoop schiphol hanteren zijn kwaliteit, veiligheid en capaciteit.

Kwaliteit van Plaza is niet voldoende. NS wil graag 1 appart reisdomein met poortjes afgesloten. Nu is de functie treinstation/ verblijfruimte met elkaar verweven.

- Wat zijn volgens u de belangrijkste afwegingen in de bereikbaarheid van een luchthaven?

- Hoe functioneert het openbaar vervoer systeem rondom luchthaven Schiphol volgens u?

Schiphol is bijna een te goede OV knoop geworden; het is een van de grootste overstap knopen in de regio en na Utrecht, Amsterdam CS en Rotterdam CS het grootste treinstation in Nederland. Nu we maatregelen moeten treffen om de capaciteit te verbeteren doen we ook onderzoek om overstappers op een andere plek te laten overstappen. Daarbij zal Amsterdam Zuid een grotere rol gaan spelen. Capaciteit zal moeten worden gehaald uit extra infrastructuur of meer platform capaciteit op het station zelf. Ook kan het materieel worden verandert om meer passagiers te kunnen vervoeren.

MIRT verkenning middellange termijn. Capaciteit op de perrons is het knelpunt. Perron 1 & 2 extra stijgpunt naar buiten. Veel lengte op de perrons, te weinig breedte die eigenlijk wel nodig is. Tunnel leent zich niet om te verbreden.

Bussen op Plaza ergens anders stationeren om de treintunnel meer ruimte te geven. Bussen naar +1, ruimte daaronder gebruiken voor extra stijgpunten van de treintunnel.

Reizigersprognose gemaakt tot 2040 via WLO scenario's. Ervaring leert dat het hoogscenario op Schiphol het beste beeld geeft. Met die prognose knelt de capaciteit al ruim voor 2040.

De spoortunnel heeft wel een optimale capaciteit, maar die kunnen niet via de perrons worden afgewikkeld. De halteertijden zijn ook te kort. Daardoor loopt de dienstregeling vaak niet goed. PHS 32 treinen per uur per richting via Schiphol. Op papier past het, maar praktisch wringt het wel. NMCA per 1 mei vrijgegeven, daarin staan ook capaciteit problemen rondom Schiphol uitgewerkt.

Kortetermijn maatregelen met betrekking tot NS kaartautomaten zijn inmiddels opgelost.

Grote OV knoop Schiphol wordt niet alleen gebruikt door OV gebruikers maar ook door de werknemers van Schiphol. Knoop wordt heel intensief gebruikt door beide groepen.

- Zijn er aspecten die zeker verbeterd moeten worden in het OV systeem?

Schiphol heeft er mee te kampen dat door de ligging van het station in een tunnel, eventuele gewenste verbindingen enorm duur zijn. Meer capaciteit op de perrons, de roltrappen in de centrale hal (ook natuurlijke wayfinding, apart treindomein) is noodzakelijk.

- In hoeverre denkt u dat er nog uitbreidingsmogelijkheden zijn in het OV netwerk rondom Schiphol?

Er wordt al jaren gestudeerd op aanvullende modaliteiten. Dit varieert van een aparte metrolijn vanuit Amsterdam, gebruik van het bestaande spoor als lightrail (metro/ sneltram). In combinatie met de uitbreidingsplannen van Schiphol zelf (terminal Noord/West) en de toenemende drukte op de perrons lijken deze kansrijker te worden.

Dedicated metro tussen Schiphol en Zuid op een eigen infrastructuur voor alle gebruikers. Maar hoe worden de passagiersstromen in dat geval met overstappen. Maak je de complexiteit dan niet nog groter.

Beter kijken naar dienstregeling. Spoor 1/2 is heel druk maar andere sporen zijn minder druk. Kijken hoe de passagiers beter te verdelen. Ambitie van Amsterdam is om Zuid meer te laten groeien ten opzichte van CS. CS is ingesloten en heeft weinig uitbreidingsmogelijkheden.

- Heeft uw organisatie doelen gesteld om de bereikbaarheid van de luchthaven te verbeteren?

Ja voor de vervoerregio is de MKS een van de belangrijkste OV-knopen in de MRA. Met de nieuwe aanbesteding van de concessie Amstelland-Meerlanden eerder dit jaar is ook ingezet op een verdere uitbreiding van het busnetwerk. Connexxion heeft deze aanbesteding gewonnen en gaat bijna volledig met electrische bussen rijden en zet veel meer en ook langer materieel in om de reizigersgroei op te kunnen vangen.

- Wat doet uw organisatie om de bereikbaarheid van de luchthaven te verbeteren?

Vervoerregio participeert zowel qua inzet als financieel in de lopende MIRT verkenning MKS. Daarnaast in haar rol als concessieverlener als hierboven vermeld.

Gedragsonderzoek is net gestart. Mensen vertonen onbegrijpelijk gedrag. Door het soepeler te laten lopen wordt de capaciteit alleen maar groter.

Natuurlijke wayfinding is op Schiphol niet duidelijk. Daar moet een passagier op de borden worden gestuurd om zijn weg te vinden.

Duidelijker busstation die aangeeft waar welke bus vertrekt. Binnen MIRT verkenning is dit ook een thema. Busstation niet vervuilen met vervoer wat er niet hoeft te zijn.

- Zijn er concrete plannen om de bereikbaarheid van de luchthaven te verbeteren?

MIRT en Concessie

- Zijn er innovaties op het gebied van OV naar de luchthaven die de gehele visie op OV kunnen veranderen?

Ja het gebruik van het sprinterspoor voor lightrailvoertuigen is een systeemsprong

Meer creativiteit gewenst in de volgende innovaties/ ontwikkelingen van de spoorwereld.

- Wat zijn uw persoonlijke ervaringen met de bereikbaarheid van de luchthaven met het OV?

Ik woon in Leiden en werk op Schiphol en Amsterdam dus ben daar een aardig ervaren gebruiker. Ik zie dat het treinnetwerk erg zwaar wordt belast en dat dat vaak tot verstoringen leidt. Ook de SHL zit in de DRL te weinig tijdruimte om alle mensen met bagage in en uit te laten stappen. Dat geeft oplopende vertragingen. Betrouwbaar en voorspelbaar netwerk door goede informatievoorziening.

Zakelijke reiziger wordt ook graag verwend. Maakt vaak hele strakke planningen.

- Wat zijn uw persoonlijke overwegingen wanneer u met het OV naar de luchthaven reist?

Ik neem altijd de trein omdat deze perfect aansluit op mijn werkplek. En parkeren zowel in Amsterdam als op SHL te duur is.

Interview ProRail Amsterdam- Alexandre Vanhoutte & Douwe Westervaarder- 30/6/2017

- Wat speelt er volgens u een rol bij een goede bereikbaarheid van een luchthaven?
Betrouwbaarheid van aansluitingen, beleving van de totale reis, reistijd.

- Wat zijn volgens u de belangrijkste afwegingen in de bereikbaarheid van een luchthaven?

Parkeerkosten op luchthaven vaak heel hoog, dit maakt de keuze voor OV vaak makkelijk gemaakt.

- Hoe functioneert het openbaar vervoer systeem rondom luchthaven Schiphol volgens u?

Station plaza heeft zo zijn problemen. Naar PHS- SAAL zijn er nieuwe ontwikkelingen. Snelle groei van de luchthaven is met name het probleem en gaat sneller dan gedacht. Daarnaast groeit het vervoer rondom Amsterdam ook heel snel. Veel woningbouw in Amsterdam, waardoor dus nog meer vervoer moet komen.
Spoor 1-2 veranderingen moesten snel worden geimplementeerd. Duidelijke piekperiode op Schiphol. Werkzaamheden moeten in de dalperiode worden uitgevoerd. Overzichtelijker maken van Plaza. Schiphol is daar de baas. Uit die gesprekken worden ook maatregelen getrokken. Extra kaartautomaten nodig. Op die kleine postzegel is het zoeken naar ruimte. Crowdmanagement. Bevoegdheid om mensen toegang te ontzeggen tot het perron. Veiligheid gaat dan voor de wensen van de passagiers.

- Zijn er aspecten die zeker verbeterd moeten worden in het OV systeem?

Intelligent platform bar, waarbij de treinopstelling en de wagons kunnen worden weergegeven. Daarbij kan worden gedacht aan de drukte in de wagons. Hiermee de spreiding op het perron worden aangepakt. Dit wordt op spoor 1-2 ingevoerd.

- In hoeverre denkt u dat er nog uitbreidingsmogelijkheden zijn in het OV netwerk rondom Schiphol?

Middellangetermijn komt een extra stijgpunt. Langetermijn loopt nu een MIRT verkenning. Daarin wordt een enorme schaalsprong gemaakt op het station. Optillen van busplatform naar +1, waardoor je de loopstromen meer ruimte geven. Meer commercieel domein, Plaza wordt groter en stromen worden uit elkaar gehaald.
Amsterdam travel ticket.
Zuid wordt alleen maar belangrijker. Betere informatie geven aan reizigers om ze ook naar Zuid te laten reizen omdat Amsterdam daardoor beter bereikbaar is. Zuid zal de rol gaan overnemen van Amsterdam Centraal. Vanuit Schiphol kun je niet direct in het hart van Amsterdam komen, weliswaar met overstap.

- Heeft ProRail doelen gesteld om de bereikbaarheid van de luchthaven te verbeteren?

- Wat doet ProRail om de bereikbaarheid van de luchthaven te verbeteren?
Programma Hoogfrequent Spoor, ingedeeld in corridoors. S-U-N, SAAL, Lelystad raken aan Schiphol.
NMCA, erg geschrokken van de resultaten. Knelpunten zijn erger dan vermoed. Met name Noordvleugel van de Randstad, rondom Schiphol.
Voorstel om PHS nogmaals door te rekenen, omdat we niet vertrouwen of het oplossend vermogen voldoende is. PHS alternatief voor Amsterdam zuid/west tak, kijken of het mogelijk is om de infrastructuur beter te gebruiken. Lege treinen door de Schiphol tunnel is niet gewenst.

De lange afstand Ics en sprinters knellen elkaar. Homogeniseren van treinen op ring-Amsterdam naar Schiphol.

Westtak versprinteren, homogeniseren. Veel meer reizigers naar hun bestemming te vervoeren.

Vervoerprobleem AMS- Schiphol aanpakken, nieuwe woongebieden ontsluiten, toeristen naar hun bestemming brengen. Alle overige treinen gaan naar Amsterdam Zuid.

Voor Middellange termijn moet een meer structurele keuze gemaakt worden. Ga je door met sprinter en vertaal je dat naar light train met hogere frequenties. Of ga je het metronetwerk vastmaken aan sporen in Schiphol tunnel, gebruikmakend van de ruimte die er is. Trein sporen eruit en metro sporen erin.

- Zijn er innovaties op het gebied van OV naar de luchthaven die de gehele visie op OV kunnen veranderen?

[3e richting: Voertuig ontwikkelen wat hybride is, waarmee je op trein en metro netwerk kan rijden. Geen ingrepen in de infrastructuur. In het voertuig vind de systeemomschakeling plaats. In Hamburg is dit al het geval. Dit kan op drukke knooppunten rechtstreekse verbindingen bieden. Dit kan wel voor veel problemen zorgen. Die worden nu uitgezocht. Amsterdam wil dit heel graag. Als dit idee werkt dan kan dat op alle richtingen worden ingevoerd.

Nooit verder dan het eerste grote knooppunt in verband met robuustheid.]

Na het uitbreiden via spoor moet worden gekeken naar materieel oplossingen. Hemboog, zaandam-amsterdam wordt nu nog ondermaats gebruikt. Druk vanuit Noord-Holland is groot om hier iets aan te doen.

- Wat zijn uw persoonlijke ervaringen met de bereikbaarheid van de luchthaven met het OV?

- Wat zijn uw persoonlijke overwegingen wanneer u met het OV naar de luchthaven reist?

Douwe:

Evident naar Schiphol met het OV. Kom vanuit Vijfhuizen/ Haarlem via Zuidtangent. Zonder overstap 4x per uur. Geen parkeerplaats betalen.

Duidelijkheid is voor alle passagiers belangrijk.

Amsterdam travel ticket is nu een groot succes. Beter en duidelijker voor internationale passagiers. Wordt veel reclame voor gemaakt. Het sluit aan bij de behoefte van passagiers.

Alexandre:

Woon in Zaandijk. Utrecht is makkelijk te bereiken maar Schiphol is lastig. Laag frequent netwerk sluit aan op een laag frequent systeen. In het weekend is dat lastig aangezien de systemen niet op elkaar aansluiten. Binnen 20 km afstand van Schiphol is het dus al slecht. Reistijd, betrouwbaarheid van aansluitingen, reisbeleving.

Hogere frequentie kan problemen oplossen, niet alleen voor Schiphol zelf maar ook voor de herkomsten van passagiers.

Schiphol, Amsterdam en Ring Amsterdam moeten in combinatie met elkaar worden bekeken. Kunnen niet appart genomen worden.

Zakelijk reiziger reist makkelijker,

Mentaal aspect lijkt hetzelfde voor zakelijke reiziger als de vakantie reiziger. Alleen de fysieke aspecten zullen verschillen.

Interview NS Utrecht- Wim Oosterwijk 7/8/2017

- Wat speelt er volgens u een rol bij een goede bereikbaarheid van een luchthaven?

Bij het ontsluiten van een luchthaven zijn een aantal aspecten belangrijk. Daarbij moet het vooral gaan om capaciteit, directheid en stiptheid. Daarnaast is kwaliteit een belangrijk punt. Het is voor een luchthaven als schiphol van belang om naar veel steden in Nederland directe treinverbindingen aan te bieden in verband met overstappen van reizigers met baggage. Om al die treinen te kunnen aanbieden is genoeg capaciteit op het spoor nodig. Daar zit nu het grootste probleem bij Schiphol. Er kan niet snel en makkelijk een nieuwe tunnel of een nieuwe terminal worden gemaakt met de middelen die daarvoor beschikbaar zijn.

- Wat zijn volgens u de belangrijkste afwegingen in de bereikbaarheid van een luchthaven?

De directheid is belangrijk. Daartegenover staat de reistijd van die trein ritten. Een paar minuten korter reizen gaat ten kosten van een directe verbinding naar Schiphol. Je moet goed het evenwicht blijven houden tussen de reistijd en directheid van de aangeboden treinen.

- Hoe functioneert het openbaar vervoer systeem rondom luchthaven Schiphol volgens u?

De treinen die nu worden uitgevoerd functioneren goed. De stiptheid op dit traject is erg hoog en de uitval van treinen is in de afgelopen 2-3 jaar enorm afgenomen. In de dienstregeling is nog maar weinig ruimte om nog meer diensten aan te bieden zonder aan de uitval en stiptheid te komen.

- Zijn er aspecten die zeker verbeterd moeten worden in het OV systeem?

De capaciteit van het systeem zou voor de groei die we zien enorm moeten worden uitgebreid. Binnen 10 jaar zal het systeem vastlopen op de capaciteit die geboden wordt. Hier moet dus enorm in worden geinvesteerd om na die 10 jaar nog verder te kunnen reizen met de trein.

- In hoeverre denkt u dat er nog uitbreidingsmogelijkheden in de dienstregeling zijn in het spoor netwerk rondom Schiphol?

De dienstregeling zit aardig krap. Daar zal weinig meer in worden verandert.

- Wat doet NS om de bereikbaarheid van de luchthaven te verbeteren?

Er wordt veel gestudeerd op de case Schiphol. Voor NS is de taak om zo min mogelijk treinen uit te laten vallen en de stiptheid goed te houden.

- Wat zijn de klantwensen die worden meegenomen in het opstellen van de treinproducten?

Binnen reizigersonderzoeken wordt veel gekeken naar het comfort, veilgheidsgevoel op station, veiligheidsgevoel in de trein, stiptheid en gebruiksgemak. Daarbij speelt ticketing ook een rol. Zeker op Schiphol is dit heel anders dan in de rest van Nederland. Hier moeten meer duidelijke verkooppunten zijn waar internationale reizigers hun kaartjes kunnen kopen. Ook is de reisinformatie voorziening aangepast op Schiphol. Zo wordt niet meer het eindpunt aangegeven op de borden maar Amsterdam CS om de toeristen in de goede trein te laten komen.

- Hoe wordt daar rekening mee gehouden bij het inzetten van de diensten?

Er wordt zeker gekeken naar de verschillen in voorkeuren van passagiers. Zo wordt op het traject rondom Schiphol ervoor gekozen om meer sprinters in te zetten die geschikt zijn voor meer baggage met minder zitplekken tot gevolg. Het gaat hier natuurlijk wel om openbaar vervoer. En daarom moet rekeningen gehouden worden met alle reizigers. Daarbij speelt dat de luchtvaartreiziger niet de hoofdmoot vormt in de treinen die langs Schiphol komen. Het maken van treinen speciaal voor de luchthaven is daarom niet rendabel en niet doelgericht.

- Zijn er innovaties op het gebied van OV naar de luchthaven die de gehele visie op OV kunnen veranderen?

Er wordt nu veel gekeken naar treinen in de fluide vorm tussen metro en intercity in, maar daar zit nog teveel onzekerheid in om daar nu al veel van te verwachten.

- Wat zijn uw persoonlijke ervaringen met de bereikbaarheid van de luchthaven met het OV?

De bereikbaarheid is goed vanuit mijn woonplaats. Ik reis altijd met de trein als ik naar de luchthaven moet. Ook wanneer ik voor zakelijke reizen richting de luchthaven moet gebruik ik de trein als vervoermiddel.

- Wat zijn uw persoonlijke overwegingen wanneer u met het OV naar de luchthaven reist?

Het aantal overstappen is wel een belangrijke overweging. 1 overstap is nog te doen, maar zodra er meer in de reis zitten dan ga ik toch twijfelen om de auto te pakken. Ook het aantal baggage wat ik meeneem speelt een rol in de keuze.

Appendix B: Public   transport   network   maps European airports

London Gatwick & Heathrow

Oslo Gardermoen Airport
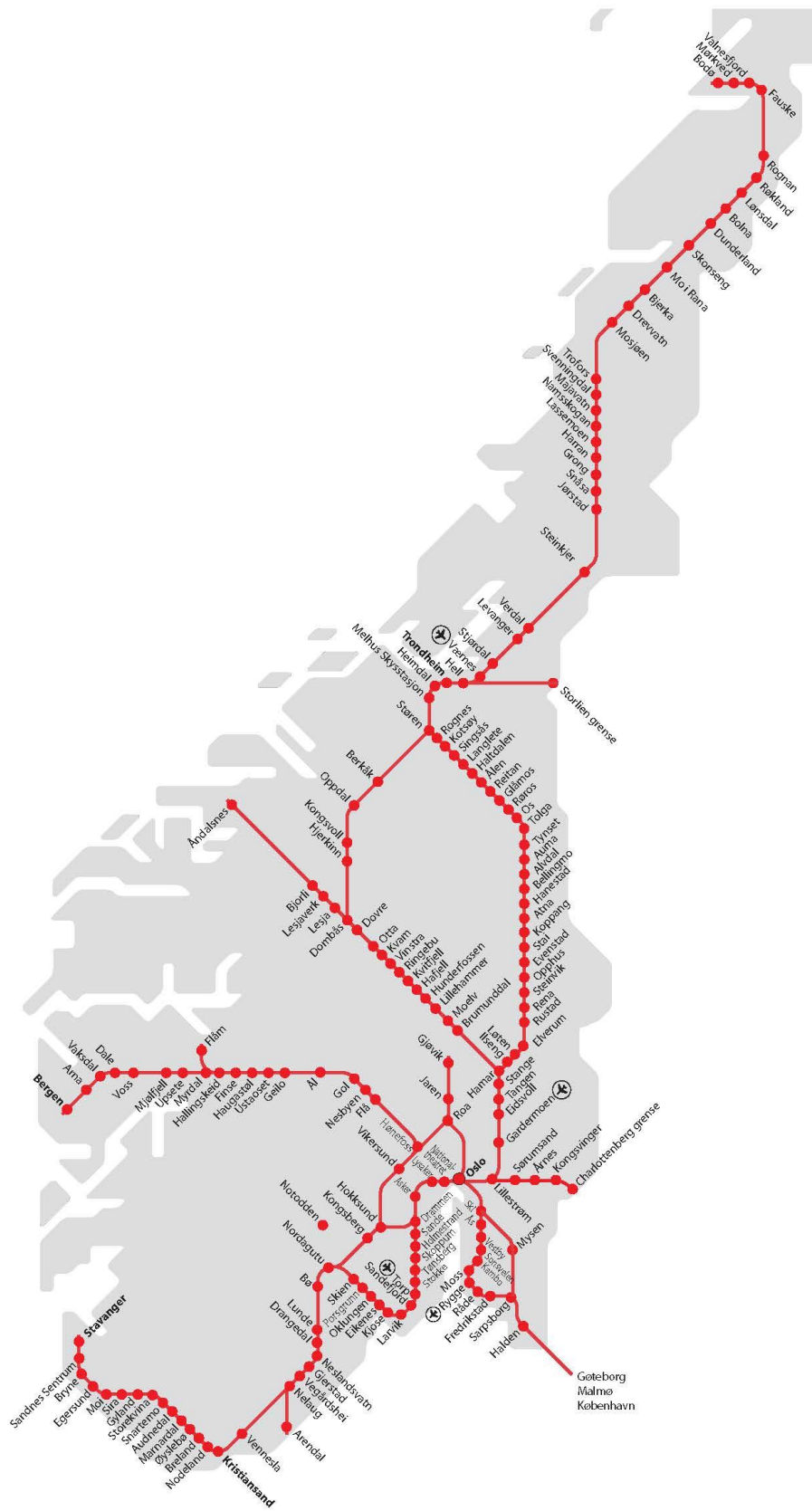
NSB Regiontog *Regional Trains*

R10 Drammen – Lillehammer

R11 Skien – Eidsvoll

R20 Oslo S – Halden
Enkelte avganger til/fra Göteborg.
* Tog retning Halden – ingen avstigning for Moss.

R30 Oslo S – Gjøvik
* På Stryken stopper toget ved behov i bestemte perioder.

NSB Lokaltog *Local Trains*

L1 Spikkestad – Lillestrøm

L2 Stabekk – Ski
Stopper på alle stasjoner.

L2x Rushtidsavganger Stabekk – Ski
Stopper ikke på alle stasjoner.

L3 Oslo S – Jaren
Stopper på alle stasjoner.
* På Stryken stopper toget ved behov i bestemte perioder.

L12 Kongsberg – Eidsvoll

L13 Drammen – Dal

L14 Asker – Kongsvinger
* Tuen og Bodung betjenes kun av enkelte rushtidsavganger.

L21 Stabekk – Moss

L22 Skøyen – Mysen
Til/fra Oslo S – Rakkestad i rushtiden.

Flytoget *Airport Express Train*

Kun for reiser til og fra Oslo Lufthavn. Her gjelder kun Flytogets kort og billetter.
For travel to and from Oslo Airport only. Only travel cards and tickets issued by The Airport Express train are valid here.

F1 Oslo S – Oslo Lufthavn / Oslo Airport
Direkte

F1x Stabekk – Oslo Lufthavn / Oslo Airport
Stopper ikke på Lillestrøm

F2 Drammen – Oslo Lufthavn / Oslo Airport
Stopper på alle Flytogstasjoner

Jernbaneverket

Stockholm Arlanda

Vienna

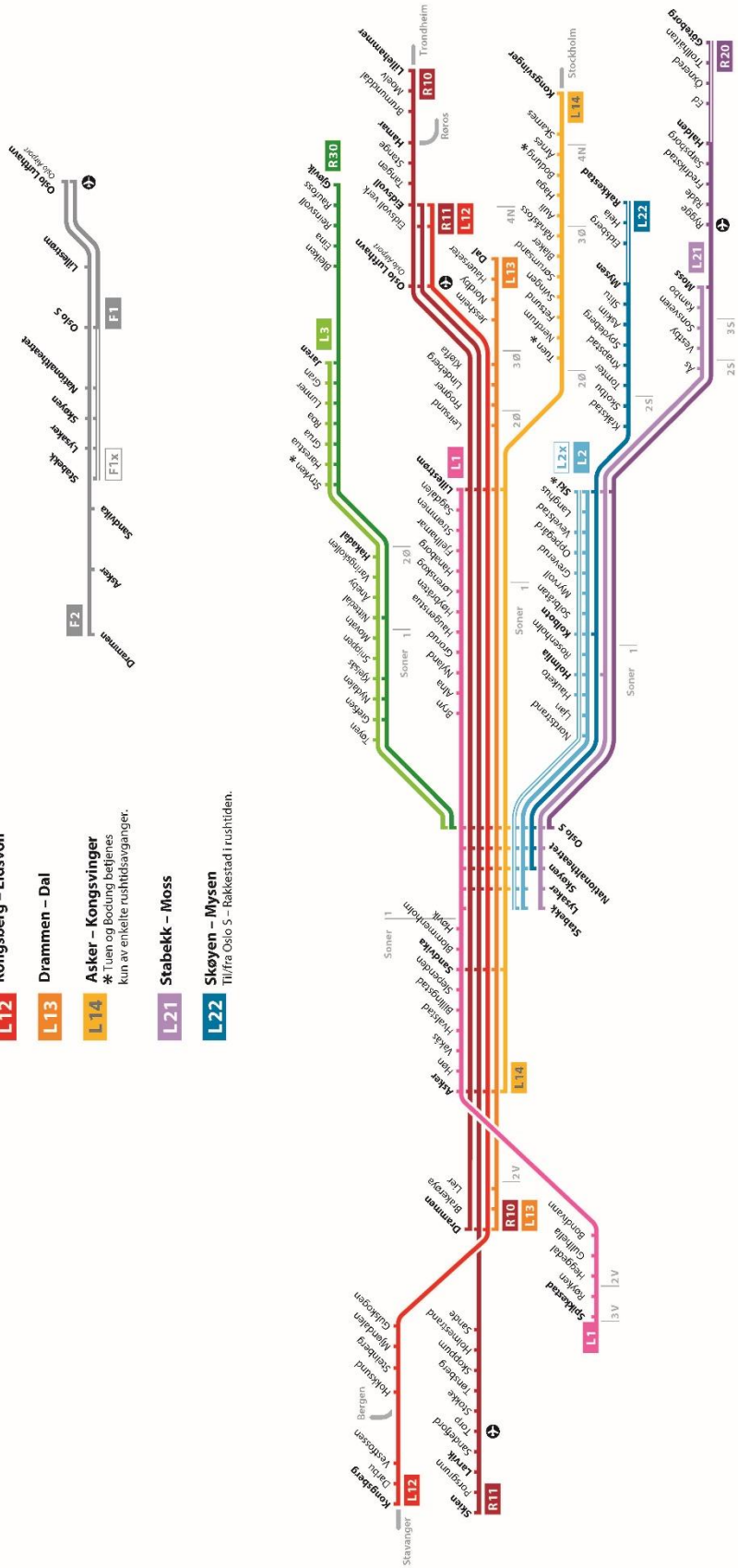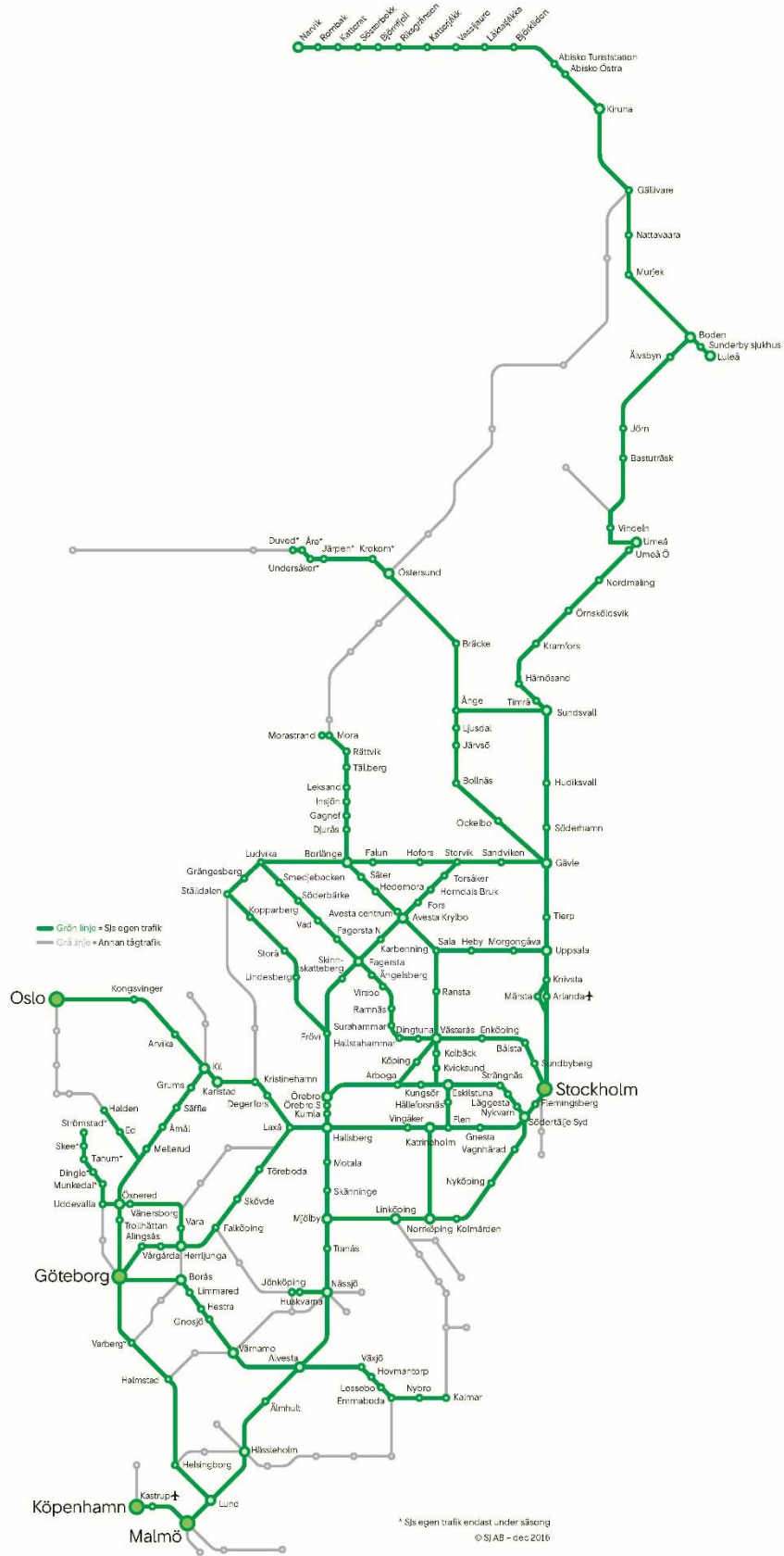Wien U-Bahn Plan
Vienna underground map

CITY AIRPORT TRAIN

Spoorkaart
2017
www.spoorkaart2017.nl

Treinreiziger.nl

ICE-Netz 2017

Gültig vom 11. 12. 2016 bis 09. 12. 2017

DB

ICE-Linien

▬▬	Linie 10, 47, 84 (TGV)
▬▬	Linie 11, 31
▬▬	Linie 12, 89 (Railjet) 91
▬▬	Linie 20, 62 (Railjet)
▬▬	Linie 22
▬▬	Linie 25, 79
▬▬	Linie 28, 43
▬▬	Linie 41, 83 (TGV)
▬▬	Linie 15, 42
▬▬	Linie 45, 82, 90 (Railjet)
▬▬	Linie 49
▬▬	Linie 50
▬▬	Linie 75, 78

1) L 10 Halt im 2 Std-Takt
2) L 11 kein Halt
3) L 28 Halt im 2 Std-Takt
4) L 28 Halt nur einzelner Züge
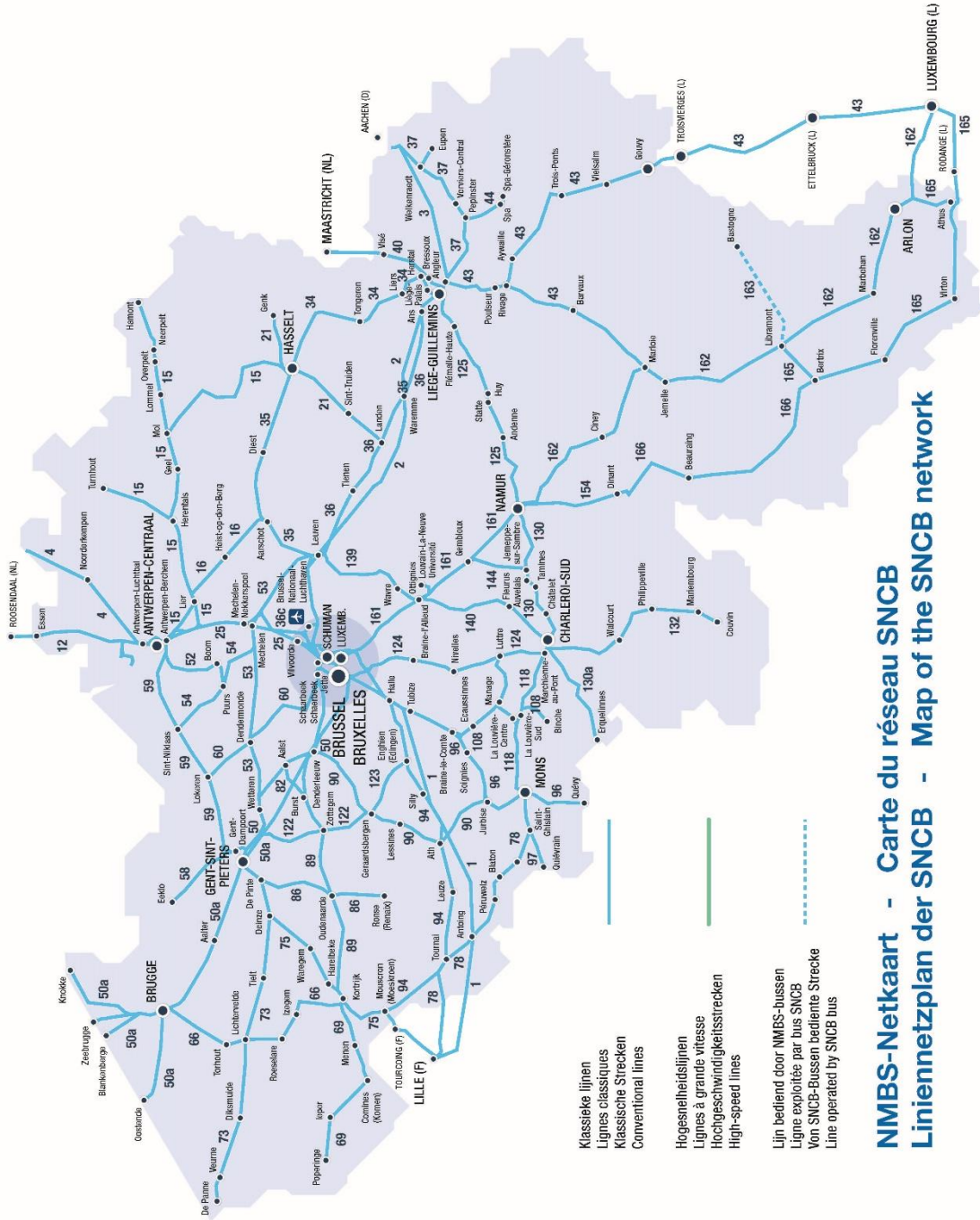5) nur Sa im Wintersport/Sommer
6) L 50 Halt im 2 Std-Takt
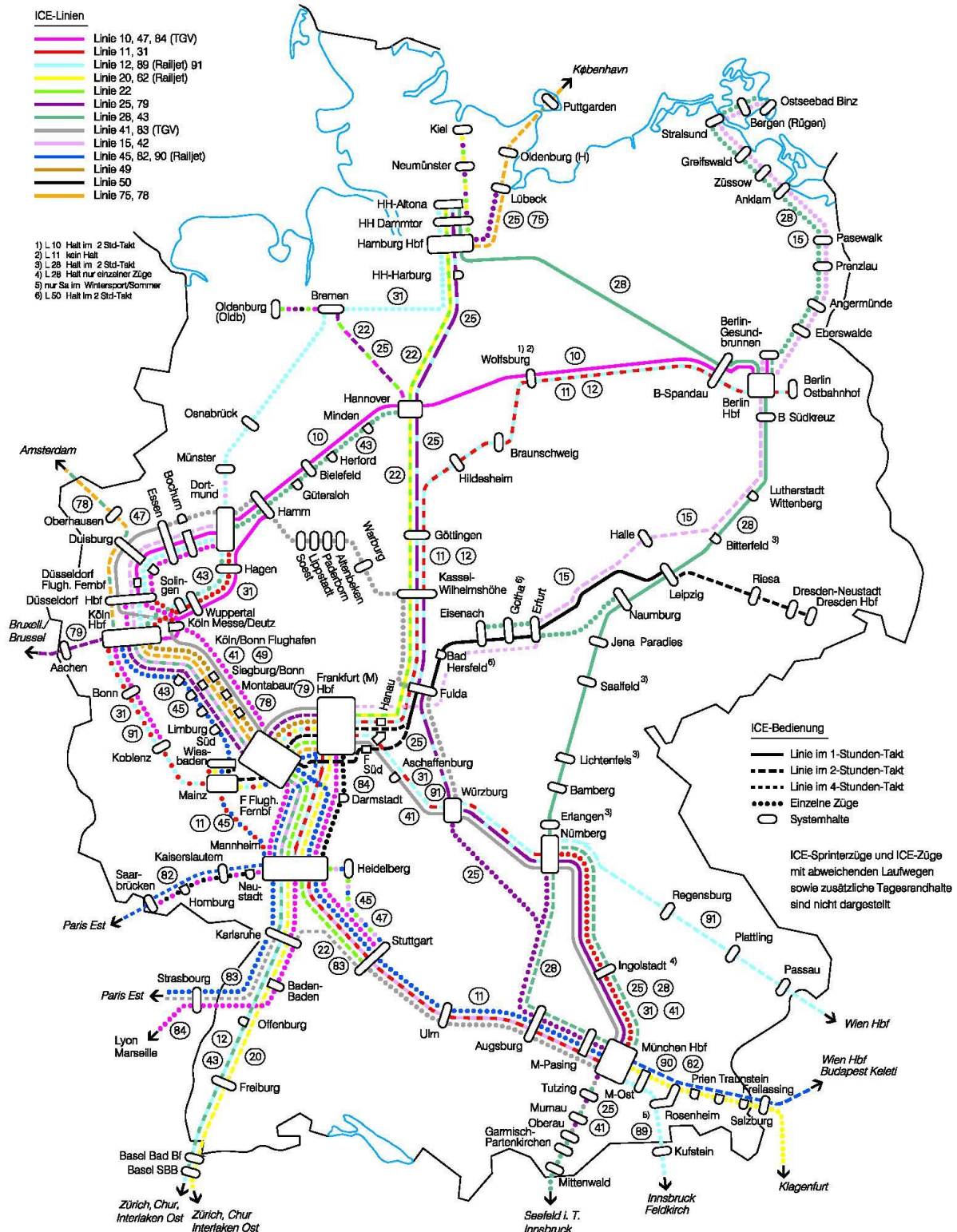
ICE-Bedienung

▬▬	Linie im 1-Stunden-Takt
▬ ▬	Linie im 2-Stunden-Takt
- - -	Linie im 4-Stunden-Takt
•••••	Einzelne Züge
⬭	Systemhalte

ICE-Sprinterzüge und ICE-Züge
mit abweichenden Laufwegen
sowie zusätzliche Tagesrandhalte
sind nicht dargestellt

København
Puttgarden
Ostseebad Binz
Bergen (Rügen)
Stralsund
Greifswald
Züssow
Anklam
Pasewalk
Prenzlau
Angermünde
Eberswalde
Kiel
Neumünster
Oldenburg (H)
Lübeck
HH-Altona
HH Dammtor
Hamburg Hbf
HH-Harburg
Bremen
Oldenburg (Oldb)
Wolfsburg
Berlin-Gesundbrunnen
B-Spandau
Berlin Hbf
Berlin Ostbahnhof
B Südkreuz
Hannover
Minden
Osnabrück
Braunschweig
Hildesheim
Amsterdam
Münster
Herford
Bielefeld
Gütersloh
Göttingen
Halle
Lutherstadt Wittenberg
Bitterfeld
Bochum
Dortmund
Essen
Oberhausen
Duisburg
Hamm
Hagen
Warburg
Altenbeken
Paderborn
Lippstadt
Soest
Kassel-Wilhelmshöhe
Naumburg
Leipzig
Riesa
Dresden-Neustadt
Dresden Hbf
Düsseldorf Flugh. Fernbf
Düsseldorf Hbf
Solingen
Eisenach
Gotha
Erfurt
Jena Paradies
Bruxell./Brussel
Köln Hbf
Wuppertal
Köln Messe/Deutz
Bad Hersfeld
Saalfeld
Aachen
Köln/Bonn Flughafen
Siegburg/Bonn
Montabaur
Frankfurt (M) Hbf
Hanau
Fulda
Bonn
Limburg Süd
Wiesbaden
Koblenz
F Süd
Aschaffenburg
Lichtenfels
Mainz
Darmstadt
Würzburg
Bamberg
F Flugh. Fernbf
Erlangen
Nürnberg
Mannheim
Heidelberg
Kaiserslautern
Saarbrücken
Neustadt
Homburg
Regensburg
Plattling
Passau
Paris Est
Karlsruhe
Stuttgart
Ingolstadt
Wien Hbf
Strasbourg
Baden-Baden
Paris Est
Lyon Marseille
Offenburg
Ulm
Augsburg
München Hbf
Prien Traunstein Freilassing
Wien Hbf
Budapest Keleti
M-Pasing
Salzburg
Freiburg
Tutzing
Murnau
Oberau
M-Ost
Rosenheim
Garmisch-Partenkirchen
Kufstein
Basel Bad Bf
Basel SBB
Mittenwald
Innsbruck Feldkirch
Klagenfurt
Zürich, Chur, Interlaken Ost
Zürich, Chur Interlaken Ost
Seefeld i. T. Innsbruck

Kartografie: DB Netz AG, Geoinformationsmanagement - Visualisierung (I.NPP 41(V))
Im Galluspark 23, 60326 Frankfurt am Main
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Redaktion: DB Fernverkehr AG
V.FBZ 21
Stand: Dezember 2016

Brussels

NMBS-Netkaart - Carte du réseau SNCB
Liniennetzplan der SNCB - Map of the SNCB network

Klassieke lijnen
Lignes classiques
Klassische Strecken
Conventional lines

Hogesnelheidslijnen
Lignes à grande vitesse
Hochgeschwindigkeitsstrecken
High-speed lines

Lijn bediend door NMBS-bussen
Ligne exploitée par bus SNCB
Von SNCB-Bussen bediente Strecke
Line operated by SNCB bus

Appendix C: User class calculation

63.600.000 Passengers 2016	37,8% Transfer	62,2% OD Passengers	= 24.040.800 OD Passengers
Travel motive air passengers	32% Business	50% Leisure	18% Other
1909 FTE Schiphol 2016	*260= 496340 FTE/Year		
42% PT modal split			
= 208.463 PT Employees	= 3.231.083 PT Business	= 5.048.568 PT Leisure	=1.817.484 PT Other
Total PT= 10.305.598			
2% PT Employees	31% PT Business	49% PT Leisure	18% PT Other

Source: (SchipholGroup, 2017c)

Appendix D: Actor analysis

| Stakeholders	Interest
Ministry of Infrastructure en Environment	Good accessible and durable public transport hub Schiphol Airport
Ministry of Finance	Good and healthy airport on financial aspects
Ministry of Safety and justice	Safe and secure airport system
Province of Noord-Holland	Safe and fast transport within Noord-Holland. Defining geographical environment around airport
Municipality of Haarlemmermeer	Most sustainable airport region
Schiphol Group	Developing Schiphol Airport to Europe's most preferred airport
ProRail	Offer reliable train product for operators and passengers
NS	Promote public transport and offering fast, safe, user friendly and affordable train product
Vervoerregio Amsterdam	Offering regional and urban public transport in Amsterdam as well as around Schiphol. Participating in research programs to improve public transport
National public transport providers	Offering bus services at Schiphol at a sufficient quality and quantity
Travellers and traveller organizations	Accessible locations in a fast, affordable and comfortable way

	Limited importance	Great importance
Limited options to replace	Medium dependency	High dependency
Can easily be replaced	Limited dependency	Medium dependency

Stakeholders	Important resources	Replaceable? [Yes, no]	Dependency [limited, average, high]	Critical stakeholder? [Yes, no]
Ministry of Infrastructure en Environment	Lawmaker and responsible party	No	High	Yes
Ministry of Finance	Shareholder for 70%	No	Average	Yes
Ministry of Safety and justice	Lawmaker for safety and security regulations at Schiphol	No	High	Yes
Province of Noord-Holland	Defining party in area development	No	High	Yes
Municipality of Haarlemmermeer	Important party for the inhabitants of the region	No	Average	Yes
Schiphol Group	Daily operator and knowledge of the functioning of the system	Yes	Average	No
ProRail	Daily operator of the rail infrastructure. Knowledge and resources to maintain the network	No	High	Yes
NS	Daily operator of the train services. Knowledge of the rolling stock and timetable	Yes	Average	Yes
Vervoerregio Amsterdam	Concession granter and monitoring quality of PT in and around Amsterdam. Knowledge of the network and daily operations	No	Average	Yes
National public transport providers	Knowledge of the bus fleet and maintenance of it. Daily operator with operational knowledge	Yes	Average	No
Travellers and traveller organizations	Users of the system	Yes	Limited	No

	Dedicated stakeholders		Non-dedicated stakeholders	
	Critical stakeholders	Non-critical stakeholders	Critical stakeholders	Non-critical stakeholders
Similar/ supportive interests and objectives	Ministry of I&E Ministry of F Ministry of S&J Province of Noord-Holland Municipality Haarlemmermeer Vervoerregio Amsterdam ProRail NS	Schiphol Group National PT providers		
Conflicting interests and objectives		Travellers & traveller organizations		

	Low level of interest	High level of interest
Low Power	Crowd: minimal effect	Subjects: Keep informed Schiphol Group National PT providers
High Power	Context setters: keep satisfied Travellers & traveller organizations	Key players Ministry of Infrastructure and Environment Ministry of Finance Ministry of Safety and Justice Province of Noord-Holland Municipality of Haarlemmermeer ProRail NS Vervoerregio Amsterdan

Formal relationship diagram
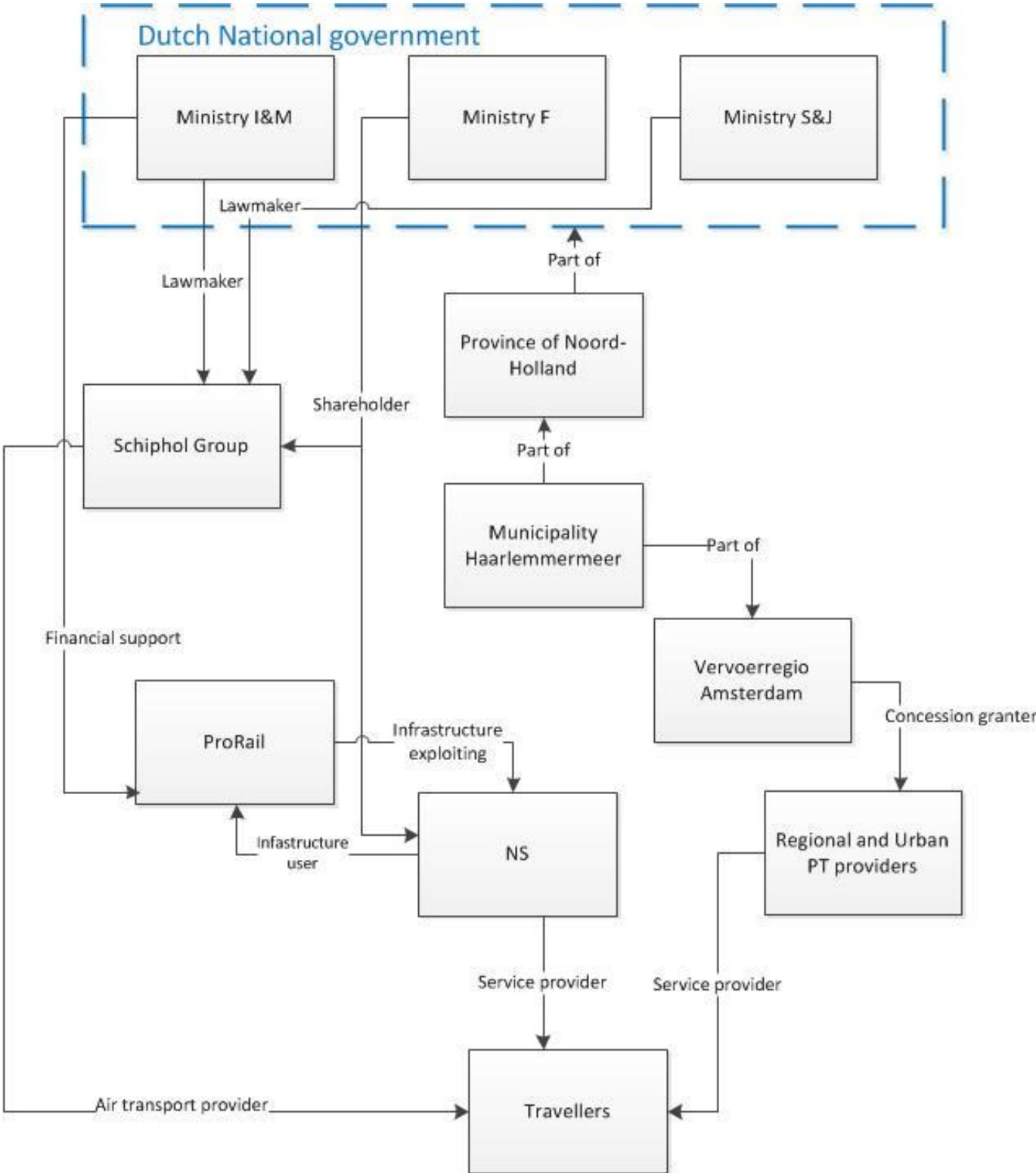
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