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Capacity Analysis of Rail Container Freight Shuttle Train

Which factors are important for running this kind of train?

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To my lovely parents ***Guoxiang Chen*** and ***Xiurong Yang*****,** I dedicate this volume in token of affection and gratitude.

By *Yang Chen*

This thesis is dedicated to my dear parents ***Yunpeng Shi*** and ***Yugui Fan***, who give me a joyful life**.**

By *Huirong Shi*

Abstract

Banverket, the Swedish National Rail Administration, and the Port of Göteborg are interested in finding which factors are important for carrying the rail container freight shuttle trains. The capacity analysis is being researched on a railway link. We propose that capacity on a railway link can be assessed by analyze the interrelationship of different sections in between the whole link.

This report covers an account of our implementation of Vänerexpressen AB case. We focus on how different factors in between the whole rail link interact each other and how the capacity be influenced by the interaction.

The interrelationship of different sections is important for finding a practical way to increase the rail capacity. Our results constitute an important piece in a work that has the potential of making a real difference in the way in which capacity related issues in this field are handled.

Acknowledgement

We would like to take advantage on this occasion to express our gratitude to the people who have helped us in the completion of this thesis.

First all, we would like to thank Banverket for giving us the opportunity to carry out this studying, especially thank the Strategic Planner Mr. Per Rosquist, Mr. Bent Rydhed for their assistance.

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Also we want to express our gratitude to our supervisor Professor Lars Brigelius for his discussions, guidance and feedback through the entire process of thesis. Furthermore, we are ever grateful for the support given to us by Yang You, Ann McKinnon and Kajsa Strandberg. Many thanks also to PhD. Rickard Bergqvist for his assistance in the writing process.

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Göteborg, December 2003

Yang Chen Huirong Shi

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1. Introduction

In this first chapter we give the background to our case. Furthermore, we introduce the current situation and present research problems. Moreover, we present the purpose, the case of the company and the outline of the thesis as well as our scope.

1.1 The current situation of this case

There exist a lot of industries, for example, the coffee industry and forest industry within the circle with radius 70km, in the center of Karlstad. It obviously made Karlstad an important goods output and transfer center. The goods need to be transported by the Rail Container Freight Shuttle Trains to the Port of Göteborg. After the trains arrive at the Port, they are loaded and unloaded onto the ships and then transported all over the world. This procedure also fits for goods flow in the opposite direction; the goods (Since the goods are all unit load, we will use *containers* to replace the *goods* somewhere in this thesis) transported by the ship from all over the world are unloaded and reloaded onto the container freight shuttle trains in the port and then send to Karlstad.

Within this chain, the Port of Göteborg plays a role as the original/destination terminal. Obviously, it has a very important position: a link in the chain.

“Göteborg will be the natural goods hub for sea transport in northern Europe. Just like our owners, we think that the Göteborg region has every prospect of developing into a logistics center for Scandinavia, and also for the Baltic region. Large quantities of Nordic goods are now transited over the continental ports, creating bottlenecks and increasing environmental impact. Development of Göteborg as a goods hub will mean better competition prospects for industry and the creation of job opportunities in the logistic functions. But this also places demands on the infrastructure, access to land and not least our own success in attracting new lines and increasing the range of services. At the same

time we must continue our work with measures to enhance efficiency in order thereby to further improve our competitiveness. ”[1]

When Göteborg, one of the most important centers of industry in North Europe spreads out before you, its port should not be over looked.

“The Port of Göteborg is situated on the west coast of Sweden that gives easy access to the North Sea and beyond. The port is also at the mouth of a deep wide river and an offshore archipelago protects it from the prevailing wind. All these facts have contributed in making the port the largest Nordic port (Norway, Sweden, Denmark and Finland.) ”[2]

Because of its strategic position in Scandinavia and its willing to become even more powerful in the future, a number of investments that will improve the competitive position.

Vänerexpresen AB, one of the rail operators who operate the rail container freight shuttle trains in Karlstad, have the responsibility of transporting the goods from Karlstad to Göteborg.

[1] A word from the President, Eric Nilsson, 2002, Annual Report

[2] http://www.sakrafarleder.nu/Imp_Doc/Projbeskr_eng_030321.pdf

1.2 How the problem arise

At this moment, there are two alternatives for Vänverexpressen to transport their containers to the Port of Göteborg. One is that the train runs along the west line from Karlstad to Göteborg. The other is that one also runs along the east line from Karlstad to Göteborg.

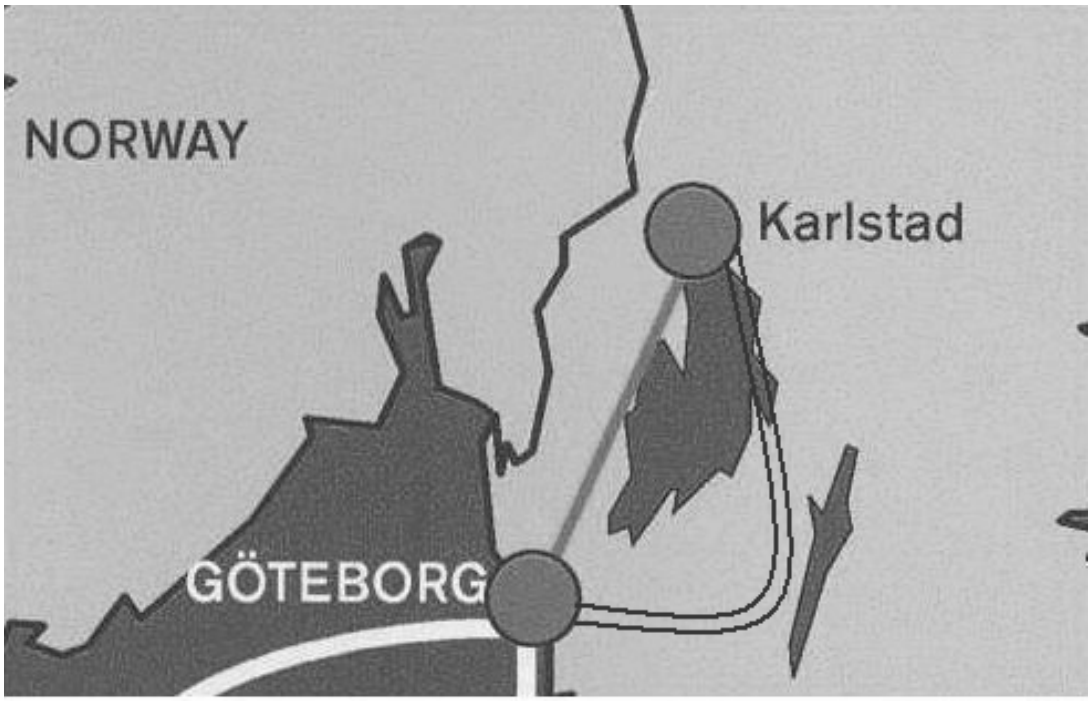

Figure 1: Outline of the link from Göteborg to Karlstad[3]

"This link between Skälebol on the Northern Link and Kil is called the Vänern Line and this link continues to Karlstad. It carries both passenger and goods traffic."[4]

The west line is a single-tracked line. Most Swedish railways have only one track.

[3] Rail, Road & Logistics, 2003, Port of Göteborg

[4] http://www.banverket.se/templates/StandardTtH____3638.asp

“In a single channel flow, a single-tracked line, traffic can only be driven in one direction at a time. All load carriers must be situated in one of the two end points of the channel before the flow can be turned around. This means that the frequency of the traffic between the terminals q5 the ends of the link gets very low if traffic is to be driven in both directions, and if at the same time, there is a great distance between the terminals. It means that in every moment only one unit, one train set can be situated in the link, and there can be no traffic in the other direction until the train set has reached the terminal. ”[5]

The east line is double-tracked and if compared with the singled-tracked one it has a sufficient increase of rail capacity. But, according to other characteristics, it may not be efficient for goods transportation.

1.3 Our proposal of this thesis

Our task here is to find which factors are important for increasing the capacity along the west link for these container freight shuttle trains. Based on the correlated theories that we have learned, we will try to find these important factors through our research on behalf of Banverket.

Banverket, the Swedish National Rail Administration is interested in accessing a practical way to increase the rail capacity for the container freight shuttle trains.

A better-developed railroad capacity would bring an increased flow in the goods, which are transported by rail. Obviously, the rail bound traffic has significant capacity limitation. It is not wise to just increase the capacity only by improve the infrastructure facility because it is not cost efficient. On the contrary, some other management issues can better improve the rail bound capacity.

[5] Fundamentals of Logistics, 2002, p. 86

When mentioning rail capacity, track configuration comes first. We also find that the capacity is not only relates to the track configuration, but also, to some other issues which are included in the whole transportation chain, for example, the handling and management of the port, the train terminals as well as the activities of the rail operators. All of these parameters are very important and need to be further evaluated. We describe the whole transportation like this:

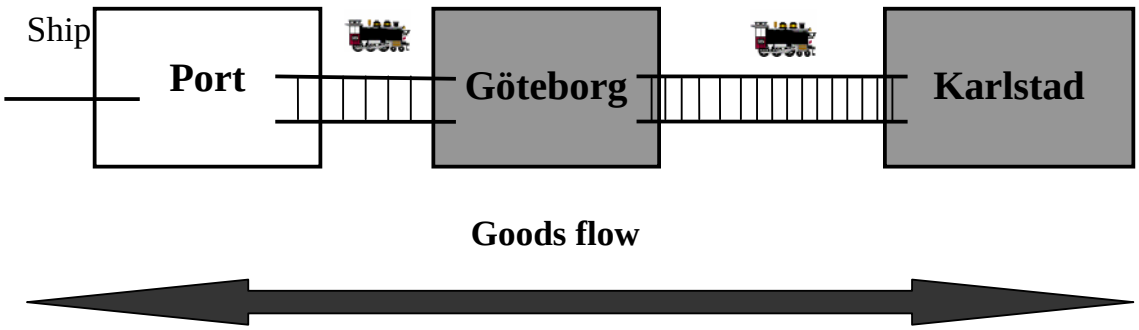

Figure 2: Description of whole link[6]

Every section in between the above transportation chain plays an important role and has a strong tie to the whole link. To some extent, there is a trade-off when working on how to increase the capacity. To the infrastructure-orient point of view, double track can make the capacity significantly increased but from a cost efficient-orient point of view the better way is to well integrate all the sections within the link. This thesis covers an account of our implementation of some methods to do the analysis. Our major contribution to the project is to find the important factors, which might influence the rail capacity and might achieve a significant increase in the rail capacity.

Furthermore, also for the railroad capacity, every key point, which constitutes a single section of the whole chain, is the basic and core parameter to the capacity, and might become the bottleneck. We will exert our utmost to find out and analyze the key points and try to find the important factors via the key points.

[6] Authors

When thinking what the key points are, we will take the following steps:

- Research the whole transportation chain and divide the chain into different sections, for example, the terminals and the rail operators as well as the conditions of the trains are sections in the whole chain.
- Analysis the above sections and think about the activities which will happen in between these sections.
- Evaluate all these activities and then identify which ones are the key points and need to be further evaluated.
- Select some certain methods to classify and test these key points.
- Determine the important factors by testing the key points.

1.4 Out line of the thesis

The structure of the thesis is to be prescribed like this: the first part is the introduction about the whole case.

Then the methodology part tells how we conduct our research, and the main method we will select to get the evidence for our empirical data. The survey, questions to different persons who are in charge of different parts within the link is the basis of our research work.

The theoretical framework comes as the third part. In this part we will describe related theory according to our knowledge gained from the book: Lumsden, K.R., 2002, *Fundamental of Logistics,* translation of selected chapters of the book "*Logistikens Grunder*". Since this case is in the areas between technology and economy, but with mean focus on the business administration, the technical theory has a strong tie to business theory, which is very much correlated.

The analysis is definitely the most important part about the thesis. In this part we will draw a conclusion about our research and show our opinion and suggestion about this real world case.

Last but not the least, the final part gives the suggestion for the future research in this domain.

1.5 Our scope to this thesis

We focus on finding the factors, which might increase the capacity, and here in this thesis we only carry our research on the railway link in between Karlstad and Göteborg. All the conclusions we draw are only based on our research, and perhaps only fit this specific link.

2. Methodology

The purpose of methodology chapter is to present the methods and the procedures that we have used in this research. Each section of this chapter will explain how we have implemented the theory in our thesis. The study point of the methodology chapter will be the research strategy, design of the case study and the scientific research approach. After that, in the section of quality of the research, we will describe the validity and reliability.

It known to us all that the methodology part is definitely a very important part of the whole thesis. Using a suitable way to describe your problem is half of the success.

The methods we employ in our paper were shown in the literature. For example, ***Case Study Research in Logistics.***

Our objective is to find the important factors, which might influence the rail capacity by doing research and analysis of the container freight shuttles from Göteborg to Karlstad. This link consists of by different sections, and each section has a tight relationship to the capacity. Our method to this case is to study every section and find the bottleneck of the whole link. We treat as a case study. According to different case study methods, we can solve the real problem based on our knowledge of the literature. How can we obtain the real forceful verifications to support our study?

2.1 Case study

The answer is the case study.

A case study is an ideal methodology when a holistic, in-depth investigation is needed.[7] Case studies have been widely used in a lot of research fields. Whether the study is experimental or quasi-experimental, the data collection

[7] Feagin, Orum, & Sjöberg, 1991

and analysis methods are known to hide some details.[8] Case studies, on the other hand, are designed to bring out the details from the viewpoint of the participants by using multiple sources of data.

Our case study will choose one or more fundamental and important factors to analysis to understand the whole system.

Case studies are multi-perspective analyses. This means that the researcher considers not just the voice and perspective of the actors, but also of the relevant groups of actors and the interaction between them. This one aspect is a salient point in the characteristic that case studies possess. They give a voice to the powerless and voiceless. When sociological investigations present many studies of the homeless and powerless, they do so from the viewpoint of the "elite".[9]

For our case study, we replicated Levy's study.[10] Each stage of the methodology will consist of a discussion of procedures recommended, followed by a discussion of the application of those procedures in the proposed study:

1. Design the case study protocol:
   - Develop and review the protocol
   - Determine required skills for case study
   - Select necessary theories as the basis for study
2. Conduct the case study:
   - Prepare for data collection
   - Unfold the case study
3. Present and analyze case study evidence:
   - Analytic strategy
4. Develop conclusions, recommendations, and implications based on the evidence

[8] Stake, 1995

[9] Feagin, Orum, & Sjoberg, 1991

[10] Levy's, 1988

The following parts will give more discussion of the above steps according to the order of the current study. And every part, which begins with the literature's procedures, is followed by the current study's application.

2.2 Design the case study protocol

The first stage in the case study methodology recommended by Yin is the development of the case study protocol.[11]

Recommended Procedures in Determine the Required Skills

Yin suggested that the researcher must possess or acquire the following skills: the ability to ask good questions and to interpret the responses, be a good listener, be adaptive and flexible so as to react to various situations, have a firm grasp of issues being studied, and be unbiased by preconceived notions.[12] The investigator must be able to function as a "senior" investigator.[13]

We have learned quantities of basic logistics theories from the textbooks, which join a large number of facts from real-world experience, what in turn can solve the true case. Also in future the theories need to be proved and improved by practice. So we call the practice, the basic driving force or the theories. According to this, when solving a problem, we have the theories as our stepping-stone, and we will then find the real-world experience as our important verification.

After an overview of the whole link as well as every section, we would like to research it one step at a time. And we will treat these sections as *sub-cases.* All the problems reflected in the sub-case will be the potential bottleneck to the whole link.

[11] Yin, 1994
[12] Ibid.
[13] Feagin, Orum, & Sjöberg, 1991

2.3 Conduct the case study, Preparation for data collection, Unfold the case study

2.3.1 Recommended procedures

The second stage of the methodology recommended by Yin, and which were used in the current study is the conduct of the case study. There are three tasks in this stage that must be carried out for a successful project: *Preparation for Data Collection*, *Distribution of the Questionnaire*, and *Conducting Interviews*.[14]

Once the protocol has been developed and tested, it puts the project into the second phase - the actual execution of the plan. In this phase the primary activity is that of data collection. The protocol described above addresses the types of evidence that are available in the case organization. In case studies, data collection should be treated as a design issue that will enhance the construct and internal validity of the study, as well as the external validity and reliability.[15]

Yin identified six primary sources of evidence for case study research.[16] The use of each of these might require different skills from the researcher. Not all sources are essential in every case study, but the importance of multiple sources of data to the reliability of the study is well established.[17] The six sources identified by Yin are:[18]

- Documentation
- Archival records
- Interviews

[14] Yin, 1994
[15] Ibid.
[16] Ibid.
[17] Stake, 1995; Yin, 1994
[18] Yin, 1994

- Direct observation
- Participant observation
- Physical artifacts

Documentation. Documents can be letters, memoranda, agendas, study reports, or any items that could add to the data base. The validity of the documents should be carefully reviewed so as to avoid incorrect data being included in the data base.

Archival records. Archival records could be useful in some studies since they include service records, maps, and charts, lists of names, survey data, and even personal records such as diaries. The investigator must be meticulous in determining the origin of the records and their accuracy.

Interviews. Interviews are one of the most important sources of case study information. The interview could take one of several forms: open-ended, focused, or structured. In an open-ended interview, the researcher could ask for the informant's opinion on events or facts. This could serve to corroborate previously gathered data. In a focused interview, the respondent is interviewed for only a short time, and the questions asked could have come from the case study protocol. The structured interview is particularly useful in studies of neighbourhoods where a formal survey is required. The use of tape recorders during the interviews is left to the discretion of the parties involved.

We want our research to be eloquent to the readers. The interviews were set to the co-related staffs, and also the detailed questions were prepared for those who are also involved in this work. Since they all have relationship with this occupation, their attitudes and answers to these questions must be a sufficient evidence for us to excerpt.

Our field is business administration and organization, in combination with engineering science. In other words we are in the border-land between technology and economy, but with mean focus on business administration. Since the railway technology is not our strong suit, and also as a student whose field is logistics and transportation economics, we put our emphasis on how to

well integrate all the management issues of these rail shuttles. The interviews which we set were to responsible persons, for instance, the market manager of the port, the strategic planner of Banverket, as well as the product manager of the rail operators and so on, are all in charge of part of this transportation chain. We were able to gain first hand management answers to our thesis from them.

Besides the management aspects, who operates the machines and how they operate them is still needs to be further investigated. Some well-prepared questions were sent to the operators to obtain firsthand information. By anatomizing these questions we could uncover the problems existing in practice and further.

Direct observation. Direct observation in a case study occurs when the investigator makes a site visit to gather data. The observations could be formal or casual activities, but the reliability of the observation is the main concern. Using multiple observers is one way to guard against this problem.

Participant observation. Participant observation is a unique mode of observation in which the researcher may actually participate in the events being studied. This technique could be used in studies of neighbourhoods or organizations, and frequently in anthropological studies. The main concern is the potential bias of the researcher as an active participant. While the information may not be available in any other way, the researcher should carefully consider the drawbacks.

Physical artifacts. Physical artefacts could be any physical evidence that might be gathered during a site visit. That might include tools, art works, notebooks, computer output, and other such physical evidence.

Weaknesses and strengths of the primary sources

No single source has a complete advantage over the others; rather, they might be complementary and could be used in tandem. Thus a case study should use as many sources as are relevant to the study. The graph below indicates the strengths and weaknesses of each type:

Source of Evidence	Strengths	Weaknesses
Documentation	Stable – repeated review Unobtrusive – exist prior to case study Exact – names etc. Broad coverage – extended time span	Retrievability – difficult Biased selectivity Reporting bias – reflects author bias Access – maybe be blocked
Archival Records	same as above precise and quantitative	Same as above Privacy might inhibit access
Interviews	Targeted – focuses on case study topic Insightful – provides perceived causal inferences	Bias due to poor questions Response bias Incomplete recollection Reflexivity – interviewee expresses what interviewer wants to hear
Direct Observation	Reality – covers events in real time Contextual – covers event context	Time – consuming Selectivity – might miss facts Reflexivity – observer's presence might cause change Cost – observers need time
Participant Observation	Same as above Insightful into interpersonal behavior	Same as above Bias due to investigator's actions
Physical Artifacts	Insightful into cultural features Insightful into technical operations	Selectivity Availability

Table 1: weaknesses and strengths of the primary sources[19]

[19] Yin, 1994, p. 80

2.3.2 Our routine procedure to the case study

In this phase, we do our utmost to use all relevant sources. There are two types of databases in this procedure, which should be gathered. One is the actual data, which needs to be organized and documented, and the other one is the report of the investigator.

At the beginning of our research, we divide the whole link into several sections, we analysis these sections one by one. These sections are: track configuration, train and transportation, terminals, and management aspect. Some problems in each section will be researched by interviews and questionnaires.

2.3.3 Sample select

So far, there is no formal rule to define the size of the survey. Actually, the size of the survey depends on the actual available resources. Now, researchers find that a moderate sample size is sufficient statistically and operationally. Additionally, the size of the survey is relative with what results are used and who wants them.

In order to make the results reliable from the sample of the survey to larger areas, the choice of the survey must be according to some scientifically rules. For example, when we choose people, we should make each person in the population have a measurable chance of selection.

Mr. Stig-Göran Thorén at Banverket Trafik is in charge of how to create the timetable. His answer to the related questions is viral to this problem.

As mentioned before, Mr. Gunnar is the only one person who can be asked about Vänerexpressen, and then his answer is of course as professional as the above one. He could grant us an interview face to face. Interview surveys—whether face-to-face or by telephone—offer distinct advantages over self-reported data collection. The ***"presence"*** of an interview can increase cooperation rates and make it possible for respondents to get immediate

clarifications. He described the procedure or how he worked with the container shuttles.

The situation of the Port of Göteborg is a little more complex than others. Unlike a census, where all members of the population are studied, surveys gather information from only a portion of a population of interest -- the size of the sample depending on the purpose of the study. We employ a qualitative approach. Qualitative research evaluates, uses concept to explicate, focuses on aesthetics in texts, is theoretical based, interprets, and leads to an evaluation[20]. On the other hand, *planning the questionnaire is one of the most critical stages in the survey development process.* Information is collected by means of standardized procedures so that every individual is asked the same questions in more or less the same way. We will select three port loading and unloading operators and one supervisor to get the information we need. They should in different age groups and be selected by us randomly. In order to know the track configuration, Mr. Per Rosquist, the strategic planner of Banverket, and also the person responsible of this project, gave us a lot of documentations about the track and infrastructure configuration which can be used in our thesis.

2.4 Analyze case study evidence

2.4.1 Analytic strategy

Recommended procedure

The following discussion will present the *Analytic Strategy* that should be followed in the course of evaluating data gathered in the previous stage of the study.

"Data analysis consists of examining, categorizing, tabulating, or otherwise recombining the evidence to address the initial propositions of a study."[21] The

[20] Berge, 2000, p. 14
[21] Yin, 1994

analysis of case study is one of the least developed aspects of the case study methodology.

The researcher needs to rely on experience and the literature to present the evidence in various ways, using various interpretations. This becomes necessary because statistical analysis is not necessarily used in all case studies. However, not all case studies lend themselves to statistical analysis, and in fact the attempt to make the study conducive to such analysis could inhibit the development of other aspects of the study. Miles and Huberman have suggested alternative analytic techniques of analysis in such situations, such as using arrays to display the data, creating displays, tabulating the frequency of events, ordering the information, and other methods. This must be done in a way that will not bias the results.[22]

When there is a ***"clean"*** file the survey data are ready for us to begin summarizing what has been learned. We will have a careful and in-depth study on these data according to the analytic strategy.

2.5 Develop conclusions, recommendations, and implications based on the evidence

The purpose of our research conclusion is to make the user understand the implications of our findings. All of our conclusions and recommendations are based on the information we collected and our analytical work combined with the theory presented in our theoretical framework. And also we intend to use a clear way, which is easy for the readers to understand, to present our recommendations.

[22] Miles and Huberman, 1984

2.6 Research quality

2.6.1 Reliability

Reliability manifests the operation procedure of the research, such as interview and data collections. The main purpose is to minimize the errors and biases in the research.[23] Two main methods, protocol and database, can help to increase the reliability of case study research. These two methods will guide the investigator in carrying out the case study.[24]

To increase our study reliability, all of the written materials come from reliable sources. Our interview is in accordance with the interview principles in order to avoid the influence of our own bias with regard to the questions to the interviewees. The interviewees who chose have a lot of experiences in their work area. And we carry out the interview with the interviewees face-to-face to get the first-hand data. The two members of our study group will simultaneously take notes, and we will also record the interview so that the questions serve as a base for further discussion. We made further investigations by email and telephone; which corrected some confusion in the data. Finally, we discuss the information we have received in order to avoid misunderstandings due to different language backgrounds.

2.6.2 Validity

The idea of credible research design is to maximize validity, which can provide a clear explanation of the phenomenon under study and controls all possible biases that could distort the research findings. Three types of validity typically are considered when designing applied research as stated below:[25]

[23] Yin, 1994
[24] Ibid.
[25] Cook & Campbell, 1979

Construct validity: the extent to which the constructs in the conceptual framework are operationalized successfully (e.g., measured) in the research study.

Internal validity: this concept applies to impact (cause – effect) questions and refers to the extent to which causal conclusions can be drawn.

External validity: the extent to which it is possible to generalize from the data and context of the research study to broader populations and settings (especially those specified in the statement of the original problem/issue).

Since our study is a qualitative research study, our main purpose is to give the results on the analytical level.

3. Theoretical framework

In this chapter we present the theoretical concepts that we use in our research. The theories that we used have structured our thinking process and have been of great use when the results were analyzed.

This thesis discusses and analysis the rail capacity within a certain link, from the surface meaning of this topic, the basic theory is the rail capacity, but when the research goes further some other related theories need to be reconsidered.

It is simply not enough for us to just think what the rail capacity is and how to increase it. The rail capacity is to be set as the core of the whole link, and we should put emphasis on the research of what the relationship is between all the related theories and how they work together to influence the rail capacity. The working routines of the container freight shuttles are simply described as the below graph:

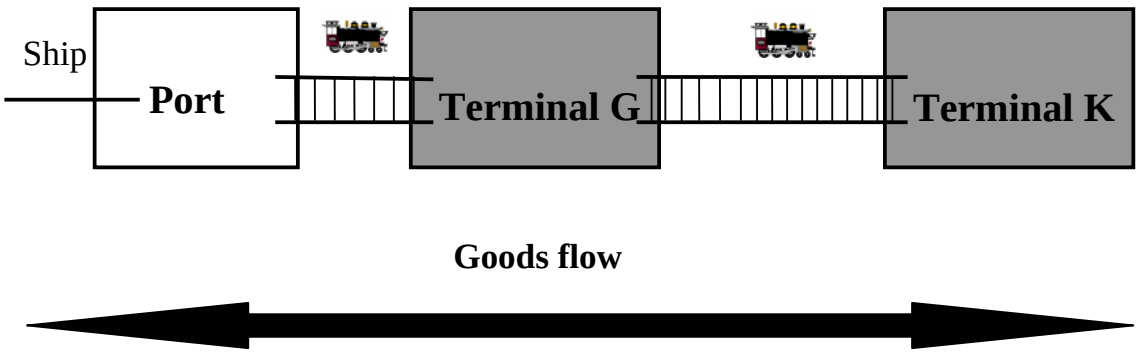

Figure 3: Working routines of container freight shuttle[26]

Let us give a simple explanation to the above procedure. Customer A buys service from a shipping company B. The shipping company B takes responsibility to transport the goods for customer A to the Port C and then unloaded at Port C. The working staff in the port operates the unloading activities, and then reloads these containers to the container freight shuttle train D. The rail operator E provides the container freight train. The operator E is in

[26] Authors

charges of the rail transportation from the Port to the destination terminal to be unloaded there.

It appears to be a very simple procedure to transport the goods between the terminals, but in fact each section of this link would influence the capacity of the whole link even with a very small problem. Before we define the real problems we need to know what they are and how they work, that make the theory part the stepping-stone of our research project. Below is the graph we use to facilitate us to form a theoretical framework.

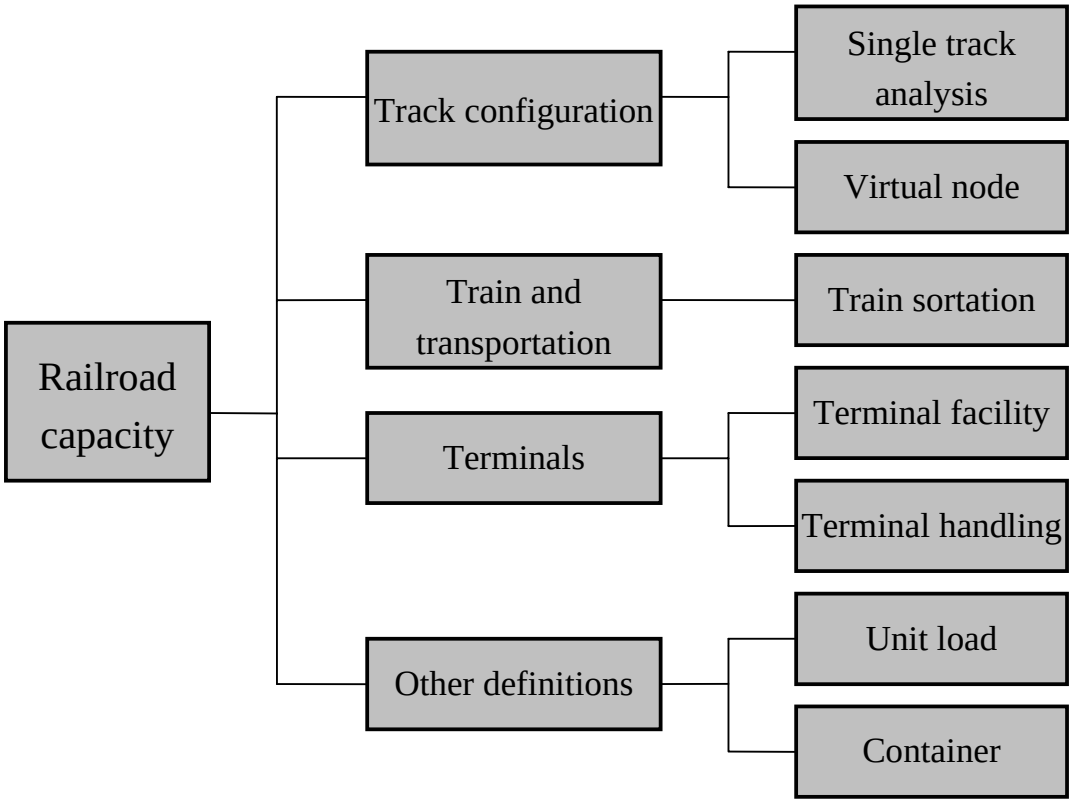

Figure 4: Theoretical frame work[27]

According to the above graph, we mainly quote the theory from our textbook: Lumsden, K.R., 2002, *Fundamental of Logistics,* translation of selected chapters of the book "*Logistikens Grunder*". As we said before the rail capacity is the core of the whole system. We mean the real word experience and the basic logistics theory to be a guidance of this task. The ambition of this chapter

[27] Authors

is to give a comprehensive impression of the basic principles, which are relative with the railway transportation and railway capacity. A thorough review of influences of the key points concerning railway transportation is also mentioned.

3.1 Track configuration

Before we begin the further analysis we would like to explain the basic concept of the railway capacity.

The process of determining the capacity of a given rail line involves consideration of the specific combination of the trains and track configuration.

The capacity of the railway when mentioning the track configuration is one of the main characteristics of rail bound traffic function in large goods flow. The adaptation of the railway system to the large flow of the trains has a straightness requirement of the length of the trains and frequencies. Then the simplest solution to this adaptation is a single-tracked railway line between two O/D terminals. This type of rail bound traffic has significant limitations in capacity, as both meetings and overtaking are limited to a few places at the same time as the maximum length of the trains is dimensioned by the structure of the line and of the length, the location and the closeness of the meeting places.

3.1.1 Single channel – single-tracked traffic

Goods can only be transported in one direction at a time in a single channel flow, a single-tracked line. All load carriers must wait at one of the two terminals of the channel before the flow can be turned around. Because of this, the capacity of single track is limited. And, if the frequency between two terminals is very low, when traffic is to be driven in both directions, and if at the same time there is a long distance (l_t) between the terminals, then only one train set can be transported on the line in one direction until the train set has reached the terminal.

The link time is the time it takes to drive the train from one terminal to the other (t_t). In the single tracked traffic, the interval time between two departure trains will be twice the link time. This results in a low frequency regarding possible departures along a single- track.

$f_e = 1/ (2*t_t)$

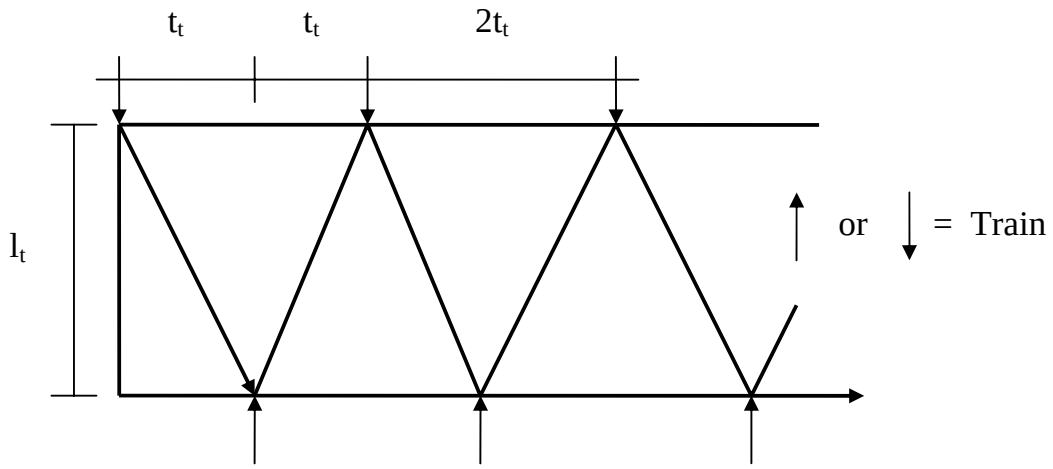

Figure 5: Single track traffic[28]

[28] Lumsden, K.R., 2002, p. 87

The capacity of the link depends on the following factors: (1) The capacity of the link, i.e. the number of load carriers in the link (in the train set), (2) The speed of the load carriers (the train).

"One way to increase the capacity in the form of possible goods flow in a single-tracked traffic is to time allocates the direction of the traffic. This means that the traffic in one direction is given priority during a certain period of time (t_a) and that new train is constantly departing during this allocation of time. The necessary safety distance between two trains traveling in the same directions (t_s) then only dimensions the time between the departures. This continues as long as the track is time allocated for traffic in this direction, which would be anything from a given number of link times during a day to the alternative that the traffic on uneven weekdays goes in one direction, and on even weekdays in the other direction. In this way the capacity is of course heavily increased but the time between departures in one direction can in the worst cases be the whole time allocation, i.e. an entire day."[29]

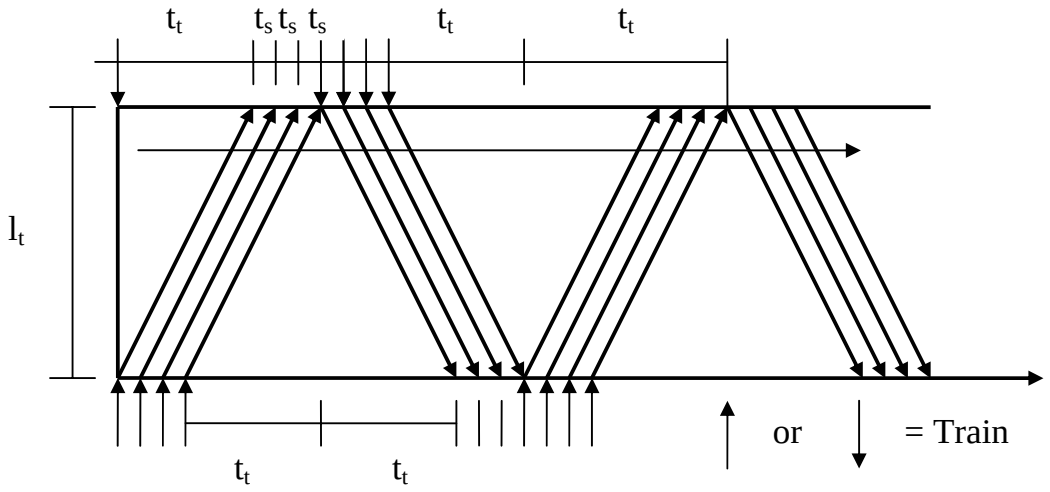

Figure 6: Single track traffic --- time interval[30]

"Speed separation, i.e. time allocation considering the speed of the traffic, is an additional way to increase the capacity of a single-track. This means that all traffic with the same speed is located to the same period of time thus

[29] Lumsden, K.R., 2002, p. 87
[30] Ibid. P. 87

eliminating waiting time for slower trains ahead. For example can all traffic with fast passenger trains (tts) be driven in the daytime (t d) and the slower freight trains (ttl) at night (tn). In this way it can be avoided that fast train must slow down due to limited possibilities of overtaking."[31]

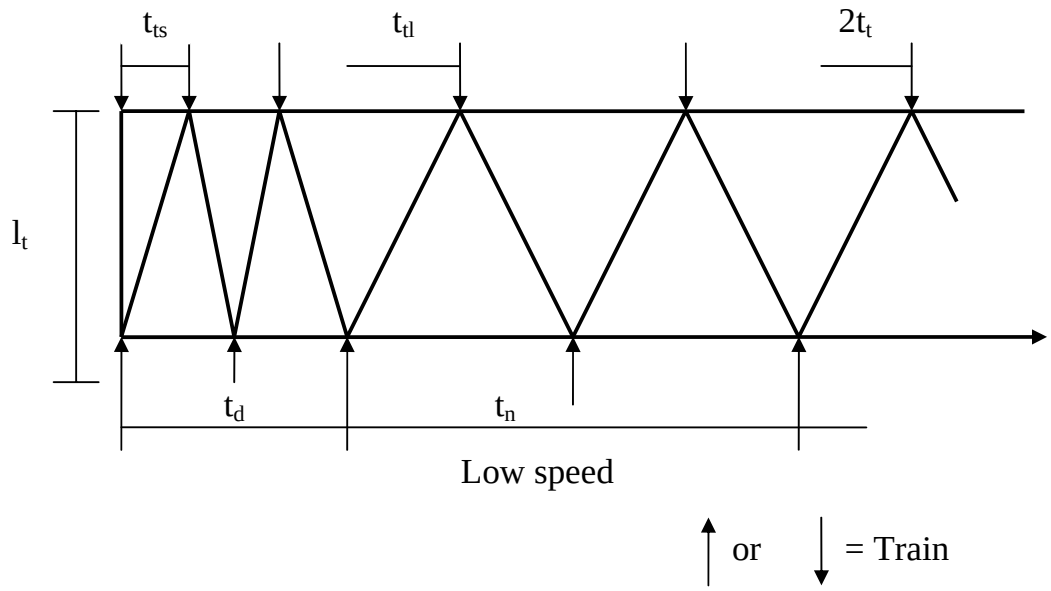

Figure 7: Rail traffic, one channel with time allocated speed (space-time diagram)[32]

3.1.2 Virtual node- tracks for meetings and overtaking

In single-tracked traffic between two railway stations, two nodes, the track is blocked for traffic in the opposite direction. This holds from the moment that the train has left the departing terminal, the start node of the relation, until it has reached the next terminal, the end node of the relation. The time when the opposite traffic is blocked is consequently identical with the link –time (tt), the time it takes to move the train between the two terminals.

[31]Lumsden, K.R., 2002, p. 88
[32] Ibid., p. 88

In order to increase the flow capacity in a single channel, i.e. in a single-tracked railway, one or several possibilities of meetings and overtaking, virtual nodes, can be located along the link.

"The virtual node is an extra track, large enough to allow a train of a certain length to be driven into it and to be stopped in order to allow a train driven in the opposite direction to pass."[33]

The extra track (lvn) should of course be much shorter than the link (lt__lvn)

In the single-tracked link, on the other hand, the load carriers meet in the middle of the section, after which one of the trains must be driven into the virtual node. This means in turn that the trains must slow down and wait for each other. The average speed for the single-tracked railway is consequently lower than for the double-tracked railway, and the difference is depending on the location of the meeting-place in the link and on the acceleration and retardation times for the train.

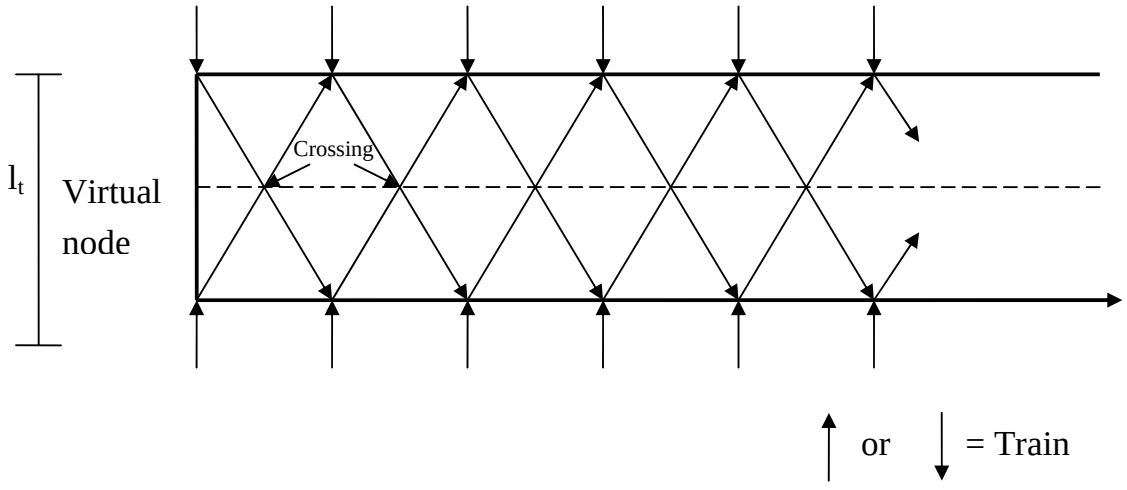

Figure 8: Rail traffic using one channel with virtual nodes, meeting point (space-time diagram)[34]

It is often necessary to mix trains with different speed in the traffic between two terminals, in a link. This means that queues will rapidly arise along a track

[33] Lumsden, K.R., 2002, p. 90
[34] Ibid., p. 90

where trains with different speeds are driven. Trains with high speeds (vh), for example passenger trains, will quickly catch up slower trains' ahead (v1), for example freight trains. The fast trains must then slow down to the speed of the slower trains (VL). If there are several types of trains with different speeds in the link, all trains will eventually have the speed of the slowest train.

The virtual node makes it possible to mix trains with different speeds but with the same direction with maintained (or marginally reduced) flow capacity compared to time allocated directions during a given period of time.

The extra track, the virtual node, then offers a possibility to direct the slower trains into the extra track when a faster train is approaching from behind, and in this way give priority to the faster trains. This means that the slower trains, usually the freight trains, in principle can be forced to use the virtual node very often. Hence, the average speed of the freight trains (vg) is considerably lower than the highest possible speed (VL)

3.1.3 Control of the single-tracked line

Control of the traffic on a single-tracked line with nodes is limited to information about the speed of the trains, time of departure and arrival and whether problems arise such as engine failures.

The complexity of the control increases when the number of nodes in the link increases. This is due to the fact that a system with many nodes is very unstable, and therefore disruptions causing delays easily occur. Earlier it has been pointed out that a single-tracked railway with a large number of nodes is, in principle, as efficient regarding flow capacity as a double-tracked railway.

This theoretical argument proves to be invalid in practice as a result of the disturbance susceptibility of a system with many nodes. The cause of this is the instability of the system. For such a system increasing demands for exactitude are made regarding speed control and positioning.

Since rail capacity is not easy to estimate and calculate, there might be a lot of ideas on this question. For this thesis, we have to identify either the capacity refers to the flow of the goods or the number of the train wagons.

3.2 Train and transportation

3.2.1 Freight trains

A freight train is combinations of the wagons to form trains in different ways. Two extremes can be identified – wagon transports in the form of a combination of customer – specific wagons which have no relationship and can therefore be continuously marshaled, and full trains with coherent traffic between the sending and receiving terminal.

The demands on, and the conditions for, goods transports with railway lead to a number of principally different designs of the transport systems along two dimensions – the combination of wagon to form trains and the planning of the train traffic.

The characteristic of railway transport is based on a large goods flow. The European railway system has a general payload of about 800 and 1600 tons for the freight trains, excluding ore. This means that as a consequence, the systems for transportation of goods with rail bound traffic must primarily be adapted to these large flows both in a physical way, and in the way of time.

On the other hand, the design of the railway systems must be in such a way that the goods flow should be efficiently concentrated. We should notice that it is very important to figure out the breaking of the train sets and marshalling are not cost efficiency and might loss time. As the consequence, it is necessary for the railway traffic to keep together the connected trains to the fullest possible extent.

3.2.2 Railway wagons

"Railway wagons that are solely intended for transports of containers and swap bodies can be built with the simple construction of a flat wagon. The only requirement is the securing sticks that secure the load carrier's lower corner boxes. The most common container wagon has two axes, intended for 2 TEU (1*40 feet or 2*20 feet). The wagon support a maximum of 28.5 ton, which is lower than the maximum weight of two fully loaded 20-foot containers, which is why there is also grip tools available for a centrally placed 20-foot container."[35]

3.2.3 Separation of the passenger- and goods transport

Although we focus only on rail freight transportation, here we still need to say something about the passenger trains. The speed of the passenger trains is faster than the freight trains. A good combination of the passenger trains and freight trains in the same link will significantly increase the capacity, at least the capacity of the freight trains will not be influenced by the passenger trains

"Rail bound transport has a completely different characteristic for passenger and goods transports. The transportation of passengers must in all essentials take place in the daytime as a result of the individual's demand for acceptable possibilities to sleep at night. At the same time the goods are often transported between terminals in cycles with such a character that the transportation can take place when there is no normal production or consumption, i.e. "overnight traffic".

Here, the passenger and goods transports complement each other in an extraordinary way. This leads to a *time-dependent separat*ion with passenger transports in the daytime and goods transports at night.

[35] Lumsden, K.R., 2002, p. 296

The connection between the train's maximum load per axle and the carrying capacity of the track has also become a dividing line between different types of railroad transports. A passenger wagon has normally a lower axle pressure than a loaded freight wagon. Before the introduction of fast trains, all tracks were constructed to be able to carry both passenger and goods transports, i.e. a maximum axle pressure of 22.5 tons. This limit is now constantly changing by an upgrading to 25 tons.

When new tracks are built it is important to specify what kind of transportation they are to be used for. The tracks built for only fast train transports with lower axle weights consequently exclude normal goods transport. Possibilities of a powerful increase of the axle pressure are created, as the passenger transportation is transferred to these fast train tracks and creates space for the goods transports on the older tracks. In accordance there is a *track-bearing dependent separation* between passenger and goods transport.

3.3 Terminal

3.3.1 Definition

Terminal can be described simply like this: it is a necessary part of any transport system. It is used to change from one transport mode to another and to terminate transport process. Railways used 'station', or a place where a railway train stopped, or becomes stationary. Water transport generally uses the word 'port'. "[36]

Transport Terminal facilities:

- Arrival and departure lanes
- Docking and Parking areas for the transport vehicles
- Areas for cargo - vehicle interchange, i.e. modal interchange

[36] http://www.unb.ca/web/transpo/mynet/mty97.htm

- Holding, storage, and processing areas
- Traffic Control facilities
- Terminal administration areas
- Transshipment
- Consolidation
- Terminal operations, maintenance, safety, and security areas
- Parking areas for terminal personnel, customers, and visitors
- Transport vehicle-servicing areas
- Others

More often the definition of TERMINAL in our mind refers to the terminal building or some other terminal facilities, but in fact the terminal is not as simple as we imagined. As we know the ideal transport is the goods to be performed in one unit directly from the supplier to the customer, a door-to-door transport, as early as possible.

This definition can be used in internal as well as external material flows of a terminal. Behind the apparently simple function, according to the definition, a series of activities is consequently concealed, in theory and in practice. The reshaping of the loads demands that the goods are loaded and unloaded to and from different transport modes.

An extensive sorting procedure is necessary in the terminal in order for the goods to reach the correct destination without delay, and it would be better to carry these value-adding activities in the terminal than in the customers.

Since the departure and arrival times may not be integrated that accurately then the goods have to be buffered for some period of time when waiting for the coming transport. Arrivals and departures of the means of transportation are to be coordinated at the same time as the terminal; if possible this should not be exposed to too large variations in the passing goods flow.

On the other hand, the capacity and scale of the terminal has to adapt the loading scale otherwise the unexpected waste would occur and also lead to a high terminal costs. Last, but not the least, the additional cost of the buildings,

land, staff, equipment and other operative costs have to be compensated by the reduced costs in the moving operations.

3.3.2 The most important terminal activities-Handling

"A terminal is a node in a transport network between the supplier and the customer, it binds together transport modes with different characteristics into a transport chain in order to meet the supplier's and the customer's demand for frequency and capacity in the flow. The activities in a terminal will consequently be connected to problems created from differences, since the varying structure between customers and suppliers as well as between different means of transportation must be overcome. This, among other things, leads to the fact that the problems are of a very varying sort depending on if they regards the operative activities or new constructions and/or expansion."[37]

It is often a long time for means of transportation or goods to load or unload at the terminal, and normally we call it the queue problem. The main factor, which affects the queue problem, is the distribution of arrivals and departures within a whole day in the terminal.

The size and dimensioning of a terminal is quite difficult to calculate in an optimum way, which leads to a difficulty in controlling this queue problem. As a service facility, the terminal is sometimes, to some extent, over dimensioned in order to satisfy the intensity of arrivals and departures. While conversely, some other value-adding services in the terminal such as sorting, warehousing as well as partial assembly, etc., can be served in case of a low utilization of the terminal.

Each incoming means of transportation must be adapted to the loading and unloading procedures. As a result of the variation in capacity and structure for the different transport modes, large differences exist between the different means of transportation. All in all, this also leads to further variations in the

[37]Lumsden, K.R., 2002, p. 315

terminal activities that will have to be planned into an already uneven degree of utilization.

3.3.3 Frequently used terminal equipment-terminal vehicles

The simple way to increase the capacity of the goods flow is to mix some other means of transportation. The goods, which need to be transported to the customers, have to be conveyed to the rail terminal by train first, and unloaded, thereafter that uses the trucks to send the goods to the specific receivers. With the combination of the truck facilities the door-to-door service can be easily realized.

The activities of a terminal in a simple word mean to inter store the goods in a terminal. As a consequence of the principle to create unit loads as early as possible in the flow, demands rise of having the equipment for transferring unit loads within the terminal. A number of different types of trucks have been developed in order to be able to handle these unit loads. The handling of the unit loads can be divided into pure transportation performed by trucks, and pure lifting.

Since the terminal activities have been enlarged by other functions, for example storing and sorting, the demand for trucks has increased even more. The functions existing in the producing companies have consequently a correspondence in the terminal.

3.3.4 Handling cargo in terminals

In order to preserve the unit load carriers' advantages in the terminals, they must be equipped with specialized vehicles that can handle full units without breaking them. This implies that the vehicles together with the cargo units represent large weights with a limited maneuverability. Consequently, terminals must have access to large and flat areas that allow high wheel pressure.

3.3.5 Terminal trucks

Trucks used in combined systems are designed to fit the load carriers that they will handle.

Trucks for container transports are usually equipped with hoist devices. Usually, there is some kind of hoisting device available that enables disconnection on the ground or transfers between truck and railway wagon. Simpler trucks with low flats can be used when the goods receivers and senders have the hoist devices.

3.3.6 Straddle carriers

The equipment used for loading and unloading ships and railway wagons is, within the terminal area, operated by straddle carriers that move containers that hang underneath a construction similar to a portal with four legs and wheels. To save space in the disposition area, containers are stacked and the straddle carriers are therefore made high enough so that they can straddle two or three stacked containers.

3.3.7 Handling – yokes

The interface between the load carrier and the handling equipment consists of some form of grip device, in this context called a yoke. There are many types of yokes, but they are commonly adapted to a standard for unit load carriers' grip holds, normally the container's corner boxes.

For handling containers with heavier counterbalanced forklift trucks, it is sometimes more convenient to use *side lift yokes*. This yoke grips the container from the side, but due to the fact that containers are not designed that way, only empty containers can be lifted. However, slightly loaded containers can be handled, which is more common with RoRo – ships where the different decks are near each other.

For handling empty containers in small and low passages, an *end lift yoke* can be used, but it is not that common, and just as with the side lifts yoke, it is useful only when handling empty containers.

The described yokes are manufactured as complements to trucks and cranes. To avoid time consuming changes of yokes in terminals for different types of load carriers, (primarily terminals for handling between railway wagons and trucks) combination yokes are used, which can handle the three standard types ISO – containers, swap bodies and semi – trailers.

Since the handling yokes exist in, and constitute the interface between the means of transportation during transferring of the unit, it is from the unit's control point of view, important to know where and when the transferring occurs. Intelligent yokes have been developed, which in addition of lifting the unit, also handles data gathering (information about the goods) for all superior data systems, i.e. positioning, invoicing etc.

3.3.8 Rail terminal

Infrastructure

"The term "rail infrastructure" generally refers to railway lines, including any structure or equipment that facilitates railway operations, as well as crossings of or interactions with those railway lines by public or private roads, utility companies or other facilities."[38]

As we all know that the infrastructure of the railway has a strong tie to the rail capacity, for example, short length of the station has difficulty in storing the trains.

[38] http://www.cta-otc.gc.ca/rail-ferro/railways/definition_e.html

Handling in the rail terminal

Compared with road transport, the variations in the intensity of arrivals and departures for goods of train transport are not more obvious because of the number of the customers are large but the volumes of the goods are small when consolidating.

Generally, some free disposal wagons will be offered to the customers who have large volumes of consignments within the rail transport. This free disposal time lasts from 12 to 24 hours after the train arrives at the terminal. The benefit of these free disposal wagons is the elimination of the standstill cost. A more even utilization of the loading and unloading equipment is consequently obtained by the fact that the loading unit is available for unloading and loading during a longer period of time.

At the loading/ unloading of several railway-carriages in a train over a loading/unloading point (loading ramp for example) marshalling of the entire train is necessary at every disconnection of any rail carriage.

3.3.9 Sea terminal

Most harbors, however, are the connection between a ship transport and a land-based transport such as railway and truck. “The large difference in capacity of the ship and the capacity of the land-based means of transportation must therefore be overcome. This can be made either by a powerful concentration of trucks and railway carriages at the arrival of the ship, resource concentration, or by storage of the goods in the harbor, goods storing.”[39]

The lying time is the time, which ships are in the harbor for loading and unloading, and it continuously decreases for different reasons. The reduction of the lying time of the ships means the improved departure frequency and at the same time as the result the transport capacity is also increased for the integrated

[39]Lumsden, K.R., 2002, p. 334

relationship between them. Hence it becomes necessary and desirable to speed up the time for loading and unloading, the turnaround time. A fast turnaround of the ship will demand large arrangement areas while waiting for further transportation.

The large arrangement areas are located near the quay in order to facilitate fast loading and unloading.

Rail bound traffic is relatively inflexible compared with other means of transportation since it is bound to one single track. Railway traffic in a harbor sometimes disturbs all other traffic which leads to the railway tracks are located far from the harbor in order not to disturb the loading and unloading operations. Naturally this creates long transportation when loading and unloading the ships.

"Ships for unit load transports are divided according to how the load carriers are loaded or unloaded. LoLo-ships (Lift on Lift off) are loaded and unloaded with vertical lifters directly in the load room or on deck, unlike ships where load is rilled over ramps to their final positions on different decks – RoRo-ships (Roll on Roll off)."[40]

Terminal trucks

In some terminals, containers are loaded on specially designed low wagons, so-called gooseneck wagons, immediately after arrival at the terminal, mainly in ports. Terminal trucks according to the RoRo-principle operate all horizontal movements

[40]Lumsden, K.R., 2002, p. 294

Land-based cranes

"The land-based crane is the most common crane. The cranes run on rails on the quay, on which the cranes can be located to the desired position."[41]. The cranes can be used to serve a ship that lie at anchor for loading and unloading, which makes the handling faster. "During loading, containers are lifted from a truck or a serving tractor. Depending on where in the ship the container is going to be loaded, a loading cycle takes between 1.5 and 3 minutes. "[42]

Sea terminal handling-vehicle dependent handling

The unit load principle is built on the fact that a load carrier should be unbroken from sender to receiver. In order to collect and deliver a load carrier at the sender and the receiver without own equipment; the equipment should be part of the vehicles.

3.3.10 Administrative routines at a goods terminal

The administrative function of the terminal is a critical factor, to some extent, a little bit complicated that makes the speed of the terminal material flow slowly. The industry analyses of the function of the terminals indicate that the administrative routines are more important than the handling of the goods itself. So, it makes more changes in the administrative areas.

The two factors that will influence the result of the terminal activities are physical handling and the administrative routines, when design the whole transport system, it is necessary to consider the methods and design a suitable system for handling as well as distribution in the terminal. Likewise, the profits, calculated through the rationalizing physical methods, in order not to be influenced by the increased costs in the administrative flow, has to reconsider every change of administrative routines in the handling or the transport

[41]Lumsden, K.R., 2002, p. 299
[42]Ibid., p. 299

methods. It is important to obtain the same high speed for the flow of documents as for the material flow.

The administrative routines existing in the terminal for incoming goods are a confirmation of:

- The documentation of the quantity and the receiving time of the goods
- The documentation of the goods placement

For the outgoing goods there must be a supply of information to the terminal as to:

- The identity of the goods
- The destination, the receiver
- The time for dispatch

From the terminal there has to be a confirmation that the goods has been shipped:

- Right quantity
- Predestined quality
- Weight of the consignment
- Number of parcels
- Marking
- Way of transport etc

At export deliveries there are, in addition, a number of documents that have to be written and ready before the goods can be shipped away.

3.4 Other related theories

3.4.1 Unit load

Unit Load – "A single item, a number of items, or bulk material which is arranged and restrained so that the load can be stored, picked up, and moved between two locations as a single mass."[43]

Unit load principles

In order to fulfill the functions that the unit load principle aims at, a number of physical requirements must be met.

- Size – In order to establish the effectiveness, the unit loads need to be as large as possible, and at the same time not too large for avoid much weight.

- Time – the used units should be formed as early as possible in the beginning of the logistics chain and broken down as late as possible in the end of the logistics chain, preferably in the place of consumption.

- Shape – the unit load must be stable in order to be mixed with other unit loads of different weights.

- Handling – the used load carriers must be easy to handle with all the present equipment found in the transport system, thus, in all places where handling activities occur.

[43] http://www.unitload.vt.edu/

Advantage of the unit load

- Reduced handling time
- Simpler and faster transferring between transport means
- Reduced terminal time for the transport means
- Reduced damages on goods
- Reduced packaging costs
- Easier to choose load carrier type
- Simpler documentation
- Simpler rules for responsibility and insurances

Tips of handling unit loads

The basic idea with all unit load systems is that in between all means of transportation, the load should not break to pass through all the links in the transport chain and, through mechanized handling equipment and unified handling methods, be transferred in a simple way.

In an integrated transport system for containers, there is a need to enable transferring of containers between different means of transportation. In addition to this, there exists shorter container transports in relation to terminal transports.

Independently of which means of transportation the transferring of containers occurs, one should separate two principally different handling methods. During LoLo – handling, the transfer occurs with the help of cranes or similar. During RoRo – handling, the container slides or rolls on a chassis during the moment of transfer.

3.4.2 Container

Container is widely used by a larger holder in wide transport systems. Its main purpose is to integrate the goods in an economical way to be convenient to transport by trucks, trains, ships and aeroplanes and also to be transferred between them. The term container does not include vehicles or conventional packages.

"According to the proposed standardization of containers given by ISO, a holder is called a container if it fulfills a number of criteria:

- A transport unit with a durable construction
- Strong enough to allow repetitive usage
- Specially designed to ease transfer between different means of transportation without reloading the goods
- Equipped with facilities that allow fast and efficient handling, especially in transfers between different means of transportation
- Designed to ease the loading and unloading of the goods in it
- Have an inner volume of at least 1 cubic meter"[44]

Because of the standardization of the width and length of containers for handling by the vehicles, there is a way which increases the capacity of the containers is increase the height of containers.

[44] Lumsden, K.R., 2002, p. 288

4. Empirical data study

In this chapter we present our empirical findings in our field study. The findings are presented in the following order: Port of Göteborg AB, Green cargo AB, Vänerexpressen AB, Banverket Trafik. These findings will be used in the next chapter where, we conduct our analysis.

4.1 Preparation for empirical data study

The questions were distributed through the container terminal of the Port of Göteborg to several full-time workers, and others recommended by the Deans. This data gathering activity was co-sponsored by Banverket.

The similar questions were also distributed to the person responsible at Vänerexpressen. They are main aspect of the link and their views were considered valuable. Since there are only two persons working for this company and only one can speak English between them, then only Mr. Gunnar was questioned. Although, only one person participates, the answer is not distorted in the results.

The port operators face-to-face answered the completed questions, but the questions to Vänerexpressen were done by telephone. The in-depth study of the interviews will help us a lot in obtaining a strong impression of the terminal handling.

The direct observation was carried when we did the research. We set face-to-face interviews and asked questions to the participants. For example, Mr Claes Sundmark showed us around the Port of Göteborg, this give us an immediate impression of the port.

We prefer participant observation. We took it for granted that it would be perfect that we could become “one” of them. We could stay together to see how they worked and how they manage those container freight shuttles, and also it

was perfect if we could devote ourselves to the tasks of knowing the communication skills among different parts of the whole transportation chain and their solvents when unpredictable events come into being. But, in fact, it was not possible for us to do so.

4.2 The presentation of our empirical data

The interviews were granted to the related sections of whole link. The following presentation of the data is according to these different sections.

4.2.1 Port of Göteborg

As the destination spot of the whole link, Port of Göteborg plays a very important role between them. On 9th July 2003 Mr. Claes Sundmark, the sales and marketing manager, granted us an interview about the general information of the port and the rail shuttles. Below are the main problems of the Port of Göteborg concerning the rail transportation:

- Infrastructure problems and capacity problem
- Timetable problem especially in the morning or evening
- Complex procedures for operate slot time. It needs some flexibility
- The rail operators need to push harder for their products and make a better booking system

Some facts about the container terminal

Tractors	19
Straddle	28
Reach stackers	5
Rail-mounted gantries	2
Forklifts	44
Reefer plugs	200
Berths	10

Goods	33.5 million tones
TEU	756,000
RoRo units	430, 000
New cars	265,000
CSI status (container security initiative)	USA critical

Table 2: Facts about the container terminal[45]

Everyday trains depart from and arrive at the Port of Göteborg with overnight services to all major cities in Sweden, Norway and Denmark. In the year 2004 the port rail will be electrified.

The container freight rail shuttle

The landside port-related cargo transport is today dominated by trucking. The Port Company has the ambition that at least half of the increase in general cargo shipments in future should arrive at or depart from the port by rail.

The attention to rail transport is triggered by the environmental aspect of rail vs. road transport but also the double commercial aspect of making the port more attractive through smooth feeding systems and increasing its hinterland. The Port does not take part in financial ventures in rail transport. Rather, it co-operates with rail operators to offer frequent rail shuttles between the port and centers of production and consumption in Sweden and neighboring countries.

[45] Container,2003, Port of Göteborg

These are direct cargo express trains that are loaded at dockside (in the import case) and forwarded without marshalling to e.g., Stockholm, Oslo or industrial productions centers in mid-Sweden. The destinations covered from the Port of Göteborg by rail shuttles include the following (with frequency and operator): Oslo, Karlstad, Södertälje/Stockholm, Insjön/Borlänge, Helsingborg, Malmö, Eskilstuna and Gävle.

The rail shuttles made a rapid progress in the year 2002

The capacity of the port railway line is not in itself a limitation, even though 42 goods trains frequent the line every 24 hours. Although rail transport rose by 20%, transport by lorry is and will remain dominant, greatly dependent on its flexibility but also on the location of industry.

Port of Göteborg AB has a vision that half of all volumes arriving should be transported by rail. In 2002, 84,500 units were handled, a rise of 20% over the previous year, and our ambition is to double this in five to six years.

The IT department of the Port of the Göteborg has developed an internet based service for pre-advising. By advising the container terminal in advance the hauilers can reduce both standstill and waiting times. The result is a more efficient use of resources, smoother running of operations and less environmental impact. Pre-advised goods continue to increase and at present 85 per cent of all goods to the container terminal are pre-advised. A total of 430000 ro-ro units were handled in the port in 2002. About two million tons of goods are transported in the modal flows.

4.2.2 Handling activities in the Port of Göteborg

The handling activities in the port are the critical facts, which will influence the capacity of the whole link, every potential problem happened during handling, might produce the bottleneck of the whole capacity. We have an in-depth study on how they handle the containers in the port. We put emphasis on how they work and which internal and external factors would influence their work. The

interview carried on 19th Nov. 2003 was to three port operators and one supervisor. Based on their attitude and answers some small problems, which were once overlooked by us, now need to be studied further. Our interview questions are designed concerning the operation activities.

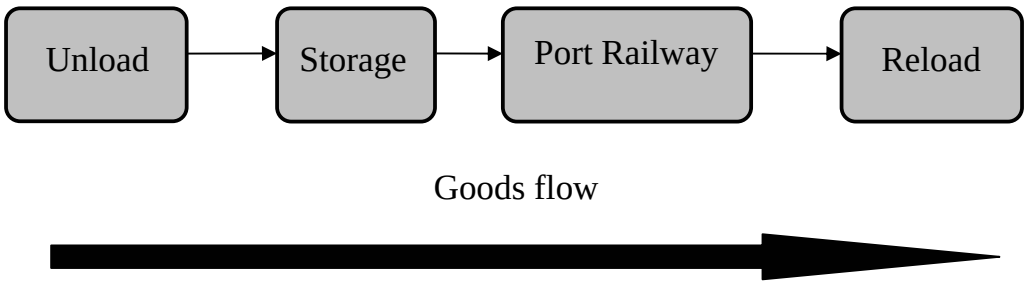

Figure 9: Goods flow direction in the port[46]

The peak time for loading and unloading is from 07:00 to 21:00.

When the goods come into the port, the port operators unload the goods from the port with the port's equipment. Several problems interested us very much, the just-in-time unloading can save a lot of time, and the JIT was affected by several issues, for instance, whether the ships could arrive on time, their unloading speed, and the condition of the machines for unloading, as well as their knowledge of their work.

Frankly speaking, they are not satisfied with the punctuality of the ships arriving. The unpunctuality would influence the JIT when unloading the containers.

Before the ships come into the port, the shipping company sends the facts about the ship to the port, for example, the length of the ship and then a suitable crane will be chosen and moved to the berth place by the port for unloading activities.

[46] Authors

Although the ships seldom arrive on time, they are all satisfied with their speed of unloading. Generally, around 25 units per hour is their normal speed, and they think this speed is ok. How many units they can handle depends on the different number of ships and the different types of the ships. The supervisor told us that 17 hours * 20 units * 8 cranes = 2720 containers are the maximum capacity per day at the Port of Göteborg. The working hours are from 7:00 to 24:00 without a break. Big ships are easier to be unloaded then the small ones.

For some reasons the unloading cannot finish within this period of time, they have to work overtime. Whether they have to work overtime depends on whether the ships arrive on time. Generally, they have to work overtime. For example, the ships A will arrive at 7: 00 and ship B at 10:00, there have three hours for ship A to unload the containers. In case of the delay of ship A, it must influence the loading time of the ship B, then the workers who are responsible for the unloading have to work overtime. Another example is, ship A arrives on time but cannot be unloaded immediately, the workers have to wait until the new order for unloading comes in. According to the workers, sometime they would like to be a volunteer to finish the unloading.

Also they have further and more efficient equipment when demands arise on handling large volumes in a short period of time.

Sometimes they have to handle dangerous goods. As a supervisor, it is his responsibility to have related knowledge about the dangerous goods; while, to the operators they will get a very detailed instruction about the routine procedure of how to handle the goods. What they should do is just follow these instructions. Anyway, when problem arises, they have to report to the supervisor for further instruction. They do not think the handling of the dangerous goods will influence their working speed.

Some machines for unloading and loading are not new, but the situation seems optimistic. The old machines have been in use for about 7 years and they are all accompanied with some big or small problems. The small ones can be skipped but the big ones have to wait for repair after they have called for help. According to the different kinds of goods, they have suitable handling

machines. The operators said that they got used to these machines and it would cost a lot to replace an old machine. Every year they have to replace for the two or three cranes. As the main operators they all have quite good knowledge of those machines.

After, as the figure shows above, the container needs to be stored in the port for some period of time and then reloaded to the rail wagons. How to put the containers into storage and how to pick them up after storage are two different aspects.

First, all the containers are stored outside, and stored according to the ships. That means the containers, which are convoyed by the same ship to the port, will be stored together. They do not store the goods according to different customers. Generally, the goods stay at the ports around three days free of charge, and if the goods are stored in the ports for more than three days, the customers have to pay an extra fee as the rent. In reality some customers treat the port as their warehouse. There is enough space to store the containers. The supervisor said it has never happened that there is no space for storage. The maximum height for store the containers is third floors, so far it is only two floors. However, the 3-floor-height will bring difficulties in moving the lower containers. There is no value-adding service to the containers.

After storage, the goods have to be reloaded to the rail wagons, the place where the goods stored are not far away from the port railways. The operator think that no matter how long the distance between the storage area and the railway, it will not affect the reloading. Since there is no need to sort the containers, they are just handled by serial numbers.

Every container is given a number. Three container numbers become a reference for the containers. Just login the port booking system then you will get whatever you want by searching the container numbers. Mr. Danies Johansson granted us an interview about the port information system. The coming graph shows working procedures of their information system:

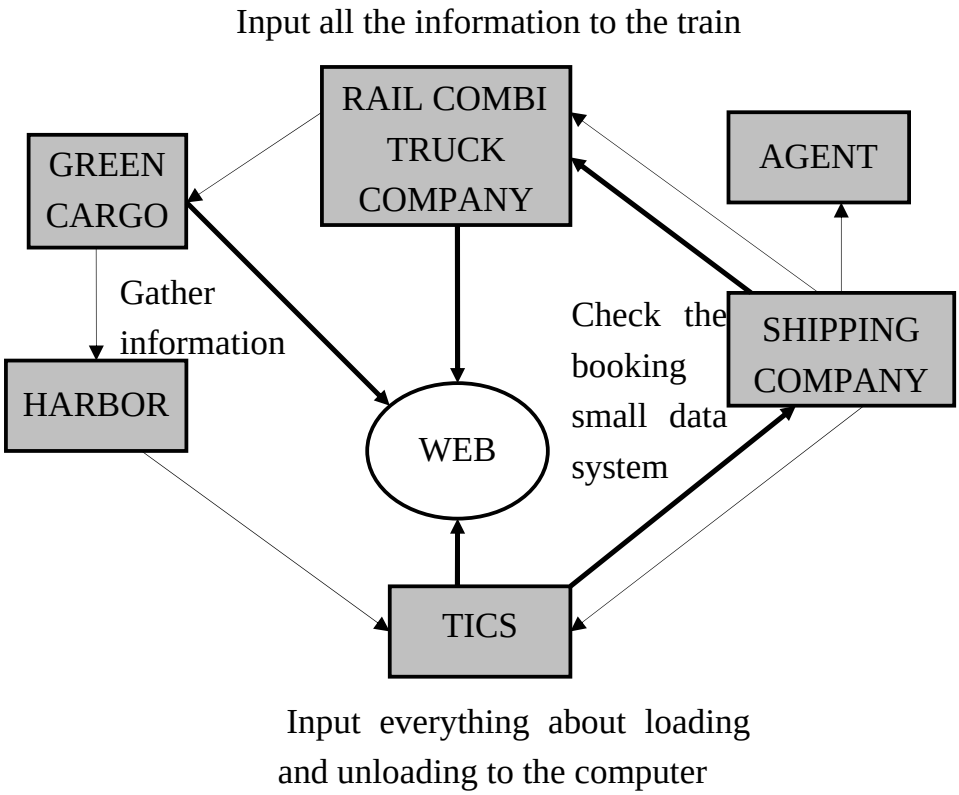

Figure 10: The information system in the Port of Göteborg[47]

Before the ships come into the port, everything about the containers needs to be known by the port, it is the shipping company's responsibility to transfer the shipping documents to the port. Among the shipping documents, you will know the detailed information about the unit load but the characteristics of the goods can be neglected. The shipping documents should be transferred without any delay. Some companies can provide good service but some cannot.

They have everyday distribution plan for the arrivals and departures. Since all these participants to the interviews have been working in their work area for more 10 years, and have a lot of knowledge and experience of this domain, they have obtained fast reaction abilities when facing emergency.

[47] Dannies Johansson, Port of Göteborg

4.2.3 Service provider- Green Cargo

After the port handling, the goods transportation carried by trains will be the procedure we will focus on.

Mr. Rolf Petersson working for Green Cargo introduced Green Cargo that provides the locomotive that many customers want, and Rail Combi provides the operate service of the trains. Rail Combi provide rolling stock to the customers according to the kind of the goods. The customers themselves decide which kind of wagons should be used. There is only one type of the locomotive being used by Green Cargo this far. This type of locomotive has served at least 20 years, and it will be continuing service for another 10 years. Green Cargo employs the train drivers. Green Cargo provides a training program to them for about four or five years. So far, most of the drivers have been working for more than ten years.

For the infrastructure, improvement of the track configuration has a long way to go, a lot of money should be invested in building the new track, and secondly, the cost for the maintenance is also very high.

During the transportation, the drivers have a list of information about the goods. In case of emergency, Banverket will get the information first, and prepare for the repair accompany with Green Cargo.

The main problems of the freight trains is that the terminals are very busy from 23:00 till 6:00 in the next morning because there are a lot of trains needed to be handled during that period of time.

One factor which influences the time and capacity of the railroad is that during transportation the freight trains sometimes have to stop to wait for the passenger trains in a terminal or in the virtual node. So far, the speed of the train is not a problem. The normal speed of the train is 90 kilometers per hour (km/h), but for some container trains, it could reach 110 km/h and for some post trains, it could reach 160 km/h. The locomotive has enough power to reach

this speed. The best solution to increase the capacity is to mix the different trains within a link.

4.2.4 Main actor of the link

After running for 6 hours, the trains stopped at Karlstad, now the Vänerexpressen will be the main actor.

Vänerexpressen is in charge of container shuttle trains for the line from Göteborg to Karlstad. Its partners are Vänerhamn-harbor Karlstad, ELB- Lorry Company and BKtåg. They buy the container service from their partner.

The industries around this area are traditional forest industry as well as the coffee industry; Löfbergs and Lila are their two main customers in the coffee industry. StoraEnso and Tetra Pak are their two main customers. There are only two employees beside him in this company.

As with the port we want to know whether the train can arrive at the terminal on time, Mr. Gunnar's answer satisfied us very much. According to him, the punctuality of the train is very good.

The peak time for trains loading and unloading is from 8:30 am to 2:30 pm.

The whole train will be managed during that time. The average time for loading and unloading is ten minutes per wagon, and only one train needs to load or unload per day. 43 wagons are the maximum for loading and unloading per day. They seldom work overtime, and it is very unusual to work overtime. According to their main business, they do not have dangerous goods to be handled.

There are no free disposal wagons provided for the customers. Every customer is treated equally. There is only one train need to be handled per day, and they have an everyday distribution plan for the arrivals and departures to suit the high emergent handling frequency.

The condition of the equipment for loading and unloading is very good; they replaced the old machines at the end of 2002. Also, they have more efficient equipment when demands arise on handling large volumes in a short period of time. According to different kinds of goods they have suitable machines for handling.

Commonly, the goods stay at the terminal from 1 to 5 days, but the storage costs are low. How containers are stored depends on what day they are supposed to depart. The distance between the railway and the storage place is about 500 meters. Almost all the goods are stored outside. If they have the requirement to store goods inside then they buy the service from Vänerhamn. This distance is convenient for them to handle. All the goods are unit loads; it is not important to know what the goods are. What the customers care very much about is whether the goods can be transported in the right place at the right time.

A well-run information system will benefit the port information system a lot. The messengers are sent through the EDIfact to the Port of Göteborg. One messenger about the goods goes to the port. One sent to the rail operators and one sent to the train drivers.

A special information system according to their own business' requirements was made. Their timetable is temporary and it depends on the deadline of the goods, which decided by the Göteborg harbor, and should also based on the customers' requirements. Green Cargo is responsible for the cargo unloading. All orders are registered in their computer, and they can see the order list from that. They take the order list to see what number of order is being shipped during that day. By now different customers will be given different key words with specific orders, and with key words they can login the system to check the information they need from the Vänerexpressen's information database. It is of great importance to obtain the same high speed for the flow of documents as for the material flow. The documents can be picked up from the booking system. Information needs can be checked out as a reference from the booking system.

Kept in charge of this company for five years, he is experienced in this domain. He thought his fast reaction ability is very good. Although he does not think that he has a very good knowledge at his machines, he can still handle the problem for the workshop to solve the problems is just 300 meters away from the location of their company, and he thinks it is very convenient for him to solve the emergent problems.

Mr. Gunnar Gärdin's final conclusion to the container freight shuttle trains can be described like this:

Generally speaking, he is very satisfied with the current situation concerning the container freight shuttles from Gothenburg to Karlstad. The service provided by the Port of Göteborg and Banverket (timetable) is good, and the situation in Karlstad terminal is also works very well. The service, which is provided by Green Cargo in the Port of Göteborg, is not good.

4.2.5 Importance of a flexible and reasonable timetable

Above are all the details of the link, one important fact should not be neglect, as mentioned several times before is that we focus not only on the technical issues, but also on the management issues in this thesis. A well-designed timetable can significantly increase the railroad capacity. Mr. Stig-Göran Throén is responsible for the creation of the timetable.

First, let us look briefly at the timetable:

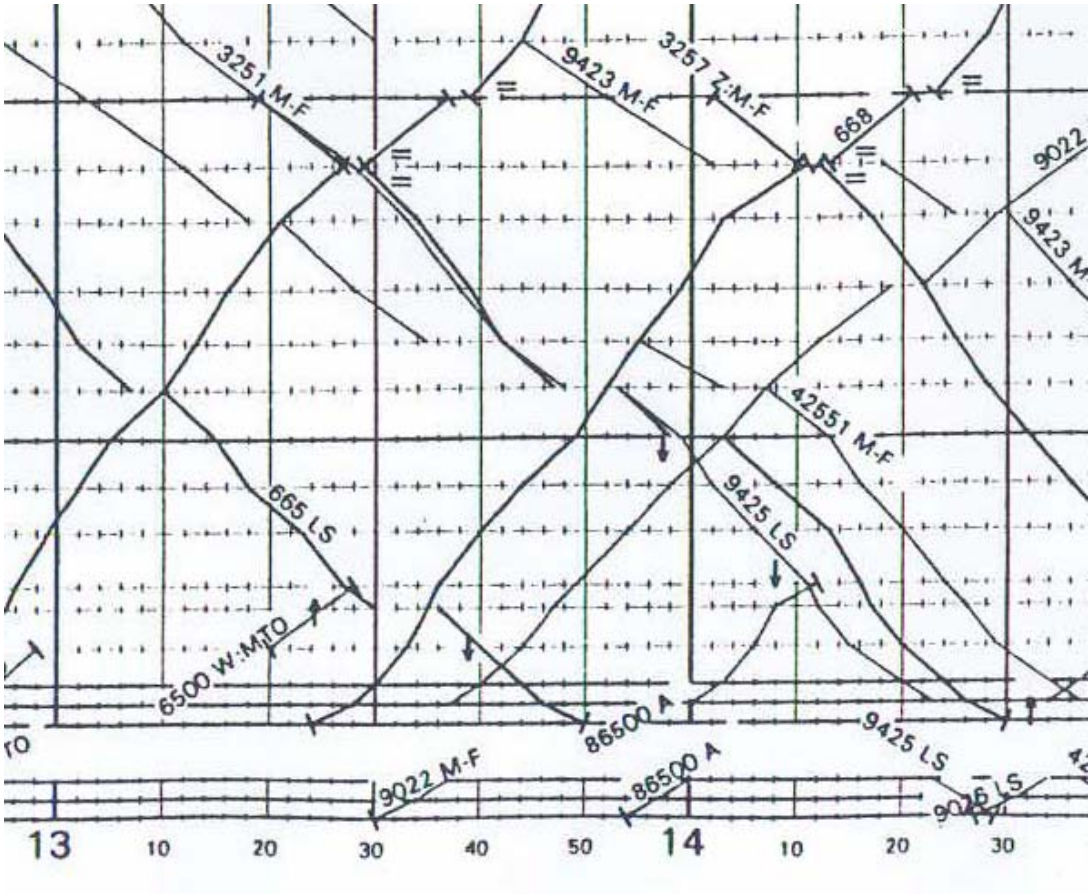

Figure 11: Part of the current time of this link [48](See appendix 1)

Above is part of the current timetable. The parallelized line represents each station along the link; for example, the fifth lowest line is Olskroken in Göteborg. The vertical line represents the time. The italic line represents the train running in this link. For example, train 9022 departs from Olskroken at 13:38, and continues running till the fifteenth lowest line (Upphärad) at 14:18. After 4 minutes staying at that station, the train departures from that station till some other places.

The creation of a timetable is a tough and complex task needs to process the data on the computer and calculate them by some certain mathematics via the software. New timetable comes every six months after the negotiation with the rail operators.

[48] Part of the current timetable Between Göteborg and Karlstad

Simply speaking, first, the rail operators hand in their special requirement about the slots time they want, and then all these requirements were integrated and processed by the computer to create a new one, which would satisfy all of them. And then Banverket Trafik will set some period of time for the rail operators to testify the newly made timetable. The feedbacks are rejoined to Banverket Trafik to make a modification after test.

In order to make a reasonable timetable and can satisfy almost every rail operator, first the operators have to ask for rules and priorities and then point out which is the most important train. So far, there is no priority for the operators, but Banverket Trafik has now perceived the necessity to set the rules of the priority to the operators. The best solution of the rules is still undertaking by them. They treat the operators equally but they give the right to the operators to give priority to their own trains. Generally, priorities were given to 10 trains. Every timetable should be credit by traffic.

The most important issue for creating a good timetable is to know the detailed information about infrastructure specification and the geography characteristics as well as the track configuration. Also, all the stations by which the trains pass through have to be further evaluated. At the same time some other issues are no less important than the geography issues. For example, the speed and the length of the trains needs to be gathered first and input into the computer system to calculate how long it will take from Göteborg to Karlstad.

So far, everything goes well on the timetable. Almost all the rail operators satisfied with the timetable. Concerning the quality of the timetable, about 85% -90% rail operators are satisfied with the current timetable, but this percentage is just a ballpark number estimated by Stig Göran Thoren without certification.

But, to tell the truth, there are a lot of trains during the peak time especially the passenger trains. When deciding which kind of train has the priority to arrange their schedule first they prefer fair slot allocation-No **Grandfather Clause.**

"GRANDFATHER CLAUSE - A provision exempting persons or other entities already engaged in an activity from rules or legislation affecting that activity. Grandfather clauses sometimes are added to legislation in order to avoid antagonizing groups with established interests in the activities affected."[49]

Each kind of train has equal opportunity to allocate the slot, but the fact is which kind of train can have the priority of allocating the slot first depends on that can bring more social benefit. According to this rule, this far, passenger trains have more priority than the freight trains. During the daytime everyday from 13:30 to 15:00 and 17:00 to 19:00, there are a lot of passenger trains running on this link, so it becomes very difficult to add a slot within this period of time. Every small change of the slots may bring a big rearrangement of the entire timetable. Too many passenger trains appropriate a lot of slots, which seems the main problem of the current situation.

Banverket Trafik constructs timetables based on the options of all the rail operators. No free space will offer to the rail operators to let them arrange their own slot.

The timetable is improved twice every year by *tågtrafikledningen*. This will be in the middle of June, and in the middle of December.

Whether the timetable needs to be improved depend on the operators. After some certain period of time, some problem might arise. The rail operators come back to Banverket Trafik to present their special requirements. The basic principle for the adjustment is the modification should not affect other operator's slots. This modification only refers to the rearrangement of the slots but it does not mean to add some slots to the current timetable.

Since "Customer First", although it is "*very very*" difficult to add slots in the peak time, this does not mean that it is impossible to add the slots during the other period of time in the timetable. Currently, it does not reach maximum rail capacity.

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[49] http://www.lectlaw.com/def/g035.htm

According to Mr. Stig-Göran Thorén, it does not reach maximum rail capacity but it is very difficult to add slots at peak times. It seems that adding the length of the train become a feasible way to increase the capacity. The rail capacity has a strong tie to the infrastructure. The maximum train should be no longer than 630 meters, that means each station the train pass through has to be built longer than the length of the train otherwise it would be not possible to stop at this kind of short station. If the length of the train is too long then the time the trains pass through the station will definitely increase. This kind of small train station cannot be treated as a virtual node to store the trains. On the other hand, the very long train passing a level crossing will bring a long interregnum to other means of transportation. At the place where the train meets obey the rules like that: the freight trains have to stop and wait for the passenger trains to pass through first, and the trains with high significance pass also through first.

5. Final analysis and conclusions

In this chapter we will analyse the findings presented in the previous chapter. The model used for analysing the empirical data is presented in this chapter. And this section also includes the conclusions drawn from the analysis of the obtained material from our field study.

The empirical study has paved the way for our research. Now we will focus on how to find the fundamental problems.

5.1 Port analysis

The port analysis on the basis of logistics theory combined with the real situation of the Port of Göteborg. Before we begin our research, we found that the terminal facilities and terminal handling might influence the whole transportation chain. Therefore, we exert our utmost to find the key points involved in the terminal. These key points are the detailed information about the handling activities and the facilities. We ask these key points to the port operators and try to find the problem via their answers. The key points we identified are, for instance:

- Loading and unloading time
- Transit time (influence the port inventory level)
- Information system (share goods information with terminals and rail operators)
- The location of the railway in the port
- Whether the containers can be searched by serial numbers
- Can the containers be found very quickly under customer's requirement?
- Allocate the berth for the in coming ships
- Efficiency, experience, knowledge, back ground, fast reaction ability of the personnel who manipulate the handling machines
- The suitable machines to handle different kinds of containers
- Communicate with the customs

- Shipping document transit speed and electrified documentation
- The warehouse in the harbor
- Dangerous goods handling
- Dispatch in the harbor
- The interval between the goods arriving at the port and the goods waiting for load

The design of the interviews to the port staff is enwrapped in these key points. According to their answers to these key points, we find one main problem:

The lack of the goods is the basic parameter to the capacity problem, and the punctuality of whether the ships can arrive on time is the main reason cause for the lack of the goods.

The port staff is not satisfied with the punctuality of the ships arriving. Since the delay of the ships will influence the unloading and loading. If the ships cannot come into the port on time all the operators have to wait until it arrives.

According to different arriving schedules, they have to arrange some period of time to do the unloading and loading to this trains, all these operation slots are fixed which means the delay of one train might appropriate other trains unloading and loading. Sometimes, the ship cannot be unloaded even though it has already arrived. Unloading is postponed for some reasons.

Because the unloading cannot finish within the fixed period of time, the operators have to work overtime. Sometimes, even some circumstances occur that there are a lot of operators available for unloading one ship but sometimes there are no enough operators for unloading.

Before the ships arrive, the shipping company needs to send all the information about the ship to the port, according to this information, the crane can be arranged to unload the containers. Normally, they move the cranes to the berth place waiting for the ship coming in. In case of the delay of the ship, the crane has to wait, it is time consuming for the cranes, and otherwise it may be used for some other ships.

The weather factor seems to be a problem to do with unpunctuality, even on the windy days, also the situation and waiting time of other ports which they passed by might influence the ships time of arrival.

5.2 Rail transportation analysis

This part of analysis on the basis of rail transportation theories combined with the real situation of the shuttle trains. The key points we developed in this section is the basis of our research and analysis. We ask these key points to the involved persons and try to find the problem via their answers. The key points we identified are listed below:

- Handling time in the rail terminal
- Modern driven engines to shunt the wagons
- How to ensure the train arrives on schedule
- Transportation documents transition
- Rolling stock
- Reasonable and flexible timetable
- Information system
- Booking system for the customers
- Follow-up service as well as the monitoring
- Track and tracing system
- Speed of the train
- Length of the train
- Signal and electrical system
- Personnel who drive the trains
- Environment and weather factors
- Competitive, customer-oriented and technically safe infrastructure for railway operators
- Maximum allowable axle load
- Track facilities
- Fast reaction for emergency

The design of the interviews to the correlated staff with these key points helped us to find the biggest problem of the section.

Several problems are important to the capacity, for instance, maintenance of the track and infrastructure facilities as well as the follow-up service and so on.

Definitely, single-tracked line has capacity limitation but a well-integrated and better improvement of the correlated issues around the link should significantly increase the rail capacity.

Besides the track limitations, along the link the problems now existing are: some infrastructure facilities along this link does not seem to be in good condition for use, and during the peak time there are lots of passenger trains running within this link.

The rail operator needs to make sure the train can arrive at the terminal on time. Every tight delay at the beginning of each direction might cause big delays in the middle of the link.

Capacity, to some extent, means goods flow or number of trains. The surface meaning of this definition seems to be that if there are a lot trains running along the link the capacity could be significantly increased, but we found that it is better to load every wagon with their maxi capacity than just run more trains along the whole link.

5.3 Timetable analysis

Trains cannot run without a timetable. Conducting a flexible and reasonable timetable may take a lot of time and a lot of money needs to be invested in them. Also, the computer simulation and creation of the timetable need to be thought over and over. As management issue of the whole chain, timetables play a very important role.

When we talked about the timetable with Banverket Trafik, we came to the conclusion that they care a lot about whether the customer's requirements can be satisfied to the utmost.

According to the interview, the infrastructure impact to the conduction of the timetable was mentioned several times, especially, the length of the station. Trains cannot be stored in a station that is shorter than the length of the train. The infrastructure between Göterborg and Alingsås is very old, which made the commute crowded.

Another problem is that it is difficult to add slots at peak times. Since the addition might influence other customers. Every small change will bring a big variance of the entire timetable.

So far, Banverket does not give priorities to the customers, and they do not have the rules on how to allocate the priorities. The absence of rules sometimes, to some extent, will influence the equality of the customers.

5.4 Final conclusion: Interrelationship between different factors

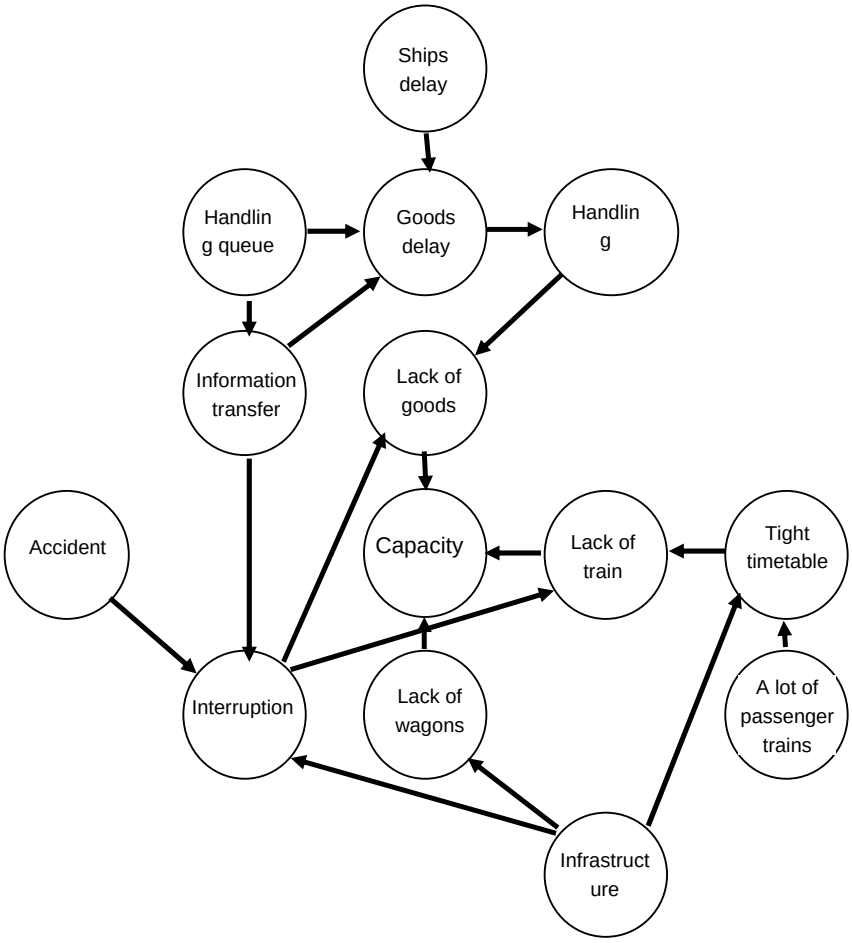

Figure 12: Interrelationship between different factors[50]

We begin our research with an analysis of each factor in between each section, after which we find the potential factor. We need to find the interrelationship between them and how they interact with each other. The graph above shows the interrelationship we discovered from our research. We find that there are two main chains for this net, the first one is centred on the goods, and second

[50] Authors

one is centred on the number of trains. In light of the theory, the rail capacity can be studied along two directions- the goods flow joins the number of trains. Our research work and our conclusion have proved this matter.

5.4.1 Interrelationship centred on the goods flow

The first interrelationship chain comes around the goods. When the capacity problem happened, we find that the main cause is the lack of goods. When the train arrives there happened to be no goods that can be reloaded on them. There was therefore a lack of goods.

Generally, there are two possibilities when reloading the goods to the trains. First, when the ships arrive at the port, it happened that the train arrive at the port at the same time, and then the goods can be unloaded from the ship and reloaded to the train directly. Second, the goods were unloaded from the ships and stored in the storage place in the port waiting for the trains to send them on. Under these two different circumstances, in case of some special reasons, the goods delay might be caused.

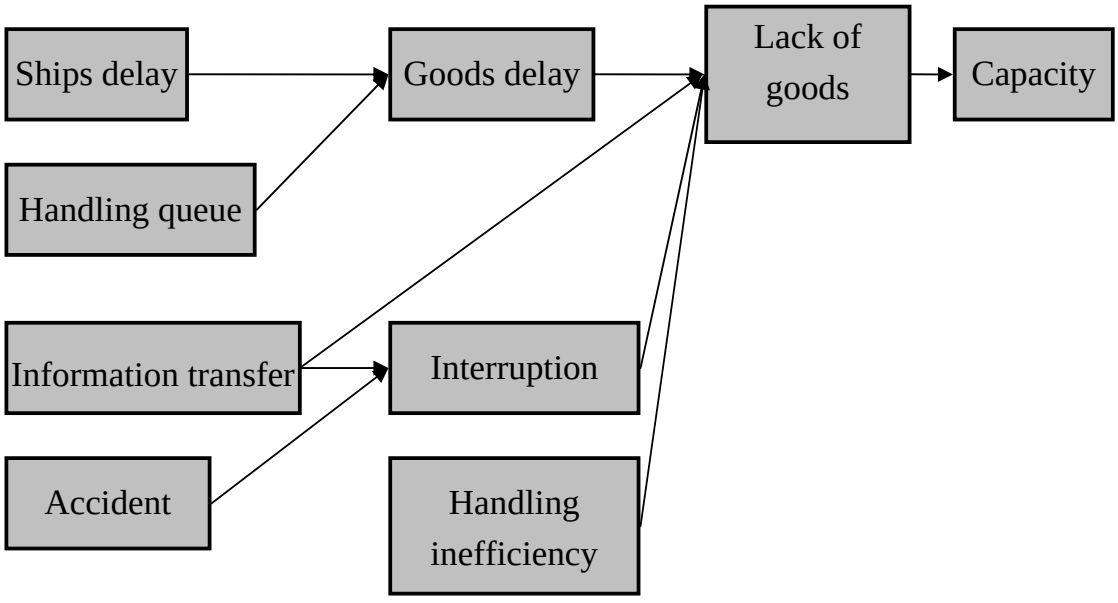

Figure 13: Interrelationship centered on goods[51]

[51] Authors

The direct reason that leads to the lack of the goods may be caused by the goods delay. There are some reasons for the goods delay, as the above figure shows that ships delay and handling queue as well as the information mistake or failure might cause the delay of the goods.

As we mentioned several times, the ships cannot be unloaded in case of the delay, and on the other hand, the different size and the shape of the ship may bring different handling speed when unloaded them.

In light of our interview, before the ships arrive at the port, the port staff needs to prepare the crane for unloading. The ships can seldom arrive on time and it makes it time consuming for unloading the ships. Sometimes the ships cannot be unloaded immediately even though they arrive at the port just in time. These are the main reasons for the goods delay. If there is several ships need to be unloaded at the same, the queue for handling will occur. This is another reason for the delay of the goods. On the other hand, if there are some mistakes and delay when transferring the information, the delay of the goods will occur out of question.

The train arrives at the port under fixed timetable. If there are now enough goods to be loaded during that time then the optimised capacity cannot be achieved.

Control failure and hazards cause accidents and accidents interrupt the rail transportation. When the interrupting occurs, the train has to stop for further constructions and repair. When the train stops, it has to be stored in a certain track and repaired immediately. This standstill might influence the other trains passing through, and furthermore leads the lack of goods. Sometimes, the wrong information transfer in between the whole link during an emergency leads to a link interruption.

Handling efficiency influences the capacity. Whether the operators in the port can handle the goods in an efficient way will strongly affect the terminal turn around time. Experienced as they are, their handling speed at the Port of Göteborg is quite good.

According to our interview, the operators in the port are not so satisfied with the handling machines and sometimes they have to wait for unloading and loading. The main factor that influences the capacity is that the integration of the operators handling activities, and the conditions of the machines are not so good. This weak integration causes the handling inefficiency.

Make sure the ship comes into the port on time and joins some other activities, might be the solution to this problem.

- Good integration with the shipping companies

The port has to have a good relationship and integration with the shipping companies, they also have to make sure they can get the information of the ships without any delay and without any mistake. In case of any change, they can get the new information as quickly as possible. That means a well-developed information system is very important for both the port and the shipping companies.

- Increase the unloading and loading speed

High loading and unloading speed can avoid the lack of the goods and can decrease the turn around time. According to the operators, they think their unloading and loading speed is ok. As we mentioned, sometimes although the ships can come into the port just in time, it has to wait until further instructions. The increased loading and unloading speed means the decreased turn around time. If the time consuming can be well allocated and the condition of the handling machines can be improved then the turn around time can be definitely decreased. That is the reason why we think the loading and unloading speed can be improved. But this improvement needs the good handling machines and well arrangement of the working process.

- A further developed information system

All the participants who granted us interviews are all proud of their computer systems. Then we can say that they have a very good computer system. Our suggestion to this point is to make sure this information is secured enough and also the maintenance should not be overlooked.

- Replacement and maintenance of the old machines

Some machines are very old and some are new. The operators do not complain too much about the situation of the machines. To the cost orient point of view, it costs a lot to replace the old one. But frankly speaking, when it needs to be replaced, please do not think too much about the money. And also doing maintenance every day can make the machines work longer.

- Reasonable Dispatch in the harbor

The dispatch here means dispatch everything, no matter whether the activities or the persons. Make everyday arrival and departure plan is as important as above.

5.4.2 Interrelationship centred on the number of the trains

Not only the goods but also the train and the other factors centred on the train seem as important as the terminal handling activities. Below we will discover the interrelationship around the train.

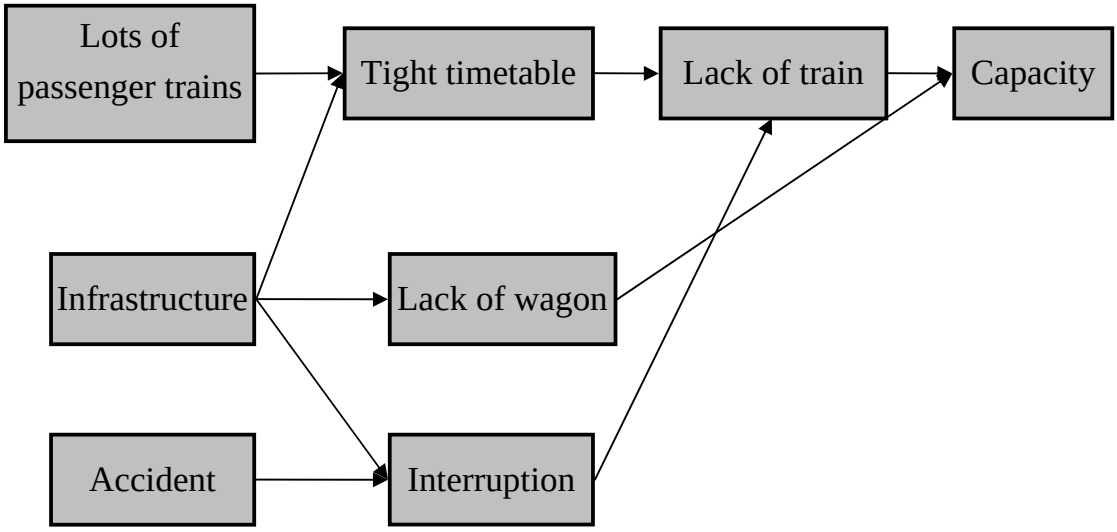

Figure 14: Interrelationship centered on trains[52]

[52] Authors

From 13:00 to 15:00 is the peak time for current timetable. At that period of time, there are a lot of passenger trains running along this link. Since the passenger trains now have higher priority than the freight trains, the freight trains have to stop to wait for the passenger trains to pass through when they meet. This large amount of passenger trains mixed with freight trains and the standstill leads to an even tighter and tensed timetable. This means fewer freight trains during peak time and definitely less rail capacity.

Now, the timetable for Vänerexpressen from Monday to Friday is:

"Tåg Avgångar

Vänerexpressen trafikerar varje helgfri måndag till fredag sträckan mellan Karlstad och Göteborg.

Tåg mot Göteborg	
Avgång Karlstad	Ankomst Göteborg
14:00	20:00

Tåg mot Karlstad	
Avgång Göteborg	Ankomst Karlstad
01:50	08:00" [53]

Above is the current timetable of the shuttle. The train leaves from Karlstad at 14:00 and arrives at Göteborg at 20:00. When the train arrives at Göteborg, it was unloaded and loaded in Göteborg. At 01:50, the train departures from Göteborg with newly loaded goods and arrive at Karlstad at 8:00 (English explanation to the above Swedish timetable). From the graph below, the area filled with dark green shows the transportation period while the light green shows the unloading and loading period in these two terminals.

[53] http://www.vanerexpressen.com

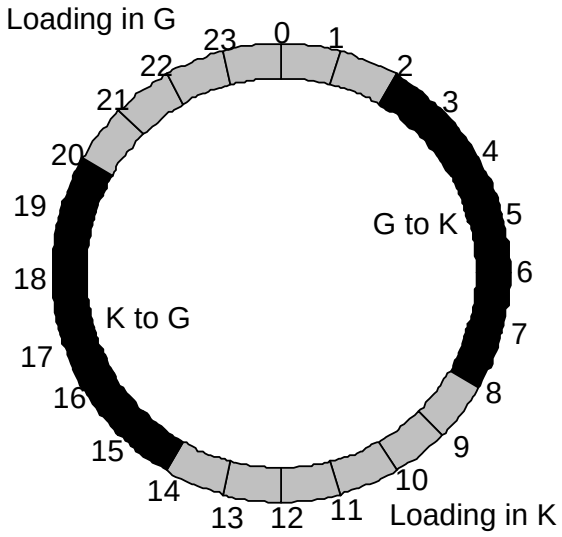

Figure 15: Current timetable[54]

According to the current timetable, from 13:00 to 19:00 is the peak time for all the trains. The train from Karlstad is now running during this period of time. From 8:00 to 14:00 is also the peak time for loading the trains in Karlstad. Base on this, we try to give our alternative as below:

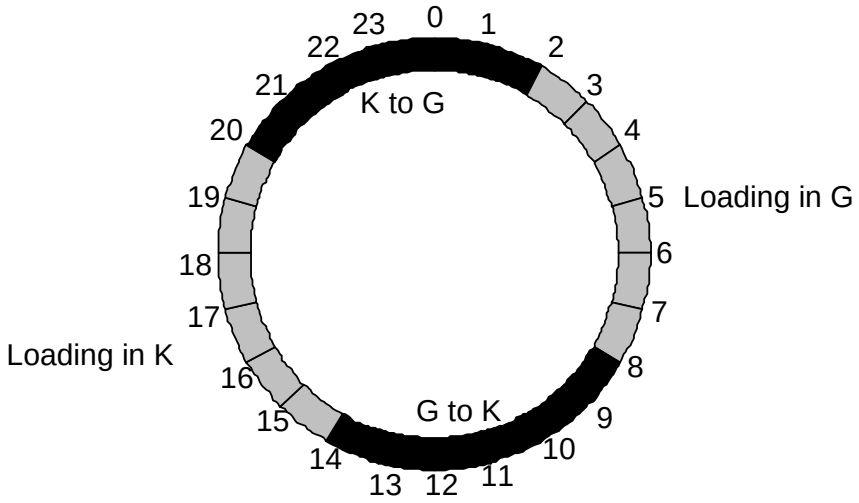

Figure 16: Alternative timetable for the current one[55]

[54] Authors
[55] Ibid.

The new timetable suggests that the train in Karlstad should depart at 20:00 and arrive at Göteborg at 02:00. From 02:00 to 08:00 the train can be unloaded and loaded at the Port of Göteborg and then send the goods to Karlstad. The purpose of our suggestion is avoiding peak times.

We give this suggestion because there are lots of trains during peak times. The train running at peak times may need to stop several times to wait for other trains to pass through. Also, if peak times can be avoided then the chance of the accidents can be decreased at the same time. In light of our interview, we know that it is very difficult to add slots in the peak time but it can be added in some other periods, this new schedule should be a reasonable one to manipulate.

On the other hand, this new schedule for loading and unloading in the port avoids the port handling peak time.

When creating a reasonable and flexible timetable, a lot of information needs to be reconsidered before the creation can begin. The geographical characteristics have to be gathered first and further evaluated and research made into the infrastructure along the link. For example, you need to know the detailed information about the train station: the length and the sloping and so on.

Since the short station cannot store the trains, and the trains can not stop at the short stations when designing the timetable, they need to exert their utmost to avoid the train stopping at the short stations. This gives difficulties when conducting a timetable and also this limitation made the timetable tight in certain periods. Also, sometimes, in order to fit the current situation of the infrastructure, the train cannot string so many wagons. Further, when facing emergency or accident, the short station or weak infrastructure facilities might cause the interruption of the transportation. All in all, the infrastructure could be a potential factor to the capacity. Besides this, some other improvements can also be made.

- Avoid long time stop at short station

Each station the train passes through has to be built longer than the length of the train otherwise it would be not possible to stop at this kind of short stations.

If the length of the train is too long then the time the train passes through the station will increase definitely. This kind of small train station can not be treated as a virtual node to store the trains. On the other hand, the very long train to pass a level crossing will bring a long interregnum to other means of transportation. At the place where the trains meet obey the rules like that: the freight trains have to stop and wait for the passenger trains to pass through first and the trains with high significance pass through first. Our suggestion here is avoid the long time stop at the short stations otherwise just try to decrease the standstill time in the short stations.

- Find a practical way to add slot

It is very difficult to add slot at peak times. We can see from the timetable that there are a lot of trains at peak times. For example, the network of the trains from 13:00 to 15:00 is very intensive. We suggest that the length of the train perhaps can be lengthened. This should be a reasonable scheme, but there is another problem, the station may not be long enough to match a very long train. According to the current timetable, timeslot can be added in other periods.

- Peak time allocation

Exert the utmost to improve the working efficiency at peak times and try to decrease the handling time of one unit. If it possible, move some trains from peak times to other period of time.

- Give priorities to customers

In order to make a reasonable timetable and can satisfy almost every rail operator, first the operators have to ask Banverket Trafik for rules and priorities and then point out which is the most important train. Banverket Trafik treats the operators similar but they give rights to the operators to give priority to their own trains. Generally, priorities were put to 10 trains. If the priority can be set to the operators then they can allocate the slots to the most important operators first. The priority can avoid a large number of trains during the peak time. Now the operators have equality opportunities to allocate their slots. Who can bring more social benefit will have the priority of allocating the slot first. Try to set some clauses to define the classes of different customers and give high priority to the important operators could be a good solution to the capacity problem.

- Everyday maintenance to the rail tracks

To be in service longer, the everyday maintenance should not be overlooked.

- Maintenance of the locomotives

All the locomotives are kept using for about 20 years and will continue use for another 10 years. This made the maintenance very important. And also the locomotives drivers need to be well trained to solve the problem of accident.

- Ensure the condition of the infrastructure is good and convenient for the trains to pass through

We have mentioned, for example, the shorter train station have problems to store the trains, it is difficult for the trains to stop at shorter stations, In some cases, the length of the station is shorter than the train.

- Banverket should provide very good follow-up service and a very good central control system

A central control system reduces the time and labor required to issue instructions. Trains kept moving while the instructions were issued, but the systems required many traffic control employees at the stations along the line. Remote control switches reduce the time required to head in and out of sidings or cross over from one track to another by eliminating the use of hand throw switches. Remote control switches can be, and have been operated by traffic control employees at local control stations. One of the advantages is the reduced cost for capacity (no employees at stations along the line) than it is increased capacity.

- The service provided by the Green Cargo in the Port of Göteborg needs to be improved

- Mix different speed trains within a single link

The better way to increase the capacity is to mix different speed trains within a link. It is difficult to do than just say it, anyway, it still a good way to increase the capacity.

6. Suggestion for future research

In the last chapter of this thesis we discuss areas that are in need of future research connected to our thesis. We did not have the opportunity to investigate theses areas of interests. We believe that the suggestions following are also interesting by the port of Göteborg AB and Banverket as well as the other rail operators.

6.1 Frequent rail shuttles between the port and centres of production and consumption in Sweden and neighbouring countries

Port of Göteborg Rail Centre has Sweden's best conditions regarding weight and profile for rail transportation. In 2004, the Port's current railway track will be electrified. Apart from the rail shuttle system and the combined rail terminal traffic system there are dedicated customer designed rail shuttles for transportation of steel, cars, paper and bananas.

The rail tracks to and from the port area are the most frequently used tracks in Sweden and the port is one of the main rail cargo stations. Everyday trains depart from, and arrive at the Port of Göteborg with overnight services to all major cities in Sweden, Denmark and Norway. The destinations covered from the Port of Göteborg by rail shuttles include the following (with frequency and operator):

- Oslo
- Karlstad
- Södertälje/Stockholm
- Insjön/Borlänge
- Helsingborg
- Malmö
- Eskilstuna
- Gävle

We just selected one link as our main research objective, but we are also interested in the other two links, which are worth further investigation.

Oslo to and from Göteborg

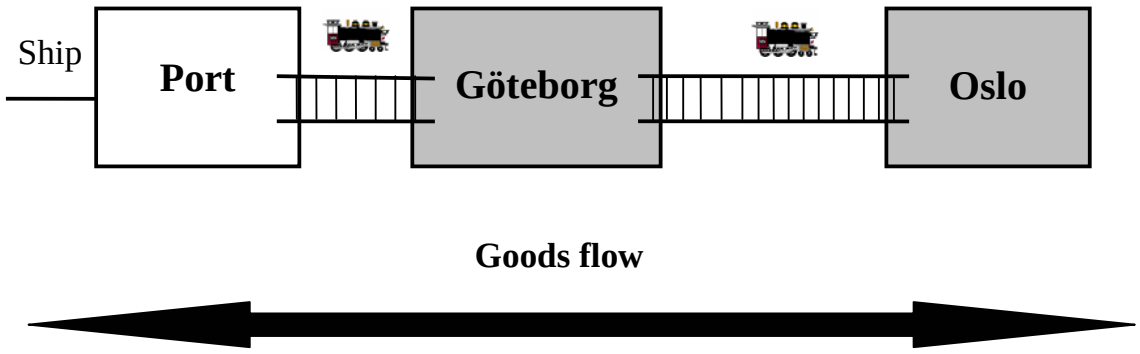

Figure 17: The rail container freight shuttle train from Göteborg to Olso[56]

This is also a single-tracked line between Oslo and Göteborg. The trains are now called GORE Express (Göteborg Oslo Rail Express). The line connects with two huge cities within north Europe, and it is important for Norway to transport the goods overseas.

Stockholm to and from Göteborg

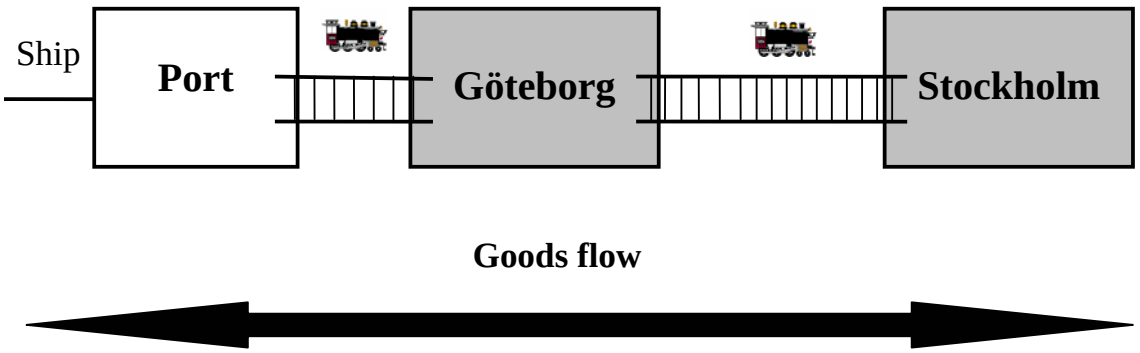

Figure 18: The rail container freight shuttle train from Göteborg to Stockholm[57]

[56] Authors
[57] Ibid.

The line between Stockholm and the second largest city- Göteborg is double-tracked. Although, double-tracked, it is still not possible to run more cargo trains in the morning or in the afternoon because of the high frequency.

Today the landside port-related cargo transport is dominated by trucking. The Port of Göteborg AB has the ambition that at least half of the increase in general cargo shipments in the future should arrive at or depart from the port by rail. The attention to rail transport is triggered by the environmental aspect of rail VS road transport but also the double commercial aspect of making the port more attractive through smooth feeding systems and increasing its hinterland.

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Interview

Bent Rydhed, Strategic Planner, Banverket, 21st April, 2003

Claes Sundmark, Manager Sales and Marketing, Port of Göteborg, 9th July, 2003

Dannies Johansson, Product Manager, Port of Goteborg, 24th September, 2003

Gunnar Gärdin, Marknad och drift, Vänerexpressen AB, 11th November, 2003

Per Rosquist, Strategic Planner, Banverket

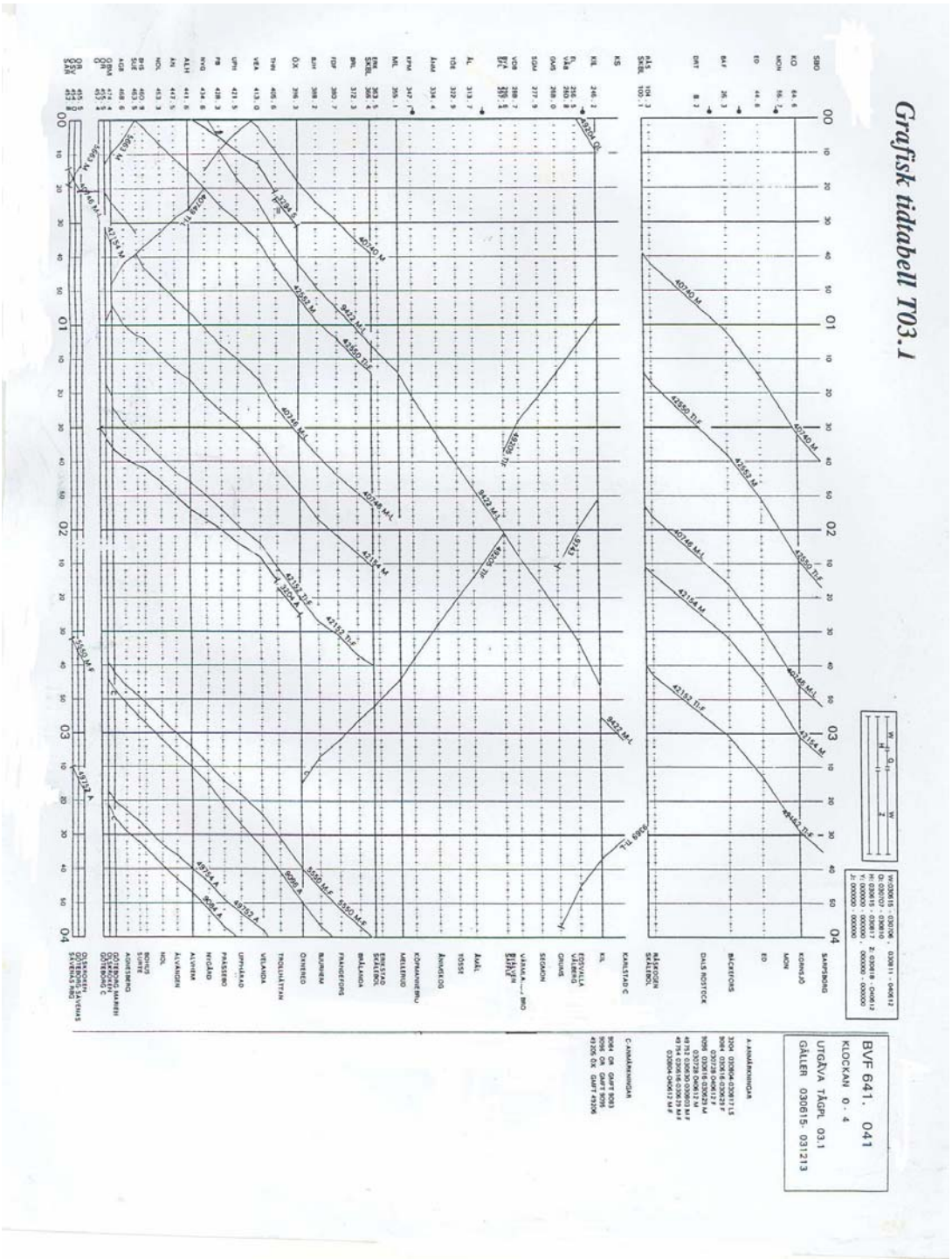
Rolf Petersson, Green Cargo, 21st October 2003

Stig-Göran Throen, Banverket Trafik, 3rd November, 2003

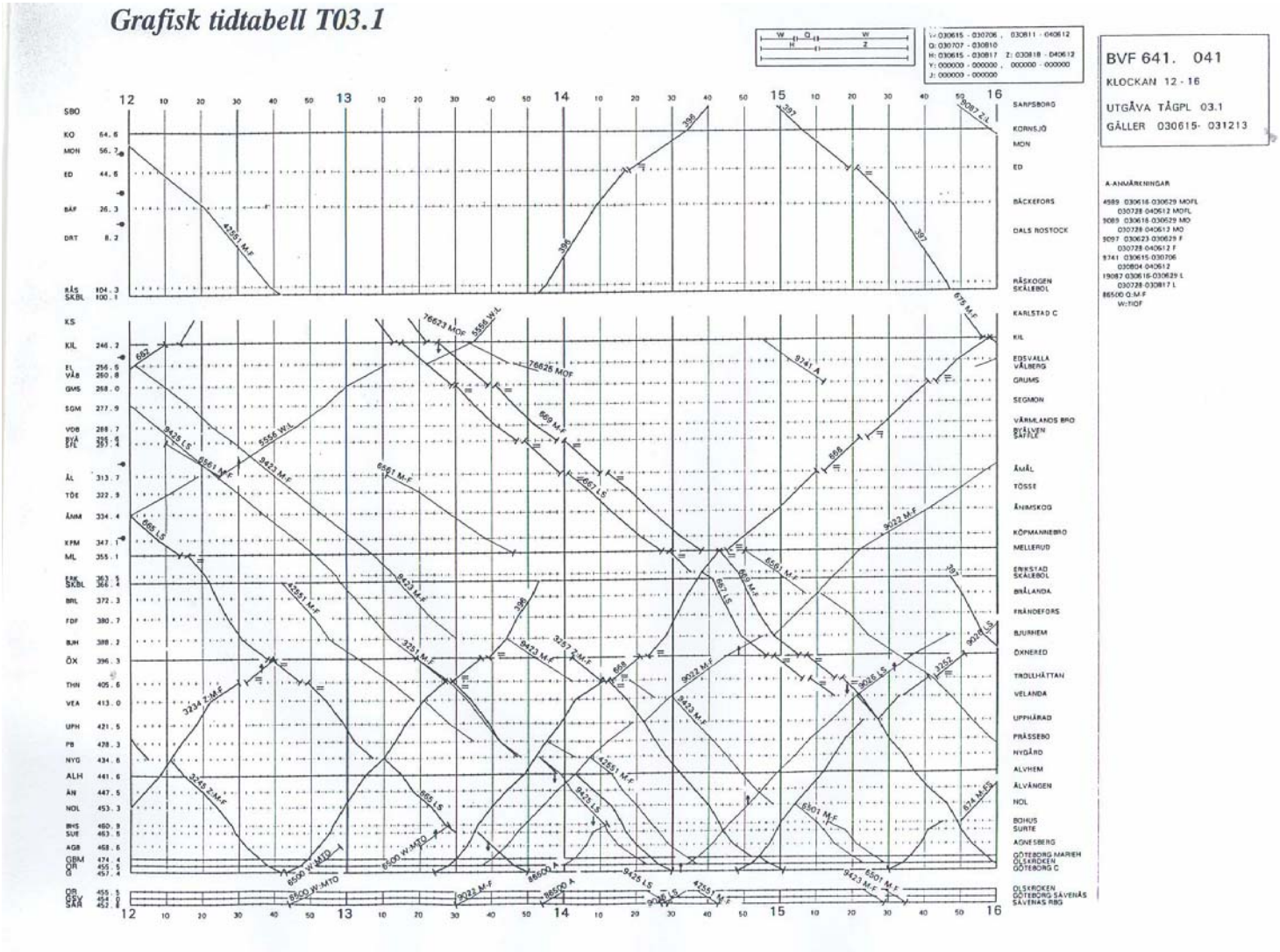
Three operators and one supervisor in the Port of Göteborg (anonymous) 18th November, 2003

Appendix 1

Part of the current timetable Between Göteborg and Karlstad made by Banverket Trafik



Grafisk tidtabell T03.1



Appendix 2

Interview questions to Vänerexpressen

1. Do you satisfy with the punctuality of trains arriving and departure?
A: unsatisfied
B: it is ok
C: satisfied
D: quite satisfied, but still need some improvements
E: Perfect

2. Generally, for how long it will take you to loading and unloading a wagon?
_____

3. Do you always need work overtime? How many hours per time? _____
A: Yes, we need
B: No, but sometimes we have to work overtime.
C: No, we never work overtime

4. Do you satisfy the machine that you manipulate for unloading and loading?
A: unsatisfied
B: it is ok
C: satisfied
D: quite satisfied, but still need some improvements
E: Perfect

5. Normally, how many wagons can you load and unload per day?
_____

6. Do you have more efficient equipment when demands arise on handling large volumes in a short period of time?
A: Yes, we have
B: No, we have not
C: Sorry, I do not know

7. Normally, for how long the goods stay at the terminal?

_____

8. How do you evaluate your knowledge when handle dangerous or perishable goods

A: fresh

B: just a little

C: have some knowledge about that

D: yes, I have good knowledge but I still need to improve

E: Perfect skilled

9. Is the distance between the warehouse and the railway in the port long or short?

A; long

B: it is ok

C: short

10. Do you think this distance is convenient for you to transit the goods?

A: inconvenient

B: it is ok

C: convenient

D: quite convenient, but still need some improvements

E: Perfect

11. Normally, the port will provide free disposal of the wagons for certain customers, then what are your criterions to identify this kind of customers. And how many wagons in general do you offer per customer?

12. For how many years did you work at this place?

_____

13. Do you have related knowledge of this domain?

_____

14. How do you evaluate you fast reaction ability when facing emergency?
A: Bad
B: Just so so
C: my fast reaction ability is good
D: my fast reaction ability is quite good
E: I have perfect fast reaction ability

15. Do you have a good knowledge of your machine?
A: I do not have any knowledge about that
B: Just so so
C: I have good knowledge about that
D: My have quite good knowledge about that
E: I have perfect knowledge about that

16. Do you think it still needs to be improved?
A: No, they do not need to be improved
B: If some improvement can be made that would be so good
C. They need to be improved
D. They need to be improved immediately
E: We need a new machine

17. According to different kinds of goods, do you have suitable handling machines?
A: Yes, we have
B: No, We have not
C: Sorry I have no idea

18. How many years do these machines put into use?
_____

19. Please evaluate the current situation of these machines?

20. When is the peak time for loading and unloading during a whole day?

21. Normally, how many trains arrival and departure in one day,

22. Will the trains stay in the terminal for a long time?

23. Do you always have emergent handling?

24. How the transportation documents is transmit within terminals and operators as well as the port

25. Can the wagon and goods information be found through the computer very quickly under customer's requirement?
A: they cannot be found
B: they can, but accompanies mistake
C: They can
D: They can, but still need some improvements
E: Perfect

26. Whether the wagon information can be searched by serial numbers?
A: Yes
B: No

27. Can you get the information you need from the document without any mistake?
A: Yes
B: No
C: It depends

28. It is of great importance to obtain the same high speed for the flow of documents as for the material flow. Can you get the transportation document without any delay?
A: Yes
B: No
C: It depends

29. Can the information system convey specific information in a number of blowing respects?
1) Do you have the specification of the goods entering the sorting terminal?

A: Yes B: No

2) When do the goods entering the terminal?

3) The quantity and the composition of the goods.

4) How the goods is identified.

A: Yes B: No

5) The destination of the goods to be transported after unloading

A: Yes B: No

6) When the goods is to be sent on.

A: Yes B: No

Specification of the destination and the customers.

A; Yes B: No

30. Do you have enough space to store the good especially in the peak time?

31. Do you store the goods according to different customers?

32. Concerning the queue problem, do you have everyday distribution plan for the arrivals and departures?

33. Do you have good commendations for us?

Appendix 3

Interview questions to the port staffs

1. Do you satisfy with the punctuality of ships arriving?
A: unsatisfied
B: it is ok
C: satisfied
D: quite satisfied, but still need some improvements
E: Perfect

2. Generally, for how long it will take you to unloading a container?

3. Do you always need work overtime? How many hours per time? _____
A: Yes, we need
B: No, but sometimes we have to work overtime.
C: No, we never work overtime

4. Do you satisfy the machine that you manipulate for unloading and loading?
A: unsatisfied
B: it is ok
C: satisfied
D: quite satisfied, but still need some improvements
E: Perfect

5. Normally, how many containers can you load and unload per day?
_____

6. Do you satisfy the berth of the ships that need to be handled? And is it convenient for you to handle?
A: unsatisfied
B: it is ok
C: satisfied
D: quite satisfied, but still need some improvements

E: Perfect

7. Do you have further and more efficient equipment when demands arise on handling large volumes in a short period of time?
A: Yes, we have
B: No, we have not
C: Sorry, I do not know

8. Normally, for how long the goods stay at the port?
_____

9. How do you evaluate your knowledge when handle dangerous or perishable goods
A: fresh
B: just a little
C: have some knowledge about that
D: yes, I have good knowledge but I still need to improve
E: Perfect skilled

10. Do you think the loading and unloading of these kinds of goods will affect the efficiency of the terminal handling time?
A: Yes
B: No
C: sorry, I have no idea

11. Is the distance between the warehouse and the railway in the port long or short?
A; long
B: it is ok
C: short

12. Do you think this distance is convenient for you to transit the goods?
A: inconvenient
B: it is ok
C: convenient

D: quite convenient, but still need some improvements
E: Perfect

13. Do you think the design of the railway in the port is reasonable?
A: unreasonable
B: it is ok
C: reasonable
D: quite reasonable, but still need some improvements
E: Perfect

14. For how many years did you work at this place?
_____

15. Do you have related knowledge of this domain?
_____

16. How do you evaluate you fast reaction ability when facing emergency?
A: Bad
B: Just so so
C: my fast reaction ability is good
D: my fast reaction ability is quite good
E: I have perfect fast reaction ability

17. Do you have a good knowledge of your machine?
A: I do not have any knowledge about that
B: Just so so
C: I have good knowledge about that
D: My have quite good knowledge about that
E: I have perfect knowledge about that

18. Do you think it still needs to be improved?
A: No, they do not need to be improved
B: If some improvement can be made that would be so good
C. They need to be improved
D. They need to be improved immediately

E: We need a new machine

19. According to different kinds of goods, do you have suitable handling machines?
A: Yes, we have
B: No, We have not
C: Sorry I have no idea

20. How many years do these machines put into use?
_____

21. When is the peak time for loading and unloading during a whole day?

22. Can the container be found through the computer very quickly under customer's requirement?
A: they cannot be found
B: they can, but accompanies mistake
C: They can
D: They can, but still need some improvements
D: Perfect

23. Whether the containers can be searched by serial numbers?
A: Yes
B: No

24. Can you get the information you need from the shipping document without any mistake?
A: Yes
B: No
C: It depends

25. It is of great importance to obtain the same high speed for the flow of documents as for the material flow. Can you get the shipping document without any delay?
A: Yes

B: No
C: It depends

26. Can the information system convey specific information in a number of respects (as below)

The specification of the goods enters the sorting terminal. A: Yes *B: No*

From where does the goods enter the terminal. *A: Yes* B: No

When do the goods entering the terminal? *A: Yes* B; No

The quantity and the composition of the goods. *A: Yes* B; No

How the goods is identified. A: Yes *B: No*

The destination of the goods to be transported after unloading. *A: Yes* B: No

When the goods is to be sent on. *A: Yes* B: No

Specification of the destination and the customers. *A; Yes* B: No

27. Do you have enough space to store the good especially in the peak time?
A: yes, we have
B: No, we do not have
C: It depends

28. Do you store the goods according to different customers?
A: Yes
B: No
C: It depends

29. How do you treat the goods, which never put in stores, but passes directly through the terminal? (The goods are transferred directly from the incoming and outgoing gate without any value adding handling in between.)

30. Concerning the queue problem, do you have everyday distribution plan for the arrivals and departures
A: Yes we have
B: No, we do not have