Thesis 279

Intermodal Airport Access:

A Multiple Case Study Research of a Future Travel Center at Malmö Airport with Railway Connection

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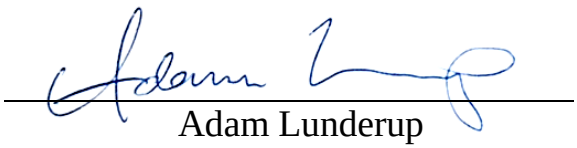
Preface

This Master thesis has been conducted during the spring of 2015 in collaboration with Swedavia, Malmö Airport. This marks the end of my education and has been my final assignment in Master of Science in Civil Engineering, Faculty of Engineering, at Lund University.Since I came in contact with Swedavia and Malmö Airport, my experience has been highly educational, valuable and unique. I've had the opportunity to attend workshops about airport access, visited various airports within Swedavia and got to know Malmö Airport. I would like express my thanks and gratitude to my supervisors Cecilia Hagert and Henrik Ivre at Swedavia for their guidance, support and feedback throughout my thesis. Further, I would like to thank my supervisor from Faculty of Engineering, at Lund University, Andreas Persson for his continuous feedback and bouncing ideas. I would also like to thank the case study airports, companies and people interviewed.

Finally, a big thank you to all my friends and family who has been a great support throughout my education.

Lund, May 29th 2015



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Abstract

Title: Intermodal Airport Access: *A multiple case study research on a future travel center at Malmö Airport with a rail connection*.

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Background: Malmö Airport is inadequate in providing sufficient airport access and struggles with the adjacent and more accessible Copenhagen Airport. Since 1999 there has been ongoing investigations about improving the access at Malmö Airport, which up until today is a work in progress. Malmö Airport has been visited by more than 2.1 million passengers in the year of 2014 and the number of passengers is growing in both domestic and international flights. Since The Öresund-region is known to be a climate-smart and sustainable region, Malmö Airport emphasizes the importance of a better intermodal airport access. An integrated railway connecting Malmö Airport can contribute to a more sustainable and environmentally friendly region.

Purpose: The formulated purpose for this master thesis is: *"Locating and promote a future travel center for an intermodal traffic solution, providing adequate airport access to Malmö Airport".* A number of underlying research questions were also formulated to enhance understanding of this master thesis.

- How to obtain sustainable intermodal airport access with various transportation modes

- The function and vision of the travel center and simultaneously provide satisfaction amongst users at Malmö Airport

- Identify and locate a travel center for optimal airport access with railway connection

Method: The methodology chosen for this master thesis is mainly inspired by a multiple case study method (Yin, 2013). In order to answer the questions from the purpose and the research questions presented, a thorough discussion of method was completed to give the appropriate design for this master thesis. The matter of airport access at Malmö Airport is still hypothetical, which gives no direct data from the now existing airport. However, a multiple case study from two or more airports providing some sort of railway connection, would add clues on how Malmö Airport would operate under such circumstances. In this report, two airports have been studied. Firstly, Göteborg Landvetter Airport, which is now under its planning phase of a railway connection. Secondly, Ängelholm Helsingborg Airport, which will soon have new train station in the airport's vicinity.

The framework established for the case studies are primarily based on Yin (2013), Trost (2010) and Patel & Davidsson (2011). Further, a multiple case study will provide ideas to this master thesis and approach the matter in order to bring out best results. The addition of qualitative interview will brings more validity of method approach for this thesis. As a final step, the matter of Malmö Airport's future will of intermodal airport access will be discussed in the analysis chapter 5.

Conclusions: There are motivators to support a future railway connection at Malmö Airport. The growth of the Öresund-region, environment aspects and a more intermodal solution are some of the major motivators. A travel center in the north part of the terminal is the suggested placement. Challenges will be in transferring car travelers to public transportation when a railway connection is operational.

Keywords: Airport access, railway connection, intermodal, transportation mode, travel center

Sammanfattning

Titel: Intermodal flygplatstillgänglighet: *En flerfaldig fallstudieundersökning av ett framtida resecentrum för Malmö Airport med en tåganslutning*.

Författare: Adam Lunderup

Handledare: Andreas Persson, Faculty of Engineering, Lund University
Cecilia Hagert, Swedavia AB
Henrik Ivre, Swedavia AB

Bakgrund: Malmö Airport har svårigheter att bidra med tillräcklig flygplatstillgänglighet och konkurrerar med den närliggande och mer tillgängliga Copenhagen Airport. Sedan 1999 har det utförs studier om hur man skulle kunna förbättra tillgängligheten till flygplatsen, vilket fram till idag är en utmaning. I nuläget besöktes Malmö Airport av mer än 2.1 miljoner under 2014 och flygplatsen växer stadigt inom både inrikes och utrikesflyg. Eftersom Öresundsregionen är känd för att vara en klimatsmart och hållbar region, betonar Malmö Airport vikten av ett bättre tillgänglighetsalternativ till flygplatsen. En integrerad järnvägsanslutning till Malmö Airport skulle kunna bidra till en mer hållbar och miljövänlig region.

Syfte: Det framtagna syftet för examensarbete är: *”Lokalisera och främja ett framtida resecentrum för en intermodal trafiklösning som bidrar med en lämplig flygplatstillgänglighet till Malmö Airport”*. Ett antal underliggande undersökningsfrågor är utöver syftet formulerade för att ge mer förståelsen för examensarbetet.

- Hur man bibehåller en hållbar intermodal flygplatstillgänglighet med olika transportsätt

- funktionen och visionen för resecentret som samtidigt uppnår en god kundnöjdhet bland användarna på Malmö Airport

- Identifiera och lokalisera resecentret för optimal flygplatstillgänglighet med järnvägsanslutning

Metod: Metodiken som är framtagen för detta examensarbete är främst inspirerat av en flerfaldig fallstudiemetod (Yin, 2013). För att svara på frågorna som togs fram i syftet och undersökningsfrågorna, gjordes en ingående diskussion av metodval för att ge lämplig design av examensarbetet. Frågan angående flygplatstillgänglighet till Malmö Airport är fortfarande hypotetisk, vilket gör att ingen data finns tillgänglig från den befintliga flygplatsen. Dock ger en flerfaldig fallstudie från andra flygplatser med järnvägsanslutning ledtrådar om huruvida Malmö Airport skulle fungera under liknande omständigheter. Två utvalda flygplatser kommer att ha fokus i examensarbetets fallstudier. Den första är Göteborg Landvetter Airport, vilket nu är i projekteringsstadiet för en framtida tåganslutning. Den andra är Ängelholm Helsingborg Airport, som snart har en närliggande tågstation vid flygplatsen.

Ramverket för fallstudierna är initialt baserat av Yin (2013), Trost (2010) och Patel & Davidsson (2011). En flerfaldig fallstudie kommer att bidra till idéer för examensarbetet och angripa ämnet på ett sätt som ger trovärdiga resultat. Tillägget av kvalitativa intervjuer ger ytterligare validitet som val av metod. Slutligen kommer Malmö Airport bli analyserat i kapitel 5 för att undersöka dess framtida flygplatstillgänglighet.

Slutsatser: Det finns flera motiveringar för att stödja en framtida järnvägsförbindelse till Malmö Airport. Tillväxten av Öresundsregionen, miljöaspekter och en mer intermodal lösning är några av de viktigaste argumenten för järnvägsförbindelsen. Ett resecentrum i den norra delen av terminalen är den föreslagna placeringen. Utmaningar ligger i att överföra bilresenärer till kollektivtrafik när en järnvägsförbindelse är i drift.

Nyckelord: Flygplatstillgänglighet, järnvägsanslutning, transportsätt, intermodal, resecentrum

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1 Introduction

This chapter gives an introduction of the master thesis and its underlying questions will be provided. A presentation of the company, the main case and airports will be included. The underlying events which this master thesis is based on will give the reader a clear background of why this investigation was conducted.

1.1 Background

Malmö Airport is the fifth largest airport in Sweden and it is located just outside the major cities of Malmö, Lund and not too far from Copenhagen (Swedavia, About Swedavia, 2015). The Airport first opened in 1972 and is now one of Swedavia's ten airports. In 2014, Malmö Airport had over 2.1 million passengers and the number of international and domestic flights are increasing. Because of Malmö Airport's location, in the center of the rapidly growing Öresund-region, the airport could be a strategic gateway to the region and the rest of the world. Thus, only if Malmö Airport was more integrated with the public access system. Since the opening of the rail link between Malmö and Denmark in 2000, which attracted more passengers to Copenhagen Airport, Malmö Airport struggles with airport access.

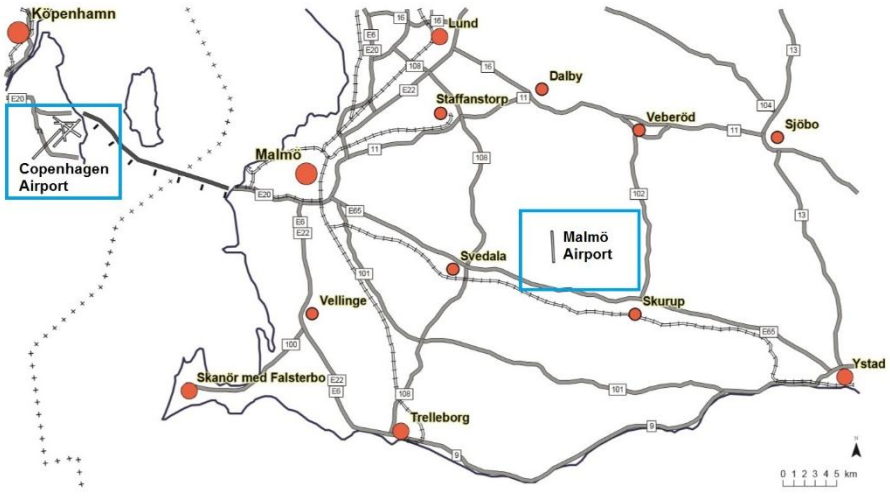

Figure 1 - Overview of the region (Sturupsaxeln AB, 2005)

"Better infrastructure, including air and rail connections, is an essential requirement for the growth of southern Sweden and the Öresund-region. (Swedavia, 2015)

In the year of 1999, a feasibility study was conducted in order to investigate the possibility of a rail connection at Malmö Airport. This study was completed by

local authorities, adjacent municipalities and the public (Nordgren, 2014). A cooperation named Sturupsaxeln AB, consisting of Malmö city and the municipalities of Svedala and Skurup, was formed to investigate the possibility of railway access. The main goal of the project was to create a fast connection between Malmö Airport and Copenhagen Airport and at the same time, increase the accessibility to the rest of the region (Sturupsaxeln AB, 2005). This cooperation led to another investigation completed in 2005, namely, an environmental impact analysis combined with a railway investigation, which also was partly funded by the EU[1]. The purpose of this comprehensive study completed in 2005 was mainly to clarify the conditions for a railway extension to Malmö Airport, from the existing track between Malmö city and Simrishamn. In 2010, Banverket (now part of Trafikverket) turned the project down. The motive of turning it down was financial aspects, which were considered insufficient and unsolved (Nordgren, Sturupspendeln, 2014). According to Nordgren[2] (2015), the project about a railway connection came to life again in 2013 and is today in its feasibility-stage and in terms of becoming a part ot the regional plans of infrastructure.

Access to Malmö Airport can only be executed by car, taxi and special airport buses (private company). The investigation alternatives from the Malmö *et.al* (2005) consisted of three future potential transportation systems: quick buses, train via side track and a pervading railway connection through the airport. The railway system require certain radiuses, gradients and technical aspects when dealing with high speed. The study examined four various railway corridors, consisting of the alternatives UA1o, UA1v, UA2v4 and UA2o. In figure 2 below, these railway corridors are presented.

[1] European Union
[2] Nordgren, G. (2015, Mars 27). Sturupspendeln. (A. Lunderup, Interviewer)

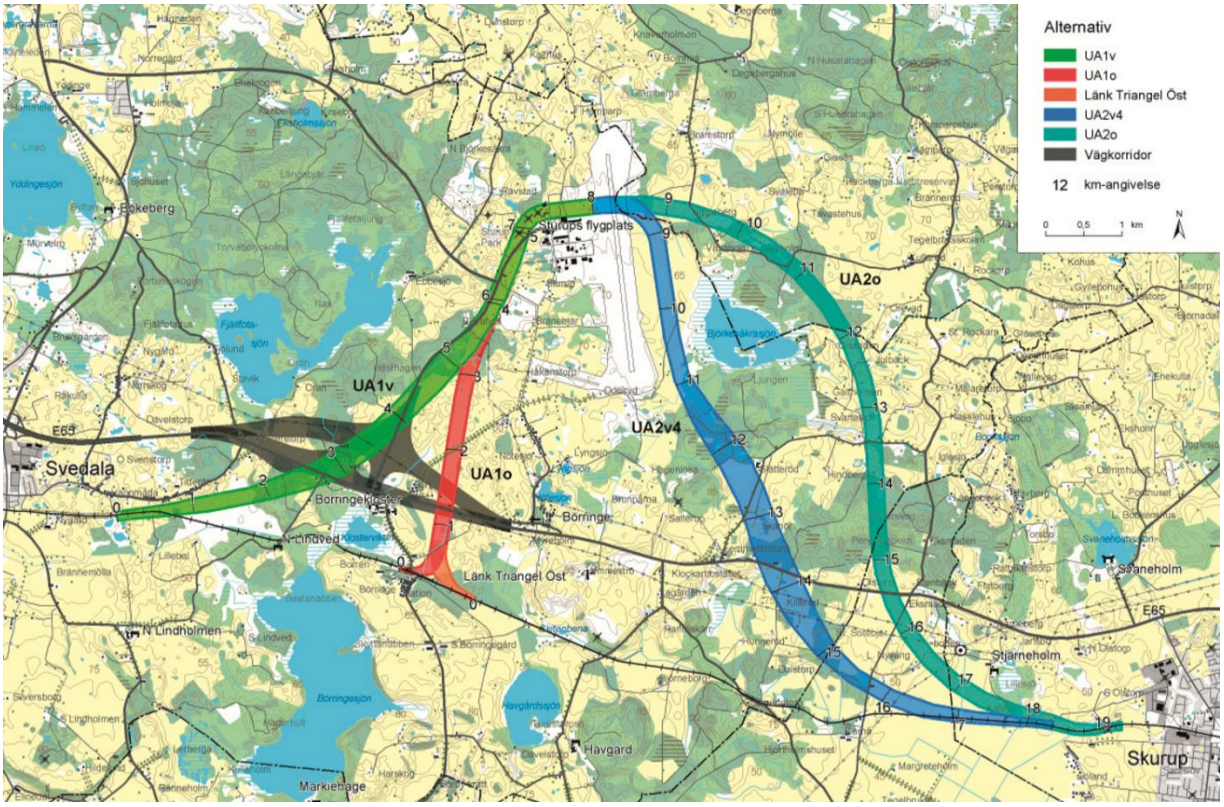

Figure 2 - Railway corridors (Sturupsaxeln AB, 2005)

If a pervading railway is to be establish, a tunnel underneath the airport and runways have to be constructed. There are many airports with a train connection and various reports have discussed the benefits with a train station at airports to enhance access (TCRP, 2000;Ashford, Mumayiz, & Wright, 2001).

1.2 Swedavia

Swedavia is a state-owned group that owns, operates and develops ten airports across Sweden. Their main role is to create satisfying access to favor traveling, business and meetings in a sustainable way and to connect Sweden with the rest of the world.

"Swedavia's vision is to bring the world closer" (Swedavia, 2015)

There were a total of 33,5 million passengers who flew via the airports of Swedavia in 2013. Same year, the group had an estimated revenue of 4,7 billion SEK and had 2500 coworkers. Moreover, Swedavia has two business segments, Aviation and Real estate. In figure 3 below, the company structure is displayed.

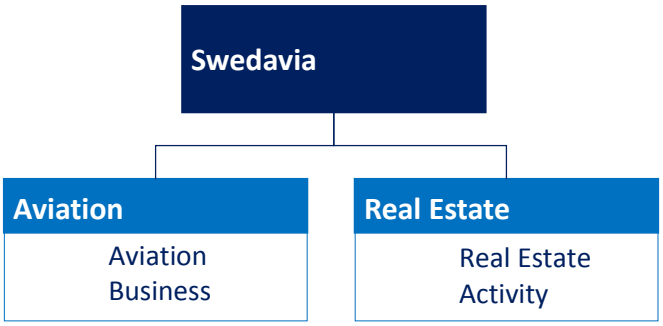

Figure 3 - Swedavia's Business model segments

Since environmental impact of aviation is always in focus, Swedavia is working actively with a climate work program including global climate goals established within the aviation branch (Swedavia, 2015). When the Swedish Transport Administration (Trafikverket) released a report in 2011, about increasing the railway capacity in Sweden, Swedavia was positive and added the importance with integrated transportation modes (Trafikforum och Resforum, 2011). Moreover, Torborg Chetkovich, CEO of Swedavia states:

> "*We must not forget that a more efficient infrastructure creates conditions for higher growth in Sweden. For example, in the Öresund-region, a better integrated rail network will support improved availability, both in Skåne and internationally*" (Trafikforum och Reseforum, 2011)

1.3 Problem description

At the heart of this study, challenges will be to provide sustainable and efficient airport access to Malmö Airport. Since airport access investigations has been ongoing since 1999, insight of how the airport will operate in the future are of interest. Especially when a new transportation mode is implemented combined with other modes. I, together with Swedavia and the Faculty of Engineering at Lund University, found it interesting to examine an intermodal travel center with respect of the new rail connection. Furthermore, Swedavia (2015) states that no report has not yet investigated the actual travel center and an operational railway connection, which would be of interest to the company and might be a part of their own master plan for Malmö Airport.

1.4 Purpose

Based on the matter of providing a sustainable and adequate airport access to Malmö Airport, the formulated purpose of this master thesis is:

"Locating and promote a future travel center for an intermodal traffic solution, providing adequate airport access to Malmö Airport".

The results presented in this thesis can be viewed as general guidelines to intermodal airport access, since it discusses: theories based on various airports

(and size), case studies and interviews within the aviation industry. However, the analysis will aim to give an insight of Malmö Airport's future airport access.

1.4.1 Research questions

A number of underlying research questions were also formulated to enhance understanding of the master thesis.

- How to obtain sustainable intermodal airport access with various transportation modes

- The function and vision of the travel center and to achieve satisfaction amongst passenger at Malmö Airport

- Identify and locate a travel center for optimal airport access with rail connection

1.5 Delimitations

This master thesis is limited to only include airport access and intermodal functions of airports. Moreover, focus will first address airports in general and finally Malmö Airport. Since the documentation for the subject today is limited, this master thesis will be based and analyzed on available data and findings from Malmö Airport and other similar projects regarding airport access. In order to enhance validity to the report the case studies will, in the extent possible, try represent airports of equal size compared to Malmö Airport. This was suggested both by me and Swedavia, since larger airports most likely have different conditions (Ivre, 2015)[3].This master thesis assume that a travel center with a rail connection are to be constructed, at Malmö Airport, but with no respect of financial aspects.

1.6 Target Audience

The target audience for this master thesis consist of three major groups. Firstly, the employees in the aviation industry and in first hand my supervisors from both Swedavia and the Faculty of Engineering at Lund University. Secondly, students at Lund University or other higher education specialized in infrastructure. Thirdly, people from other departments in infrastructure or

[3] Ivre, H. (2015, April 8). Interview Swedavia. (A. Lunderup, Interviewer)

people in general with less experience but are interested in sustainable infrastructure, aviation et cetera.

1.7 Structure of the report

The structure of this master thesis consists of six major parts, which are presented briefly in figure 4 below.

Figure 4 - Outlay of report

1.7.1 Chapter 1 – Introduction

This chapter gives an introduction of the master thesis and its underlying questions will be provided. A presentation of the company, the main case and airports will be included. The underlying events which this master thesis is based on will give the reader a clear background of why this investigation was conducted.

1.7.2 Chapter 2 – Methodology

This chapter offers a coverage and overview of the methodology selected for this master thesis. Methods along with case study design are discussed to provide suitable approaches regarding the subject. Further, the chapter then describes the investigation process of this master thesis and how it is conducted and analyzed while maintaining quality and validity.

1.7.3 Chapter 3 – Theoretical framework

In this theoretical chapter areas concerning access to airports and other contiguous matters will be covered. An overview of the access market will be discussed thoroughly and connect with parameters such as forecasting demand and terminal design. Further, this chapter highlights some of the theoretical frameworks which are often partly used in the more comprehensive master planning.

1.7.4 Chapter 4 – Empirical study

In this chapter the empirical data will be presented. A combination of interviews and multiple case studies will be discussed and to some extent, be linked with presented theory from chapter three. The methods presented in chapter two are taken in consideration when constructing the cases and they form a foundation

for the final examination of the Malmö Airport issue. A selection of people were interviewed in this study in order to enhance this master thesis validity.

The outlay of the empirical study will first discuss findings from Malmö Airport. Secondly, the multiple case studies Göteborg Landvetter Airport and Ängelholm Helsingborg Airport will be presented. Finally, empirical input will further be investigation in the analysis chapter four.

1.7.5 Chapter 5 – Analysis

In this chapter all empirical studies and theories from chapter 3 are being studied with respect of Malmö Airport and its possibilities of operating a future intermodal travel center with a rail connection. There lies is a challenge in comparing a hypothetical assumption about an airport and its supposedly future scenario. However, based on the theories, selected airport case studies and other empirical findings, this master thesis should provide illustrative suggestions of Malmö Airport.

1.7.6 Chapter 6 – Discussion/Conclusion

In this chapter the investigation will be discussed by extracting key findings from the analysis, which then are transformed to answer the research questions of the master thesis. An overall quality and validity discussion will also be addressed in this chapter. Finally, suggestions on the future scenario at Malmö Airport will be presented along with my personal reflections regarding the thesis.

2 Methodology

This chapter offers a coverage and overview of the methodology selected for this master thesis. Methods along with case study design are discussed to provide suitable approaches regarding the subject. Further, the chapter then describes the investigation process of this master thesis and how it is conducted and analyzed while maintaining quality and validity.

2.1 Research strategies

There are different types of research strategies and some of the most common have been given definitions to distinguish one from another. Most frequently used strategies are explorative, descriptive and hypothetic methods. Each one is mostly conducted separately depending on the matter (Patel & Davidsson, 2011). The selection of strategy is then based on the problem in question, in order to bring out quality of the research intended (Yin, 2013; Patel & Davidsson, 2011). Explorative research is generally used when filling uncertainties of your knowledge, which provides investigation in the research. The purpose of explorative research is mainly to collect as much knowledge as possible within a subject. This type of research requires creativity when the investigation aims to reach new understanding. This research method consists of many various techniques (Patel & Davidsson, 2011).

Within problem areas where a certain amount of knowledge of your research already exists is namely called descriptive. This research concerns relations connected with the past and the presence. In contrast to explorative research, descriptive focuses on a more thorough and detailed view of the selected phenomenon (Patel & Davidsson, 2011). Since the matter is more detailed when using descriptive methods, the use of technics is narrowed down to usually one.

The third research is called hypothesis-testing. This research preferably applies on problem areas where the amount of knowledge is comprehensive and with already developed theories. When doing hypothesis-testing research connections between theories and assumptions of the reality are being conducted (Patel & Davidsson, 2011).

These three variations of research, explorative, descriptive and hypothesis-testing are usually conducted separately (Patel & Davidsson, 2011). Only in larger projects a combination of two or three are used. Examples of research when more than one research is necessary could be when your phenomenon is descriptive but provided with too little knowledge necessary. An explorative

study could then first enlighten knowledge due to its all-round approach and decide how the descriptive study should focus.

Nowadays, research are usually divided into qualitative and quantitative research. The designations are aimed at how we choose to process, generate and analyze gathered information. With qualitative research your data collection focuses on what Yin (2013) calls "soft" data. That could be described as qualitative interviews or interpret analyzes, which intend to be mostly in verbal context. The other method is quantitative research which basically includes measurements with data collections, statistics and analyzing methods. These both research methods are viewed as opposites in figure 5. Despite their differences in approaches they are often combined when doing a research (Yin, 2013). Mainly because research today most likely is somewhere in between these two methods.

Figure 5 - Quantitative and qualitative research displayed as endpoints (Patel & Davidsson, 2011)

Strategies are according to Yin (2013) often misunderstood when finding the appropriate research method for an investigation. A common reasoning amongst case studies is that one might think that they only are suitable for exploratory investigations and that descriptive studies should use surveys. Therefore this misconception of strategy choice can be questioned. Yin (2013) describes various case studies with the approach of not being exploratory ones and therefore case studies are far from being only exploratory.

2.1.1 Choosing strategy

When evaluating strategies for the investigation three conditions combined with five major methods build up a selections of choice (Yin, 2013). The conditions consists of (1) the type of research question, (2) the extent of control over behavioral events, and (3) degree of focus on contemporary events (Yin, 2013). This evaluation strategy is displayed in table 1.

Table 1 - Relevant Situations for Different Research Methods (Yin, 2013)

METHODS	(1) Form of Research question	(2) Requires Control of Behavioral Events?	(3) Focuses on Contemporary Events?
Experiment	how, why?	yes	yes
Survey	who, what, where, how many, how much?	no	yes
Archival Analysis	who, what, where, how many, how much?	no	yes/no
History	how, why?	no	no
Case Study	how, why?	no	yes

The importance of defining your research question is a crucial part (Yin, 2013). As shown in table 1 the series of questions is: "who", "what", "where", "how" and "why". The "what" question can be parted in two types of questions. The first being an exploratory questions, such as "What can we learn from this master thesis", which preferably demands exploratory methods in order to fulfill its investigation (Yin, 2013). The second type of "what" question takes form into "how many" and "how much" questions. These questions preferably requires survey methods or/and archival studies. However, Yin (2013) argues that an exploratory study can be used over all five questions. In contrary "how" and "why" are more exploratory. It is most suitable to use methods as case study, history or experiment. Further, the definition of a research question is of great importance when choosing research method and one must not forget that an overlap between methods could be useful and often used.

Case study is an optimal choice of research method as it is suitable when examining contemporary events (Yin, 2013). Case studies of an already existing travel centers, with similar airports in the same size as Malmö airport, would benefit the research questions named in chapter 1. Yin (2013) argues that a case study has a unique way of processing varieties of evidence such as: documents, interviews, observations etc.

2.2 Case study research

A case study is a research method focused on a specific group, process, event et cetera (Yin, 2013; Patel & Davidsson, 2011). When conducting a case study

you want to create a clear picture as possible of your whole case. Therefore various information must be studied and processed.

In depth there is a two-part definition of what a case study is. Firstly, a case study is an empirical inquiry. In other words it investigates a contemporary case in depth while its boundaries between contexts are vague (Yin, 2013). This provides our research with understanding of the case selected. Secondly a new definition occurs when our case is not connected with a real-world scenario. Other methods are therefore necessary in a case study in forms of relevant features. For example: more data, multiple sources and having them to converge. Since a case study consist of various methods within itself, a selection of a single case study or a multiple case study must be chosen before initiation of the investigation.

2.2.1 Single or multiple-case study

It is argued that a multiple case study is more preferable than a single case study (Yin, 2013). Despite that, most designs of case studies could however be achieved successfully. A multiple case study is less vulnerable than a single case study, meaning that the single case is mostly successful when having a strong argument (Yin, 2013). Moreover, Yin (2013) therefore suggests a multiple case study over a single case study. Firstly, a multiple case study allows us to benefit from more than two cases. That is far more powerful comparing with a single case study. Secondly, when conducting more than two cases your investigation will produce greater effects such as reliability and significance to your case. Moreover, a multiple case study is more comprehensive than a single case study. It requires a more extensive investigation when dealing with multiple cases and this should be considered before choosing, when a multiple case study approach is more time consuming and demanding.

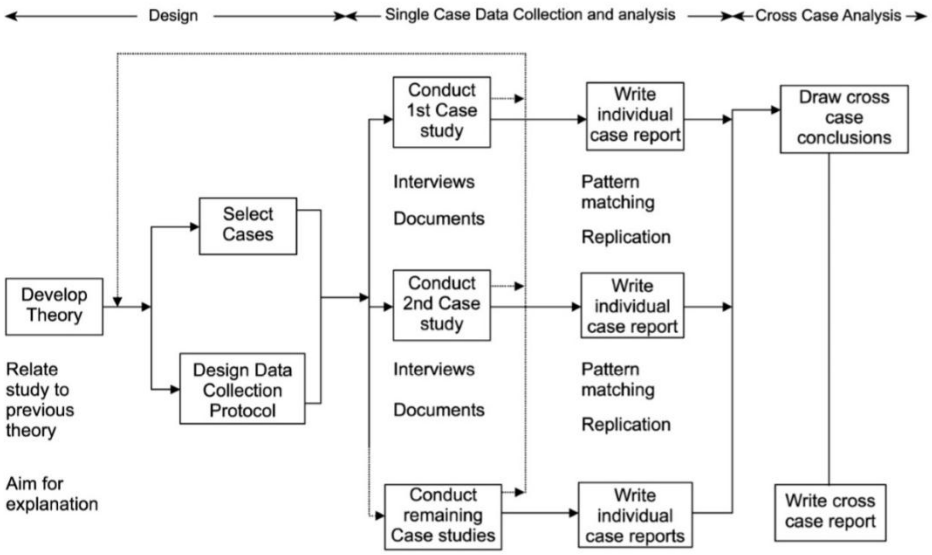

Figure 6 - Multiple-case study method (Yin, 2013)

2.2.2 Case study design

When designing a case study five components are most essential. These components are listed below:

1. A case study's questions
2. Its propositions, if any
3. Its unit(s) of analysis
4. The logic linking the data to the propositions
5. The criteria for interpreting the findings

The first component consists of what type of *study question* is used in the investigation. As described earlier in section 2.1.1, a case study with the question "how" and "why" would be most appropriate. To increase relevance of your choice of questions a minor examination of similar case-topics can be useful. Further, this should benefit your imagination when constructing your case questions (Yin, 2013).

The second component is the *study propositions*, which immediate attention to the propositions intended within the extent of the study (Yin, 2013). For example, if there was a study question: "How and why can train connections collaborate with other intermodal transportations at an airports"? This questions with "how" and "why" addresses a case study, but it is not sufficient enough to address on what you should study. A suggestion from Yin (2013) clarifies that if you could state some propositions along with your question which can navigate towards appropriate evidence, it is a good design. For instance, assume that new flows of passengers emerge with a new train connection. Since passengers have mutual interest independent on what transport they use, how

does this affect the existing terminals? This example directs evidence useful from the main question.

Unit of analysis is the third component out of the five, describing how the case should be studied. In order to fulfill this component one must consider two steps, defining the case and bounding the case. Firstly, when defining the case Yin (2013) explains that a case/individual usually has the focus as the investigations primary unit are to be analyzed. The more information that is given about the topic, questions, propositions, the more feasible your study is (Yin, 2013). Besides that, the other component should be carried out in advance. When dealing with a wide case (as this master thesis) it is important to define the unit of analysis. To avoid your topic being divided in various case studies the questions should always be of your interest and to be bases within your case topic. For example, this master thesis could easily be divided in several case studies. Case study about: optimal train stretch to the airport, geological conditions with a train tunnel under the airport, etc. Since this is a complicated matter, Yin (2013) suggests no closure when deciding your unit of analysis since this might change during the data collections process. A revisit to this component is therefore useful as the investigation moves forward. Asking colleagues is also a great way to prevent incorrectly definition of your unit of analysis.

Secondly, bounding the case becomes essential as it clarifies your case further. The case should be distinguished from what not will be included in the study. The estimation of beginning and ending of the case is desirable within the boundaries of your case. When bounding your case ibid. stresses the importance of comparison with previous research. If possible, comparing similar unit of analysis in your field of focus could help finding appropriate literature (Yin, 2013).

The fourth component is *linking data to propositions* and explains this process. Analytic techniques used when linking data to propositions are: pattern matching, explanation building, time-series analysis logic models and cross case synthesis. As of this, various techniques can be used and preferably a combination of a selection would be beneficial for your study. Especially helpful is when in the design phase pay attention to the time series analysis. Literature can mark a specific time in your case, and with this attention, literature with the ability to trace change over time is a major strength when conducting a case study. One extra precaution aspect when processing data is to avoid having too much data and not having enough data. This of course requires experience but benefit your case study (Yin, 2013).

The fifth component concerning *criteria for interpreting a case study's finding* are commonly connected with quantitative studies, especially when processing statistics (Yin, 2013). However, this is seldom used in a case study and therefore other interpreting methods are being adapted. Interpreting strategies in a case study could be to identify and address rival explanation for your findings. It has been described by ibid. to be most beneficial to address such rivals to interpret your findings and by adding more rivals you address and reject, the stronger findings. During the design process it is therefore important to enumerate rivals, to include such data aside from your data collection, to provide essential fundamentals of your data.

2.2.3 Theory development

Based on these five components described in the previous chapter, we can initiate a theory or theoretical proposition development related to the study. It is supposedly beneficial according to Yin (2013) to make two theories, where one of them is a rival theory. In doing so, you increase the conditions of including your five components. In other words, the rival theory is a statement that describes the opposite or for example "if it does not work". The theory development is mainly an aid in generalizing your findings in a case study and should therefore be a part of the design process.

2.2.4 Quality and validity

To assure your research design having good quality the quality and validity can be tested. A tactical and an efficient way of examining your research data is can be executed according to a four design test chart displayed in table 2 below (Yin, 2013).

Table 2 - Case Study Tactics for Four Design Tests (Yin, 2013)

TEST	Case Study Tactic
Construct validity	• Use multiple sources of evidence • Establish chain of evidence • Have key informants review draft case study report
Internal Validity	• Do pattern matching • Do explanation building • Address rival explanation • Use logic models
External Validity	• Use theory in single-case studies • Use replication logic in multiple-case studies
Reliability	• Use case study protocol • Develop case study database

Construct validity is when identifying correct operational measures of concept. According to Yin (2013), this first test is rather difficult in terms of finding the appropriate measures. To increase success of this test a recommendation of tactics is presented, which is shown in table 2 above.

The second test is *Internal validity* which is beneficial when sorting out how an event x led to event y. This test is only useful when conducting exploratory studies. It is stated by Yin (2013), that for best achievement, this test should be seen as an analytic tactic. Tactics is shown in table 2 above.

The third test is called *external validity* and deals with findings whether they are generalizable, regardless to the results. It is said to be crucial what type of research question you use in terms of satisfy this test. According to Yin (2013) one must consider having the appropriate research question. It basically helps with "how" and "why" questions combined with good data has shown to be helpful.

The last test is named *reliability* which focuses on demonstration that the operations of the study can be repeated. The goal however is to minimize the errors in the case study (Yin, 2013). To maximize the reliability it is suggested

to document the data thoroughly to ensure external viewers to rely on your research. Yet again, table 2 above shows the tactics for this test.

2.3 Selected Methodology Approach

This master thesis follows the directions of presented approach of case study methods by (Yin, 2013). Firstly, the research strategy selected is a case study, based on the fact that this master thesis is explorative and will be based on contemporary events, in the extent possible. There will be two case studies conducted in order to maximize the validity of this master thesis, as described in chapter 2.3.1 (Single or multiple-case study). As for the actual design and approach for this thesis, a customization has to be done. The two cases differ from each other have to be altered in order to achieve good information for the analysis. Both cases follows the guidelines of the five components from 2.3.2 (Case study design) as much as possible. The outcome of the cases are then discussed in the empirical data chapter 4 and the theoretical framework in chapter 3 provides theoretical evidence for both cases. Since the subject of the two cases differs, a certain interview method is used to support each case. Interviews have been conducted ongoing and written down, then implemented as data. No interview has been fully transcribed nor recorded since this master thesis is limited in both time and resources. Some claim that the outcome of interviews is better when not having them recorded since a more open dialogue can be obtained (Trost, 2010). Moreover, the notes from the interviews are summarized in notes with key elements and will only be used when writing the report. A general interview guide for this master thesis is displayed in appendix A. Ethical aspects of the interviews follow suggestion from Trost (2010) and consist of an approval from the person being interviewed, before publishing the master thesis. Finally, the analysis of this master thesis then discusses Malmö Airport with respect of gathered theoretical framework, empirical findings and conclusions from the case studies.

3 Theoretical framework

In this theoretical chapter areas concerning access to airports and other contiguous matters will be covered. An overview of the access market will be discussed thoroughly and connect with parameters such as forecasting demand and terminal design. Further, this chapter highlights some of the theoretical frameworks which are often partly used in the more comprehensive master planning.

3.1 Definition of Airport access

The definition of access is described in Ashford *et.al* (2001) as three major areas, which is commonly used in design and preparation of access systems:

1. Collection and processing, if necessary, of passengers in the central area of the city and other centers of high demand
2. Movement of passengers, cargo, and service traffic to the airport by surface or air vehicles
3. Distribution of access traffic and internal circulation traffic to terminals and gate positions

Since the access trip for each traveler is different it becomes a difficult task for the designer to mark where each trip begins and ends. Therefore, a general approach is used and focuses of the end point of where the traveler arrives in the vicinity of the air terminal. Ashford *et.al* (2001) also mention the importance of optimal access planning, since it is a main part of passenger's entire experience, from the point of origin to their final destination.

3.2 Access problems

In the early days of aviation, airport access was considered less of a problem in comparison to today. By comparing the situation around 1920 in the USA with today, costs for air traveling in 1920 was so high that only a few people used existing modes for accessing the airport (Ashford *et.al*, 2001). During this time it was easy to get around with car without heavy traffic. Around 1965, technology evolved in combination with rapid urbanization and congested roads made an impact on the airport access. This change is further described by Várhelyi (2010), who cliams that this was a trend in both America and Europe. In Sweden, the ownership of a car was essential for ones needs of transportation and the road network developed to be the most crucial network of transportation. There is also a change in short-haul trips over the last 50 years, as shown in figure 7 below. Despite the improvements of jet engines the overall process time has not shortened because of the now longer access time.

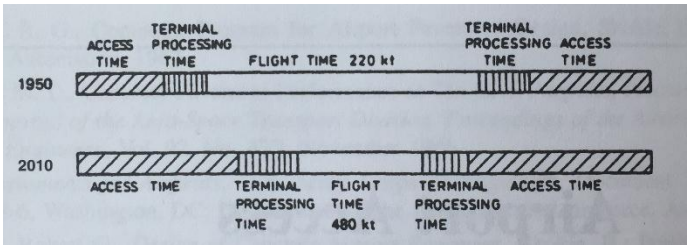

Figure 7 - Comparison of short-haul city-center-to-city-center travel, 1950-2010 (Ashford et.al, 2001)

Speculation about future access problems is further described by Ashford et.al (2001), where it is stated that most airports developed over the next 50 years will mostly be connected to the existing transportation infrastructure. A great opposition in both United States and in Europe about exploiting green fields when creating new airports support the fact that already existing airports will develop and expand. Furthermore, this aspect is more debated in Europe, where the population is dense and environmental intrusion of the airport industry Ashford et.al (2001).

"Many of the access problems facing the existing airports will continue well in the future." (Ashford *et.al*, 2001)

3.3 Access for whom?

When planning the access system it is crucial to define the users. There is many times a misconception that only air passengers qualify as the only traveler. Moreover, the population of an airport is diverse and consists of various users. Therefore, users must be taken in consideration in the access planning. The common users are listed below (Ashford *et.al*, 2001;Graham, 2003):

- Air travelers
- Senders and greeters
- Visitors
- Employees
- Air cargo access personnel
- Persons who supply service to airport

Depending on the airports size, location, and functions the population between the listed users varies. However, the majority of the access market share consists mainly of two groups, passengers and airport employees/workers. In table 3 below, an estimated proportion of users are listed based upon various airports (Ashford *et.al*, 2001).

*Table 3 - Proportion of passengers, workers, visitors and greeters/senders at selected airports. (*senders and greeters included). (Ashford et.al, 2001)*

Airports	Proportions of users			
	Passengers	Senders and greeters	Workers	Visitors
Frankfurt	0.60	0.06	0.29	0.05
Vienna	0.51	0.22	0.19	0.08
Paris-Orly	0.62	0.07	0.23	0.08
Amsterdam	0.41	0.23	0.28	0.08
Toronto	0.38	0.54	0.08	Not included
Atlanta	0.39	0.26	0.09	0.26
Los Angeles	0.42	0.46	0.12	Not included
New York - JFK	0.37	0.48	0.15	Not included
Bogoto	0.21	0.42	0.36	Negligible
Mexico City	0.35	0.52	0.13	Negligible
Curaçao	0.25	0.64	0.08	0.03
Tokyo-Haneda	0.66	0.11	0.17	0.06
Singapore	0.23	0.61	0.16	Negligible
Melbourne	0.46	0.32	0.14	0.08
U.S airports	0.33-0.56	-	0.11-0.16	0.31-0.42*

As shown in table 3 above, the characteristic of the airport's ground access is the product of air travel. Moreover, at some airports with non-aeronautic activities (NAI) a wider range of passengers are attracted with the airport ground access. Both Ashford *et.al* (2001) and TCRP (2000) emphasize the importance of investigating the ground access market of the airport. Especially when designing and choosing appropriate modes of transportation. Air travelers and airport employees make up the largest groups of the airport population. One must define all market segments of an airport to identify the largest group for a service or a product. The greatest challenge is to point out the key groups who will use the services available or the services intended in the future. Each group provides travelling patterns that are useful when designing access modes. Further, there tends to be a service and location attribute that dominates the choice of ground access mode. In depth, the air passenger segments consist of four different groups listed and discussed below (TCRP, 2000).

List of airport passengers:

- **Air passenger market**
    - Resident Business
    - Resident Non-business
    - Non-resident Business
    - Non-resident Non-business
- **Airport Employee Market**
    - Airport Employees – Flight Crew

- Airport Employees – Nonflight Crew

- **Airport Market Plus**

3.3.1 Visitors of Airport Ground Access

Air Passengers Market

Resident Business

The resident business traveler is the most frequent traveler amongst the user groups (TCRP, 2000). Due to their frequency in air traveling, it is easy to establish a certain pattern in their access decisions. These travelers are likely the most efficient traveler, meaning that they choose access with care in order to achieve reliability and cost efficiency in their choice of access modes. Typical characteristics of resident business travelers is commonly very little luggage, compared to the nonbusiness traveler, and their duration of the trip, which usually is shorter compared to the nonbusiness traveler. Because of their luggage proportions, resident business travelers are more suitable for public transportation options. However, it is argued that these travelers are cautious when considering public transportation since it is more unreliable to reach their destination in time (Windle & Dresner, 1994). Further, the use of public transportation must also be flawless in peak hours, since the majority of the residential business travelers most likely travel to and from the airport around that time. Finally, reports from TCRP (2000) states that resident business travelers usually access by car and use expensive car parking and are mainly time sensitive.

Resident Nonbusiness

Resident nonbusiness travelers are most likely to have more luggage and longer duration in their trip in contrast to the resident business traveler. They are also more sensitive in costs compared to the business travelers (Harvey, 1987;TCRP, 2000). Moreover, because of their luggage and usually large travel parties, these travelers are more aware of access cost and usually needs help with luggage handling. Compared to the resident business traveler, these nonbusiness passengers have less information about access modes and travel mostly during off-peak hours. Their patterns in access varies slightly more than business air passengers since its more common they travel more seldom. TCRP (2000) also argues that its more likely these travelers are being dropped off or picked up at airports and that they can be candidates for using public transportations, especially if the access is more convenient and adjacent to their point of origin. Finally, there travelers are mainly cost sensitive.

Nonresident Business

Nonresident business travelers differs from the others, since they often are destined for a place of business or hotels. These travelers are therefore often located within city centers or near regional attractions (TCRP, 2000). Depending on the business assigned for the traveler they require more flexibility in comparison to other travelers in terms of transportation. Accordingly, it is further argued that nonresident business air passengers use the most efficient transportation without regard the cost. Most common choice of access mode is taxi or rental cars. However, they could be users of public transportation mode only when it delivers expedience and nearby access to their wanted location without delay and multiple stops.

Nonresident Nonbusiness

Nonresident nonbusiness travelers have least or little knowledge of available access modes at any airport. However, these travelers could make multiple trips within their stay from same or different airports (TCRP, 2000). Air passengers with nonresident nonbusiness purposes are often staying at hotels or a place of resident. This segment tend to choose access options by what is most easy and available for them, such as door-to-door vans, share-ride or taxis. It is possible for this segment to access with public transportation only if it is reliable, convenient and displayed as an alternative. Further, TCRP (2000) claims that this segment could be choosing public transportation regardless, since the airport is unfamiliar.

Airport Employee Market

Airport Employees – Flight Crew

This segment comprises of pilots and flight attendants who are traveling to the airport from a certain city or nearby. Depending on their duty, flight crew employees may be returning home after several days. Based on these characteristics, TCRP (2000) argues that their trip from the airport take place after a few days and may not commute more than maybe once a week to the airport. Because of their infrequent commuting to and from the airport, this segment is not a large market for public transportation. This segment constitute a major market group amongst airport employees and overall, the majority of the flight crew access by car and park them during their trips.

Airport Employees – Nonflight Crew

Airport employees of nonflight crew commute on a more regular basis compared to flight crew employees. This segment on employees have a great variety in terms of work schedule. Since there is jobs spread all out over the airport, car has an advantage over scheduled public transportation. Additionally, using cars is also less expensive, when nonflight employees often have free parking. However, the more inconvenient the parking places are, employees consider other access modes when reaching their required location. If this segment where to use commuting alternatives like public transportation, TCRP (2000) argues that nonflight crew employees are sensitive to cost, since they travel several times during the week. The group of nonflight crew employees who are strong candidates for public transportation is entry-lever and low wage workers. In addition to its potential, difficulties with working hours being outside the public transportation system. Further, since many workers are unable to access by car a public transportation alternative would be most suitable and should be highlighted for this segment of passenger (TCRP, 2000).

Airport Market Plus

In addition to the above listed categories of passengers, a common way of addressing and separating them are namely just, business and non-business/leisure travelers (Harvey, 1987). As mentioned in the airport passenger market segments above, a simple way of characterizing the business and non-business is cost and time. Business travelers are more sensitive to time and are insensitive to costs, since they seldom pay their own travel expense. Nonbusiness travelers are on the other hand more sensitive to cost (Pels *et.al*, 2001; Harvey, 1987). Further studies conducted by Hess & W. Polak (2005) explained behavior pattern amongst leisure and business travelers. Results showed that access time, in terms of sensitivity, was more randomly spread amongst business travelers. Leisure travelers showed on the other hand less pronounced results (Hess & W. Polak, 2005).

However, the market are constantly changing and more recent studies suggest a more thorough breakdown. Moreover, a rearrangement combined with non-aeronautical passengers can affect the public transport access system. In a case study at Zurich airport all users where divided into two groups, namely: Aeronautically induced (AI) and non-aeronautically induced (NAI) (Orth, Frei, & Weidmann, 2014). The study claimed that (AI) referred to visitors caused by airport activities and (NAI) to visitors generated by non-airport activities. According to the Zurich case study, the public transportation improved by

adding (NAI), resulting a higher passenger numbers and with a more equal distribution during a day.

3.3.2 Swedavia passenger segmentation

When Swedavia entered the aviation business, investigations has been conducted of targeting groups of their airports. A segmentation of passengers has resulted in prioritized target groups which can be useful in establishing improvements the airports (Swedavia, 2012). Moreover, when increasing passenger satisfaction the profit increase as well. The method used in finding the target groups consisted of a comprehensive survey all across the nation and will assume passengers living in Sweden. Moreover, same passengers are most likely to be find outside Sweden as well. The groups consists of 7 types of passengers. Active Cosmopolitans, Effective commuters, Positive Epicurean travelers, Image conscious novices, Confident positive travelers, worried social awareness travelers and Careful inexperienced travelers. The groups with most priority are described below.

The *Active cosmopolitan* are passengers with airport experience and travels frequently. They are positive traveling with airplanes and enjoy spending time at airport. The airport should be attractive, innovative and provide a wide range of shopping to satisfy active cosmopolitans. There is a tendency of high income amongst these passengers and prefer car access amongst other passenger groups.

Other experienced air travelers are the *Effective commuters*. These group consists mainly of business travelers and are the most frequent traveler amongst all passengers. Satisfactory factors are effective processes, quite workplaces and wireless internet. Moreover, access time is a crucial factor within this segment.

The *Positive Epicurean* travelers have less frequency in traveling compared to the above mentioned and spend more time at the airport. A wide range of shopping and food is important attribute amongst these travelers.

The final segment is the *Image conscious novices'* passengers. They are younger people with less income and have little experience with airports but enjoy flying. These passengers find personal service and signs of direction to be important attributes. Image conscious novices are mainly non-business travelers.

According to the investigation in targeting groups, Malmö Airport showed a majority of the Effective commuters (37 %), followed by Active cosmopolitan (18%) and Careful inexperienced (12%) of the market share in 2012. Figure 8 below displays the segmentation.

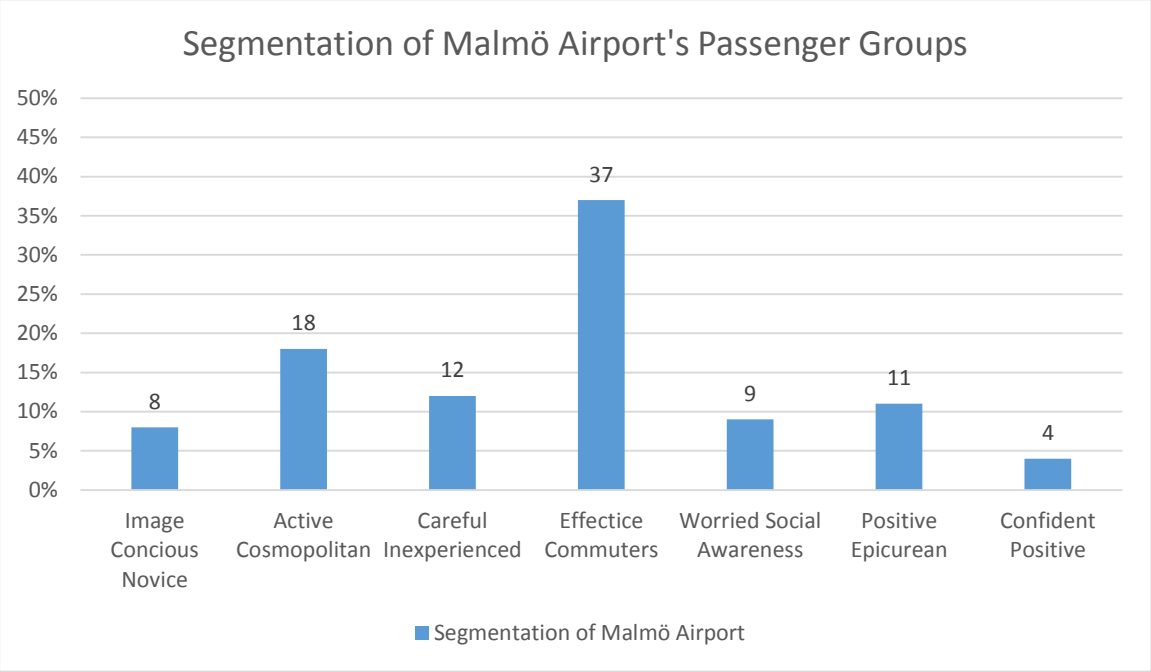

Figure 8 - Segmentation of Malmö Airport 2012 (Swedavia, 2012)

In depth, these passenger groups can be displayed in a business and non-business sense. From the report about target groups of Swedavia, a segmentation was performed (Swedavia, 2012). Figure 9 displays each target group in respect of business and non-business purpose.

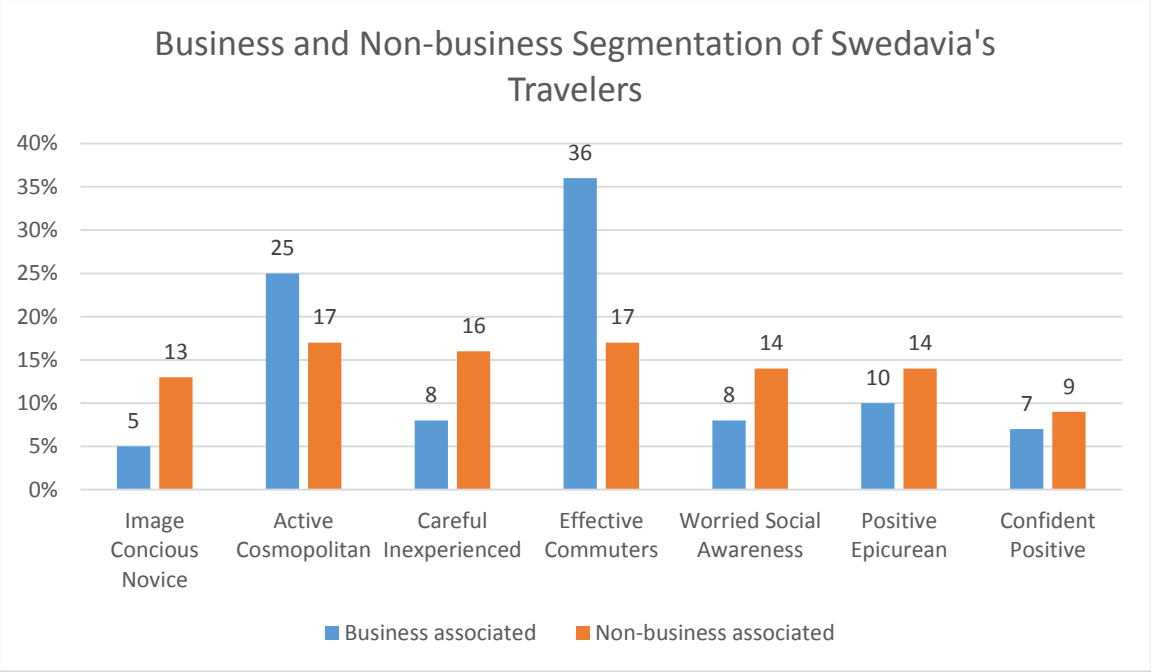

Figure 9 - Business and Non-business segmentation of Swedavia (Swedavia, 2012)

From figure 9, the groups with a majority of business related travels are Effective Commuters and Active Cosmopolitans.

Malmö Airport does not only consist of air travelers. Today, Malmö airport provide a total workforce of 1200 employees (Swedavia, 2015).

3.4 Access systems

The access system is complex and the demand for the airport facilities varies depending on the existing infrastructure. However, the frequent use of cars all over the world, and especially in America, does not decide whether the airport access should constitute by car-friendly access in majority. According to Ashford *et.al* (2001), approximately 25% of the American population does not own a car. Therefore, some public transportation are required for provide adequate airport access. In Comparison, 41% of the Swedish population does not own a car (Statistiska Centralbyrån, 2015). Moreover, the access system of any given airport is linked with several attributes, which we will discuss further. In figure 10 below, a simple chart from explains the access system for an individual or group (passenger, employee, visitor et cetera.).

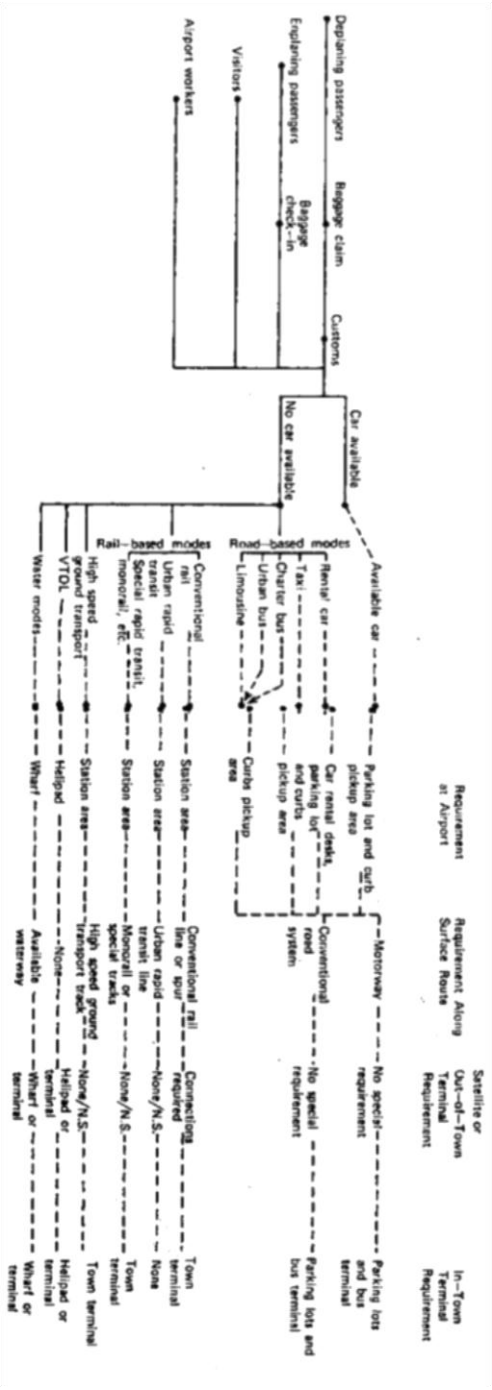

Figure 10 - Access system chart (Ashford et.al, 2001)

3.4.1 Access Modes

There are different access modes available or to be designed at an airport. A variety of modes is necessary in order to satisfy the need from users traveling to and from the airport. Ashford *et.al* (2001) states the importance of investigation of different modes in term of planning process. Therefore, each access mode has its advantages and disadvantages, which is why this is worth examining.

Car

The car is the most common mode of airport access in the United States and in the rest of the world. Advantages of this mode is many, from great flexibility, convenient factor of direct origin-destination movement and relatively reliable of getting in time (Ashford *et.al*, 2001). Other aspects as traveling with luggage, accompanying children, elderly or handicapped are factors proving benefits of using car. Further, since ones destination is not always within the city center a car is more flexible with respect to the origin-destination movement. When travelling during a short time parking is less expensive, especially of the car has more than one traveler (Ashford *et.al*, 2001).

Disadvantages of this mode is mainly surface congestion and the contribution of raised air pollution (Budd *et.al*, 2014). When individual airport traveler interact with daily traffic and in association with the infrastructure needed of parking places at the airport congestion is obvious (Ashford *et.al*, 2001;TCRP, 2000). Because of congestion uncertainties when accessing the airport the reliability of getting to wanted destination decreases. In term of parking opportunities, parking in the vicinity is often highly expensive, causing travelers to use cheaper and more remote parking places. According to Ashford *et.al* (2001), remote parking can have negative effect on the overall access time, since it seriously lowers the convenience level for the air passenger.

Taxi

Taxi is frequently used as an access mode to airports. There is a notable increase of frequency difference when an airport has high proportions of business travelers, combined with nearby locations to city centers. Benefits of this mode is described by Ashford *et.al* (2001) to offer high level of convenience because of different aspects. Taxis provides the traveler with origin-destination access, easy luggage handling and is less expensive, when traveling more than one person. Depending on the circumstances, the overall trip with this mode can be convenient. However, for the single traveler this mode is relatively expensive.

Moreover, Taxi share the same circumstances with surface congestion as the automobile. It is explained by Ashford *et.al* (2001), that same vulnerabilities occur in non-airport traffic, which makes the trip slower than expected. Another characteristic of congestion concerning taxi is located around the loading and unloading areas. The problem occurs because of the passenger's low rate and that the road space required is often too small, causing the congestion. Examples of dealing with this type of congestion can be to establish taxi pool areas. A taxi dispatcher summons the taxis when needed for passengers within the terminal. When having taxi pool areas, congestion around the terminal is located at a distant in preventing long lines of passenger waiting and causing congestion at the terminal landside.

Buses

Three types of buses will be addressed in this section. Firstly, the charter buses, which are often when transporting charter passengers. Secondly, urban buses, which stands for the regular commuter bus. Thirdly, special buses will be discussed, which are commonly used in the access market. Finally, bus is a public transportation mode.

Charter buses are commonly used for chartered flights and provide passengers with direct access to their final destinations from and to the airport. This is used in many European countries, Mediterranean and in ski areas. Because of their nonstop access, this mode offers a reasonably high service level (Ashford *et.al*, 2001). Combined with high loading factors, low access costs and its high number of passenger per vehicle, congestion is seldom caused by charter buses. Disadvantages of this mode is mainly to share access with airport and non-airport traffic. It is described that charted buses are more vulnerable to traffic congestion since delay can cause passenger to wait. Further, this mode deals only with a minor portion of the total access demand and is not available for the general public (Ashford *et.al*, 2001).

There are some cities, where the airport can be accessed by conventional *urban bus* service. Airport employee may constitute as a great user of this mode. Employees travel with less or no luggage compared to passengers and could be the most suitable ones. Ashford *et.al* (2001), emphasizes that one should remember that this only works if employees can be distributed to their workplace, since the majority does not work nearby the terminal. From the airport passenger perspective, urban buses is less convenient. Further, it is explained that passengers who are unfamiliar to the city can experience difficulties when routing for their destination. Luggage is yet another problem,

which can be hard to maneuver, especially when sharing with non-airport travelers during peak hours. Moreover, urban buses are facing major delays compared to the taxi, when buses make multiple stops and vulnerable for congestion. Depending on the city infrastructure, the overall access time varies but is in general fairly low due to its multiple stops and low service. As mentioned, urban buses could be useful for airport employees and thereby make savings in staff car facilities (Ashford *et.al*, 2001).

Special bus, or sometimes limousine service, is one of the most common access and usually connects airport with city central areas. There are two major advantages for this mode according to Ashford *et.al* (2001). Firstly, it is fairly cheap, especially for the single traveler and not necessarily cheap when traveling in large parties. Secondly, it offers great level of convenience for travelers destined within the central areas. As discussed previously about ground access, problems are obvious. Limousines and special buses can only serve a selection of locations with non-stop service, which cannot suit everybody. As for every other vehicles, it can be unreliable to use this mode in terms of delays from surface congestion, especially if there is no segregated right-of-way for this mode. Moreover, the congestion aspect is more perplexed if the user is required to access highly dense areas, such as railway stations, where heavy movement of traffic already is palpable (Ashford *et.al*, 2001).

Conventional Railway

There are only a limited number of airports providing conventional railway for airport access (e.g., Frankfurt, Amsterdam, London-Gatwick and Zurich). This type of railway access often connects with the existing railway network with a short spur line, constructed for the immediate airport access. In terms of only construct a short line of track, costs aren't necessary expensive, compared to a longer fully city-to-airport connection. Road congestion is reduced since conventional railway is separated from other modes, which marks a huge advantage in order to provide reliability and less delays (Ashford *et.al*, 2001). Further, a conventional railway is often connected with the city center and generally a higher speed compared to other public transportations. Despite rapid connections due to less stops, it is described that the overall access time is still inadequate. There are several aspects connected with the access time such as where one constitute of the city central stop. Passenger's origin at the city central faces difficulties when being mix with non-air travelers, especially during peak hours. Further, handling luggage during these circumstances is also an issue linked to overall access. Finally, conventional railway systems in general serve the airport as its best when easy access is provided by an extensive urban distribution system, such as: Urban buses, taxi or urban rapid transit.

Specialized Rail Systems and High-Speed Ground Transport

This mode can be summarized and discussed simultaneously, as both specialized rail systems and high-speed ground transport share the rapid origin-destination function. More characteristics other than the above mentioned speed are separation with its own system, with the ability of avoiding city congestion. During the 1980s, planner started investigate this exclusive access mode, especially in highly dense cities. During their investigations from this era, a manifest of difficulties where described and summarized (Ashford *et.al*, 2001):

- Specialized high-speed systems are highly expensive, both in construction and in fares when operational
- System often designed between the central of a city, by that only satisfying a minority of plausible users
- Airport-city center systems are likely to attract more people in an already dense area
- Transfers between other transportation modes within a dense city area meets complications in terms of luggage maneuvering
- Passengers arriving from airports to city central require smooth and adequate transportation options to reach final destinations

Moreover, one of the hardest challenges in providing an already dense urban area with a segregated right-of-way transportation mode is the construction. It may require tunneling, great amount of space and are time consuming. Further, the need of such systems are only feasible in high dense cities, where segregation cost increase with respect of greater urban densities. Finally, this mode is rare and therefore only existing in major cities as New York, London and Tokyo. Studies has shown that benefits of these type of systems function at its best when the distance is relatively long. As explained by Ashford *et.al* (2001), shorter distances are not as time saving and attract the travelers with other modes. Yet again, big cities should consider this transportation mode when distance between CBD[4]-airport is large and with high dense population.

Conventional Urban Rapid Transit

A conventional urban rapid transit system provides direct access to the airport terminal from urban areas. This access mode has several advantages. Firstly, these modes often provide air passengers with overall access to urban areas. Secondly, this transportation mode is separated from the surface road system, which brings reliability and less delays for passengers. These airport-link systems are usually connected with the existing systems, which brings more

[4] Central Business District (TCRP, 2000)

flexibility to the region and airport access. Heathrow is a good example where this systems was successful. According to Ashford *et.al* (2001), the system was fairly inexpensive and carried around 25% of the market share of access. Even though the percentage is quite low, but make a great convenience for the frequent workers and visitors, who often use the Heathrow underground system. As with all transportation modes, there are always negative aspects. Significant flaws with conventional urban rapid transit are low speed, frequent stops and luggage handling in combination with other traveler. Since the system serve central areas and often connected with a big network, this mode is constantly in need of multiple stops. Moreover, an air passengers overall access time gets longer. Further, the combination of passengers not aiming for the airport add difficulties with luggage handling, especially in more central areas. Therefore, the major three flaws can be summarized to following:

- Distance to air terminal and rail terminal are often too far to walk with luggage
- The remote rail terminal is often served by shuttle bus, creating inconvenience for the air traveler
- Interchange with luggage is a drawback for the air traveler, who might carry luggage through flight and stairs

3.4.2 Airport and access choice

Access choice is crucial part of the context in whole, since the actual choice of a passengers affects airport selection, airline, time of travel, cost categories and certainly, what transportation mode to choose (Harvey, 1987). This subsection of access choice is complex since it include far more parameters than expected and this modal choice subject has been discussed thoroughly in both reports and articles. There is moreover a close connection between passenger types and transportation mode, which has been discussed previously. In early discussions, Harvey (1987) argued that business and leisure travelers where the significant factors in modal choice, since a major difference in preferences where found. This listed factor is often mentioned to be one out of many key factors, which describes that non-business travelers usually are more sensitive to costs compared to the time concerning business traveler (Pels *et.al*, 2001). In addition to the comparison between the business and leisure traveler, Hess & W. Polak (2005) argues that business travelers are more sensitive to time. It is further stated that access choice regarding costs, frequency and time et cetera, differs from each passenger type. In recent years, more comprehensive tools and models have been established over the years in determining a passenger's choice of access to an airport.

The distribution of airport varies in different countries in respect of region, infrastructure and other external factors. The access modal choice is often discussed in multi-airport regions, since a passenger with the ambition of traveling by air, first have to choose airport. There is evidence of a higher value in access time amongst business travelers, but it is also an important factor amongst leisure/non-business travelers. In a case study by Pels *et al* (2003) it is argued that access time in general have significant impact of the airport choice, especially in a multi-airport region. In addition to access time, other important airport level-of-service attributes where discussed in a report about multi-airport regions in Hong Kong (Becky, 2008). Firstly, the number of airlines played an important role in the passenger's selection. As previously stated, the business traveler's importance of access time was yet again stated. Secondly, the variation in haul trips was linked to passenger's airport choice. A long-haul trip tends to attract passengers with an airport providing a great variety of different airlines. A medium-haul air traveler finds the shopping selection at an airport as a selection attribute. The short-haul traveler found ground access to the airport as their key attribute in airport selection ibid. Finally, in regards of airports in a multi-airport region, there is an ongoing competition of survival. There has been studies conducted about airports and how their decision are affecting both passengers and airlines (Ishii *et.al*, 2009). This is important in terms of airline reliance, when airline loss in a multi-airport region is common. However, in creating independence from airline reliance, business risk is reduced.

The access regardning transportation mode is next level of choice, after the selection of airport. Qualites and experinces of passengers or visitors have great impact on the transportation access market. Holmberg (2010) discusses three major concepts of a travelers values: Accessibility, Comfort level and safety. In addition to those concepts, the passengers attidude towards a certain transportaion mode can vary from each individual. According to Holmberg (2010) an attidude against a certain transportation mode can change by attracting a person, for example from car to public transportation. Further, studies about attracting passenger markets from car to public transportation has been an essential part of gaining knowledge in transportation mode choice (Budd *et.al*, 2014). As previosly discussed, a close connection between the passenger market and transportation mode can be used to identify the airport ground access. A study of Manchester Airport conducted by Budd *et.al* (2014) suggested six factors affecting the ground access choice amongst passenger. They were:

- Mode choice
- purpose

- luggage
- travel group size
- access time
- distance of journey

When analyzing these six factors, eight types of passengers where identifyed. Six of them had access to car and the two remaining had no-car access. A summery of the eight passenger types is shown in table 4 below, with respect of market share. Yellow marks passengers with potential of changing to public transportation. Green marks passenger with more potential of changing into public transportation.

Table 4 - Summary of passenger segments (Budd et.al, 2014)

Segments	Car access	Share (%)
1. Complacent motorist	Yes	16.9
2. Dogmatic drop-offs	Yes	15.6
3. Ardent taxi users	Yes	13.8
4. Devoted drivers	Yes	16.9
5. Conflicted greens	Yes	9.2
6. Environmental champions	Yes	5.9
7. Pessimistic lift seekers	No	11.3
8. Public transport advocates	No	10.4

Each of the eight passenger segment where discussed by their attitude profile. The conclusion showed passengers who could be reduced in car usage. Firstly, those who would be most resistant to change were *Devoted drivers* and *Ardent taxi users*. Devoted drivers are positive towards car use, are not positive in public transportation and are generally negative to taxis. The Ardent taxi users are positive towards taxi consider car access to airport as a barrier and have relatively negative attitudes against public transportation (Budd *et.al*, 2014).

Secondly, there were passengers with the potential of encourage public transportation, namely *Public transport advocates* and *Environmental champions*. Public transport advocates does not have car access, find usage of public transportation easy and have positive attitude towards public transportation. Moreover, they also stays indifferent of any public transport mode. Environmental champions are slightly more positive towards public

transportation compared to the public transport advocates and are negative towards drop-off car mode at airports.

Additionally, for a behavior changing perspective, the groups *Conflicted greens* and the *Pessimistic lift seekers* are arguably those with most potential. Conflicted greens are positive to both public transportation and car, hence the name "conflicted". Pessimistic lift seekers struggles with the attitude towards public transportation, finds taxi and drop off more convenient and do not own a car. As previously stated by Holmberg (2010), constraints of individuals attitude in a mode choice can be altered by reducing their barriers. A social psychological approach in ground access research gives important knowledge of future airport access design (Budd *et.al*, 2014).

Due to change in factors affecting airports access choice, transportation market also have an impact of change. The airport industry have in recent years been struggling with low-cost carriers, which have consequences on airport access (de Neufville, Planning Airport Access in an Era of Low-Cost Airlines, 2006). It is argued that major infrastructure project, such as rapid rail way connection, are not the most effective access in terms of low-cost airlines. The explanation lies in the reasoning that low-cost airlines tends to be more spread across a multi-airport region. When low cost carriers reduce overall costs, passengers will also be more disperse amongst airports within the same area. de Neufville (2006) argues that support for special rail projects to airports decreases, since it cannot satisfy all airports in the area. A more flexible approach would be the use of rubber-tired modes (buses), since they can serve a whole region at lower costs. In contrary, new implementations of transportation modes has shown to reduce surface congestion with airport access. In an investigation of a new high quality public transportation implemented at Taiwan Airport, the market share of public transportation increased (Jou *et.al*, 2011). In order to assess the results, key factors such as out-of-vehicle travel time and in-vehicle travel time were essential for outbound traveler's access choice. Additionally, time saving and the level of service were described to be more important in comparison with price.

Finally, a key role in access choice and the appropriate transportation mode is, apart from attributes discussed above, integration with other modes. Moreover, as much integration amongst transportation modes and within the transport network of the region is important. This creates a wider range of options for the passenger and rail systems plays a key role in success (TCRP, 2000;de Neufville, 2006).

3.5 Rail Way Systems

Improvements of public transportation at airport is often implemented with a rail access. There are many airports providing rail access today and many has shown to provide improved overall airport access. A report by TCRP (2000) examined 14 different airport in respect of rail way access and found that rail way systems combined with bus service held a key role in making airport access succesfull in public transportation (de Neufville, 2006; TCRP, 2000). In the research from TCRP (2000), the 14 systems were ranked in combined market share of rail and bus service and can be are displayed in figure 11 below. Other transportation modes such as share ride service (such as door to door rides) played a minor role, and are therefore excluded in their analysis.

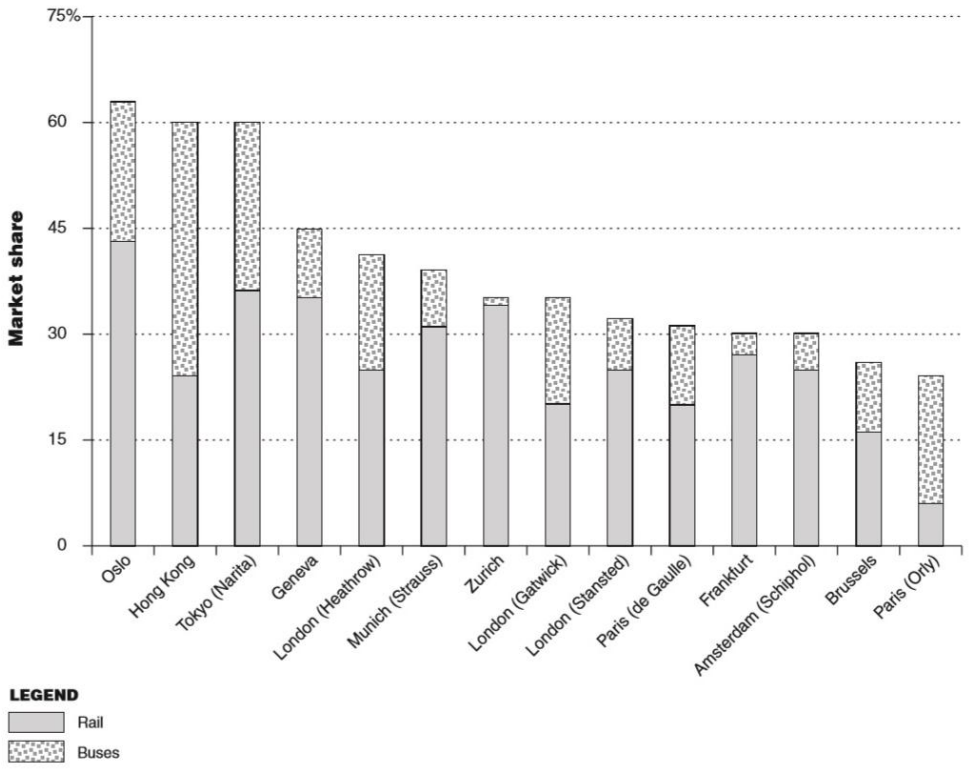

Figure 11 - market shares of rail and bus at international airports (TCRP, 2000)

When examining successful airport access systems it is essential to investigate the key elements. Firstly, the experience of the user must be taken in consideration, since passenger's plays the main role in the majority at airports. The following discussion is focused on the trip between ones origin and to the airport. Moreover, TCRP (2000) states that there is insufficient evidence when only looking on the line-haul transport itself. Moreover, the users modal choice is influenced by the extent on the access itself, meaning a system approach is

necessary when examining various access systems. An example of this matter can be explained with a deplaning passenger. First, the passenger experience the airport connection after arrival and the quality; secondly, the line-haul service from the airport to the city; and thirdly, the next modal change (if destination is outside the city area). The luggage handling is another parameter affecting the airport system which also should be added in the passenger's experience. Therefore, TCRP (2000) has listed four key elements when examining airport systems to measure each airport and their level of successfulness. The cumulate experience of the traveler is based on these summarized factors:

1. **Line-haul service**. This segment discusses the transportation between an airport and the city centers. Both cost and time are usually compared when evaluating line-haul service
2. **Integration with the regional transportation system**. This second segment discusses the relationship between other transportation modes. It can usually be investigated when comparing other metropolitan systems, such as a terminal-inner city connection system connects with the rest of the systems available
3. **Quality of the airport-rail connection**. The discussion concerning the quality of rail-airport connection can be both architectural and design related. Locations at airport is usually luggage claim, check-in areas and terminal. The physical transfer of passenger is discussed and so is the location of the airport
4. **Luggage-handling strategy**. This final segment discusses and reviews an airports strategy to handle luggage of the air traveler

From the report, the highest percentage of public transportation users were according figure 8 above Oslo Airport. The airports were examined in regards of the four factors above to point out how they were successful.

3.5.1 Example Oslo Airport

Oslo Airport at Gardemoen opened in 1998 and held approximately 24.3 million passenger the year of 2014, which made them the second largest airport in Scandinavia (Oslo Lufthavn, 2014). The airport is located 48 km from downtown Oslo and are served with a variation of transportation modes. A high-speed train connects the airport and the city of Oslo and have an advantage of the transportation market share due to its smooth and rapid transfer. Figure 12 below displays the market share of Oslo Airport.

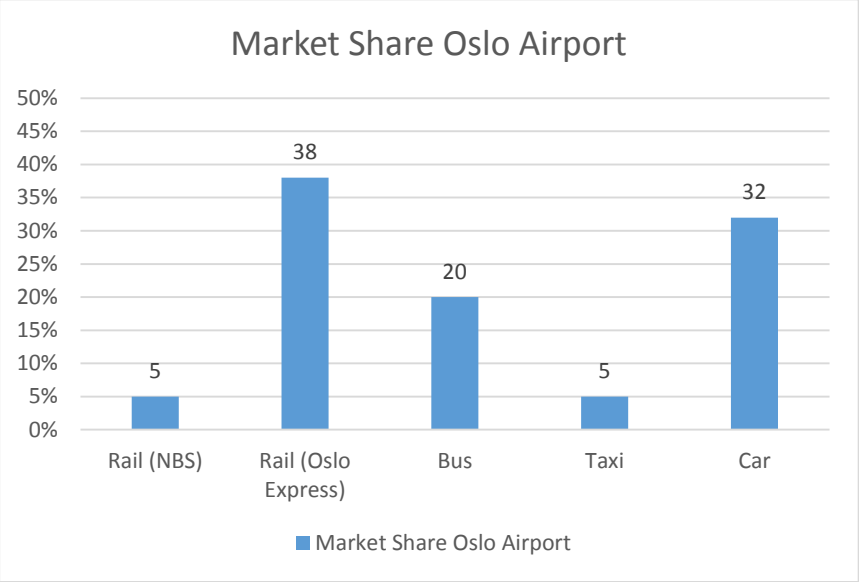

Figure 12 - Market Share Oslo Airport 1999 (TCRP, 2000)

In their Line-haul service, the airport is connected with two types of rail modes. The first one is a national railway service (NSB). The second train is rapid rail connection called the Oslo Express especially designed for air travelers. Time between city and airport takes 20 min with Oslo Express and 30 min with the NSB (TCRP, 2000).

In the context of integration with regional transportation system, Oslo Airport Express and the NBS train are well integrated with other transport systems. They both connects to the Oslo central, with further connections with the rest of the region and also connects with both areas southwest and north of Oslo.

In quality aspects, Oslo Airport provides both centralized transports combined with integration amongst other transportation modes, in other words, good intermodal access. The meaning of centralized airport means that the gates are being served by a single landside terminal. Moreover, the station is located right underneath the terminal facility. Escalators service are provided from the train station and small walking distances to both luggage claim and check in gives good quality.

In luggage-handling, the design of Oslo Express was design to provide good luggage handling and are designed with a unique seating concept combined with luggage-storage areas.

Finally, the market characteristics at Oslo Airport indicated an estimated 48% of the air travelers destined to Oslo city and around 11% to other parts, using the high speed train. Moreover, the managers of Oslo Airport Express focuses on business travelers and gives another estimation of 58% business related travelers out of all participants of Oslo Airport Express.

3.5.2 Intermodal planning with rail

Intermodal integration is beneficial in urban expansion since it can improve existing infrastructure. According to Vesperman & Wald (2010), ground access is not always addressed when passenger numbers at airports grow. It is crucial to look over the ground access when facing increasing numbers of passengers. Moreover, four motivators of intermodal integration where described as: customer needs, expansion of catchment area, increased air capacity and increased landside area. Vesperman & Wald (2010) also argues that rail integration is one of the most promising keys in the context of successful intermodal airport access system.

Ground vehicles are often referred to be unreliable in terms of airport access because of surface congestion. Since time is an essential attribute, other transportation mode have appeared at airports. Namely, rail bound transports. Moreover, the implementation of high speed rail ways connecting the airport have been an interesting topic. This is both an environmentally friendly alternative in airport access, since it transfer shorter air trips from planes to trains and creates a more integrated infrastructure (Givoni & Banister, 2007).

Further, a study about finding the appropriate public transportation system to Sari International Airport, indicated that a rail system would be suitable (Shafabakhsh *et.al*, 2014). Nine criteria's were analyzed and was given weights in order to assess the appropriate transportation mode. The investigation claimed that train would be the most appropriate mode. From the investigation, table 5 and 6 below displays their research.

Table 5 - The weights of effective parameters (Shafabakhsh et.al, 2014)

Number	Criteria	Weight
1	Safety	0,18928
2	Reliability	0,12735
3	Access time	0,11851
4	Access cost	0,11459
5	Easy access to system	0,10862
6	Comfort	0,10689
7	Time headway	0,07951
8	Interest to system	0,07830
9	Construction costs	0,07690

Table 6 - Prioritizing the alternatives (Shafabakhsh et.al, 2014)

Priority	Alternative
1	Train
2	Bus
3	Van shuttle

3.6 Terminal Design

3.6.1 Functions of Airport Terminal

This segment discusses the main functions of passenger terminals at airports. According to Ashford *et.al* (2001), the terminals represents the majority of large costs in airport infrastructure. This has to do with passengers have consequently been accustomed to expensive and grand designs of terminals, which basically has nothing to do with their intended functions. Three main functions of airport terminals are described by Ashford *et.al* (2001):

1. *Change of mode*. Air trips are commonly a mixture of different modes, with surface access to and from the airport. Since the passenger is changing modes, they are physically forced to move through the airport terminal, often is prescribed patterns.

2. *Processing*. The terminal provides various processes, such as: ticketing, check-in, separating/reuniting passengers with luggage, security checks. All of these named functions requires space.

3. *Change of movement type*. Since there is always a small group entering and leaving the airport, the terminal functions as a reservoir that collects and process passengers in batches. Further, the arrival side also has a reverse pattern. The terminal must also provide passenger holding space.

3.6.1 Landside and Airside Interface

The terminal acts as a transfer point between airside and landside. This master thesis focuses more on the landside access, but it is important to understand other functions of the terminal. Other functions is passenger processing, holding areas, internal circulation and at the same time establish good service for the passengers (Ashford *et.al*, 2001).

Outside the facilities of the terminal, the landside access takes place at the curbside loading and unloading areas. Various types of access modes can be used here, such as cars, taxis, buses et cetera.

3.6.2 Terminal layout and distribution concepts

Depending on the size of the airport, the passenger and luggage flows could be in need of more than one vertical level. Small airports usually only need one level to satisfy their flows. However, with increasing and complex flows, airports often requires areas with more than one level. Such expansions are highly difficult to achieve on an already existing airport, since it changes the existing structure, especially if an expansion never has been planned (Ashford *et.al*, 2001).

Typical separation concepts of flows are: One level, one and one half levels, two levels and three levels. According to Ashford *et.al* (2001), the two level approach is the most common and effective solution to separate flows. Typical flow arrangements with two levels are to have deplaning passengers in the upper level, then descending down for governmental control. Luggage flows are located in the lower levels. Advantages with the two level separations are mostly the advantage of maximal site utilization and good flow characteristics. Moreover, the separation with enplaning and deplaning passengers are easily established with a two level structure. In figure 13 below, the separation arrangement of flows are displayed.

→ (solid line): Passenger Paths

- → - (dotted line): Luggage Paths

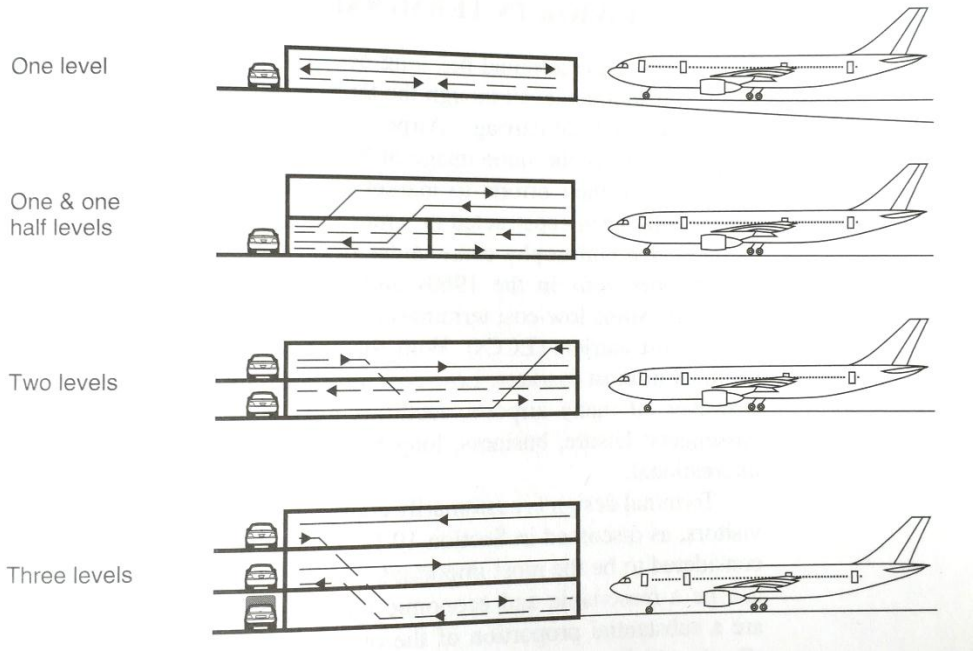

Figure 13 - Separation arrangement of passenger and luggage flows

4 Empirical Study

In this chapter the empirical data will be presented. A combination of interviews and multiple case studies will be discussed and to some extent, be linked with presented theory from chapter three. The methods presented in chapter two are taken in consideration when constructing the cases and they form a foundation for the final examination of the Malmö Airport issue. A selection of people were interviewed in this study in order to enhance this master thesis validity.

The outlay of the empirical study will first discuss findings from Malmö Airport. Secondly, the multiple case studies Göteborg Landvetter Airport and Ängelholm Helsingborg Airport will be presented. Finally, empirical input will further be investigation in the analysis chapter four.

4.1 Malmö Airport research

4.1.1 Malmö Airport Today

Malmö Airport served 2.1 million passengers in 2014 and forecast indicates increased numbers in the future. Understanding the market share of Malmö Airport today is crucial when investigating a future intermodal airport access. In figure 14 below, an overview of Malmö Airport is displayed.

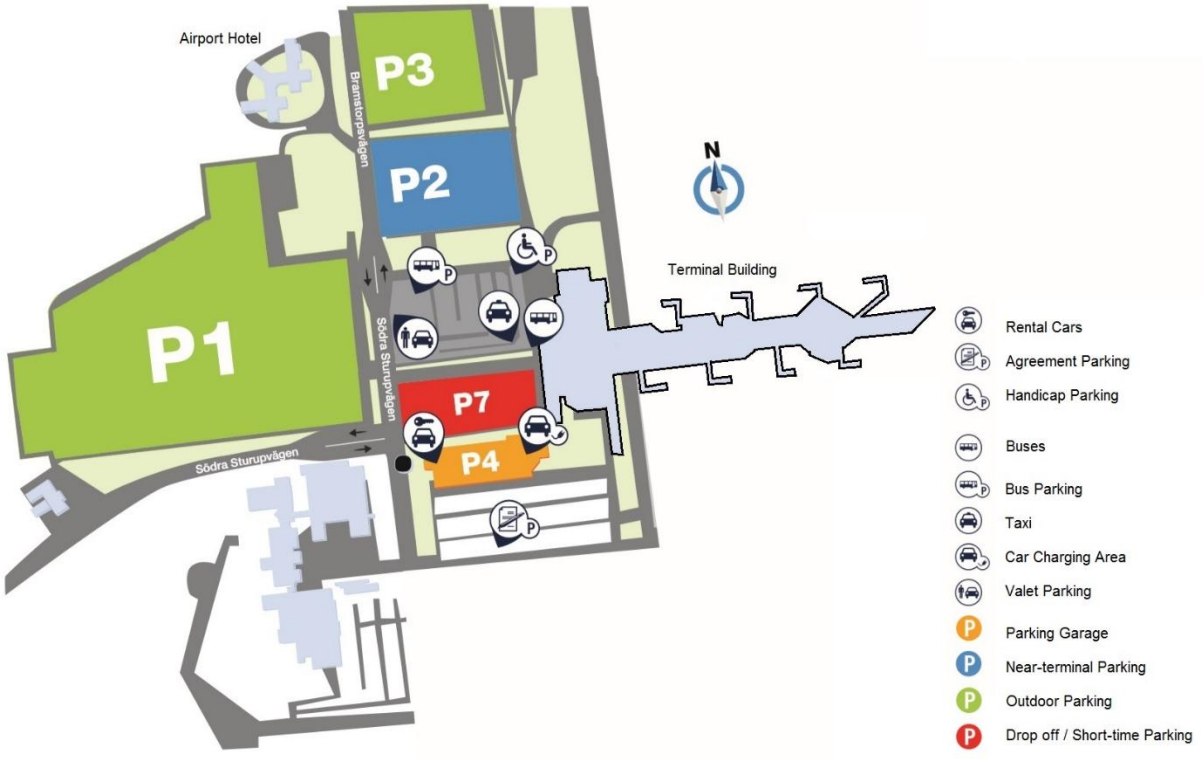

Figure 14 - Chart over Malmö Airport (Swedavia, 2015)

In February 2015, a workshop was held by WSP at Malmö Airport in order to decide a plan of action for the future. Participants were mainly local authorities, airport staff and various stakeholders. From the workshop and data provided from Swedavia, the airport access can be investigated to enhance further analysis in chapter 5 of this master thesis.

The market share of Malmö Airport's annual travel survey 2014 is displayed in figure 15 below. Numbers of passengers accessing by car are in majority and car is the most frequent transportation mode. When combining the three car segments; Car parked, Car returning and Taxi, which correspond to 86 % using car as a transportation mode. The workshop from February 2015 had similar numbers between 85-90% in car travelers. Moreover, there is a tendency amongst business travelers to favor the access with taxi and car (WSP, 2015).

The access time and comfort levels of car transportation is fairly high, since the majority of travelers within Skåne can access the airport within 30 minutes. Moreover, patterns of passengers accessing the airport at Malmö Airport can be summarized from the workshop 2015 (WSP, 2015). The list is displayed below.

- 90% of passengers at Malmö Airport are resident travelers (originate from Skåne)
- Approximately 45% originate from Malmö and 15 % from Lund
- The remaining 40% of the passengers are spread amongst 20-25 smaller parts in the region
- The majority of non-resident travelers prefer the special airport bus

In simple words, the 90 % originating from Skåne can be linked to the car users and the remaining 10 % can be linked to public transportation. Further, visitors of the region are the most frequent users of public transportation (WSP, 2015).

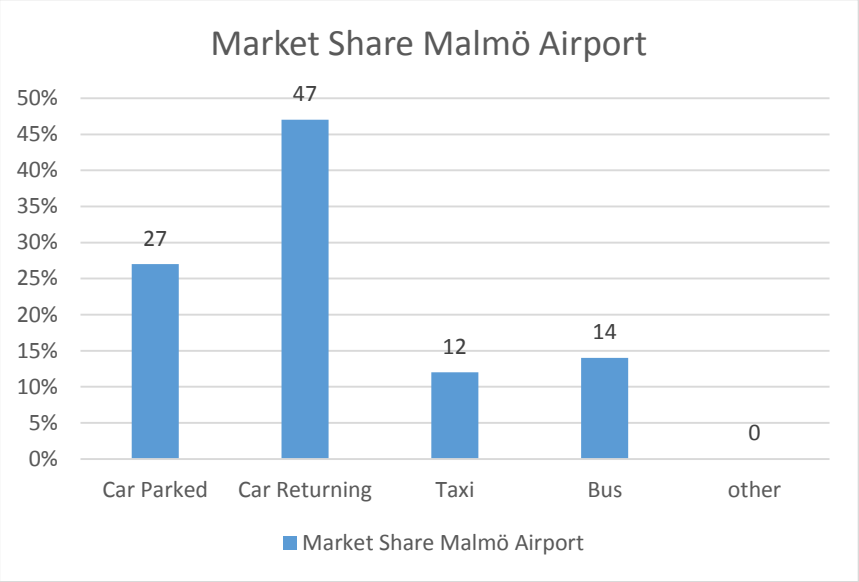

Figure 15 - Market Share Malmö Airport 2014 (WSP, 2015)

The only public transportation provided are buses (Airport Coaches) originating from the major cities of Malmö and Lund. Only 14% of the total market share is served by public transportation and tends to attract non-resident travelers. Amongst the 1 200 employees at Malmö Airport, only 10% access with public transportation. The cause is presented to be insufficient comfort levels of travel time, frequency, options in public transportation modes and integration with the access system within the region (WSP, 2015). Moreover, since Malmö Airport is an around the clock workplace, employees working on an irregular time schedule and cannot rely on public transportation, which only serves the airport in everyday working hours. Additionally, the bus schedule is adapted in line with departure and incoming flights, which goes beyond regular working hours. Other difficulties in providing sustainable access in public transportation is due to: easy car access, passenger spread and clear peak hours of passengers in mornings (07.00-10.00) and evenings (17.00-22.00). Between those hours the activity at the airport is significantly lower.

A benchmark comparison between airports were conducted by WSP (2015) to illustrate available airport access of public transportation. A modified version can be viewed in table 7 below.

Table 7- Benchmarking between airports (WSP, 2015)

Parameters	Malmö C – Malmö Airport	Lund C – Malmö Airport	Gothenburg C – Landvetter Airport	Malmö C – Copenhagen Airport
Distance (km)	31	28	27	-
Travel time car (min)	25-30	25-30	20-25	-
Travel time bus (min)	40-50	40	30	20
Fares (SEK)	99	99	99	107
Departures per week	123	106	338	530
Frequency between departures (min)	40	50	15	10

The workshop at Malmö Airport resulted in two approaches for plan of actions, short- term and long-term. The main issue is to establish a sustainable and environmentally friendly airport access (WSP, 2015).

In a short-term perspective (2017-2020), a more integrated public transportation would be desirable and attract more passengers from cars to public transportation.

In a long-term perspective (2030), there could be needs for larger infrastructure solutions, such as a rail connection. Depending on passenger numbers, external factors and travel habits, this approach needs more thorough research. Moreover, if passenger numbers increase at a fast rate in the Öresund-region, there is support to establish a rail access to Malmö Airport. If so, it will be possible to link Malmö Airport with Copenhagen Airport and support the region with a more environmentally friendly transportation mode.

Since multiple airports have been addressed in this segment a comparison in passenger numbers amongst Malmö Airport, Göteborg Landvetter Airport and Copenhagen Airport will be addressed below:

- Malmö Airport 2.1 million in 2014
- Göteborg Landvetter Airport 5.2 million in 2014

- Copenhagen Airport 25.6 million in 2014 (Copenhagen Airport A/S, 2014).

About access time to Malmö Airport in the future, an analysis with time schedules can give an indication of future access time with train.

At this point, you can within 21 minutes reach Copenhagen Airport from Malmö C and 35 minutes if you originate from Lund central station. Since Malmö Airport is situated in the vicinity of the small cities of Skurup and Svedala, an approximation in travel time can be gathered from Skånetrafiken (2015). According to today's train schedule, Malmö C – Malmö Airport will take 25 min and Lund C – Malmö Airport will take 38 min (Skånetrafiken , 2015).

4.1.2 National Interest Malmö Airport

This master thesis investigates how a potential future rail connection at Malmö Airport could operate. Since the airport is of national interest, it is protected by the Swedish government according to environmental code in Miljöbalken 3 kap §8 (Miljö- och energidepartementet, 2015), to support future development and prevent the airport from actions which could cause significant damage. Moreover, the national interest is a critical factor in the rail connection process, since the national interest support future development (Swedavia, 2015). Characteristics of national interest is summarized below:

- Are of great importance for nature conservation, cultural heritage conservation or outdoor recreation
- Contains valuable substances, such as mineral deposits
- Represent important conditions for business, energy supply and communications
- Are of importance for the total defense

Comprehension of National Interest at Malmö Airport

The national interest at Malmö Airport comprises two parallel runways, each 3300 meters in length. Several aspects support this development and runway capacity expansion (Trafikverket, 2013). Firstly, Malmö Airport is situated in the third largest city region in Sweden and being adjacent to Copenhagen can according to Trafikverket (2013), enhance future growth unlike other regions. Secondly, since urbanization is continuing in Sweden and in the rest of the world, the aviation industry is most likely to grow in the future. Finally, Malmö Airport has unique access to surrounding land around the airport, in contrary to the urban dense Copenhagen Airport. The expansion of runway capacity is thereby more achievable at Malmö Airport, which marks why there is great importance of future growth of Malmö Airport.

Moreover, Malmö Airport is a secondary airport[5] (meaning Malmö Airport is smaller) when being compared with the much greater Copenhagen Airport. Despite various magnitudes, an airport has its own conditions and mechanisms which affects their own development potential. Historically, secondary airports have shown to be faster in growth during a shorter period of time compared to larger airports. This phenomenon often occurs due to low budget airline investments at secondary airports (Trafikverket, 2013). Examples of Swedish secondary airports with fast growth are Stockholm Skavsta Airport and Göteborg City Airport.

According to Trafikverket (2013), the forecast of future demands indicates growth at Malmö Airport. This has to do with a combination in society development in the Öresund-region, which justifies the decision of national interest at Malmö Airport. However, making an accurate future forecast of capacity is difficult and results in uncertainties. When creating a future scenario, assumptions must be made, which never give an exact answer. Even though, according to Trafikverket (2013), the national interest of Malmö Airport is justified.

A national interest is never static, meaning that is has to be reconsidered if conditions of the future air traffic and the need of access change. Figure 16 below shows the current area of national interest at Malmö Airport.

[5] Secondary Airports are, in contrast to major airports, outside major city centers and are secondary to the major airports (de Neufville,2004).

Figure 166 - National Interest boundaries at Malmö Airport (Trafikverket, 2013)

Value description

When doing specification of national interest of air traffic, value description marks the significant aspects of and airport's value to society. Below, in figure 17, from Trafikverket (2013) displays the three factors connected with value description.

Figure 177 - Value Description Based of Airport National Interest (TRV 2013)

External factors:

The aviation industry has been growing constantly since 1960-1970, especially when jet engines premiered within civil air traffic. This also marks the starting point of global tourism, which is contributing to the air traffic growth.

Moreover, population development, changes in economics, technical conditions, politics, liberalization and increasing amount of low cost airlines are also some external factors affecting the aviation industry (Trafikverket, 2013).

The Öresund-region has shown stable growth during the last 10-15 years (Trafikverket, 2013). As of now, the region holds approximately 3 785 000 people and they expect to cross 4 million around the year 2021 (Trafikverket, 2013). Skåne alone holds around 1 million people and is rapidly growing according to population forecasts. One major factor to the region's success of growth is the access between the two major cities Copenhagen and Malmö. Both tourism and business are essential components for the Öresund since there is frequent commuting between the two cities, which are growing every year.

Airport development:

Within the Öresund-region there are several airports competing with each other. The largest is arguably Copenhagen Airport, with 22.7 million passengers in year 2011 and with over 150 direct flights to destinations all over the world (Trafikverket, 2013).

Malmö Airport is the fifth largest airport in Sweden with 2.1 million passengers in 2012 (Trafikverket, 2013). Out of all flights, the domestic flights holds around 1,2 million passengers and remaining consists of charter and low cost flights. The catchment area is primary around the cities Malmö and Lund, but also around the west coast of Skåne. Further, Malmö Airport is accompanied by airports in Kristianstad, Ängelholm and Roskilde (Denmark), which means competition in development. For Malmö Airport, Copenhagen airport is the greatest competitor, since they have increasing number of passengers and they are investing in a new terminal for increasing their international flights. The catchment area of the Öresund-region is shown in figure 18 below.

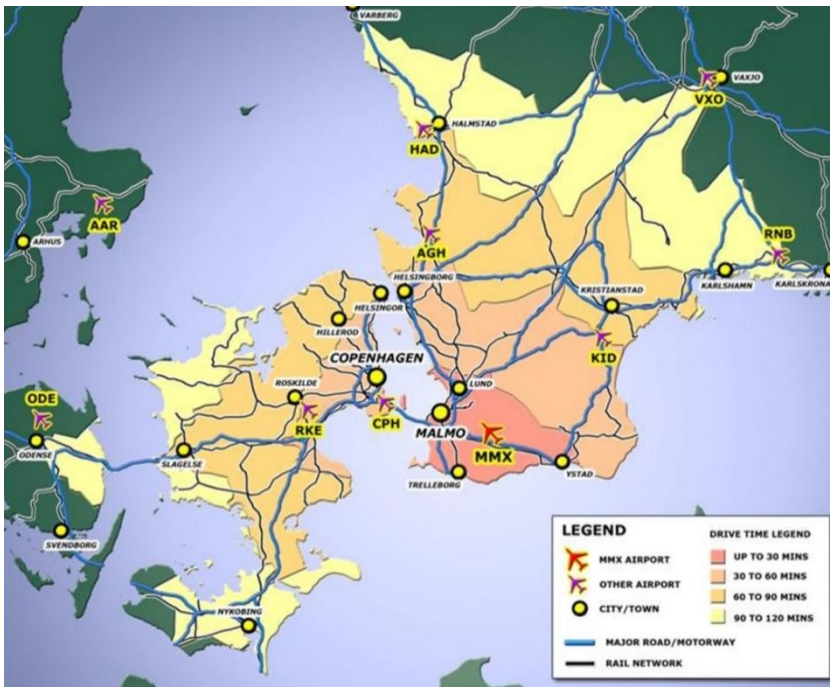

Figure 188 - Airports around the Öresund-region (Trafikverket, 2013)

Malmö Airport have been dominating the domestic market of Sweden, with flights mainly to Stockholm. However, the international market has varied over the years and are according to Trafikverket (2013) instable. The trend of international flights has over the last years increased due to spreading of low cost flights over other airports (WSP, 2015).

As for future forecasting about the amount of passengers and movements, a prognostic analysis forecast approximately 7 million with 81 000 movements (numbers of landings and take offs) in the year of 2030 (Trafikverket ,2013).

Intermodal aspects and Accessibility

In the regional transport infrastructure plan of 2010-2021 (Region Skåne, 2010), it is mentioned that Skåne has good supply of flight links. In terms of the airport around Skåne, Copenhagen Airport is more accessible compared to Malmö Airport. This is mainly because of the geographic location of Copenhagen airports and with an enhanced railway system from Sweden (the City Tunnel). This provides quicker access to Copenhagen airport than before. The report from Trafikverket (2013) also states that with the new railway system to Copenhagen, people in Skåne has probably the best connection with the rest of the world compared to everyone else in Sweden.

Car or bus

Travelling by car to Malmö Airport is the most commonly used transportation mode. Car provides most flexibility and greater access than buses. Special buses

called “Airport Coaches” have two routes to and from the airport. The first route departures to and from Malmö and the other one to and from Lund. The company providing this special bus service is “Flygbussarna AB” and they are not included in the urban bus system. Moreover, they do not have the same bus rates as the regional buses around the region. The two routes are according to Trafikverket (2013) primarily focused on domestic travelers to the larger cities of Malmö and Lund.

Railway system

There is no natural connection between Malmö Airport and the already existing railway system today. However, the railway Ystadsbanan (Connects Malmö with Ystad) is fairly close to Malmö Airport. Attempts to connect the already existing railway with the airport has been ongoing over the last years and resulted in a feasibility and environmental impact study combined with a railway report (Sturupspendeln). This is discussed more in the background segment of this thesis.

This railway-airport project is however not included in the plans of The Swedish Transport Administration, nor in the region. Nevertheless, the project is mentioned in the railway strategy plans for long term planning.

The project can only proceed when the financials issues are solved. Only then can the project be sent to the government to be tested and given permission for construction. As of today, Trafikverket (2013) explains that there is yet no one wanting to take the main responsibility for the project, since there are no financial supporters.

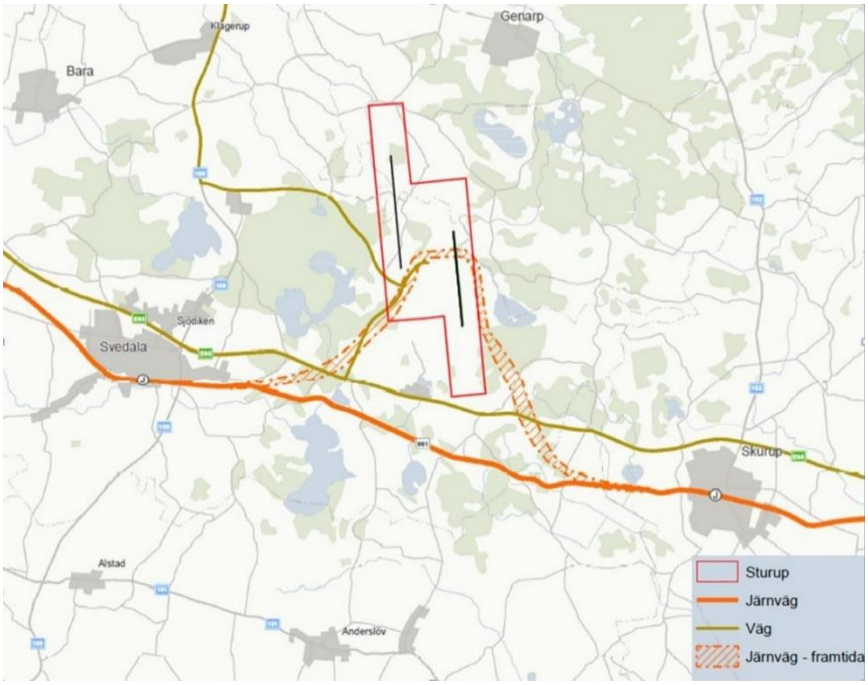

Figure 19 - Area of national interest with train connection (Trafikverket, 2013)

Land Claims at Malmö Airport

National interests at an airport comprises an area where necessary aviation facilities can be held in a long term perspective. Within the term "aviation facilities", the land area around the airport and aviation related equipment are included. Further, the national interest area and size also depends on land needs for future expansions of the airport functions.

Geographically, the general distribution of land claims of an airport is as follows:

- 500 meter spread from each side of the center of the runway
- Add 1500 meter from each runway edge
- In longitudinal, the runway should be protected to provide good visibility
- Reserve land that can be used by the public near the airport in order to protect them from risks of starting/landing aircrafts (Trafikverket, 2013)

Commercial activities can occur within the national interest but they are not a part of the aviation, therefore commercial activities can face the risk of closure, if the airport are in need of additional land.

As mentioned in this segment, the national interest of Malmö Airport protects two parallel runways with the length of 3300 meters each. Trafikverket (2013) explains that the existing runway today measures 2800 meters and should expand an additional 500 meters before maximum capacity is reached. This is to provide the airport with future demands and a wider range of aircrafts.

Finally, according to Trafikverket (2013), the main reason of land claims of a parallel runway is created to ensure the future capacity in the Öresund-region.

Additionally, to determine the future demands of the existing runway at Malmö Airport, consultants at Swedavia has made a forecast of its maximum capacity. The maximum one-runway-system can, theoretically (based on analysis conducted by Swedavia), be around 42-46 movements per hour. Additionally, Ivre[6] (2015) describes these movements to be general maximum one-runway capacity for every airport. However, depending on certain circumstances, there are exceptions. As an example, London Gatwick airport can have 50 movements in runway capacity. Moreover, these figures depends on the distribution between landings and takeoffs, in order to prevent aircraft queues. Combining the numbers of movement with the already existing airport size, it is equivalent to approximately 5.5 - 6 million passengers per year at Malmö Airport (Trafikverket, 2013).

4.1.3 Railway Access Suggestions

The Swedish Transport Administration (Trafikverket) is significant to add as empirical data for this mater thesis. Mainly because of their rail infrastructure development plans all across Sweden. Moreover, they decide from orders of the government what to construct in order to achieve sustainable community development (Trafikverket, 2015). Further, The Swedish Transport Administration is a state agency with the responsibility of long term planning and maintenance of the transport system. This include road traffic, rail traffic, shipping and air traffic. This following segment is based on an interview of Bjurek[7] (2015) from the transport department who were involved with the major rail way infrastructure project "the City Tunnel". The interview was conducted in Malmö at one of the offices of The Swedish Transport Administration.

Between the years of 2005 and 2010, a major rail infrastructure project called "the City Tunnel" in Malmö was constructed. The project consisted of three new underground rail stations. One semi-underground station and two with a tunnel connection with a smooth link to the major city of Copenhagen. The three stations constructed in the the "City Tunnel"- project had different designs. The first station is located in the central parts below the former Central Station of Malmö. Secondly, the underground station called "Triangeln" won an architect price in 2011 (Swedish Association of Architects, 2015). The last station was

[6] Ivre, H. (2015, April 8). Interview Swedavia. (A. Lunderup, Interviewer)

[7] Bjurek, H. (2015, March 10). Train station at Malmö Airport. (A. Lunderup, Interviewer)

"Hyllie Station", which has a more of an outdoor design in terms of openness to its surroundings. Hyllie Station was later shown to bring less satisfaction amongst passenger since it is more exposed to wind compared to the other two stations. Additionally, when analyzing station values in terms of passenger satisfaction, certain factors are significant (Bjurek, 2015)[8]. The first desired elements when planning a station is daylight, since it brings perceptions of comfort amongst travelers. Moreover, an investigation of climate impact is highly significant in any case, since too much open space can cause inconvenience of snow on the tracks. A first suggestion of a possible future station at Malmö Airport is that it should be properly sealed from external exposure and weatherproofed.

As for the case of Malmö Airport, a tunnel has been suggested to link the already existing railway. In doing so, a new station is supposedly to be constructed adjacent to the terminal buildings.

From the interview, following suggestions were described:

- Dimensions for the platforms regarding train stations it is most likely to be around 320-340 meters in length and approximately 20 meters in width. These measurers suggest a train station with two parallel platforms with two tracks.

- If the station is underground, the element of light is essential for positive passenger experience. Safety is also important when designing rail projects.

- Location of station should be connected with central areas of the airport's commercial markets and within fair walking distance. Moreover the functions from the station should be concentrated as much as possible. A southern location can have economic benefits, since this would imply less rail, in contrast to a north location.

- All trains will most likely stop at this hypothetical train station which promotes smooth curved rails of the track (if the trains will pervade the airport through a tunnel).

[8] Bjurek, H. (2015, March 10). Train station at Malmö Airport. (A. Lunderup, Interviewer)

These above mentioned suggestion are similar to the only known documents about a train tunnel at Malmö Airport. According to Malmö *et.al* (2005), in the rapport about the environmental impact analysis combined with a railway investigation, some facts about location and details are briefly described. These are the following suggestions from the report:

- The railway tunnel underneath the runway has to be at least 2 meters deeper in contrast to the rest of the railway tunnel, since the runway is located lower in comparison with the terminal building
- Two separate tunnels are to be constructed (for safety reason) with a length of 700 meters, between 6+900 and 8+480 in figure 16.
- A platform between the railway tracks gives easier orientation for the user and will have a length of 650 meters, between 7+600 and 7+830 in figure 16
- The tunnel will be constructed with concrete and will be buried underground.
- The depth of the tunnel will be 62.7 meters in the profile image in appendix D

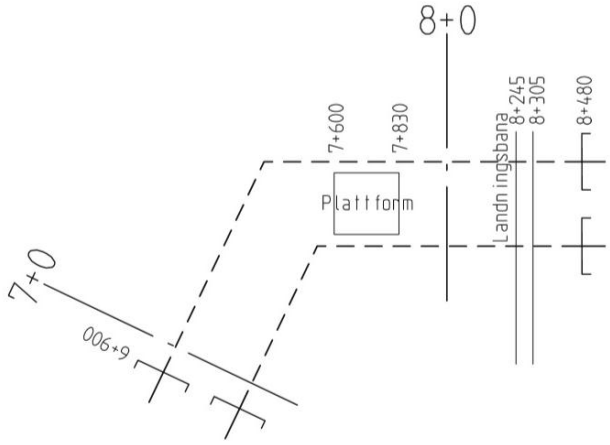

Figure 190 - Illustration of pervading railway tunnel

Further, when construction a railway connection at an airport there are certain rules and regulations in order to prevent disturbance of the ILS[9] at aircrafts (Trafikverket, 2010). According to Swedish regulations regarding constructions of new railways near an airport, the transport department of Sweden has a rule that permission is needed if the railway is within 4 000 meters from the center of the runway. Further, the report in question aims to achieve intermodal cooperation between trains and airports, while maintaining good safety. The

[9] the instrument landing system

conclusion of the report by Trafikverket (2010) argues that if a railway is placed in a tunnel, no disturbances of the ILS will occur. Moreover, evidence from case studies in the report shows that a railway can be constructed down to 300-400 meters without jeopardizing safeties regarding the ILS.

4.1.4 Development of Malmö Airport

The latest report regarding development of Malmö Airport was published by the Air Navigation Service of Sweden[10] (LFV) in 2001, which serves as a regulatory document. The document is in first hand a description of the land use of the airport and serves as a base in eventual development projects (LFV, 2001).

The Swedish government has imposed that constructions at Malmö Airport should follow architectural values. Therefore, LFV has established a plan of action regarding architectural aspects. The plan of actions consists of following goals:

- The architecture shall represent the region, culture, ecological conditions and promote an airport being a place of communication
- The airport shall have good orientation
- The airport shall have functionality and be able to adapt

In addition to the plan of action regarding architectural values, the identity of Malmö Airport is also of great importance in the context of development. A common theme is the strong and constant yellow color of the buildings within the airport's area.

"*The yellow color compensates for blackness in runways and parking spaces*" (LFV, 2001)

An identity plan for Malmö Airport has therefore been established, to regulate constructions and development.

Identity of Malmö Airport

- Materials outside the terminal shall be associated with the region
- The airport user shall, when entering and leaving the airport, experience the place as a part of Skåne
- The yellow color is the overall visual identity of the airport

Landscape and Layout

- The landscape shall, in the extent possible, implemented in the design

[10] LFV - Luftfartsverket

- The entrance room should not be too large, since it could create disorientation amongst passengers
- Outward buildings can be used as weather protection at bus stops and taxi areas

Buildings

- Maintain yellow colors, but express new buildings with self-depending shapes
- New material and colors shall be implemented if it holds as complementary attributes
- If necessary, buildings can be connected with glass aisles
- Entrances shall announce the identity of the buildings

Finally, the report suggest a proposition of development regarding the national interest of two parallel runways in the future. Moreover, Ivre[11] (2015) explains that the first step of development after maximum capacity is an extension of the terminal north, including a new pier. This can be displayed in appendix B.

[11] Ivre, H. (2015, April 8). Interview Swedavia. (A. Lunderup, Interviewer)

4.2 Case Study I – Göteborg Landvetter Airport

This case study of Göteborg Landvetter Airport are conducted by the methods provided from chapter 2 (Methodology). Since this is a part of a multiple case study with the aim of providing good quality, the strategy and design is based on the five components described by Yin (2013) in section 2.3.2. Moreover, the quality and validity are discussed in section 2.3.4.

4.2.1 About the airport

Göteborg Landvetter Airport is Sweden's second largest airport, inaugurated in 1977, and had over 5.2 million passengers in the year of 2014. The airport has around 3500 employees over more than a hundred companies (Swedavia, 2015). Due to Göteborg Landvetter Airport's strategically location in the west of Sweden, great connections to the harbor in Gothenburg and other major cities make the airport important in import and export. Moreover, Göteborg Landvetter Airport has been pointed out by the European Union to be a very important hub in both connecting the world and international shipping.

Since the planning process of the anticipated future high-speed rail connection, linking Gothenburg with Stockholm, Göteborg Landvetter Airport surfaced as a strong candidate for a new station (Hvidt *et.al* , 2013). As of now, the first phase of the rail connection is undergoing projecting, which includes designing an airport train station.

4.2.2 Research question and propositions

Since this minor case study are meant to contribute to Malmö Airport travel access with insight from Göteborg Landvetter Airport planned one, different underlying propositions are used, since this is an ongoing project.

- How will the location of the station affect the intermodal transportation access at Göteborg Landvetter Airport?
- What were the determinants in preparing an airport with a train connection?
- How will a future high-speed rail access impact the access market?

4.2.3 Collected data

Intermodal access at Göteborg Landvetter Airport

As of now, you can access Göteborg Landvetter Airport by car, taxi and bus. According to figure 21 below, the airport's market segments of the year 2014 still showing high percentage of car users. Moreover, as stated in the section "access problems", the car could be a key suspect in why access time to airports has increased during the last decades. Over the last decades, the car has

increased in numbers in Sweden and also in the rest of the world, which explains the congestions issue of road networks (Várhelyi, 2010).

Göteborg Landvetter Airport lies in between two of Sweden's larger cities, Gothenburg and Borås. Today, you can only access the airport from Gothenburg, if you desire the public transportation mode, which explains the car use before public transportation.

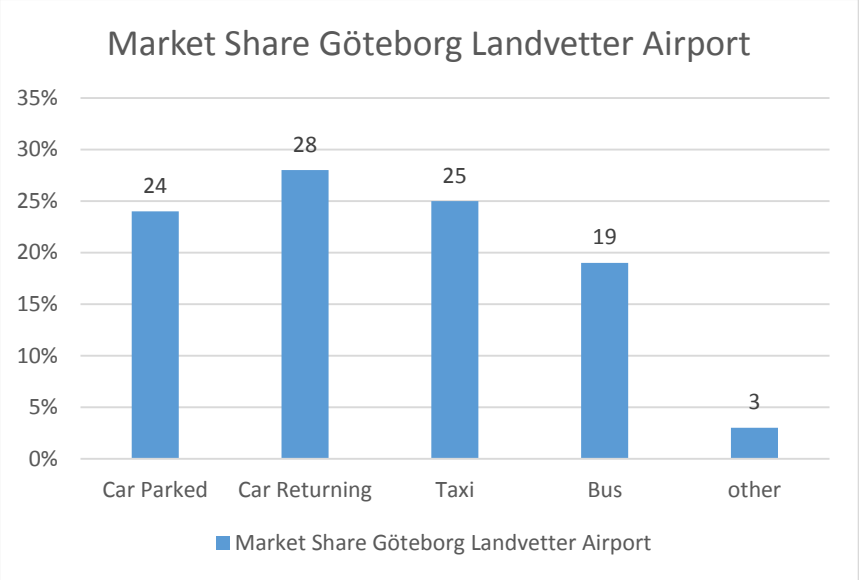

Figure 21 - Transport to the airport Market share 2013

According to the investigation in targeting groups, Göteborg Landvetter Airport showed a majority of the Active Cosmopolitan 25 %, followed by Effective Commuters 23% and Careful Inexperienced 12% of the market share in 2012. Figure 22 below displays the segmentation of Göteborg Landvetter Airport. In regards of business and leisure passengers, the distribution is approximately 50% in each passenger type (Wiberg, 2015)[12].

[12] Wiberg, H. (2015, Mars 31). Case study Landvetter Airport. (A. Lunderup, Interviewer)

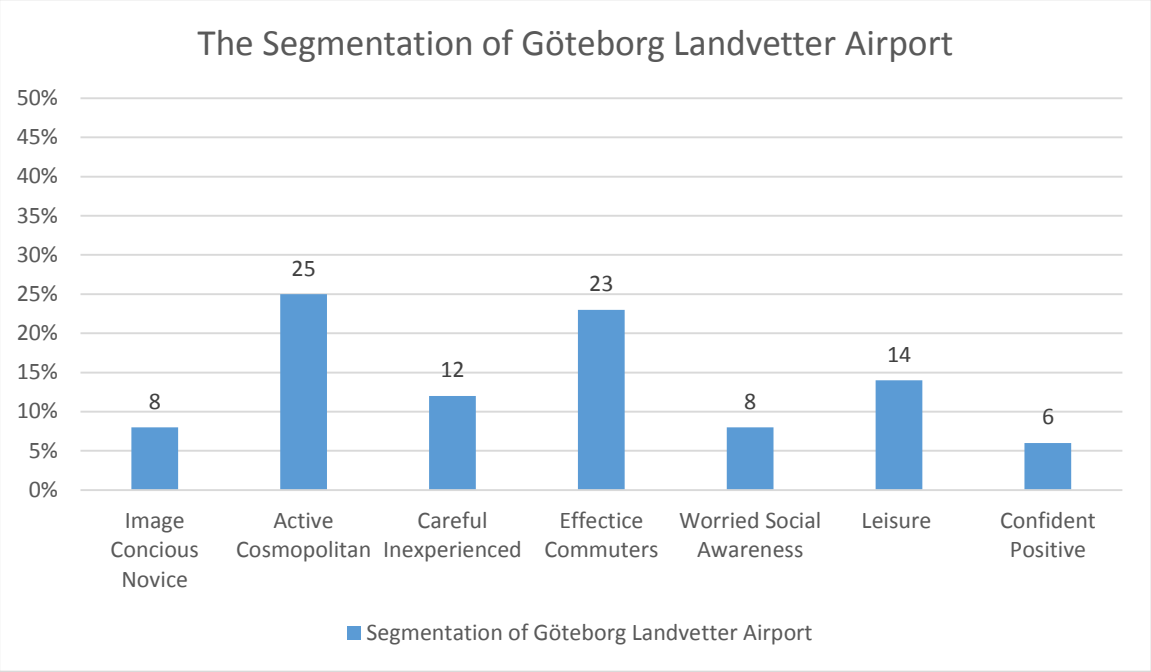

Figure 202 – The Segmentation of Göteborg Landvetter Airport 2012 (Swedavia, 2012)

In the development plans of intermodal access at Göteborg Landvetter Airport, divide the impact of passenger growth into three parts; Landside, terminal and airside.

The landside interface will become more streamlined as Wiberg[13] (2015) explains that it will make flows more efficient and visual for the passengers. Secondly, the terminal will be expand in luggage handling and security checks. When combining train entrance a different flow will appear between the landside-terminal interfaces, which promotes terminal expansion in the vicinity of the entrance/landside interface. Finally, a comprehensive terminal expansion on the airside will in the future bring more and flexible piers.

International access Gothenburg

A high speed rail way will might connect Gothenburg with Stockholm with an underground station at the airport. In a report about international access Hvidt *et.al* (2013) describes several aspects of why the region around Gothenburg is important good airport access. Gothenburg is a strategic hub in shipping and the report states that an airport region often build up a center of development. The access concerning the report are namely *direct access*: flight routes to and from Gothenburg and *indirect access*: possibilities of reaching Gothenburg through other hubs. Moreover, the comprehensive projects of high speed trains both

[13] Wiberg, H. (2015, Mars 31). Case study Landvetter Airport. (A. Lunderup, Interviewer)

vertically and horizontally crossing Gothenburg adds the importance of great airport access, supporting a train station at Göteborg Landvetter Airport. In an interview with Wiberg[14] (2015) explains that we live in a multicultural and global society and that the benefits with high speed are namely a wider range of catchment area. In addition to the future rail network Wiberg[14] (2015) stays positive in terms of maintaining a growing aviation market. On the other hand, there is a risk of a decreasing aviation market in domestic flights when travel times between major cities in Sweden will become shorter. Below, in table 8, approximate traveling times with high speed train through the COINCO[15] railway track are displayed.

Table 8 - Approximate travel times produced by Ramböll 2012 (Hvidt et.al, 2013)

Travel time between Gothenburg and suggested stations with high speed trains through COINCO-track	
Station	**Travel time (hours)**
Oslo C	01:10
Lund C	01:10
Malmö C	01:15
Copenhagen Airport	01:35
Copenhagen City	01:47

[14] Wiberg, H. (2015, Mars 31). Case study Landvetter Airport. (A. Lunderup, Interviewer)

[15] COINCO is an acronym for *Corridor for Innovation and Cooperation*, which is a group with the ambition of creating a high speed rail infrastructure between Berlin and Oslo (COINCO, 2015).

Figure 213 - Future train corridors with high speed train (Hvidt Thelle & Stefansdotter, 2013)

The railway phase concerning Göteborg Landvetter Airport is the link between the communities of Mölndal-Bollebygd. The main focus of the project lies in connecting two important transportation modes, such as aviation and railway, with the expectations of transferring ground transportations to trains (Banverket, 2003). Moreover, an important element in this project will be the interpretation of the new train station at the airport.

Idea and vision

The idea is to connect a station at Göteborg Landvetter Airport. In an interview with Wiberg[16] (2015), it is stated that the long term strategies for better access are namely: Better travel- and transportation options, intermodal travel center and connect with the rest of our world combined with an Airport City. A big part of Göteborg Landvetter Airport's strategic goals are mainly the new rail connection with a station underneath the terminal facility.

The passage through the airport will be in a tunnel underneath the airport area and more specifically, just below the airport terminal. Satisfactory factors regarding the project is to create a comfortable, easily transferring between transportation modes with the perception of attractiveness (Banverket, 2003). In addition to the main vision, there is other factors implemented in the idea and vision concept of the train station. The idea is explained to bring a unique identity and to create a direct visual contact with "the world above" from the underground station level. In addition to the visual aspects of connection the station, the entrance to the station has specific design in order to achieve further connections with the underground and terminal. In the vicinity of the entrance

[16] Wiberg, H. (2015, Mars 31). Case study Landvetter Airport. (A. Lunderup, Interviewer)

there are elevators and escalators combined with a glimpse of the station below. This gives the sense of control and safety for passengers. As for the underground station, the room is to be generously in terms of volume to bring a sense of overviewing the surroundings.

Linking airport – train station

A key element is to locate the appropriate link between the airport and the train. There was a study in the railway investigation conducted by Banverket (2003), where three concepts of connections were discussed. Firstly, there is the concept of two entrances, one in the terminal and the second placed outside and away from the facility. Secondly, there was a concept of one single entrance just outside the terminal facility. In the final suggestion, one single entrance was to be placed inside the terminal. The conclusion of the report from Banverket (2003), stated that the optimal solution of the airport-train station link was to create an indoor entrance in the terminal. Further, this is based on satisfactory parameters of the passenger perspective, where it is said to bring most comfort for travelers. In addition to this early report, an interview from a representative of Göteborg Landvetter Airport, Wiberg[17] (2015) states that there will be two entrances to the underground station. One in the corner of the terminal and one in the vicinity of the hotel, outside the facilities. The second entrance is strategically placed due to the future airport city, which is in early stages of development. The track should be located in the north part of the rail-corridor to enhance connection with future facilities of the airport city.

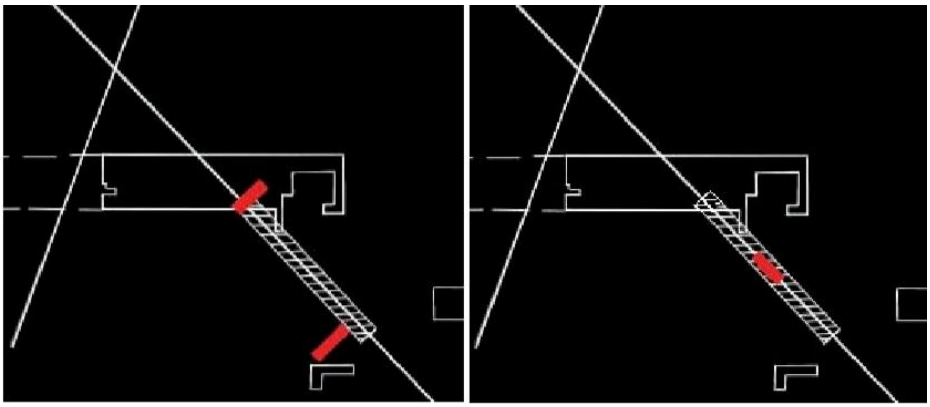

Figure 224 and 25 - Concept art of station entrance. To the left two entrances are displayed and to the right, one entrance is displayed (Banverket, 2003).

[17] Wiberg, H. (2015, Mars 31). Case study Landvetter Airport. (A. Lunderup, Interviewer)

Landvetter station design concept

The interpretation of the Landvetter Airport station is, as previously stated, intended to offer an attractive environments with a strong identity and simultaneously contribute a sense of control and safety amongst travelers (Banverket, 2003). The terminal entrance has a primary focus of the relationship between the terminal room and the underground station room. Central key issues concerns aspects of natural and artificial lighting design in the underground station. According to both Banverket (2003) and Wiberg[18] (2015), the station will be placed 30 meters below the surface. In addition to the depth question, Ivre[19] (2015) mentions that Göteborg Landvetter Airport is situated on a small hill, which demands a certain depth in order to maintain a horizontal and straight line to and from the tunnel. This is displayed in figure 26 below.

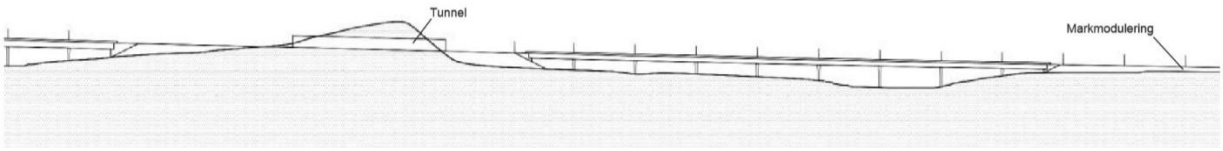

Figure 236 - Section in length with bridge and tunnel. Scale 1:2000 (Banverket, 2003)

The placement of the entrance inside the terminal is discussed by Banverket (2003) and should be located around the check-in disks and the arrival hall. Wiberg[18] (2015) explains the location in detail and according to ongoing planning, the actual location is to be located in the south west corner of the terminal. This also adjacent to where the future airport-hotel will be located.

All tunnel switching's are to be design as elliptical concrete shells who support the surrounding mountain. The tunnel itself is also in the elliptic shape with a double-track railway (Banverket, 2003).

[18] Wiberg, H. (2015, Mars 31). Case study Landvetter Airport. (A. Lunderup, Interviewer)

[19] Ivre, H. (2015, April 8). Interview Swedavia. (A. Lunderup, Interviewer)

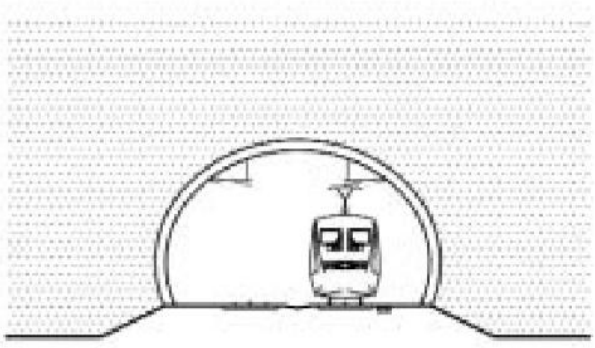

Figure 247 - Front, tunnel switching scale 1:400 (Banverket, 2003)

The design for the station itself are described to be created as an arched glass construction, with both special lightning. Moreover, the glass construction will perform as passenger safety, in terms of fractionation between the train and the passengers on the platform. The glass shield is also supposedly to be protective in sound proofing aspects as well. In the report by Banverket (2003) there has been two concepts of interpretation. Firstly, there is the concept of one major arched glass construction centralized over the platform. Secondly, there is two minor glass constructions enclosing the trains on both sides. Both concepts are presented below in figures 28 and 29.

The cross section of the station and underground platform are shown in figure 30. As mentioned previously, two entrances are described and will be constructed (Wiberg, 2015)[20]. In the early stages of planning, the second entrance were only described to be prepared and not fully constructed (Banverket, 2003).

[20] Wiberg, H. (2015, Mars 31). Case study Landvetter Airport. (A. Lunderup, Interviewer)

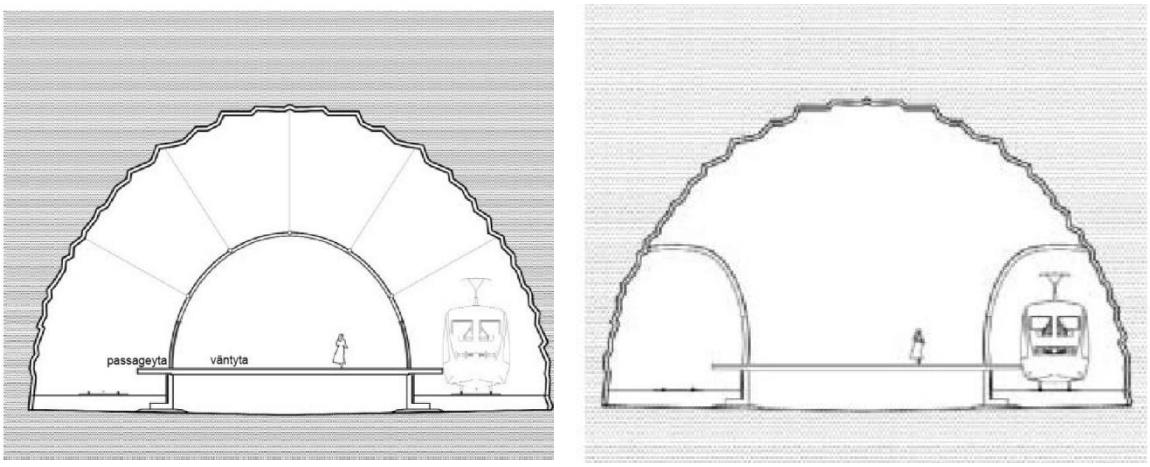

Figure 258 and 29 – Station concept 1 and 2 Göteborg Landvetter Airport (Banverket, 2003)

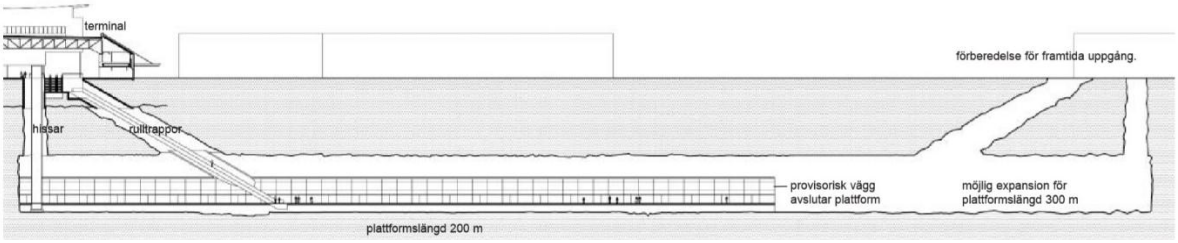

Figure 260 - Longitudinal section of station Göteborg Landvetter Airport scale 1:800 (Banverket, 2003)

4.2.4 Analysis of Case I

In this section presented findings of the Göteborg Landvetter Airport case study is analyzed in respect with the theoretical framework from chapter 3 Theory, in order to assess key elements of airport access that can be applied at Malmö Airport.

At this point, Göteborg Landvetter Airport is a good example of a well-functioning airport with great conditions for their future airport rail access. The geographic location is the initial attribute of their advantage of future access, since the comprehensive railway project between Gothenburg and Stockholm will link the airport to major cities, increase their catchment area and provide passengers with a more sustainable rail way access. Göteborg Landvetter Airport could experience the multi-airport region competition, since a number of airports are located within the area. However, this risk are reduced by having good airport access according to Pels *et.al* (2003). Additionally, since there is support of improved airport access at Göteborg Landvetter Airport described by Hvidt *et.al* (2013), it is more likely that they will be a primary choice of airport.

Passenger and transportation is next segment to be analyzed. From the collected data about segmentation of passenger there is a majority of non-business

passengers (Swedavia, 2012). According to Wiberg[21] (2015), the distribution amongst leisure travelers and business travelers can be approximate to equal amounts. Since the investigation of passenger groups were conducted on resident travelers, a comparison from the theoretical chapter and the data on segmentation from Swedavia (2012) can be done. As described by several authors, the resident business traveler is mainly concerned by access time and the resident non-business is more concerned with costs (TCRP, 2000; Harvey, 1987). Additionally, the plans of an airport city at Göteborg Landvetter Airport will according to Orth *et.al* (2014), add passenger types of non-aeronautically induced (NAI) nature. This will have effects on access, since NAI passengers will not necessarily access the airport on regular peak hours. Transportation modes of today at Göteborg Landvetter Airport is car, taxi and airport bus service. It is argued in the theory chapter that the majority of business travelers favor car or taxi due to time and comfort reasons (Budd *et.al*, 2014). The fact that no bus service is available between the airport and eastern city of Borås, the only option is to access by car or taxi.

The access choice will look differently when a rail connection will be operational at Göteborg Landvetter Airport. Since the society gets more multicultural, which a wide range of passenger types will be attracted and the support and need for an attractive airport access is essential. According to TCRP (2000), a rail connecting the airports has been shown to be a key factor in assessing a successful airport access system. Especially in the case of Göteborg Landvetter Airport, where an airport city are to be constructed (Orth *et.al*, 2014).

The placement of the entrance in the terminal is a good and strategically well location for future demands. As mentioned in the theory chapter 3, the terminal functions are namely; change of mode, processing and change of movement type. The interface between landside and terminal should operate adequate because the entrance placement lies in the corner of the terminal. As previously stated, Wiberg (2015) describes that the placement of entrance does not have to be centralized. Thus, TCRP (2000) argues the benefits of a centralized location at Oslo Airport. Moreover, since the entrance/ground level at Göteborg Landvetter Airport already is more centralized, compared to the upper terminal level, walking distance is short and will continue so in the future after the expansion (Wiberg, 2015)[21]. Further, compared to Oslo's centralized entrance location, both will be similar in smooth access. One must have in mind that Oslo

[21] Wiberg, H. (2015, Mars 31). Case study Landvetter Airport. (A. Lunderup, Interviewer)

is roughly 5 times larger than Landvetter (numbers of passengers), which emphasizes a more centralized location at Oslo Airport.

Another unique aspect of Göteborg Landvetter Airport, is their one and one half level terminal structure. As stated in chapter 3, Ashford *et.al* (2001) argues that with increased flows, airports often requires more than one level. An airport operating under such conditions are likely to operate well with increasing passengers, which Göteborg Landvetter Airport forecasts with expansions and an airport city.

Challenges lies in the intermodal aspects of integrating transportation modes at the airport. This is yet another key element in successful airport access, since the addition of a new mode can be both beneficial, according to Jou *et.al* (2011), but also demands better integration with transportation modes and the regional transportation network (de Neufville, Planning Airport Access in an Era of Low-Cost Airlines, 2006). The keys is to attract passengers to the new rail mode, which can be explained further by addressing the reasoning of passenger values (Holmberg, 2010). The data from this case study describes that the train platform combined with satisfactory attributes like light, feeling connected with ground level and creating a protective glass arch, will attract passengers (Banverket, 2003). Additionally, the discussion of converting car users to public transportation mode by Budd *et.al* (2014), claims that mode choice can be altered by reducing their psychological barriers. This suggest a major market segments of public transportation in the future at Göteborg Landvetter Airport.

4.2.5 Quality and Validity control

The aim of this case study is to provide knowledge in how an airport can operate in terms of intermodal access regarding rail connections. According to Yin (2013), a contemporary event or case will provide best result when adding insight to a non existing scenario, for example Malmö Airport. It can be argued that Göteborg Landvetter Airport is not contemporaty enough, since the project is in its early stages of developemnt. However, due to the detailed reports and information in the data colletcion, this case study will provide sufficient evidence of support the rail project at Malmö Airport.

The theory chapter works as a data base and support empiraical findings of this case study. The quality can be questioned since many reports refer to much greater airports in size. Airports with a large number of passengers is different compared to smaller ones. However, the theory chapter describes key factors applicable at any airports, such as passenger types, transportation modes and airport choice et cetera. To enhance quality and validity throughout the case

study, the test described in the methodology chapter were used in the extent possible.

4.3 Ängelholm Helsingborg Airport Case II

This case study of Ängelholm Helsingborg Airport is following the methods provided from chapter 2 Methodology. The structure of this case is similar to the Göteborg Landvetter Airport case, but the matter is different. This airport is smaller in numbers of passenger compared with both Göteborg Landvetter Airport and Malmö Airport, but constitute similarities in the content of railway access. Ängelholm Helsingborg Airport will have a new train station in its vicinity of the airport, which could bring interesting insight for this master thesis. Same design and approach is applied in this second case study.

4.3.1 About the Airport

Ängelholm Helsingborg Airport is located in the north-west corner of Skåne and is now a private airport, owned by Peab Company since 2011. From the beginning, Ängelholm Helsingborg Airport was operating by the control of the Swedish military and not until 1960, civil flights routes was first initiated. Today, the size of the airport in numbers of passengers were in the year of 2014 approximately 408 000 (Ängelholm Helsingborg, 2015).

4.3.2 Research question and propositions

Based on this master thesis main research question, *"How is a travel center designed for an intermodal solution providing adequate airport access to Malmö Airport".* Since this minor case study are meant to contribute Malmö Airport with insight from Ängelholm Helsingborg Airport, different underlying propositions are used, since this airport differs from both Malmö and Göteborg Landvetter in both size and conditions.

- How will the location of the nearby station affect the intermodal transportation access at Ängelholm Helsingborg Airport?
- What are the plausible effects of a nearby train station for the airport?
- How will a future high-speed rail access impact the airport?

4.3.3 Collected data

The data is based on an interview conducted at Ängelholm Helsingborg Airport, documents about the airport, documents about the region and the new train station.

Intermodal access at Ängelholm Helsingborg Airport

The airport can be accessed by car, taxi, bus. The most commonly used transportation mode is cars. The obvious choice of accessing by car can firstly be explained by the airport's location. In figures 32 and 33, it is shown that the airport has a close exit to the major road network. Secondly, the majority of business travelers to and from the airport prefer cars and taxis. Further, another

benefit with car access can be addressed with parking. The most remote parking place will give an estimated walking distance of approximately 2.5 minutes, which is small in comparison to a walking distance at a close parking place at Copenhagen airport (Olsson, 2015)[22]. Additionally, the vast majority of passengers at Ängelholm Helsingborg Airport are business travelers.

The airport is also served by buses from both Helsingborg and Ängelholm. Benefits of this transportation mode is less costs compared to parking fees. Moreover, the bus mode provides the passengers with the closest airport access, since the bus is allowed to transfer air travelers just outside the entrance. However, taxi cabs is also allowed to transfer passengers by the entrance. The price of accessing the airport by bus is 50 SEK from Ängelholm and 120 SEK from Helsingborg. The frequency is mostly one bus an hour and adapts to landings and takeoffs at the airport.

The market shares in transportation at Ängelholm Helsingborg Airport can be shown in figure 31, where a survey was conducted at the airport in 2014. The majority of passengers use car, 93% and only 7% are using public transportation.

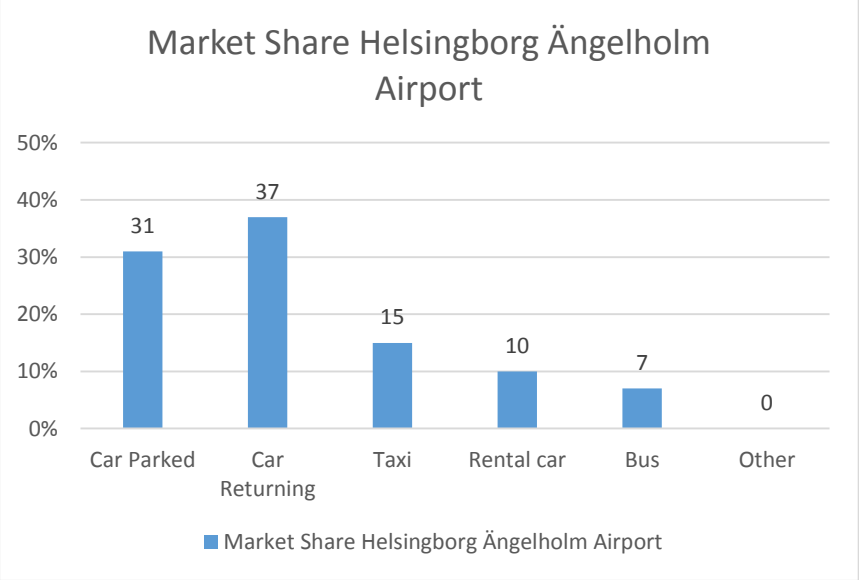

Figure 27 - Market share Ängelholm Helsingborg Airport 2014

In December 2015 a new train station will be opened just north of Ängelholm. This new train station could give the airport new access conditions, since it could alter the transportation market (Olsson, 2015)[22]. The location of the new station will be in Barkåkra, at a distance approximately 2 km from the airport.

[22] Olsson, S. (2015, April 16). Ängelholm Helsingborg Airport. (A. Lunderup, Interviewer)

The CEO of Ängelholm Helsingborg Airport is pleased with the new station but emphasizes the importance of connecting it with the airport (Olsson, 2015)[23]. As of now, there is talk in having more trains stopping at the new station and adding the airport's name to the station. This will add a new group of passengers to the airports in both intermodal and environmentally friendly aspects (Ängelholm Helsingborg, 2015). Further, a shuttle between the new station and the airport must be created in order to operate as a new transportation mode.

Future plans of Ängelholm Helsingborg Airport

Ängelholm Helsingborg Airport is located in the Öresund-region and has been selected to be protected by the Swedish government according to the national interest of the airport. In a national interest specification report, it is explained that Ängelholm Helsingborg Airport could be of importance of ensure runway capacity of the Öresund-region in a long term perspective (Trafikverket, 2011). In depth, Ängelholm Helsingborg Airport has according to the national interest, a capacity limit forecasted in 2025 with 667 000 passengers. To ensure runway capacity, an extension of the runway of 400 meter to a total length of 2350 should satisfy the region. In addition to a runway extension, it is also stated that a new terminal area could be planned west of the existing runway. All extension plans will be within the boundaries of the national interest area. Finally, the region of Skåne claims that the road and railway infrastructure combined with public transportation connections to airport is important (Trafikverket, 2011).

In the year of 2009, the Swedish government defined ten selected airports in which will be supported for a sustainable aviation system, in a long term perspective (Regeringen, 2009). Ängelholm Helsingborg Airport is not included by this selection. However, the airport could be in regional or local authorities in the future (Trafikverket, 2011).

Since a new station is about to open in the airport's vicinity, new future plans where discussed in the interview with Ängelholm Helsingborg Airport (Olsson, 2015). With a closer location of a train station, suggestions of moving the entire terminal facilities to the west side of the runway would be beneficial in airport access. In doing so, a quicker access between the airport and the train station would occur. Olsson[23] (2015) describes this to be an interesting approach of development.

However, it can be argued that business travelers will have less priority, since the road network around the airport will then have a more unfavorable position, in comparison to the location today. Since business travelers are the most

[23] Olsson, S. (2015, April 16). Ängelholm Helsingborg Airport. (A. Lunderup, Interviewer)

frequent users of cars and taxis to and from the airport, they will have less priority if the terminal moves to the west side of the airport. Further, Olsson[24] (2015) states that the airport will operate well and are not likely to be extended nor moved in the near future, since Ängelholm Helsingborg Airport does not have the needs of serving as a transportation hub, as for example Copenhagen Airport.

In figure 32 to the left, the train connection is displayed with to different terminal positions. Figure 33 to the right shows an example car route from a road exit to different terminals. Index 1 marks the existing terminal and index 2 marks the future terminal.

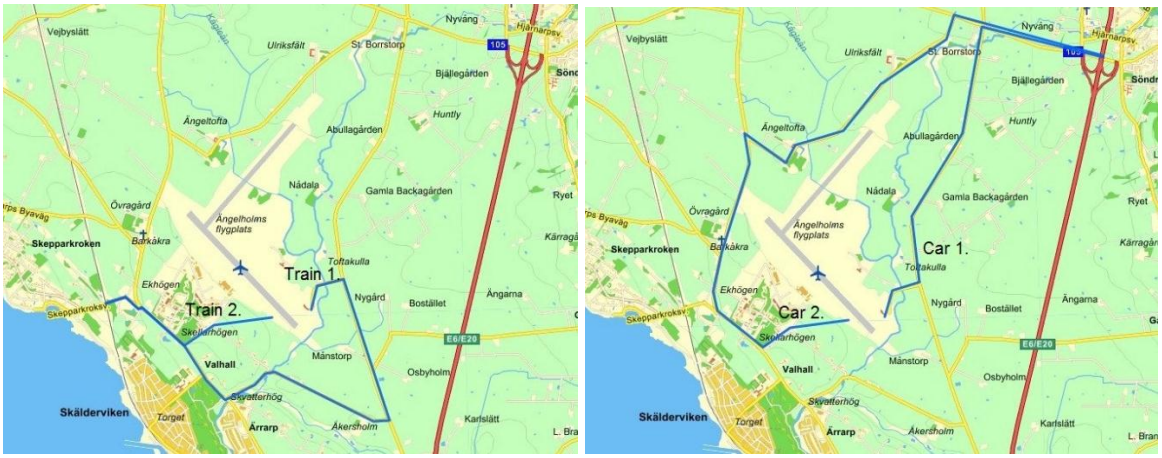

Figure 32 and 33 - Train and Airport, Car and Airport, Train 1: route to existing terminal, Train 2: route to future terminal in west, Car 1: route to existing terminal, Car 2: route to future terminal in west.

Table 9- Distance comparison with ground transportation between existing and new terminal.

Location of Terminal	Train station – Airport (km)	Car exit – Airport (km)
Terminal 1 (existing)	**7**	**5.67**
Terminal 2 (potential)	**2.46**	**9.71**

International access Ängelholm Helsingborg Airport

Ängelholm Helsingborg Airport has a unique location in terms of catchment area, since the railway network runs across the cities of Helsingborg and Ängelholm. As mention by Hvidt *et.al* (2013), the catchment can increase, but only if the high speed trains stop at Helsingborg or and Ängelholm. The city of Helsingborg strives to get a train stop with the high speed train coming in from Stockholm, before moving towards Malmö and Copenhagen. Moreover, the

[24] Olsson, S. (2015, April 16). Ängelholm Helsingborg Airport. (A. Lunderup, Interviewer)

demand of a better rail network in Sweden has been increasing since the existing network is both congested and worn out (Helsingborgs kommun, 2015).

4.3.4 Analysis of Case II

In this section an analysis of Case II will be presented. Findings will be discussed in respect of the theoretical framework from chapter 3, in order to assess key elements of airport access that can be applied on Malmö Airport.

Nowadays, Ängelholm Helsingborg Airport operates well as a minor airport in the north-west of the Öresund-region. The catchment area span between Skåne and Halland with connections in both Helsingborg and Ängelholm. However, the Öresund-region can be viewed as a multi-airport region, which requires certain demands of airport access (Pels *et.al*, 2003). The airports affecting access at Ängelholm Helsingborg is namely Halmstad Airport in the north, Malmö Airport in south and Kristianstad Airport in the east. As discussed in the theory chapter 3, access time is an important key factor in airport choice in a multi-airport region. Provided data argues that Ängelholm Helsingborg Airport competitive in terms of access time according to Olsson[25] (2015), especially with the short distances from parking spaces and small airport size in comparison to Copenhagen Airport.

According to figure 21, market share at Ängelholm Helsingborg Airport, there is a significant overweight in car users of 93% against 7% of public transportation access. As mentioned from Olsson[25] (2015) the car is an easy alternative in airport access since walking distances are short, access time adequate and the majority of travelers are of business nature. Moreover, the business travelers generally finds costs to be insignificant in contrast to access time (Harvey, 1987; TCRP, 2000). With these facts presented, a more detailed investigation of the car passengers must be conducted in order to attract car travelers to public transportation.

The research by Budd *et.al* (2014), describes that certain groups of car users can be converted if their attitude towards public transportation is changed. Moreover, the groups *Conflicted greens* and the *Pessimistic lift seekers* are arguably those with most potential of attitude change.

With an upcoming train station nearby the airport, new opportunities opens up in terms of intermodal access at Ängelholm Helsingborg Airport. The images in figures 32 and 33 indicates a shorter distance to the airport. However, the existing terminal is argued to be misplaced in contrary to the distance and time

[25] Olsson, S. (2015, April 16). Ängelholm Helsingborg Airport. (A. Lunderup, Interviewer)

it would take to access the airport from the new train station. In table 9, an example of car-terminal and train station-terminal is presented. If you would access the airport today from the new station, it would be a 7 km distance with a vehicle. The same scenario but from the northern road exit would be approximately 5.7 km. Depending on where you originate from, these distances can be crucial. If new location of the terminal, west of the runway, Distances would change. Access from the new station to the new terminal would have a shorter distance on 2.5 km compared to the before 7 km. However, the distance from the northern road exit would increase from 5.7 km to 9.7 km. yet again, place of origin would determine whether its beneficial moving the terminal or not.

Additionally, studies provided by Budd *et.al* (2014), about attracting car users to public transportation, support an alternate placement of terminal in combination with the new station, since distances and access time can be shorter. Regardless the terminal location, a transportation mode to the new station is crucial in terms of changing towards a more sustainable and environmentally friendly airport. When the market shares of car access today is high 93%, a shuttle transport between the new station and the airport is likely to show a change in transportation market shares.

4.3.5 Quality and validity control

The aim of this case study is to provide knowledge in how an airport can operate in terms of intermodal access regarding rail connections. According to Yin (2013), a contemporary event or case will provide best result when adding insight to a non existing scenario, for example Malmö Airport. The case of Ängelholm Helsingborg Airport has a different train scenario in comparison with the intended Malmö Airport case, where a station are to be construced at the airport and not away from the airport. With this reasoning, it can be argued that Ängelholm Helsingborg Airport will provide less support in terms of finding clues to apply on Malmö Airport. However, in terms of intermodal airport access the case adds more quality and validity, since a new shuttle between the train station and Ängelholm Helsingborg Airport will make an impact on the airport access.

The theory in chapter three works as a data base and support empiraical findings of the case study. The quality can again be questioned, since many reports refer to much greater airports in size. Airport with a large number of passengers is different compared to smaller ones. However, as mentioned previously in Case I , the theory chapter three describes key factors applicable at any airports, such as passenger types, transportation modes and airport choice et cetera. To

enhance quality and validity throughout the case study, the test described in the methodology chapter were used in the extent possible.

5 Analysis

In this chapter all empirical studies and theories from chapter 3 are being studied with respect of Malmö Airport and its possibilities of operating a future intermodal travel center with a rail connection. There lies is a challenge in comparing a hypothetical assumption about an airport and its supposedly future scenario. However, based on the theories, selected airport case studies and other empirical findings, this master thesis should provide illustrative suggestions of Malmö Airport.

5.1 Airport choice in the Öresund-region

In this section we describe theory along with empirical findings in order to answer the research questions for this master thesis. For optimal structure of the analysis, chapters will divide the matter in sections. This is essential for the first research question, about how to obtain optimal and sustainable airport access with various transportation modes. A subdivision similar to the theory chapter, where airport choice will be the initial subject, followed by airport users and transportation. Additionally, the end of this chapter will then analyze rail access.

Access choice in a multi-airport region has been described to be the first attribute in regarding ground access, mainly because users must first choose an airport of their choice. Malmö Airport has alternative airports distributed across the Öresund-region, especially the adjacent and larger Copenhagen Airport. According to Pels *et.al* (2003), access time is crucial in airport choice and especially when there are other airports in a region. Along with access time, Becky (2008) explained that the level of service at airports were also important for the airport users. These attributes in the context of airport choice support the choice of Copenhagen Airport which is both bigger (in passengers) and provides more level of service.

However, access time can be argued to be similar depending of the user's origin. Access time between Malmö Airport and Copenhagen Airport indicates a shorter travel time to Copenhagen Airport from both Malmö and Lund in contrary of Malmö Airport. Further, there is a greater range in access mode choice to Copenhagen Airport, since they have a rail connection at the airport. Since Malmö Airport does not have a rail connection, the difference of ground vehicle access time can be compared. The difference in access time between two cities-Malmö Airport and two cities-Copenhagen Airport, can be displayed in table 10. Additionally, if Malmö Airport would have a rail link as described in the background chapter, estimated travel times from empirical data can be added to display access time in various transportation modes.

Table 10- Access time comparison

Access time by (minutes)	Travel routes to and from Malmö Airport and Copenhagen Airport			
	Malmö Airport		Copenhagen Airport	
	Malmö C	Lund C	Malmö C	Lund C
Car	25-30	25-30	20	30
Bus	40-50	40	20	-
Train[26]	25	38	21	33-38

However, Copenhagen Airport is larger and is most likely to have a greater range in shopping options. In that case, Malmö Airport can compete in short haul distances, since access time is also an essential attribute in choice of airport. Further, short haul trips can be linked with low-cost carriers and that they tend to be more spread across a multi-airport region (de Neufville, Planning Airport Access in an Era of Low-Cost Airlines, 2006). This suggest that the airport size is insignificant when dealing with short haul trips. Moreover, Malmö Airport could gain more passengers in attracting short haul trips and if they provide shorter access time. At this point, Malmö Airport has had an increase in low cost carriers over the last years (WSP, 2015). Therefore, passenger types and transportation modes are next segments to be analyzed.

5.2 Airport Users

In this next segment of analysis we focus on the airport user, as a continuation of the first research question addressed in previous segment about airport choice. Further, this segment will be used to evaluate and determine travel patterns amongst airport users today and in the future of Malmö Airport.

In evaluating each user, a combination of theory provided from chapter 3 can be used to create a distribution chart (TCRP, 2000;Ashford *et.al*, 2001;Harvey, 1987;Orth *et.al*, 2014).

In figure 34 below, all airport users mentioned in this master thesis are displayed. Note, non-business travelers are synonymes to leisure travelers.

[26] Estimated times based on train schedules at Ystadsbanan (Skånetrafiken , 2015)

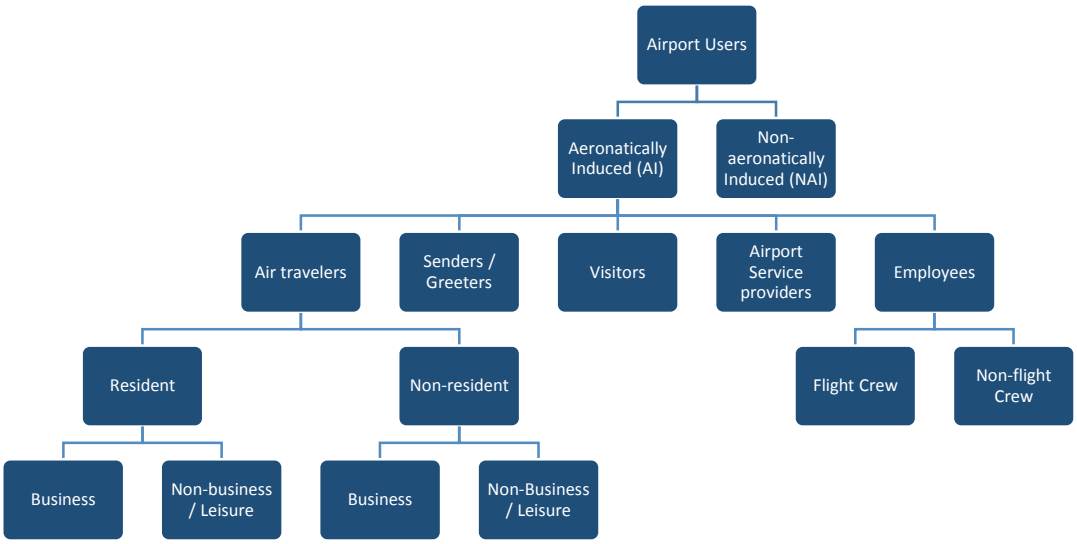

Figure 284 - Airport Users Distribution Chart

All users have their own expectations, values and views on the choice of access mode. To answer the research question about how to obtain optimal and sustainable airport access with various transportation modes, all airport users must be discussed.

The first breakdown of airport users are the two groups named aeronautically induced (AI) and non-aeronautically induced (NAI). As Orth *et.al* (2014) described, the impact of NAI travelers have effects on airport access, since they do not share the characteristics of AI travelers. Moreover, it is argued that NAI travelers have positive effects on public transportation. At this point, Malmö Airport is mainly only in the AI sense. However, Göteborg Landvetter Airport could attract NAI travelers in the future, since they intend to expand into an airport city, which will implicate NAI activities (Wiberg, 2015)[27]. However, if Malmö Airport would construct a train connection through the airport, NAI travelers would in fact use the public transportation in order to reach their final destination beyond the airport and a rail connection can have a wide range of users.

In the AI sense, there are several users to address. The main users that are often referred in the context of airport access are passengers and airport employees. As described in the theory chapter 3, airport passenger can be divided into subdivisions. Each subdivision of air passengers have characteristics in terms of costs and time, amongst other things. As an example, business passengers are time sensitive in comparison with the leisure travelers, who are cost sensitive (Pels et al, 2001). In this context, Swedavia have established key groups

[27] Wiberg, H. (2015, Mars 31). Case study Landvetter Airport. (A. Lunderup, Interviewer)

amongst travelers to improve passenger satisfaction at their airports. According to the segmentation of passengers at Malmö Airport 2012, the majority of passengers were business related, which support time to be an important element in access choice to Malmö Airport (Swedavia, 2012).

Further, the resident and non-resident aspects also have an impact of access choice. The resident business traveler can more easily create a travel pattern in contrast to the non-resident. Moreover, the non-resident traveler demands more flexibility in airport access, since their travel varies depending on their business assigned. The main difference between a resident and non-resident non-business traveler is knowledge (TCRP, 2000). Moreover, a non-resident traveler are less likely to use public transportation because they have little or no knowledge of the airport access. This segmentation of resident non-resident is not frequently used in reports about airport access. However, from empirical findings of Malmö Airport, the resident and non-resident segmentation is essential in transport aspects and will be discussed in chapter 5.3. The most frequent way in addressing air travelers is mainly business travelers and non-business travelers.

The two case studies provided a different view of the passenger market in comparison with Malmö Airport. At Göteborg Landvetter Airport, the active commuters held a total of 25% of the passenger groups, followed by 23% of the effective commuters. As described, these passengers differs mainly because of effective commuters holds more business related trips in comparison to the active cosmopolitans, which is discussed in the Swedavia segmentation of passengers. At Ängelholm Helsingborg Airport, the most common airport users are business travelers, also called the effective commuter (Swedavia, 2012).

The characteristics of business passengers are namely time sensitiveness and they are a common passenger group amongst all airports users (Harvey, 1987). However, Göteborg Landvetter Airport does not hold the same majority in business passengers in comparison with Malmö Airport and Ängelholm Helsingborg Airport. According to empirical data from Case I, the distribution amongst business travelers and leisure travelers is 50%.

In summary, the passengers of Malmö Airport in respect with the case studies and theory holds, following attributes can be displayed:

- Passengers at Malmö Airport are mainly business related and holds airport access and efficient processing attractive
- The overall passengers are resident travelers with 90% which creates patterns in airport access
- Resident travelers have more knowledge in contrast to the non-resident

- Non-resident passengers use bus as transportation mode more frequently in contrast to resident passengers

5.3 Transportation modes

There are many options in transportation modes in regards of airport access in a theory perspective. According to Ashford *et al* (2001), a variety of access mode is benefical since airport users view attractiveness of transportation differently. All trasportation modes will not be analyzed in all the extent of this segment, since Malmö Airport does not provide all modes presented in chapter 3. As for Malmö Airport, the available access mode are the following:

- Car
- Taxi
- Special airport buses
- Charter buses
- *Train (Future)*

The car is the most frequently used mode in airport access, mainly because of luggage handling, comfort and flexibility. The disadvantages are namely road congestion, parking fees and aspects of air pollution (Budd et.al, 2014). According to theory and empirical findings, Malmö Airport has evidence of a majority of business passengers. These passengers are time sensitive and prefer cars over public transportation. The market share of Malmö Airport displays the majority of car users, where the car mode market share is 74%, followed by 12% taxi and only 14% with airport buses.

The characteristics of car can also be addressed to the taxi mode. The main difference between a car and a taxi is walking distances. A taxi usually provides the passenger with nearby terminal access, which is positive from a level-of-service point of view. Cars on the other hand could face a remote parking space, which lowers the convenience level for the air traveler. In an airport point of view, much surface space is required in providing cars and taxi since it holds parking spaces, parking garage, drop of spaces and taxi pool areas (Ashford *et.al*, 2001).

At this point, all transportation modes at Malmö Airport are in the context of ground vehicles. Apart from the more common transportation modes cars and taxis, the airport can be accessed by special airport buses (Airport Coaches). Advantages for buses in general are less costs and direct access to central areas. Three types of buses were discussed in the theory chapter 3. Namely, Charter bus, urban bus and special bus (Ashford *et al*, 2001). Urban buses can be used if the airport is included in the cities bus network. This mode can provide good

access for airport employees, depending on their working hours. Special buses are common at airport and provide direct access to city centers. Malmö Airport is severed by special airport buses and can transfer the user to two major cities Malmö and Lund in the region. However, buses are ground vehicles, which make them vulnerable for traffic congestion. Since access time is a crucial matter amongst air passengers, buses can be viewed as an uncertain transportation mode, due to traffic congestion. According to empirical data, Malmö Airport has a majority of business related air travelers, who are time sensitive and attracts to efficient and rapid airport access. This can support an alternative transportation mode, since a rail connection does not share the road congestion dilemma.

Finally, the advantages of ground vehicle transportation modes are depending on the transportation mode itself. Buses provide good access and can be cheaper in comparison to the car. Car on the other hand can be good in flexibility, but could face expensive car parking and remote parking place. However, disadvantages can be summarized for all ground transportation modes and be linked with traffic congestions. Congestion can affect access time negative, since delay is unattractive for the airport users. In an environmental perspective, ground vehicles are viewed as being candidates of raised air pollutions (Budd *et.al*, 2014).

5.4 Rail Access Planning

The first research question can now be fully analyzed, since airport choice, airport users and transport have been discussed. As theories suggests, an intermodal airport access is essential for optimal access functions. Moreover, as Vesperman & Wald (2010) describes, the improvements of airport ground access can be motivated by various aspects. Further, it is not only passenger growth that can be a motivator, but also expansions in catchment area, landside area and customer satisfaction. In terms of customer satisfaction, Malmö Airport should design airport access in regards of their key users, namely business travelers. Moreover, these users are according to theory and empirical findings the most frequent users of cars (WSP, 2015).

With a new transportation mode, it can therefore not be obvious that business travelers would abandoned their car for a rail bound access choice. As Holmberg (2010) explains, qualities and experiences of transportation modes varies and have great impact in the access market. Additionally, a study about attracting passengers from car to public transportation support a market change if a new transportation mode is introduced (Budd *et.al*, 2014). Since Malmö Airport consist of approximately 90% car users (including taxi), the study from

Budd *et.al* (2014) suggests that car users can be willing to change transportation mode, in support of a new rail mode.

In Case I, Göteborg Landvetter Airport, there are several elements in the support of a rail connection. Firstly, the geographic location makes the airport of value in terms of shipping, import and export. Moreover, Göteborg Landvetter Airport is the second largest airport, which adds importance. With a new high speed rail connection between Gothenburg and Stockholm, a train station at Göteborg Landvetter Airport is essential in sustainable infrastructure for both the region and also Sweden. How well the new rail mode is going to operate in the future is yet unknown. However, there are evidence of success from various authors described in the theory chapter 3, for example Oslo Airport.

Since Göteborg Landvetter Airport is about to evolve into an airport city, the non-aeronautically induced passengers (NAI) will emerge as a new airport user. According to Orth *et.al* (2014), an airport providing NAI activities at airport has shown to have higher passenger numbers traveling with public transportations. The future airport city will also provide more work opportunities, which can attract more users with public transportation (Wiberg, 2015)[28]. However, a high speed train can have negative effects on air traveling, since passengers transfer from air to rail in short haul trips. According to Wiberg[28] (2015), this would rather increase the aviation industry, since the high speed rail will expand Göteborg Landvetter Airport's catchment area.

Finally, Malmö Airport can learn from Göteborg Landvetter Airport in three ways. Firstly, Malmö Airport is located in a growing region with close bonds to Denmark and the rest of Europe. Secondly, the airport is in the vicinity of a future high speed rail (COINCO), connecting major cities in Sweden with Europe. Thirdly, Malmö Airport and Göteborg Landvetter Airport is a part of Swedavia, meaning that both airport have high environmental goals, which support a rail connection (Swedavia, 2015). These three lessons from Göteborg Landvetter Airport can be referred as similar motivators in support of intermodal airport access, described by Vesperman & Wald (2010).

In Case II, the intermodal situation is different in contrast to Case I. Unlike Malmö Airport and Göteborg Landvetter Airport, Ängelholm Helsingborg Airport have no plans in connecting the airport with a rail mode. However, a new train station are about to be constructed nearby the airport which can impact the intermodal airport access (Olsson, 2015)[29]. As Case II describes, a new

[28] Wiberg, H. (2015, Mars 31). Case study Landvetter Airport. (A. Lunderup, Interviewer)

[29] Olsson, S. (2015, April 16). Ängelholm Helsingborg Airport. (A. Lunderup, Interviewer)

potential terminal location could be beneficial in sustainability and environmental aspects, since there is a majority of car users accessing the airport. Thus, the new terminal location will only create a hybrid train-shuttle mode, since there has to be a shuttle between the new station and the airport. Moreover, if a shuttle are to be created, evidence from Budd *et.al* (2014) suggests that car users can be willing to change transportation mode, which is more environmentally friendly.

In addressing Malmö Airport with Case II, evidence support some solutions when having opportunities in altering the airport access market. Thus, Malmö Airport requires a larger reconstruction in adding a rail connection, since a small section of rail are to be linked with the existing rail network (Ystadbanan). Motives exists, as mentioned by Vesperman & Wald (2010) and in a long term perspective, environmental aspects can never be addressed to soon.

5.5 Future Malmö Airport

This section refers to research questions two and three, regarding the actual travel center and its functions. Moreover, where the optimal placement is and what will its vision and functions be.

In terms of placement there are two significant locations. The first placement is described in appendix C – Vision Concept 2 (LFV, 2001) and indicates a train station entrance in the north part of the terminal building. However, it is argued by Bjurek[30] (2015) that a location in the south part can be more economical, in the context of a shorter railway haul, in contrast to the north suggestion. However, since this thesis will not discuss financial aspects and costs regarding a railway project, a north location can be suggested. Moreover, since expansion plans, according to Ivre[31] (2015), involves a northern expansion of terminal buildings, the example of a station located in the north part will be more beneficial in terms of airport access. In figure 35 below, the north and south placements are displayed with a red line showing the potential track. Additionally, note the difference in track length between A and B. Further, as shown in figure 35 below, there are no existing buildings around area A. This can favor the construction, since area B have adjacent buildings which can implicate construction.

[30] Bjurek, H. (2015, March 10). Train station at Malmö Airport. (A. Lunderup, Interviewer)

[31] Ivre, H. (2015, April 8). Interview Swedavia. (A. Lunderup, Interviewer)

Figure 295 - Suggestions of station location with railway track at Malmö Airport, image based on (Swedavia, 2015)

From the context of future expansion plans and the favoring construction aspects of placement A, as shown in figure 35. The beneficial placement of a travel center at Malmö Airport should be in north part. Further studies are to be done whether a travel center are to be constructed before or after the parallel runway project. Regardless what is first, the location of a north travel center will provide good airport access. Moreover, at Oslo Airport and Göteborg Landvetter Airport, the placement has shown to be of great importance. However, if the airport already has short distances and one level (as Malmö Airport), the walking distance between suggestion A and B, from figure 35, can be viewed as equal. Thus, a future expansion would suggest the position A, since it will be more centralized in a future perspective.

When addressing the final research question about the function and vision of the future travel center, some architectural guidelines have been suggested by LFV (2001), which are described in the empirical chapter. The theme and identity of Malmö Airport is as described yellow and glass aisles is suggested between buildings. Both Bjurek[32] (2015) and Case II suggest glass constructions as element of attractiveness. In appendix E – master thesis vision concept, pictures of a hypothetical outcome is visualized, as my final assignment for this master thesis.

[32] Bjurek, H. (2015, March 10). Train station at Malmö Airport. (A. Lunderup, Interviewer)

6 Discussion/Conclusion

In this chapter the investigation will be discussed by extracting key findings from the analysis, which then are transformed to answer the research questions of the master thesis. An overall quality and validity discussion will also be addressed in this chapter. Finally, suggestions on the future scenario at Malmö Airport will be presented along with the authors personal reflections regarding the thesis.

6.1 General discussion

Airport access is complex since it is strongly linked with airport and regional activities. Moreover, findings about various variables like airport user behavior, transportation modes and airport size can all add clues on an airport investigated in terms of airport access.

When the goal of this master thesis was created, the initial interest was in finding the appropriate location of a supposedly new travel center, in combination with a rail connection. In the comprehensive environmental impact analysis, combined with a railway investigation, little information about the underground train station existed. The thesis needed a wider range in research question, than pointing out an optimal location at the airport. However, the location is important, since it determines the distance an airport user with train access have to walk in order to reach its destination. Moreover, the actual location could according to employees at Malmö Airport only be at certain areas. A more interesting approach, in combination with travel center location, lies in how an airport would operate under new circumstances, like with a new transportation mode. The research questions evolved in promoting an intermodal airport access with rail connection, which provided the final product of this master thesis.

In early stages of this thesis, recommendation was given to the author to not focus on large airports, since Malmö Airport is a secondary airport. The main reason was that larger airports have different conditions in contrast to a secondary airport like Malmö Airport. However, most of the theories are based on large airports and finding data from smaller airports was a challenge. Moreover, in assessing more balance to the thesis, case studies were to be conducted on smaller airports, Göteborg Landvetter Airport and Ängelholm Helsingborg Airport. Finally, a combination of theories from large airport and case studies from smaller airport would bring stability in the support of a rail connection at Malmö Airport. Additionally, the reason why Copenhagen Airport was not used as a case study, is based on two major factors. Firstly,

Copenhagen Airport is a large airport and holds approximately 12 times the passengers in contrast to Malmö Airport. This could, as described earlier, give unbalance in the results, when Malmö Airport is a secondary airport (smaller). Secondly, Copenhagen Airport did not have the resources in providing an interview nor information at any time.

During the data collection process of this master thesis, the author has come across different views and opinions on the future rail way to Malmö Airport. As mentioned in the delimitation segment, this thesis will not add financial aspects of what the proposed railway project would involve. However, there are unsolved economic difficulties in this railway project, since it requires financial support from stakeholders. This is mentioned in the background segment. Despite the economic factors, this thesis goal is to explain and give an insight of an intermodal airport access at Malmö Airport with a rail connection, regardless.

6.2 Conclusion

The analysis in chapter 5 indicated that theory, cases and empirical finding can be used in gaining knowledge to the Malmö Airport issue. A Summary of this master thesis's conclusions, regarding an intermodal airport access at Malmö Airport, are displayed below.

The first research question "*How to obtain sustainable intermodal airport access with various transportation modes",* holds following conclusions:

- Malmö Airport can be attractive in a multi airport region when providing better airport access, despite the airport being secondary. Since Copenhagen Airport is the major airport in the region, short-haul trips can be an attractive attribute in a competitive sense, because Copenhagen will most likely dominate in long-haul trips in the future.

- Airport users at Malmö Airport are mainly business passengers and affects the market share of transportation modes, which favors car access. If a railway connection are to be implemented it must have high level-of-service, combined with competing access time, if car users are to be transferred from car to rail.

- Improvements of airport access is important for non-resident travelers, who tends to choose public transportation as access if being introduced. Non-resident travelers at Malmö Airport are today the most frequent

users of public transportation, which adds importance of good public transportation and railway connection.

- Intermodal access combined with railway connection can be improved if non-aeronautical activates are provided at Malmö Airport. This adds a wider range of the airport user market and airport access is more spread out during the day, instead of the more common peak-hour access.

- There are many motivators for constructing a railway connection to Malmö Airport. Firstly, Öresund-region is an expansive region and sustainable infrastructure is important. Moreover, congested roads will have a relief if the railway network is better integrated with important hubs, for example Malmö Airport. Secondly, it is a more environmentally friendly transport alternative in comparison with car. Thirdly, there is a possibility of a scenario were Copenhagen Airport and Malmö Airport need collaboration, if Copenhagen Airport reach maximum capacity and needs a release. A better link between the two airports is therefore necessary.

In addressing the two remaining research questions of "*The function and vision of the travel center and simultaneously provide satisfaction amongst users at Malmö Airport*" and "*Identify and locate a travel center for optimal airport access with railway connection* " , these were the following conclusions:

- The travel center should be constructed to provide airport users with the sense of connection between underground and terminal level, in order to achieve a pleasant experience and satisfaction. Guidelines indicates that glass is a good element of material for the travel center. To maximize and facilitate orientation, signs should be implemented in the vicinity of the new train entrance.

- A travel center are to be placed in the north part of the existing terminal for optimal airport access, as displayed in appendix E. One entrance is located inside the terminal building.

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Appendix

Appendix A – General Interview Guide

- *Presentation of the master thesis' purpose and education*

Initial Discussion

1. Describe the situation of airport access today
    a. What are the most frequent airport users?
    b. What are the available transportation modes?
    c. How do the transportation modes collaborate?
    d. How does the public transportation look like in the region
    e. Where are the major city centers around the airport

Railway Impact

2. How will a railway connection affect the airport (Case 1)
3. How will a nearby railway station affect the airport (Case 2)
4. What are the motivators for implementing railway access to the airport?
5. Are there any negative aspects of improved railways on the aviation business?

Future Plans

6. What are the future plans regarding intermodal airport access?
7. How can the terminal layout be improved, in order to enhance airport access?

Final

8. Are there any other factors you find important when developing intermodal airport access with railway connection?

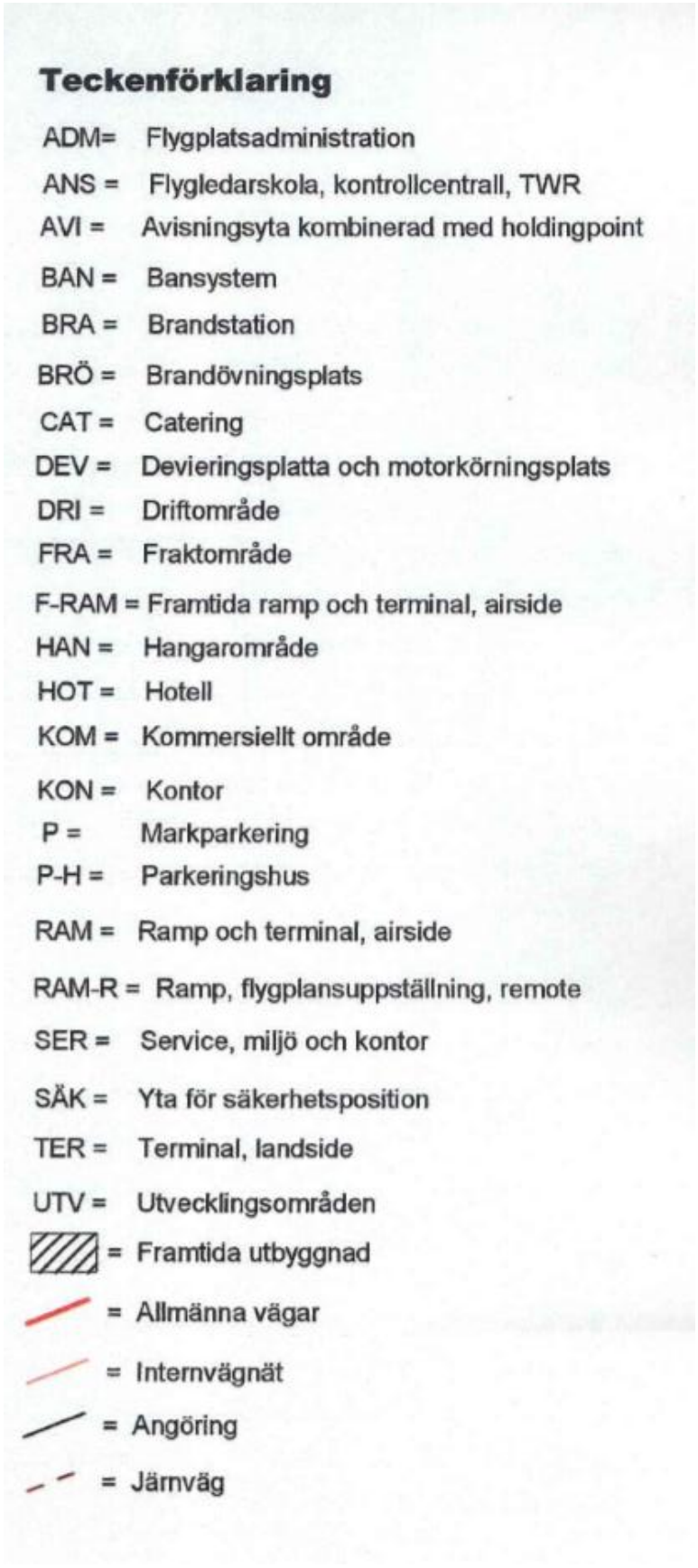
Appendix B – Vision Concept 1

Terminal expansion vision concept phase 1 (Ivre, 2015).

Appendix C – Vision Concept 2

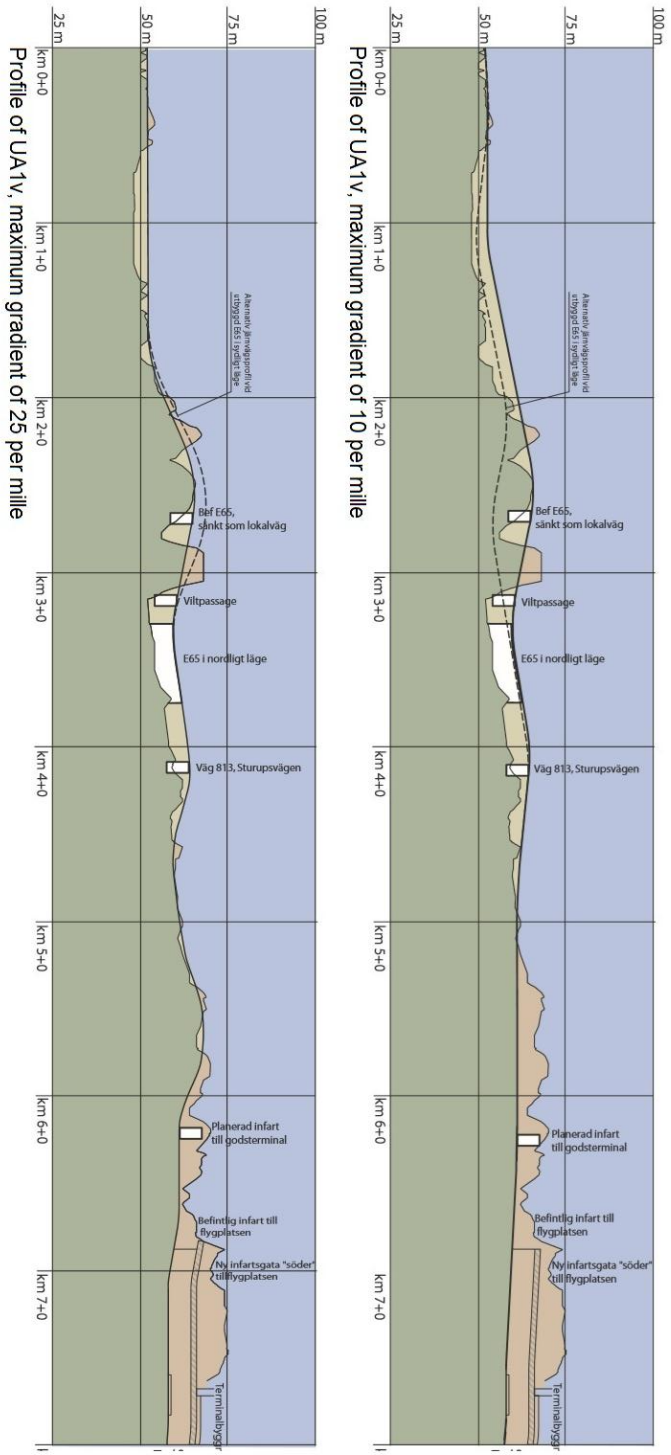
Terminal expansion regarding a parallel runway (LFV, 2001).

Legend of vision concept 2 in swedish

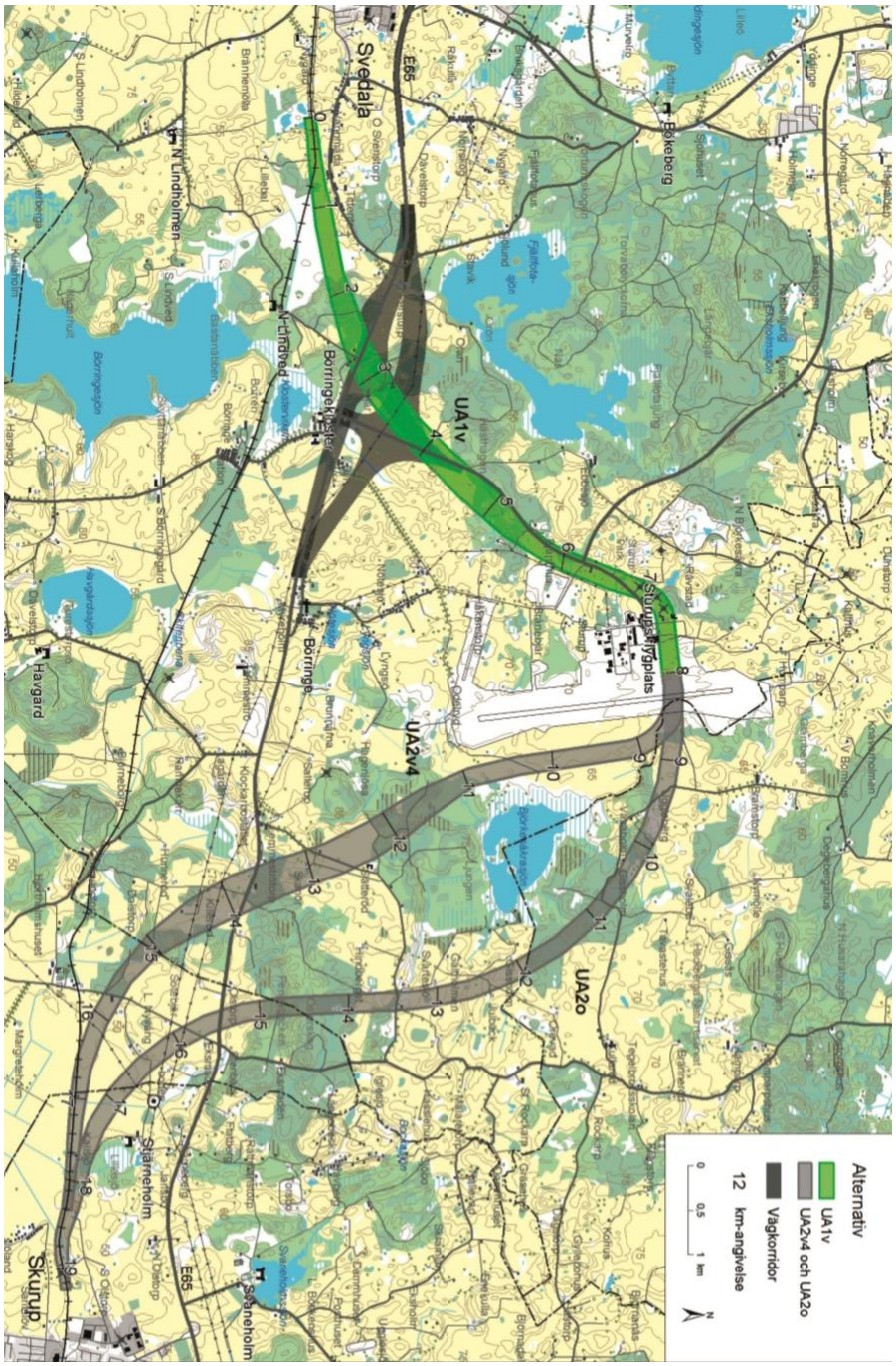


Appendix D – Tunnel Suggestion

Profile of tunnel with various gradients (Malmö *et.al*, 2005).



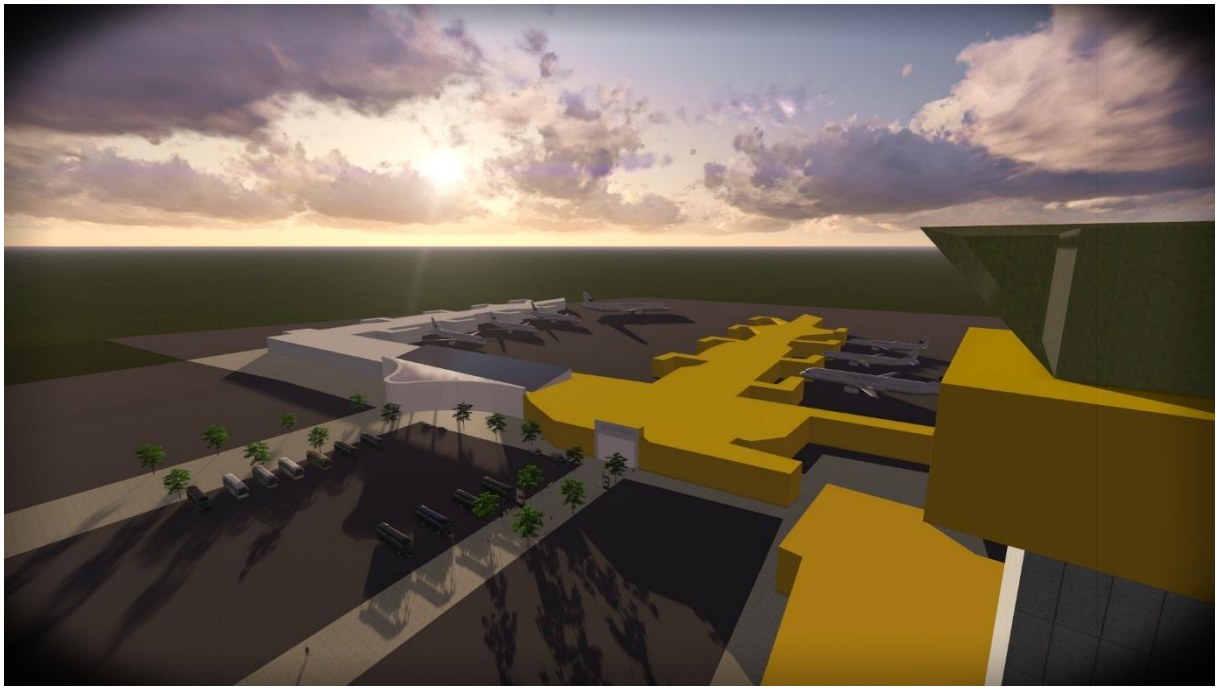
Alternatives of pervading tunnel from Malmö *et.al* (2005)



Appendix E – Master Thesis Vision Concept

Malmö Airport from a distance

Malmö Airport overview



Existing entrance at Malmö Airport

New entrance at Malmö Airport