



UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

The Road to Intermodal Transport

-A study of the economic, environmental and societal effects from the usage of 2x40 feet vehicles for pre and post haulage

Anders Bertilsson and Cecilia Olsson

Graduate School

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Supervisor: Rickard Bergqvist

Preface

Throughout our studies at Gothenburg University, School of Business, Economics and Law, focus has been on improving logistic efficiency that will lead to long term competitive and environmental sustainable solutions. Sweden has a logistical handicap compared to the rest of Europe due to its location. Therefore Sweden has a large focus on making transportation and logistics as efficient as possible.

One initiative to increase efficiency and lower emissions is through green transport corridors. The initiative aims at sustainable development of logistics systems. As a member of the workgroup 'Intermodal Transports' within Green Corridors, our tutor Rickard Bergqvist presented us with a thesis subject where focus was on the pre-and post haulage of intermodal road and rail transports over short distances. The thesis is a pre-study within Green Corridors presenting a case study of Skaraborg.

Abstract

An increased environmental concern regarding the transport sector's effects on the environment has resulted in the promotion of intermodal transport. Intermodal transport faces fierce competition on short distances. One reason for this is high pre- and post haulage costs. The purpose of this paper is to investigate how intermodal freight transports can be made more efficient in the cooperation between road and rail, and how they can be made more environmental friendly. The concept of double haulage, vehicles carrying 2x40ft containers, will be introduced and further evaluated as a means to improve the pre- and post haulage part of intermodal transports.

The study was conducted with help from several interviews where experts from various parts of the transport sector contributed with their knowledge. Implementing double haulage requires some special concerns. Since the vehicle combinations violates Swedish traffic regulations on length dimensions, the rules and regulations need to be investigated together with the process of obtaining an exemption from the Swedish Transport Agency.

A case study where double haulage is introduced is investigated. Within the case study different scenarios are created where a solution of moving goods from road to an intermodal road and rail solution is presented. The results indicates that with an intermodal double haulage solution there is a potential of cost savings between 5-8% compared to road transport only while the savings in emissions are far greater, up to 80%. Opinions and statements concerning long vehicles from the interviewees are analyzed together with the technical aspects and calculation results from the case study in order to see the future potential of double haulage. Aspects as traffic safety and infrastructure are handled as well.

For future research it is suggested to investigate how the concept can be developed further in relation to Railport Scandinavia. In this way it would be investigated if double haulage can support the development of the rail shuttle system.

Acknowledgements

This paper required much information that was not published and therefore we are very grateful to all our interviewees. Their expert knowledge guided us through the different processes and steps along the research process. Thank you all for your quick responses and help despite your busy agendas.

We would also like to thank our tutor Rickard Bergqvist for his inspiration, commitment and enthusiasm for the subject and his assistance throughout the thesis project.

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Anders Bertilsson



Cecilia Olsson

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1 Definitions

Intermodal transport – “The movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport without handling the goods themselves in changing modes” (UN/ECE, 2001).

Combined transport – “Intermodal transport where the major part of the European journey is by rail, inland waterways or sea and any initial and/or final leg carried out by road are as short as possible.” (UN/ECE, 2001).

Double haulage – long and/or heavy vehicles used for the feeder part of the intermodal transport (2 x 40 ft containers which exceeds Swedish length regulations).

Railport – The Port of Gothenburg terminology for an inland terminal in cooperation with the Port of Gothenburg.

1.1 Abbreviations

DTD – Door -to-door

EMS – European Modular System

NTM - Network for Transports and Environment (Nätverket för Transporter och Miljö)

PH – Pre Haulage

PPH – Pre-and Post Haulage

SIKA – Swedish Institute for Transport and Communications Analysis (Statens institut för kommunikationsanalys)

SRA – Swedish Road Administration (Vägverket)

STA – Swedish Transport Agency (Transportstyrelsen)

TEU - Twenty-foot Equivalent Unit

VTI – Swedish National Road and Transport Research Institute (Statens väg- och transportforskningsinstitut)

VVFS – Swedish Road Administration Body of Law (Vägverkets Författningssamling)

2 Introduction

Sweden, together with the other Nordic countries, is by its geographic location seen to have a logistical handicap compared to other parts of Europe where the main markets, large terminals and production units for many international companies are located. Therefore there is a large incentive to make transportation and logistics network as effective and efficient as possible in the Nordic countries. Within the transportation sector several EU projects focus on intermodal improvements i.e. better cooperation between different transports modes. EU projects such as “Marco Polo”, consists of several programs to benefit the more environmental friendly modes of transportation. This paper puts a focus on the relation and collaboration between rail and road transportation.

A Swedish project called Green Corridors aims at promoting sustainable transport paths within Sweden and from Sweden to the rest of Europe. The project encourages the industry to promote intermodal transports to handle the increasing transport volumes (Back, 2008). An important part of the development of intermodal transportation within Sweden is the expansion of the Port of Gothenburg. Today there are 25 rail shuttles from the Port of Gothenburg heading 23 destinations throughout Sweden and Scandinavia. As a result of lack of space in Gothenburg a project called Railport Scandinavia were developed by the Port of Gothenburg in order to be able to expand. The aim of the project is to make it possible for inland terminals to assist the Port of Gothenburg with e.g. warehousing, documentation and in some cases customs clearance (Port of Gothenburg, 2009).

Within rail transportation, wagon loads have historically been the most frequent load carrier. After the invention of the container more and more goods transported on rail is loaded in containers. The area where containers are most frequently used is within intermodal transportation, where they are easy to transfer between the different modes involved in the transport chain. The amount of cargo that is transported in containers has been growing extensively the past years, much due to improved planning and control systems. This growth gives room for an increase of intermodal transports. In Sweden containerization has lead to an increase in intermodal transports and in feeder transports to and from the harbor. Between 2001 and 2007 the intermodal traffic increased with 63% (Nelldal & Wajsman, 2008).

It is clear that the intermodal sector is gaining ground; the focus on transports has increased from both government and industry. We have seen containerization changing the settings for the transport market and today the logistic network is under constant development, introducing Railports and rail shuttles. This progress raises potential for the development of a sustainable transport sector. Rail transport combined with road traffic is a promising way to achieve this.

2.1 Background

Historically seen rail transport has lost market shares in favor of road transports. This is mainly explained by the higher efficiency of road transports. In Sweden there is a history of allowing long vehicles that has benefited road transports. At the same time as road transports has faced technological progress and fast development the railway has faced problems (Lundqvist, 2007, Nelldal & Wajsman, 2008). This has resulted in that the market share for railway has been cut in half, at the same time as the transport sector has grown with 75% during the past 25 years.

The increased awareness of the environmental and climate effects the transport sector is responsible for has increased the demand for more sustainable intermodal road-rail solutions. The market share of intermodal transport in Europe was in the year of 2000 between 2 and 4% (Bottani & Rizzi, 2007). However the market share of intermodal transports has started to grow in Europe, between 1990 and 1996 the average annual growth in ton kilometer was 9.3%. It is believed that intermodal transports have a potential of 30% of the market share in Europe on the most developed logistical areas.

Even though a growth in intermodal transports has started to take place, there is still one transport segment where intermodal transports are weak; this is the segment of short distance transport. Intermodal road-rail transport is believed to be most efficient in large flows over long distances. It is among others the pre-and post haulage (PPH) costs that need to be offset by longer distances. When the distance decreases PPH becomes more crucial. It was reported in 1998 that the break-even distance for domestic rail transports is 350km with both pre-and post haulage. (Bärthel & Woxenius, 2004). Shorter distances are more sensitive to pre-and post haulage costs and other transshipment costs than long distances; this is because these costs have a greater proportion of total costs on shorter distances (Bontekoning & Priemus, 2004).

Intermodal transports are considered to have big growth potentials, especially as mentioned above, in areas with short distances but also in small consignments and flows demanding speed and reliability. In 2001 75% of the freight in Northwest Europe was moved over distances shorter than 150km, in these markets road transports are competing in speed and reliability. In this segment, where road transports benefits from their speed and reliability, the cons with rail transport becomes evident. Today rail transports are considered to be weak in areas such as frequency, availability, reliability and time. The rail service needs to improve both costs and quality to be able to compete with road in certain segments (Bontekoning & Priemus, 2004).

In order to gain these market shares, innovative actions need to be taken that can increase the potentials of this segment. Aspects of loading and unloading has been investigated on how to make this process more effective, but the pre-and post haulage part is still not very explored.

2.2 Problem Discussion

It is a fact that the interest for intermodal transports has increased together with an increased environmental consciousness, and there is potential for growth in this sector. Despite this there are however some obstacles in the way. In order for intermodal transports to be able to compete in short distances the cost and quality parameters need to be fulfilled.

Sweden has a tradition of long vehicles and an extensive work has been made to strengthen roads and bridges to make it possible to allow 25.25m and 60 ton vehicles (Lundqvist, 2007). In Europe today there is an intensive debate in whether to allow longer vehicles, the limit today for European vehicles is 18.75m. The discussion in Sweden is one step further than this; for several years 32m trucks have been driving for in the Port of Gothenburg. Another project started in January 2009 called "En Trave Till" (ETT), allowing 30m long lumber trucks in Northern Sweden. These trials have resulted in research about the external effects from longer vehicles. So far they have proven to be cost efficient with lower CO₂ emissions (Arkiv: Åkeri & Transport, 2008).

As stated previously the pre-and post haulage costs are important in short intermodal distances. The concept of long vehicles, or double haulage (i.e. driving with 2x40ft containers) might be used to increase the competitiveness of intermodal transports on short distances. There is however some considerations that need to be taken into account when approaching this concept. Environmental aspects together with economical costs must be assessed. Other aspects concern the safety on the road and limitations in the usage of these long vehicles. Such limitations are exemptions and traffic regulations allowing the vehicles to traffic public roads. Since the introduction of double haulage is not intended to replace or directly compete with rail freight, but to complement it, it is important that the utilization is controlled.

2.3 Purpose

The aim of this paper is to investigate how intermodal freight transports can be made more efficient in the cooperation between road and rail, and how they can be made more environmental friendly. The focus will be on the short distance segment; the characteristics and potential of this segment makes it very interesting for research. The concept of double haulage will be introduced and further evaluated as a means to improve the pre-and post haulage part of intermodal transports. An illustrating example in Skaraborg will be used in order to show potential benefits from the double haulage.

2.4 Problem Formulation

How can double haulage, in the pre-and post haulage, support intermodal road-rail transport?

In order to answer this rather general question three sub-questions are formulated that will set the research focus:

1. What are the economical and environmental effects from double haulage in the pre and post haulage?
2. What are the societal effects from introducing double haulage?
3. How does the process of being granted exemption for extra long and/or heavy vehicles look?

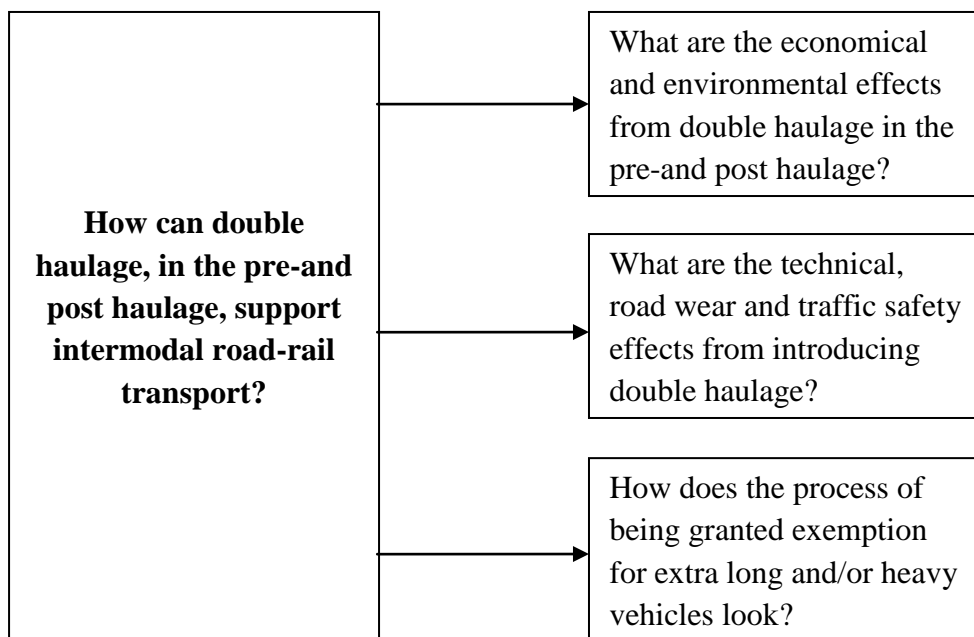


Fig. 1 Research Problem

The first sub-question is answered through a case study where economical and environmental effects are calculated. The second question contains societal aspects such as traffic safety, road wear and technical aspects of the concept. Information is collected from existing studies, research and through interviews. The third sub-question is answered with help from available information on websites together with interviews with the decisions makers and people that have an exemption or waiting for a decision.

2.5 Limitations

Throughout the entire paper it is Swedish conditions only that are taken into consideration and analyzed when it comes to legislation, costs, road standards etc.

Only the possible effects of double haulage presented in the research question will be investigated. There are likely additional aspects one needs to consider, but they are out of the scope of this research.

3 Methodology and Research Design

3.1 Information Need

Theory concerning intermodal transport, long vehicle combinations and exemptions for extra long and/or heavy vehicles was a starting point. Theory has been found in textbooks, reports, articles, information pamphlets and further information thru mail correspondence and interviews with key persons concerning the transport system.

3.2 Data Collection

The data collection process started with the collection of background information. This information was gathered from scientific articles found in databases such as Business Source Premier and consisted mainly of general information about intermodal transports. Both articles from Sweden and Europe were collected, US articles were not chosen. This was because the rail structure in USA differs a lot from Europe and research from the US market wouldn't be applicable in our case. Input data for the calculation example was gathered as well. Data needed was emission parameters from the NTM framework, distances and goods volumes.

The second step in the data collection concerned information about transferring goods from road to rail, both from a historic perspective and future development. In addition, reports about long vehicle's effects on environment and society were collected. The following step concerned information about the regulatory framework for long vehicles; lengths and weights allowed and requirements for exceeding these regulations. In this stage the different interview objects where contacted. Our contact at SRA informed us about the exemption process and suggested us to contact STA, the new agency where traffic regulations are administrated.

The figure below illustrates the different areas for which information where gathered and how the information search process developed.

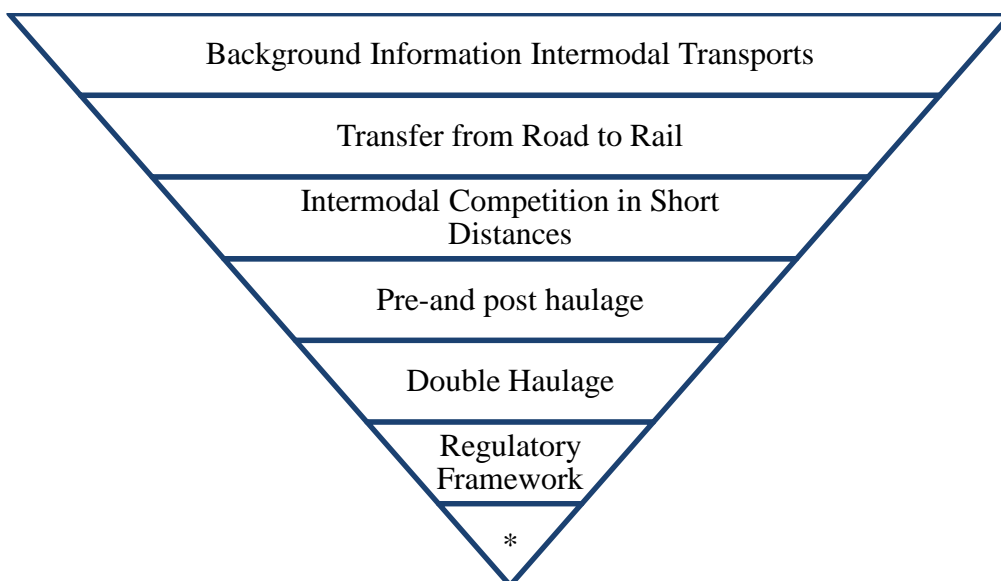


Fig. 2 Information Funnel

3.2.1 Interviews

The persons considered having expert knowledge about the subject where approached by phone or via e-mail. Pre-prepared questions where used mainly as a guideline and the aim was to have the respondent speak rather freely, only guided by a few questions. The whole interview was recorded with a recording device.

The following persons were contacted:

Tomas Arvidsson	PGF Transport, Vaggeryd
Lennart Cider, Lena Larsson	Volvo Technology, Gothenburg
Thomas Holmstrand	Swedish Road Administration, Gothenburg
Anders Lundqvist	Swedish Transport Agency, Borlänge
Lars Berndtsson	GA Åkerierna, Tjörn
Stig-Göran Thorén	Port of Gothenburg

Tomas Arvidsson, PGF Transport

When PGF was contacted they were in the middle of the decision process for an application for a traffic regulation. Therefore it was interesting to contact them and see their perspective on the matter. Arvidsson was contacted at several occasions as updates from the decision process were received. The goal with the interview was to retrieve background information about the regulation application and to follow the process. The contact with Arvidsson has taken place via e-mail or telephone.

Lennart Cider and Lena Larsson, Project Coordinators ETT, Volvo Technology

Cider and Larsson were contacted due to their involvement in the ETT-project. The interest in ETT comes from the longer vehicles used and the exemptions and traffic regulation needed. The goal with the interview was to find out more about the background of the project, how the exemption process has looked and some technicalities related to this kind of vehicles. The interview took place at the Volvo Technology premises in Chalmers Science Park in Gothenburg.

Thomas Holmstrand, National coordinator Abnormal transports / Public Transport and Commercial Traffic, Swedish Road Administration

Holmstrand was contacted in order to gain information about the regulations that exist concerning traffic exemptions today. The purpose of the interview was to gain further information about the decision process for exemptions and to find out more about the SRA's policy towards longer vehicles. Another aspect investigated was if the decision process has changed during the past years. The meeting with Holmstrand took place at SRA's premises in Gothenburg.

Anders Lundqvist, Head of Commercial Transports, Swedish Transport Agency

In January 2009 the system for transport exemptions changed and a new agency was created, the Swedish Transport Agency. Lundqvist was contacted in order to gain information about how the new organization functions. The goal with the interview was to see how STA works with traffic regulations and to see how the attitude

towards long vehicles is. Due to the fact that STA is located in Borlänge, this interview was conducted via telephone.

Lars Berndtsson, CEO, GA Åkerierna

GA Åkerierna has been driving 2x40ft container vehicles for several years in the port of Gothenburg. They were contacted in order to gain information about the more practical and technical aspect of the long vehicles and to see if there have been any problems associated with this concept. The interview took place at the GA premises on Tjörn.

Stig-Göran Thorén, General Manager Business Area Rail, Port of Gothenburg

Thorén was interviewed to gain information about the rail shuttles going to and from the port of Gothenburg and the development of Railport Scandinavia. The goal of the interview was to see how the division of containers looks like and how the harbor sees the future of rail usage, if there are any changes expected for the future. The interview took place at Handelshögskolan Gothenburg.

3.3 Analytical Method

In the analysis all theories, respondent information and model calculations are compared and discussed to find relations, connections or disparities. Thanks to interviews with respondents from separate areas their answer together could give a good overall picture of the subject.

In the analysis focus is on bringing the separate sections together and using the information for answering our research questions. The focus was once again turned towards our research questions and by analyzing the sub questions an answer for the main question was searched.

3.4 Reliability

Double haulage as a concept is still rather unexplored, therefore an open approach has been applied. This means that the authors didn't have experiences or knowledge before the research started that might have affected or biased the research process. This open approach has made it possible to adjust the research as findings have emerged; this has been necessary considering the little knowledge that was held on beforehand. In line with this the interview objects evolved during the process; one interview led to further contacts and additional interviews.

The interviews were recorded using an MP3 player, the average interview time was between 45-60 minutes. The recording made the transcript process much easier and the possibility to double check answers made the transcripts more reliable. The interview objects' reliability is considered to be high. This is explained by the fact that the persons interviewed are well informed in their area of expertise and there is no sensitive information or arbitrary situations that might encourage unreliable answers. In cases when possible it has been preferred to meet the respondents in person rather than interviewing over the telephone. This is explained by the

unstructured interview guides and that is it considered easier to have an open conversation with the respondents in person compared to over the phone. The possibility that the interviewer affects the respondent is regarded to be low and outweighed by the positive effects of conducting the interview face to face. The interviews that have been conducted over telephone have been done so because of geographic distances. All interviews have been conducted in Swedish and then translated to English. The interviewees have been given the opportunity to read the English manuscripts in order to avoid translation mistakes.

3.5 Validity

In order to cover the problem from many different angles the interview objects were gathered from many different parts of the exemption process. This was made so that the same question would be viewed from many different perspectives; the decision makers, the ones who will be affected by a decision and the ones waiting for a decision to be made.

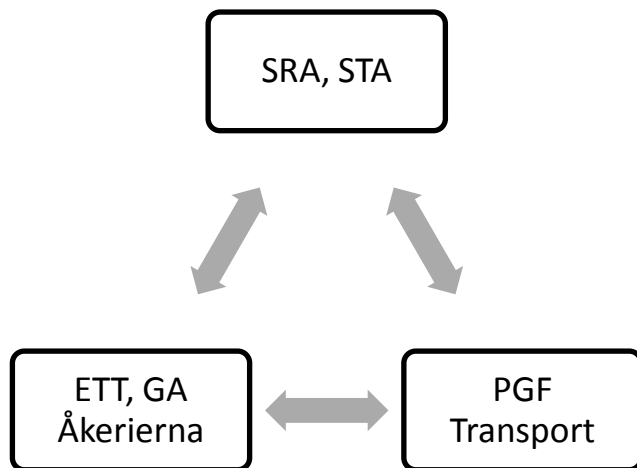


Fig. 3 Triangulation

Project ETT, PGF Transport and GA Åkerierna are all involved in the practical side of the decision process for traffic regulations, however PGF Transport is still in the process of being granted exemption. Most of the inquiries and questions concerning exemptions and regulations come to SRA and from there matters of divisible loads are directed towards STA which connects all these actors with each other. In this way all areas of exemptions, regulations and long vehicles were covered. Information about the decision process was gathered both from the ones taken the decisions and from someone waiting for a decision. Together with this the technical aspects of these vehicles were covered as well, both from policy and government perspectives and from people who works with these vehicles daily.

Interview objects were chosen with consideration to their involvement and experience of double haulage or long vehicles. After having written down the interviews, the manuscripts were sent back to the respondents so that they could check the answers. This was made to increase the validity of the transcripts and make sure that no misunderstandings during the transcript process have taken place.

3.6 Thesis Outline

In chapter 4 and 5 relevant theories and information about intermodal and its characteristics is presented and the different sources are put in contrast to each other. In these chapters the information comes from secondary sources such as articles, books, statistics, web pages etc.

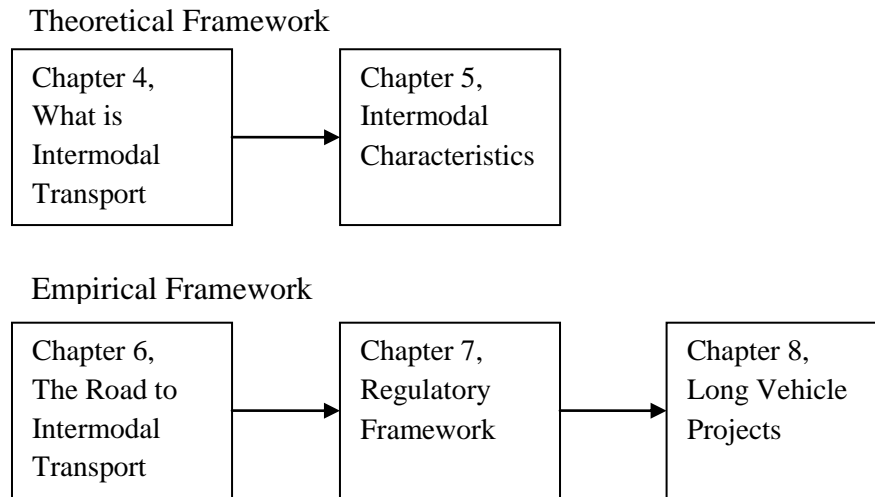


Fig. 4 Thesis Outline I

Empirical information gathered from the interviews is presented in chapter 6, 7 and 8. Chapter 6 explains the basic regulation admitting long vehicle and in chapter 7 focuses is on the rules and regulations associated with driving with long vehicles and also give an example of an exemption process. In chapter 8 a few examples where long vehicles are used is presented. The different examples are at different stages of the exemption process. In this section primary data is mixed with secondary data to provide an accurate overview of the different topics and examples.

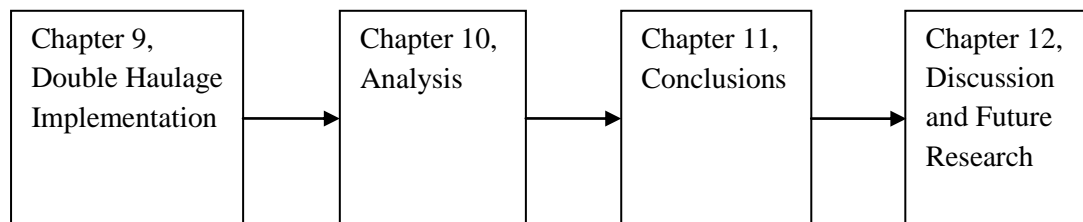


Fig. 5 Thesis Outline II

In chapter 9 Double Haulage as a concept is further discussed and the investigated case is introduced. Both results and several tests are displayed. In chapter 10 an analysis is presented, theories are compared to the empirical research as well as with the results discussed in chapter 9. Conclusions are given in chapter 11 and then follow a discussion concerning the results and future research in chapter 12.

4 What is Intermodal Transport

Intermodal transport is the movement of goods, with at least two transport modes used successively, in the same loading unit and without touching the goods themselves while switching between modes. Stone (2008) claims that intermodal transport, i.e. road and rail, are not designed to complement one another, in fact they are more designed to compete against each other. This causes problems when one wants to interconnect the modes in an intermodal freight network (Stone, 2008).

The modal split between road and rail in Europe 2006 showed a share of 45.6% for road and 10.5% for rail (European Commission, 2007). Analyzing overall freight growth, road transports have had an annual growth between 1995 and 2006 of 3.5% compared to 1.1% for rail. However looking only at the growth between 2005 and 2006 shows a road transport growth of 4.9% compared to 5.2% for rail. The transport work (in million ton kilometers) on Swedish railways 2006 was calculated to 22,271. The same amount for 1998 was 19,163. Transport work for domestic road traffic in 2006 was 35,455 million ton kilometer (SIKA, 2007). Intermodal transports have around 4% of market shares of total transport work in Sweden today (Trafikuskottet, 2007).

4.1 The Development of Intermodal Transport

Around the middle of the 20th century trucks began to be competitive with trains even for longer distances and trucks took over goods that used to be transported on rail. This forced the railroad to develop to remain competitive and intermodal transports were taken into use. With the invention and introduction of the container in the 1960's, intermodal transport development began to take off. With the container the degree of globalization rose and goods could now be transported all over the world and easily be transferred between modes. The container was an efficient intermodal tool, especially for the sea leg of a transport chain where the containers provide a good utilization rate for ships (Nelldal, Bark, Wajzman, & Troche, 2005). The container made it, as mentioned above, easier to move goods in one and the same loading unit between modes; however it is not until recent years that the use of the container has increased on rail. The reason is said to be that the handling costs were too great compared to the operational costs. Still the containerization assisted the development of intermodal transport since the containers were easy to use on rail, truck and sea and also during warehousing due to the possibility to stack them on top of each other. There are nowadays much more different goods that are transported in containers compared to when the container first was introduced. This is one reason why rail had to expand its use of containers for intermodal transports and this expansion is one reason why intermodal transports increased with 63 % between 2001 and 2007 in Sweden (Nelldal & Wajzman, 2008). In 2004 the amount of goods transported with intermodal transport reached an ever high level of 6.2 million tons in Sweden. This goods flow is concentrated to certain routes, many going to and from the port of Gothenburg, where infrastructure concerning tracks and terminal

WHAT IS INTERMODAL TRANSPORT

areas is enough developed to cope with the time and quality parameters that is set up for intermodal transports (Nelldal, Bark, Wajzman, & Troche, 2005).

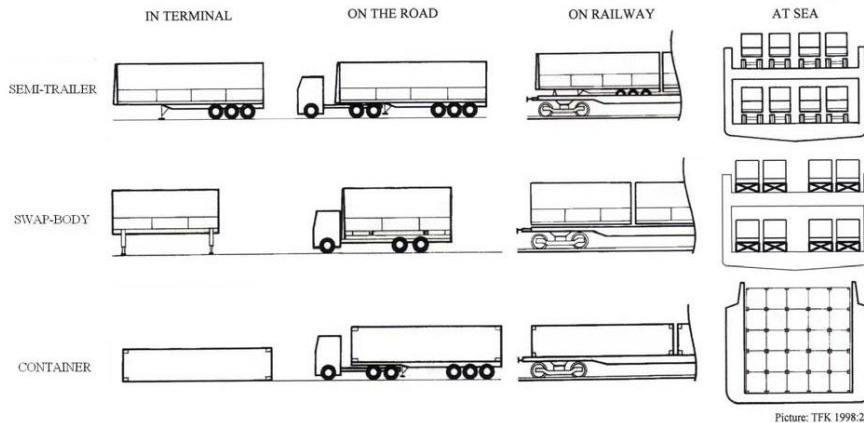


Fig. 6 Load carrier, Åkerman & Jonsson, 2007, p.50

In the figure above a schematic view of the most common load carriers; semitrailers, swap bodies and containers are shown. Illustrated is also how they fit on road, rail and ship and how they can be handled when being in terminals. Containers provide the best cargo utilization onboard ships while swap bodies and semitrailers is seen to have better fill rates for road vehicles, at least with the current length restrictions on road (Åkerman & Jonsson, 2007). Each load carrier and the difference between them will be further explained in section 5.3.

Nelldal et al (2005), describes different intermodal systems where light intermodal systems is said to be the best solution for short and medium long distances. The idea behind light intermodal systems is that the train shall carry a forklift with it that is able to load and unload all load carriers that are carried by the train. The most common load carriers for such a solution are containers and swap bodies. Terminals can be run without crew but needs to be located on side tracks to ease load and unloading which can be done by the train driver. Besides being more efficient on short distances the light intermodal system also offers a good solution to work as a shuttle carrier for intermodal systems on longer distances (Nelldal, Bark, Wajzman, & Troche, 2005).

One problem for intermodal transports is that terminal costs and feeder transports are expensive and this makes it hard to gain market shares. It is suggested that investments in big terminals, Freight Service Centers, and small terminals are needed to make intermodal transports more competitive. It is very important that investments in smaller terminals aren't forgotten. Further, terminal technologies need to be developed such as fully automated transfer of containers between rail, road and sea (Traffic Committee, 2007). British research shows some barriers to development of rail freight; extra time for transshipping, inflexibility and diversity of origins and destinations. In order to increase rail freight, active decisions need to be taken, encouraging a modal shift is not enough but an interchange between freight transport policy and spatial planning is needed to develop a rail-based intermodal

WHAT IS INTERMODAL TRANSPORT

environment. Some driving factors benefiting rail freight can be identified; increasing congestion on roads leading to decreased reliability, a shortage of drivers and environmental costs. It is important that the transshipment from road to rail is quick in order to maximize the cost savings per km achieved for rail freight (Boodoo, 2005). Another problem identified in intermodal transports, especially the international segment, is the lack of integration between IT systems. In intermodal transportations the information need is vital for optimizing loading, trucking, train loading and terminals and it needs to be correct. The failure from railways to handle this has been a main problem for intermodal effectiveness (Stone, 2008).

To ensure a more time- and cost-efficient intermodal transport chain the pre and post haulage need further development. It is believed by many that the next step in developing road freight transport is the implementation of 32m vehicles. When investigating the effects of 32m long vehicles, Scandinavia is a good place to start due to the calmer traffic conditions and more space. A 32m truck has already operated in the Port of Gothenburg for several years. The environment benefits from longer but fewer trucks, there are no doubts that the fuel consumption per ton kilometer will decrease claims Lars-Göran Löwenadler, Volvo. One objection to longer vehicles is that they are harder for other road user to pass, but there is no research proving this point (Sandblom, 2007).

5 Intermodal Characteristics

5.1 Transfer of Goods from Road to Rail

A time series analysis of road and rail transports during the last 30 years shows no indications that road and rail steal transport volumes from each other. Not even during periods when it is known that major cost-affecting changes took place. The research indicates that road and rail are good at different aspects and that the competition between them is affected by this. This further implies that changes resulting in moderate changes of competitiveness cannot outweigh the comparative differences. The effects of higher prices on road transport would have on the railway is investigated by VTI; the results show that railway operators would benefit more from following the price increase than by keeping the price low to gain market shares. In certain goods categories road transports have won market shares from rail transport, this can be explained by both an increased amount of goods but more importantly it is explained by the increased distances with road transports. Trucks have gained competitiveness over rail in longer distances (VTI, 2008). Due to the fact that most goods transported on truck today have earlier been transported on railway, it is believed that it can be transferred back to rail again (Nelldal & Wajsman, 2008). The same is assumed for the newly generated goods; it can be transferred to rail though the characteristics of the goods are the same.

In the development of freight transports it is believed that the truck will benefit from an increase of concepts like JIT. The centralization of warehouses might benefit rail transports when longer and heavier transports are needed. The possibility to transfer goods from road to rail might decrease as the competition from foreign haulers will lower the prices for road transports. Another advantage for rail transports might be a higher demand from customers on environmental friendly transports. Technical improvements in intermodal terminals such as automatic horizontal transfers of load units would increase the efficiency; then the trains and trucks could arrive in the terminal independent of one another and during all hours, which would make it easier to optimize the traffic system (Nelldal & Wajsman, 2008).

The railway has lost market shares due to the rapid development of the truck sector and the due to problems within the rail sector. In the beginning of the 1990's the gross weight of the road vehicles was raised from 51 tons to 60 tons, increasing efficiency with almost 30%. The increase of road traffic can, in addition to heavier and longer vehicles, be explained by infrastructure investments and an even and high transport standard (Nelldal & Wajsman, 2008). Given the fact that 92% of the amount of goods (60% of transport work) are performed on distances under 300km, and it is assumed that railway is competitive at distances over 300km, the railway companies compete for about 8% of the amount of goods transported and 40% of transport work (2005 year's figures) (VTI, 2008).

There are other aspects one need to consider before transferring goods and one is that the railway network today is very crowded and it is hard to find place for new freight

trains, especially in Gothenburg and Stockholm (VTI, 2008). One suggestion to create more space for freight trains is the development of the passenger freight network to a fast train network, which would release space on the railway. If no investments are made in the railway net international truck traffic would increase to 13 000 trucks per day. This can be compared with 60 freight trains instead, if investments are made in the railway net there would be 3 trains per hour instead of 150 trucks (Traffic Committee, 2007). Around year 2000 an incentive to increase the axle load on railways was started, this incentive is believed to benefit freight transports on railway. The axle load is increased from 22.5 ton to 25 ton on parts of the railway net.

5.2 Quality Characteristics

Rail traffic has traditionally had problems with quality parameters, when it comes to cost it is competitive but there are problems regarding quality (Traffic Committee, 2007). To consider railway as an alternative to road the transport buyer requires a high enough service quality. The fact that road transports are likely faster than rail, implies that the railway transport goods of lower value since higher value products can bear higher transport costs. The service must be improved to be able to compete for high-value goods and perishables so that rail services can compete in speed and reliability in these markets. Transport buyers define cost and quality as the most important parameters, but even environment is growing in importance when choosing transport mode (Nelldal & Wajzman, 2008). It can be said that first some basic requirements concerning delivery security, frequency and transport time need to be fulfilled, when this is done price becomes a competitive factor. When it comes to small shipments over short distances road transports are often the only option (VTI, 2008). The cons with intermodal transport in short distance markets are considered to be mainly frequency, availability, reliability and time (Bontekoning & Priemus, 2004). For short distances the rail service needs to improve both costs and quality. Pre-and post haulage, end-haulage and transshipment costs need to be reduced.

A main obstacle identified for the development of short distance intermodal rail services is the unfavorable traction rates compared to long distance services. Other obstacles are inappropriate infrastructure for intermodal services at terminals and the access to infrastructure for short distance services. A suggested action to promote intermodal transports feasible in short time is to adjust the freight train rates in accordance to the distance they are operating (Tsamboulas, 2008).

Shorter distances are more sensitive to pre-and post haulage costs and other transshipment costs than long distances, this is because these costs have a greater proportion of total costs in shorter distances. There are many researchers investigating how to make the intermodal transport more effective, these innovations consist of both an organizational and a technical dimension. Many intermodal operators try to combine a favorable cost-quality aspect of block-trains in shuttle

systems with the higher flexibility of bundling wagons as in a hub and spoke system (Bontekoning & Priemus, 2004).

5.3 Load Carriers

When it comes to the choice of load carrier for intermodal transports the choice depends on parameters such as the characteristics on what is being transported, time sensitivity, quality and reliability demands.

For rail the difference between wagon load and intermodal transport is mainly the size and measurements and therefore also the weight and type of cargo that can be transported. Wagon loads are able to carry up to 64 ton with a capacity of 168 square meters while intermodal transports (road-rail) are divided into different load carriers, with a combined capacity of approximately 40- 60 tons and 100 square meters per wagon. This difference in size and weight gives rise to an uneven competition situation between wagon loads and intermodal transport. However when goods are transported to harbors for further transport on rail or by sea, the situation improves for intermodal transport. The goods only need to be transported with trucks to the rail terminal at one end of the system because in the other end the containers or trailers will be loaded onto a ship or put for warehousing such as in the Port of Gothenburg. Concerning the load carriers used for intermodal transport a general split can be made into containers, swap bodies and semi trailers. There was quite an even distribution between the three concerning total transport works in 2004, with a slightly higher percentage for containers (36%) and swap bodies (34%) compared to semi trailers (30%) (Nelldal, Bark, Wajzman, & Troche, 2005). It is believed ISO containers, swap bodies and trailers all give lower load efficiency on train, but are despite this the most desirable and realistic units for domestic trade (Stone, 2008).

Containers

Containers are standardized according to ISO standards to suit trucks, trains and ships. The standardized measurements of containers are 20ft (1 TEU), 30ft, and 40ft long and they are all 8ft wide. The height of a container differs between 8, 8.5 and 9ft high. However containers are available in more shapes and sizes. In 2004 the 20ft container was used for approximately 50% of the transport work in Sweden. The maximum load weight of a container depends on the size of it, for 20ft the load weight is 21.6 ton and for 40ft its 26.5 ton. Normally a railcar fits 2x20ft containers, all other sizes need a separate railcar. The standardized sizes of containers make it possible to stack up to six fully loaded containers on top of each other. Empty trips as a part of the total transport work were 19% for land transports and 13% for transports going to ports, in 2004. This can be seen as the containers are more efficient used for international transports compared to domestic land transports.



Fig. 7 Container, Åkerman & Jonsson, 2007, p.13

Swap bodies

Swap bodies is built up from a frame which usually has a construction in addition to it, often in the shape of a container or a lorry platform. Swap bodies need to be able to be connected and separated from the vehicle. When separated from a truck it is often placed on supporting legs in the correct height for a truck to pick it up. The size and weight measurement of swap bodies doesn't follow certain standards in the same way as containers but are modified to fit the size regulation of road transports. Empty trips as a part of the total transport work were 5% in 2004 for land transports and 2% for transports going to ports.

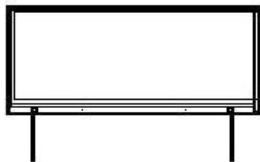


Fig. 8 Swap body on supporting legs, Åkerman & Jonsson, 2007, p.17

Semitrailers

Semitrailer is a load carrier which has its own set of wheels, often two or three axles, and can be connected with a trailer hitch to a truck. The maximum length of a semitrailer is 13.6m. Semitrailers can be lifted or rolled onto a railcar or aboard vessels. When transported on rail there is a need for special railcars otherwise the height limit is exceeded. A flat bottomed railcar or railcars with special build-in pockets for the trailers wheels are often used. Size and weight limitations are, as swap bodies, limited by regulations for road transports. The empty trips as a part of the total transport work were 3% in 2004 for land transports and practically nothing for transports going to ports.

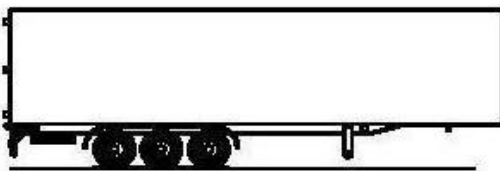


Fig. 9 Semitrailer, Åkerman & Jonsson, 2007, p.17

Trailer

Trailers are more common in Sweden and Finland compared to rest of Europe due to the length restriction within Europe. Maximum length of a trailer is 12m but it is also

available in shorter lengths which combined with other load carriers can reach the EMS (European Modular System) maximum length of 25.25m (in Sweden and Finland).

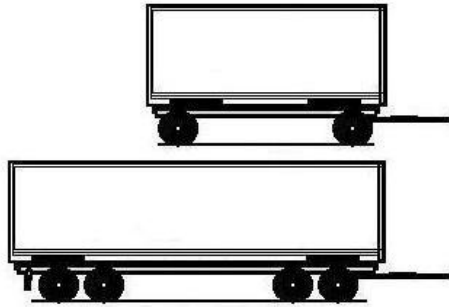


Fig. 10 Trailer, Åkerman & Jonsson, 2007, p.18

Truck and Tractor

The trucks that are used for the feeder part of the intermodal transport chain are the same kind of trucks used for regular door-to-door transports. As long as the engine strength is strong enough to carry the load any truck could be used for the road part. What is preferable is a truck with as high Euro classification as possible in order to reduce the level of emissions.

A tractor is meant to tow different load carriers such as semi trailers or links, which means that a tractor itself has no load carrier.



Fig. 11 Tractor, Åkerman & Jonsson, 2007, p.18

In contrast to a tractor a truck can also be equipped with a load carrier. Trucks are usually equipped with towing devices to be able to connect a further load carrier.

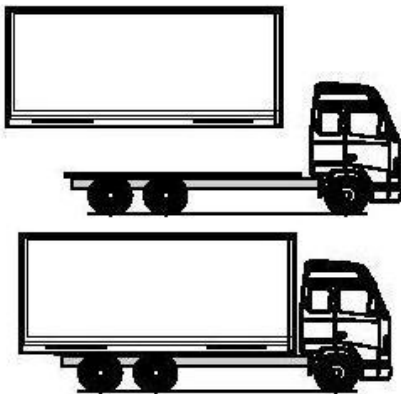


Fig. 12 Truck, Åkerman & Jonsson, 2007, p.18

One problem when it comes to intermodal transports on road and rail is that the load carriers are poorly developed to work efficiently between the modes. Equipment is adapted to cargo and road freight, not to railways. This is seen today with a wide range of semi trailers and swap bodies adapted to cargo and to maximize utilization of the road vehicle. They all require appropriate railcars when transported on rail.

Link

A link is a vehicle used to couple a semi-trailer to a tractor while at the same time being able to carry a swap body or other load carrier.

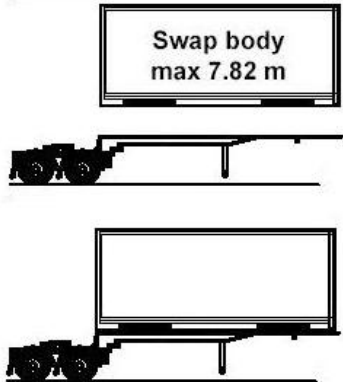


Fig. 13 Link, Åkerman & Jonsson, 2007, p.15

EMS European Modular System

The European Modular System is based on certain standards that can be connected in various ways. Within EU a short trailer can be connected to a truck without breaching the length limitation of 18.75m which is illustrated below.

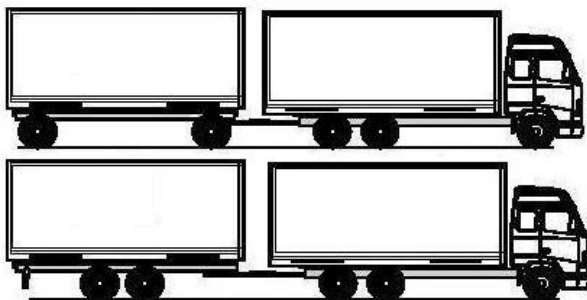


Fig. 14 EMS EU, Åkerman & Jonsson, 2007, p.17

However in Sweden and Finland where the length is limited to 25.25m a truck can be coupled to a semitrailer. Two different ways to achieve good length utilization is shown in the figure below where a semitrailer is connected via a dolly to a truck and in the second alternative a link is used instead of a dolly.

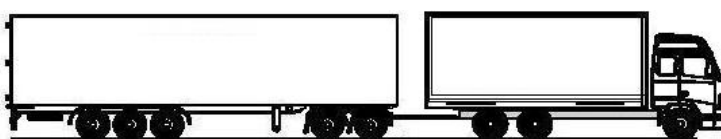


Fig. 15 EMS Dolly, Åkerman & Jonsson, 2007, p.16

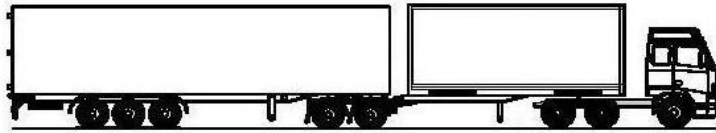


Fig. 16 EMS Link, Åkerman & Jonsson, 2007, p.16

The same utilization can also be seen in the figure below where a tractor tows a semitrailer and a short trailer.

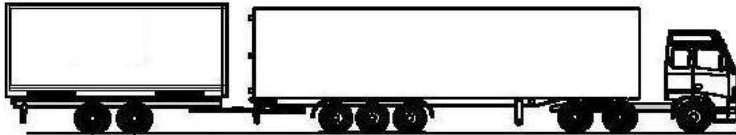


Fig. 17 EMS, Åkerman & Jonsson, 2007, p.16

Thru the modular system (EMS) Sweden and Finland has made it possible to drive with 25,25m long vehicles while the rest of Europe has a length restriction of 18,75m. Both these systems are constructed by the same building bricks and in accordance to EG directive 96/53 and therefore the system can be used even when crossing borders as long as the length restrictions are kept. Sweden and Finland can by utilizing the different standards of the EMS, and by using two trucks, be as efficient as other parts of Europe needing three trucks. As illustrated in the figure below.

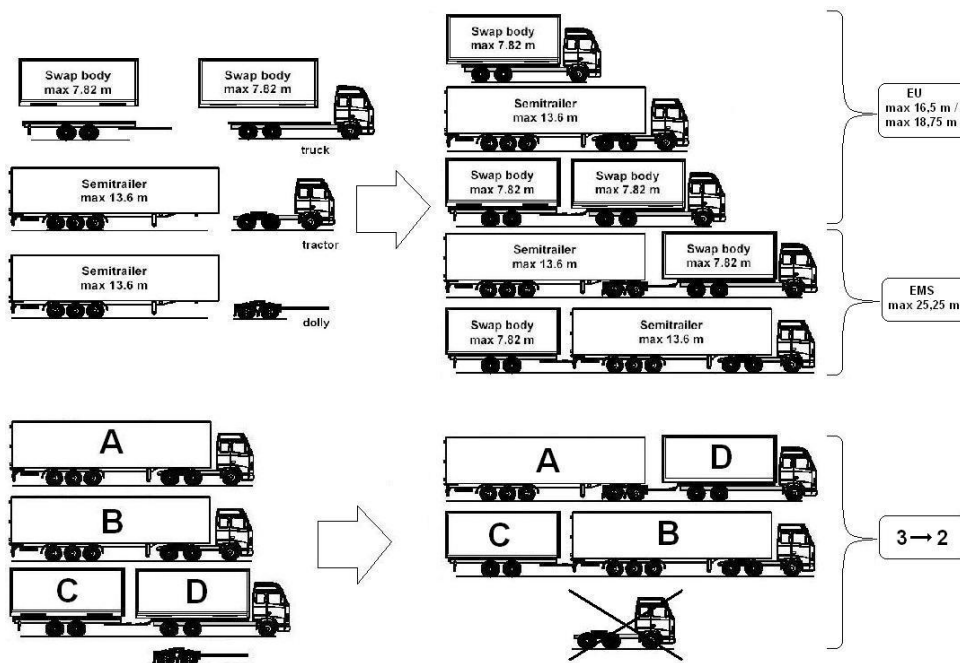


Fig. 18 EMS System, Åkerman & Jonsson, 2007, p.1

As shown in the figure above the EMS standards, which is represented as A, B, C and D, provide that three trucks easily can be replaced with two trucks when crossing

border into Sweden or Finland and still be able to transport the same amount of load carriers.

A further development of the EMS standards gives room for even longer and heavier vehicle combinations, examples of which is shown in the figure below.

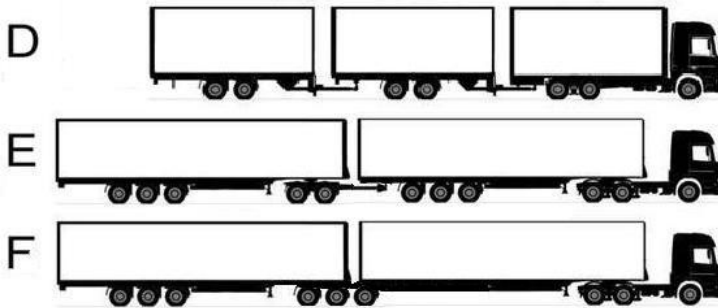


Fig. 19 Possible future combinations, Åkerman & Jonsson, 2007, p.69

By increasing the length restriction on road with a few meters combinations D, E and F would be possible. E and F are the most interesting combinations for this paper. And as an example combination F above is to be compared with the project running in the Port of Gothenburg, where 2x40ft containers are transported at the same time. EU directive 96/53, together with national and regional legislation, would need to be updated for these combinations to come true at a European level. However there is an opening to use such combinations shown above as trials or for local transports which does not affect the competitive situation on a higher level (Åkerman & Jonsson, 2007).

6 The Road to Intermodal Transport

The rail shuttle system from the Port of Gothenburg has proven to be a big success since it was first launched. In 2004 the transport work from intermodal transport was around 4%, the increase that has been seen in later years is attributed to the rail shuttle success (Mellin & Vierth, 2008). The figure below shows the development in intermodal transports in Sweden.

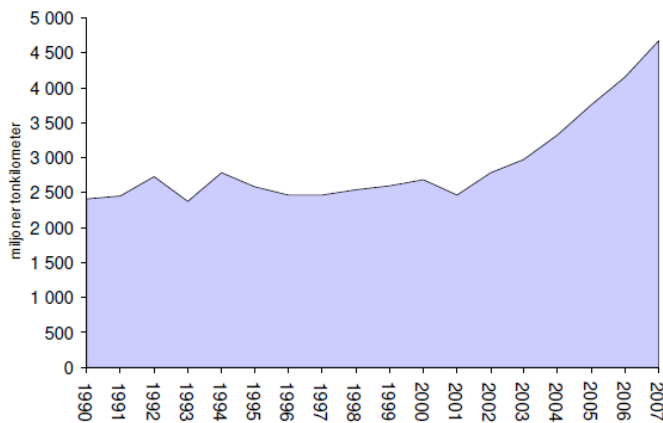


Fig. 20 Transport work intermodal rail transport in Sweden (SIKA Statistik 2008:29, p. 19)

6.1 Railport Scandinavia

Railport Scandinavia is a rail shuttle system where the basic idea is a good cooperation between the Port of Gothenburg, the Railport terminals, several rail operators, goods owners and the Swedish Rail Administration. The rail shuttle system can be compared to public transport, but is a service for goods and this makes the system highly dependent on the quality of performance. The concept of Railport Scandinavia aims at improving the flow thru the harbor in more efficient ways. The inland terminals, Railports, can also be used for storage and customs clearance. The main flows of goods transported on the rail shuttled are destined for export or of course import going from the harbor destined to various locations in Sweden (Thorén, 2009).

The Port of Gothenburg aims at developing the rail shuttle system further, the goal is to grow with two new shuttles each year. There have been tremendous developments over the years and currently approximately 55% of all the container traffic in the port is handled on rail. The shuttle system spans over 23 different locations with a total of 25 trains departing. What limits the growth of the shuttle system is, besides physical limits of the area of the harbor, the length restrictions on Swedish railroads. The standard in Sweden is set to 630m long trains however all investments in infrastructure are made to coop with trains being up to 750m long. The best way to achieve growth is therefore according to Thorén (2009) to increase the flow of containers thru the harbor and to increase efficiency on current trains. The external limitation of the infrastructure is the responsibility of the Swedish Rail

Administration and not the Port of Gothenburg (Thorén, 2009, Port of Gothenburg, 2009).

When handling various containers one thing can be determined, handling only 40ft containers would be easier than only 20ft or a mix of the two. Therefore only 40ft can be seen as the preferred choice and would lead to an increase of efficiency concerning flows through the harbor. Within the harbor a system of calculating units instead of TEU or similar is used. There are a large number of different container types even though the development that can be seen in the harbor is that there is slightly more 40ft containers compared to 20ft containers. Each unit is given a factor of 1.67 to calculate the number of TEUs e.g. on a train (Thorén, 2009).

Besides the container transport, transporting trailers on train is increasing and the port now offers trailer transport on some of its routes. The short term goal, according to Magnus Kårestedt (CEO Port of Gothenburg), is that 10% of all trailers handled in the Port of Gothenburg shall be transported to and from the port on rail. There are more parameters that need to be considered when transporting trailers on rail compared to containers, such as the need for specialized rail cars, which is mentioned as one of the reasons why this segment has developed in a slower pace than the container segment (Port of Gothenburg, 2009). Trailers are loaded and unloaded in a different area of the harbor and since specialization of the trailers are needed to be able to lift them on the train the handling cost is slightly higher compared to containers. The trailer segment is a bit harder to plan and to distribute due to the fact that trailers don't go between two points but are transported in more complex patterns, where the goods might have several unloading destinations, and is therefore controlled differently by forwarders or carriers (Thorén, 2009).

The shortest shuttle operating from the harbor is only 12km and destined from the harbor to the city. Another of the shorter shuttles is the one destined for Skaraborg and one reason why the short distance segment still can be run without a loss is explained by the time trucks are stuck in traffic jam in connection to Gothenburg, however competition is strong in these short distance segments (Thorén, 2009).

6.2 Long Vehicles – Double Haulage

As stated previously; intermodal transport is facing fierce competition in the short distance segment. One explanation to this is the high PPH costs. Due to the short distance on rail the PPH costs are a high share of total costs. In the introduction the concept of double haulage is presented and explained as simply the movement of two 40ft containers on the same vehicle. The practical feasibility of double haulage will be investigated in a case study and presented further in section 9. There are however several theoretical aspects to consider as well, such as the traffic regulations for vehicles exceeding length limitations and effects on the society such as environment and safety. These aspects will be investigated in the following sections.

6.2.1 Rules and Regulations

There are many rules and regulations controlling the traffic on the Swedish roads. The roads are classified in three different levels, depending on their bearing. 92% of the Swedish roads have the highest bearing (BK1). The lower levels are more common in urban areas. Continuing from this there are weight, measure and axle pressure regulations, which depend on what classification the road has. The following numbers are valid for roads with bearing level 1 (BK1). The first regulation concerns the axle pressure, which cannot exceed 10 ton or 11.5 ton for the leading axle. The bogie pressure (two axles within less than 2 meters) ranges from 16 ton to 20 ton depending on the distance between them. A triple axle has less than 5 meter between the last and the third axle. The maximum triple axle pressure for BK 1 is 24 ton. The highest gross weight is determined by the highest axle, bogie and triple pressures, the highest allowed vehicle weight and the distance between the first and the last axle. Given an example; if the distance between the first and the last axle is 18 meter or more the highest gross weight allowed is 60 ton, given all other regulations followed. The width constraints are 260cm for heavy vehicles and the length 24m (25.25m) (Swedish Road Administration, 2008a). For more information see Appendix 14.1.

In a previous section the European Modular System (EMS) was introduced. This means that since 1997 the longest allowed vehicles in Sweden are 25.25m. This combination demands consistency with the EMS standards. This means that three European standard vehicles can easily be transferred to two 25.25m vehicles. The system is built on the standard lengths of swap bodies and semi trailers. There is however some other regulations that need to be followed; each vehicle needs to have ABS brakes and should be able to turn in an inner radius of 2m and the outer radius of 12.5m (Swedish Road Administration, 2008a).

	Swedish vehicles	European Vehicles
Max. Length (m)	25.25	18.75
Max. Total Weight (ton)	60	40
Max. Load Weight (ton)	36-42	22-26
Max. Volume (m ³)	130-140	85-96
EURO- Pallets	51-54	33-36

Table 1 Swedish and European vehicle measures

The table above shows the difference between Sweden and the rest of Europe in vehicle length, volume and weight.

6.2.2 Road Wear and Safety

When discussing longer or heavier vehicles on our roads, there are some possible effects that need to be investigated beside the potential gains in costs and emissions. In a report from VTI the effects from longer and heavier vehicles are investigated. The background for the report is the longer and heavier vehicles allowed in Sweden (and Finland) compared to the other EU countries. If Swedish vehicle dimensions

were to be set to the same maximum size as the rest of EU (18.75m instead of 25.25m) it is showed that the transport cost per vehicle would decrease but the number of vehicles would increase. In average 1.37 vehicles of maximum EU size would be needed to replace 1 Swedish vehicle of the maximum size. In total the costs for truck transports are believed to increase with 24% (VTI, 2008). According to European research 60 ton vehicles are 12.5% more fuel efficient per ton kilometer compared to a standard European 40 ton vehicle (Transport & Mobility Leuven, 2008). Schenker AB is discussing the benefits of the ability to use 32m long vehicles. The capacity of each truck would increase with 50m³ which would lead to a fuel reduction of 15% per ton. For Schenker this decrease would reduce the number of trucks travelling the distance Gothenburg to Stockholm from 35 to 25 transports per day and the infrastructure wouldn't need investments as long as the total weight is kept at 60 ton (Schenker, 2008).

Road Wear

Road wear is affected by the axle load of the vehicles. To calculate road wear the "power of four rule" is used, this means that if the axle load is doubled the road wear increases by 16. The calculations give a standard number of axles and show how many ten-ton-axles the vehicle corresponds to in road wear. The number of standard axles in an average Swedish vehicle is calculated to 1.3. This in turn gives a standard road wear from a heavy vehicle calculated to 1.3 ten-ton-axles. The results from the research shows that with EU vehicle dimensions, the road wear would decrease. To be noted here however is that this result is based on an assumption of number of axles in the vehicle. Some combinations decrease road wear as well (VTI, 2008). In January 2009 the ETT project was started in Northern Sweden with 30m long lumber trucks weighing up to 90 ton, compared to maximum 60 ton on Swedish roads. According to the project representatives the higher total weight does not affect road wear negatively, instead the longer vehicles give a better distributed axle load that decreases road wear (Arkiv: Åkeri & Transport, 2008).

Road Safety

During the 1970's the effects of the length of vehicles were studied in Sweden. The result showed that the risk was related to length of the vehicle; the consequences was independent of the length but the expected increase in traffic work resulting from shorter vehicles would offset these effects, giving the final result that shorter vehicles would worsen road safety. Since the weight of a vehicle protects the person inside the vehicle, but increases the risks for others involved in an accident, one person killed in a heavy vehicle would result in 13 deaths outside the truck (VTI, 2008). An European investigation regarding the effects of allowing longer and/or heavier vehicles supports the findings that a slightly increased vehicle mass would not decrease road safety (Transport & Mobility Leuven, 2008). The report further shows that the European countries would benefit from introducing the same measures as Sweden; 25.25m long and 60 ton weight.

Another aspect of road safety and longer vehicles would be when other road users want to pass the long vehicle. Long vehicles take longer time to pass and are therefore assumed to be involved in more accidents. It is showed that when passing an 18m long vehicle the time window is 4.5 seconds and when passing a 24m the time window is 4.3 seconds. There is however no material showing that a decreased vehicle length would decrease the cost of accidents caused by passing of other vehicles. The final result shows that a decrease in vehicle dimensions to EU standards would increase the costs for accidents (VTI, 2008).

7 Regulatory Framework

Over the last years SRA has seen a steady increase in the number of exemption applications. They relate this increase to the general increase in heavy goods traffic. The main part of the applications comes from the carriers themselves, usually they have a customer with these special needs, but SRA usually only has contact with the carriers. It is noted from many directions that this way of thinking is becoming more and more attractive and one wants to try new models, taking both lengths and weights one step further. These projects might need to be gathered so that an overall picture can be seen and prevent projects from developing everywhere without any control. Therefore it is important to have someone with a coordination responsibility, so that all information and projects is transparent to all persons involved (Holmstrand, 2009).

There are several things to consider when giving exemptions; for heavy transports the increased risks, damages and bearing of bridges are crucial. For long transports however the main issue is the accessibility. It is an infrastructural question that the vehicle can drive through for example roundabouts. Here one needs to reflect over how roads and infrastructure are planned in the future. We are building too tight today, the vehicles are becoming bigger and the roads are not always adjusted to this. When for example big components to wind turbines are transported a lane straight through the roundabout might be a good solution. Usually accessibility isn't an issue in industrial areas or on motorways. The traffic situation on the roads affects as well; in Northern Sweden where ETT is rolling the traffic isn't very dense compared to the Western regions of Sweden. Another concern is the number of vehicles on the roads, many long vehicles might cause congestion, despite the fact that the number of vehicles has decreased the vehicles are longer (Holmstrand, 2009). However, according to Lundqvist (2009) one might prefer to use the longest vehicles on the main roads and decouple to shorter vehicle combinations outside urban areas (Lundqvist, 2009).

Another side of the issue is the competitive situation; in what situations these vehicles should be allowed. It has to be very clear so that one carrier isn't allowed to drive but another is. For this reason the module system was developed, giving the same conditions to both Swedish and international carriers. The module system was developed in relation to Sweden's entry into the European Union. The EMS was a compromise so that Sweden wouldn't be forced to decrease the allowed vehicle lengths. The EMS is a good foundation to build on for further development of vehicle length and weights. There might be a risk that the implementation of longer vehicles might be seen as a bit too offensive on a European level, considering that they don't even allow 25.25m vehicle combinations. But as long as it is kept on a local level there shouldn't be any problems (Holmstrand, 2009). There are now trials to drive with vehicles that are 25,25m in Holland, Denmark and Norway and the incentive to drive with even longer combinations in Sweden might be disturbing this

process, therefore the projects of extra long vehicles needs to be handled carefully and as smooth as possible (Lundqvist, 2009).

7.1 Transport Exemptions

As understood from the section above there are situations when the traffic regulations are hard to follow. In situations like that an exemption can be applied for. Applications for exemptions should be sent to the Swedish Road Administration (SRA) where the decision is made. If the transport only takes place in one municipality the local municipal office can be contacted, but if there are several municipalities involved the regional SRA office needs to be contacted. It is also possible to apply via the SRA website. The exemption allows you to transport long, wide or heavy goods. When investigating the requirements needed for transport exemptions for long or heavy vehicles one of the first statements from SRA is that "...the load to be transported is indivisible." (Swedish Road Administration, 2008b).

The term indivisible load is used frequently together with transport exemptions and might therefore need some further explanation. With indivisible load SRA means load that cannot be divided in two or more part loads without unnecessary costs or damages. A container containing indivisible load is not considered to be indivisible. Neither is customs sealing. A machine is considered indivisible though, even if it practically can be taken apart (Holmstrand, 2007).

When reviewing the application for exemption considerations are taken concerning the bearing capacity of the roads and bridges, road safety and the suitability of the vehicle or vehicle combinations (Holmstrand, 2007). When the exempted transport is on the way, special marking and signs are necessary to notify other road users about the vehicles and, in some cases, escorts are required (Swedish Road Administration, 2008b). The exemption for transports exceeding the regulations for length, width or height is normally valid for a month. It is however possible to get an exemption for continuous transports over a certain stretch of road or transports on public roads with indivisible cargo not over 30m long, this exemption is valid for maximum one year (Swedish Road Administration, 2008b). To exempt transports with divisible, heavy loads, an exemption have to be given from the SRA director-general. This has the consequence that the local exemption authority normally can't give exemptions for divisible load.

7.2 Traffic Regulations

From 1st of January 2009 an organizational change within the Swedish Road Administration took place which led to that projects with divisible loads are handled by the Swedish Transport Agency (STA) while projects for indivisible loads still are handled by the SRA. With regard to how the road traffic regulations are built; exemptions and regulations are two different parts. One part concerns exemptions in individual cases; then there is a requirement that the load is indivisible. If not it would be hard to know where to draw the line, if many carriers would like to drive both longer and heavier the situation might be arbitrary. It is also a demand in the EG

directive that the load has to be indivisible if exemptions should be allowed. The second part concerns the fact that the STA can provide exceptions, but these are not exemptions but an enlarged legislation, a traffic regulation, and there is no requirement for indivisibility here (Holmstrand, Swedish Road Administration, 2009).

The rules concerning road bearing, road availability, traffic safety etc, is the same as when applying for an exemption for indivisible load. STA is working towards an improvement of the traffic efficiency on the Swedish roads and these long vehicle combinations might be one answer if used under the right circumstances and right areas. The process of granting a traffic regulation follows the process that is regulated in the administrative board set of regulations. The starting point is that one part initiates the process, either an administrative authority that wishes to test something new, or someone from the business world. After an initiative is taken the process continues with a proposal that includes a consequence description. It is vital to show what consequences are expected so that there is a ground to base the regulation decision on. All actors that can be affected by a regulation shall then say their points and thoughts about the proposal and when all involved are satisfied a decision can be made. This whole matter is a process which last over a few months from start to finish (Lundqvist, 2009). An illustration of the decision process for traffic regulations is shown in the chart below.

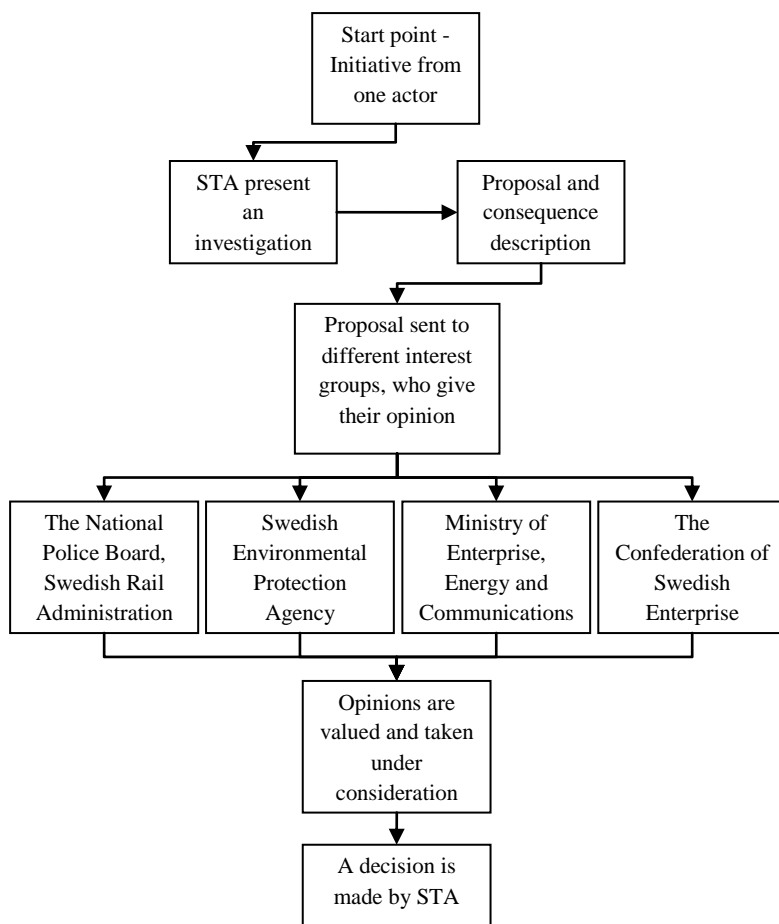


Fig. 21 Schematic chart of traffic regulation decision process

What is important to consider for traffic regulations is that there is no possibility to direct a regulation towards a certain actor or even group of actors. When a regulation is approved it is open for anyone that fulfills the requirements listed in the regulation. This gives an opening for competition even if one actor alone puts in the time and money to investigate a possibility for a regulation anyone fulfilling the requirements can then take advantage of it. There are a few exceptions and that is when it is not a traffic regulation but a test situation when new technology or similar is tested. Then the exemption is open only to that specific actor (Lundqvist, 2009).

7.2.1 Traffic Regulation Example

The county administrative board of Västra Götaland in 2003 proposed a change, in a writing to Ministry of Enterprise, Energy and Communications, of the rules for long or heavy transports within industrial areas to make exemptions easier. The county administrative board points out that the central issue isn't to increase the competitiveness of truck freight. The central issue is how to gain benefits in an environmental, logistic and infrastructure perspective with bigger but fewer vehicles (County Administrative Board, Västra Götaland, 2003).

In SRA's Statement of Opinion concerning the writing they have some considerations about the environmental savings proposed from the original report,

but they are positive to the writing. They refer to the fact that transports with 2x40ft containers have already taken place in the port of Gothenburg. According to SRA there haven't been any effects on traffic security because of these long vehicles. EG directive 96/53 control dimensions and weights of trucks and trailers in national and international traffic, in order to allow 2x40ft container transports without conflicting the directive there are two alternatives to consider. First, article 4.4 in the directive allows deviating dimensions if the transports are national and not affecting international competition such as the forest industry. The second deviation concerns vehicle combinations with new technology or constructions (Skogö, 2004). Several governmental and nongovernmental bodies have given their statements of opinions concerning the writing.

The National Police Board supports the suggestion, as long as it only concerns limited terminal-, port areas and similar. The Board does not support the suggestion in allowing these long vehicles on public roads (Berg, 2003). Statements of opinions are collected from regional police authorities as well, where Västra Götaland supports the suggestion and Stockholm and Skåne object to the suggestion. In Skåne one claims that the industrial areas in many bigger cities are geographically separated and that there is a risk that very long vehicles will traffic bigger parts of the cities (Andersson, 2003). In Stockholm the traffic security with longer vehicles is questioned and no motive for changing the rules regarding vehicle dimensions is seen (Vangstad, 2003).

The National Rail Administration is critical to the fact that longer and heavier vehicles would decrease the environmental effects from freight transports. Therefore no reasons to changing the rules are found. Already today Sweden allows the longest and heaviest vehicles in Europe, and this affects the competitive situation of rail freight negatively. Another restriction concerns the project description where freight transports to and from the port of Gothenburg is mentioned. The National Rail Administration has no objections to longer vehicles within the port and terminal area, but would like to see the transports to and from the port being on rail (Bylund, 2003). The Swedish International Freight Association supports the suggestion, considering it fits their efforts of benefitting effective and long term sustainable freight transports (Back, 2003). The Confederation of Swedish Enterprise strongly supports the suggestion (Hallsten, 2003), so does the Swedish Environmental Protection Agency, provided that the usage of these vehicles only takes place in limited areas (Olsson, 2003).

The 4th of October 2005 SRA provided the following in regulation VVFS 2005:104, concerning the suggestion of longer vehicle lengths in the port of Gothenburg. Traffic regulation (VVFS 2005:104) came into effect 1st of November 2005 and remains in force to, at the latest, 31st of October 2015. The regulation concerns certain predetermined roads in the port of Gothenburg and limits the length of vehicle combination to 32m, all load included, and the weight is limited to 72 ton. The regulation allows traffic on the following public roads; Nordatlanten and

Oljevägen, between the intersection with Arendals Allé and its Western intersection with Nordatlanten. For the vehicles to be allowed to drive they must be equipped with warning signs that are clearly visible both from the front and from the back of the truck. The truck must also be equipped with at least one orange warning lamp (Holmstrand, 2009).

8 Long Vehicle Projects

Examples of different projects concerning long vehicles and the different stages that these projects have gone through will be presented below. Starting off with a project that runs between the port of Gothenburg and Arendal that has been running for some years, moving on to the project ETT (En Trave Till) that started to run in the north of Sweden in January 2009, continuing with a project in Vaggeryd, Småland, where Tomas Arvidsson from PGF Transport has applied for exemption to drive 2x40ft containers, but still waiting for an answer.

8.1 Port of Gothenburg – Arendal

In the Port of Gothenburg there has been an exemption for long vehicles for several years. A carrier has been exempted to transport 2x40ft containers between the port and Arendal, both on private and public roads in the harbor area. This gives a vehicle combination around 30m, just a few meters more than the regulations allow. The total transport distance is approximately 5km and is run once every hour. The exemption needed to be renewed in spring 2002 and with help from among others the Port of Gothenburg, the exemption was renewed, at this time the county administrative board was responsible for this kind of exemptions. To help the new exemption decision calculations were made to show the benefits from the longer vehicles, it was showed that this combination would cut the number of vehicles in half and reduce emissions with 30 – 40% (Jivén, 2003).

Due to changes in regulation the port had to acquire a renewed permit for its long vehicles and in 2005 the traffic regulation which allowed driving these long vehicles was issued, as explained in the previous chapter. The old system remained still for another couple of years before the new project approved by the Swedish Road Administration started in the fall of 2007. The traffic regulation (VVFS 2005:104) that is valid until 2015 on certain predetermined roads in the port of Gothenburg limits the length of vehicle combination to 32m, all load included, and the weight is limited to 72 ton (Holmstrand, 2009). The original idea is that the traffic regulation shouldn't need to be renewed after 2015. The expectation is that most roads within the harbor area that today are public roads shall be turned into private roads or private roads shall be built alongside the public roads so the rules of the harbor shall apply instead of the traffic regulations (Lundqvist, 2009).

Since 2007 the long vehicles has been driven by GA Åkerierna and the project has been running smoothly and without incidents or accidents even though it can be many cars driving in the area, especially during rush hours since many office workers uses the public roads that the long vehicles are driving on today. The vehicles used by GA Åkerierna are specialized so that there is one more maneuverable axle which pulls the second trailer out from turns and gives stability to the vehicle (Berndtsson, 2009).

8.2 ETT (En Trave Till)

ETT is a co-operation between several partners, among who you for example find Volvo, SRA and Skogforsk. Volvo stands behind the technology of the project and they were first involved in the project in April 2007. The project was held on a conceptual basis during the entire 2007 and during 2008 all exemptions and permissions were outlined. In January 2009 the trucks started rolling. Volvo Technology says that this is a very fast development of a project compared to what is normally seen. It is calculated that this project will reduce fuel costs with approximately 20% (Cider & Larsson, 2009).

From January 1st 2009 a 29m long and 90 ton heavy timber truck is rolling between Piteå and Överkalix in northern Sweden, a distance of approximately 160km. A special truck is needed, being able to carry a vehicle weight of 100 ton. The trailer is built on a modular system where the platforms could be carrying 4 TEUs instead of timber stacks. For the different exemptions and permissions a close co-operation with SRA was needed. One permission concerns the road stretch the vehicle is traveling, it needed to be approved for this kind of transports. For example one bridge needed to be strengthened; otherwise two heavy vehicles wouldn't be able to meet on this very stretch of the road. This means that theoretically another carrier is allowed to travel this distance with the same type of vehicle. The difference would then be a special permission held by ETT, allowing this vehicle to have a speed of 80km/h, which is not usually allowed for vehicles with this many steering links. The vehicle has three steering links and can turn around in a diameter of 25m. The trailer has 11 axles, giving an axle pressure of ca 8 ton, which is below many other trailers on the roads where the axle pressure can be up to 11 ton.

Four drivers are taking turns driving the vehicle, each taking two trips every day resulting in a vehicle usage of four trips per day. The drivers had a full day of education in how to handle the long vehicle. The new vehicle combination cannot collect the timber directly in the forest, but a smaller vehicle has to transport the timber to a bigger road. This has the consequence of an extra lift, but the costs from this are outweighed by the decreased costs on the main transport leg. Another effect from this is that the crane operators, who are a scarce resource, can work fully with loading timber and don't have to waste time on transporting.

Despite the fact that the project hasn't been running for so long, some tests have already been possible to take. Statistics have been gathered from around 500 occasions when other road users have been passing the long vehicle combination. Many of the worries raised around the project have concerned the passing situations, but the difference in length between these and traditional timber trucks is marginal. According to this statistics there haven't been any incidents so far.

The project is run under a three year test period, after that the results are assessed by the SRA. If the results are positive a change in the traffic regulation is expected. If everything happens without hinders, this could be reality in five years. Another

aspect of ETT is the competitive situation with rail freight, the road stretch chosen for ETT is deliberately chosen due to the fact that there is no rail alternative here. Volvo Technology states that if there is a train alternative this would be so much cheaper, in spite of the long vehicles used on road, that the rail alternative would be chosen (Cider & Larsson, 2009).

8.3 PGF Transport, Vaggeryd

In the summer of 2008 Tomas Arvidsson at PGF Transport in Vaggeryd applied for an exemption for extra long vehicle combinations. The exemption will be a trial during 1.5 years, and if the outcome is positive the exemption will be continuing. The vehicles shall be used for pick-up and delivery between an intermodal terminal and the goods receiver's premises. The transport distance is approximately 17 km where the E4 (European highway) is used for the main part of the journey. PGF wants to use extra long vehicles in transport flows where large customers have steady flows and where 40ft containers is the most common load carrier. The E4 is considered to be a very safe road and has two lanes and no tricky passages, this is a condition for getting an exemption (Arvidsson, 2009).

One train arrives and departs at the intermodal terminal daily, five days a week. The train consists of forty wagons carrying containers and out of this approximately ten 40 feet containers are to be delivered to PGF customers. Today this would mean that ten trucks would pick up one container each and deliver to customer premises. PGF Transport wants that each truck could carry two 40 feet containers which would cut the number of trucks needed in half. This is, according to Tomas Arvidsson, "...an excellent opportunity to see that if the correct logistical and traffic qualifications are at hand both environmental and economical benefits can be achieved".

It is not yet certain by how much PGF Transport would need to exceed the length limitation. Different solutions provide different answers, but what is certain is that two 40ft containers must be able to fit on one load carrier and for this purpose the maximum length legislation need to be breached with a few meters. One has looked at solutions applied in the USA and Australia, but they are not found applicable for Sweden. This vehicle expansion can be made without increasing the axle pressure on the vehicle, which is a crucial point for the wear and tear of the road system (Arvidsson, 2009). Another part of the vehicle design is that it has to be dividable when arriving to the end-customer; this is a criterion so that no micro terminals, where reloading has to take place, are needed. If this should be needed the profits would disappear.

So far the exemption process has been rather complicated, and PGF is still waiting for a decision (March 2009). It is found that the rules and regulations are built around exemptions for indivisible loads, making the process for divisible goods long. Another issue has been who should make the decision; PGF's application is between two systems in the creation of the Transport Agency in the beginning of 2009.

Another factor complicating the process is the fear of receiving an overload of applications like this after the decision is made (Arvidsson, 2009).

8.4 Time Axis

The chart below shows the development in the long vehicle area during the past decade and gives a summary of the previous sections.

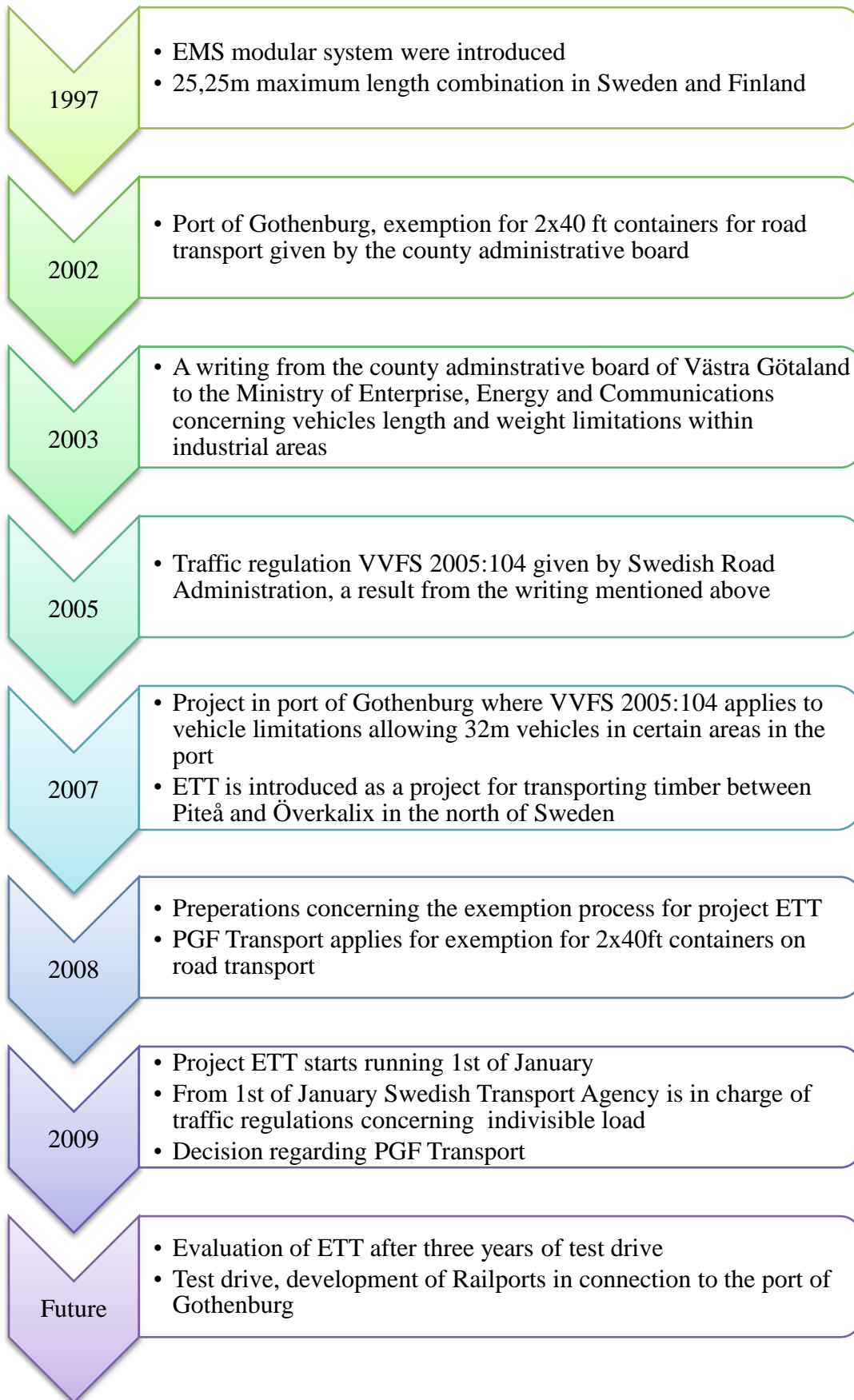


Fig. 22 Time Axis

9 Double Haulage Implementation

9.1 Case Presentation

Within the intermodal group of the Green Corridors focus is on making pre-and post haulage from intermodal terminals more efficient. One aspect of pre-and post haulage efficiency is the introduction of double haulage, i.e. the transport of 4TEU on one vehicle. The Skaraborg region is very suitable for a project like this due to the distance from the Port of Gothenburg and the connection to the rail shuttle system. In the region of Skaraborg there are a few intermodal terminals and there are large producers within various industries, where the automotive industry is strongly represented. The goods volumes generated by the industries in the area are another contributing factor for the suitability of Skaraborg. Therefore a case study between Port of Gothenburg and Skaraborg was created. The case investigates economical and environmental benefits of switching from traditional road transport to intermodal road rail transport supported by double haulage. In the selection of intermodal terminal the intermodal terminal nearest the production sites in Skaraborg is used.

When comparing scenarios the same unit must be used, therefore a standard weight of 10 ton is given to 20ft containers and 20 ton to 40ft containers. A 20ft container will be referred to as 1TEU (Twenty-foot Equivalent Unit) in the following sections and a 40ft container is equivalent to 2TEU.

In order to calculate relative cost changes and environmental emission savings from the case three different scenarios has been created. In scenario 1, named All Road, the goods is transported door-to-door by truck.



Fig. 23 Scenario 1, All Road

In Scenario 2, named Intermodal Standard Haulage, rail is used for the main distance and a normal truck carrying 2-3TEU is used in the pre-and post haulage operation, this will be referred to as Standard Haulage.



Fig. 24 Scenario 2, Intermodal Standard Haulage

In scenario 3, named Intermodal Double Haulage, rail is used for the main distance, but for pre-and post haulage operations double haulage is used to carry up to 4TEU, this will be referred to as Double Haulage.

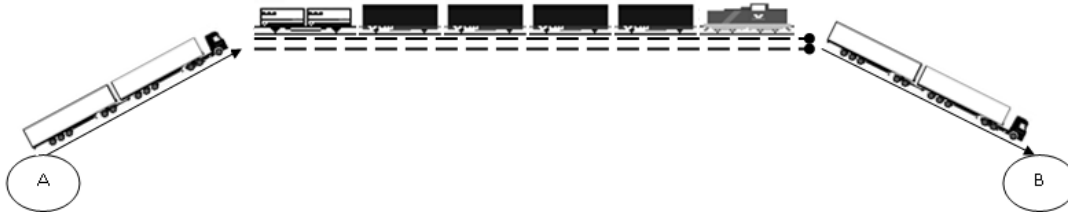


Fig. 25 Scenario 3, Intermodal Double Haulage

In order to evaluate and compare these different scenarios with each other a model comparing costs and emissions for relevant distances needed to be created. The emission data is based on the facts and figures that can be found in the NTM framework, which is further explained in section 9.3.

9.2 Costs

The cost parameters analyzed in the model are presented in the table below.

	All Road	Standard Haulage	Double Haulage
All Road SEK/km	x		
PPH Cost SEK/km		x	x
Rail SEK/container		x	x
Rail SEK/lift		x	x
Total	x	x	x

Table 2 Cost Parameters

As the table above shows, the rail scenarios have several cost parameters to take into account. In the table below the costs for the case study are presented.

	Cost
All Road SEK/km	35
PPH Cost SEK/km	40
Rail SEK/container (40ft)	2600
Rail SEK/container (20ft)	1400
Rail SEK/lift (1 TEU)	150
Total	x

Table 3 Costs

9.3 Emission and Environmental Effects

NTM which stands for the Network for Transports and Environment is a non-profit organization that started in 1993 and which aims to generalize costs and calculation methods concerning fuel consumptions and environmental impact from the different

modes within the transport sector. A long term goal of NTM is that more companies shall include environmental costs in their logistical cost calculations, even for international transports. Therefore NTM is cooperating with several other institutes in Europe and in the US (NTM, 2007a). This paper uses NTM to access input to environmental calculations for road and rail transports. These reports consists of information concerning size, weight, fuel consumption, energy use, fill rates and emission data that is needed to estimate and calculate environmental emissions. The information from NTM can be used as a framework when case specific information isn't available. The NTM framework starts with a choice of carrier type and Euro standard of the engine, there are ten different trucks to choose between and five Euro classifications. When the correct truck is chosen the fuel type and fuel consumptions needs to be determined. Emissions concerning the distance travelled and what roads are used are given the default values of NTM in order to calculate the environmental performance. The emissions can then be allocated to the transported cargo (NTM, 2008).

9.4 Approach

Case Skaraborg is due to distance and goods volume reasons divided into two sub cases, case F and case S:

	Case F	Case S
Total Distance (km)	140	170
Pre Haulage Distance (km)	20	5
Goods volume (Index)	100	300

Table 4 Case Specifics

The goods volumes for each case are represented by an index number, case F is given the index of 100 and case S 300, indicating that the goods volumes for case S are approximately 3 times the volume of case F.

The two cases were approached in the following way; environmental emissions were gathered with help from the NTM framework. To do this data regarding distances, type of trucks, fill rates and annual tons shipped was gathered. Relevant cost data was gathered thru contacts with people in the industry and analyzing previously collected material.

Distances

The distances were measured and calculated by using the webpage www.hitta.se where routes can be chosen and it is easy to follow what roads are being used to complete the journey from start to finish. For case F the pre haulage distance is set to 20km and the equivalent for case S is 5km. When pre-and post haulage is applied the distance within Port of Gothenburg is set to 5km. The NTM framework distinguishes road transport in three different segments, highway, rural and urban roads. Concerning the division of highway, rural and urban, the different distances in each category are found with help from a map together with appreciation of the different

distances. In this paper highway is calculated for the parts driven on European roads (e.g. E6, E20) and other major roads. Rural is calculated as the distance driven on main roads (country roads) that are not seen as highways, e.g. the road between production site and intermodal terminal. And finally urban distance is seen as the distance travelled within cities and industrial areas i.e. pick-up and delivery areas.

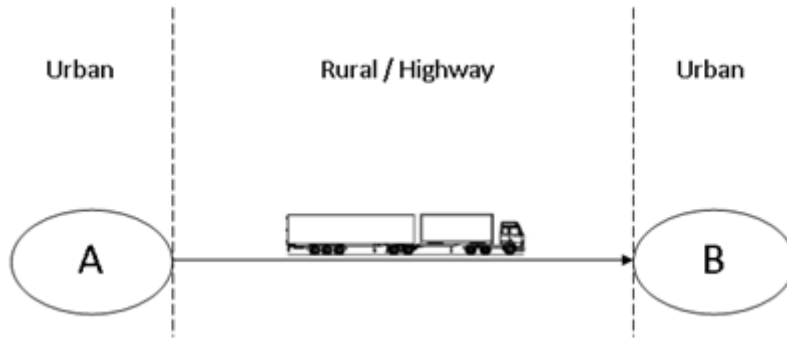


Fig. 26 Urban, Rural, Highway

According to NTM a positioning distance shall be added to all trips to counter for time and cost spent to position the truck to the correct place. NTM suggest a positioning distance of 50% of total distance but that was decided to be too high in this case. Mainly local haulers are used for these pre-and post haulage transportations and therefore 50% of total distance is too large. For each trip a positioning distance of 20km has been added. The positioning distance is set to the same emission levels as when driving in urban areas.

Fuel Consumption

First of all when calculating fuel consumption it needs to be determined what type of truck that is used. The fuel consumption differs between the available NTM standards. For all scenarios, both DTD truck and intermodal solution truck 10 is chosen. It is, except for one that carries mega-trailers, the largest truck in NTM and is therefore capable of carrying the volumes and weights that the different scenarios demands. Since there was no data of actual fuel consumption for the different scenarios NTM data has been used in all calculations. For scenario 3 where Double Haulage is used an increase of 5% of the NTM figures is added to the fuel consumption of truck 10. Another aspect needed in NTM to determine the fuel consumption is the cargo capacity utilization.

Utilization Rate

For the All Road scenario a utilization rate of 80% is used. A utilization rate of 75% is suggested in the NTM framework; a utilization rate of 80% is approximately 2.5TEU out of 3TEU, therefore 2.5 TEU for the All Road scenario is considered to be generous. The truck used for road transports in the All Road scenario is therefore assumed to take an average of 2.5 TEU.

DOUBLE HAULAGE IMPLEMENTATION

For the Standard Haulage and Double Haulage scenarios a utilization rate of 100% is used initially and is chosen for comparative reasons. Costs and emissions for PPH in these scenarios need to be compared in a competitive way, to be able to do that a reference point is needed and the best alternative is taking full utilization for both scenarios to start with and then to move on from that. Later in this chapter the effects from different utilization rates for PPH is investigated. Since the All Road scenario won't be compared directly with the PPH in the Standard and Double Haulage scenarios the different utilization rates are not conflicting. The All Road scenario will be compared to an intermodal scenario, and then an average fill rate of 100% for road transports is not valid.

For the positioning distance the utilization rate is calculated as zero, since the trucks are empty.

<u>Scenario</u>	<u>Utilization Rate</u>
All Road	80%
Standard Haulage	100%
Double Haulage	100%

Table 5 Utilization Rate

Exhaust Gas Emission

The exhaust gas data are taken from the NTM framework. The type of engine is chosen to be an average of Euro 3 due to lack of information of higher Euro standards and the fact that Euro 3 is still a representative average. Emissions for Hydro Carbon (HC), Carbon Monoxide (CO), Nitrogen Oxides (NOx), Particulate Matter (PM), Carbon Dioxides (CO₂), Methane (CH₄) and Sulfur Oxides (SO_x) are measured. The emissions are calculated on a yearly basis and measured in a total number of kilograms where the model aims to show emission savings when comparing the different scenarios. Rail scenarios are assumed to be without any emissions; the energy for the trains comes from renewable energy sources.

9.5 Scenario Presentation

The All Road scenario, which describes the situation today, is used as a reference point for the following scenarios so that changes could be measured and put in relation with each other. In scenario 2, Standard Haulage, a shift is made from all road transport to an alternative with transport to nearest intermodal terminal with truck and the main transport leg on rail. In scenario 3, Double Haulage, the effects from replacing the transports to and from terminals with trucks being able to carry 2x40ft containers (4 TEUs instead of 2 or 3 TEUs) are investigated. Scenario 2 is created in order to separate the effects from a modal shift from the effects from Double Haulage and to compare PPH effects.

Scenario 1 All Road



Fig. 27 Scenario 1 All Road

Costs for road traffic are expressed as a cost per km. For a standard truck travelling 140km (distance between point A and B case F), the cost is appreciated to 35SEK/km. In case S, which has a longer distance this cost/km had to be adjusted. If the same cost would have been used the cost per trip would have increased from 4,900SEK to 5,950SEK, this would be an increase of 21%. An increased distance of 21% (30km longer) does not motivate a cost increase of this amount considering the cost structure of this kind of transports. That is, many of the initial costs (fixed costs) will exist independently of distance. Therefore the cost per km for the distance exceeding 140km in case S will only be the operative costs i.e. the fuel consumption. The fuel consumption is calculated to 0.4 liter per kilometer at cost of 7.00SEK/liter. This results in a cost of 4,984SEK/trip for the second case, compared to 5,950SEK if no adjustments would be made. 4,984SEK will be used in the calculations.

Scenario 2 Intermodal Standard Haulage



Fig. 28 Scenario 2 Standard Haulage

The same truck as in the All Road scenario is used for the delivery to and from intermodal terminals. In the intermodal scenarios a cost of 150SEK/TEU per lift is added. Costs for rail transport are expressed in a cost per container; 1,400SEK for a 20ft container and 2,600SEK for a 40ft container. The main part of this cost is expected to be a fixed cost (track rates, licenses, etc.) while only a small part is depending on the distance. Therefore it is only slightly more expensive to transport goods an extra 30km. An increase of 10% of cost per container is added to the cost of transporting on rail to the terminal in case S compared to the terminal in case F.

Scenario 3 Intermodal Double Haulage

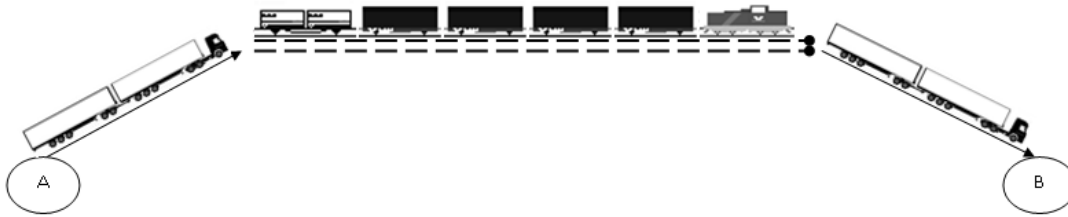


Fig. 29 Scenario 3 Double Haulage

Given the fuel consumption data for a 25.25m truck from NTM, some adjustments are needed when adapting to a 2x40ft truck. Considering the fact that this truck will be longer, might weigh more and most likely be less aero dynamic the fuel consumption will slightly increase. The figures need to be adjusted for this in scenario 3. Based in the calculations made for the MOG report, where fuel consumption was calculated to increase from 3,8 liters per truck and 10km to 4,0 liters per truck and 10km (Jivén, 2003), the same increase of 5% is used in scenario 3. The same is valid for the kilometer cost; the 2x40ft truck will have a slightly higher operative cost, it is appreciated to somewhere between 35-40 SEK/km. Where 40 SEK/km is assumed to be a good estimate.

9.6 Results Discussion

Goods Volume

Goods Volume (index)	Case F	Case S
	Saving %	
100	6%	8%
200	6%	8%
300	6%	8%

Table 6 Economies of Scale

For the table above an index volume of 100, 200 and 300 is used to demonstrate that the system has no economies of scale. Each case should be viewed separately since this table takes no consideration to the volume relationship between the cases. As showed in the table; the system has no economies of scale as it is today. This would mean that even though a small amount of goods would be transferred to rail the gain in percentage would still be the same. It should however be noted that considering the nature of the rate system in the transport sector it is often the case that bigger volumes affect the transport rate in a beneficial way for the transport buyer.

	Case F	Case S
Total Distance (km)	140	170
Pre Haulage Distance (km)	20	5
Goods volume (Index)	100	300

Table 7 Case Specifics

Above the case specific details from previous section are presented again as a reminder before looking into the results from the different cases. The results should be in relation to the different goods volumes and distances.

9.6.1 Total Costs

Costs Case F

	All Road	Double Haulage
Road	6 370 000	812 500
Rail		4 225 000
Lift		975 000
Total	6 370 000	6 012 500
SEK cost saving		357 500
% cost saving		6%

Table 8 Results Case F

Costs Case S

	All Road	Double Haulage
Road	22 000 000	1 100 000
Rail		15 730 000
Lift		3 300 000
Total	22 000 000	20 130 000
SEK cost saving		1 870 000
% cost saving		8%

Table 9 Results Case S

Case S shows a slightly higher cost saving than case F. This can be explained by the longer distance in case S. When talking about transferring goods from road to rail, there is often a break-even distance; a certain distance that needs to be reached for a rail alternative to be profitable. This distance is usually appreciated to be around 300-350km (Bärthel & Woxenius, 2004). Our model tells us that the rail solution is slightly more beneficial in the case with the longer distance; but the distance is still much shorter than the assumed break-even distance.

Case F

Utilization Rate (TEU)	4	3,75	3,5	3,25
Double Haulage				
Cost saving (%) in total cost, Double Haulage compared to All Road	6%	5%	4%	3%

Table 10 Utilization Rate Double Haulage Case F

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Case S				
Utilization Rate (TEU)	4	3,75	3,5	3,25
Double Haulage				
Cost saving (%) in total cost, Double Haulage compared to All Road	8%	8%	7,5%	7%

Table 11 Utilization Rate Double Haulage Case S

The tables above show the cost saving in total costs depending on the utilization rate of the Double Haulage scenario compared to the All Road scenario. The cost saving from the double haulage implementation is affected by utilization rate for double haulage. It is showed that even when having utilization at 3.25TEU (80%), Double Haulage is still profitable compared to All Road.

Pre-and Post Haulage or Pre Haulage Only

In this chapter when the implementation of double haulage is investigated it is assumed that the goods are transported both to and from terminals. In the case with the rail shuttle, Railport Scandinavia, there is however only haulage in one end of the transport. In this system the goods is taken to a terminal and loaded on train to the Port of Gothenburg and there loaded on a ship. This means that there is no post haulage in the system.

PPH vs. PH		
	Case F	Case S
Cost saving total cost pre-and post haulage	6%	8%
Cost saving total cost pre haulage only	5%	7%

Table 12 PPH vs. PH

The table above shows the effects on the results when adapting the model to only pre haulage. One can see that with only pre haulage the total cost saving decreases with approximately 1 percentage point.

9.6.2 Emissions

Emissions Skaraborg			
	All Road	Standard Haulage	Double Haulage
Kg/year			
HC	538	142	112
CO	2 580	632	498
NOx	11 556	2 299	1 811
PM	271	67	53
CO2	1 301 782	247 430	194 851
CH4	13	3	3
SOx	7	1	1

Table 13 Emissions Skaraborg

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The introduction of Double Haulage will reduce emissions with an average of 21% in Skaraborg compared to Standard Haulage. Compared to the All Road scenario, the savings from a modal shift with Double Haulage are much higher, around 80%, due to the lack of emissions from rail transport.

Emission Savings			
	Standard Haulage (3 TEU)	Standard Haulage (2,5 TEU)	Standard Haulage (2 TEU)
Emission savings if using Double Haulage (4TEU) instead of Standard Haulage	21%	34%	43%

Table 14 Emission Savings

The table above shows how the emission savings in Skaraborg changes as the capacity utilization varies. The table compares a utilization change for Standard Haulage ranging from 2TEU to 3TEU compared to Double Haulage with a fixed utilization of 4TEU.

9.6.3 Pre-and Post Haulage Costs

Pre-and post haulage cost effects							
Case F							
	Double Haulage (4TEU)	Double Haulage (3.75TEU)	Double Haulage (3.5TEU)	Double Haulage (3.25TEU)	Standard Haulage (3TEU)	Standard Haulage (2.5TEU)	Standard Haulage (2TEU)
PPH cost	812 500	867 000	929 000	1 000 000	950 000	1 137 500	1 420 000
Total cost	6 012 500	6 067 000	6 129 000	6 200 000	6 150 000	6 337 500	6 620 000
PPH of total cost	14%	14%	15%	16%	15%	18%	21%
Case S							
	Double Haulage (4TEU)	Double Haulage (3.75TEU)	Double Haulage (3.5TEU)	Double Haulage (3.25TEU)	Standard Haulage (3TEU)	Standard Haulage (2.5TEU)	Standard Haulage (2TEU)
PPH cost	1 100 000	1 173 000	1 257 000	1 354 000	1 285 000	1 540 000	1 925 000
Total cost	20 130 000	20 203 000	20 287 000	20 384 000	20 315 000	20 570 000	20 995 000
PPH of total cost	5%	6%	6%	7%	6%	7%	9%

Table 15 Pre-and post haulage cost effects

The table above shows a comparison of different utilization rates for PPH. It shows the share of total cost PPH has together with the change in PPH costs for different utilization rates compared to 4TEU. The table shows a comparison of Standard-and Double Haulage. In case F the PPH share of total cost ranges from 14-21% depending on utilization rate. One can see that the introduction of Double Haulage reduces the PPH cost from 15% to 14% of total cost when comparing Standard Haulage 3TEU to Double Haulage 4TEU. In case S the PPH share of total cost ranges from 5-9%. The percentage of PPH decreases from 6% with Standard Haulage 3TEU to 5% with Double Haulage 4TEU. The rather high difference in percentage between the two cases can be explained by the shorter PPH distance,

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longer total distances and higher volumes in case S, giving a higher total cost where PPH costs have a lower share.

The table below shows how the efficiency in the PPH changes as the load rate changes. The lower utilization rate you have in Standard Haulage, the greater is the cost saving if introducing Double Haulage (4TEU). The table also shows that a Double Haulage utilization rate of 3.25TEU is less profitable than Standard Haulage at 3TEU. A saving of 13% for Double Haulage 3.5TEU compared to 14% for Standard Haulage 3TEU. This indicates that one must reach a utilization rate closer to 3.5TEU for Double Haulage for it to be profitable (See diagram 2-5). In reality one might believe that an average load rate will be around 2.5 TEU. To be noted is that in certain regions in Sweden the 40ft container is used almost exclusively. This means that the PPH saving here would be at 43% if implementing double haulage compared to standard haulage. One example of this situation is the case of PGF Transport where the usage of 40ft containers is dominant and one will get a comparison between 2TEU and 4TEU.

Pre-and post haulage utilization effects

	Double Haulage (4TEU)	Double Haulage (3.75TEU)	Double Haulage (3.5TEU)	Double Haulage (3.25TEU)	Standard Haulage (3TEU)	Standard Haulage (2.5TEU)	Standard Haulage (2TEU)
Cost saving PPH when using Double Haulage (4TEU)		6%	13%	19%	14%	29%	43%

Table 16 PPH Load Rate

9.7 Model Validation

In order to create the model some assumptions had to be made. The following sections investigate how these assumptions affect the outcome.

Fuel Consumption

Based on calculations made for the MOG-report the fuel consumption was set to increase with 5% with the usage of Double Haulage. This can be seen as a bit low, after interviewing GA Åkerierna, who has experience from driving this kind of vehicles and claims that fuel consumption increases with almost 30%.

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Emissions		
Kg/year	Fuel cons. +5%	Fuel cons. +30%
HC	112	125
CO	498	557
NOx	1 811	2 023
PM	53	59
CO2	194 851	217 628
CH4	3	3
SOx	1	1
Emission Increase		12%

Table 17 Fuel Consumption

As the table above shows, a fuel consumption increase of 30% for double haulage instead of 5% would in average increase emissions with 12%. This increase is considered to be moderate, considering the major difference between the All Road and Double Haulage scenario. Therefore 5% is considered to be valid. Taking CO2 as an example; the All Road scenario has emissions of 1 300 ton/year, compared to this emission of 218 ton (+30%) instead of 195 ton (+5%) for Double Haulage, i.e. 23 ton per year, is only a 1.8% increase (23/1 300).

Positioning

When consulting the NTM framework for guidance considering the positioning distance they state that if the distance is not known; 50% of the total distance should be used as positioning. In this case, as stated earlier, the carriers are local and therefore 50% is too long for positioning.

Emissions				
Kg/year	Positioning 20 km		Positioning 50%	
	All Road	Double Haulage	All Road	Double Haulage
HC	118	30	167	25
CO	528	138	745	117
NOx	2 334	529	3 107	453
PM	57	14	80	12
CO2	266 710	57 228	349 827	49 046
CH4	2,84	0,72	4,03	0,60
SOx	1,34	0,29	1,76	0,25

Table 18 Positioning

When changing positioning distance to 50% instead of a fixed 20km, the positioning decreases emissions for the PPH distances and increases emissions the All Road scenario. This can be attributed to the short distances in the PPH part. The diagram below shows the total effects from a change of positioning distances, comparing scenario All Road with Double Haulage.

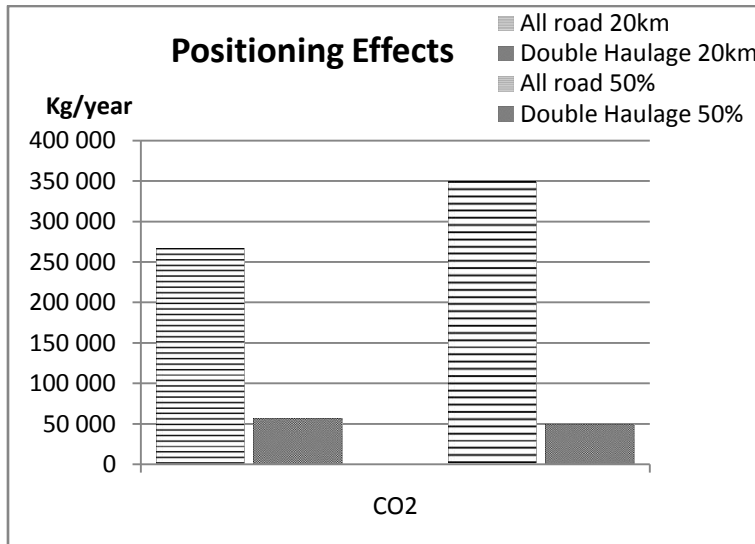


Diagram 1 CO2 effects from positioning

As seen above; a change in the positioning distance to 50% of the total distance has major effects on the All Road scenario, compared to a small decrease in the Double Haulage scenario. An increase of positioning of 50% of total distance would result in a positioning distance of 70km for case F which is considered unrealistic.

9.8 Sensitivity Analysis

The sensitivity analysis aims at showing the span of variation the input parameters for the model have. The analysis shows how sensitive the system is to the different input parameters, utilization rate, PPH cost and PPH distance, aiming at investigating if there is one parameter that is more crucial than the others.

Utilization Rate

It was mentioned in the beginning of this chapter that the utilization rates for the Standard Haulage and the Double Haulage scenarios were both set to 100% for comparative reasons. It was also said that a utilization rate of 100% is not very likely in reality. In the following section the utilization rates will be analyzed in order to see how sensitive the model and its results are to a change in utilization rate.

DOUBLE HAULAGE IMPLEMENTATION

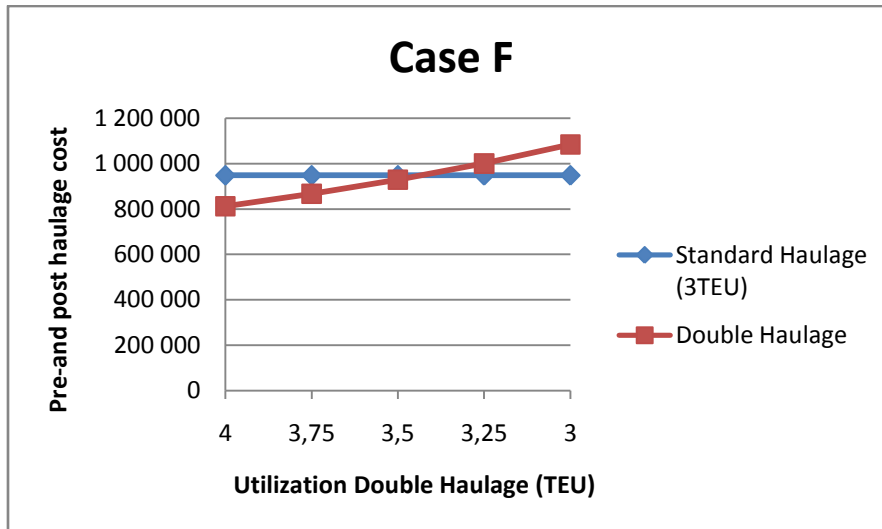


Diagram 2 Utilization Rate Case F

The diagram above shows how the utilization rate (measured in TEU) can decrease for Double Haulage before Standard Haulage becomes more profitable. Standard Haulage is here set to 3TEU. The graphs tell us that Double Haulage is preferable with a utilization rate of approximately 3.5 TEU (88%) and above (Recall table 16).

Recalling the utilization of 80% set for All Road and that it's considered to be very high, one might draw the conclusion that a utilization of 88% for Double Haulage to be profitable is very high as well.

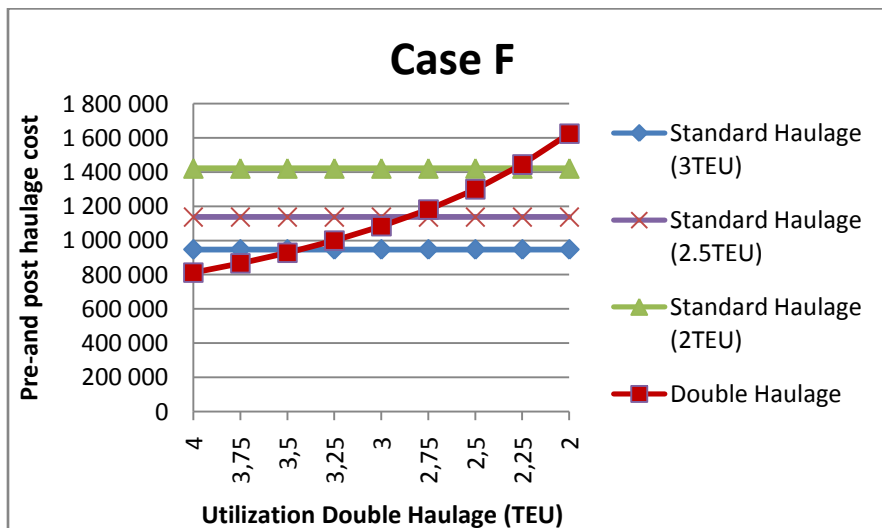


Diagram 3 Utilization Rate Case F

The diagram above shows the same two graphs as in Diagram 2 together with two additional graphs. The two new graphs represent different utilization rates for the Standard Haulage scenario. In the same way as the utilization can vary for Double Haulage, it can naturally vary for Standard Haulage as well. The diagram above takes all of these issues in consideration and one can find the different break-evens for different utilization rates.

DOUBLE HAULAGE IMPLEMENTATION

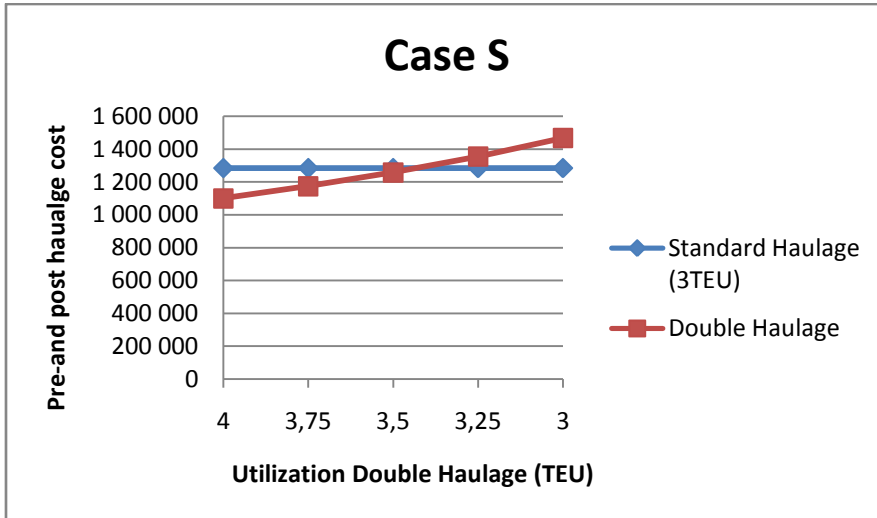


Diagram 4 Utilization Rate Case S

Case S shows the same results as Case F. A utilization of approximately 3.5TEU (88%) is needed to make Double Haulage more profitable than Standard Haulage. One might have believed that the shorter PPH distance in Case S would have had affects on the sensitivity of the utilization rates. I.e. the analysis shows that with greater PPH distances is the efficiency in Double Haulage increases. One explanation of this is that the PPH distance of 5km (Case S) and 20km (Case F) respectively are too close to each other for a difference like this to be noted. See Diagram 8 PPH Distance.

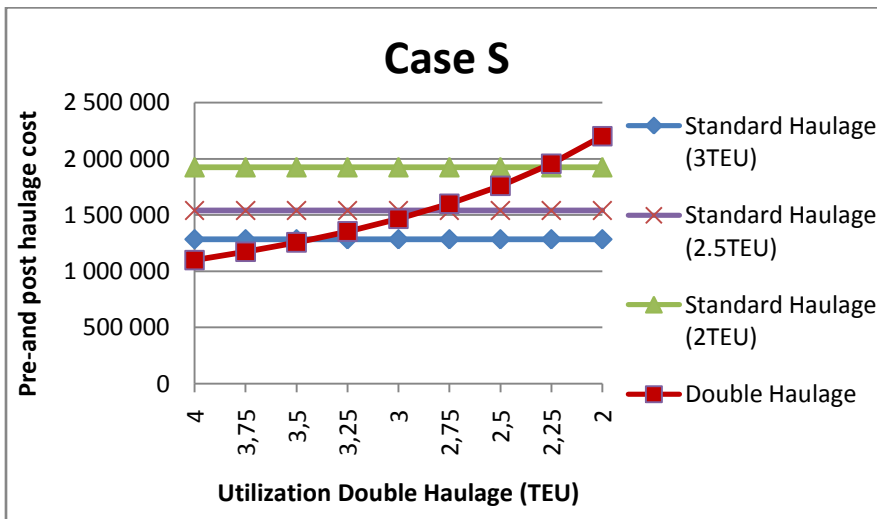


Diagram 5 Utilization Rate Case S

The diagram above shows how the utilization rates are related. The lower utilization you have on Standard Haulage, the lower utilization is needed to make Double Haulage more profitable.

For the following sections the utilization rates are the same as at the point of origin; 3TEU for Standard Haulage and 4TEU for Double Haulage. It should however be noted that changing utilization rates would have the same affects on the results of the following analyses as in the previous section. That is, an unfavorable change in

utilization rate (i.e. decrease) for one scenario will result in a favorable cost effect on the other scenario.

PPH Cost

The model’s sensitivity concerning the cost for Double Haulage was investigated. Initially the PPH cost was set to 40SEK/km, the purpose of the investigation was to see how sensitive the model is to a change in PPH costs.

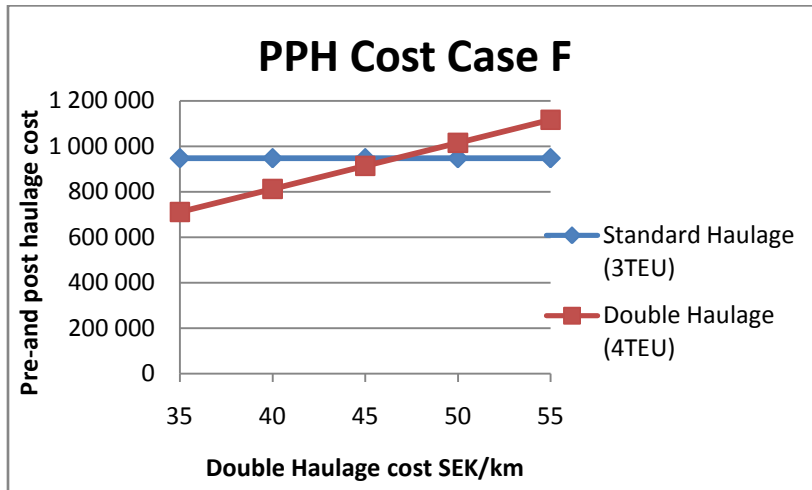


Diagram 6 PPH Cost Case F

As can be seen above and below; the break-even is around 45SEK for both case F and Case S. This is valid for the original utilization rate of 4TEU for Double Haulage and 3 TEU for Standard Haulage. Having a smaller utilization rate for Standard Haulage to begin with would mean that Double Haulage could bear a higher cost per kilometer if 4TEU is achieved.

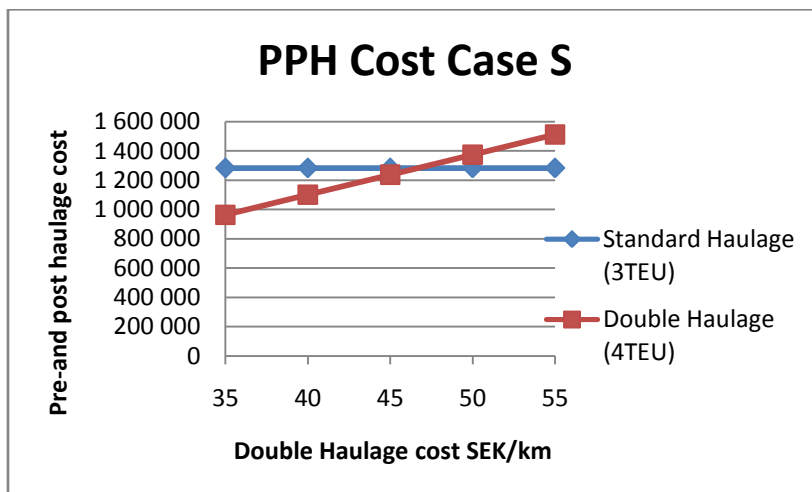


Diagram 7 PPH Cost Case S

PPH Distance

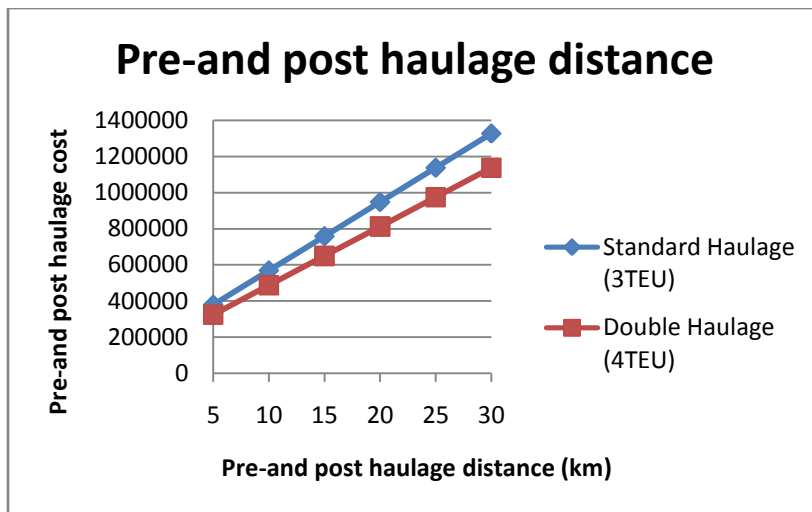


Diagram 8 PPH Distance

Following the two graphs in the diagram above, the Standard Haulage graph shows a steeper cost increase, this fact increases the distance between the graphs as the PPH distance grows. The diagram indicates that when the PPH distance increases; the cost saving for Double Haulage increases as well. The Double Haulage is more efficient and gives fewer trips, resulting in a lower cost.

It should however be noted that the PPH distance cannot be infinite; the double haulage is meant for pre-and post haulage and not door-to-door transports.

10 Analysis

What should be noted and remembered throughout this entire section is that double haulage is introduced for pre-and post haulage and not door to door transport. Even though some comparisons are made with research looking at the effects from vehicle lengths on the society, (including all types of road transports), one should bear in mind that door to door transport with double haulage is not the intention of this paper.

In the introduction of this paper the research question was presented:

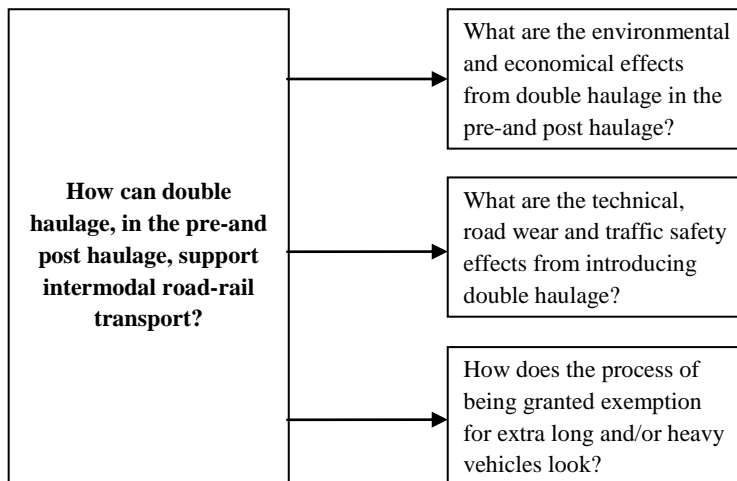


Fig. 30 Research Question

To answer our main research question three different areas were chosen to look closer on. These areas together cover many aspects of double haulage. The following sections will present an analysis of these three areas.

What are the environmental and economical effects from double haulage in the pre and post haulage?

In the report from VTI (2008) the effects from shortening the vehicles in Sweden are investigated. The report shows that shorter vehicles would mean higher transport costs for the society. A European study investigated the opposite; what would the effects on the environment be if Europe implemented Swedish vehicle dimensions. The result showed that this would generate CO₂ savings (Mellin & Vierth, 2008).

The results from the environmental impacts when comparing all road and intermodal double haulage are perhaps not very surprisingly. It is well known that transferring goods from road to rail means great savings in environmental emissions. Rail transport is considered climate neutral in Sweden due to its use of green electricity. The environmental analysis from the case study indicates emission savings around 80% when transferring goods from road to rail with double haulage. This saving might decrease slightly when increasing the fuel consumption for double haulage, but that would only give a marginal difference. When comparing emissions between

Standard Haulage and Double Haulage the emission savings for Double Haulage is somewhere in the span of 20-40% depending on the utilization rate that is used as illustrated below:

Emission Savings			
	Standard Haulage (2 TEU)	Standard Haulage (2,5 TEU)	Standard Haulage (3 TEU)
Savings compared to Double Haulage (4TEU)	43%	34%	21%

Table 19 Emissions

This can be compared to the calculated emission savings for double haulage in the Port of Gothenburg (Jivén, 2003) that were estimated between 30-40%. One might argue that this environmental saving is reason enough to make a modal shift. But as the business environment look today environmental savings must be followed by economic savings as well.

The case studies in this paper show how the increased efficiency, in fewer trips per year, decreases the PPH costs when introducing double haulage. The results indicate that double haulage can lower transport costs with approximately 3-6% for case F and 7-8% for case S, depending on utilization rate in double haulage. See Table 20 below.

Case F				
Utilization Rate (TEU)	4	3,75	3,5	3,25
Double Haulage				
Cost saving (%) in total cost, Double Haulage compared to All Road	6%	5%	4%	3%
Case S				
Utilization Rate (TEU)	4	3,75	3,5	3,25
Double Haulage				
Cost saving (%) in total cost, Double Haulage compared to All Road	8%	8%	7,5%	7%

Table 20 Cost Savings

If the introduction of double haulage shall be as successful as possible it is important that goods flows are stable and a good utilization rate can be applied. The stable goods flow will make it possible to achieve better planning resulting in high utilization rates. The goods would also preferable need to be transferable to 40ft containers in order to get the most favorable handling and utilization, both on rail and on truck. When PPH cost for Standard Haulage is compared to Double Haulage a utilization rate of 88% (3.5TEU) is required for Double Haulage to remain profitable in the case where Standard Haulage utilizes 3TEU. This is indicated in the diagram below where the break-even is where Double Haulage utilizes approximately 3.5TEU.

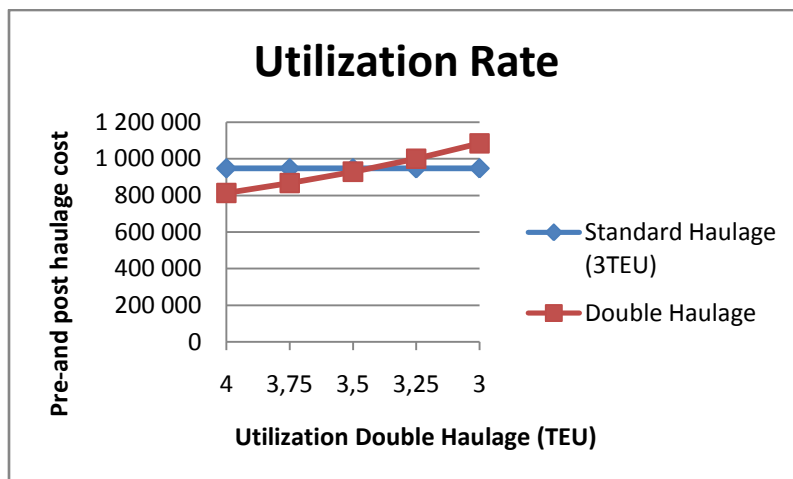


Diagram 9 Utilization Rate

When introducing the subject of long vehicles, it is believed by some that the best would be to drive the main distance with longer vehicles and then stop outside the cities and de-couple to shorter vehicles outside the city (Lundqvist, 2009). This would however mean that road would compete with rail on the main haulage and that is something that should be avoided. In the ETT project this is avoided by the very fact that on the road stretch ETT traffics there is no rail alternative. Even if new technology decreases the environmental impacts from road traffic, it can still not compete with rail in this area. Arvidsson (2009) claims that it is crucial that the load carriers are able to drive all the way to its final destination without further de-coupling points. Usage of for example micro terminals outside city areas where long vehicles, performing pre-and post haulage, are de-coupled and the load continues on smaller trucks would eat up the profit margins and the system would not be profitable.

Intermodal transport has according to transport buyers had some problems with time and quality parameters (Nelldal & Wajzman, 2008). In many cases road transport is chosen because it is faster than an intermodal alternative. In the case of Skaraborg however the road transports have to pass through Gothenburg, meaning that a considerable amount of time is spent in traffic jam. According to Thorén (2009) are the rail shuttles very reliable in the sense of arrival and departure times. Another issue raising today is the environmental consciousness of the consumers, putting higher demands on the transport buyers. Nelldal and Wajzman (2008) identify environmental aspects as a more and more important parameter in the decision of buying transports. In cases like the one in Skaraborg, where there is a rail solution available, it might therefore be hard to argument for not using it in the future.

What are the technical, road wear and traffic safety effects from introducing double haulage?

In order to analyze potential benefits from a modal shift, one need to make sure that the technical requirements are fulfilled e.g. are the goods transferable from road to

rail. The historical competition between road and rail (Nelldal & Wajzman, 2008) can be seen as one of the reasons for the development of the different load carriers; trailers on road and containers at sea and eventually on rail. These are aspects that make a transfer of goods between modes harder; the load carriers are developed for full efficiency on one mode only. This indicates that either the usage of containers on road, or the usage of trailers on rail, has to be more efficient. Today we can see that a more integrated thinking is developing, e.g. Railport Scandinavia has started to take trailers on their shuttle trains instead of only containers (Port of Gothenburg, 2009).

There are more technical aspects that should be considered in the scope of double haulage, one is the vehicle combinations to be used. Without going too much into details it is suggested (Holmstrand, 2009) that the EMS could be used as base and a similar solution with modules is created for this type of vehicles as well. EMS would provide a certain level of safety and control over the vehicles used. In the EMS it is regulated how the different parts of the vehicles need to be equipped with brakes, the length of the brake path and the acceptable turning radius.

There is an infrastructural aspect that needs to be covered as well when analyzing the double haulage concept. It is easy to believe that longer vehicles would affect the infrastructure in a negative way and create more wear and tear than vehicles of 25.25m. Are these long vehicles based on EMS standards (ETT, GA Åkerierna) the axle load can be decreased, despite the longer vehicles, and therefore affect the road wear in a positive way. Even though there are high requirements on these vehicles when it comes to turning radius and brakes, there might be some infrastructure changes that are needed. On small country roads there might be hard to pass these vehicles and it might be certain roundabouts that are too small. One example of solving this problem would be making a lane straight through the roundabout where the long vehicles could pass (Holmstrand, 2009). The infrastructure for the two cases in the paper differs; case S has pre haulage in an industrial area and the case F has the main part of the pre haulage on a country road. These are very different situations and the accessibility might be a problem, especially in smaller towns that are not planned for heavy traffic. In industrial areas however the planning has usually taken heavy traffic in consideration, making access easier.

The traffic safety effects from longer vehicles are somewhat unclear. One might argue that the longer vehicles will reduce the number of fronts on the roads and that will reduce the number of accidents. There are however no research supporting this (VTI, 2008). But should there be an accident where a long vehicle is involved this view might change. One must consider that longer vehicles take longer time to pass and that there might be an increased risk when passing these vehicles. Neither here is there any research to support this fact, but project ETT nor GA Åkerierna both operating long vehicles, have not seen any problems in traffic safety.

How does the process of being granted exemption for extra long and/or heavy vehicles look?

Getting an exemption for indivisible load involves that you send an application to SRA. For these situations there is a framework that is used and the key whether to get an exemption or not depends if the load is indivisible or not (Swedish Road Administration, 2008b). However when the load is divisible, it is the STA that takes the decision. This is a process that is adjusted from case to case and there is no general framework in the same meaning as in the exemption situation. This can be explained by the need for a regulation when load are divisible. A regulation is more extensive work since it need a change in the legislation and must not violate any EU directives. Each case with its specific parameters is considered separately (Lundqvist, 2009). The fact that a traffic regulation is needed for divisible load leads to a lengthy process before the decision is taken.

According to Arvidsson (2009) it has been a very lengthy process waiting for a regulation decision and he has experienced some hesitation in who should take the decision. This might be explained by the organizational changes made within the Swedish Road Administration where the Swedish Transport Agency were developed and appointed responsible for divisible load and traffic regulations. The application from PGF Transport can thereby be said to have been caught between two systems.

One factor affecting the regulation decision is the road type, in the case of PGF Transport the transports would take place on E4, which is a high standard road. In the Port of Gothenburg one can to some extent avoid the problem of road type thanks to the private roads. For case S a similar solution might be valid since the haulage takes place in an industrial area and is limited to a few kilometers. In case F however the 20km haulage is on a country road, which might cause a longer and more extensive investigation from STA and the different interest groups involved in the process.

Since each inquiry to the STA is reviewed separately it might seem difficult to make the traffic regulation process faster and more efficient. The fact that it is often many different interest groups that has to give their statements of opinion makes the process long and complex as well. This means that the process of traffic regulations is considered more like a guideline for in which order things shall be done than an actual decision process. However the process for granting exemptions for indivisible load consists of a standardized set of rules so one might argue that a standardization of the regulation process for divisible load would be possible.

In later years an increase in the number of exemption applications has been noticed (Holmstrand, 2009). If this trend continues, the arguments for a standardized decisions process become even more crucial. With an increased number of applications the need of control is more evident as well. As of today, there is no central unit having an overall picture of, or organizing, the long vehicle projects. There must be an overall picture available as the number of applications increases so

that the applicants can be ensured a fair decision. Avoiding arbitrary situation where two similar situations has been treated differently.

In the traffic regulation example presented in this paper several statements of opinions were presented. One could among others find the National Rail Administration's doubtful statement were they are afraid that the longer vehicles would compete with rail. One might believe that double haulage introduced for PPH only would be found more positive from the National Rail Administration. A further development of double haulage in cooperation with intermodal transports would help to promote rail transports and could lead to a better door-to-door intermodal transport solution.

From a political aspect there is also a certain cautiousness concerning longer vehicles due to the fact that Sweden together with Finland already have the longest vehicles in Europe (VTI, 2008). Both Holmstrand (2009) and Lundqvist (2009) emphasize the importance of international interest when discussing vehicle lengths. For example, if Sweden would start lobbying for even longer vehicles there might be voices raised that this would prevent fair competition. It is here that the modular concept such as EMS becomes even more important; a similar concept could help international competition and double haulage wouldn't be the same threat (Holmstrand, 2009). At various places in Europe tests of driving with 25.25m vehicles are performed and the incentive to go even longer in Sweden might conflict with the process of moving from 18.75m towards 25.25m around Europe (Lundqvist, 2009). Therefore one can argue that using EMS standards for double haulage would have more positive reactions from other countries. The EMS standards would mean that competition would be open to anyone, Swedish as well as European haulers.

11 Conclusion

Double haulage can support intermodal transports in the pre-and post haulage in making the PPH part more efficient. Double haulage would reduce the number of trips and increase the efficiency with better load rates. The case study shows that double haulage support intermodal transports in more efficient pre-and post haulage. The result of this would be emissions savings of approximately 80% with an intermodal double haulage solution compared to all road. Both costs and emissions are lower with double haulage compared to standard haulage. Emissions savings, range between 20-40%, and cost savings, range between 15-40%, depending on the utilization rates. What must be remembered is that when implementing double haulage the utilization rates must be high, if not; double haulage is not profitable. The total cost saving, comparing transports on road only with an intermodal double haulage solution, ranges from 3-6% in case F and 7-8% for case S depending on the utilization rate achieved for double haulage.

Another aspect that must be considered is the exemption or regulation, if no regulation is granted the entire concept fails. The decision process of today is not standardized and if double haulage should be a common concept in the future this process needs to be developed. Traffic safety and infrastructural issues need to be remembered as well; so far no research has showed that longer vehicles would be riskier. Concerning infrastructure the main issue is accessibility, infrastructure planning in history has not taken this kind of vehicles in consideration and it might be hard to have this kind of vehicles in urban areas.

Throughout the thesis work it has been noticed that the area of long vehicles raises both interest and some concerns. It is many aspects that need to be covered to evaluate the concept, and this paper has presented a selection of these. It is clear that the transport sector stands before great changes with increased demands from consumers; this might lead to new ways of development. One way of development that would be interesting to see would be an increased cooperation between the different modes, where concepts like double haulage can be introduced. Competition between the transport modes is not all bad, it is in many cases fierce competition that drives development, but it can also hinder development with protectionist strategies.

12 Discussion and Future Research

The intermodal solution presented in the case study is an intermodal solution within Railport Scandinavia. For future research it would be interesting to see how the concept of double haulage can be further developed in relation to the rail shuttle system. It is a fact that the shorter shuttles today have had problems with profitability and if double haulage could be implemented on a broader scale this might help solving this problem. The model used for this case can be developed further and adapted to new distances and goods volumes to see how big potential the rail shuttle together with double haulage can have in other regions and in the whole of Sweden.

The rail shuttle has developed fast and has gained international attention. The aim is to keep this fast development and introduce new shuttles and concepts to attract new customers. As the development is today the Port of Gothenburg has launched initiatives to take trailers on the rail shuttles. With this development in mind an interesting research would be to look at double haulage together with rail shuttles and trailers. The focus in the case study has been on container traffic, i.e. it is not only an issue of transferring goods from road to rail but also of transferring goods from trailer to container. As the situation is today handling costs for trailers on rail are slightly higher than for containers. There is also a time aspect to consider; trailers take longer time to handle. This is however aspects that are likely to improve as the usage develop. Another issue is the length of the double haulage vehicles, they would be even longer than the container combinations and might make the exemption process more difficult. Nevertheless it would be interesting to examine the potential of Railport Scandinavia in general and the trailer segment in particular.

The traffic regulations existing as of today have no requirements when it comes to time limits. The long vehicles can therefore be driven at any time during the day. This is an issue that needs some consideration as well. If there would be a problem getting an exemption due to heavy traffic or similar in a certain area one might consider giving an exemption that is only valid during certain times and limited to a certain speed. It might also be the case that alternative routes can be used or public roads within industrial areas can be made into private roads, such as in the Port of Gothenburg. Recalling the analysis of utilization rates and that good planning is required to reach these high rates, one might argue that if such good planning is already in place for maximizing double haulage efficiency; then driving on limited times wouldn't be a problem either.

The EMS system is something that has been brought up at several occasions in the paper. The detailed technical aspects of the vehicle construction are out of the scope of this paper and have therefore not been given that much attention. There are however some aspects that should not be neglected. At several occasions during the research process concerns about implementing even longer vehicles and what the reactions would be from the rest of Europe were raised. Therefore it is very crucial that the vehicles are built on some kind of modular system that can easily be adjusted

DISCUSSION AND FUTURE RESEARCH

to fit international standards. Another issue that should be stressed is that the vehicles are only meant for PPH transports; and these are rarely executed by non-Swedish haulers. Yet another aspect of EMS is traffic safety; developing a concept like EMS for double haulage would mean that traffic safety aspects such as brake standards and turning radius would be guaranteed as well. To further develop the reasoning around the EMS standards and what type of load carriers to use in cooperation with double haulage and intermodal transports would be an interesting area for future research.

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14 Appendices

14.1 Vikt- och dimensionsbestämmelser

(grundregler i trafikförordningen.)

4 kap.

11 § Vagnar som inte är enskilda delas in i tre bärighetsklasser. Om inte annat har föreskrivits tillhör en allmän väg bärighetsklass 1 (BK1) och övriga vagnar som inte är enskilda bärighetsklass 2 (BK2). Föreskrifter om att en allmän väg eller del av en sådan väg skall tillhöra bärighetsklass 2 eller 3 meddelas av Vägverket eller, om kommunen är väghållare, av kommunen. Föreskrifter om att någon annan väg som inte är enskild eller en del av en sådan väg skall tillhöra bärighetsklass 1 eller 3 meddelas av kommunen.

12 § På vägar som inte är enskilda får motordrivna fordon eller därtill kopplade fordon föras endast om de värden för respektive bärighetsklass som anges nedan inte överskrids.

	BK 1	BK 2	BK 3
1. Axeltryck			
a. Axel som inte är drivande	10 ton	10 ton	8 ton
b. Drivande axel	11,5 ton	10 ton	8 ton
2. Boggitryck			
a. Avståndet mellan axlarna är mindre än 1,0 meter	11,5 ton	11,5 ton	11,5
ton			
b. Avståndet mellan axlarna är 1,0 meter eller större men inte 1,3 meter	18 ton	16 ton	12 ton
c. Avståndet mellan axlarna är 1,3 meter eller större men inte 1,8 meter	16 ton	16 ton	12 ton
d. Avståndet mellan axlarna är 1,3 meter eller större men inte 1,8 meter och drivaxeln är försedd med dubbelmonterade hjul och luftfjädring eller likvärdig fjädring, eller drivaxlarna är försedda med dubbelmonterade			
hjul och vikten inte överstiger 9,5 ton på någon av axlarna	19 ton	16 ton	12 ton
e. Avståndet mellan axlarna är 1,8 meter eller större	20 ton	16 ton	12 ton
3. Trippelaxeltryck			
a. Avståndet mellan de yttre axlarna är mindre än 2,6 meter	21 ton	20 ton	13 ton
b. Avståndet mellan det yttre axlarna är 2,6 meter eller större	24 ton	2 ton	13 ton
4. Bruttovikt av fordon och fordonståg			
a. Fordon på hjul	Bil. 1	Bil. 2	Bil. 3
b. Fordon på band eller medar	18 ton	18 ton	18 ton

Vägverket får meddela föreskrifter om att fordon eller fordonståg får föras trots att de värden som anges i första stycket överskrids. Föreskrifterna skall vara förenade med sådana villkor i fråga om förändring och fordonets konstruktion och utrustning att trafiksäkerheten inte äventyras. Föreskrifterna får begränsas till en viss väg eller ett visst vägnät

13 § På vägar som inte är enskilda får fordonståg föras endast om de värden som anges nedan för avståndet mellan den första axeln på ett tillkopplat fordon och den sista axeln på fordonet som det är kopplat till inte underskrids.

	BK 1	BK 2	BK 3
1. Båda axlarna är enkelaxlar	3 meter	3 meter	3
meter			
2. Den ena axeln är en enkelaxel och den andra ingår i en boggi	3 meter	4 meter	4
meter			
eller trippelaxel			
3. Axlarna ingår i var sin boggi	4 meter	4 meter	4
meter			
4. Den ena axeln ingår i en boggi och den andra i en trippelaxel	5 meter	-	-
eller båda i en trippelaxel			

Ett fordonståg får dock föras på sådan väg som avses i första stycket om vikten för varje möjlig kombination av axlar inom fordonståget understiger högsta tillåtna bruttovikt för motsvarande avstånd mellan första och sista axeln enligt bilaga 1-3 till denna förordning. Vid jämförelse med bilaga 1 skall de värden som anges för släpvagnar gälla, om den tillåtna bruttovikten därigenom blir högre. Vägverket får meddela föreskrifter om att fordonståg får föras trots att de värden som anges i första och andra styckena underskrids. Föreskrifterna skall vara förenade med sådana villkor i fråga om förändring och fordonets konstruktion och utrustning att trafiksäkerheten inte äventyras. Föreskrifterna får begränsas till en viss väg eller ett visst vägnät.

14 § Trots bestämmelserna i 12 § 4, 13 § och bilaga 1 får fordon och fordonståg som huvudsakligen används i internationell trafik föras på vägar med bärighetsklass 1 om följande längdmått och bruttovikter inte överskrids.

1. 26 ton för treaxligt motorfordon.
2. 38 ton för fyraxligt fordonståg.
3. 40 ton för fem- eller sexaxligt fordonståg.
4. 44 ton för treaxligt motorfordon med två- eller treaxlig påhängsvagn vid transport av 40 fots ISO- container.
5. 16,5 meter för bil med påhängsvagn.
6. 18,75 meter för bil med släpvagn.

15 § Om ett motordrivet fordon eller ett därtill kopplat fordon lastas så att lasten på någondera sidan skjuter ut mer än 20 centimeter utanför fordonet eller om fordonets bredd, lasten inräknad, överstiger 260 centimeter eller för en buss 255 centimeter, får fordonet eller därtill kopplat fordon föras endast på enskild väg.

Följande fordon får dock föras på väg som inte är enskild.

1. Lätt motorcykel vars bredd med last inte överstiger 120 centimeter.
2. Redskap som används i jordbruksarbete, även om bredden överstiger 260 centimeter.
3. Fordon som är lastat med opackat hö eller liknande, även om lasten på någon sida skjuter ut mer än 20 centimeter utanför fordonet.
4. Traktor med påmonterat redskap eller utrustning även om fordonet är bredare än

260 centimeter,

redskap eller utrustning inräknad.

5. Motorredskap vid kortare färd till eller från en arbetsplats eller för liknande ändamål,

även om fordonet är bredare än 260 centimeter, redskap eller utrustning inräknad.

Vägverket får föreskriva att fordon eller fordonståg som transporterar odelbar last får föras på vägar som inte är enskilda trots att den bredd som anges i första stycket överskrids. Lasten får därvid skjutas ut mer än 20 centimeter utanför fordonet.

Föreskrifterna skall vara förenade med sådana villkor att trafiksäkerheten inte äventyras.

Trots vad som sägs i första stycket får bussar som registrerats före den 1 november 2004 och vars utförande därefter inte väsentligen har förändrats, till utgången av år 2020 föras på andra vägar än enskilda om fordonets bredd, lasten inräknad, inte överstiger 260 centimeter.

17 § Ett annat motordrivet fordon än en buss med eller utan ett därtill kopplat fordon får inte föras på andra vägar än enskilda om fordonet eller fordonståget, lasten inräknad, är längre än 24,0 meter. Längden av ett fordonståg, lasten inräknad, får dock uppgå till 25,25 meter om följande villkor är uppfyllda.

1. Varje ingående fordon är utrustat med sådana låsningsfria bromsar och kopplingsanordningar som Vägverket föreskriver.

2. Varje ingående motordrivet fordon har en största längd av 12,0 meter.

3. Varje ingående ledbuss har en största längd av 18,0 meter.

4. Varje ingående släpvagn, utom påhängsvagn, har en största längd av 12,0 meter.

5. Avståndet mellan kopplingstappen och bakkanten på en påhängsvagn inte överstiger 12,0 meter.

6. Det horisontella avståndet mellan kopplingstappen och varje punkt på framkanten av en påhängsvagn inte överstiger 2,04 meter.

7 a. Fordonstågets sammanlagda lastlängd bakom förarhytten, mätt parallellt med fordonstågets längsgående axel, inte överstiger 21,86 meter.

7 b. Avståndet, mätt parallellt med fordonstågets längsgående axel, från den längst fram belägna yttre punkten på lastutrymmet bakom förarhytten till den längst bak belägna yttre punkten på fordonståget inte överstiger 22,9 meter.

8. Fordonsbredden, utom för påbyggnad för temperaturkontrollerade fordon, är högst 2,55 meter.

9. Bredden på påbyggnad för temperaturkontrollerade fordon är högst 2,60 meter.

10. Varje ingående motordrivet fordon som är i rörelse kan vända inom en cirkelring som har en yttre radie på 12,5 meter och en inre radie på 5,3 meter.

11. Fordonståget uppfyller de vändningskrav som Vägverket föreskriver.

Bestämmelserna om längd och avstånd i andra stycket 2-5 skall omfatta även avtagbara påbyggnader och standardiserade godsbehållare såsom containrar.

Fordon som har registrerats före den 1 november 1997 och vars utförande därefter inte väsentligen har förändrats, skall till utgången av år 2006 inte omfattas av bestämmelserna i andra stycket 2-10.

Vägverket får föreskriva att fordon eller fordonståg får föras trots att de längder som anges i första stycket överskrids. Föreskrifterna skall vara förenade med sådana villkor att trafiksäkerheten inte äventyras.

17 a § En buss med eller utan ett därtill kopplat fordon får föras på andra vägar än enskilda endast om fordonets eller fordonstågets längd, lasten inräknad, inte överstiger de mått som anges nedan samt uppfyller de vändningskrav som Vägverket föreskriver.

Fordon Längd

Buss med två axlar 13,5 meter

Buss med fler än två axlar 15,0 meter

Ledbuss 18,75 meter

Buss med släpvagn 18,75 meter

Bussar som har registrerats före den 1 juli 2004 och vars utförande därefter inte väsentligen har förändrats, skall till utgången av år 2020 inte omfattas av bestämmelserna i första stycket. Förordning (2004:285).

Bruttoviktstabell BK 1 (bilaga 1)

Avståndet i meter mellan fordonets eller fordonstågets första och sista axel

Högsta tillåtna bruttovikt i ton för fordonet eller fordonståget

	mindre än 1,0	11,5
	men inte 1,3	16
1,3	men inte 1,8	18
1,8	men inte 2,0	20
2,0	men inte 2,6	21
2,6	men inte 5,0	24
5,00	men inte 5,20	25
5,20	men inte 5,40	26
5,40	men inte 5,60	27
5,60	men inte 5,80	28
5,80	men inte 6,00	29
6,00	men inte 6,20	30
6,20	men inte 6,40	31
6,40	men inte 8,25	32
8,25	men inte 8,50	33*
8,50	men inte 8,75	34*
8,75	men inte 9,00	35*
9,00	men inte 9,25	36*
9,25	men inte 9,50	37
9,50	men inte 9,75	38
9,75	men inte 10,00	39
10,00	men inte 10,25	40

10,25	men inte 10,50	41
10,50	men inte 10,75	42
10,75	men inte 11,00	43
11,00	men inte 11,25	44
11,25	men inte 11,50	45
11,50	men inte 11,75	46
11,75	men inte 12,00	47
12,0	men inte 12,5	48
12,5	men inte 13,0	49
13,0	men inte 13,5	50
13,5	men inte 14,0	51
14,0	men inte 14,5	52
14,5	men inte 15,0	53
15,0	men inte 15,5	54
15,5	men inte 16,0	55
16,0	men inte 16,5	56
16,5	men inte 17,0	57
17,0	men inte 17,5	58
17,5	men inte 18,0	59
18,0	och större	60

*) För en släpvagn eller för en dolly med tillkopplad påhängsvagn med ett minsta avstånd mellan första och sista axeln av 6,6 meter gäller dock följande

Avstånd i meter mellan släpvagnens första och sista axel eller mellan dollyns första och påhängsvagnens sista axel	Högsta tillåtna bruttovikt i ton för släpvagnen eller för dollyn med tillkopplad påhängsvagn	
6,6	men inte 6,8	33
6,8	men inte 7,0	34
7,0	men inte 7,2	35
7,2	och större	36

Bruttoviktstabell BK 2 (bilaga 2)

Tabell över högsta tillåtna bruttovikter vid olika axelavstånd på BK 2 vägnätet

Avståndet i meter mellan fordonets eller fordonstågets första och sista axel	Högsta tillåtna bruttovikt i ton för fordonet eller fordonståget
mindre än 2,0	16,00
2,0	20,00
2,6	22,00
4,8	22,16
5,0	22,50
5,2	22,84
5,4	23,18
5,6	23,52
5,8	23,86
6,0	24,20
6,2	24,54
6,4	24,88
6,6	25,22
6,8	25,56
7,0	25,90
7,2	26,24
7,4	26,58
7,6	26,92
7,8	27,26
8,0	27,60
8,2	27,94
8,4	28,28
8,6	28,62
8,8	28,96
9,0	29,30
9,2	29,64
9,4	29,98
9,6	30,32
9,8	30,66
10,0	31,00
10,2	31,34
10,4	31,68
10,6	32,02
10,8	32,36
11,0	32,70
11,2	33,04

11,4	men inte 13,4	38,00
13,4	men inte 13,6	38,04
13,6	men inte 13,8	38,56
13,8	men inte 14,0	39,08
14,0	men inte 14,2	39,60
14,2	men inte 14,4	40,12
14,4	men inte 14,6	40,64
14,6	men inte 14,8	41,16
14,8	men inte 15,0	41,68
15,0	men inte 15,2	42,20
15,2	men inte 15,4	42,72
15,4	men inte 15,6	43,24
15,6	men inte 15,8	43,76
15,8	men inte 16,0	44,28
16,0	men inte 16,2	44,80
16,2	men inte 16,4	45,32
16,4	men inte 16,6	45,84
16,6	men inte 16,8	46,36
16,8	men inte 17,0	46,88
17,0	men inte 17,2	47,40
17,2	men inte 17,4	47,92
17,4	men inte 17,6	48,44
17,6	men inte 17,8	48,96
17,8	men inte 18,0	49,48
18,0	men inte 18,2	50,00
18,2	men inte 18,4	50,52
18,4	men inte 18,5	51,04
18,5	och större	51,40

Bruttoviktstabell BK 3 (bilaga 3)

Tabell över högsta tillåtna bruttovikter vid olika axelavstånd på BK 3 vägnätet

Avståndet i meter mellan fordonets eller fordonstågets första och sista axel		Högsta tillåtna bruttovikt i ton för fordonet eller fordonståget
	mindre än 2,0	12,0
2,0	men inte 2,4	12,5
2,4	men inte 2,8	13,0
2,8	men inte 3,2	13,5
3,2	men inte 3,6	14,0
3,6	men inte 4,0	14,5
4,0	men inte 4,4	15,0
4,4	men inte 4,8	15,5
4,8	men inte 5,2	16,0
5,2	men inte 5,6	16,5
5,6	men inte 6,0	17,0
6,0	men inte 6,4	17,5
6,4	men inte 6,8	18,0
6,8	men inte 7,2	18,5
7,2	men inte 7,6	19,0
7,6	men inte 8,0	19,5
8,0	men inte 8,4	20,0
8,4	men inte 8,8	20,5
8,8	men inte 9,2	21,0
9,2	men inte 9,6	21,5
9,6	men inte 10,0	22,0
10,0	men inte 10,4	22,5
10,4	men inte 10,8	23,0
10,8	men inte 11,2	23,5
11,2	men inte 11,6	24,0
11,6	men inte 12,0	24,5
12,0	men inte 12,4	25,0
12,4	men inte 12,8	25,5
12,8	men inte 13,2	26,0
13,2	men inte 13,6	26,5
13,6	men inte 14,0	27,0
14,0	men inte 14,4	27,5
14,4	men inte 14,8	28,0
14,8	men inte 15,2	28,5
15,2	men inte 15,6	29,0
15,6	men inte 16,0	29,5
16,0	men inte 16,4	30,0
16,4	men inte 16,8	30,5
16,8	men inte 17,2	31,0

17,2	men inte 17,6	31,5
17,6	men inte 18,0	32,0
18,0	men inte 18,4	32,5
18,4	men inte 18,8	33,0
18,8	men inte 19,2	33,5
19,2	men inte 19,6	34,0
19,6	men inte 20,0	34,5
20,0	men inte 20,4	35,0
20,4	men inte 20,8	35,5
20,8	men inte 21,2	36,0
21,2	men inte 21,6	36,5
21,6	men inte 22,0	37,0

Är axelavståndet 22,0 meter eller större utgör högsta tillåtna bruttovikten 37,5 ton med tillägg av 0,25 ton för varje 0,2 meter varmed axelavståndet överstiger 22,0 meter.

Source: Vägverket. (2008a). *Lasta lagligt - Vikt- och dimensionsbestämmelser för tunga fordon 2008*. Borlänge: Vägverket

14.2 Interview Manuscript Tomas Arvidsson

PGF Transport, Vaggeryd, 2009-03-05. Telephone interview

Berätta om projektet!

1. Hur transporteras containrarna till terminalen?
2. Hur ofta kör man och vilka volymer ingår i projektet?
3. Med hur mycket förväntas ni överskrida längdrestriktionen?
4. Hur upplever du beslutsprocessen?
5. När förväntar du dig att beslut kommer att fattas?
6. Vad har du fått för svar hittills?
7. Har du varit i kontakt med många instanser?
8. Hur förändras kostnadsbilden?

Målet med intervjun:

- Bakgrundsinfo om ansökan
- Info om hur processen med ansökan sett ut
- Status idag

14.3 Interview Manuscript Lennart Cider and Lena Larsson

Volvo Technology, Gothenburg, 2009-03-10

1. Vilken är er roll i projektet?
2. Bakomliggande faktorer:
3. Vad ligger bakom initiativet till ETT?
4. Hur länge löper projektet?
5. Finns det någon risk med att dessa fordon konkurrerar ut tågtransporter?
6. Vad krävs för att projektet ska anses vara lyckosamt?
7. Vad blir nästa steg om så är fallet?
8. Finns det några risker med projektet?
9. Vilka parametrar är det som studeras under projektet?
10. Finns det några data om bränsleförbrukning för de långa/tunga fordonen?
11. Hur har lastbilarna behövt modifieras? Med tanke på bromsförmåga och axeltryck etc.?
12. Hur gick dispensförfarandet till?
13. Vilka är argumenten för att få köra med delbart gods?

Målet med intervjun:

- Ta reda bakomliggande faktorer till projektet.
- Dispens. Varför gick det när godset är delbart.
- Bränsleförbrukning, hur har den förändrats.
- Forskning angående trafiksäkerhet.
- Förklaring av tekniska detaljer.

14.4 Interview Manuscript Tomas Holmstrand

Swedish Road Administration, Gothenburg, 2009-03-16

1. Vilken är din arbetsroll på Vägverket?
2. Är du delaktig vid projekt för långa fordon för tillfället? (Såsom långa timmerbilar i Västsverige.)
3. Hur ser processen ut för att ansöka om dispens?
4. Vilka instanser är inblandade?
5. Har ni sett någon förändring angående dispenser de senaste åren, från Vägverkets sida, eller från åkeriers sida?
6. Hur ser framtiden ut när det gäller trafiken med långa fordon?
7. Är trafiken med långa fordon något man är intresserad av att utveckla eller finns det andra faktorer som spelar in? (T ex järnvägsindustrin, konkurrensmässigt)?
8. Vad för problem kan uppstå om för många dispenser skulle accepteras?
9. Projekt som körs, hur resonerade vägverket för att ge dispens? (ETT, Gbg hamn)
10. Vad krävs för att få dispens när gods är delbart, som Arendal eller ETT?
11. Från VV sida; skulle det göra någon skillnad gällande dispenser om det var transporter endast avsedda för att forsla gods till intermodala terminaler och inte ersätta ordinarie fordon ute på vägarna?
12. Vad för risker finns med att underlätta för att kunna köra 2x40ft i industriområden?

Målet med intervjun:

- Vi vill veta hur beslutsprocessen kan göras lättare. Hur tänker VV angående dispensprocessen.
- Har beslutsprocessen förändrats, kommer den att förändras?
- Är VV nöjda med dagens system?
- Hur ser VV på framtiden inom detta område.

14.5 Interview Manuscript Anders Lundqvist

Swedish Transport Agency, Borlänge, 2009-03-27. Telephone interview

1. Vilken är din arbetsroll på Transportstyrelsen?
2. Hur går det till när en trafikföreskrift för överskridande av längd eller vikt ges?
3. Vad ställs för krav?
4. Hur ställer sig TS till längre fordonskombinationer?
5. Kommer det många förfrågningar angående trafikföreskrifter för längd och vikt? Har det skett någon förändring (ökat?)
6. Hur ser tidsramen ut för ett beslutsfattande? (Från förfrågan till beslut)
7. Hur går tankarna angående konkurrenssituationen då längre fordon godkänns?
8. Anses forslingstransporter som ”lokala” transporter liknande skogstransporter och på så sätt inte hotar konkurrensen på EU nivå?
9. Föreskriften Gbg hamn:
Skulle den föreskrift som gäller Gbg hamn kunna byggas ut och användas på andra industriområden i landet?
10. Hur ställer man sig till att tillåta liknande fordon i forsling till och från intermodala terminaler?
11. Om detta vore en möjlighet; största risken?
12. Krävdes det en föreskrift för projekt ETT, eller körs det på enbart dispens?

Målet med intervjun:

- Ta reda på hur arbetet med trafikföreskrifter går till
- Hur man resonerar kring långa fordon
- Vilka hinder finns för projektet

14.6 Interview Manuscript Lars Berndtsson

GA Åkerierna, Tjörn, 2009-03-31.

1. Har ni som åkeri behövt vara i kontakt med några myndigheter eller har det skötts av andra parter?
2. Upplever ni att det finns några problem med att köra dessa långa ekipage?
3. Har ni upplevt några klagomål eller andra problem?
4. Hur påverkar ett sådant här koncept konkurrenssituationen?
5. Är fordonen specialanpassade för just detta ändamål eller är det ordinarie delar som kan vara ihopkopplade? Kan de användas till annat eller blir det mycket tid de står stilla?
6. Vad ställs för krav på svängradie, bromsar etc.?
7. Hur ser bränsleförbrukning ut för dessa ekipage?
8. Hur upplever chaufförerna det?
9. Ställs det ytterligare krav på chaufförerna?
10. Vad är hastighetsbegränsningen för dessa fordon?

Mål med intervjun:

- Ta reda på tekniska detaljer angående fordonen
- Har det varit några problem eller klagomål

14.7 Interview Manuscript Stig-Göran Thorén

Port of Gothenburg, Handelshögskolan Gothenburg, 2009-04-24.

1. Hur ser utvecklingen av containerpendlar ut? (Växa med 2 pendlar om året och öka kapaciteten på befintliga)
2. Något som hindrar utvecklingen?
 - Vad är den största flaskhalsen i systemet?
 - Några infrastruktur begränsningar?
 - Om; Hur kan man lösa dessa?
3. Hur ser du på framtiden för järnvägspendlarna till och från hamnen?
4. Hur lång strecka är pendlarna i genomsnitt? (finns det något minimiavstånd?)
5. Andel containrar? (40/20)
6. Hur ser man på hanteringen av 20 vs 40 fotare, är det något man föredrar?
7. Hur ser utvecklingen ut för trailers?
8. Hur skiljer sig hanteringen mellan container och trailer?
9. Vilken är den potentiella volymen för pendelsystemet?
 - T.ex. är man nära maxkapacitet?

Målet med intervjun:

- Ta reda på mer information om hamnpendlarna och hur framtiden ser ut
- Utvecklingen av Railport Scandinavia