ROUTING ANALYSIS USING INTERMODAL TRANSPORT CHAINS

Case: DSV Road Oy

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ABSTRACT

This thesis focuses on transport services production, maintaining carrier criteria in integrated transports, through careful consideration of transportation systems behaviour. Routing possibilities for DSV Road Oy are analysed for groupage services between Finland and Great Britain.

The aim of theory is to identify carrier criteria through the role of transport in the logistics system. There exist choice criteria with emphasis on the importance of reliability, speed and cost to the customer of carrier services. The role of planning, instructing and monitoring in the production process are crucial in the ever changing environment of activities in which transportation is produced. The focus is on identifying operating plans through which transportation systems are run, in order to establish system behaviour. Integrated transports allow for the coverage of increasing geographical and time differences. The ability for a carrier to take advantage of intermodal transport chains offers significant advantages over single mode alternatives. The aim is to address some benefits through modal service characteristics with emphasis on the importance of green logistics.

Transport services production is the processes of physical activities that form the physical distribution system. It is a continuous effort to improve the usage of physical transportation system to further advance the performance of distribution. The ability for a carrier to improve the performance of distribution is directly dependant on the transportation infrastructure available.

The empirical part consists of an analysis carried out for a transportation service provider, DSV Road Oy. Hypothetical conditions are set in which direct sailings from Finland to Great Britain do not exist. The aim of the study is to allocate alternative routing solutions, using intermodal transport chains. The purpose of the theory is to set performance measures through which the alternatives can be judged. These measures are a combination of carrier criteria and operating plans.

The results showed that although one route is more suitable to service the groupage export flows, there is no absolute solution. The importance of schedule adherence became evident, and the four alternative routes under analysis all ranked high in some areas of performance. This has led to a conclusion that the growing importance of flexibility and carrier's ability to provide tailor made solutions increase with the routing possibilities.

Key words: carrier criteria, integrated transports, operating plans, transport service production

Lahden ammattikorkeakoulu
liiketalouden laitos

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Tradenomin koulutusohjelman opinnäytetyö, 74 sivua, 4 liitesivustoa

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TIIVISTELMÄ

Tämä tutkielma keskittyy kuljetustason hallintaan integroitujen kuljetusten kuljetuspalvelutuotannossa. DSV Road Oy:lle analysoidaan reititysvaihtoehtoja Suomen ja Iso-Britannian väliselle kumipyöräliikenteelle.

Teorian tarkoituksena on määrittää palvelutasomittareita, ottaen kuljetuspalvelut huomioon keskinäisenä osana logistisen ketjun kokonaisuudessa. Kuljetusaikaan, hintaan ja luotettavuuteen liittyvillä suoritemittareilla havaitaan erityinen painopiste kuljetuspalvelutuotannossa. Kuljetushallinnan rooli määritellään osoittamaan operatiivisen suunnittelun, ohjauksen ja seurannan kriittisen merkityksen jatkuvasti olosuhteiltaan vaihtelevassa kuljetustoimintaympäristössä. Kuljetusjärjestelmän tärkeä osa-alue on operatiivisten suunnitelmien vaikutus kokonaisuuteen. Integroidut kuljetukset mahdollistavat paikka- ja aikaerojen synnyttämän kuljetustarpeen suorittamisen, parantaen suorituskykyä yksittäisiin kuljetusmuotoihin verrattuna. Tarkoituksena on havainnollistaa kuljetusmuotoihin liittyviä ominaisuuksia suoritemittareina, ottaen erityisesti huomioon vihreän logistiikan merkitystä intermodaali-kuljetusketjuissa.

Kuljetuspalvelutuotanto on jakelukokonaisuus joka muodostuu yksittäisistä toiminnoista. Jatkuvana tavoitteena pyritään tehostamaan fyysisen liikenneverkon käyttöä ja suorituskykyä. Tämä edellyttää tarvittavan infrastruktuurin läsnäoloa.

Tutkielmassa, kuljetusyritys DSV Road Oy:n, viennin kappaletavarakuljetuksille etsitään sopivia reititysvaihtoehtoja, ottaen huomioon palvelun vaatimat operatiiviset kriteerit. Hypoteettinen oletus asetetaan jolloin suorat laivayhteydet Suomen ja Iso-Britannian väliltä eliminoidaan. Tarkoituksena on havainnollistaa realistisia reititysvaihtoehtoja käyttäen intermodaali-kuljetusketjuja. Operatiivista hallintaa ja palvelutasomittareita käytetään reittisuoritteiden tarkastelussa.

Tutkielma osoittaa, ettei yhtä absoluuttista reititystä löytynyt, vaikkakin yksi neljästä reititysvaihtoehdosta soveltuu parhaiten kappaletavaraliikenteen tuotantoon. Yksikään reitti ei osoittautunut parhaaksi vaihtoehdoksi kaikilla suoritealueilla, vaan kaikilla on hyviä ominaisuuksia suoritemittarista riippuen. Yhteenvedoksi voidaan todeta että reititysmahdollisuuksien kasvaessa, palvelutarjonnan joustavuutta voidaan lisätä.

Avainsanat: palvelutasomittari, integroidut kuljetukset, operatiiviset suunnitelmat, kuljetusten suorittajat

KEY CONCEPTS

Activity analysis	a tool used for activity-based management, allocation of performance measurement through activities
Carrier criteria	conditions that enable choice upon which a decision can be based; the ideal in terms of how a carrier can be judged
Connection patterns	time required for transfers in a transportation system
Contingency planning	alternative solutions when plans do not go accordingly
Drop & pick principle	propulsion units used to meet connections for interchange; not driver accompanied traffic
Green logistics	achieving a more sustainable balance between economic, environmental and social objectives; investing into the sustainability of logistics systems
Groupage	unit load consisting of goods belonging to several shippers
Integrated transports	the usage of more than one mode of transport while transferring a unit to its final delivery point
Intermodal transport chain	the use of at least two modes of transportation whilst moving the unit to its destination, the interchange happens at a terminal specifically designed for such a purpose
Operating plans	a transportation system is ran through operating plans

Propulsion unit	allocation and providing of units adequately to cater for the demands on traffic in a cost effective manner recognising that there is an uneven need
Routing	the way in which the geographical distance is covered to reach final destination
Routing Analysis	allocation and in depths study of alternative solutions to cover a distance
Transport coordination	methods used to plan, instruct and monitor the physical activities
Transport infrastructure	physical components that support the entire structure of transportation operations; guideways, terminals and stations
Transportation system	combination of internal and external components through which transport services are produced
Transportation systems analysis	a framework, a qualitative organising principle for analysing a transportation system

TABLE OF CONTENTS

1 INTRODUCTION

The process of this study, works towards allocating intermodal transport chains, whilst abstracting operating plans and maintaining carrier criteria in a transportation system. The theory parts concentrate on identifying carrier criteria, transportation service production planning, and integrated transportation. The empirical part, on the other hand, is conducted for a case company and entails the allocation of routing possibilities, using intermodal transport chains. The idea is to implement operating plans and measure performance of the alternatives.

1.1 Thesis structure

The study begins with a look at carrier criteria, through the role of transport in the logistics system. Adequate carrier selection enables maximisation of cost-benefit trade off and allocation of suitable physical distribution solutions. Economic, technical, social and organisational criteria are used to evaluate the carrier performance. Economic criteria determine the monetary values of the service, while technical criteria concentrate on reliability issues. Social criteria evaluate possibilities of following current trends and organisational criteria image related factors, such as risk-reduction.

Carrier criteria are a complex issue as customers have different needs and demands on the service required. Reliability of service, cost and transit time are identified as key criterion. Other criteria are also identified, to mention shipment tracing, care in handling, convenient schedules and increasing importance of green logistics. Logistics systems emphasise reduction of costs and cycle time whilst congestion, increasing travel distance and decrease in time given to do so, all contribute stress on transportation systems.

It is a continuous effort for the carrier to maintain and improve the level of service in the ever changing environment surrounding transport service production. The purpose for identifying carrier criteria is to establish performance measures for the empirical part of the study and in order to evaluate the effects of transportation systems behaviour on customer service standards.

The study continues with a closer look at transport service production. Transportation is produced in a continuously changing environment of activities. On the other hand, a failed or disrupted transportation is challenging to replace and creates excess costs. Each activity adds benefit to the service, however, at the same time cumulates costs. It is of importance to allocate costs to the correct category, determined by type of activity. The five categories of transport costs are labour, equipment, organisational, handling and channel costs. The cost structure is identified in order to establish relevance of channel costs, to support the calculations in the case study. The cost structure is also identified to emphasise the importance of profitability in the context of transport planning.

Planning is a continuous effort to improve the usage of physical transportation systems to further advance the performance of distribution. The role of strategic planning, operations planning and transport coordination is looked at from that perspective. The purpose is to form an understanding of what is involved in transport coordination and what are factors of importance from the planning and organisation points of view.

Particular focus is on operating plans that make the transportation system function. These operating plans include way, schedule, crew assignment, flow distribution, connection patterns and contingency planning. These are issues that are crucial in order to make a transportation system perform adequately and will be abstracted to the case study.

The sections on carrier criteria and transport planning are followed by a look at integrated transports. The growing demand to benefit from combined transportation systems is a continuous effort to distribute congestion in international freight forwarding. Integrated transportation refers to the usage of more than one mode of transport while bringing the unit of carriage from the shipper to the receiver. In this study, the focus is on intermodal transport chains.

The characteristics of the different modes of transportation will be studied in more detail to identify how to benefit from using intermodal transportation systems. The modes of transportation are road, rail, water, air and pipeline. Air and pipeline are not included in this study, as the transport chains to support the case study concentrate on road, rail and sea.

The ability for a carrier to take advantage of an intermodal transport chain is directly dependant on the transportation infrastructure available in each market. Infrastructure supports the entire structure of transport operations and therefore a closer look at infrastructure is in place. An understanding of infrastructure creates a better platform for allocating real world solutions.

To finish off the theoretical part of the study, one of the major benefits of intermodal transport chains is identified; the growing importance of green logistics, a central issue in the entire logistics process. Transportation is one of the largest consumers of energy and creates environmental expenses through congestion, noise and air pollution. Where there is a possibility to move road traffic to both rail and sea, it promotes an environmentally friendly approach. This is a performance measure in the context of the case study.

The empirical part covers the second half of the study. It focuses on finding alternative routing solutions, taking into consideration the carrier criteria and transport planning. The topics discussed, can be identified in figure 12 as the internal and external components of transportation systems. The use of integrated transportation systems in the real world will be evaluated and the findings of the research will be discussed in detail to finish off.

Figure 1 demonstrates the process of the Thesis, as discussed above, so the reader can clearly follow the study.

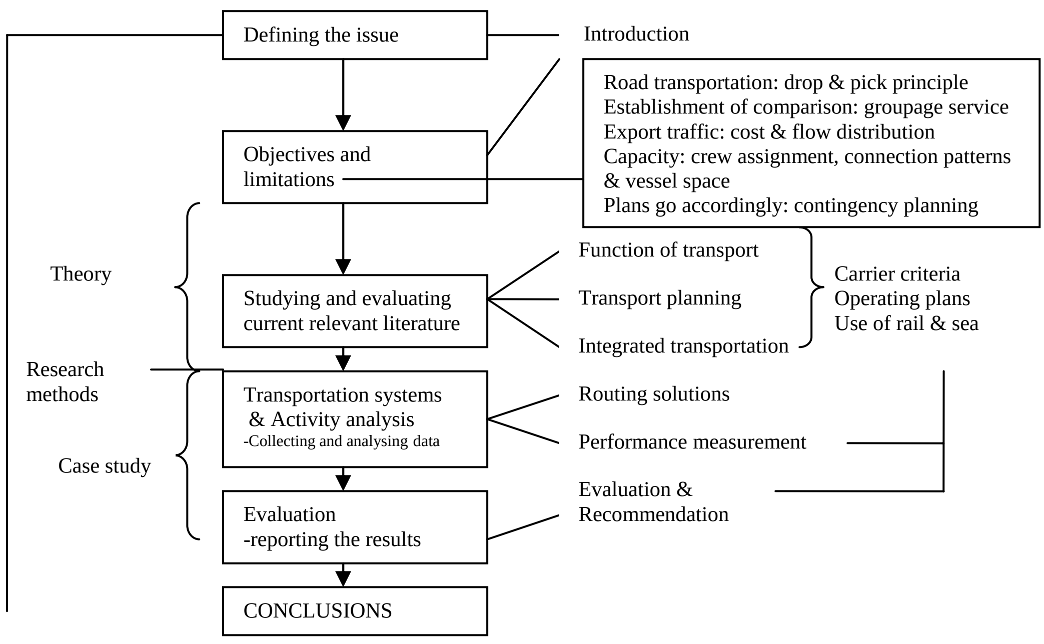


Figure 1 - Process of Thesis

1.2 Objective

The aim of this study is to allocate and analyse alternative routing possibilities from Finland to Great Britain for drop and pick trailer service as opposed to using direct sea crossings. The purpose of this study is to provide the interest group, case company, with a realistic idea of routing solutions.

The changes in the industrial structure of Finland have an impact on the direct export vessel sailings. For instance, forest and paper industry sectors are moving production to more profitable locations abroad, whilst 42.8 % of seaborne exports alone are sawn woods and other forestry products (Finnish Maritime Administration, 2007). These changes in industries dominating the export sailing schedules could jeopardise the position of seaborne general cargo exports, placing excess pressure on transportation service providers. These changes provide the cause for this routing analysis, as explained in more detail under section 5.1.

In order to measure the performance of these alternative routing solutions, it is of essence to identify carrier criteria from both the customers’ and the service providers’ points of view. To identify adequate measuring criteria the role of transportation as part of the logistics process must be established. In particular from the customers’ point of view; what are the quality service standards that suppliers and buyers look for when allocating service providers for transportation. From the service providers’ perspective it must be determined whether or not the required standards can be achieved and what needs consideration in order to do so.

The objective of this study is to provide the case company with alternative routing solutions taking adequate performance measuring criteria into account. These alternative routes can then be used alongside already used routes to increase scheduling possibilities. The idea is to consider transport planning and elements such as scheduling and contingency planning by abstracting real world into the analysis. The purpose is to measure the operational performance of the allocated routes.

1.3 Limitations

First of all, it is necessary to identify that this study focuses on road transportation. The case study is conducted for a road transportation service provider. The services connect a supplier and a buyer by carrying goods from the collection point to the delivery point as agreed. In the context of this study, the carrier focuses is on supplying drop and pick trailer services. The modes of transportation used in the transit process do not affect the customer, shipper or the receiver with respect to the contract of transit. The carrier makes a separate contract with the service provider of other modes of transportation in order to meet the freight payers' requirements for the contract of transit and the transportation of goods from the collection to the delivery destinations as agreed.

At this point, it is of importance to clarify briefly the parties involved in a contract of transit, as specified by the Finnish Freight Forwarders Association (2005, 294):

- Consignee or customer (freight payer) is the party who makes the contract with the carrier
- Carrier (transportation service provider) is the party who makes the contract with the customer (freight payer) and is responsible for the transit of the cargo
- Shipper (collection point) is the party who releases the cargo for transportation to the assigned carrier
- Receiver (delivery point) is the party who is assigned as the destination for the delivery

Although contracts of transit may vary in accordance with the needs and requirements of the customers involved.

The goods are carried by trailers on a weekly departure basis. These trailers travel on a drop and pick principle which indicates that it is not driver accompanied traffic. The units are moved by propulsion units and travel sea crossings or other combined modes without driver units. The combined transportation systems and the benefits of using integrated transport will be discussed in chapter 4.

The traffic flow is further narrowed down in order to create an environment where comparison can be established. Therefore, it is necessary to use a certain type of trailer service to create that comparison. Although in reality the findings of this study are beneficial to all the types of trailer services; full-loads, part-loads and groupage trailers, conducting this study is only possible by focusing on groupage trailer service. This creates the possibility to compare routing alternatives as the distance to travel in all cases is the same. In the case of full- and part-loads the collection and delivery points are unknown. However, the groupage trailers always travel from one terminal to the next, as the goods are collected and delivered by local and regional distribution systems. The terminals facilitate the composition and decomposition of the units, as demonstrated in figure 11.

Another limitation to the traffic flow is that this study focuses on export traffic. In reality the export and the import services are worked in combinations to ensure maximum effectiveness. Therefore, the traffic flow is examined from the point of view of trailers moving across without combinations. This affects the cost comparison in this study, as one unit will carry the costs of two legs of a journey rather than one. This would not be the case if the study focused on combinations of matching export and import flows. However, although the aim of this study is to find alternative export routes in reality the routings can be reversed to benefit the import trailer service.

The discussed limitations are implemented to simplify this study and to create a possibility for comparison. On the other hand, they are factors which will not affect the findings of the case study, as they are issues which can be worked around. It is possible to tailor calculations to accommodate the channel costs to full- and part-load services when the collection and delivery points are known. It is also realistic to work export and import trailers in combo, spreading the cost of haul between the two flows.

However, there are limiting factors that affect the implementation of findings. For the empirical part of this study, it is necessary to assume that the required capacity is available. By capacity the particular reference is on the availability of propulsion units to move the trailers as required. With the resources available for this study, it is not a possibility to analyse the available capacity of propulsion. If driver accompanied traffic is served, rather than drop and pick traffic, capacity in this sense is not an issue.

For the purpose of this study, an assumption is made that each party responsible for propulsion is able to meet connection patterns for interchange. The available capacity of propulsion units varies in accordance with volumes of traffic, or in other words demand. There are specific seasons when it can be said that demand is higher than normally but overall it is impossible to predict. It requires confirmation prior to sending a trailer a specific way. When using intermodal transport chains, this affects capacity of modal services; the availability of required space must be assumed to be adequate. However, this issue is addressed in the sense of contingency planning, which is introduced in chapter 3.

It is only possible to forecast the happenings between starting and finishing points when analysing transportation systems. Unforeseen conditions affect transportation which cannot be expected or predicted. In particular, when the focus is on scheduling it is impossible to detect factors that may lead to delays and cause a snowball effect on the whole planned process. Weather conditions, vehicle breakdowns, delays in connective schedules and traffic congestion are some factors to be mentioned. It is necessary to assume that things go according to plan; however, this is looked at in the context of contingency planning. On a continuous basis, transportation systems are challenged by unforeseen circumstances and external influences, thus, is not unique to this study.

The scheduling possibilities under analysis in this study, however, are restricted to a timeframe. Due to the unforeseen changes, the schedules of service providers, particularly for sea crossings, may be altered subject to no notice. These may cause further delays until the situation can be brought back to standard services. In reality scheduling is an ongoing process; however, this study will provide an overall picture of current possibilities.

Although there are factors which narrow down and simplify the empirical part of this study, various assumptions necessary to provide findings in a setting where comparison can be established, it will not affect the value of the findings. It is only necessary to identify these limitations so that the reader can establish the setting in which this study is carried out.

The following subheading on research methods discusses the ways in which the case study is conducted and analysed in order to achieve realistic solutions.

1.4 Research methods

Finding the right types of tools to carry out the case study is essential. It requires an understanding of the practical side of operations, which needs to be illustrated to the reader. The methods used to illustrate the research are both qualitative and quantitative.

A qualitative research method is ideal when the objective is to determine a causal relation. Qualitative findings are based on instrumental theories, generalisations that cater for numerous occurrences, based on conclusions indicating a result assumed to function in reality. The theories are used to find patterns or similarities through which it is possible to explain, forecast or control the phenomenon under analysis. Behind a qualitative research, a hypothesis is drawn to examine an established theory to determine its worth. The findings of qualitative research are not tested in reality and are explained in theories, in written format (Silius and Tervakari, 2005).

Findings of quantitative research on the other hand are presented in equation or mathematical form. In quantitative research, a systematic and logical plan is used to gather numerical information that is analysed using statistical procedures. Quantitative research does not argue to conclude findings that indicate the absolute truth, however, is based on statistical analysis and probability. The phenomenon under analysis must accommodate systematic measurement, or sections of the phenomenon must accommodate isolation for measurement (Oulu University Library, 2002). For instance, in this case study, numerical information is gathered to measure performance to complement the qualitative methods.

Two tools are used in the routing analysis; a transportation systems analysis and an activity analysis are implemented in collaboration to achieve the most desirable recommendation. The transportation systems analysis focuses more on finding alternative solutions in the real world whilst the activity analysis focuses on the physical activities involved.

The activities within the operations framework, however, determine the alternative real world solution and therefore the two analyses go hand in hand and overlap to benefit one another. The crucial factors in this study are a thorough comprehension of the physical activities involved and comparing those against performance measures which will be identified in the theoretical part of this thesis.

Transportation systems analysis is a framework, a qualitative organising principle for analysing a system. When using such qualitative form for an analysis the results are presented in form of words rather than numerical or in equation form. This form of analysis is ideal when the question is of operating a new transportation system optimally whilst maintaining an efficient level of performance.

The idea is to begin looking for alternative solutions to the ones currently used in reality. The goal is to search for better way of doing things or in this case new ways whilst maintaining good level of service trade off.

The second step is to try and forecast the performance of the alternative. In this case it is possible to use comparison to the existing transportation system; however, it is of essence to identify performance measures or measures of effectiveness.

This brings the analysis to the third step, which is to identify or develop performance measures which can then subsequently be used to analyse and decide whether the new system is operating effectively. These performance measures or carrier criteria will be under examination in chapter 2.

Abstracting the real world into the framework is an important step in the process because it is not possible to carry out experimentation in the real world. It is in simple terms not feasible or realistic to try out a new system to see how well it operates, it must be evaluated otherwise. The experimentation is done by taking various factors into account from the real world. Chapters 3 and 4 focus on the transport planning and coordination, and integrated transport chain related factors. It must be carefully considered as the abstraction conforms to the view of reality. Although these abstractions are very simplified form of reality, they provide an insight to the way systems perform (Sussman 2000, 115 – 129).

The most attractive alternative routing solutions will be identified and further looked at by using an activity analysis. Numerical data is collected and performance is measured based on calculations. As stated under heading 3.1, eliminating excess activities is a cost cutting factor in operations including transportation. Activity processes form a new chain of operations, it is of importance to identify the activities precisely in order to clarify what cumulates against performance measures to try and eliminate such with alternative functions.

An activity analysis is used as a tool for activity-based management. Although various performance measures will be identified in the theory section of this study, one of the key criteria from the carrier's point of view is cost management. One of the main objectives for activity-based management is allocating cost cutting activities. As indicated by Oksanen (2003, 14) although calculations do not reduce the costs involved, a thorough knowledge of the cost cumulating activities can improve the processes and encourage towards more effective activity processes. Activity-based management also focuses toward improvement of quality, flexibility and service standards which all play an important role in this study.

The aim in the case study is to allocate a few routing solutions, using the transportations system analysis, for which the activity processes are identified by using an activity analysis. The recommendations and conclusion at the end of the study indicates possible problem areas and what type of service in particular benefits from the findings.

A closer look at the frameworks for the research methods is done in the empirical part of this study, in chapter 5, under sections 5.3 and 5.4.

Practical experience in the transport industry has contributed to the process and findings of the study. Eight years of work experience in local, regional, national and international distribution and transportation system coordination plays a crucial role in understanding systems behaviour and the impact and importance of operating plans. In order to establish and allocate real world routing alternatives to complement an already existing transportation system, it is of essence to have an in depth understanding of transport service production and its unique characteristics.

2 FUNCTION OF TRANSPORT

In order to find adequate carrier criteria, it is essential to identify the function of transportation. Today, the role of transport has reached a point where cargo from one country enters another in no substantial length of time. The required travel distance is increasing while the time needed to do so is decreasing. Key factors that impact transport as specified by Benson et al (1994, 3);

1. A complex outline of trade nations
2. A growing population
3. An increasing wealth of nations
4. A decline in interferences with transport
5. A constant pursuit for economies of scale in transport operations
6. Increasingly serious environmental problems

The main function of transport is to connect goods and services to consumers. As transportation takes time, it is necessary to try and narrow the time gap in between to protect the cargo from deterioration, damage and keep it safe from burglary and theft. Oksanen (2004, 27) defines the geographical and time differences that create the environment of physical activities, through which transportation service is produced. On the other hand, transportation service production creates subsequent activities as demonstrated in figure 2 below.

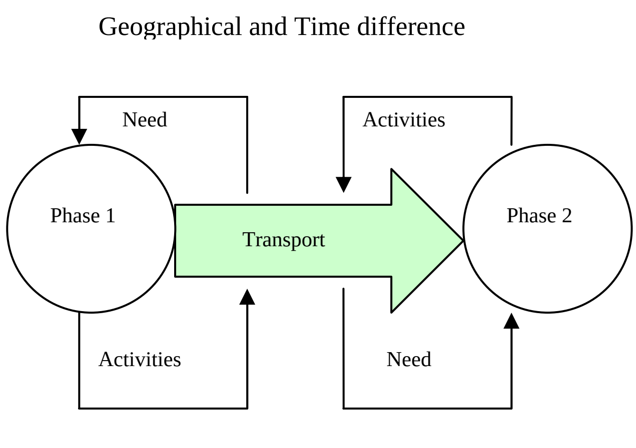


Figure 2 - Need and activity interrelationship in supply chains (Oksanen 2004, 27)

In order to pin point the service criteria for customer demands, it is of essence to have a clear comprehension of what role transportation plays in the supply chain. The Values which customers use to weigh the standard of service determine the carrier criteria. Once the elements are identified they can then be taken into consideration when transport planning and coordination is implemented. This introduces the next subheading, logistics system.

2.1 Logistics system: role of transport

To identify the service criteria, it is crucial to have a thorough comprehension of transportation and its role in the entire logistics process. Gourdin (2001, 84) emphasises the importance of transportation in the logistics system, he stresses how all transport decisions should be made taking the whole logistics system into account. Transportation connects goods with consumers and determines the length of time it takes for the arrival of the physical goods after the placing of order. The physical movement of the goods is an essential part of the process, without transportation, there is no distribution. Figure 3 demonstrates the role of transportation within the context of the logistics system.

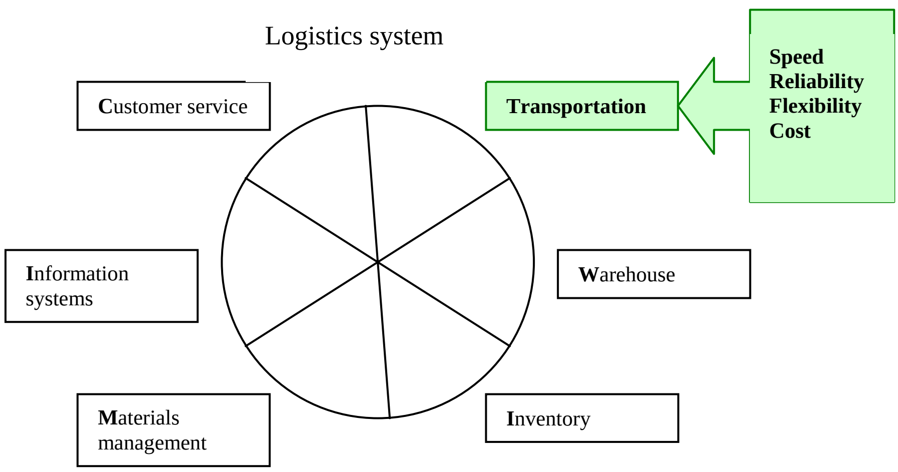


Figure 3 - Transportation in the logistics system (Gourdin 2001, 85)

Speed, reliability, flexibility and cost are key elements of transportation and how the logistics process can benefit from it. Transport time, reliability and cost are also identified by Leenders et al (2002, 413) as crucial elements for service criteria. These identical performance measuring criteria can be found in both new and relatively old material. Sartjärvi (1988, 85) talks about the elements that fall to the responsibility of transportation when measuring the level of service; number of delivery days, time it takes from placing the order to getting the physical goods and reliability of the service. These measures of effectiveness can also be identified as the five requirements of logistics which can only be fulfilled through successfully implemented transportation services (Jobber 2004, 16 – 19);

1. The right product
2. At the right place
3. On the right time
4. With the right service
5. For the right cost and price

Jobber (2004, 657) also discusses some methods of improving customer service standards in physical distribution. These methods are in direct relation with transport;

- Improve accuracy, speed and reliability of deliveries
- Shorten time between order and delivery
- Improve consistency between order and delivery time
- Be proactive in notifying customer of delays
- Raise flexibility
- Develop contingency plans for urgent orders
- Ensure fast reaction time to unforeseen problems (e.g. stolen goods, damage in transit)

As in any logistics system the emphasis is on reducing costs and cycle time or lead time while the service needs of customers increase. This issue is central in continuously increasing demand for competitive transportation services. This also indicates that with the right transportation service provider, it is possible to maximise the cost-benefit trade off with suitable physical distribution solutions.

2.2 Carrier criteria

The increasing demand for competitive transportation service providers is evident through the important role it plays in the logistics system, as discussed under the previous subheading. Customers of transportation services have different needs with respect to what is required in order to satisfy the need. Under this section of the study the focus is on transportation service criteria. Jobber (2004, 75) divides these service criteria or choice criteria into four categories as demonstrated in figure 4 below.

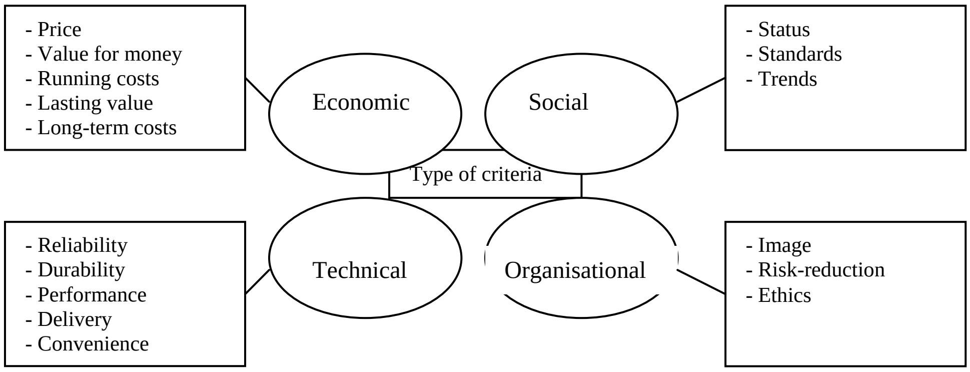


Figure 4 – Choice criteria used when evaluating alternatives

Now, a closer look at carrier criteria used when evaluating alternative transportation service providers.

2.2.1 Reliability

Reliability is difficult to measure, in a way it could be said that reliability is the overall performance over a longer period of time. Reliability refers to the ability to keep promises of service standards and determines the overall quality of the service.

Bask and Laine (2000, 42) identified reliability and cost as key criteria for customers when choosing a carrier. Reliability however was the most important element for all customers that took part in their survey.

Reliability in a nut shell refers to the carrier’s ability to perform as specified by the contract of transit; it could be referred to as how dependable the service provider is. All other service criteria fall under reliability; eg on-time collection and delivery, safe arrival of goods, value for money, flexibility of service, shipment traceability, and handling of claims. This makes it more difficult to measure and is evaluated over a longer period of time.

2.2.2 Cost

As with any purchasing process, cost is a determent of whether the purchase is value for money. Value for money is an important concept when evaluating transportation costs, and could also be referred to as cost-benefit trade off. The cost-benefit concept will be introduced under heading 3.3.6.

Logistics costs divide into three categories; inventory carrying costs, administrative costs and transportation costs. Transportation cost accounts for the largest portion of the entire logistics costs. These costs can account for as much as 40% of the total price of goods when sold forward (Leenders et al 2002, 411).

Although one of the primary objectives of logistics management is to minimise costs through cost cutting activities, it is not the only objective. As transportation costs account for the most part of the logistics costs, it is an obvious target for particular cost monitoring.

This also creates an extremely competitive environment in which transportation service providers operate. Pricing or rates play a crucial role in gaining customers and in determining the level of service offered. The high costs of transportation services are explained through the high running costs of offering transportation services. These cost factors are looked at in more detail on page 22. This will establish a better understanding of how the costs are cumulated.

2.2.3 Speed

Transport time, or speed, refers to the transit time for the goods in carriage. The transport time indicates the length in time a carrier requires to bring the goods from the collection to the delivery point. This length in time is an important element in the purchasing process and indicates to the consignee the lead time of a specific delivery.

Based on the transportation time, a buyer can determine the order quantities, inventory requirements and frequency of ordering process. The time it takes to transport the goods needs to lay in harmony with the customer's scheduling process. The deliveries are required as specified, not too early and not too late.

Scheduling is an important concept in the logistics system; it requires thorough understanding of the duration of transport. This connects the transport time with the reliability criteria. The transport duration can also be interlinked with the cost criteria, as special delivery times may require solutions that are more costly. The purchasing department needs to evaluate the various options carefully, in order to determine adequate cost-benefit service trade off.

The transport time depends on the geographical distance to be travelled and the infrastructure available to cover the distance. The need to try and narrow the time gap in between the geographical difference was introduced on page 11. This is necessary not only to meet customer needs with respect to the duration of the journey, but also to protect the cargo from deterioration, damage and keep it safe from burglary and theft.

Figure 5 shows the service criteria discussed, which will be used to evaluate performance later on in the empirical section of this study.

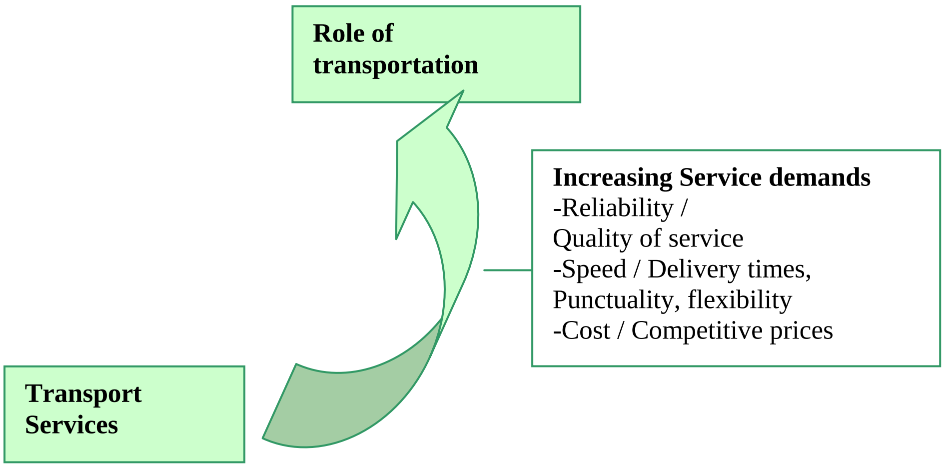


Figure 5 - Carrier criteria in transportation

Although reliability, speed and cost are key criteria used to measure transportation performance, there are other elements that are crucial for customers' choosing transportation service providers, carriers. Some of these elements will be addressed under the next subheading.

2.3 Carrier evaluation

Choosing a carrier or a transportation service provider is a complex issue for customers. It requires careful evaluation of alternatives and measurement of the carrier's provided service standards. Table 1 below addresses more service criteria, as defined by Leenders et al (2002, 432).

Table 1 - Criteria used when choosing a carrier

Criteria	
On-time delivery	Carrier's ability to deliver within agreed time; not too early, not too late
Rates	Carrier's ability to give rates accordingly and cater for economies of scale
Geographical coverage	Carrier's ability to transfer goods within the required geographical areas
Time in transit	How much time does a carrier need to bring goods from collection to delivery point
Shipment tracing	How easy is it for customers' to follow goods in transit, is the information available on-line or does it require follow-up and expediting by telephone
Care in handling	Will the goods arrive in good condition, no loss or damage during transit
Financial condition of carrier	Is the carrier able to finance possible claims that may occur, is the carrier a possible long-term partner
Door-to-door deliveries	Is the carrier able to cater for the entire transportation service required, from shipper to receiver
Routing	What route is the carrier using to transfer the goods, is it safe
Type of equipment	Does the carrier have clean, odour free equipment, does the carrier have special equipment to cater for wide range of services
Convenient schedules	Is the carrier able to carry out the service through a schedule suitable to the customer
Handling of claims	What is the carrier's approach to the handling of claims, is it done adequately
Insurance coverage	How are the goods covered for during transit
EDI capabilities	Electronic data interchange, is it a possibility with the carrier in question

Sakki (2003, 160) specifies the increasing importance of environmental issues and sustainable development of carriers'. This has become a key criterion for some customers when choosing transportation service providers. The concept of green logistics will be looked at in more detail under chapter 4 on integrated transport.

Flexibility is also an important concept when evaluating transportation service providers. Jobber (2004, 657) addresses methods of improving customer service standards in physical distribution and raising flexibility is mentioned. Although flexibility is often related to other service criteria, transport time in particular, it is becoming an increasingly important performance measure. This is evident through the increasing customer demands and the need to find suitable transportation solutions to meet the demands.

As identified in this chapter, the role of transportation in the logistics process is a crucial one. From the carriers' point of view, it is of essence to monitor the required service criteria on a continuous basis in order to provide quality standard services to customers. If the freight payer's decision making process is considered, an evaluation of the performance is a continuous one, as demonstrated in figure 6 below.

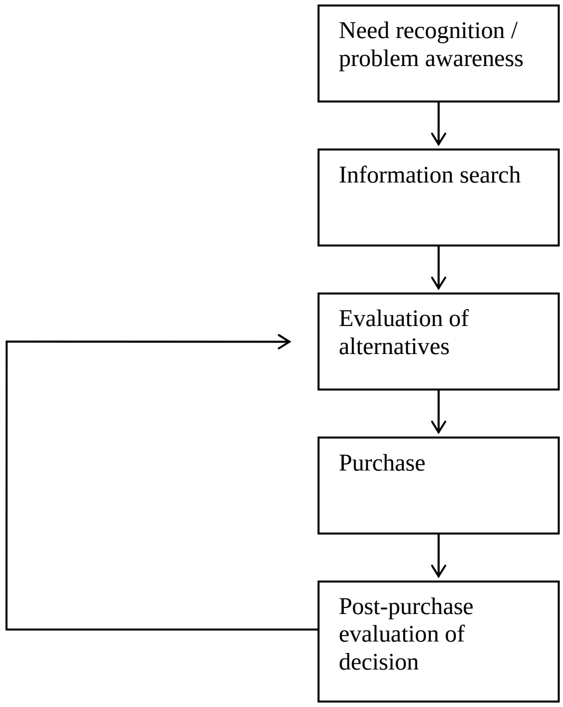


Figure 6 - The purchase decision-making process (Jobber 2004, 69)

This concludes the part on service criteria. The purpose is to emphasise that maintaining and improving the level of service is a continuous effort, in the ever changing environment surrounding transportation, discussed in the next chapter.

3 TRANSPORT PLANNING

Although the transport connection between the collection and delivery points may seem straight forward, there are numerous activities that take place. In reality the management of a transportation system and implementation of physical activities require planning and organisation.

When the focus is on transport service production it is essential to identify characteristics that vary from the production of goods. These elements clarify the factors central to transport planning. Oksanen (2004, 26) identifies some of these characteristics:

- Transportation is not a materialistic production that can be stored or consumed like physical goods.
- Transportation is not produced in a factory but rather in a continuously changing environment of activities.
- The demand on transportation services changes with seasons of the year, weekly, daily and even hourly.
- Production of transportation is regulated by various acts; permits, working and driving hours, technical regulations with respect to equipment etc.
- A failed or disrupted transportation is more challenging to replace than a physical product and creates excessive costs.

The transport service production is a continuous effort to improve the usage of the physical transportation system, and infrastructure, to further advance the performance of the distribution. This requires cooperation amongst and between companies as well as governments.

As indicated on page 15, transportation costs account for the largest portion of the overall logistics cost. A successful transportation services provider must have a thorough understanding of the costs involved with each activity, in order to implement successful transport plans. The following subheading addresses how transportation costs are divided. This will also give an indication of the types of activities contributing to particular costs.

3.1 Transportation costs

Transport planning, instructing and monitoring must be carried out with knowledge of the cost elements involved. The ability to calculate costs within a transportation system is a key to cost effective operations.

As mentioned earlier, transportation is not produced in a factory but rather in a continuously changing environment of activities. Each activity adds benefit to the service, but on the other hand cumulates costs. Oksanen (2003, 73) and Turney (2002, 169) discuss how activities can be used to reduce costs, shown in table 2 below.

Table 2 - Cost cutting activities

Rule	**Instruction referring to activity**	**Examples - Operating plans**
1	Reduce required time and effort	Way, schedule, connection patterns
2	Eliminate unnecessary activities	Cost/level of service trade off
3	Choose activity with lowest cost	Evaluation of alternatives
4	Divide activity when possible	Distribution flows
5	Use resources available	Crew assignment, propulsion unit

Economical operations are a priority and take centre stage in all areas of transport planning; strategic and operations. It is essential to look at cost elements to identify what type of costs are involved, economical operations and profitability measure two different factors. There are times, however, when other benefits are greater than running economical operations, eg the purchasing power of a customer. These are only seldom occasions and are conducted after careful evaluation.

In the long-term, however, an operation that is not profitable will lead to a termination. In a transportation company, the overall profitability is determined by the sum of the performance and profitability created through the transportation equipment usage. For this reason alone, it is necessary to calculate profitability prior to carrying out activities (Oksanen 2004, 103).

Calculations of targets are implemented as part of a company’s strategic planning and aims to produce numerical back-up for the financial direction the company aims to achieve. Follow-up calculations are performed to see whether the planned direction is achieved. The following figure shows the position of target and follo-up calculations with respect to profitability, as described by Oksanen (2004, 103).

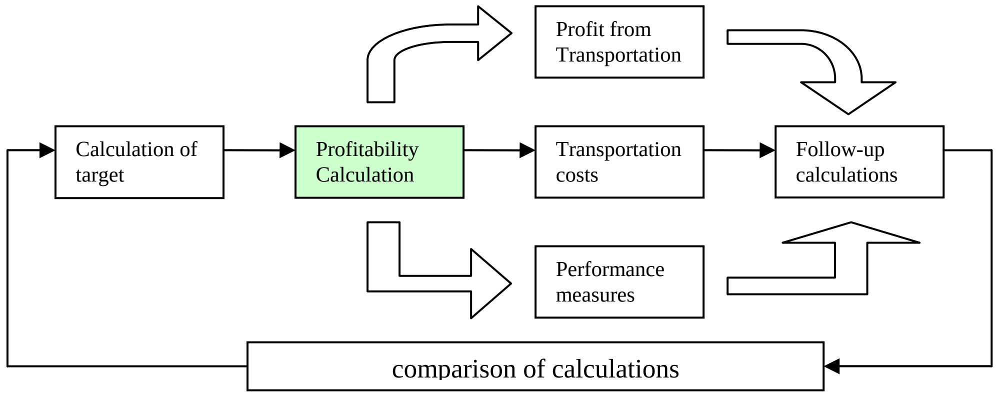


Figure 7 - Profitability calculation in transport planning

The expenses that occur in road transportation are categorised into five main areas. Oksanen (2003, 42 – 44) describes these to fall under labour expenses and variable and fixed equipment expenses, and channel expenses especially relevant in international transport.

Sometimes it is difficult to allocate an expense to any one specific category and thus an activity analysis is often performed to identify primary and secondary functions in the process. It is then straight forward to allocate an expense or a cost.

The five categories of transport costs as specified by Oksanen (2003, 44):

1. Transportation labour costs
2. Transportation equipment costs
3. Transportation organisation's costs
4. Handling costs
5. Channel costs

These categories are the same for all modes of transportation, however, vary in composition depending on the mode of transport in question. The various modes of transportation will be defined in chapter 4 on integrated transport.

If these five categories of costs are looked at from a road transport perspective, table 3 below can be drawn (Oksanen 2004, 60 – 63).

Table 3 – Road transport: five categories of costs

1. Transportation labour costs	
These costs are accumulated through personnel carrying out the transportation services. These consist of salaries and other benefits paid out.	- Drivers' salaries - Direct salary expenses - Other fringe benefits (eg lunch, travelling and accommodation)
2. Transportation equipment costs	
Fixed costs These costs are allocated to equipment either directly or indirectly and are not dependant on the short-term activity level of the equipment.	- Depreciation and interest of assets - Insurance costs (eg traffic, vehicle and trailer) - Traffic fees (eg vehicle taxes, permits and other expenditure paid to official bodies) - Maintenance expenses (eg storage and washing of vehicles) - Vehicle administration fees
Variable costs These costs accumulate through the usage of the equipment and directly or indirectly relate to the activity level of the equipment.	- Fuel expenses - Repair and service of vehicles - Tyre expenses
3. Transportation organisation's costs	
These costs are accumulated through the establishment and running of the transportation organisation.	- Fixed salary expenses (eg management and operational personnel's salaries) - Office expenses (eg rents paid, electricity and heating expenses) - Information flow (eg telephoning and information systems expenses) - Marketing and public relations - Administration costs (eg bookkeeping, auditing, legal services) - Research, development and training - Membership fees etc
4. Handling costs	
These costs are accumulated through the handling of the goods that are being transported, sorted and stored.	- Insurance for goods in transit - Warehousing and handling costs - Other handling costs (eg labelling, outsourcing)
5. Channel costs	
These costs accumulate through the usage of transportation infrastructure and systems (some only affect road transportation when combined transportation systems are used).	- road, toll, customs, tunnel fees - railway - port, vessel and channel fees etc

An activity analysis in the empirical section 6.4 includes a bill of activities which shows in detail what is included in specific channel costs for a particular route.

3.2 Strategic planning

The strategic planning of transportation handles the operations as a whole, and looks at the functions as part of the logistics chain. The planning is a continuous process, implemented in annual budgeting processes.

The basis for the process is to evaluate competition and to set the operational environment for the transportation activities. The aim is to define locations for warehouses and depots, the units, the geographical areas to be covered by units, and the division of activities for units, level of service and the control of flows as an entity.

The purpose of strategic planning can also be clarified by stating the objectives of transportation as defined by Ailawadi and Singh (2006, 79):

1. To transfer goods from collection point to its destination, whilst minimising temporal, financial and environmental resource costs
2. To minimise expenses due to loss and damage
3. To meet customer demand with respect to both delivery and shipment information availability

To summarise the purpose of strategic planning in transportation, it is in place to guarantee a supply for demand required by customers, and to ensure cost effective and practical distribution networks or transportation systems. These efforts concentrate on information and physical flows and the integration of infrastructural and other networks (Mäkelä and Mäntynen 1998, 138 – 139).

3.3 Operations planning

The operational activities are carried out in accordance with the strategic planning and concentrate on the planning and monitoring of the physical flows. The result of operations planning is a plan of activities to be carried out in accordance by the conditions set in strategic planning.

These plans of activities include such as, the following day’s collections, loading of export trailers and routing of traffic. When these plans are implemented, the coordination moves towards instructing and monitoring of those plans. The operational planning is often a joined effort by various parties involved, looking after different areas of the plan, for instance domestic haulage and distribution, warehouse personnel and international traffic coordination. The implication of operating plans is a joined effort and therefore emphasises the importance of information flow.

Some key elements of operating plans defined by Sussman (2000, 21-25) include schedule, crew assignment, flow distribution, connection patterns, cost/level of service trade off and contingency planning. These will be looked at in more detail under the following subheadings.

3.3.1 Way

The way, as defined by Benson et al (1994, 25), refers to the routing used to bring the shipment from point A to point B. This means the way in which the geographical distance is covered, and directly refers to the physical infrastructure used. The way would instigate the mode of transport and the infrastructure that supports such. Later on, in the empirical part of this study, various routing alternatives will be analysed that all bring the unit from point A to point B, using a different way. The way used is highly dependant on the availability of infrastructure. Infrastructure is discussed in more detail in section 4.3.

3.3.2 Schedule

The schedule must be accountable and suit the departure and arrival requirements, for instance a vessel should depart on a given day to subsequently accommodate the timeframe suitable to provide an agreed service (Sussman 2000, 21). The way, as discussed under the previous subheading, determines the route which the traffic uses taking into account schedules. The actual performance delivered with respect to schedule is how the service level is measured.

In order to provide an agreed delivery time it is essential to receive the transportation order in good time. The customer is aware of a given deadline for collections which allows the export coordinator time to implement necessary activities to plan and instruct the collection of goods. Leenders et al (2002, 413) talks about the objectives of choosing a carrier and emphasises the importance of awareness towards transport time required. Different modes of transport in particular, cover distance at different speeds. In order to cater for a production schedule it is essential to know the required transport time. The different modes of transport are addressed under section 4.1, in modal service characteristics.

Scheduling is also affected by unforeseen circumstances which make each transportation process unique. Oksanen (2004, 27) refers to weather and traffic conditions, changes in infrastructure and capacity to perform as some of the elements that make it difficult to measure transportation level of service.

Scheduling is a central element in transport planning. An adequate schedule and implementation of activities and organisation accordingly is the basis for a good level of service. The process runs through the entire transportation system from the receipt of the transportation order, arranging collection, planning of export vehicle, booking of vehicles to carry out road transportation and in the case of international haulage, booking of connective modes of transport and adequately organising partners to carry out required activities to the time of final delivery. Timing is essential to ensure schedules are met.

3.3.3 Crew assignment

Crew assignment refers to the ability to allocate and provide drivers adequately to cater for the demands on traffic in a cost effective manner recognising that there is an uneven need (Sussman 2000, 22). Benson et all (1994, 24-25) refers to this as propulsion unit, although this indicates to the unit used to pull the trailer, every unit must have a driver.

This concept is often talked about as the capacity to supply in accordance with demand. Capacity refers to the overall ability to service the demand in various areas of transportation, whereas crew assignment and propulsion unit focuses on the ability to allocate drivers and units to service the demand.

3.3.4 Flow distribution

Flow distribution looks at the imbalance of flows; how to distribute units within the transportation system to where they are needed (Sussman 2000, 23). In order to avoid running empty units or carrying out one way shunts.

This indicates the planning of haulage and distribution in such a manner that places an unloading of a unit, where loading of another shipment is due. This also refers to propulsion units and the ability to work them in combinations with flows of traffic. If one unit is hauled to a location, another unit should be available for haulage to another location from where the first unit is dropped.

The running of empty units over geographical distances is a very costly operation. It indicates that the costs are allocated to one unit, rather than split in half and carried by two units. This could indicate having to carry out operations at a loss.

This is a particularly challenging part of operations planning due to the ever changing environment in which transport services are produced and due to the geographical imbalances of demand, transportation orders, and supply, available units.

3.3.5 Connection patterns

Connection patterns refer to the time required for transfers. Scheduling and the way, route used, are directly connected to connection patterns. In order to operate as a transportation system, connection patterns must be adequately timed (Sussman 2000, 23). This is an important element particularly when combined transportation systems are used. Connection patterns influences the levels of service and the overall performance of a service.

A connection pattern in some literature is described as the terminal. Terminal is often thought of as a warehouse facility alone, but in a transportation system it is also known as the junction where a mode of transport can be changed to another (Benson et al 1994, 25).

As transportation is often affected by unforeseen circumstances, such as vehicle breakdowns, delays in scheduled services, weather conditions and traffic congestion, connection pattern may need to be altered. Through contingency planning, as discussed under heading 3.3.7, it is possible to plan ahead in case of such events.

3.3.6 Cost/level of service trade off

Cost/level of service trade off looks at the relationship between the quality of service to the customer and the costs involved (Sussman 2000, 24). This is a complex issue in transportation planning and must be weighed carefully. Allocating resources is costly however adds value to the level of service. The question that cost/level of service trade off emphasises, is the standard of level a customer is looking for, and how much they are willing to pay for it.

This raises the necessity for flexibility. Through tailor made solutions, costs rise. The key element from the planning point of view is whether or not it is worth the effort; financially and influenced by the purchasing power of the customer. Is the benefit greater than the cost, and what the level of service offered is?

3.3.7 Contingency planning

Contingency planning looks at alternative solutions when plans do not go accordingly. Transportation systems are affected by various external factors that may be unforeseen, for instance poor weather conditions. It is always advisable to know alternatives prior to things going wrong (Sussman 2000, 25).

Through a thorough understanding of scheduling possibilities and connection pattern behaviour, it is possible to make alternative plans according to need. However, when moving from plan A to plan B, the whole transport chain is affected and can cause particular congestion on crew assignment, propulsion units and distribution flows. Unravelling the congestion can cause further delays and the need for plan C.

Transport planning in a transportation system is a complex issue in its own right. Table 20, in the appendices demonstrates other key elements used in transport planning, as discussed by Sussman (2000, 59-113). These elements will be looked at in more detail, in chapter 5, in the empirical section of this study when the aim is to demonstrate how these impact the operations planning in practice.

3.4 Transport coordination

The methods used to plan, instruct and monitor the physical distribution form an entity of a transportation company, without which successful operations are not achievable. The physical distribution on the other hand consists of activities that produce transportation services or form transportation systems.

The transport coordination is to determine the following information as a basis for the actual process of physical activities to follow, demonstrated in the following table.

Table 4 – Basis for transport coordination

What is being transported	mass, volume, effective weight, packaging etc
Who are the parties involved	consignee, shipper, receiver, carrier etc
From **where** to where	collection point, delivery point, terms of delivery ie freight payer
How is the movement going to take place	delivery and handling instructions etc
When is the transfer carried out	collection and delivery times, schedules etc

Mäkelä and Mäntynen (1998, 138) divide the transport coordination activities into three categories;

- Planning; the process begins prior to carrying out the activities, it is a plan of activities to follow.
- Instructing; it is the giving of instructions and the controlling of the plan of activities, often requires the ability to react to the changes in the operational environment.
- Monitoring; is the process of monitoring the relationship between the plan of activities and how the plans were implemented in reality. These performance measures can then be recorded accordingly.

The role of transport coordination within the context of strategic and operations planning is a crucial one. The coordination process ensures that the transportation activities take place in reality. Transport coordination is the process which ensures that the physical activities are performed in order to form a transportation system, in other words transportation services.

This is often a joined effort through various departments within an organisation. Each department is in charge of different areas of the coordination process. The various areas could indicate geographical divisions or operational divisions, in the end a joined effort fulfils the purpose and creates the linked chains of activities.

The role of transport coordination in the entity can be demonstrated in form of a figure, shown below.

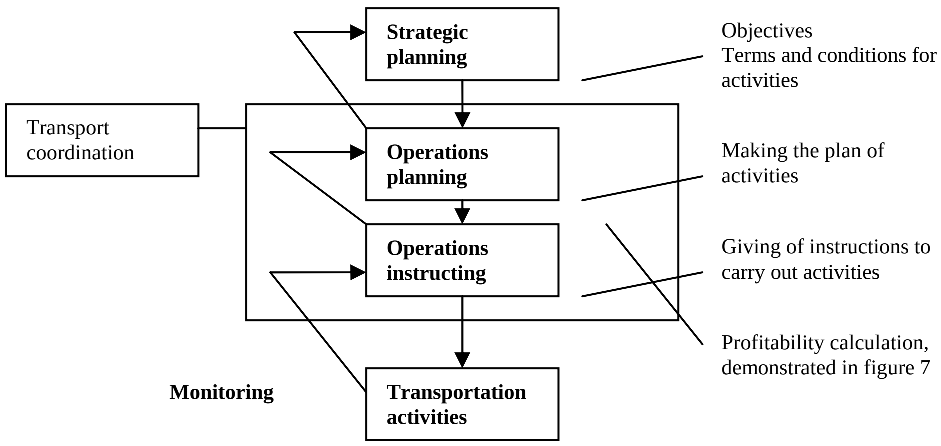


Figure 8 - Transport coordination (Mäkelä and Mäntynen 1998, 139)

The different areas, which departments are responsible for, are also referred to as levels, and as they are dependent on each other in order to form an entity, they are referred to as the integrated levels of transport coordination. Mäkelä and Mäntynen (1998, 137) define the integrated levels of transport coordination as shown in figure 9 below.

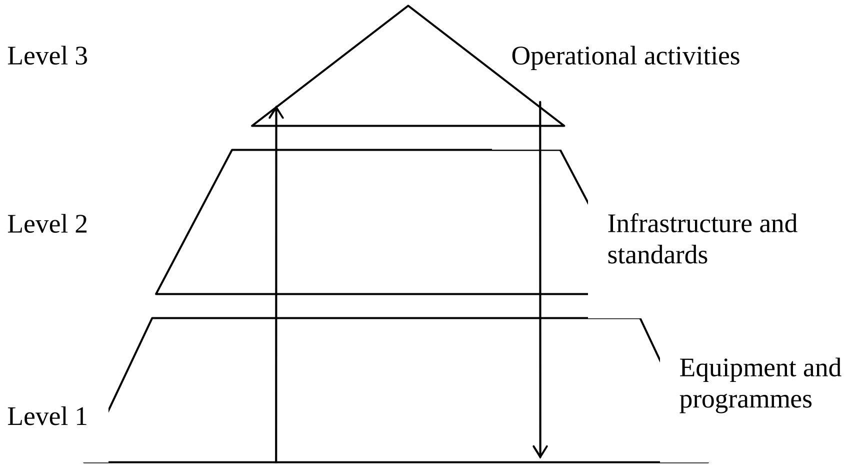


Figure 9 - An entity formed by different levels of coordination

Transportation coordination, in other words, planning, instructing and monitoring of transport journeys within a transportation network are all complex tasks. Not only is transportation production unique in its characteristics, as discussed in the beginning of this chapter, the management of such requires in depth ongoing study of the operational environment.

4 INTEGRATED TRANSPORTS

Referring to integrated transportation indicates the usage of more than one mode of transport while transferring a shipment from its collection to the final delivery point. During the delivery process the goods are not moved from the unit of carriage. Bask and Laine (2000, 14) identify the units of carriage as containers, deep sea and airfreight units, trailers, full vehicles and train carriages.

There are five primary modes of transportation:

1. Rail - Train
2. Road - Motor carrier
3. Pipeline - Pipeline
4. Water - Vessel
5. Air - Aircraft

Each of the transportation modes have specific characteristics which need to be considered as a cost benefit trade off, this is introduced under the next heading. This study will not include pipeline or air.

In integrated transports, the transportation of goods is done in such a manner that the goods are loaded into the unit of carriage at the collection point and unloaded from the unit at the final delivery point. The unit of carriage is transhipped from at least one mode of transport to another. It is important to remember that in integrated transport chains, the shipment is not moved from the unit of carriage when changing transportation modes.

Depending on the type of technique used to tranship the unit of carriage, or the type of transportation chain in question, various terms are used to describe integrated transports. The most common terms used, as described by Oksanen (2004, 22); intermodal-, combo-, bimodal-, huckaback-, piggyback transportation and rollende landstrasse. This study will focus on the use of intermodal transport chains.

4.1 Modal service characteristics

Each mode of transport has specific characteristics. The ability for a carrier to take advantage of intermodal transport chains offers significant advantages over single mode alternatives. The various parts of the geographical distance covered are arranged through activities, on a mode by mode and country by country basis (Gourdin 2001, 100), or a distance by distance principle.

Table 5 indicates characteristics associated with particular modes of transportation.

Table 5 - Modal service characteristics (Gourdin 2001, 86)

	Rail	**Road**	**Water**	**Air**	**Pipeline**
Door	Sometimes	Yes	Sometimes	No	Sometimes
Price	Low	High	Very low	Very high	Very low
Speed	Slow	Fast	Very slow	Very fast	Slow
Reliability	Medium	Medium	Low	Very high	Very high
Packaging needs	High	Medium	High	Low	Nil
Risk of loss and damage	High	Medium	Medium	Low	Very low
Flexibility	Low	High	Low	Very low	Very low
Environmental impact	Low	High	Low	Medium	Low

The above table demonstrates some of the characteristics of each mode of transport and an ideal platform to make some basic comparisons between them.

Due to great efficiency in terminal, pick-up and delivery operations road transportation is flexible and has no substantial competition in door-to-door services. This flexibility gives motor carriers the widest market coverage, in comparison to any other mode (Ellram et al 1998, 220).

Road transportation is also fast in comparison to rail and water, however cost-effective over shorter distances. Although motor carriage is versatile with respect to shipment sizes and distance coverage, it is more efficient with smaller shipments over shorter distances (Ellram et al 1998, 220-221). This poses an opportunity to implement the usage of intermodal transportation, by combining the use of rail where distance to cover is relatively long, approximately 500 kilometres or more. However, this requires supporting infrastructure.

Rail transportation is limited to its fixed track facilities and therefore lacks the flexibility of road transportation. In most cases, rail transportation offers terminal-to-terminal services rather than door-to-door. Rail services are less frequent, however, efficient over longer distances and cost less in comparison to road transportation. Rail can also cater for heavier shipments than road (Ellram et al 1998, 221-222).

Water transportation can be categorised into various segments, however, the focus of this study is on sea transportation. Water transportation in general concentrates on low-value items, for which transit time is not critical. The use of sea or ocean transport depends on the geographical location, and the length of haul varies in accordance. Water transportation is the dominant mode in international shipping and is the most inexpensive method of shipping high-bulk, low value commodities (Ellram et al 1998, 224-225). An intermodal transport chain, combining road and sea, can be implemented when the geographical locations allow for it.

The purpose of intermodal transport chains is to lower the costs or to benefit the transportation system's overall performance. Due to locations alone, particularly in international business, integrated transport chains make the geographical coverage possible. This introduces the next subheading on intermodal transport.

4.2 Intermodal transport chains

Intermodal transportation involves the use of at least two modes of transportation whilst moving the unit of carriage from the origin to its destination. In intermodal transportation, the transhipment of the unit from one mode to another happens at a terminal specifically designed for such a purpose (Comtois et al, 2007a). This is demonstrated in the figure below.

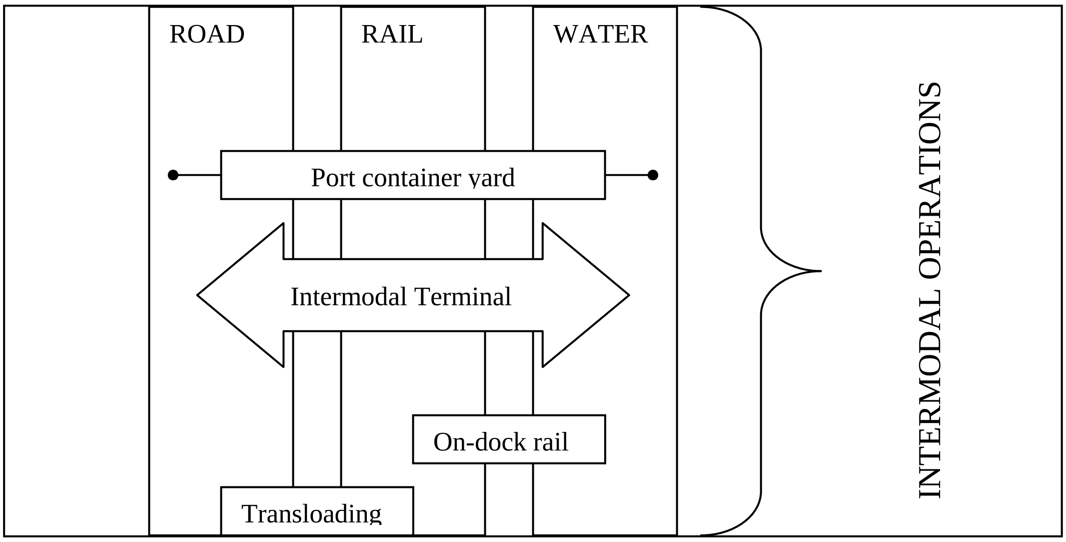


Figure 10 – Intermodal operations (Comtois et al, 2007b)

Composition, connection, interchange and decomposition are the four main functions that define intermodal transport chains.

Composition is the sorting of goods in a terminal into a unit of carriage for intermodal interchange. Composition offers interchange possibilities for either a local to regional distribution systems or national to international distribution systems.

The connection is the flow of units between at least two national or international terminals, in order to support the distribution systems.

Interchange is the change of modes at terminals specifically designed for the purpose. This is the point where the foremost intermodal function takes place.

Decomposition happens at the arrival depot. This is when the shipments are consolidated for local or regional distribution systems; this is demonstrated in the figure below (Comtois et al, 2007c).

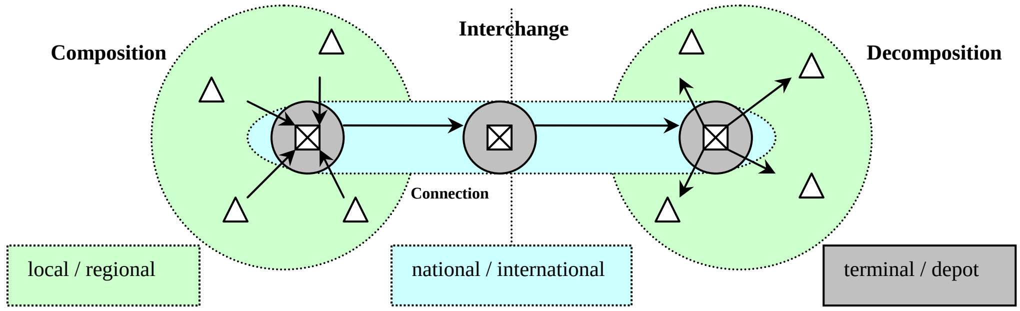


Figure 11 – Intermodal transport chain (Comtois et al, 2007c)

To address some issues of relevance with respect to intermodal chains, Hakaniemi and Suoniemi (1990, 264 – 265) identify benefits of drop and pick trailer traffic, particularly when using intermodal transport chains. One of the central elements is the know-how of drivers as they are operating in familiar surroundings and are aware of the customs in the region where they pull the trailers. The operators in the countries in question would also have a more in depth understanding of how the connecting modes carry out their procedures and what the national requirements are. This factor eliminates possible misunderstandings due to cultural and lingual differences.

As discussed by Faulks (1999, 47) the concept of safe arrival is an increasingly important issue in transportation. Goods must arrive without loss, damage or delay and it is at points of interchange that these are most likely to occur. Although the goods are not physically moved from the unit of carriage it is an important concept to remember, particularly when considering the number of times the unit of carriage is transhipped. It becomes more difficult to allocate the point of damage or theft, when there are numerous connections involved.

As mentioned earlier in the previous chapter, the management and implementation of physical activities in connecting the different modes of transport require careful planning. Not only are there various activities involved, there are also numerous organisations or companies that make the connections possible. It is often the case that road transportation, port activities, loading and off-loading of units of carriage on to the vessel and the shipping service are all carried out by different organisations. The coordination of these physical activities as a process requires cooperation amongst the organisations involved. These transport activities involve financial flows together with adequate supporting activities, substantial information flows and delivery dockets and other documentation which need to be considered (Bask and Laine 2000, 28).

4.3 Infrastructure

The ability for a carrier to take advantage of an intermodal transport chain is directly dependant on the transportation infrastructure available in each market.

Infrastructure in general refers to structural elements that provide the framework supporting an entire structure. In different contexts, infrastructure is used to describe different things, however, meaning frameworks that support entire structures. This is also the case in transportation; infrastructure supports the entire structure of operations.

Although infrastructure is only one of the many components of transportation systems, it plays a crucial role in the operational plans and implementation of physical activities. Infrastructure and its usage are directly influenced by the external components, in particular the Government; road transportation uses public road networks. The figure below demonstrates some of the internal and external components of transportation systems as discussed by Sussman (2000, 11-31).

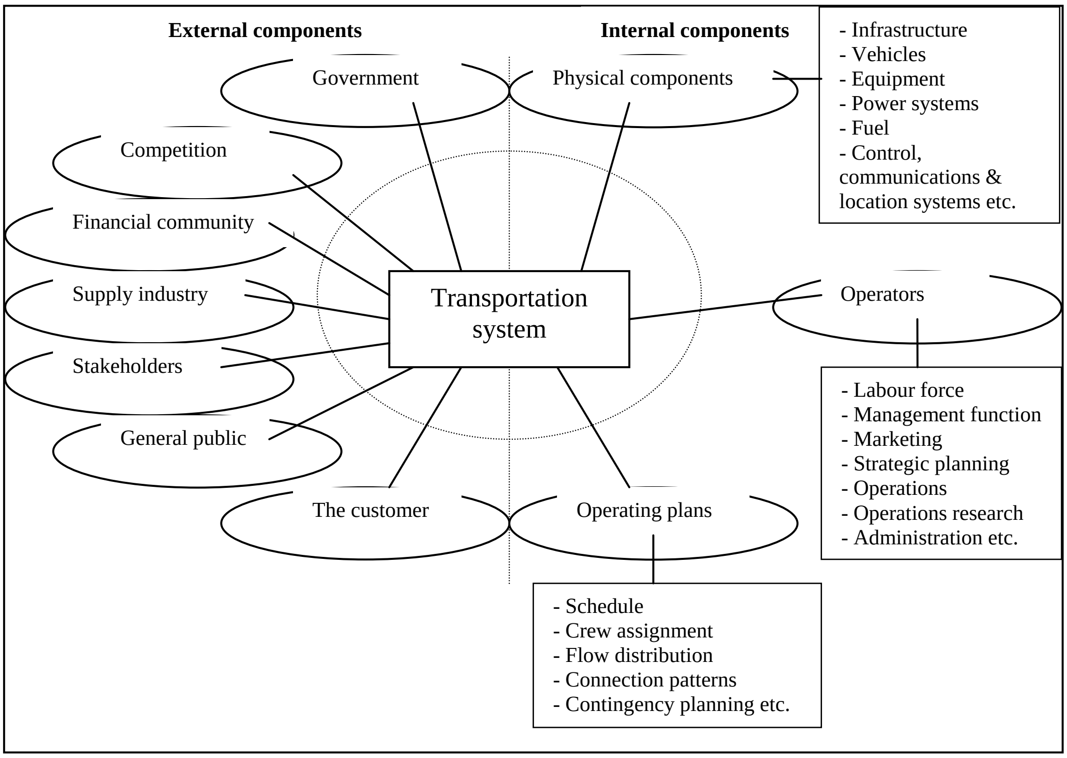


Figure 12 – External and internal components of transportation systems

Transport infrastructure is often thought of as the road and rail network of a country alone; however it refers to other physical elements too. Infrastructure is divided into three categories; guideways, terminals and stations (Sussman 2000, 11).

Guideways are categorised into general purpose guideways and special purpose guideways. General purpose guideways are designed for the general use, for instance motorways. Any motor vehicle can be driven on the motorway, the law permitting to do so. Special purpose guideways, on the other hand, are built for the use of specific vehicles. An example would be railroad, only suitable for the use of railroad cars. Guideways are also referred to as links, links that cater for flows of traffic, either one way or in both directions. There are guideways, or links, that cannot be seen, such as air corridors, used in air transportation and underground pipelines for pipeline transportation (Sussman 2000; 11, 49). Air corridors are an exception to most guideways, as they are not physically built infrastructure.

The second category of infrastructure is terminal, or node. Nodes, or terminals, are places where the departure of vehicles is regulated; it is the point at which links are connected. The terminals also offer a point where the system can be accessed. Terminals often cater for storage facilities, for example port areas offer parking facilities for trailers. Terminals, as shown in figure 11, provide the point of interchange in intermodal transport chains (Sussman 2000; 12, 49).

The last category of infrastructure refers to stations; points where the transportation system can be entered or exited. There are also stations that can be referred to as nodes (Sussman 2000; 12, 49). For instance a railway station can be a node, whereas an underground station is only a place to get on or off the system.

Without adequate guideways and terminals, the transportation system cannot function. An example can demonstrate what lack of infrastructure means in reality. In his article, Eerolainen (2008, 4), explains how only 4 % of motor vehicles, travelling via Finland to Russia are transported by train. The majority of the vehicles, annually 700 000 – 800 000, are hauled by road despite the congestion on the motorways. This is due to the lack of railway terminals that can facilitate the handling of the motor vehicles destined for the Russian market.

Infrastructure has an important economical role in a country. Policies are often developed to further advance the use of infrastructure. This is also the case in the European Union.

The Common Transport Policy has been developed within the EU. The main objectives of the Common Transport Policy, as identified by Europa (2007a) are:

- To remove barriers at the borders between Member States, in order to cater for the free movement of persons and goods
- To complete the internal market for transport, ensure sustainable development, manage funding programmes and spatial planning, improve safety and develop international cooperation
- To lay down conditions under which non-resident carriers may operate transport services within a Member State

Trans-European Transport Networks (TEN-T) are also developed to unite European regions with up-to-date facilities to ensure that the free movement of goods is efficient. TEN-T covers road and intermodal transport, waterways and seaports, and the European high-speed railway network (Europa 2007b). All of these policies and projects support the continuous development and maintenance of infrastructure at some level.

4.4 Green Logistics

As shown in figure 3, the logistics is the integrated management of activities involved; transport, warehouse, inventory, materials management and information systems. One of the main objectives is to meet customer requirements at minimum costs.

These costs have been looked at in monetary terms only, prior to the concern for the environment. With the growing concern for the environment, these costs are no longer associated in monetary terms only. Climate change, air pollution, noise, vibration and accidents are some of these external costs related to logistics. Green logistics aims for a more sustainable balance between environmental, economic and social objectives. This is demonstrated in figure 13 below (Green Logistics, 2008).

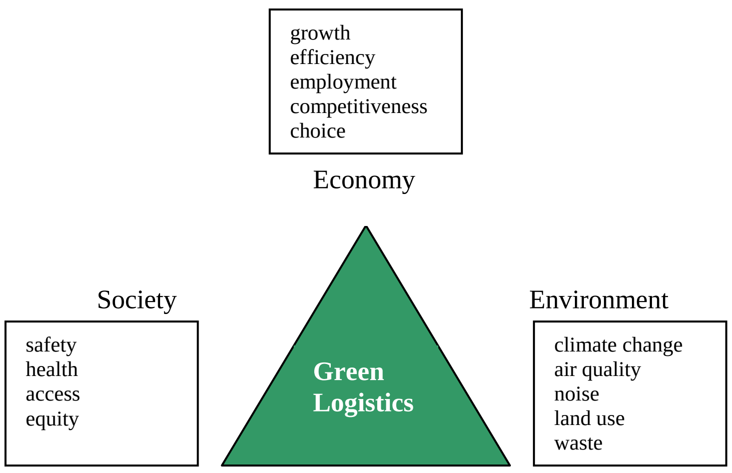


Figure 13 – Sustainable logistics

Bask and Laine (2000, 15) address the main benefit of using intermodal transportation in road transport, the promotion of green logistics. When there is availability to move road traffic by sea and rail it increases an environmentally friendly approach. Green logistics has become increasingly important as the concerns for the environment have become a central issue.

As shown in table 5, road transportation has the highest impact on the environment. Rail and sea both indicate a lower environmental impact and this poses an opportunity to promote green logistics when infrastructure supports the transportation system to do so.

Transportation is one of the largest consumers of energy and creates environmental expenses through congestion, air and noise pollution. Table 6 below, indicates some of the environmental impacts posed through transportation, as illustrated by Kalenoja and Kuukka-Ruotsalainen (2001, 19).

Table 6 - Environmental impacts posed through transportation

Impact	**Main cause of impact**	**Main contributor to cause**	**Coverage of impact**
Global warming	CO_2	Road transportation	Global
Decrease in the ozone layer	CFC combinations, Haloalkane, NO_x	Air transportation	Global
Tropospheric ozone	NO_x, VOC, HC	Road transportation	Regional
Acid rain	NO_x	Road transportation	Regional
Hazardous chemicals	various	Road transportation, rail transportation	Local
Oil and fuel leakages	Fuels, oils	Sea transportation	Local
Land use	various	Roads, airports	Local
Noise	various	All modes of transportation	Local
Wastes	combinations	All modes of transportation	Local

Policies are developed to make logistics greener within the European Union. These policies concentrate on the following (Browne et al 1994, 282 – 290):

- Improvements in lorry design
- Making road transport comparatively more expensive
- Encouraged use of combined transport; intermodal networks

The White Paper (European transport policy for 2010: time to decide) indicates some strategies developed to improve the quality and efficiency of transportation.

One of the main strategies involves moving the transportation off the roads into other modes, by investing to improve the linkages between the modes. These efforts are in place to improve environmental performance and to remove traffic congestion (Kajander and Karvonen 2001, 16).

It is evident that green logistics and environmentally friendly performance is of importance, in the entire logistics system, not only a concern of transportation and carrier criteria.

5 CASE STUDY: DSV Road Oy

The empirical part of this thesis is carried out for a global transportation and logistics solutions provider, in particular, a division located in Finland. DSV Road Oy, part of De Sammensluttede Vongmænd (The Joint Hauliers), DSV Road Holding A/S. DSV is listed on the Copenhagen Stock Exchange, Denmark.

The Group’s structure is separated into three divisions; Road, Air & Sea (DSV Air & Sea Holding A/S) and Solutions (DSV Solutions Holding A/S). DSV Road concentrates on providing transportation services by road, and its core market area is Europe. DSV Air & Sea operates in airfreight and deep sea services, and connects Europe with the USA and Far East. DSV Solutions focus on providing complete logistics solutions to its customers. DSV Group operates in 150 countries and has an average annual turnover of 4.4 billion euros, and employs approximately 19,000 people. The Road division’s share of the turnover is 3.2 billion euros and employs approximately 11,600 personnel.

DSV Road Oy had a turnover of 88.7 million euros in 2005 and employs 185 people on permanent bases. DSV Road Oy has headquarters in Vantaa and other locations in Finland are Turku, Tampere, Oulu, Jyväskylä and Kotka, however, in addition to those through a solid network of transport partners the whole of Finland has service coverage.

DSV Road Oy concentrates on providing transportation services between suppliers and buyers for a door-to-door service on a Europe wide scale. This study is conducted for the UK export department, however, will benefit the Irish export department as Great Britain is a gateway for the Irish traffic.

The UK export trailers are shipped to Hull, Immingham and Tilbury or Harwich ports in the UK, depending on whether the cargo is destined for the North or the South of the country. The geographical division is determined by DSV with respect to the delivery points in the UK.

Hull and Immingham cater for the traffic destined for the North and Tilbury and Harwich subsequently for the South. The division, North and South, is only a rough determent of which port to ship the goods to. The geographical locations are further assigned to specific terminals, however, for the purpose of this study, only the rough destinations are required. The figure below indicates the approximate locations of the ports indicated on the previous page.

Source: BBC 2007

Figure 14 – location of entry ports

Therefore, indicating that the focus is on two entry ports in Great Britain, and two separate service areas. Some background information is in place, to establish the cause for this study.

5.1 Background

By taking a closer look at the annual statistics provided by the Finnish Port Association (2007) for the export transit traffic in 2006, it is possible to identify that general cargo accounted for only 2.3 % of the exports passing through the Finnish ports, of which 70 % passes through the port of Helsinki. Liquid bulk accounted for 34.8 % and dry bulk for the remaining 62.9 %.

From these figures it is possible to recognise that liquid and dry bulk dominates the export shipping schedules for direct vessel sailings out of Finland. Statistics issued by the Finnish Maritime Administration (2007) show that 42.8 % of exports from Finland to foreign countries by sea alone are sawn wood and other forestry products. In his article Pöysä (2007, 3) talks about internal issues affecting the forest and paper industry sectors in Finland, these factors raise the risk of moving production to more profitable locations abroad.

These statistics alone lead to an assumption that possible changes in industries dominating the export sailing schedules could jeopardise the position of seaborne general cargo exports. This assumption on the other hand provides the cause for this case study as part of strategic planning.

General cargo exports do not provide enough volume to shipping lines in order to guarantee and sustain a continuous flow of direct sailings out of Finland, in this case to the United Kingdom. It is not so long ago, in the beginning of 2007 that one major shipping line pulled out a direct sailing service from Helsinki to Tilbury due to a lack of demand.

These scheduling issues put excess pressure on transportation services providers. A European logistics survey was conducted to identify what it is that has changed decreasing logistics costs to rise. Davis (2004, 24) links the raising costs to increased service expectations and lead time; customers are becoming more demanding looking for more frequent and smaller deliveries. Globalisation increases the physical distance between material goods and increasing transportation costs are partly affected by raising diesel prices and traffic congestion.

By implementing a hypothetical situation where direct sailings from Finland to UK do not exist, it is possible to establish the basis for this study.

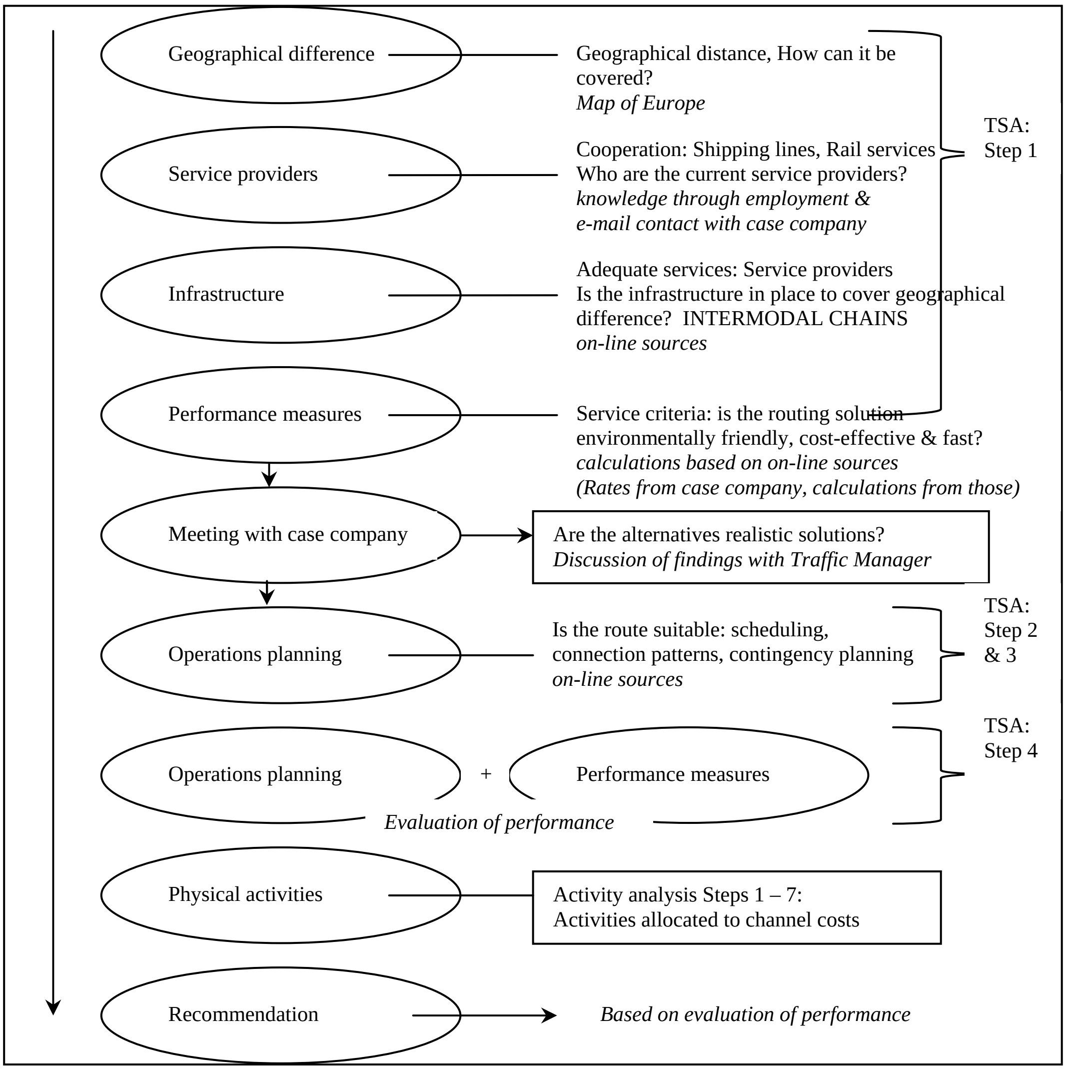
5.2 Foreword

The primary focus of this case study is to allocate alternative routing solutions from Finland to Great Britain for weekly trailer services, catering for the North and South of the country. The key criterion for these alternatives is to maintain the current quality of service standards or carrier criteria. The routes currently in use are used as a source of comparison in the performance measuring process.

The operational unit is a groupage export trailer. Groupage is defined by Benson et al (1994, 8-9) as a unit load consisting of goods belonging to several shippers. The carrier takes responsibility of the goods for majority of the transit, distributing them to their final delivery points after arrival in the foreign port.

Groupage shipments are collected and delivered by local distribution systems, referred to as composition and decomposition in an intermodal transport chain, as demonstrated in figure 11. As identified under limitations in chapter 1, in order to establish comparison it is necessary to assume that the trailer passes through the terminal. With full- and part-load trailer services, it is not always the case and therefore the collection and delivery points are unknown.

In order to allocate solutions to the questions under analysis, what the alternative routing solutions are, and how the operational plans affect the service criteria, a research process is established. This research process is demonstrated in the figure below.



TSA: Transport systems analysis

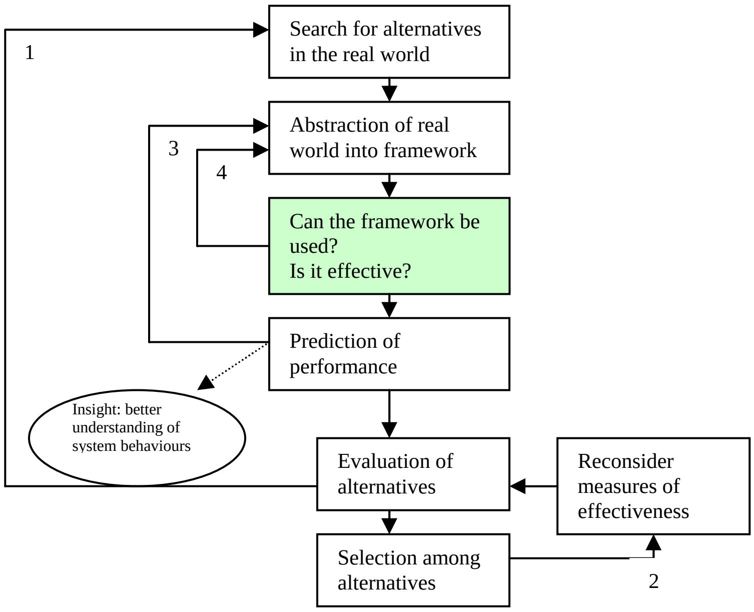
Figure 15 – Case study: Research process

The chapters covering function of transport, transport planning and integrated transport are in place to support the case study. Together with the information gathered in the theory, the correct analysing tools are necessary. Although the research methods were introduced in chapter 1, the next headings will take a closer look at the mentioned.

5.3 Transportation systems analysis

The transportation systems analysis was briefly introduced in chapter 1, under the subheading research methods. The main idea for a transportation systems analysis is to search for real world alternatives. The crucial part of the framework is to look at the predictions for performance for various alternatives, evaluate those alternatives and select only alternatives that make sense.

The predictions for performance are done by considering the service criteria and operational plans. The figure below shows a framework for systems analysis.



1. Does the evaluation suggest other alternatives? 2. Are the measures of effectiveness appropriate?
3. Is the abstraction good at predicting? 4. Develop new abstraction.

Figure 16 - A systems analysis framework (Sussman 2000, 129)

The starting point for the empirical research is to look for alternative solutions in the real world. It is necessary to allocate possible countries of passage, adequate connections and schedules. From the findings then it is necessary to narrow the possibilities down to the most attractive ones. The most attractive solutions will then be further studied by using an activity analysis. The four steps in the framework are:

1. Search for alternatives in the real world
2. Abstraction of real world into framework

3. Prediction of performance
4. Can the framework be used, is it effective?

The steps will be followed in the above order, as demonstrated in figure 15.

5.4 Activity analysis

This analysing tool was also introduced under section 1.4. As transportation flows are connected by various activities, it is crucial to have a thorough understanding of the activities involved. It is through these activities that costs are cumulated and transportation systems managed.

It is then possible to try and eliminate unnecessary activities or find solutions to replace such. By a thorough understanding of the links that form the complete chain, in this case activities, it is possible to manage the transportation process adequately. The figure 17 below demonstrates the 7 stages in an activity analysis.

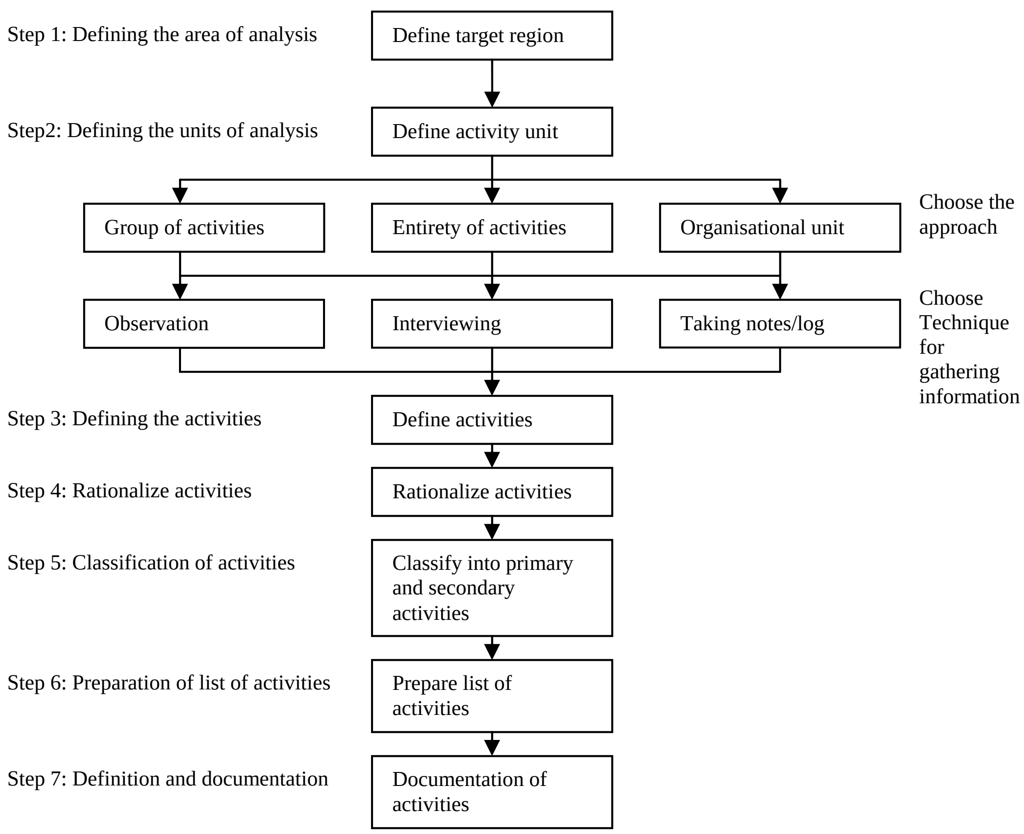


Figure 17 - Process of activity analysis (Oksanen 2003, 104)

The activities are allocated to the channel costs in the context of this study. The implementation of the activity analysis, as demonstrated in the above figure, is to identify the intermodal transport chain related activities.

6 THE WAY: ROUTING

As discussed under section 3.3.1, the way refers to the route assignment. The way indicates how the geographical distance is covered to reach the delivery point. This chapter covers the process and findings of the case study.

Transportation systems analysis:

Step 1- Search for alternatives in the real world

As demonstrated in figure 16, the starting point for a systems analysis framework is to search for alternatives in the real world. In this case the question lies on countries which traffic can pass through to reach Great Britain using intermodal transport chains.

The countries of passage have not been randomly picked; they all offer a realistic opportunity to be implemented into the transportation system. Allocating possible routes and the countries which the trailers pass through to get to the final destination has been a joint evaluation together with already existing knowledge of possibilities and by gathering information, using online sources for already established service providers, for both sea crossings and railways.

A focus is to keep within the European Union borders and the scope of the Common Transport Policy. The Common Transport Policy is briefly introduced on page 36. This would indicate that Norway for instance does not provide an alternative route solution even though geographically it lies between Finland and Great Britain.

The aim for these alternative solutions is not to bring excess activities, such as customs procedures and required additional paperwork. As shown in table 2, the aim is to eliminate excess activities in order to cut costs. It is in fact not necessary to accompany trailers with ships mail within the EU and the trend is moving towards electronic exchange of data and documents.

The focus in this study is on moving trailers from Finland to UK, thus the combinations to take a closer look at are between road, rail and water. It is inevitable to find suitable sea crossings based on the geographical locations alone, but it is also a possibility to benefit from the usage of rail.

The findings of the search for real world alternatives indicates four possible countries of passage; Denmark, Germany, the Netherlands and Sweden. Possible countries of passage are demonstrated in figure 18 below.

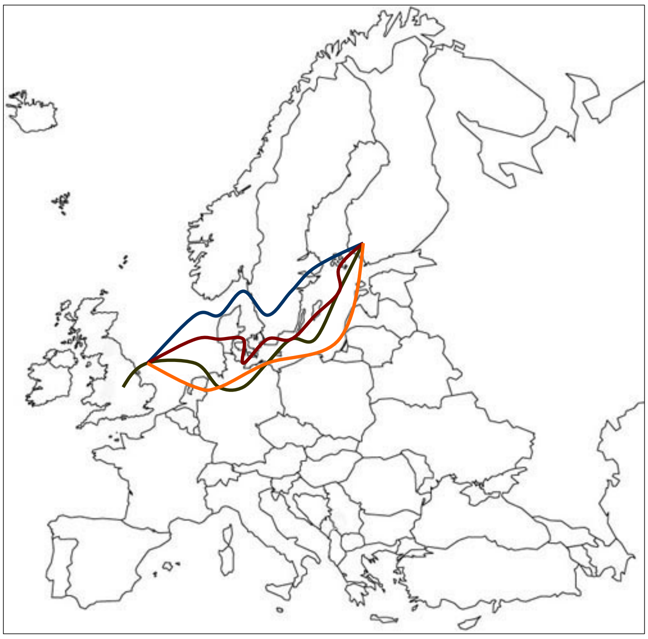


Figure 18 - Countries of passage (map: JEF-Europe 2005)

In order to clarify the way, simplified figures are drawn to demonstrate in more detail the path over the geographical distance, see appendix 2. Figures 20, 22, 24 and 26 illustrate the backup for figure 18.

Appendix 3, on the other hand, indicates in more detail the findings of the search for real world alternatives. Table 21 shows the carrier criteria considerations, indicating the cost and duration for each channel, as well as measuring green logistics through how many kilometres are covered by road.

A closer look at the country specific intermodal transport chains, in appendix 2, figures 21, 23, 25 and 27. The adequate infrastructure is in place for the chains to be further studied.

In depths look at the activities involved in using these routes is taken in the activity analysis under section 6.4. The activity analysis will identify the process of transportation from Finland to Great Britain in detail, and allow for comparison with the already existing service standards.

6.1 Performance measurement

After conducting the first step of the transportation systems analysis, as shown in appendix 3, based on the average performance of each country specific route, the following table can be drawn.

Table 7 – Country specific performance measurement

Route		Speed: Actual time in transit	Green logistics: Total km driven	Cost: Total cost to carrier
Direct	9	5	1	3
Denmark	9	4	4	1
Germany	13	3	5	5
Netherlands	7	2	3	2
Sweden	7	1	2	4

1 = most attractive, lowest score = most attractive

However, the above findings ignore the behaviour of the transportation systems. Therefore it is necessary to evaluate the performance by abstraction of real world into the framework.

Transportation systems analysis:

Step 2 - Abstraction of real world into framework

Step 3 – Prediction of performance

Abstracting of real world is a process of trying to find out how the transportation system behaves in reality. The performance measures have been identified in the theory part of this thesis. The focus is on transportation time, costs and green logistics. Transportation time and costs will in turn be the tools to evaluating reliability and level of service.

On the other hand it is necessary to determine how the schedules, connection patterns and contingency planning will affect the performance measurement.

As discussed in the theoretical part of this study in operations planning, heading 3.3, schedule, crew assignment, flow distribution, connection patterns, cost/level of service trade off and contingency planning are key elements in transport coordination. This section of the thesis will briefly outline what considerations must be taken into account in practice and what role these elements play with respect to performance measurement.

The schedule must meet the requirements of DSV Road Oy. The majority of trailer departures fall toward the end of the week, aiming for Friday afternoon. This is due to;

1. Majority of export collections are conducted Wednesday / Thursday, even Friday morning from nearby areas, allowing for the cargo to be available for export loading by Friday midday. Often, the cargo is not ready for collection from the supplier earlier and also to avoid congestion of goods in the terminal building.
2. A Friday departure allows for arrival in Great Britain in the beginning of the following week which in turn gives enough time for local and regional distribution systems to deliver the goods to their final destinations by Thursday, latest Friday. This indicates a rough delivery time of one week from the time of collection to the time of final delivery.

This indicates the need to look for vessel departures that service the traffic accordingly, which identifies the first requirement when allocating alternative routing solutions.

Crew assignment falls to the category of secondary activities in this study. The duty of assigning propulsion units adequately to meet the demand of the traffic is the responsibility of haulage. This will also not affect the domestic haulage in Finland as the volume of trailers is not due to change from the current situation. However, the port of exit will have an impact on crew assignment and therefore the aim is to find solutions that do not change the current use of exit ports. Currently the majority of groupage departures are from Helsinki and some from Hanko, which is taken into consideration.

Flow distribution is also a secondary function in this study, see table 14. This relates to the imbalance of export and import trailers. Although it is possible to study the relationship between the average numbers of export trailers to those of import trailers, it is a complex issue when countries of passage, through intermodal transport chains, are in the equation.

Even if the relationships between export and import trailers are studied, ignorance towards activities to and from other countries using similar connection patterns is inevitable. Finland's position of trailer imbalance with respect to UK does not supply realistic situation of flow distribution, as other traffic streams using similar connection patterns are ignored. It is the duty of haulage to ensure that trailers do not run empty and that one way shunts are not conducted.

Connection pattern refers to the time required for transfers, scheduling and routing in order to operate as a transportation system. Connection patterns are taken into account by allowing enough time between connective schedules. The exit timetables must be realistic and allow for trailers to be pulled across meeting the closing time of the next transportation mode. Connection patterns and schedule are in close cooperation, both a central element when allocating alternative routing solutions.

Transport time, reliability and cost are common service criteria. Because the focus is on allocating new solutions, the already used routes can be used as a comparison tool to indicate a cost versus level-of-service trade-off. Reliability of service cannot be measured as effectively as the comparison of transport time and cost with the already established routes. Abstraction from the real world does also not indicate the real world situation, however, it must be assumed to do so as discussed in the limitations under subheading 1.3.

Contingency planning looks at alternative solutions when plans do not go accordingly. This can be looked at it more detail by assuming possible delays and by examining how those delays would affect the particular route. For instance, it is possible to assume that a trailer does not meet a connecting mode of transport and consequently examine the effect it would have on agreed timeframes.

Table 8 below indicates the current performance and will be the basis for comparison in this study.

Table 8 - Direct sailings from Finland to Great Britain* Cost excluding handling charges at ports

Departure Depot	Port of Exit	Departure	Arrival	Port of Entry	Arrival Depot	Travel Time/h (days)	Carrier	Driven km	Total Cost (€)Index*
Vantaa	Helsinki	Sun 18:00	Wed 07:00	Hull	Immingham	61,57 (2,58)	A	65	681.25
Turku	Rauma	Fri 15:00	Mon 07:00	Hull	Immingham	66,01 (2,75)	A	138	716.67
Vantaa	Hanko	Fri 15:30	Mon 06:00	Tilbury	Purfleet	64,30 (2,69)	B	151	599.65

A complete schedule for direct connections from Finland to the UK can be found at the back of this report in appendix 4. Table 8 only recognises the connections most suitable for groupage departures. To clarify the performance measures, the table needs some explanation.

The departure and arrival days indicate the duration of the entire journey, whereas travel time indicates the actual time in transit. Connection patterns are indicated in the difference between the total duration of the journey and the actual transit time.

The schedules indicate that groupage trailers leave towards the end of the week and arrive in time for delivery by the end of the following week. The aim is to allocate departures that suit the groupage departures, falling towards the end of the week, arriving in UK early the following week. Both the trailers destined for the North and the South of the UK need to be accommodated, indicating a need to find connection patterns that arrive accordingly.

The kilometres driven are calculated to measure environmentally friendly routes. The principle is that less geographical coverage by road, the fewer burdens on the environment is caused. The kilometres driven are compared amongst the routes to identify the ranking.

The total costs involved also instigate the price level of carriage. Therefore, the total cost should remain relatively similar to that of the current situation. The distribution of extra costs over a groupage trailer is a complex issue.

Contingency planning is looked at by allocating the next possible scheduled departure in case the planned connection is failed. This indicates the next possible time of arrival in the entry port.

By allocating solutions that maintain the current level of service, it is possible to state that the reliability of service is not altered. This is the basis for the performance measurement of the alternative routes, now looked at in more depth.

Route A

As illustrated in figure 21, the intermodal chain transporting via Denmark is formed by using road and sea.

Table 9 below indicates the scheduling possibilities and the performance measures when transporting via Denmark.

Table 9 - Finland to Great Britain via Denmark

departure depot	port of exit	departure	arrival	port of entry	arrival depot	travel time/h (days)	carrier	driven km	total cost (€)Index*
Vantaa	Helsinki	Sat 15:00	Mon 07:00	Århus			A		
(Århus)	Esbjerg	Mon 21:30	Tue 14:30	Immingham	Immingham	59,09 (2,46)	E	192	557.29
Next connection to Harwich from Esbjerg									
	Esbjerg	Tue 18:45	Wed 12:00	Harwich			E		
Next connection to Immingham from Esbjerg									
	Esbjerg	Tue 21:30	Wed 14:30	Immingham			E		

* Total cost excluding handling charges at ports

The cost: transporting via Denmark is the most attractive alternative when cost is considered. The total cost of primary activities, see table 14, are not altered negatively.

Green logistics: this route is not the most environmentally friendly solution as the connection from Århus to Esbjerg is done by road. The distance, however, is not near the 500 kilometre margin, often used when evaluating possibilities of using rail. When the transportation is done by road it also means that no special equipment is required with respect to trailers.

Delivery / reliability: scheduling is ideal for the trailers heading to the North of the UK, arriving in Immingham on the following week's Tuesday rather than Wednesday. The trailers heading for the South of the UK on the other hand are not served accordingly. If they depart Finland on Saturday, they will not arrive in the UK until midday Wednesday, a direct route can accommodate this traffic flow better with an early Monday morning arrival. Due to the heavy haulage costs in the UK, sending Southern trailers to the Northern ports is not a recommended option.

Contingency planning: the following sailing brings the trailers to the UK by Wednesday afternoon, indicating a positive result.

Route B

Transporting via Germany allows for flexibility with respect to sailing schedules out of Finland. Table 24, in appendix 4, indicates 12 scheduling possibilities and performance measures when transporting via Germany. Table 10, on the other hand, shows the most attractive solutions for groupage trailers.

Table 10 - Finland to Great Britain via Germany

departure depot	port of exit	departure	arrival	port of entry	arrival depot	travel time/h (days)	carrier	driven km	total cost (€)Index*
1. Vantaa	**Helsinki**	**Fri 18:00**	Sat 20:00	Travemünde			A		
1.(Travemünde)	Cuxhaven	Mon 19:00	Tue 16:00	Immingham	Immingham	51,28 (2,14)	E	249	798.61
2. Vantaa	**Helsinki**	**Fri 22:00**	Sun 07:00	Travemünde			A		
2.(Travemünde)	Cuxhaven	Mon 19:00	Tue 16:00	Immingham	Immingham	58,28 (2,43)	E	249	798.61
3. Vantaa	**Helsinki**	**Sat 18:00**	Sun 20:00	Travemünde			A		
3.(Travemünde)	Cuxhaven	Mon 19:00	Tue 16:00	Immingham	Immingham	51,28 (2,14)	E	249	798.61
Next connection to Immingham from Cuxhaven									
	Cuxhaven	Tue 19:00	Wed 17:30	Immingham			E		

* Total cost excluding handling charges at ports

The cost: Germany is the most expensive routing solution out of the four possibilities. This indicates a rise of over 19 % on the average cost of direct sailings. The cost distribution indicates a problem area where groupage service is concerned.

Green logistics: this solution is also the least environmentally friendly option. The long haul by road also contributes to wear on the equipment and subsequently additional equipment costs. However, other benefits of using road are the same as with transporting via Denmark.

Delivery / reliability: although there are numerous sailing possibilities out of Finland, there is only a limited possibility of connections from Germany onward to the UK. The trailers for the North are accommodated, allowing for Friday evening or Saturday departure, arriving in the UK by Tuesday afternoon.

No connection out of Cuxhaven to serve the Southern UK trailers, which again turns out expensive if shipped via Immingham.

Contingency planning: not as positive as the next sailing brings the trailers to the UK late Wednesday evening. This is more of a concern considering the Sunday driving ban in Germany.

Route C

Transporting to Great Britain via Netherlands requires shipment of trailers to Germany, from Germany onwards to the Netherlands and finally to Great Britain.

The interchange of trailers in this case becomes more complex and this poses risks in its own right. However, there are benefits in doing so, to mention the use of railroads and the scheduling possibilities Netherlands offers onward to Great Britain. Table 25, in appendix 4, indicates 24 scheduling possibilities and performance measures routing trailers via Netherlands. Table 11 below only shows only the most attractive solutions for groupage.

Table 11 – Finland to Great Britain via Netherlands

departure depot	port of exit	departure	arrival	port of entry	arrival depot	travel time/h (days)	carrier	driven km	total cost (€)Index*
1., 2. & 3. Vantaa	**Helsinki**	**Fri 18:00**	Sat 20:00	Travemünde			A		
1., 2. & 3. (Travemünde)	Lübeck	Tue 19:30	Wed 11:00	Rotterdam			H		
1.(Rotterdam)	Rotterdam	Wed 19:00	Thu 01:45	Harwich	Purfleet	44,6 (1,86)	G	145	677.08
2.(Rotterdam)	Hoek van Holland	Wed 14:45	Wed 20:15	Harwich	Purfleet	45,04 (1,88)	G	177	677.08
3.(Rotterdam)	Hoek van Holland	Wed 21:00	Thu 07:00	Killingholme	Immingham	48,05 (2,0)	G	70	639.58
4., 5. & 6. Vantaa	**Helsinki**	**Fri 22:00**	Sun 07:00	Travemünde			A		
4., 5. & 6. (Travemünde)	Lübeck	Tue 19:30	Wed 11:00	Rotterdam			H		
4.(Rotterdam)	Rotterdam	Wed 19:00	Thu 01:45	Harwich	Purfleet	51,6 (2,15)	G	145	677.08
5.(Rotterdam)	Hoek van Holland	Wed 14:45	Wed 20:15	Harwich	Purfleet	52,04 (2,17)	G	177	677.08
6.(Rotterdam)	Hoek van Holland	Wed 21:00	Thu 07:00	Killingholme	Immingham	55,05 (2,29)	G	70	639.58
7., 8. & 9. Vantaa	**Helsinki**	**Sat 18:00**	Sun 20:00	Travemünde			A		
7.,8. & 9. (Travemünde)	Lübeck	Tue 19:30	Wed 11:00	Rotterdam			H		
7.(Rotterdam)	Rotterdam	Wed 19:00	Thu 01:45	Harwich	Purfleet	40,6 (1,69)	G	145	677.08
8.(Rotterdam)	Hoek van Holland	Wed 14:45	Wed 20:15	Harwich	Purfleet	41,04 (1,71)	G	177	677.08
9.(Rotterdam)	Hoek van Holland	Wed 21:00	Thu 07:00	Killingholme	Immingham	44,05 (1,84)	G	70	639.58
Next connection to Rotterdam from Lübeck									
	Lübeck	Wed 19:30	Thu 11:00	Rotterdam			H		
Next connection to Harwich/Killingholme from Rotterdam/Hoek van Holland									
	Rotterdam	Daily 14:45 22:00	20:15 03:30	Harwich			G		
	Hoek van Holland	11:30 19:00 23:45	18:30 01:45 06:45	Harwich			G		
	Hoek van Holland	21:00	07:00	Killingholme			G		

* Total cost excluding handling charges at ports

The cost: Netherlands is an attractive solution in the sense that the costs are not altered as such. This indicates that the route can be implemented without additional costs involved.

Green logistics: this is an environmentally friendly option. This is due to the usage of rail services as illustrated in figures 24 and 25. Although the use of railroads is positive, it indicates special requirements for equipment, trailers that are suitable for rail, huckaback trailers. This poses possible pressure on the availability of equipment, if used in volumes.

Delivery / reliability: There are numerous scheduling possibilities out of Finland and also out of the Netherlands to the UK. However, the train connection from Lübeck to Rotterdam is the source of the problem when considering this route. As there is no train service on Mondays, it means that although the trailers arrive in Germany by Sunday, the next rail connection is on Tuesday evening. This indicates that the trailers will arrive in the UK by late Wednesday night or early Thursday morning, leaving too tight of a window to meet delivery requirements. On the other hand, connections are in place to serve both the North and the South of the UK.

Contingency planning: the numerous connections out of the Netherlands to the UK do not help the contingency planning with respect to the use of rail. If Tuesday rail service is not met, the following arrival day in the UK is late Thursday or early Friday, showing a negative solution.

The other solutions, Denmark, Germany and Sweden use a service for the second sea crossing with a provider with whom there is an electronic data interchange. What it means is that the system used by the case company is connected to that of the service provider, in a way that allows for the sea crossings to be booked without the need for additional internet platforms. This mutual platform allows for various benefits, to mention trailer tracking, without having to resort to other sources. This is a benefit that routing via the Netherlands cannot offer.

It must also be mentioned that the crossing between the Netherlands and the UK is a busy one. This service is also a combined passenger and freight service, which could indicate capacity problems during peak seasons.

Route D

The scheduling possibilities and performance measures transporting to the UK via Sweden are indicated in table 12 on the next page. Appendix 4, shows all the scheduling possibilities for groupage service. Only the most attractive solutions for the service are shown in table 12.

Table 12 – Finland to Great Britain via Sweden

departure depot	port of exit	departure	arrival	port of entry	arrival depot	travel time/h (days)	carrier	driven km	total cost (€)Index*
Vantaa	Helsinki	Fri 17:00	Sat 9:30	Stockholm			D		
(Stockholm)	Stockholm	Sat night	Sun am	Gothenburg			I		
(Gothenburg)	Gothenburg	Mon 21:00	Tue 22:00	Immingham	Immingham	45,57 (1,91)	E	28*	697.92
Next connection to Gothenburg from Stockholm									
	Stockholm	Daily *overnight*	am	Gothenburg			I		
Next connection to Tilbury from Gothenburg									
	Gothenburg	Tue 19:00	Thu 08:00	Tilbury			E		
Next connection to Immingham from Gothenburg									
	Gothenburg	Daily 21:00	Next day 22:00	Immingham			E		

* excludes km from and to ports from railway, *overnight*- use of rail services by night despite frequent schedule

* Total costs excluding handling charges at ports

The cost: Sweden is not attractive from the point of view of the costs involved, the channel costs rise approximately 5 % from the average cost of direct sailings.

Green logistics: The most environmentally friendly solution due to the use of rail. This is also a distance of over 500 kilometres, desirable distance to cover by rail. On the other hand in volumes, the use of rail poses excess pressure on the requirement of special equipment.

Delivery / reliability: the actual transit time is short, when scheduling is considered; the duration of the total journey is prolonged. Once again, the trailers headed to the North of the UK are served accurately, allowing for a Friday evening departure and an arrival on Tuesday night in the UK. This indicates that delivery requirements are met by the end of the week.

Contingency planning: daily departures out of Finland, daily departures for the overnight train service and daily departures to Immingham from Sweden allow for flexibility. A Wednesday night arrival, however, causes pressure for the delivery requirements in the UK.

A major limitation to transporting via Sweden is that the sailing out of Finland is done by using a passenger vessel. This means limited freight space, particularly during peak seasons and also more complicated procedures for the transportation of hazardous goods.

6.2 Evaluation of alternatives

Transportation systems analysis

Step 4 – Can the framework be used, is it effective?

Based on the findings of the second and third steps of the transportation systems analysis, the following table can be drawn.

Table 13 – Routing possibilities ranked in order of performance

Route	Reliability: Arrival time in the UK	Speed: Actual time in transit	Green logistics: Total km driven	Cost: Total cost to carrier	Scheduling: Dep/Arr		Contingency planning: Arr	Service: North/South	
Denmark (16)	1	4	3	1	Sat 15:00 (2)	Tue 14:30 (1)	Wed 14:30 (1)	YES (1)	limited (2)
Germany (22)	2	3	4	4	Sat 18:00 (1)	Tue 16:00 (2)	Wed 17:30 (2)	YES (1)	NO (3)
Netherlands (21)	4	2	2	2	Sat 18:00 (1)	Thu 07:00 / Wed 20:15 (4)	Fri 07:00 / Thu 20:15 (4)	YES (1)	YES (1)
Sweden (20)	3	1	1	3	Fri 17:00 (3)	Tue 22:00 (3)	Wed 22:00 (3)	YES (1)	limited (2)

1 = most attractive, smallest ranking = most attractive

The above table indicates the performance of the alternative routing solutions after implementing both the carrier criteria and operating plans. From the table it is possible to determine that Denmark ranks as the most attractive alternative to transporting groupage trailers from Finland to the UK, instead of the direct sailings.

Although the Netherlands ranks higher than Germany, due to the late arrival times in the UK, the route does not offer an alternative transportation solution to the groupage trailers. The following order of performance can be established through the findings of transportation systems analysis:

1. Denmark, road – sea
2. Sweden, road – rail – sea
3. Germany, road – sea

(4. Netherlands, road – rail – sea)

A major limitation to the use of intermodal networks through the above mentioned countries is the inability to service the scheduling requirements for the groupage trailers destined for the Southern areas of the UK. This poses a problem as transporting Southern trailers via the Northern ports not only adds transit time but excess haulage costs. It also affects distribution flows in the UK, as well as connection patterns, crew assignment and capacity. This issue will be addressed in more detail under heading 6.5.

6.3 Component performance

As using transportation networks is based on managing activities to form an entity, it is essential to have a thorough comprehension of the activities involved. These components, activities, form an entity, a system, and it is important to differentiate between system performance and component performance in order to evaluate performance and take corrective action.

An activity analysis is conducted for the evaluated routing solutions; Denmark, Sweden, Germany and the Netherlands. Although the Netherlands does not pose an attractive alternative for the groupage service, it does not mean that it could not be used for other areas of service. This will be discussed in more detail under section 6.5.

The purpose for conducting an activity analysis is to identify the various activities and to monitor which perform adequately. This way it is possible to evaluate the profitability and performance better.

A framework for an activity analysis is shown in figure 17. The analysing tool was introduced in subheading 1.4 on research methods and further discussed under section 5.4.

Activity analysis – step 1, area under analysis: Four routing solutions from Finland to Great Britain, identified by conducting a transportation systems analysis. Aim is to identify route specific activities for the transportation of goods via Denmark, Sweden, Germany and the Netherlands. These are also the route specific activities that traffic coordinators will need to book in advance, monitor during the transportation and take into account on top of the already performed secondary activities.

Activity analysis – step 2, activity unit: The analysis is conducted for drop and picks groupage trailer traffic. In this study, the particular customers or product groups do not play a role of relevance.

As discussed by Oksanen (2004, 165), in an activity analysis the company is divided into sections in order to study the entity of activities through hierarchy levels. This allows for the activities to be grouped and further specified. The hierarchy levels can be operational divisions, departments or delivery chains. The figure 19 below indicates the hierarchy levels for this activity analysis.

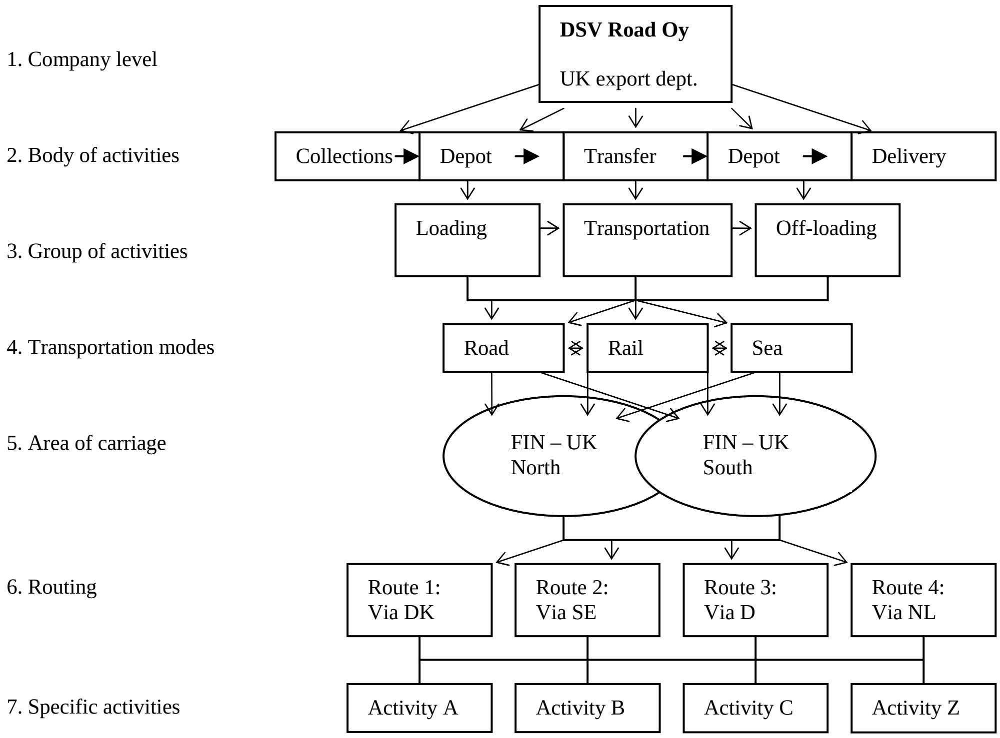


Figure 19 – Hierarchy levels for activity analysis

The above figure is a good basis for defining the areas that have been under analysis so far; transportation modes, area of carriage or transit and the routing solutions. The focus is on the route specific activities now.

Activity analysis – step 3, defining the activities: All specific or individual activities that form the entity, which are necessary in order to provide the agreed transportation service. These activities can be identified in appendix 3, transportation systems analysis; search for alternatives in the real world.

Activity analysis – step 4, rationalisation of activities: The activities, components, form a process in which each activity not only contributes to the overall performance but also cumulates the costs involved. The process is measured through criteria, performance measures, which have been identified in the theory part of this study, in chapters 2 and 3. Although the routing is looked at as an entity, the activities should be arranged in order and monitored individually. Corrective action can then be taken to eliminate problem areas.

Activity analysis – step 5, division of activities into primary and secondary: The primary and secondary activities in this case study are divided in accordance with the relevance to the routing process. In general the primary activities concentrate on the physical activities involved in the process of transferring the trailer from Finland to the UK. The secondary activities support the primary activities in order to complete the service being offered.

Activity analysis – step 6, collection of activity based information: The information for this case study has been gathered through interview with traffic manager, online sources for service providers used by case company, and personal experience through employment in the case company. The collection of information has been done by using a transportation systems analysis framework. The outline for the process is demonstrated in figure 15.

Activity analysis – step 7, Documentation of the activities: It could be said that the primary activities in this case study are in direct relation with channel costs, as introduced on page 23. The focus of the process is on bringing the trailer from point A in Finland to point B in the UK, in that sense the use of intermodal chains and interchange are in direct relation with channel costs.

It can be said that the more activities it takes to bring the trailer from A to B, the more duties are added onto the traffic coordinator in charge. The question in that case would be to identify which activities are taken care of at the country of exit, and which are the duties of the country of entry.

Table 14 below defines the route specific activities. The performance measures used in this case study are also identified.

Table 14 – Channel specific activities

Route	Primary activity	Secondary activity	Performance measure
via Denmark	- 1. Trailer shunt from depot to port of exit - 2. Sea crossing from FIN to DK - 3. Transfer by road from Århus to Esbjerk - 4. Sea crossing from DK to UK - 5. Trailer shunt from port of entry to depot	- Transportation order processing - Route/driver assigning: domestic, country specific - Loading/unloading of goods to/from vehicle: collection & delivery - Terminal handling - Planning of export loading - Handling of information and preparation of documents - Equipment related handling - Handling of claims - Port handling* eg loading/unloading of trailers to/from vessel - Invoicing etc. - Crew assignment / Propulsion unit - Flow distribution	1. Distance (km), duration (h), cost (€) 2. Cost (€), duration (h) 3. Distance (km), duration (h), cost (€) 4. Cost (€), duration (h) 5. Distance (km), duration (h), cost (€)
via Sweden	- 1. Trailer shunt from depot to port of exit - 2. Sea crossing from FIN to SE - 3. Transfer from port to railway (carried out by rail service provider) - 4. Transfer by rail from Stockholm to Gothenburg - 5. Transfer from railway to port - 6. Sea crossing from SE to UK - 7. Trailer shunt from port of entry to depot		1. Distance (km), duration (h), cost (€) 2. Cost (€), duration (h) 3. Distance (km), cost (€) 4. Cost (€), duration (h) 5. Distance (km), cost (€) 6. Cost (€), duration (h) 7. Distance (km), duration (h), cost (€)
via Germany	- 1. Trailer shunt from depot to port of exit - 2. Sea crossing from FIN to D - 3. Transfer by road from Travemünde to Cuxhaven - 4. Sea crossing from D to UK - 5. Trailer shunt from port of entry to depot		1. Distance (km), duration (h), cost (€) 2. Cost (€), duration (h) 3. Distance (km), duration (h), cost (€) 4. Cost (€), duration (h) 5. Distance (km), duration (h), cost (€)
via Netherlands	- 1. Trailer shunt from depot to port of exit - 2. Sea crossing from FIN to D - 3. Transfer by road from port to railway (carried out by rail service provider) - 4. Transfer by rail from Lübeck to Rotterdam NL - 5. Transfer from railway to port - 6. Sea crossing from NL to UK - 7. Trailer shunt from port of entry to depot		1. Distance (km), duration (h), cost (€) 2. Cost (€), duration (h) 3. Distance (km), duration (h), cost (€) 4. Cost (€), duration (h) 5. Distance (km), duration (h), cost (€) 6. Cost (€), duration (h) 7. Distance (km), duration (h), cost (€)

* Port handling is only a secondary activity for the purpose of this study

6.4 Recommendation

In this part of the study, the aim is to provide the case company with some recommendations with respect to the use of the alternative routes.

6.4.1 Southern service

One of the major limitations to the use of these intermodal transport chains is the inability to service the required standards when shipping trailers to the South of the UK. If a hypothetical situation is presented where there simply does not exist a direct sailing to accommodate the traffic flow, there must be a solution to service the Southern UK without having to ship the trailers to the Northern ports.

After a closer study of the scheduling possibilities through Denmark, Sweden and the Netherlands, a solution that poses problems in its own right is identified. If the groupage shipments destined for the South of the UK were collected and ready for export loading by early Thursday afternoon instead of Friday midday, options for export routing can be allocated. The source of comparison for the Thursday departures is indicated in the below table 15, where the direct sailing has an advantage of a Friday departure.

Table 15 – Finland to Tilbury, UK

departure depot	port of exit	departure	arrival	port of entry	arrival depot	travel time/h (days)	carrier	driven km	total cost (€)Index*
Vantaa	**Hanko**	**Fri 15:30**	**Mon 06:00**	**Tilbury**	Purfleet	64,30 (2,69)	B	151	599.65

* Total cost excluding handling charges at ports

Tables 16 – 18 indicate the routing possibilities for a Thursday departure out of Finland, arriving in the South of UK for delivery early the following week.

Table 16 – Finland to UK via Denmark, Thursday departure

departure depot	port of exit	departure	arrival	port of entry	arrival depot	travel time/h (days)	carrier	driven km	total cost (€)Index*
1. Vantaa	**Helsinki**	**Thu 18:00**	Sat 07:00	Århus			A		
1.(Århus)	Esbjerg	Sat 18:45	**Sun 12:00**	**Harwich**	Purfleet	57,45 (2,41)	E	294	625

* Excluding handling charges at the ports

Table 17 – Finland to UK via Sweden, Thursday departure

departure depot	port of exit	departure	arrival	port of entry	arrival depot	travel time/h (days)	carrier	driven km	total cost (€)Index*
Vantaa	**Helsinki**	**Thu 17:00**	Fri 9:30	Stockholm			D		
(Stockholm)	Stockholm	Fri night	Sat am	Gothenburg			I		
1. (Gothenburg)	Gothenburg	Sat 19:00	**Mon 08:00**	**Tilbury**	Purfleet	58 (2,42)	E	31*	734.38

* Driven km, excluding road transfers from railway to port and vice versa in Sweden, * Total cost excluding handling charges at ports

Table 18 – Finland to UK via Netherlands, Thursday departure

departure depot	port of exit	departure	arrival	port of entry	arrival depot	travel time/h (days)	carrier	driven km	total cost (€)Index*
1.& 2. Vantaa	**Helsinki**	**Thu 18:00**	Fri 20:00	Travemünde			A		
1. & 2. (Travemünde)	Lübeck	Sat 19:30	Sun 07:00	Rotterdam			H		
1.(Rotterdam)	Rotterdam	Sun 11:30	**Sun 18:30**	**Harwich**	Purfleet	40,6 (1,69)	G	145	671.88
2.(Rotterdam)	Hoek van Holland	Sun 14:45	**Sun 20:15**	**Harwich**	Purfleet	41,04 (1,71)	G	177	671.88

* Total cost excluding handling charges at ports

If the performance of the routes is measured, table 19 can be drawn. As indicated in the earlier part of this study, the connection from Germany to the Southern ports in the UK is not a possibility through the connections used in this study.

Table 19 – Performance measurement for Thursday departure

Route	Reliability: Arrival time in the UK	Speed: Actual time in transit	Green logistics: Total km driven	Cost: Total cost to carrier	Scheduling: Dep/Arr		Service: South
Direct (15)	3	4	3	1	Fri 15:30 (1)	Mon 06:00 (3)	Yes
Denmark (12)	1	2	4	2	Thu 18:00 (2)	Sun 12:00 (1)	Yes
Germany							No
Netherlands (12)	2	1	2	3	Thu 18:00 (2)	Sun 18:30 (2)	Yes
Sweden (19)	4	3	1	4	Thu 17:00 (3)	Mon 08:00 (4)	Yes

From the shippers' point of view, however, to change the release date for goods by bringing it forward by one day may be a complex issue. This would cause another limitation to the use of these schedules. On the other hand, the above schedules pose an attractive option for the shipment of full load trailers. They are often loaded by Thursday and ready to be shipped out on the same day.

6.4.2 Denmark

With respect to the transfer of groupage trailers from Finland to Great Britain, transit via Denmark is an attractive option. The key element is both cost and schedule, which both remain stable.

When the focus is on groupage shipments, it is a complex issue to spread excess costs over the numerous shipments on board the trailer, and therefore from the carrier's point of view, stable channel costs are an issue of particular relevance. Because the costs are not altered, it is possible to provide the weekly trailer service as agreed, without having to cover excess channel costs.

Scheduling is another way to measure reliability of service in this case. Although reliability covers numerous areas of service standards, such as delivery of cargo in good condition without damage or theft, it is also measured through the carrier's ability to meet agreed delivery schedule. Although the scheduling is challenged when the focus is on service to the South of the UK, as discussed earlier, the scheduling possibilities to Immingham are ideal. In fact, the scheduling via Denmark is an opportunity to add benefit to the level of service. The trailers arrive in the UK a day earlier, which allows for better timeframe to meet the agreed delivery frames.

If the focus is on Great Britain as a gateway for the Irish traffic, the earlier arrival in the UK is of more importance. As the Irish trailers use the Northern ports, going via Denmark allows for an earlier transfer from the East to the West coast of the country for the connecting sailings to both Ireland and Northern Ireland. This indicates a better timeframe to meet delivery schedules in Ireland.

Denmark on the other hand is not environmentally the friendliest option. Due to the transfer from Århus to Esbjerk by road, on average twice as much driving by road is necessary than with the direct sailings. The transfer by road on the other hand indicates that there is no need for special equipment, which in volumes adds pressure to the allocation of adequate trailers. Transfer by road is more reliable in a sense, as drivers are allocated to conduct the shunts.

After ranking the routes, accordingly with performance measures, Denmark scored the best results for both the service to Immingham and also in the case of the Thursday departure to Harwich. Transportation via Denmark is the most attractive solution to serve the groupage trailer traffic.

The limitation to this study does not address DSV Denmark's ability to carry out the transfers by road. It also does not address the availability of space on the vessel from Finland to Denmark, and then onward to the UK. This capacity issue from points of view, the sea crossing and haulage, poses possible problem areas. Crew assignment and flow distribution, as discussed earlier under section 3.3, are issues that need to be checked with DSV Denmark on a weekly basis to see how many connection patterns for interchanges they are able to cover.

6.4.3 Germany

Germany does not offer an ideal opportunity for the service of groupage traffic. The connection and interchange via Germany is both expensive and environmentally burdening.

The excess channel costs involved are difficult to spread over numerous shipments on board. In fact, unless the cost of transportation was raised by a percentage, in other words, new rates given to customers, it would be impossible to cover the extra costs involved. This, however, is not the case with full loads. It is possible to give special rates for full loads, in which case the extra costs are covered.

Due to the long haul by road across Germany, transfers are environmentally burdening. As discussed under section 4.4, road transportation is the least environmentally friendly mode of transportation. Due to this factor alone, and the continuously growing emphasis on green logistics, adding volumes of traffic would not be beneficial, not only on the environment but also to the added wear on the equipment.

Transit via Germany to serve the traffic flow destined for the South of Great Britain is not possible. However, the scheduling possibilities to Immingham from Cuxhaven are good. Also the schedules out of Finland to Germany are numerous and flexible. The limiting factor in Germany, causing possible delays, is the driving ban on Sundays. These flexible schedules pose an opportunity to transport urgent full loads for special rates.

In the case of full loads, the departure days need not be fixed and as there are sailings to Germany on a daily basis from various ports in Finland, this offers an opportunity for flexibility in the delivery frames for urgent full loads. It is of benefit to allocate an exit port nearby the location of loading, with departures out of Helsinki, Hamina, Hanko, Kotka, Rauma and Turku to mention a few, it is easier to allocate a cost effective exit out of Finland.

If the focus is on using a route via Germany for occasional urgent full loads, capacity issue is not as much of an issue of relevance. Vessel space for sea crossings and allocation of road haulage for the transfer across Germany would not be pressured in volumes.

6.4.4 The Netherlands

To transfer trailers from Finland to Great Britain via the Netherlands, for the purpose of groupage traffic, is only possible with a Thursday departure. Due to the limitation in the connection patterns with respect to railway service schedules, a departure out of Finland any later than Thursday would cause too tight of a delivery frame to meet agreed delivery service in the UK. This would in turn have a negative impact on the reliability of the service standards, which is surveyed to be the most important carrier criteria.

The channel costs, on the other hand, are not altered immensely. Transporting via the Netherlands is an opportunity to benefit from a relatively green route, as the use of railway service contributes toward an environmentally friendly solution. This indicates less wear on the equipment; however, the need for special equipment is an issue of relevance.

As the first leg of the journey is via Germany, transit via the Netherlands offers similar flexibility with respect to exit out of Finland as routing via Germany. The added benefit with transporting via Rotterdam is the flexible sailing schedules out of the Netherlands to the UK. Daily departures to service both, the North and the South of the UK are added value.

This poses an opportunity for the transit of full loads out of Finland to the UK, with good rates and by using an environmentally friendly solution. The scheduling limitation prevents the otherwise suitable routing solution to service the groupage traffic. Less than truck loads (LTL) or part-load trailers can reach a Thursday delivery in the UK. This requires for the final delivery destinations to have a location within reach from the arrival port.

The capacity issue in the case of this route only affects the sea crossings and the rail transfer. The question lies on the available vessel space and the rail service provider's ability to allocate space and interchange from the port to the railway and vice versa. Transporting trailers via the Netherlands does not add pressure on crew assignment and flow distribution with reference to road haulage.

6.4.5 Sweden

In order to add value to transporting via Sweden, it is necessary to benefit from the rail service from Stockholm to Gothenburg. By doing so, accessing Great Britain via Sweden is the environmentally friendliest solution. However, transferring trailers via Sweden is also costly. This poses a limitation to the use of the route for groupage traffic, the channel costs are difficult to cover, unless rates are raised permanently.

Although the scheduling out of Finland to Sweden is frequent, the sea crossing is carried out with passenger vessels. As mentioned earlier, this indicates limited vessel space particularly during peak seasons. On the other hand, this also makes the transportation of hazardous goods more complex, with more restrictions and tighter procedures.

The scheduling possibilities, however, are positive. There are frequent sailings to the UK from Gothenburg. A groupage trailer with a Friday departure arrives in Immingham on Tuesday night, allowing for instant access early Wednesday morning. A trailer headed for Tilbury on the other hand needs to depart on Thursday, restricting the possibility to service the South of the UK.

The Tuesday night arrival in Immingham indicates a better timeframe for the trailers headed to Ireland. If moved across the UK overnight, a possible sailing on Wednesday morning from the UK to Ireland is achieved.

The transit of urgent full loads via Sweden is also a possibility, in which case through special rates the extra channel costs can be covered.

The use of rail indicates that the capacity issue is in direct relation with the availability of space for both the sea crossings and rail service.

The opportunity to transport via Sweden is an option for flexibility. It also offers an opportunity for quick connection patterns through driver accompanied transportation. This on the other hand does not make the transfer via Sweden an environmentally friendly solution and adds further costs. In order to satisfy customer needs, there are times when such solutions are necessary. Using Sweden as a gateway to Great Britain is ideal for special delivery contracts, and through the scheduling possibilities is suitable for groupage, part-load and full-load services.

7 CONCLUSIONS

To find one absolute solution for routing traffic is a near impossible task. In order to satisfy the needs of both customers paying for transportation services and the service providers, thorough evaluation of alternative possibilities is necessary. In order to find optimum solutions, complex issues with respect to customer demands and transportation systems behaviour as well as operations plans need in depth consideration.

7.1 Customer demands

The main function of transport is to connect goods and services to consumers. The question within the logistics process is addressed in the length of time it takes for the physical goods to arrive from the placing of the order. This indicates the need for time that transportation takes to make the geographical and time difference. There is also a need to try and narrow the time gap, not only to meet the growing customer demands, but in order to protect the goods from deterioration, damage and theft. The customers' base their decisions with consideration of the entire logistics system in mind.

Transportation plays a crucial role in the logistics system and accounts for the largest portion of the logistics cost, which emphasises the importance of service standards. Successfully implemented transportation services guarantee the fulfilment of the five requirements of logistics; the right product, at the right place, on the right time, with the right service and for the right cost and price.

Customer demands on the other hand determine the carrier criteria. Some of the key service criteria are identified through the reliability of the service, the cost, speed and flexibility of the service. The service criteria or performance measures vary from customer to customer, which in itself poses a problem area to the transportation service provider.

Growing populations, the complexity of trading nations, an increasing wealth of nations and deregulation of transportation all have an impact on the increasing demand for transportation services. This on the other hand contributes immensely to the growing environmental problems on a global, regional and local scale. The emphasis on green logistics is a central issue and subsequently a service criterion for both, the service provider and the customer.

Allocation of an absolute transportation solution that is reliable, environmentally friendly, cost effective, fast and flexible is therefore a challenge. The allocation of routing solutions to support a service performed optimally, to benefit the parties involved, is a complex issue. It must also consider how the service provider can offer the solution and what the cost-benefit-trade off is.

Table 7 demonstrates these findings adequately. No one specific solution ranked the highest in all service criteria under analysis. The key is to find solutions that serve the purpose in the most attractive manner.

7.2 Transportation system behaviour

Although transferring goods from the collection to the final delivery point seems straight forward, numerous activities take place. Immense planning and organisation is required to manage transportation systems and in implementing the physical activities involved.

The planning and organisation, traffic coordination, is challenged as transport service production varies from the production process of goods. Transportation is produced in a continuously changing environment of activities, in which demand fluctuates and failed or disrupted transportation is a challenge to replace and creates excessive costs.

The coordination process of planning, instructing and monitoring is a continuous effort to improve the usage of the physical transportation systems and infrastructure to further advance performance. The traffic coordination requires consideration of integrated components of transport service production, including equipment and information systems, infrastructure and operating activities. The operating activities include coherence in schedule, crew assignment, flow distribution, connection patterns, cost and contingency planning.

Due to the continuously changing environment and increasing customer demands the transportation service production is challenged. It is not a simple process with straight forward solutions to harmonise the operating activities. To allocate a cost effective routing solution to support a transportation service, in which the transportation system behaves in harmony with the required schedule, allows for the desired connection patterns and offers ideal contingency plans with adequate distribution flows and crew assignment is a complex task. Keeping in mind, the service should be environmentally friendly, cost effective, fast and flexible to reach customer satisfaction.

As an example, a look back at the findings of the case study supports these findings. Although transporting via the Netherlands ranked the highest with respect to customer service criteria, see table 7, after a closer study to the operating activities, it was evident that the routing solution does not serve the weekly groupage service optimally, shown in table 13. The scheduling possibilities do not support the connection patterns and therefore service reliability would be jeopardised.

7.3 Environmental responsibility

The growing demand for green logistics and sustainable development in environmentally friendly logistics activities is evident. Through packaging and equipment design, recycling and better know-how, the entire logistics system takes responsibility for the growing environmental problems.

Transportation is one of the largest consumers of energy and creates environmental expenses through congestion, air and noise pollution. Road, rail, water and air transportation can be combined to minimise the environmental impact. Modal service specific characteristics allow for the transportation system to benefit from intermodal networks, supported by infrastructure. This usage of integrated transport promotes policies developed to create greener logistics.

The management and implementation of physical activities in connecting the different modes of transport require careful planning and organisation. The coordination of these physical activities involves cooperation amongst the service providers. A cost effective intermodal transportation system consists of an effort to harmonise operating activities. Scheduling, crew assignment, flow distribution, connection patterns, cost and contingency planning are issues of relevance. The transport service production environment is continuously changing on a larger scale, indicating a bigger challenge to meet the increasing customer demands.

The allocation of a routing solution, supported by adequate infrastructure for a transportation service, particularly sensitive to schedule adherence, is a continuous effort. Weather conditions, engine problems or other unforeseen circumstances contribute to changes in sailing schedules subject to no notice. This alone indicates the importance of continuous evaluation and monitoring of connection patterns.

7.4 Flexibility

As the needs of customers vary, the customer demands change and therefore the need to find tailor made solutions increase. This emphasises the importance of service flexibility whilst maintaining a high quality service standard.

Although the allocation of an absolute routing solution was not achievable, alternatives promote flexibility. An increasingly important service criteria demanded from transportation service providers is flexibility, flexibility to adapt to the changing needs of customer demands.

Numerous options and possibilities add benefit to the service as a whole. Being aware of the alternative solutions and how they behave contributes to the ability to provide tailor made transportation services.

SUMMARY

This study focuses on three topic areas, all central to transportation system operations. Transportation systems are composed of internal and external components, through which the system operations are implemented, monitored and evaluated, as a continuous effort to improve the overall performance.

The first main topic area, function of transport, looks at the conditions that enable customers' choice with respect to carriers. Customers, an external component of transportation systems, determine the demand of service. Without demand, there is no need for supply, and therefore the performance of the service from customers' point of view is a vital source of continuous measurement. These carrier criteria form conditions upon which customers can base decisions with respect to service requirements and standards. These service standards, on the other hand, set the ideal in terms of how the carrier can be judged.

Through the role of transport within the entire logistics process, these carrier criteria can be established. On-time delivery, geographical coverage, shipment tracing, handling of claims and care in handling are some conditions upon which carrier choice is based. It is evident, however, that the emphasis is on conditions that indicate service reliability, fast delivery times and competitive prices. On the other hand, it is also evident that the increasing complexity and wealth of trading nations has led to increasing demands on service standards. This emphasises the need to raise flexibility, improve accuracy, speed and reliability of deliveries.

The second topic area focuses on transport planning. Operating plans, an internal component of transportation systems, determine the performance of the physical activities through which transport services are produced. Transport coordination is the process of planning, instructing and monitoring operating plans. The operation planning is done in accordance with the terms and conditions set in strategic planning, in order to meet long-term objectives. This emphasises the importance of performance measurement of operating plans.

As transportation is produced in a continuously changing environment of activities, where each activity not only adds benefit, but cumulates costs, the importance of profitability calculations is evident. Profitability calculations, however, are not the only operating plan that must be considered in transport

coordination. Scheduling, connection patterns and contingency planning are some operating plans with particular importance in this study.

The third main topic area looks at integrated transports. Integrated transports enable the production of transport services in transportation systems catering for geographical coverage over longer distances. Integrated transport chains are particularly important in international trade, and in general refer to the usage of more than one mode of transportation whilst moving the unit of carriage from its origin to its destination.

This study focuses on intermodal transport chains, indicating that the interchange of the unit of carriage from one mode to another, takes place at a terminal specifically designed for such a purpose. Modal characteristics are identified in order to establish how to benefit from using different modes of transportation. Particular emphasis is on the promotion of green logistics, an increasingly important concept in transport production.

The usage of intermodal transport chains is directly dependant on the infrastructure available to make the geographical coverage. Infrastructure, a physical component of transportation systems, determines how the operating plans are implemented, thus measuring the performance of operators; transport coordinators. On the other hand, the usage of integrated transport chains affects external components of transportation systems; to mention the governments and general public.

After a closer look at the mentioned topic areas, a case study is conducted for a transportation service provider. The focus is on a transportation system that connects goods from Finland to Great Britain. The study identifies routing possibilities, using intermodal transport chains whilst striving to maintain the current level of service.

A transportation systems analysis is conducted to allocate real world alternatives to the routes currently in use. Using combinations of road, rail and sea, intermodal transport chains are allocated. The performance of the alternatives is measured through carrier criteria and operating plans. Cost, speed, reliability and green logistics of the routes is compared to rank the possibilities in order of attractiveness. Real world is abstracted into the equation by implementing operating plans, such as scheduling, connection patterns and contingency planning to identify how the routing alters the performance.

An activity analysis is conducted in order to specify activities for which performance measures are indicated. This process gives a better understanding of cost allocation to channel costs and in depths look at the activities involved. Activity based management is an important concept in transport production, as activity processes form distribution systems.

The overall performance of the routing solutions, after implementing operating plans, is ranked in order of attractiveness. The findings of the study indicate that there is not one absolute solution; rather raised flexibility is gained through allocated options. All the routes rank high in some areas of performance, which indicates a possibility to offer flexible alternatives.

Based on the performance of each route, some recommendations are given on how the transportation system can benefit from its use. It is also evident that the transportation system under analysis is particularly schedule adherent. The schedule adherence indicates the need for constant monitoring, especially in an environment where unforeseen circumstances create the need to alter plans efficiently. The findings of this study emphasise the importance of constant monitoring and evaluation, it is a continuous effort to ensure customer satisfaction and to meet required standards of strategic planning.

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APPENDIX 1

Table 20 – Transport planning in a transportation system

(Table continues to the following page)

Element	**Explanation**	**Example**
Behaviour	Customers make decisions based on transportation service expectations	Delivery time for freight does not meet expectation, eg late delivery, customer looks for alternative solutions
Transportation as part of a broader system	Transport services do not exist in isolation	Legislative, economic, social responsibilities eg environmental issues, regulations, restrictions
Competition	Availability of quality transportation service	Customer chooses alternative service provider for better value or level of service
Vehicle cycle	The flow of vehicles and measuring their cycle	Domestic haulage and distribution; how many trailers are assigned on a particular route at what frequency
Queuing and storage	Waiting for service and storage for freight	How quick is the port accessible and is there space to drop the trailer
Transfers	Intermodal transfers as determinant of service quality and costs	Transfer from road transportation to rail, cost benefit to complete system
Operating policy	Operating policy affects level of service	Customer needs to place the transportation order within a given timeframe or in advance to receive required service
Capacity	Is the capacity in place to meet required level of service	Is there enough tractor units to carry out shunts, or enough labour to deal with requirements, or is there enough space in a trailer – how to allocate capacity when demand is not constant
Supply: Level of service = volume; transportation supply	As volume reaches full capacity, level of service deteriorates	No available bookings in an export vessel, how will the trailer ship out and meet required delivery
Availability of information	Drives system operations and customer choices	Ability to make alternative plans when things do not go accordingly, eg make new vessel bookings
Infrastructure shape	Transportation infrastructure impacts the geo-economic structure	Availability of transportation infrastructure between exporting and importing counterparts
Cost, prices and level of service	Consistency between providing a service, price charged for it and level of service provided	Is the customer satisfied with the service received with respect to shipments
Cost of service	Cost of providing a service	If routing is altered, are the costs involved at the same level
Cost/level of service trade off	Tension for both customer and service provider and between them	Is the customer willing to pay more for a better service eg faster delivery schedule
Demand consolidation	Minimizing costs using demand consolidation	
Lumpy investments	Investments in capacity are often immense	New transportation systems often require bulky investments eg infrastructure
Capacity, cost and level of service	Linkages between capacity, cost and level of service	Operating flexibility; how to allocate resources whilst minimizing costs and keeping the required level of service
Peaking	Temporary peaking in demand	Demand is not always constant, how to allocate adequately eg Friday a busy exporting day in comparison with other days
Demand: Volume= level of service; transportation demand	As volume reaches full capacity; level of service deteriorates	If demand is greater than supply, how to compensate loss of level of service
Multidimensional level of service	Performance measures for level of service are complex; often simplified for analysing purposes	Measuring criteria varies. How to accommodate various needs

Different time scales	Components of transportation systems operate and change in different time scales; short-run – operating policy, medium-run – ownership, long-run – infrastructure	How flexible is the system to the changes internally and externally
Equilibrium	Is it possible to predict volumes, equilibrium for demand and supply	How much customers require trailer space in comparison with availability
Pricing	Pricing of transportation services to entice behaviour and the external impact	How to maintain competitive price levels often affected by external changes and competition eg fuel surcharge
Imbalance in flow	Geographical and temporal imbalances of flow	Does the export trailer numbers correspond with import trailer numbers, can they be worked in combinations
Network behaviour and capacity	Readjustment of flows	How can intermodal transfers be carried out effectively eg transit time required
Transportation, economic development and land use	The relationship among transportation, economic development and location of activities	Is it feasible to build a railway from Finland to Asia through Siberia?
Performance measures	Performance measures shape operations and investment	How efficient and effective is a route, how can it be improved
Balancing centralised with decentralised decisions	Balancing centralised control with decisions made by managers of system components	Who is in charge of what aspect of the system
Vehicle/infrastructure/control system decisions	investment, design and operating decisions	If a railroad is used to link a system, huckaback trailers are required – are they available

Source: Sussman 2000, 59-113

APPENDIX 2

Simplified figures for country specific routing solutions and integrated transport

PART 1

Via DENMARK

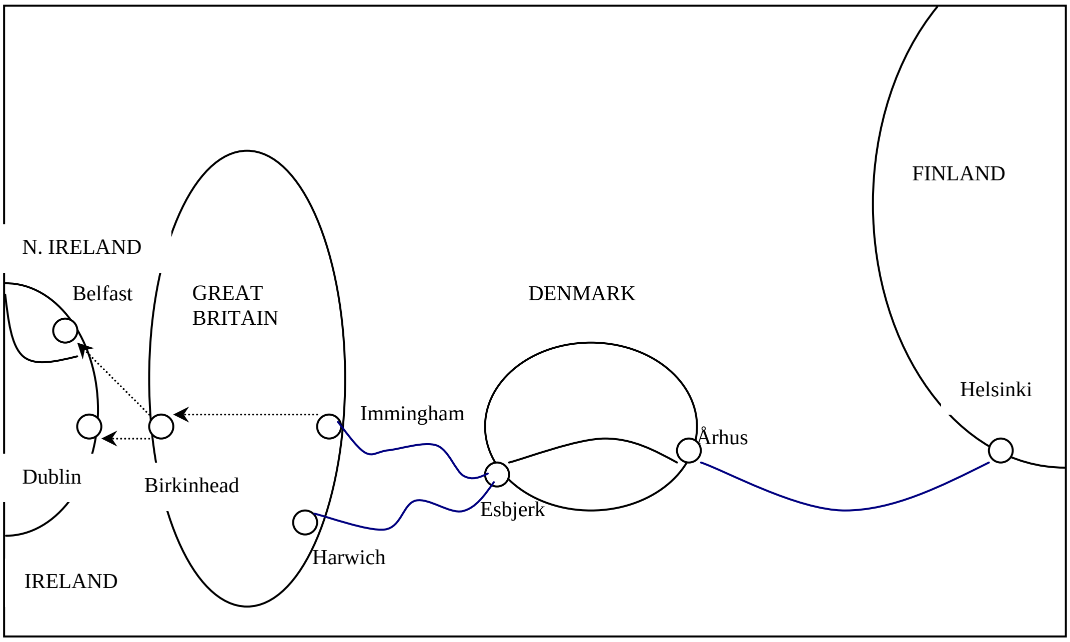


Figure 20 – From Finland to Great Britain via Denmark

(Demonstrates the connection onward to Ireland and Northern Ireland using Great Britain as a gateway)

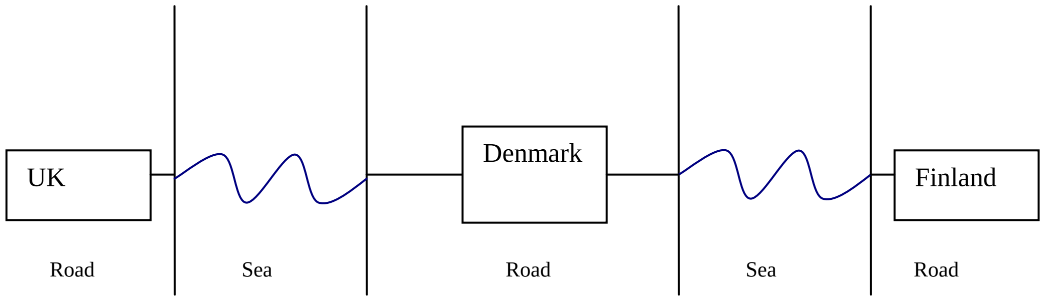
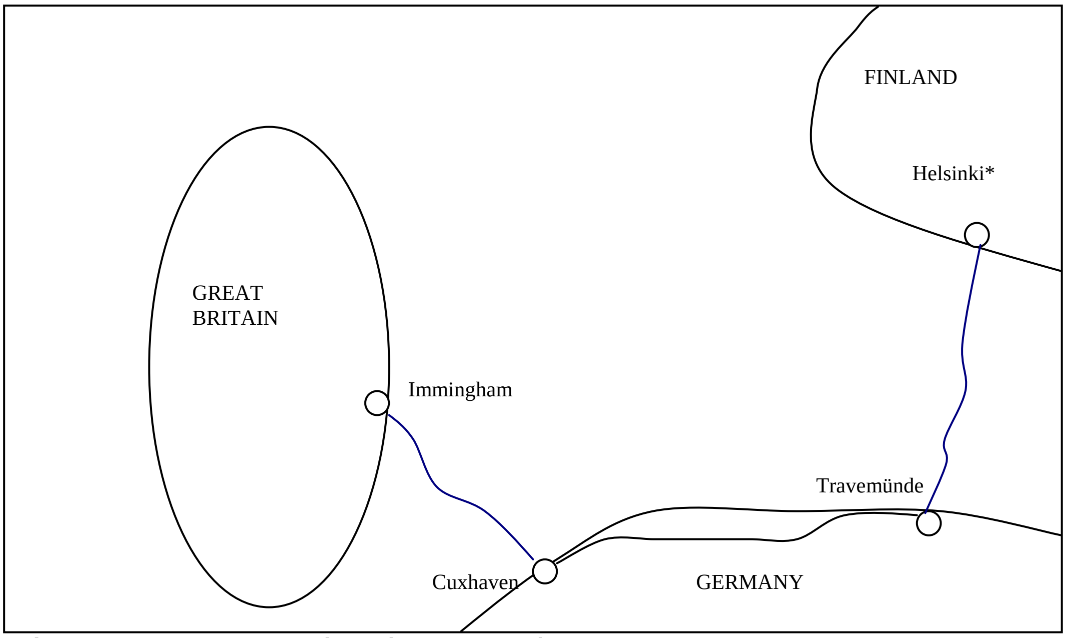


Figure 21 – Integrated transport system via Denmark

PART 2

Via GERMANY



* Alternative exit ports: Hamina, Hanko, Kotka, Rauma & Turku

Figure 22 – From Finland to Great Britain via Germany

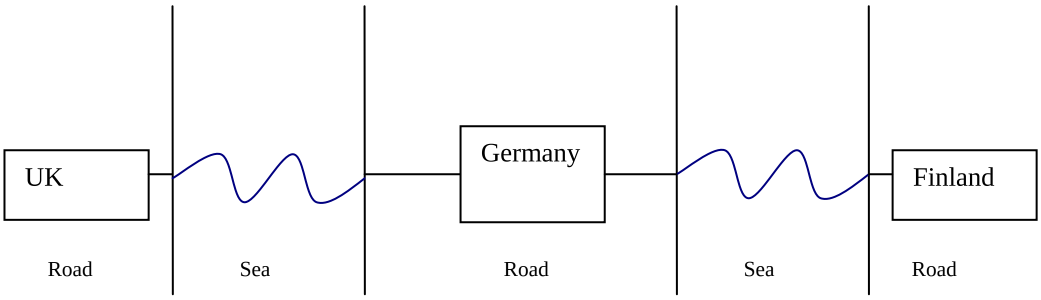
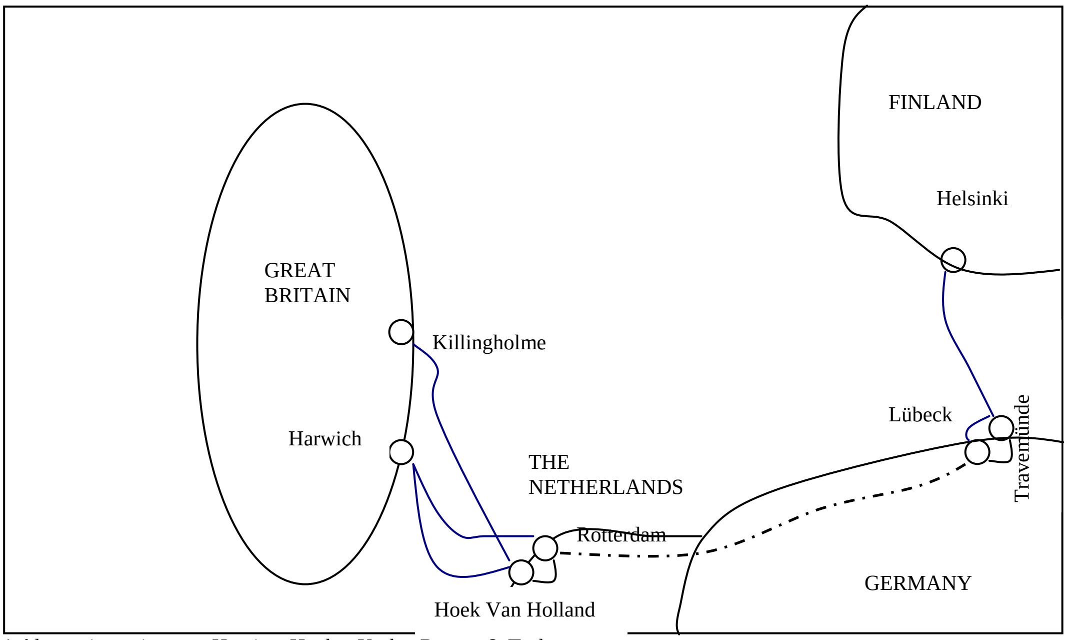


Figure 23 – Integrated transport system via Germany

PART 3

Via The NETHERLANDS



* Alternative exit ports: Hamina, Hanko, Kotka, Rauma & Turku

Figure 24 – From Finland to Great Britain via the Netherlands

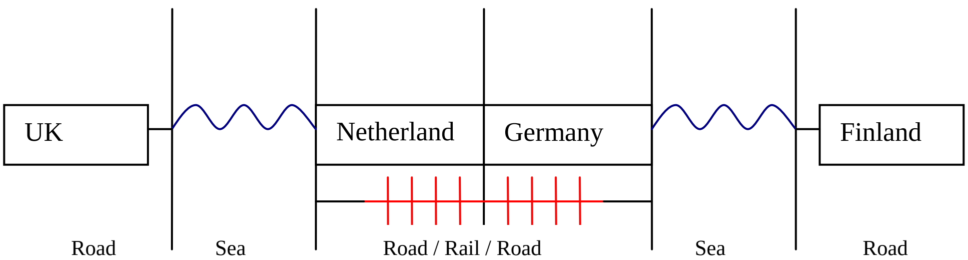
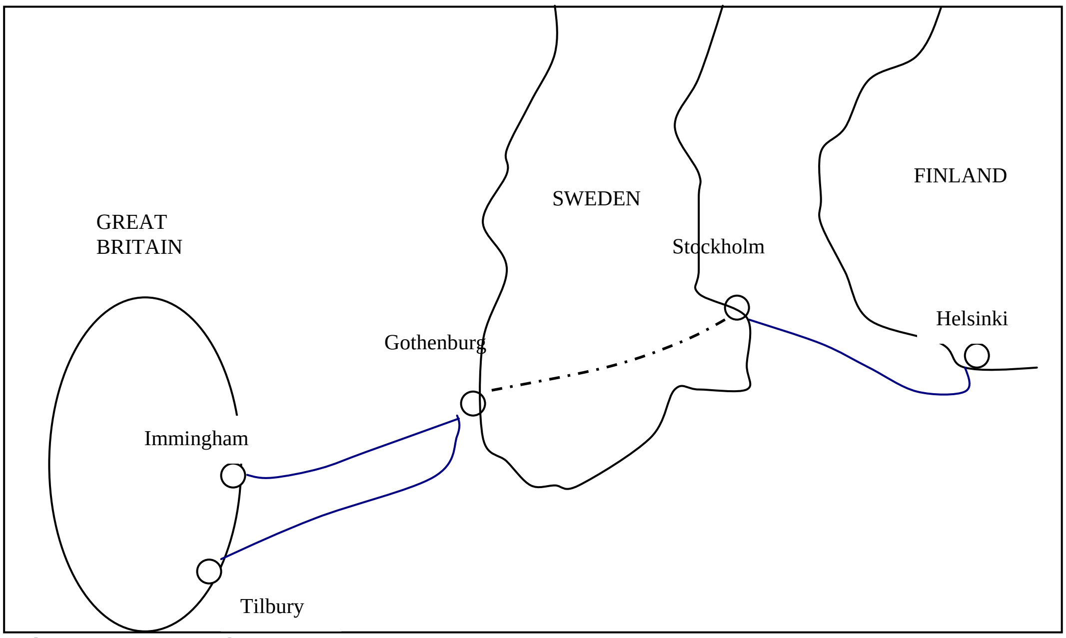


Figure 25 – Integrated transport system via the Netherlands

PART 4

Via SWEDEN



* alternative exit port Turku

Figure 26 – From Finland to Great Britain via Sweden

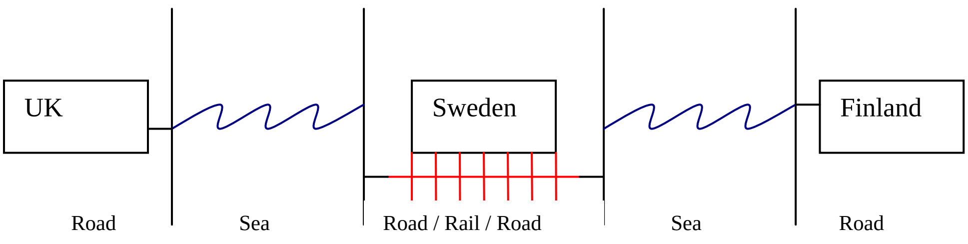


Figure 27 – Integrated transport system via Sweden

APPENDIX 3

Transportation systems analysis
Step 1 Search for real world alternatives

SEPARATE EXCEL SHEET, TABLE 21

APPENDIX 3

TRANSPORTATION SYSTEMS ANALYSIS

Step 1. Search for alternatives in the real world

Table 21 - Real world alternatives

ROAD TRANSPORTATION				SEA CROSSING					ROAD TRANSPORTATION			USE OF RAILROADS		COUNTRY OF PASSAGE	MEASURING CRITERIA			
Departure depot	Port of exit	Distance km	Cost of shunt (€)**	Departure	Arrival	Duration	Service provider	Shipping costs* (€)**	Port of entry	Distance km	Cost of shunt (€)**	From / To	Cost of train* (€)**		Duration of travel time	Duration in days	Total km driven	Total cost (€)**
Vantaa	HAMINA	144 (1h 30 min)	100	Wed 04:00	Sat 10:00	78 h	A	572.92	HULL	47 (45 min)	80.56				80 h 15 min	3.34	191	753.47
Vantaa	HELSINKI Sompa	18 (12 min)	27.78	Tue 18:00	Sat 10:00	88 h	A	572.92	HULL	47 (45 min)	80.56				89 h 03 min	3.71	65	681.25
Vantaa	HELSINKI Sompa	18 (12 min)	27.78	Sun 18:00	Wed 07:00	61 h	A	572.92	HULL	47 (45 min)	80.56				61 h 57 min	2.58	65	681.25
Vantaa	RAUMA	254 (3h 02min)	176.39	Fri 15:00	Mon 07:00	64 h	A	572.92	HULL	47 (45 min)	80.56				67 h 47 min	2.82	301	829.86
Turku	RAUMA	91 (1h 16min)	63.19	Fri 15:00	Mon 07:00	64 h	A	572.92	HULL	47 (45min)	80.56				66 h 01 min	2.75	138	716.67
Vantaa	HAMINA	144 (1h 30 min)	100	Mon 18:00	Fri 06:00	84 h	B	451.39	TILBURY	10 (15 min)	50.35				85 h 45 min	3.57	154	601.74
Vantaa	HAMINA	144 (1h 30 min)	100	Thu 16:00	Mon 06:00	86 h	B	451.39	TILBURY	10 (15 min)	50.35				87 h 45 min	3.66	154	601.74
Vantaa	HANKO	141 (1h 45min)	97.92	Fri 15:30	Mon 06:00	62,5 h	B	451.39	TILBURY	10 (15 min)	50.35				64 h 30 min	2.69	151	599.65
Turku	TURKU Länsi	6 (6min)	17.36	Tue	Fri	90 h	C	409.72	HARWICH	109 (1h 33min)	81.6				91 h 39 min	3.82	115	508.68
Vantaa	TURKU Länsi	169 (1h 51min)	117.36	Tue	Fri	90 h	C	409.72	HARWICH	109 (1h 33min)	81.6			DIRECT	93 h 24 min	3.89	278	608.68
Vantaa	HELSINKI Etelä	21 (15 min)	27.78	17:00	9:30	16,5 h	D	135.42	STOCKHOLM		I	RAIL: Stockholm - Gothenburg / I	208.33					
GOTHENBURG	GOTHENBURG	I		21:00	22:00	25 h	E	312.5	IMMINGHAM	7 (12 min)	13.89				45 h 57 min	1.91	28 + I	697.92
GOTHENBURG	GOTHENBURG	I		Tue,Thu,Sat 19:00	Thu,Sat,Mon 08:00	37 h	E	312.5	TILBURY	10 (15 min)	50.35	4h: 456 km		SWEDEN	58 h	2.42	31 + I	734.38
Vantaa 1.	NAANTALI	181 (2h)	125.69	Several daily departures		7 h	A/F	156.25	KAPELLSKÄR			DRIVER ACCOMPANIED FIN - SE						
Turku 2.	NAANTALI	14 (13min)	27.78	Several daily departures		7 h	A/F	156.25	KAPELLSKÄR					SWEDEN				
Kapellskär	GOTHENBURG	557 (6 h 05min)	298.61	21:00	22:00	25 h	E	312.5	IMMINGHAM	7 (12 min)	13.89			1.	40 h 17 min	1.68	745	906.94
Kapellskär	GOTHENBURG	557 (6 h 05min)	298.61	Tue,Thu,Sat 19:00	Thu,Sat,Mon 08:00	37 h	E	312.5	TILBURY	10 (15 min)	50.35			1.	52 h 20 min	2.18	748	943.4
Kapellskär	GOTHENBURG	557 (6 h 05min)	298.61	21:00	22:00	25 h	E	312.5	IMMINGHAM	7 (12 min)	13.89			2.	38 h 25 min	1.6	578	809.03
Kapellskär	GOTHENBURG	557 (6 h 05min)	298.61	Tue,Thu,Sat 19:00	Thu,Sat,Mon 08:00	37 h	E	312.5	TILBURY	10 (15 min)	50.35			2.	50 h 33 min	2.12	581	845.49
Vantaa	HELSINKI Sompa	18 (12 min)	27.78	Tue 18:00	Thu 07:00	37 h	A	293.4	AARHUS			ROAD: Aarhus - Esbjerk						
Vantaa	HELSINKI Sompa	18 (12min)	27.78	Thu 18:00	Sat 07:00	37 h	A	293.4	AARHUS									
Vantaa	HELSINKI Sompa	18 (12 min)	27.78	Sat 15:00	Mon 07:00	40 h	A	293.4	AARHUS									
AARHUS	ESBJERG	167 (1h 45min)	90.28	Mon - Sat 21:30	Tue - Sun 14:30	17 h	E	131.94	IMMINGHAM	7 (12 min)	13.89				56/59 h 09 min	2,34 / 2,46	192	557.29
AARHUS	ESBJERG	167 (1h 45min)	90.28	Tue, Thu, Sat 18:45	Wed, Fri, Sun 12:00	17 h 15	E	131.94	HARWICH	109 (1h 33min)	81.6			DENMARK	57/60 h 45 min	2,41 / 2,53	294	625
Vantaa 1.	HELSINKI Sompa	18 (12 min)	27.78	Mon - Sat 18:00	Tue - Sun 20:00	26 h	A	314.24	TRAVEMÛNDE	First leg out via Germany & the Netherlands		ROAD: Travemünde - Cuxhaven						
Vantaa	HELSINKI Sompa	18 (12 min)	27.78	Tue, Fri 22:00	Thu, Sun 07:00	33 h	A	314.24	TRAVEMÛNDE									
Vantaa	HELSINKI Sompa	18 (12 min)	27.78	Sun 15:00	Tue 07:00	40 h	A	261.11	TRAVEMÛNDE									
Turku 2.	TURKU Pansio	7 (6 min)	17.36	Thu 21:00	Sat 07:00	34 h	A	261.11	TRAVEMÛNDE									
Turku	TURKU Pansio	7 (6 min)	17.36	Fri 22:00	Sun 07:00	33 h	A	261.11	TRAVEMÛNDE									
Turku	TURKU Pansio	7 (6 min)	17.36	Sat 14:00	Sun 22:00	32 h	A	261.11	TRAVEMÛNDE									
Vantaa 3.	KOTKA	130 (1h 23 min)	90.28	Tue, Thu, Sat 14:00	Thu, Sat, Mon 07:00	41 h	A	261.11	LÛBECK			ROAD: Lübeck - Cuxhaven						
Vantaa 4.	HANKO	141 (1h 45min)	97.92	Mon - Fri 23:00	Wed - Sun 07:00	32 h	B	277.78	LÛBECK									
Vantaa	HANKO	141 (1h 45min)	97.92	Sat 12:00	Sun 19:00	31 h	B	277.78	LÛBECK									
Vantaa	HANKO	141 (1h 45min)	97.92	Sun 12:00	Tue 10:00	46 h	B	277.78	LÛBECK									
Vantaa 5.	HAMINA	144 (1h 30 min)	100	Tue 19:00	Fri 07:00	60 h	B	277.78	LÛBECK									
Vantaa	HAMINA	144 (1h 30 min)	100	Sat 10:00	Mon 07:00	45 h	B	277.78	LÛBECK									
Turku 6.	RAUMA	91 (1h 16min)	63.19	Tue, Sat 10:00	Fri, Mon 07:00	69 h	B	277.78	LÛBECK									
Turku	RAUMA	91 (1h 16min)	63.19	Tue 10:00	Thu 07:00	45 h	B	277.78	ROSTOCK			ROAD: Rostock - Cuxhaven						
Vantaa 7.	HAMINA	144 (1h 30 min)	100	Tue 19:00	Thu 14:00	43 h	B	277.78	ROSTOCK					GERMANY				
TRAVEMÜNDE	CUXHAVEN	224 (3 h 04min)	156.25	Mon 19:00	Tue 16:00	21 h	E	286.46	IMMINGHAM	7 (12 min)	13.89			1.	50 h 28 min	2.1	249	798.61
LÜBECK	CUXHAVEN	208 (2h 57min)	156.25	Tue 19:00	Wed 17:30	22,5 h	E	286.46	IMMINGHAM	7 (12 min)	13.89			2.	58 h 30 min	2.44	238	735.07
ROSTOCK	CUXHAVEN	322 (4h)	156.25	Thu 02:00	Thu 22:00	20 h	E	286.46	IMMINGHAM	7 (12 min)	13.89			3.	67 h 32 min	2.81	345	807.99
	CUXHAVEN			Fri 19:00	Sat 16:00	21 h	E	286.46	IMMINGHAM	7 (12 min)	13.89			4.	59 h 24 min	2.48	356	832.29
	CUXHAVEN			Sat 09:00	Sun 05:00	20 h	E	286.46	IMMINGHAM	7 (12 min)	13.89			5.	84 h 39 min	3.53	359	834.38
	CUXHAVEN						E	286.46	IMMINGHAM	7 (12 min)	13.89			6.	93 h 20 min	3.89	306	797.57
	CUXHAVEN						E	286.46	IMMINGHAM	7 (12 min)	13.89			7.	68 h 42 min	2.86	473	834.38
Same out as with Germany									LÛBECK		H	TRAIN:Lübeck - Rotterdam/ H	125					
ROTTERDAM	HOEK/EUROPOORT	32 (29 min)	34.72	14:45 / 22:00	20:15 / 03:30	5,5 h	G	88.54	HARWICH	109 (1h 33 min)	81.6	562 km (7 h)						
ROTTERDAM	HOEK/EUROPOORT	32 (29 min)	34.72	21:00	7:00	10 h	G	123.96	KILLINGHOLME	2 (04 min)	13.89							
ROTTERDAM	ROTTERDAM		34.72	11:30 / 19:00 / 23:45	18:30 / 01:45 / 06:45	6,5 h	G	88.54	HARWICH	109 (1h 33 min)	81.6			NETHERLANDS				
TRAVEMÜNDE	LÛBECK	18 (20 min)	H											hki-tra-lue-rot-hoek-har-pur	41 h 04 min	1.71	177	644.1
LÜBECK	LÛBECK		H											hki-tra-lue-rot-hoek-kill-imm	44 h 05 min	1.84	70	611.81
														kot-lue-rot-har-pur	57 h 15 min	2.39	239	681.25
														kot-lue-rot-hoek-kill-imm	59 h 56 min	2.5	164	648.96
														ham-lue-rot-har-pur	76 h 33 min	3.19	253	707.64
(€) Costs presented in Index forn**														ham-lue-rot-hoek-kill-imm	79 h 03 min	3.29	178	675.35
Shipping costs* excluding costs that occur at the Port ie handling														han-lue-rot-har-pur	48 h 48 min	2.03	250	705.56
Cost of train* including charges from and to connecting port from railway														han-lue-rot-hoek-kill-imm	51 h 18 min	2.14	175	673.26

Sources: AA Route Planner GB 2007, Andler B. 2007, DFDS Tor Line 2007a, Finnlines 2007a, Hupac Intermodal 2007, Mann Lines 2007a, Route planner and maps of Europe DE & DK 2007a & 2007b, Stena Line 2007a, Suomen Keltaiset Sivut Oy 2007, Tallink Silja 2007a, Transfennica 2007a & Via Michelin route planner SE 2007a

APPENDIX 4

TRANSPORTATION SYSTEMS ANALYSIS

Step 2 - Abstraction of real world into framework

PART 1 Direct

Table 22 – Finland to Great Britain

Departure Depot	Port of Exit	Departure	Arrival	Port of Entry	Arrival Depot	Travel Time/h (days)	Carrier	Driven km	Total Cost (€) Index
Vantaa	Hamina	Wed 04:00	Sat 10:00	Hull	Immingham	80,15 (3,34)	A	191	753.47
Vantaa	Helsinki	Tue 18:00	Sat 10:00	Hull	Immingham	89,03 (3,71)	A	65	681.25
Vantaa	*Helsinki*	*Sun 18:00*	*Wed 07:00*	*Hull*	*Immingham*	*61,57 (2,58)*	*A*	*65*	*681.25*
Vantaa	Rauma	Fri 15:00	Mon 07:00	Hull	Immingham	67,47 (2,82)	A	301	829.86
Turku	*Rauma*	*Fri 15:00*	*Mon 07:00*	*Hull*	*Immingham*	*66,01 (2,75)*	*A*	*138*	*716.67*
Vantaa	Hamina	Mon 18:00	Fri 06:00	Tilbury	Purfleet	85,45 (3,57)	B	154	601.74
Vantaa	Hamina	Thu 16:00	Mon 06:00	Tilbury	Purfleet	87,45 (3,66)	B	154	601.74
Vantaa	*Hanko*	*Fri 15:30*	*Mon 06:00*	*Tilbury*	*Purfleet*	*64,30 (2,69)*	*B*	*151*	*599.65*
Turku	Turku	Tue	Fri	Harwich	Purfleet	91,39 (3,82)	C	115	508.68
Vantaa	Turku	Tue	Fri	Harwich	Purfleet	93,24 (3,89)	C	278	608.68

Source: Finnlines (2007b), Mann Lines (2007) & Transfennica (2007b)

PART 2 Denmark

Table 23 – Finland to Great Britain via Denmark

departure depot	port of exit	departure	arrival	port of entry	arrival depot	travel time/h (days)	carrier	driven km	total cost (€) Index
1. & 2. Vantaa	Helsinki	Thu 18:00	Sat 07:00	Århus			A		
1.(Århus)	Esbjerg	Sat 18:45	Sun 12:00	Harwich	Purfleet	57,45 (2,41)	E	294	625
3. Vantaa	*Helsinki*	*Sat 15:00*	*Mon 07:00*	*Århus*			*A*		
2. & 3. (Århus)	*Esbjerg*	*Mon 21:30*	*Tue 14:30*	*Immingham*	*Immingham*	*59,09 (2,46)*	*E*	*192*	*557.29*
Next connection to Harwich from Esbjerg									
	Esbjerg	Tue 18:45	Wed 12:00	Harwich			E		
Next connection to Immingham from Esbjerg									
	Esbjerg	Tue 21:30	Wed 14:30	Immingham			E		

Source: DFDS Tor Line (2007b) & Finnlines (2007c)

PART 3 Germany

Table 24 – Finland to Great Britain via Germany

departure depot	port of exit	departure	arrival	port of entry	arrival depot	travel time/h (days)	carrier	driven km	total cost (€) Index
1. Vantaa	Helsinki	Thu 18:00	Fri 20:00	Travemünde			A		
1.(Travemünde)	Cuxhaven	Sat 09:00	Sun 05:00	Immingham	Immingham	50,28 (2,1)	E	249	798.61
2. Vantaa	**Helsinki**	**Fri 18:00**	Sat 20:00	Travemünde			A		
2.(Travemünde)	Cuxhaven	Mon 19:00	Tue 16:00	Immingham	Immingham	51,28 (2,14)	E	249	798.61
3. Vantaa	**Helsinki**	**Fri 22:00**	Sun 07:00	Travemünde			A		
3.(Travemünde)	Cuxhaven	Mon 19:00	Tue 16:00	Immingham	Immingham	58,28 (2,43)	E	249	798.61
4. Vantaa	**Helsinki**	**Sat 18:00**	Sun 20:00	Travemünde			A		
4.(Travemünde)	Cuxhaven	Mon 19:00	Tue 16:00	Immingham	Immingham	51,28 (2,14)	E	249	798.61
5. Vantaa	Kotka	Sat 14:00	Mon 07:00	Lübeck			A		
5.(Lübeck)	Cuxhaven	Mon 19:00	Tue 16:00	Immingham	Immingham	67,32 (2,81)	E	345	807.99
6. Vantaa	Hanko	Fri 23:00	Sun 07:00	Lübeck			B		
6.(Lübeck)	Cuxhaven	Mon 19:00	Tue 16:00	Immingham	Immingham	59,24 (2,48)	E	356	832.29
7. Vantaa	Hanko	Sat 12:00	Sun 19:00	Lübeck			B		
7.(Lübeck)	Cuxhaven	Mon 19:00	Tue 16:00	Immingham	Immingham	58,24 (2,43)	E	356	832.29
8. Vantaa	Hamina	Sat 10:00	Mon 07:00	Lübeck			B		
8.(Lübeck)	Cuxhaven	Mon 19:00	Tue 16:00	Immingham	Immingham	69,39 (2,89)	E	359	834.38
9. Turku	Turku	Thu 21:00	Sat 07:00	Travemünde			A		
9.(Travemünde)	Cuxhaven	Mon 19:00	Tue 16:00	Immingham	Immingham	58,30 (2,44)	E	238	735.07
10. Turku	**Turku**	**Fri 22:00**	Sun 07:00	Travemünde			A		
10.(Travemünde)	Cuxhaven	Mon 19:00	Tue 16:00	Immingham	Immingham	57,30 (2,39)	E	238	735.07
11. Turku	**Turku**	**Sat 14:00**	Sun 22:00	Travemünde			A		
11.(Travemünde)	Cuxhaven	Mon 19:00	Tue 16:00	Immingham	Immingham	56,30 (2,35)	E	238	735.07
12. Turku	**Rauma**	**Sat 10:00**	Mon 07:00	Lübeck			B		
12.(Lübeck)	Cuxhaven	Mon 19:00	Tue 16:00	Immingham	Immingham	69,39 (2,89)	E	306	797.57
Next connection to Immingham from Cuxhaven									
	Cuxhaven	Tue 19:00	Wed 17:30	Immingham			E		

Source: DFDS Tor Line (2007c), Finnlines (2007d) & Transfennica (2007c)

PART 4 The Netherlands (table continues to the following page)

Table 25 – Finland to Great Britain via the Netherlands

departure depot	port of exit	departure	arrival	port of entry	arrival depot	travel time/h (days)	carrier	driven km	total cost (€)Index
1., 2. & 3. Vantaa	Helsinki	Thu 18:00	Fri 20:00	Travemünde			A		
1., 2. & 3. (Travemünde)	Lübeck	Sat 19:30	Sun 07:00	Rotterdam			H		
1.(Rotterdam)	Rotterdam	Sun 11:30	Sun 18:30	Harwich	Purfleet	40,6 (1,69)	G	145	671.88
2.(Rotterdam)	Hoek van Holland	Sun 14:45	Sun 20:15	Harwich	Purfleet	41,04 (1,71)	G	177	671.88
3.(Rotterdam)	Hoek van Holland	Sun 21:00	Mon 07:00	Killingholme	Immingham	44,05 (1,84)	G	70	639.58
4., 5. & 6. Vantaa	**Helsinki**	**Fri 18:00**	Sat 20:00	Travemünde			A		
4., 5. & 6. (Travemünde)	Lübeck	Tue 19:30	Wed 11:00	Rotterdam			H		
4.(Rotterdam)	Rotterdam	Wed 19:00	Thu 01:45	Harwich	Purfleet	44,6 (1,86)	G	145	671.88
5.(Rotterdam)	Hoek van Holland	Wed 14:45	Wed 20:15	Harwich	Purfleet	45,04 (1,88)	G	177	671.88
6.(Rotterdam)	Hoek van Holland	Wed 21:00	Thu 07:00	Killingholme	Immingham	48,05 (2,0)	G	70	639.58
7., 8. & 9. Vantaa	**Helsinki**	**Fri 22:00**	Sun 07:00	Travemünde			A		
7., 8. & 9. (Travemünde)	Lübeck	Tue 19:30	Wed 11:00	Rotterdam			H		
7.(Rotterdam)	Rotterdam	Wed 19:00	Thu 01:45	Harwich	Purfleet	51,6 (2,15)	G	145	671.88
8.(Rotterdam)	Hoek van Holland	Wed 14:45	Wed 20:15	Harwich	Purfleet	52,04 (2,17)	G	177	671.88
9.(Rotterdam)	Hoek van Holland	Wed 21:00	Thu 07:00	Killingholme	Immingham	55,05 (2,29)	G	70	639.58
10., 11. & 12. Vantaa	**Helsinki**	**Sat 18:00**	Sun 20:00	Travemünde			A		
10.,11. & 12. (Travemünde)	Lübeck	Tue 19:30	Wed 11:00	Rotterdam			H		
10.(Rotterdam)	Rotterdam	Wed 19:00	Thu 01:45	Harwich	Purfleet	40,6 (1,69)	G	145	671.88
11.(Rotterdam)	Hoek van Holland	Wed 14:45	Wed 20:15	Harwich	Purfleet	41,04 (1,71)	G	177	671.88
12.(Rotterdam)	Hoek van Holland	Wed 21:00	Thu 07:00	Killingholme	Immingham	44,05 (1,84)	G	70	639.58
13., 14 & 15. Vantaa	Kotka	Sat 14:00	Mon 07:00	Lübeck			A		
13., 14. & 15. (Lübeck)	Lübeck	Tue 19:30	Wed 11:00	Rotterdam			H		
13.(Rotterdam)	Rotterdam	Wed 19:00	Thu 01:45	Harwich	Purfleet	57,92 (2,41)	G	239	681.25
14.(Rotterdam)	Hoek van Holland	Wed 14:45	Wed 20:15	Harwich	Purfleet	57,15 (2,39)	G	271	681.25
15.(Rotterdam)	Hoek van Holland	Wed 21:00	Thu 07:00	Killingholme	Immingham	59,56 (2,5)	G	164	648.96
16., 17. & 18. Vantaa	Hanko	Fri 23:00	Sun 07:00	Lübeck			B		
16., 17. & 18. (Lübeck)	Lübeck	Tue 19:30	Wed 11:00	Rotterdam			H		
16.(Rotterdam)	Rotterdam	Wed 19:00	Thu 01:45	Harwich	Purfleet	48,48 (2,03)	G	250	705.56
17.(Rotterdam)	Hoek van Holland	Wed 14:45	Wed 20:15	Harwich	Purfleet	48,17 (2,01)	G	282	705.56
18.(Rotterdam)	Hoek van Holland	Wed 21:00	Thu 07:00	Killingholme	Immingham	51,18 (2,14)	G	175	673.26
19., 20. & 21. Vantaa	Hanko	Sat 12:00	Sun 19:00	Lübeck			B		

19., 20. & 21. (Lübeck)	Lübeck	Tue 19:30	Wed 11:00	Rotterdam			H		
19.(Rotterdam)	Rotterdam	Wed 19:00	Thu 01:45	Harwich	Purfleet	47,48 (1,98)	G	250	705.56
20.(Rotterdam)	Hoek van Holland	Wed 14:45	Wed 20:15	Harwich	Purfleet	47,17 (1,97)	G	282	705.56
21.(Rotterdam)	Hoek van Holland	Wed 21:00	Thu 07:00	Killingholme	Immingham	50,18 (2,09)	G	175	673.26
22., 23. & 24. Vantaa	Hamina	Sat 10:00	Mon 07:00	Lübeck			B		
22., 23. & 24. (Lübeck)	Lübeck	Tue 19:30	Wed 11:00	Rotterdam			H		
22.(Rotterdam)	Rotterdam	Wed 19:00	Thu 01:45	Harwich	Purfleet	76,33 (3,19)	G	253	707.64
23.(Rotterdam)	Hoek van Holland	Wed 14:45	Wed 20:15	Harwich	Purfleet	76,02 (3,17)	G	285	707.64
24.(Rotterdam)	Hoek van Holland	Wed 21:00	Thu 07:00	Killingholme	Immingham	79,03 (3,29)	G	178	675.35
Next connection to Rotterdam from Lübeck									
	Lübeck	Wed 19:30	Thu 11:00	Rotterdam			H		
Next connection to Harwich/Killingholme from Rotterdam/Hoek van Holland									
	Rotterdam	Daily 14:45 22:00	20:15 03:30	Harwich			G		
	Hoek van Holland	11:30 19:00 23:45	18:30 01:45 06:45	Harwich			G		
	Hoek van Holland	21:00	07:00	Killingholme			G		

Source: Finnlines (2007d), Hupac Intermodal (2007), Stena Line (2007a) & Transfennica (2007c)

PART 5 Sweden

Table 26 – Finland to Great Britain via Sweden

departure depot	port of exit	departure	arrival	port of entry	arrival depot	travel time/h (days)	carrier	driven km	total cost (€) Index
Vantaa	Helsinki	Thu 17:00	Fri 9:30	Stockholm			D		
(Stockholm)	Stockholm	Fri night	Sat am	Gothenburg			I		
1. (Gothenburg)	Gothenburg	Sat 19:00	Mon 08:00	Tilbury	Purfleet	58 (2,42)	E	31*	734.38
2. (Gothenburg)	Gothenburg	Sat 21:00	Sun 22:00	Immingham	Immingham	45,57 (1,91)	E	28*	697.92
Vantaa	*Helsinki*	*Fri 17:00*	*Sat 9:30*	*Stockholm*			*D*		
(Stockholm)	*Stockholm*	*Sat night*	*Sun am*	*Gothenburg*			*I*		
3. (Gothenburg)	*Gothenburg*	*Mon 21:00*	*Tue 22:00*	*Immingham*	*Immingham*	*45,57 (1,91)*	*E*	*28**	*697.92*
Next connection to Gothenburg from Stockholm									
	Stockholm	Daily *overnight*	am	Gothenburg			I		
Next connection to Tilbury from Gothenburg									
	Gothenburg	Tue 19:00	Thu 08:00	Tilbury			E		
Next connection to Immingham from Gothenburg									
	Gothenburg	Daily 21:00	Next day 22:00	Immingham			E		

* excludes km from and to ports from railway, *overnight*- use of rail services by night despite frequent schedule

Source: DFDS Tor Line (2007d), SJ (2007) & Tallink Silja (2007)