

Development of the Short Sea Shuttle Concept

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Preface

This is the final report of the Short Sea Shuttles pre-study project. The work has been supported by Västra Götalandsregionen, Trafikverket and Logistik- och Transportstiftelsen LTS, which are all gratefully acknowledged. The purpose of the study is to develop and define a well-integrated container shipping concept – The Short Sea Shuttle Concept – that involves transportation of containers between a number of ports and a hub port with functional inland connections, fixed schedules, and high reliability and departure frequency. The work has been carried out jointly by Chalmers University of Technology, IVL Swedish Research Institute and University of Gothenburg.

The work has significantly benefited from the assistance of several persons. We want to express our sincere thanks to Professor Kaj Ringsberg, Rolf Thor at the Västra Götalandsregionen, Tomas Arvidsson at Trafikverket and Bengt Wennerberg at Logistik och Transportstiftelsen LTS for the support and the ideas, and for making this project possible. Our thanks also to our three master students at Chalmers University of Technology: Olle Engström, Robert Beach and Haiyang Liu, who carried out many of the interviews.

Göteborg, December 2013

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Summary

Efficient short sea shipping is vital for trade and industry in Northern Europe. About 90% of the volume of goods exported or imported to Sweden is transported by ships in at least one part of the transport chain. It is therefore important to find cost-effective solutions for shipping in order to improve the global availability of goods in Northern Europe and to reduce the environmental impact caused by the transport industry.

The growing importance of shipping has been highlighted in various contexts, such as the Swedish Transport Administration's capacity investigation from 2012 and in the white paper on transport from the European Commission from 2011. Both reports stress the need to shift larger volumes of cargo from the land-based infrastructure to sea. Although the traffic on the Swedish rail-network has seen very positive developments in the last few years, the same is now challenged by lack of capacity and traffic disturbances.

The purpose of this study is to develop and define a container shipping concept – The Short Sea Shuttle Concept. The concept involves transport of containers between a number of ports and a hub port with functional inland connections, fixed schedules, and high reliability and departure frequency. Punctuality and high frequency are essential factors for the shuttles, as it allows a transfer of more time-sensitive cargo to sea, which currently is transported by other modes. The increased importance of shipping in a future transport system means that there are great demands on efficiency, sustainability and economic stability. This research is limited to the transport of maritime containers, but the concept can be applicable to other types of goods and standardised load units. The focus in this report is on the development of the concept for transport of cargo within, to and from Sweden. An implementation of a system of short sea shipping links will bring preparedness for further capacity problems in railway and road infrastructures and will also open up new markets.

The Short Sea Shuttle Concept is defined as:

"High-frequency short sea liner shipping of standardised load units that is highly integrated into transport chains with functional inland connections."

The Short Sea Shuttles will be an integrated part of a longer transport chain, requiring a connection to the existing road and railway systems and deep sea services, see Figure 1. This allows transport buyers to get better access to their global markets and facilitates adaption of their logistics systems and better planning. If possible, the Short Sea Shuttles links will be established on routes where they can function as a complement to rail. In the context of Scandinavia, this potential would be especially interesting for the extension of existing rail shuttles to Port of Gothenburg with sea links connecting countries and regions surrounding the Baltic Sea and the North Sea. This would also contribute to create seamless intermodal transport solutions combining both rail and sea links. The Short Sea Shuttle can operate between two ports if the cargo flow is high enough. There are also cases where it calls a string of few ports to collect enough cargo.

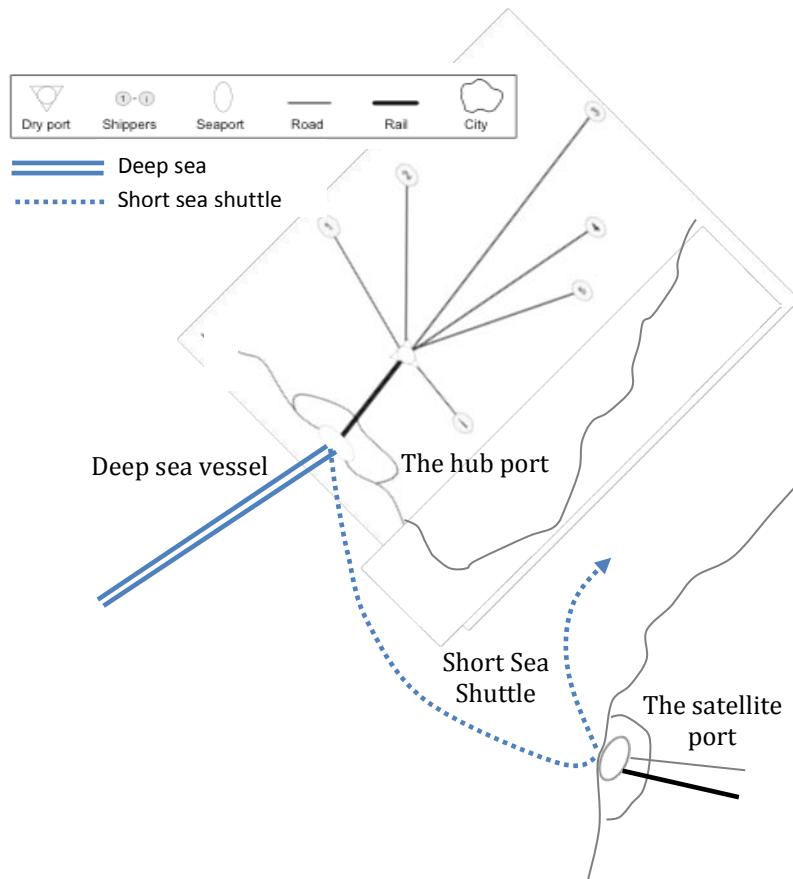


Figure 1: Conceptual outline of the Short Sea Shuttles, connected to a dry port from the hub port.

Goods transport is highly contextual and different segments serve shippers with quite diverse demand patterns. The Short Sea Shuttles aim at combining *intra-regional flows* of goods loaded in containers with *flows of containers as part of deep sea shipping*, which somewhat limits the scope of transport demands that need to be fulfilled. The estimated potential volumes should not be interpreted as “added” to the existing system of feeder services, since most of these volumes are already using the respective ports for transhipment. However, a modal shift from land based transport is expected to some extent. Further, the increasing containerisation of world commodity trade implies that the container transport in Northern Europe will also increase further in the future.

The starting point of the development of the Short Sea Shuttles is the rail shuttles and conventional feeders. The idea is to combine the two concepts to suggest a shipping concept that is more integrated in the transport chain and has higher reliability than a conventional feeder. The main difference from the current container feeder services is the demand for stricter schedules, higher frequencies and greater stability over time. The Short Sea Shuttle Concept has also been influenced by the railway shuttle system successfully implemented by the Port of Gothenburg during the past decade. Currently, the Port of Gothenburg has 26 shuttle trains running daily or weekly to/from different inland destinations in Sweden. Table 1 shows the differences and similarities between Short Sea Shuttles, rail shuttles and conventional feeder services.

Table 1: The different characteristics of Short Sea Shuttles, rail shuttles and conventional feeder services.

	Short Sea Shuttle	Rail shuttle	Conventional feeder
Timetable	Fixed	Fixed	Semi-fixed, but with short-term changes / adjustments
Frequency	At least 1/week	Up to several times/week	Varies
Punctuality	High, deviation up to 1 hour	High, deviation up to 1 hour	Low, deviation up to day/s
Time perspective	Longer, months to years	Longer, months to years	Shorter, weeks to months
Transport chain integration	High	High	Low-medium

Required departure frequency and vessel capacity utilisation, means that the size of the vessels cannot be too large. Considering the market potential in Northern Europe sizes from 350 up to 1000 TEU will be suitable on most routes. However, larger or smaller cargo volumes in some regions mean that some deviations from this suggestion can be suitable.

Comparison of similar concepts around the world indicated that none of the investigated existing shipping services covers all the features theoretically required for the Short Sea Shuttle Concept. However, all of the studied services have some characteristics in common with the suggested concept, such as schedule frequency, level of integration, types of vessels or types of goods transported.

Implementing the Short Sea Shuttle Concept affects a multitude of stakeholders with somewhat diverging interests. Whether the costs and benefits of introducing the change are unevenly distributed between the stakeholders, or decision-making in the different organisations is badly synchronised, changes never come easily. It is assumed that it is most likely that the shuttle services will be offered by the incumbent feeder shipping operators or as part of the capillary network controlled by the deep sea shipping lines. The Short Sea Shuttle Concept also creates opportunities for new business models. Coordination related to the concept is thus focused on both the operational and the commercial level.

Initial analysis of market conditions for the implementation of the concept has identified three main potential international segments for the Short Sea Shuttle Concept:

- 1) For the Norway-Sweden-Denmark route, the potential container volumes could be as much as 100 000-300 000 TEU/year
- 2) For the Sweden-Finland-Russia connection, annual goods volumes could account for as much as 1 million TEU per year
- 3) Sweden-Baltic states. This is the market segment most difficult to estimate since the hinterland connections that could be utilised are limited. However, annual volumes would probably be less than 100 000 TEU/year.

A deeper analysis of the suggested three services is not included in this project. Case studies of the three shipping services are suggested for future research. It would have been very interesting to investigate their potential from logistics, economic and environmental aspects. This work would benefit from cooperation between researchers and potential operators in order to get better information about costs aspects and to facilitate an implementation.

The main advantages of the Short Sea Shuttles Concept are lower costs for shippers, potential lower emissions and available infrastructure and vessel capacity. However, even though waterborne transport is often viewed as an environmentally friendly alternative to road transport, and despite the large potential benefits that the Short Sea Shuttles would bring to the transport system, the concept faces challenges. These are foremost related to the high costs of bunker fuel and port charges and start-up risks; new regulations and environmental charges are not negligible either. For example, implementation of the SO_x Emission Control Area (SECA) in the North and Baltic Seas involves stricter limits for sulphur in marine fuel, which means a higher cost for bunkering. As a consequence, slight decrease in waterborne transport is expected. Stricter environmental regulations are important to accomplish significant reductions in emissions from shipping, but need to be combined with a wish to move cargo from land to sea. The concept of Short Sea Shuttles also puts special requirements on fast and efficient transhipment between sea and rail which many of the smaller ports do not have. There are techniques available that could be implemented to overcome this problem. Another problem related to infrastructure is capacity deficiencies around port cities. This implies that there is a risk of delays and longer transport times that need to be reconciled. Congestion and capacity deficiencies are, however, not only an issue for the Short Sea Shuttles, but rather an issue for the whole transport system.

To summarize, the potential associated with the Short Sea Shuttle Concept is substantial. Nevertheless, implementation of the concept is a challenge in many aspects, such as costs, start-up risks, number of actors, and low goods volumes. Because of the many different stakeholders involved, a coordinator to facilitate and manage the collaboration and long-term ambitions of a Short Sea Shuttle service is probably needed. Government support at the regional, national and supra-national level is probably needed in the first stage, but the concept needs to be independent and solid after the start-up phase.

1. Introduction

This chapter offers a brief background to the ideas behind the concept and present the purpose and scope of the research, as well as the methodology. The methodology is based on a combination of literature reviews, interviews with stakeholders and workshop discussions at reference group meetings.

1.1 Background to the idea of the Short Sea Shuttle Concept

There are a number of reasons for developing waterborne transport in Northern Europe. The primary reason is a belief in the seas as potential infrastructures to create a more efficient European transport network. The increase in rail transport, especially for personal travel, has resulted in an incipient risk of traffic disruptions. In some relationships, inadequate rail and road capacity is already a significant concern, with an increasing risk of traffic congestions. According to the Swedish Transport Administration's capacity investigation (Trafikverket, 2012), these problems can partly be handled by shifting more cargo to sea and creating a more efficient transport system as a whole. Furthermore, the European Commission has for several years had an active policy promoting short sea transport in order reach the EU's sustainability targets for the transport sector, because shipping is energy efficient per transported unit and is able to solve traffic congestions. In the latest EU White Paper on transport (European Commission, 2011), there is a clear focus on the transfer of cargo from road to rail and sea.

The idea is to develop short sea shipping by introducing Short Sea Shuttles that can offer a cost-efficient shipping alternative for customers in the region. The overall aim is to improve transport and trade in Northern Europe by better integrating the countries around the Baltic Sea and part of the North Sea. It is suggested that the Short Sea Shuttle links will have good hinterland connections and will be established on routes where they can function as a complement to rail. This will bring preparedness for future capacity problems in railway and road infrastructures and will also open up new markets. The shuttle concept has been developed in close cooperation with the Port of Gothenburg and the container terminal in Gothenburg, APM Terminals. The Port of Gothenburg will function as a hub port in this study, where the short sea shipping links will complement the existing rail shuttles in the so called Railport-system that the port has successfully implemented. The Port of Gothenburg has several transoceanic direct calls, and efficient distribution of goods to and from the area would mean an improved global availability of goods in the whole of Sweden.

1.2 Purpose and scope

The purpose of this project is to develop Short Sea Shuttles as a complement to existing land-based and waterborne transport services that aim at more cost-efficient, reliable and sustainable transport in Northern Europe. The work has been carried out in close cooperation with the port and shipping industries in order to get valuable input from

industry and to facilitate a future implementation of the shuttles. The focus of the project is on the development of the concept for transport within, to and from Sweden.

Short Sea Shuttles will better integrate the countries around the Baltic Sea and part of the North Sea and are aiming at improving transport and trade in Northern Europe. A successful implementation of the shuttles would also mean that road transport in Southern and Western Sweden can be reduced. Intermodal transport is a mature concept but has not reached its full market potential in all markets. Therefore, better coordination between different modes of transport need to be given higher priority.

Despite its advantages, one can ask why short sea shipping has not yet been developed to its full potential in Northern Europe. In order to be profitable, a shipping service requires critical cargo volumes, so the fixed costs can be distributed over a larger number of units. Well-developed shipping services are of great importance for the creation of an efficient transport system and to accumulate more goods in the port in order to achieve economies of scale in the port activities. Realisation of the Short Sea Shuttles Concept implies that new markets can be opened up and that future capacity shortage in rail and road infrastructure can be handled. In addition, the integration of the sea shuttles with existing dry ports will lead to a gradual development of the "motorways of the sea".

1.3 Methodology

The literature review, together with stakeholder interviews and discussions at reference group meetings, resulted in the description of the Short Sea Shuttle Concept and its benefits for the actors of the transport system.

1.3.1 Literature review

Literature studies have been carried out throughout the research period with the purpose of identifying the state of research and areas of interest for further investigation. A broad literature review on the subjects of transport networks, intermodal transport, short sea shipping and dry ports was carried out initially, followed by an examination of reports and investigation on market potential, infrastructure requirements, new regulation, etc.

1.3.2 Interviews

In this study, the Port of Gothenburg has been chosen as a hub port for further investigations. The selection is due to its potential for development of the Short Sea Shuttles Concept and the port's success in connecting hinterland by rail.

Data was collected primarily through face-to-face interviews with various stakeholders representing different actors of the transport system of relevance for the research, such as port authorities, port terminal managers, shipping lines, shippers, etc. Semi-structured, open-ended interviews were chosen as the most appropriate method to explore the issues, as it allowed the interviewees to introduce new issues and the interviewer to follow up on topics more fully. In accordance with recommendations by Stuart et al. (2002), a case study protocol consisting of a semi-structured interview, based on a research question, was

developed in order to insure reliability. During the interview, the interviewer recapped what the interviewees had said, inviting them to develop their original statements. Some additional phone interviews as well as e-mail correspondence were carried out in order to fill the gaps. The interviews were recorded and transcribed.

In order to ensure validity, triangulation with multiple means of data collection (Voss et al., 2002; Stuart et al 2002) was also carried out. Thus, apart from having interviewees from different transport sectors, secondary data sources were used, such as internal company reports, Internet based documents and archival records. The interviews were also followed by site visits. The following companies were interviewed:

- GAC Sweden
- Green Consulting Group AB
- Joship – agent for CSAV
- Maritime Insight
- NYK Group Europe Ltd – Scandinavia
- Port of Gothenburg
- Port of Tallinn
- Stora Enso
- Unifeeder Sweden

1.3.3 Reference group meetings

A workshop on the Short Sea Shuttle Concept was carried out at Chalmers University of Technology at the first reference group meeting on February 26th 2013. The workshop started with general questions such as: What are the major characteristics of the Short Sea Shuttles? What are the major expected functions? What type of cargo is suitable? Is the Short Sea Shuttle Concept a potential solution to relieve the land based transport system? What would implementation of the concept mean to the respective stakeholders? The workshop ended with the development of a preliminary SWOT chart that was further developed after interviews and literature reviews. This method identifies positives and negatives inside an organisation (Strengths - Weaknesses) and outside of it, in the external environment (Opportunities - Threats). SWOT analysis is used by businesses and organisations for improved understanding and decision-making in different kind of situations. The SWOT-analysis is presented in Chapter 5.2 Critical parameters for the introduction of the Short Sea Shuttles. The discussion continued at the second reference group meeting on the 21st of May 2013.

Finally, preliminary results and the draft final report were discussed at the last reference group meeting on the 26th of November 2013. The comments from the group were included in the final report.

The participants in the workshops were a combination of researchers, practitioners, and actors of the transport system or potential customers. The following persons participated in one or more workshops:

- Viktor Allgurén, Port of Gothenburg
- Tomas Arvidsson, Trafikverket
- Robert Beach, Chalmers (Chalmers master student)
- Christian Bergman, Region Västra Götaland
- Rickard Bergqvist, University of Gothenburg
- Olle Engström, Chalmers (Chalmers master student)
- Erik Fridell, IVL Swedish Environmental Research Institute
- Lars Green, Maritime Forum
- Hans Gutsch, APM Terminals
- Mickael Hägg, Chalmers/Lighthouse
- Joakim Kalantari, SSPA
- Mats Kjellgren, Volvo Logistics
- Haiyang Liu, Chalmers (Chalmers master student)
- Kent Lumsden, Chalmers
- Per Gisle Rekdal, Port of Oslo
- Lars Rexius, Unifeeder
- Jonas Ringsberg, Chalmers
- Kaj Ringsberg, Chalmers/ILAB
- Violeta Roso, Chalmers
- Karin Sjöberg, IVL Swedish Environmental Institute
- Linda Styhre, IVL Swedish Environmental Institute
- Björn Södahl, Chalmers/Lighthouse
- Rolf Thor, Region Västra Götaland
- Johan Woxenius, University of Gothenburg
- Elias Wästberg, Port of Gothenburg

2 The development of short sea shipping

Over the last decade, the container shipping industry has improved its performance at an impressive pace and today is the backbone of global trade. Today, about 80% of the world's trade volumes are transported by sea (UNCTAD, 2008). The maritime part of the transport chain has employed ever larger ships to cope with increasing transport demands and to facilitate lower unit costs, with the latest vessels reaching 18 000 TEU (twenty-foot equivalent unit). To fully utilise the economies of scale, activities in ports and hinterland operations must match these large volumes. Despite heavy investments in container terminal capacity, larger ships and larger flows of containers have led to a situation where many larger ports face capacity shortages in both port operations and hinterland connections. Consequently, the main problems container ports face today, as a result of this growing containerised transport, are lack of space and growing congestion on roads and rails to the terminals. For some ports the weakest link in their transport chain is their back door, where congested roads or inadequate rail connections cause delays and raise transport costs. With a 76% market share, road transport dominates the inland goods transport market in EEA member countries and is predicted to increase (European Union Road Federation, 2008).

Shipping is vital for Swedish industries and Sweden as an export nation, where about 90% of the volume of goods exported or imported to Sweden have been transported by ship in some part of the transport chain (Tillväxtanalys, 2010). It is particularly important to find cost-effective solutions for the Swedish basic industries, where transport costs are often high in relation to the value of the goods. However, shipping faces huge challenges. Although shipping has the advantage of often being the most fuel efficient traffic mode in terms of fuel consumption or CO₂ emissions per tonne-km, its total emissions of other air pollutants are still high. This has resulted in the fact that both the IMO and the European Union in recent years have made great steps towards reducing sulphur dioxide and particulate emissions from shipping. These are important measures to make shipping more environmental friendly, but requirements need to be consistent with the desire to increase shipping's share of global transport.

Figure 2 below shows the Swedish position in the EU when it comes to short sea trade, both including RoRo and Containers. One can note that the percentage of the containers is rather low for Sweden compared to that in other leading countries, and that the share of RoRo is high mainly due to well-integrated and developed RoRo-services in Northern Europe.

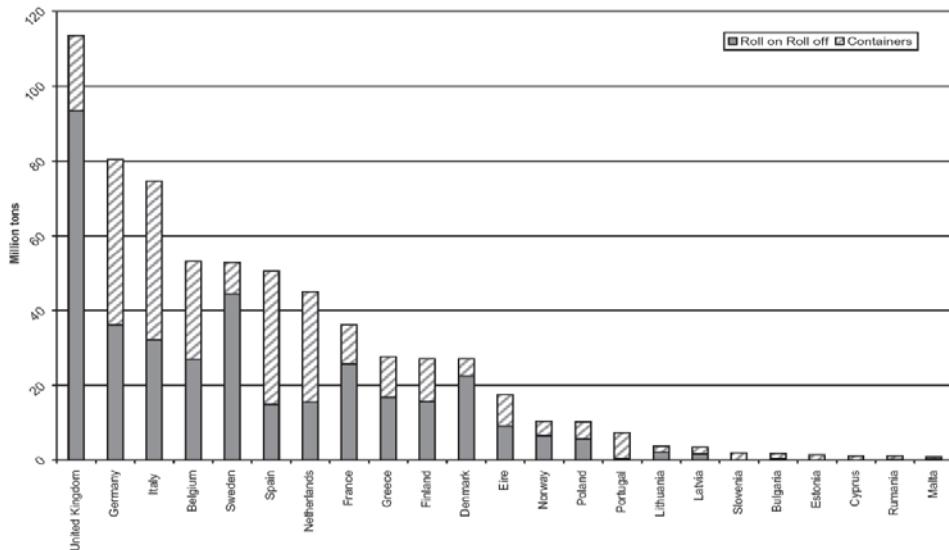


Figure 2: Short sea trade (Tonnage 2006, according to Eurostat). Source: Amerini (2008).

It is suggested that Short Sea Shuttles links will be established on routes where they can be well integrated into the transport network and function as a complement to road and rail. The Port of Gothenburg will function as a hub port in this study and the shuttle concept has been developed in close cooperation with Port of Gothenburg and the container terminal in Gothenburg, APM Terminals. The Port of Gothenburg has several transoceanic direct calls and efficient distribution of goods to and from the area would mean an improved global availability of goods. The Short Sea Shuttles discussed in this report aim at combining intra-regional flows of goods loaded in containers with flows of containers as part of deep sea shipping.

The Short Sea Shuttle Concept has been influenced by the railway shuttle system that has been implemented by Port of Gothenburg successfully over the past decade (see Figure 14). This strategy has resulted in more than 40% of all TEU being transported by rail to/from the hinterland.

An integration of the Short Sea Shuttle links with existing dry port system would be accompanied by a stepwise development strategy connected to Motorways of the Sea, and would also connect additional ports in the Baltic Sea and the North Sea that today do not have sea links to a hub port. One of the strategic decisions for the relief of the bottlenecks is the implementation of rail for inland access through dry ports. Dry ports are inland intermodal terminals with direct connection to a seaport by rail, where customers can leave and/or collect their goods in intermodal loading units. Consolidation, sorting, storage and transhipment between vehicles and traffic modes, track and trace, maintenance of containers, and customs clearance are usually available at dry ports. Scheduled and reliable high-capacity transport to and from the seaport is therefore necessary.

With new regulation on lower sulphur content of maritime fuel oil, port cities will benefit from lower SO_x, NO_x and particle emissions from shipping. Furthermore, the concept has

the potential to decrease the number of traffic accidents on the European road network and thus save human lives (Paxiao and Marlow, 2002). Since the intra-European transport system is to a large extent built up around semi-trailer transports, if implemented the concept could contribute to shifting goods away from an overcrowded land base infrastructure. Furthermore, truck transports are subject to drivers' resting hours, which is not the case when transporting cargo on a ship that operates 24/7. Transport security would also increase since shipping offer higher security levels.

Short sea shipping has the potential of carrying larger volumes of cargo. For example, implementation of the Short Sea Shuttle Concept would be beneficial for the distribution of forest products in Northern Europe, which are characterised by large volumes of cargo currently handled by industrialised RoRo-systems or bulk shipments as well as rail and conventional feeder transport. A containerised concept implemented for this type of cargo flow could benefit the cargo owners, as the container vessels, in comparison to RoRo vessels with corresponding DWT, are more fuel efficient per transported unit. This has the potential to lower overall transport costs.

The importance of efficient transport for peripheral European countries such as Sweden and Finland is significant. This matter is discussed by Parantainen and Meriläinen (2007) that claim that decreasing the transport costs in the Baltic Sea region is of major importance in order to improve the competitiveness of the regional industries. They state that the average logistical costs in Finland are 2-3 times higher than for countries in Central Europe.

3 The Short Sea Shuttles Concept

This chapter gives the definition and description of the main characteristics of the concept. The result is based on a combined analysis of findings from the interviews, workshop discussions, the SWOT analysis, and literature reviews.

3.1 Main features characterising the concept

The results from the interviews are categorised in five sections according to the main issues discussed: expected function, type of cargo, implementation requirements, input to the SWOT-analysis, and vessel size. Table 2 shows a selection of the result from the seven interviews with respondents.

Table 2: Main features characterising the Short Sea Shuttles - findings from the interviews.

Respondents	Expected function	Type of cargo	Implementation requirements	Input to the SWOT-analysis	Vessel size
Feeder operator	Cargo shift from land to sea.	Warehouse to Warehouse	Existing cargo flow. Operator.	Environ-mental friendly. Increased lead time.	700 - 1 000 TEU
Ocean shipping company	Enhanced shipping profile. Possibility to re-position empty containers. Additional transport concept in the region.	Non JIT-products. Low value cargo such as steel, forest products, chemicals.	Vessels.	Enhanced possibilities. Flexibility. Capacity to handle large batches. Decreased punctuality. Increased lead time.	
Satellite port	Increased cargo throughput. Possibility to develop a reliable transport system.	All except JIT products. Manufacturing goods aimed for production. Food and products for supermarkets.	Need for large base customers in start-up process. Organised as financially competitive concept.	More cargo – increased income. Punctual and reliable mode of transport for customers. Non-existing concept. Conservatism in the industry and amongst potential customers.	
Hub port	Attract new cargo.	All except JIT products.		Increased utilisation of the port.	
Cargo owner	Possibility for large batches.	Non time sensitive cargo.	Flow of suitable cargo.	More transport options. Increased lead time.	
Maritime consultant	Cargo shift from land to sea.	Non time sensitive cargo.	Public-Private partnership. Political will.	Existing infrastructure. Conservatism.	700 - 1 200 TEU
Freight Forwarder	Cargo shift from land to sea. Additional transport alternative.	Low-value cargo.	Well integrated in supply chains. Public-private cooperation.	Possible environmental benefits. Flexibility.	

The results show that different actors in the transport chain do have different opinions and expectations on the concept. However, what they all have in common is a positive attitude towards the concept. The main functions expected by the respondents are a possibility of shifting cargo to sea and to increase cargo throughput. Base cargo and non-time sensitive goods are suggested to be the most suitable cargo, but re-positioning of empty containers has also been discussed, both in the interviews and at the workshop.

The suggested sizes of the vessels are small, up to 1 200 TEU, however much smaller vessels have been proposed at the workshops, in order to have a high capacity utilisation with high frequency. One critical factor for an establishment of the concept is cargo volumes; without a base volume the concept will have difficulties in surviving the start-up phase. This also means that smaller vessels are more appropriate for the volumes available in Northern Europe. See further Chapter 7 Market analysis.

3.2 Critical parameters for the Short Sea Shuttles

In order to investigate critical parameters for the introduction of the Short Sea Shuttles, a SWOT-analysis was carried out. The SWOT-analysis is based on literature reviews, findings from workshop sessions and interviews with representatives from the shipping industry. The most important strengths, weakness, opportunities and threats are summarised in Table 3.

Table 3: The SWOT analysis.

Strengths	Weaknesses
<ul style="list-style-type: none"> • move goods from road and rail to sea • available infrastructure and vessels • inexpensive use of infrastructure • cargo security • availability of infrastructure i.e. fairways open mostly 24/7 • large volumes and large batches of cargo • potential reliability • increased capacity on rail 	<ul style="list-style-type: none"> • start-up risk (high entrance barriers) • high costs in port • poor adaption to variations • complex documentation and administration in comparison with intra-European truck and rail transport • increase in lead time • non-existent concept • insufficient IT
<ul style="list-style-type: none"> • Opportunities • lower costs for shippers • regional development, e.g. industries around the ports • less accidents • lower congestion • potential lower emissions • lower external costs • lower entry barriers into the market • lower road/rail maintenance costs • technology driver • vessel capacity 	<ul style="list-style-type: none"> • Threats • low profitability for shipping companies • SECA and new regulations • hard to market • to reach critical volumes for profitability • difficulties in distributing costs and benefits among involved actors

3.3 Definition of the Short Sea Shuttles

The starting point of the development of the Short Sea Shuttles was the dry port rail shuttles and conventional feeders. The idea was to combine the two concepts to suggest a shipping concept that is more integrated in the transport chain and with higher reliability than conventional feeder. Table 4 gives the differences and similarities between the three concepts.

Table 4: Differences and similarities between rail shuttles, Short Sea Shuttles and conventional feeder services.

	Short Sea Shuttle	Rail shuttle	Conventional feeder
Timetable	Fixed	Fixed	Semi-fixed, but with short-term changes / adjustments
Frequency	At least 1/week	Up to several times/week	Varies
Punctuality	High, deviation up to 1 hour	High, deviation up to 1 hour	Low, deviation up to day/s
Time perspective	Longer, months to years	Longer, months to years	Shorter, weeks to months
Transport chain integration	High	High	Low-medium

This work has resulted in a definition of the Short Sea Shuttle Concept:

"High-frequency short sea liner shipping of standardised load units that is highly integrated into transport chains with functional inland connections".

The concept involves transport of containers between satellite port/s and hub port, all with good hinterland connections. The Short Sea Shuttles need to be an integrated part of a longer transport chain, requiring a connection to the existing road and railway systems and deep sea services, as indicated in Figure 3. This allows transport buyers to get better access to their global markets and facilitates adaption of their logistics systems and better planning. Thus, the ports at which the Short Sea Shuttles call at should have good inland access that allows functional integration of the concept into the existing transport network.

The Short Sea Shuttle can operate between only two ports if the cargo flow is high enough. There are also cases where it can call a string of few satellite ports before approaching the hub port, or vice versa.

The shipping services should offer fixed schedules, and high reliability and departure frequency. Punctuality and high frequency are essential factors for the shuttles, as it allows a transfer of more time-sensitive cargo to sea, which currently is transported by other modes. This study is limited to the transport of maritime containers, but the concept can be applicable to other types of goods and standardised load units.

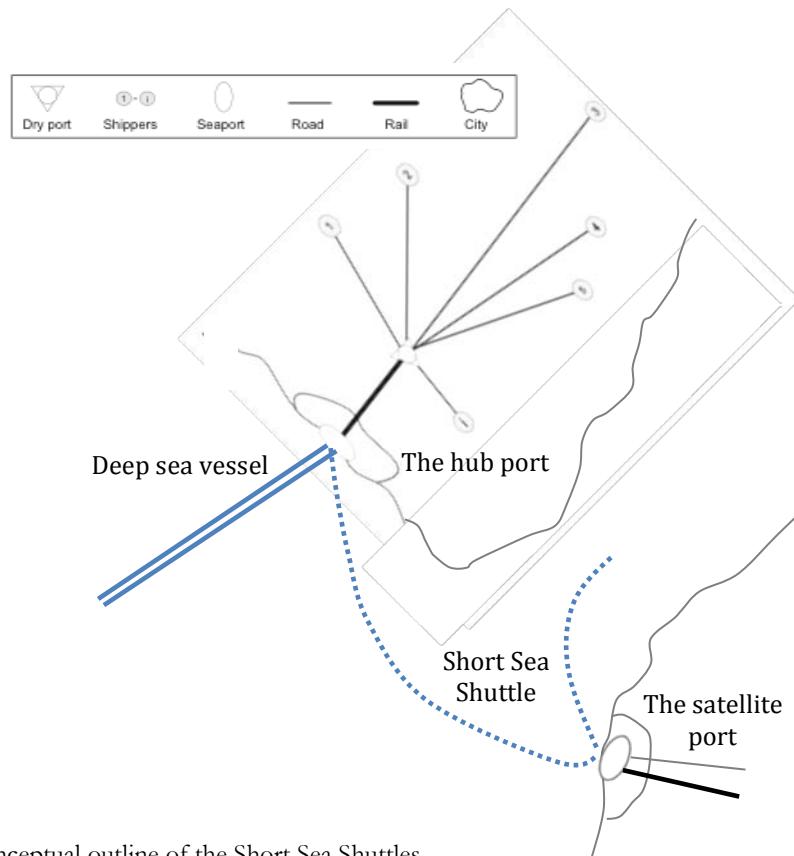


Figure 3: Conceptual outline of the Short Sea Shuttles.

The definition does not specify the size of the vessels because it depends on the volumes available on a specified route. The same applies to the frequency, which should at least be weekly, but how often within a week is determined by the market and customer demands. However, the vessels should not be too large in order to handle the relatively low cargo flows in the region. The Short Sea Shuttles do not preliminary aim at economies of scale, but rather to find their niche market by offering a high service level. Thus, the size of the vessels can be small. Suitable vessel size range was discussed both in interviews and at reference group meetings. It was finally suggested that a size between approximately 350 and 1 000 TEU is appropriate for most routes in the region, considering required vessel capacity utilisation, frequency and expected cargo volumes.

4 Maritime logistics context

The theoretical framework in this chapter gives a background and a contextual description. This chapter includes transport network, intermodal transport and transport chain integration as well as shipping and ports. The purpose is to describe related concepts and ideas in order to investigate how the Short Sea Shuttle Concept needs to adapt to these.

4.1 Transport networks

Goods transport systems are characterised by sequential transfers of goods between points of origin and destination, generally defined as nodes. Activities such as consolidation, sorting, storage and transhipment between vehicles and traffic modes are carried out in nodes. A node can be defined as a source, which can be an origin or a transhipment node, depending on the transport assignment. Links represent transport and transfer activities connecting nodes, and together with the nodes the links compose the transport network; see Figure 4. In the real system, links are served by vehicles and vessels using infrastructure. For the physical unit corresponding to transhipment nodes, the word terminal is used although traffic mode-specific terms such as *airport*, *seaport* and *station* are more common in colloquial speech.

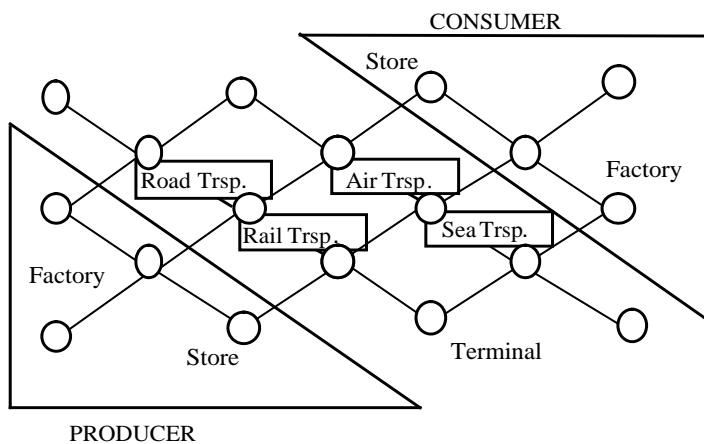


Figure 4: The components of the transport network (Lumsden, 1998).

4.2 Intermodal transport

A transhipment node has a central role in a network, and is often inconsistently called hub, dock or gateway by the transport industry. A link between different networks is defined as a gateway. In an intermodal gateway (see Figure 5), networks based on different traffic modes are linked, while intramodal gateways link networks using the same traffic mode. Traditional examples of intermodal gateways are seaports, airports and intermodal road-rail terminals. Intramodal gateways include consolidation terminals where trucks operating long-distances and pick-up and delivery routes are coordinated, respectively, and seaports offer transhipment between trans-ocean container vessels and feeder vessels or barges.

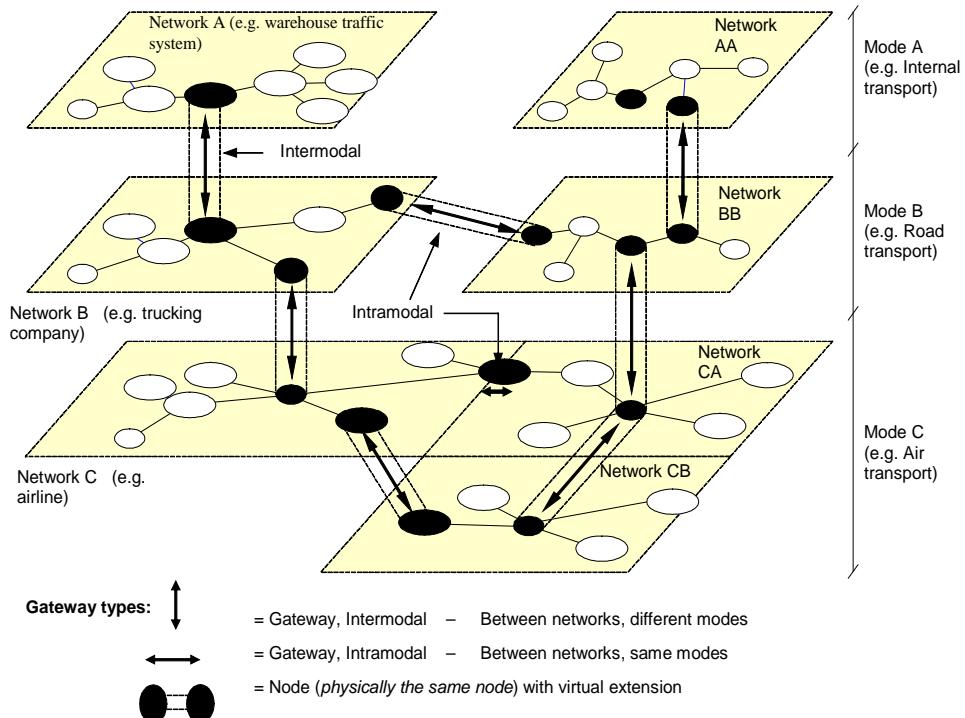


Figure 5: Intermodal and intramodal gateways (Lumsden, 2006).

Intra-European rail services are still commonly operated by use of intramodal gateways compensating for incompatible legislation, electric power supply systems, signalling systems, loading profiles and even rail gauge between neighbouring countries. The figure shows how gateways can be classified as receiving or forwarding nodes in a network, since transports do not begin or end in gateways, but only use these as a link to other networks. In other words, gateways connect different types of networks.

Transport systems have always been designed according to geographical conditions as well as according to the demand for the transport, which was determined by goods quantity and service quality. Currently, environmental issues play an important role in the design as well. One way to satisfy those demands is to use intermodal transport. There is no generally accepted definition of intermodality. The European Commission (2000) defines intermodal transport as the following: "There is a consensus that intermodal transport constitutes a transport process in which the two following conditions are fulfilled: 1) two or more different traffic modes are deployed, and 2) the goods remain in one and the same transport unit for the entire journey."

Reduced energy consumption, optimization of the usage of the main strengths of different modes, a reduction of congestion on road networks, and low environmental impacts are considered the advantages of intermodal transport. However, the main disadvantages would be difficulty in monitoring, reliability, and complexity of the chain.

4.3 Short sea shipping

Short sea shipping is a vital part of regional transport networks and an important component in supporting the commercial needs of transport and logistics in Europe and in other parts of the world with similar conditions. Waterborne transport within Europe has increased in recent years, even though the market development for short sea shipping has faced some challenges, such as the construction of fixed links, new regulations and a dramatic increase in the price of fuel (Notteboom and Vernimmen, 2009). This has been caused by technological development, the growth of trade and greater integration of parts of the supply chain (Heaver, 2001).

According to Douet and Cappuccilli (2011) there is a lack of concise and unambiguous definition for short sea shipping, which creates problems for policy makers as well as for researchers. Therefore, all variety of different definitions on short sea shipping affects the description of the Short Sea Shuttle Concept as well. In this report, the rather broad European Commission (1999) definition is used for short sea shipping, where it is defined as *the movement of cargo and passengers by sea between ports that does not involve an ocean crossing*. Stopford (1997) also uses a simple criterion and regards it as maritime transport within a region serving port to port feeder traffic in competition with land transport. The definition used in this work does not include any other criteria, but the geographical scope of the routes. Other criteria suggested by other authors are: technical criteria such as ship size, cargo handling methods, ports, networks (e.g. Marlow et al., 1997) and ship characteristics (e.g. Crilley and Dean, 1993). Further, Paixão and Marlow, (2005) made the definition more comprehensive by including criteria such as ship type, markets, logistics requirements, and service offerings.

The main advantages of short sea shipping are an alleviation of congestion, a potential reduction of the environmental impact, a decrease in overall costs to the shipper and that it is much less prone to theft and damage (PROPS, 2008). Further, SSS is cost-effective with respect to the relationship between investment and the resulting increase in transport capacity compared with inland transport (Blonk, 1994). An increase in SSS in most parts of the Europe will not require expensive additional infrastructure in the ports or fairways. As a consequence, the European Commission has an active policy to promote short sea shipping to meet the goals of the European sustainable transport policy (European Commission, 2009).

Short sea shipping currently accounts for nearly 40% of all cargo moved in Europe, and its volumes have increased over the years while its market share has remained stable (European Commission, 2009). In 2010, total short sea shipping in the EU-27 was close to 1.8 billion tonnes of goods and represented 62% of EU-27 maritime transport of goods (Eurostat, 2012). The largest type of cargo is liquid bulk, which accounted for nearly half (48%) of total short sea shipping of goods to and from the EU-27. Dry bulk is the second largest type of cargo, making up 19 percent.

Traditionally, the maritime transport industry has been divided into two major sectors: liner shipping and tramp shipping. Liner shipping provides regular services between specified

ports according to timetables and usually carries cargo for a number of different shippers, whereas tramp shipping is irregular in time and space, and the vessels are usually chartered to carry a full shipload of cargo (UNCTAD, 2004). Some liner services commute between two ports and others visit a string of ports in a fixed sequence. Furthermore, a third general mode of operation in shipping is sometimes also used, in which the cargo owner or the shipper controls the vessels: industrial shipping (Christiansen et al., 2004).

Important factors that influence customers' choice of shipping company for their cargo are space available onboard the vessel when needed, service frequency (Matear and Gray, 1993; Mangan et al., 2002), and transit time reliability, e.g., punctuality (Matear and Gray, 1993; Murphy and Hall, 1995; Cullinane and Toy, 2000; Mangan et al., 2002; Shinghal and Fowkes, 2002). Good predictability and reliability of cargo movements in liner shipping are important issues for manufacturers and traders because they can lead to inventory savings (Lagoudis et al., 2002). Thus, these requirements are important for the shipping companies to meet.

Despite these advantages, it may be asked why short sea shipping has not yet been developed to its full potential. Obstacles may include the complex documentation and administrative procedures in the ports (MarNIS, 2006). Ship owners in SSS do not sufficiently use existing electronic data interchange systems. Other problems that SSS might face are related to environmental issues that will increase the costs for shipping. SO_x Emission Control Areas (SECA) limits the sulphur content of marine fuel oil to 1.5% per mass and is already applied in designated SECAs, like the Baltic Sea, the North Sea Area and the English Channel. Furthermore, the IMO's market based measures limit carbon dioxide emissions from shipping.

In order to maintain their market position, seaports have to improve their competitiveness by adding various value-added services to their service range while keeping the price adequate. It is also of great importance that they have a functional hinterland access that might be obtained by a well-developed feeder system as a complement to land-based infrastructure.

The latest decade has been globally characterized by a strong maritime economy, and the number of vessels in the global merchant fleet has grown by 20% since 2002 (Copenhagen Economics, 2012). Meanwhile, the average size of vessels has increased, which means that the capacity of the global merchant fleet has grown even more. Despite a strong maritime shipping economy, the Swedish-flagged fleet has declined significantly in recent years, from 40% to 28% during the past five years (Copenhagen Economics, 2012). Measured in terms of capacity, the decline has gone from 20% to 13%, which to some extent depends on the fact that more new ships are registered abroad, but also that there is an increased out-flagging of existing ships (Copenhagen Economics, 2012).

4.4. Hub and spoke system

While short sea shipping is the transport of cargo in the same continent, ocean shipping refers to the transport of cargo across oceans. The ocean shipping industry is segmented and consists basically of container vessels, bulk carriers, tankers, general cargo vessels and car carriers. The ocean shipping companies use their largest vessels on major routes and limit their calls to a few major hub ports in order to save time and expenses (Gelareh and Pisinger, 2011), and to receive the necessary cargo-handling capacities (Gouvernal et al., 2009). The existence of hub ports is a consequence of economies in scale and density in shipping. Economies of density are a prevalent feature of the shipping industry, and the concentration of traffic demands and transport services exhibit a positive correlation with the efficiency of transport (Mori and Nishikimi, 2002). Therefore, companies can lower their shipping costs by taking routes linked to hub ports that process large volumes of cargo with developed specialised services and large-scale infrastructure (Behrens et al., 2006).

A hub and spoke system requires feeder vessels that complete the ocean shipping company's network (Gouvernal et al., 2009). The feeders provide the link between hub ports and satellite ports, and they normally visit a string of ports; see Figure 6. They often operate under the schedule of the deep sea vessels (Paixaõ and Marlow, 2002), yet they have a more flexible time schedule and provide a higher frequency of port calls than the deep sea vessels do (Imai et al., 2009).

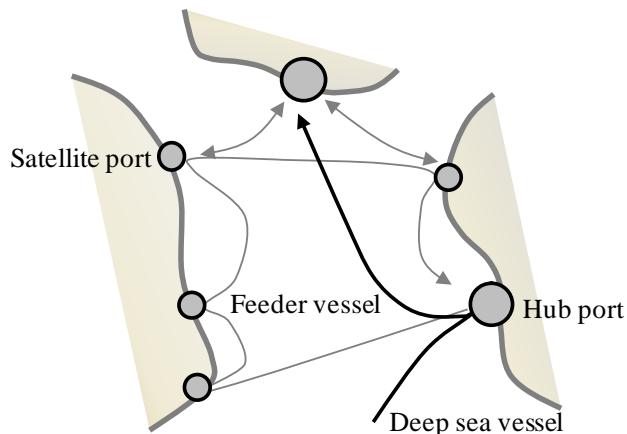


Figure 6: Hub and spoke system of direct calls and feeder services (Styhre, 2010).

The planning problem for the shipping companies consists of selecting which of a huge set of possible predefined routes to use and how many voyages to sail along the chosen string, while maximising profit (Christiansen et al., 2007). By limiting the number of port calls, the round voyage time can be shortened, which means a greater number of round trips per year and that fewer vessels are required for a specific liner shipping service. However, fewer ports mean access to fewer cargo catchment areas and higher costs for feeder services and transhipments in order to reach end-customers and end-producers (Notteboom, 2006).

Due to containerisation and the importance of obtaining economies of scale in vessel size, the hub ports must make huge investments in infrastructures and handling equipment. The main challenges seaports face today, as a result of growing containerised transport, are lack of space at seaport terminals and growing congestion on the access routes serving their terminals. Parola and Sciomachen (2005) modelled and simulated the potential growth of container flows. Their findings show that the modal imbalance results in increased road traffic congestion, since a growth in the sea flow implies an almost proportional increase in the road flow. Consequently, for some seaports the weakest link in their transport chain is their hinterland connections, where congested roads or inadequate rail connections cause delays and raise transport costs. A port may have two options: either to become a large hub port or to take the role of a satellite port in the regional transport system (Chang et al., 2008). The small and medium-sized satellite ports that do not target mega large vessels can complement the hub ports by targeting niche markets, especially in feeding, rather than competing with them (Cullinane and Khanna, 2000). This also removes much of the need for investment in the most expensive infrastructures away from the satellite port.

4.5 Vertical and horizontal integration

Both vertical and horizontal integration in the transport industry have resulted in a concentration of power at the port demand side, which has led to the shipping companies' increased market control over ports (Heaver et al., 2001; Notteboom, 2002; Song, 2002; Ha, 2003). For many years, there have been organisational, technological and commercial changes with the aim of delivering door-to-door transport solutions rather than port-to-port services (e.g. Robinson, 2002; Paixão and Marlow, 2003). This has enlarged the port's hinterland and foreland, and there is currently competition among many ports to grow and become hub ports for large shipping companies. Ports have been developed in conjunction with industrial and commercial businesses (Paixão and Marlow, 2003) into important nodes in the transport network. Consequently, the port's earlier narrow focus on cargo handling has been replaced with the establishment of a wide range of logistics and value-added activities. Thus, ports have gradually been breaking away from their traditional passive function in transport and have taken a more active role (Mangan et al., 2008). Today the port has a high priority in the shipping companies' strategy when formulating sailing schedules. This involves analysis of port selection criteria and a definition of the port's function in the international supply chain from both the ship operator's and the shipper's standpoints (Branch, 1998).

Notteboom seaports, as well vertically to transport. With functional intermediate have been However, the done cautiously legislation.

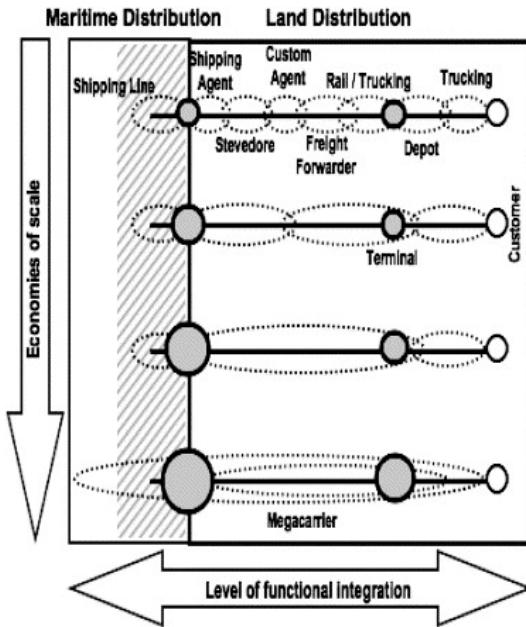


Figure 7: Functional Integration of Supply Chains (Notteboom, 2006).

(2006) states that many shipping lines, integrate control over their hinterland and an increasing level of integration, many steps in the transport chain removed (Figure 7). Vertical integration must be done cautiously and must respect anti-trust legislation.

4.6 Dry ports

Terminals may take many forms depending on the characteristics of the landscape and their proximity to the seaport and their location relative to the main infrastructure. The conscious and strategic development of intermodal terminals in the seaport's hinterland is approaching what we denote as dry ports. A dry port is an inland intermodal terminal directly connected to a seaport by rail where customers can leave/pick up their units as if directly to a seaport (Roso, 2007). This definition emphasises a connection to a seaport as well as the environmental benefit and promotion of intermodal transport. The basic idea behind the concept is shown in Figure 8.

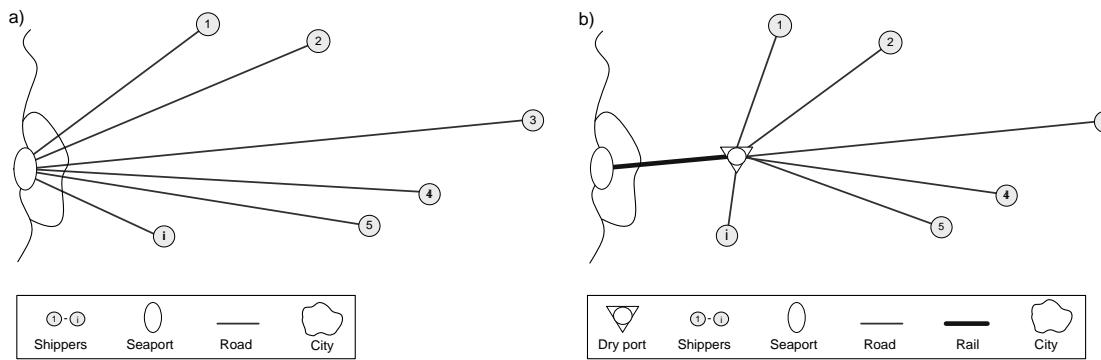


Figure 8: Basic idea behind the concept: seaport's inland access a) without a dry port and b) with a dry port (Roso, 2007).

Essentially, four functions take place at the goods terminal: transfer of cargo, mostly unitised, between two modes; the assembly of cargo in preparation for its transfer; the storage of cargo awaiting pick-up; and delivery and the logistical control of flows (Slack, 1999). In addition, services such as maintenance of containers, customs clearance, and other value-added services should take place at a dry port terminal in accordance with customers' needs. Furthermore, dry ports are categorised into distant, midrange and close dry ports, based on their function and the location. To summarise the main features of a dry port:

- Intermodal terminal,
- Situated inland,
- Rail connection to a seaport,
- Offers services that are available at seaports, such as container maintenance, storage of containers, forwarding, depot and customs clearance.

The quality of access to a dry port and the road–rail interface determines the dry port's performance. However, the quality of inland access depends on the behaviour of a large variety of actors, such as terminal operators, freight forwarders, transport operators, and port authorities (de Langen, 2004). Scheduled and reliable high-capacity transport to and from the seaport is the prerequisite. Implementation of a close dry port in a seaport's immediate hinterland increases the seaport's terminal capacity, which also involves a potential to increase productivity since bigger container ships will be able to call at the seaport. With dry port implementation, CO₂ emissions and the seaport's road congestion can be decreased because one train can substitute some 35 lorries and trucks in Europe (Roso, 2007). With a reduced number of lorries on the roads, congestion, accidents, road maintenance costs and local pollution can be reduced as well.

The concept can be compared to the case of an increased level of functional integration of supply chains (Nottiboom, 2006), where many intermediate steps in the transport chain have been removed and therefore enabled a so-called one-stop-shop, creating a single contact point. Thus the dry ports are supported by a higher level of integration with seaports than conventional inland terminals. Full implementation of a dry port could create a seamless series of physical and procedural links to provide a smooth transport flow with one interface in the form of a dry port concept instead of two, one at the seaport and the other one at the inland destination (see Figure 9).

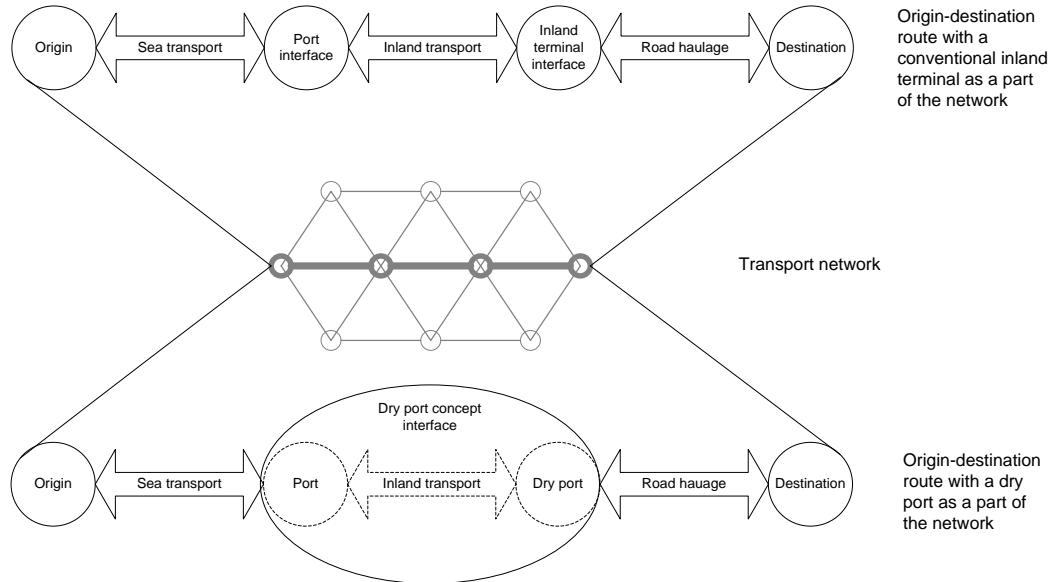


Figure 9: Transport network with and without a dry port (Roso, 2009).

A dry port may also serve as a depot and empty container storage. Road carriers would lose some market share, but in some countries where long semi-trailers are not allowed to pass through cities, as in Australia, a dry port implementation is a good solution. The benefits of distant dry ports derive from the modal shift from road to rail, resulting in reduced congestion at the seaport gates and its surroundings, as well as reduced external environmental effects along the route. The distant dry port extends the gates of the seaport inland, with shippers viewing the dry port as an interface to the seaport and shipping lines. The implementation of the dry port is not the only factor in relieving seaport congestion or improving seaport inland access; however, it is a significant component in improving seaport productivity.

5 Policy context

Effective maritime transport is crucial for Swedish trade and industry, and for Sweden as an exporting nation. However, shipping faces challenges in terms of increased costs due to new environmental regulations. This chapter contains a description of how new laws and regulations will influence the competitiveness of maritime transport up to 2020 in Northern Europe. Examples of changes that are expected to have an impact on shipping are the Sulphur Directive, NO_x regulations, the NEC Directive and new environmentally differentiated fairway and port dues. The emphasis is on the Sulphur Directive, because this will have a large impact on bunker costs for shipping to and from Swedish ports.

Even though maritime transport often is viewed as an environmentally friendly mode of transport regarding CO₂ emissions, the fuel consumption per cargo tonne varies a great deal between different shipping segments and ship sizes. Furthermore, emissions other than CO₂, such as sulphur dioxide, nitrogen oxides and particles, are high for shipping compared to other traffic modes, especially when no abatement technologies are used (Hjelle and Fridell, 2010). It is harder to regulate waterborne transportation than road transportation, because it has a lower degree of national control, and regulation must therefore be imposed on an international scale to be efficient. As a result of this, emissions of CO₂ from shipping were exempted from the Kyoto protocol since they were not able to allocate emissions to individual partner states. However, the MARPOL Annex VI regulations cover emissions of CO₂, SO₂ and NO_x from combustion in marine engines. Regulations on SO₂ and NO_x emissions will be strict in the Sulphur and Nitrogen Emission Control Areas (SECAs and NECAs).

5.1 The Sulphur directive

Shipping is a large source of atmospheric SO₂ and sulphates due to high sulphur levels in marine fuels. The regulation of sulphur in marine fuel was brought up at the Marine Environmental Protection Committee (MEPC) of IMO in 2005 and the first regulation on sulphur content on marine fuel entered into force in 2006. The main focus, at the beginning, was on acidification and “acid rain,” but recently the focus shifted to problems associated with the emission and atmospheric formation of particles that have an impact on human health, visibility, and the climate. Only a handful of ships have exhaust gas treatment for SO_x abatement on board and the amount of SO_x emissions from ships is therefore usually solely dependent on the sulphur content in the fuel. Due to increased shipping activity and absence of regulations, the SO_x emissions from international shipping have increased (Svensson, 2011), while emissions from land-based sources have decreased. Since air pollution from shipping is expected to outstrip land-based emissions by 2020 (European Parliament, 2012), urgent remedial action was needed in Europe. Consequently, stricter limits on sulphur content in marine fuels were set in order to improve air quality along the European coastline and reduce health problems caused by air pollution from ships. In 2012, the European parliament approved legislation, agreed upon by member

states that required new general limits to be in place by 2020, in large parts following the MARPOL regulations.

These new rules state that the limit for sulphur in fuels used in SECAAs is reduced from 1.0% S to 0.1% S in 2015, and globally from 3.5% S to 0.5% S by 2020 (possibly postponed till 2025). Fuels with higher sulphur content will be allowed if exhaust gas cleaning systems are used (SMA, 2009). Figure 10 shows the limits for sulphur content in marine fuels, both globally and in the Sulphur Emission Control Areas.

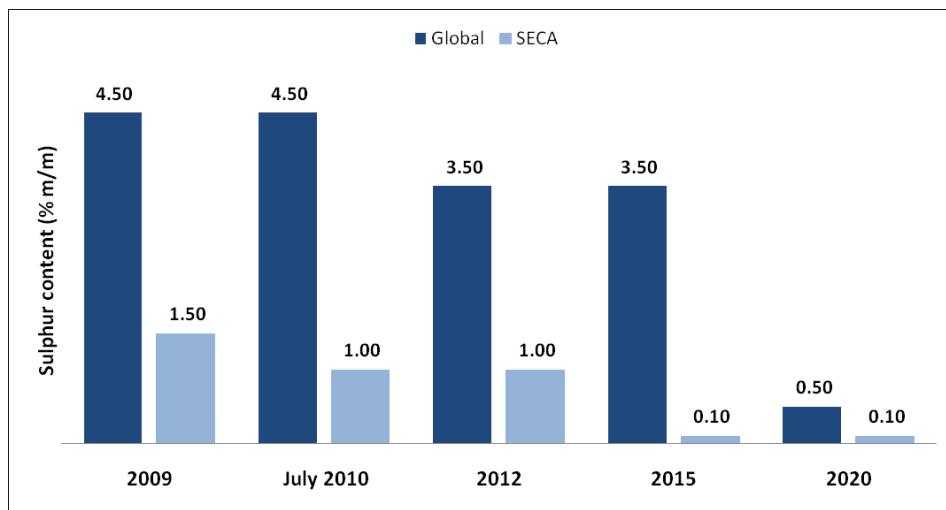


Figure 10: Sulphur content limits (Svensson, 2011).

The Baltic Sea, the North Sea and the English Channel are areas subject to sulphur control in Europe. Figure 11 shows the countries that have their whole or parts of their coastline towards the Sulphur Emission Control Area (SECA).

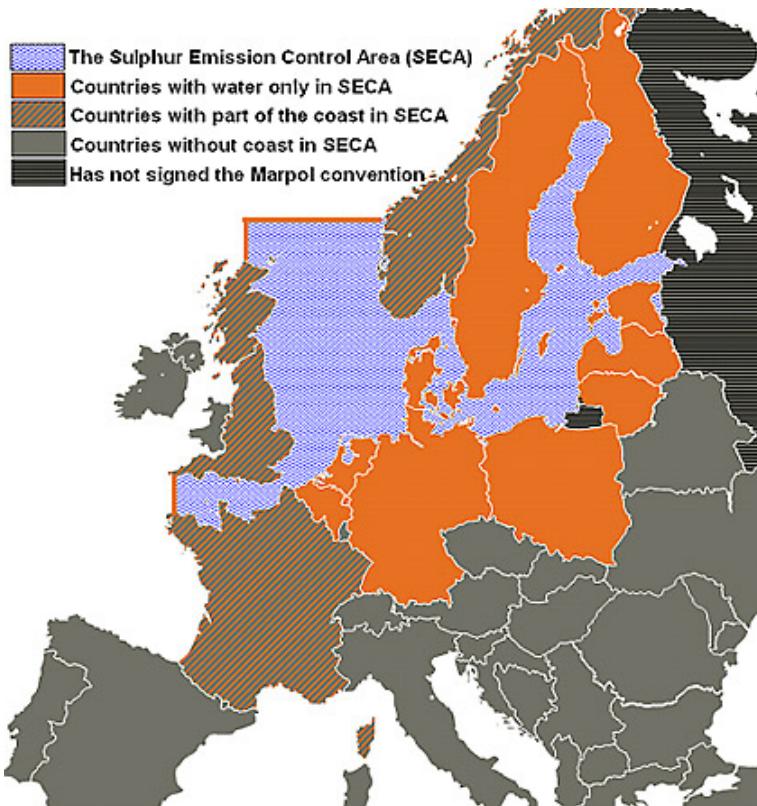


Figure 11: Countries in the SECA. Source: Jernkontoret (2013).

Consequences of the sulphur directive, including an expected modal shift, has been modelled and estimated in several studies (e.g. Notteboom, 2010; Entec, 2010; Malmqvist and Aldén, 2012; Kalli et al., 2010; Vierth, 2012; Trafikverket, 2012 , Sweco Energuide, 2012 and TRAFA, 2013). Competitive disadvantages for industries, ports and shipping companies in countries with coast lines to SECA have been anticipated as a consequence of the Sulphur Directive, and competitive imbalance within Europe is expected due to differences in bunker prices between northern Europe and the countries around the Mediterranean Sea.

Malmqvist and Aldén (2012) divide expected consequences of the sulphur directive into three parts:

- maritime consequences, such as change of fuel (resulting in increased cost) and optimisation of routes and other measures,
- logistic consequences, such as modal back-shift and intermodal opportunities,
- industrial consequences, such as competitiveness and decreased incentives for investments.

With the assumption that fuel costs represent 30% of the total cost for shipping, the internalisation of the external costs for sulphur, nitrogen and carbon dioxide will lead to an increase of the total transport cost by 12-20% according to a study by Vierth (2012). Table 5 shows the estimated effects on fuel costs in total in the SECA/NECA-area (Vierth, 2012).

Table 5: Estimated effects on fuel costs in total in the SECA/NECA-area (Vierth, 2012).

	Effect	Approximate extent
SO_x limit	Higher fuel cost	20-40%
NO_x limit	Higher fuel cost	3-4%

Malmqvist and Aldén (2012) have shown that a 5-6% increase in rail and road transport, and a 7-10% decrease in shipping can be expected. The total decrease of maritime transport in the Swedish territory is supposed to be about one billion tonne-km, which stands for about 2% of the total work of sea transport (Trafikverket, 2012). Furthermore, the introduction of these limits will increase the fuel costs with 12% for ferries, 72% for RoRo ships, 81% for container ships, and 36% for other vessel types. SMA (2009) estimates a lower increase on average. Another study by Entec (2010) concluded that the modal shift due to sulphur regulations should be between 3-50% in volume, depending on routes and price scenarios (Kalli et al., 2010). According to Sweco, the demand for maritime transport is expected to fall by 21% and by 8% for heavy road transport, while the rail freight transport is expected to increase by 11%, all as a result of the directive. They also emphasise the fact that transports to ports outside the SECA area are expected to increase (Sweco Energuide, 2012).

The modal shift will affect different types of goods and different routes to different extents. Many factors, such as cost, transit time, reliability, flexibility, frequency, security, nature of cargo, value of cargo, relationships and existing contracts with transport suppliers, influence the choice of transport service. For some cargo, e.g. dry and liquid bulk, sea transport is the only reasonable choice. Even if the cost of maritime transport will increase significantly, shipping is expected to continue to be the most cost-effective mode of transport and maintain its competitive position in these segments (Sweco Energide, 2012). Other cargoes, such as the ones carried on RoRo vessels in short sea shipping, have a higher risk for a modal shift. Also, for some routes, there is no real threat of modal shifts, such as between south Finland and Sweden, or between Sweden and the Baltic States. However, between Sweden and continental Europe, or between Finland and the continent, it is more likely that cargo is shifted to road. Also, the long-distance transports from northern Sweden to the continent might be decreased and replaced with road or rail to southern Sweden (Kalli et al., 2010).

Trafikverket (2012) concludes that the most significant individual effect is that some cargo to/from the Port of Gothenburg will be transferred to routes through the Öresund Bridge. Turesson and Weddmark (2013) also find that the Port of Gothenburg will lose cargo volumes to road and rail when shippers seek to minimise the distances at sea. On the other hand the Port of Gothenburg will attract new flows that currently are shipped out through Swedish east coast ports. Hence, the transfers from maritime transport to road transport

will mostly affect the south and middle of Sweden. Furthermore, it will be beneficial to choose a port outside the SECA-area, such as the Port of Narvik in Norway, instead of ports in the north of Sweden. Also movements from northern Swedish ports to the ones in the middle and south of Sweden will most likely be seen, which in turn will cause longer on-land connecting transports (Trafikverket, 2012).

The latest report on the Sulphur Directive and its consequences on waterborne transport in Baltic, presented by Trafa (2013), is more positive than earlier reports. According to Trafa a slight price increase for the low sulphur marine gas oil is expected; i.e. a price increase of 5 to 20% in 2015 compared to 2013. However, the fuel price increase will require adjustment for shipping such as new route planning systems, reduced speed (so called slow steaming), consolidation of goods, etc.

Alternative fuels that comply with the future sulphur limits, besides marine gas oil (MGO) or low sulphur marine diesel oil (LSMDO), are liquid natural gas (LNG), biogas (LBG), methanol/DME, bio-oil or hydrogen. LNG propulsion is a well-proven technology while other fuels for marine use are still at different stages of early development. An alternative way to reduce SO_x emissions is to use exhaust gas cleaning system technologies (Svensson, 2011) that reduce emissions to levels equivalent to emissions from combustion of 0.1% S fuel. Scrubbers are installed on a few ships and can reduce SO_x emissions cost-efficiently to levels equivalent to those from combustion of 0.1% S fuel. Moreover, slow steaming is a way to reduce fuel consumption and cost (Malmqvist and Aldén, 2012), and thus also to reduce SO_x emissions.

There is a political will to promote European short sea shipping that works for a modal shift towards maritime transport. The EU White paper on transport clearly promotes short sea shipping as an alternative to road transport (European Commission, 2011). The same white paper suggests that the different traffic modes shall carry their external costs by 2020. An internalisation of the short-term marginal social costs resulting from emissions of CO₂, NO_x and SO_x, accident risks and infrastructure use, would favour shipping before the other modes, according to a study by Kågeson (2011). In order to counteract the described risks of negative effects from the sulphur directive for the shipping industry, member states of the EU may provide support to operators in accordance with the applicable state aid rules if such aid measures are considered to be compatible with the treaty (The Maritime Executive, 2012).

5.2 MARPOL Annex VI NO_x regulation

There are on-going discussions in HELCOM regarding how to make the Baltic Sea a Nitrogen Emission Control Area (NECA). Following a decision within the MEPC, this regulation will require all ships constructed after 2016 that sail within the NECA to comply with the so-called Tier III NO_x emission limits of MARPOL. This represents a cut in NO_x emissions of about 80% compared with Tier I (Hjelle and Fridell, 2010). Regulations of NO_x are gradually tightened; today delivered engines must comply with Tier II regulations, which give a cut of about 20%. A study by HELCOM concludes that a NECA within the

Baltic Sea will have no significant effect on modal shift, but that investment and operation of emission abatement equipment will cause increases in freight rates by 2-5% for new ships (HELCOM, 2011).

Fears have been expressed regarding an increased share of old ships in traffic in NECAs, since only new ships need to comply with the regulations, which could potentially cause a competitive advantage for pre-2016 ships in these areas, and delay a replacement of old vessels.

5.3 The Gothenburg Protocol and the NEC directive

The European Air Quality Directive and the National Emission Ceiling Directive (NEC) comprise regulations on pollutant levels in ambient air and domestic emissions, respectively. Ships are large sources of SO_x, NO_x and PM_{2.5} (particles with diameters less than 2.5 µm), which are both included in the directives. Levels of PM_{2.5} and NO_x in port cities often exceed the ceiling values. NO_x reduction measures on ships are cost efficient compared to abatement of other NO_x sources (Cofala et al., 2007), and policy mechanisms that include ships and abatement measures for ship emissions are a potential way to comply with the regulations.

EU Member States, Norway, Central and Eastern European countries, and the United States and Canada have negotiated the "multi-pollutant" protocol under the Convention on Long-Range Transboundary Air Pollution (the so-called Gothenburg protocol, agreed in November 1999). The ceiling levels in the protocol are equal or less ambitious than those in the NEC Directive. One result of the Gothenburg Protocol is the Norwegian NO_x tax that was introduced followed by a NO_x fund. Ship operators can join the NO_x fund, have tax reliefs and pay tax directly to the fund from which any paying party can have financial support for installation of NO_x abatement technology. The NO_x Fund has granted more than € 300 million in investment support to NO_x abatement initiatives on ships operating in Norwegian waters. A discussion on the advantages and the disadvantages of creating a NO_x fund for the Baltic Sea is given in Kågeson (2011).

Domestic shipping could potentially be included in schemes to reach legislated emission levels and pollutant concentrations in ambient air, a measure that could result in cost increases for maritime transports. Calculations have shown that an increased use of selective catalytic reduction (SCR) equipment in order to comply with Tier III NO_x emission limits, would result in an increase of 2-4.6 % in freight rates (HELCOM, 2011). In a voluntary system, increases above these levels are not likely. There are market-based instruments, such as a NO_x fund, that can offer options to reduce emission levels and external costs without increased economic pressure on ship operators while simultaneously achieving emission reduction targets.

5.4 Fairway and port dues

Fairway dues consist of two parts: one is based on the ships' gross tonnage and differs for different vessel types, and the other part is based on the amount of cargo loaded/unloaded and differs for different types of cargo (SMA, 2009). Pilotage fees consist of three parts: the pilotage fee, order fee and travel expenses; it is possible to request pilotage exemption (*ibid*). All vessels liable for fairway dues must, at the latest one week after departure, submit a declaration for fairway dues.

In 2008, the Swedish Maritime Administration decided to increase fairway charges gradually; an increase of 10% is made for the part based on the gross tonnage and a 25% increase for cargo defined as low valued, and 5% for pilotage; gradually in 2011 and 2012 (Vierth and Mellin, 2010). Although the fairway and pilot charges constitute only a small fraction of the total shipping costs, some ports, e.g. Port of Gothenburg (Port of Gothenburg, 2013) is very critical about new higher fairway charges and worried that Swedish ports will become less attractive for international companies due to those extra charges, which are not required by other European countries.

However, the increased fairway charges are applied on international arriving vessels, meaning that short sea national transport will not be affected by these extra charges. Vessels engaged in regional or local cargo or passenger traffic in public regime or within a country are exempted from the dues.

Swedish fairway dues have been differentiated based on environmental performance (emissions of NO_x and sulphur in fuel) since 1998. The incentive of the fairway differentiation scheme is a rebate on the gross tonnage fee in port. The part of the differentiation of fairway dues that relates to sulphur content will be replaced in 2015 when the new sulphur regulations are in force.

Similar systems can and have been applied for differentiation of port fees. In Sweden, 30 ports differentiate the port fee based on sulphur content of fuel and 20 ports also include emission of NO_x in their differentiation schemes, and Finnish ports have adopted similar schemes. Other ports have chosen to base their differentiations on established environmental evaluation schemes. Examples of such schemes are the Green Award, which foremost directs tanker operators, and the Environmental Ship Index, which assesses performance according to emissions of SO₂, NO_x and CO₂. Port due differentiation is built on voluntary initiatives and participation and it is therefore not likely that such differentiation will cause significant consequences for ports or operators.

5.4.1 Tonnage tax

A new investigation into a tonnage tax system for Swedish flagged ships has been initiated by the Swedish government. The investigation should be finalized by November 2014 and include a proposal of a comprehensive system of tonnage tax.

The Swedish government's objective is that Sweden should have a competitive shipping industry from an international perspective, and the Swedish shipping industry has long

advocated a tonnage tax that is common in several other countries. Many Swedish ship owners have chosen to register their ships under foreign flags in recent years, and the aim of a tonnage tax is to increase the proportion of Swedish-flagged vessels in the Swedish merchant fleet. The Swedish parliament is positively disposed to a tonnage tax.

A tonnage tax is paid based on standard assumptions on incomes based on ship net tonnage (carrying capacity) instead of on actual income. The effect of a tonnage tax is assumed to have positive economic consequences for ship owners. The actual effect, however, will depend on the tax rates. The ongoing investigation also comprises the existing economic support for Swedish ship owners, and the impacts on the industry from a revised system is therefore still unclear.

5.4.2 Rail infrastructure charges

The Swedish rail infrastructure charges are among the lowest in Europe, representing about 5% of rail transport costs (Vierth and Mellin, 2010). Rail infrastructure charges structure differs between different countries; the charges are about twice as high in Denmark and up to ten times higher in Germany. The charges are only lower in Norway. Therefore rail infrastructure charges' share of transport costs is often higher for international than for domestic transport. According to Vierth and Mellin (2010) infrastructure charges in Europe are on average about 10 to 30% of rail costs. Higher rail infrastructure charges in Sweden could result in approximately 1% higher transport cost in total and approximately 2% higher costs for tracks on routes between Stockholm, Gothenburg and Malmö (*ibid*). Increased rail transport costs, together with limited capacity on rail network will most likely result in a modal shift for some types of goods that are appropriate for multiple handlings, like containerised goods.

6 Comparison of similar concepts

This chapter presents similar concepts of short sea shipping that have some features corresponding to the Short Sea Shuttle Concept. The similarities and main differences between existing services and the suggested concept are discussed in the last subchapter.

6.1 DFDS

DFDS Seaways is one of the largest European shipping companies, with a main focus on RoRo and RoPax services. The company also offers container shipping services between Continental Europe and Ireland, the UK and Norway, see Figure 12.



Figure 12: DFDS's container shipping (DFDS logistics, 2013).

DFDS offers a total transport concept covering activities from the shipper's warehouse to the final destination. The sailing schedules aim to suit the customers' requirements and the ports are situated close to inland road and rail infrastructure. Their focus is on a fixed and reliable sailing schedule.

For example, door-to-door container service from Spain to the UK and Ireland, in partnership with Vapores Suardiaz Norte S.L., is served by three container vessels, each sailing from Bilbao to UK and Irish ports on a weekly basis. DFDS Logistics provide a full door-to-door service with a wide range of cargo units' types. The vessels between Norway and the continent are small, less than 200TEU.

6.2 Unifeeder

Unifeeder is the largest feeder operator in Northern Europe, but also a well-established feeder service provider in the Mediterranean Sea between Spain, Algeria and Tunisia. The main aim is to act as a link for trans-ocean container shipping lines by providing coverage of ports and regions beyond their reach. The Unifeeder network forms a part of regional and global supply chains that operate on semi-fixed schedules. This means that the service can be flexible and schedules can be changed. Containerised cargo transported by Unifeeder includes refrigerated containers, tank containers, out-of-gauge units and dangerous (IMDG) goods.

Apart from its feeder service, the company offers Short Sea Services providing customers with fully multimodal and flexible door-to-door solutions, combining seaborne transport with road and/or rail. The service is made in accordance with customer needs, and is based on dense network, frequent services and advanced IT-solutions.

6.3 Grand China Shipping

The Chinese coast line is divided into three major economy regions because of the differences in industry between each of them. The first region is the area around Bohai bay, and its major ports include Dalian, Yingkou, Tianjin and Qingdao. The second one is the area around the Yangtze River Delta, and Shanghai and Ningbo are involved. The third is the Pearl River Delta. Major ports around this area include Guangzhou, Shenzhen and Hong Kong. Furthermore, Shanghai, Guangzhou and Hong Kong are major import/export hubs of China, with large transhipment volumes.

The cargo resources from north China are mainly raw materials and heavy industry products, while eastern and southern regions have light industry products, which mean there are enough volumes and a good import/export balance for container shuttle services. Companies involved in this market include the COSCO Container line, China Shipping Container and Grand China shipping.

Grand China shipping has three shuttle routes between northern and southern China, operated by seven vessels with weekly departures. The Chinese container shuttle services started long ago; the first container shuttle route opened in 1996 and has since grown to a mature transport network connecting China's northern and southern regions. The example of the route shown in Figure 13 takes 12 days. The vessels employed are approximately between 2 500 TEU and 3 000 TEU.



Figure 13: Route NSX1 Yingkou—Qingdao—Quanzhou—Huangpu—Yingkou.

6.4 Analysis of similar concepts

There are in all cases points of similarity between the services and the suggested Short Sea Shuttle Concept. While some correspondences exist regarding the schedule frequency, others have similar types of vessel sizes or some other features; however, neither of the examples cover all features of the Short Sea Shuttles.

The similar concept created by Grand China Shipping has used the term “containership shuttle” for some time now. The company has a fixed schedule, but less than one departure per week and cover very longer distances, i.e. 12 days sailing time, than initially planned for the Short Sea Shuttles. Another Chinese company, the China Shipping Line, operates shuttles between Russia and China with a large container ship intended typically for transoceanic trades. The vessel will be used for this non-oceanic route due to the major growth in Russian-Chinese trade (The Voice of Russia, 2010). Consequently, the Chinese examples do not fit entirely into the concept in a Northern European context, due to long sailing times, lower frequency, and large vessel sizes.

The Unifeeder's feeder service corresponds well with the shuttle concept but with an exception: it connects multiple ports with a flexible schedule. This means that the vessels have a feeder services function, which is not expected for the Short Sea Shuttles, as indicated in Table 4 with differences and similarities between rail shuttles, Short Sea Shuttles and conventional feeder services.

The DFDS concept corresponds best to the suggested Short Sea Shuttle Concept; it runs few times a week according to fixed and reliable schedules on non-oceanic routes, and the size of the vessels employed are small but could match the vessel size for some routes. The DFDS container services fit well with the concept's purpose, i.e. offering well-integrated and reliable shipping services. The DFDS's container service network includes many port calls on quite long stings. This is sometimes necessary to collect enough cargo, but is not

desirable for the Shuttle Concept in order to keep a high frequency and a short transit time, even though calling at more than two ports – the hub port and the satellite port – will be necessary for many markets.

7 Market analysis

This chapter presents a market description and analysis of the Short Sea Shuttle Concept. Potential goods volumes map the possible cargo for the concept in the region, where three geographical areas of particular interest for the Short Sea Shuttles are described. The next section includes capacity requirements for the shuttles in order to suggest suitable vessel size. Further, infrastructure capacity deficiencies and availability are briefly described, followed by transport demand. The demands for the Short Sea Shuttles are important information for the development of the concepts, as it sets the service requests, e.g. frequency, transport time, reliability, etc. Finally, a stakeholder's analysis is presented in the last section, in which the multitude of stakeholders with diverging interests that would be affected by the introduction of the concept is described.

7.1 Potential

Short Sea Shuttles are mainly characterised by aspects of coordination in the transport chain that links the sea transport with associated hinterland connections in a synchronised manner. A Short Sea Shuttle requires high frequency of service and substantial goods volumes, but the setup of the concept can have various characteristics. The concept also requires engaged transport system actors in order to achieve the coordination, and planning must originate from a door-to-door perspective. The shuttle concept strives to eliminate or minimise any "slack" in the transport chain related to time schedules and handling times. Coordination will become even more important in the future when the capacity of infrastructure will be highly limited during peak hours. Through volumes, frequency and economies of scale, there are prerequisites for the adoption of new technology that can make the transport chain more seamless such as tailored and automatic handling techniques at inland terminals, in ports and on vessels. Short Sea Shuttles can thus be viewed as extended infrastructure with high capacity and availability. Shuttles create a more agile and seamless transport chain with regard to service (e.g., lead-times), technology (e.g., handling, IT, tracking, security), timetables, interfaces, etc., with the aim of creating more sustainable, cost-efficient transport systems with high-quality transport.

The Short Sea Shuttle Concept also creates opportunities for new business models in which each actor in the system has the opportunity to sell and contract transport links operated by other actors in the system, thus maximising customer relations. Coordination related to the concept is thus focused on both the operational level as well as the commercial level. New business models may include better coordination and use of intermediate stops in a shipping service, and pricing of a rail-sea-rail service. The opportunity to commercially package different transport services and traffic modes can be of particular interest in circumstances where competition from direct road transport is intense. In the case of Gothenburg, this is illustrated by the ferry connections to Gothenburg-Kiel and Gothenburg-Fredrikshavn, in which the goods segment is becoming increasingly important and the competition from direct road transport is very evident. Other regions where there is a potential to better link hinterland services with existing sea shuttles and services are Stockholm, Blekinge and Skåne. In most cases, however, that

would require new and improved infrastructure since many existing terminals today have limited rail connectivity (e.g. Green Cargo, 2013).

From an existing hinterland service perspective, the main direct application of the Short Sea Shuttle Concept would be as a connection to existing rail shuttles. The Short Sea Shuttles would contribute to the construction of seamless transports that combine both rail and sea links. In the context of Scandinavia, this potential would be especially interesting for the extension of existing rail shuttles and dry ports in the Port of Gothenburg, with sea links connecting other countries and regions around the North Sea and the Baltic Sea. In Figure 14, the rail shuttles to/from the Port of Gothenburg are illustrated.



Figure 14: Scandinavian Railport system (Port of Gothenburg, 2012).

There are ports connected to rail shuttles and dry ports along the east coast of Sweden that would be interesting for the shuttles to call at. Examples of ports where an extension or a complement to rail would be especially interesting due to available potential unitised cargo are:

- Umeå
- Sundsvall
- Gävle

- Stockholm
- Norrköping

All five ports are located on the east coast of Sweden and would be suitable points of entry for goods flows to and from countries like Finland, Russia and the Baltic States. Linking a rail shuttle to and from Umeå with the existing ferry link between Umeå and Vasa while defining Vasa as a dry port in this link, would enable Finnish shippers to get direct connection to the Port of Gothenburg and associated direct calls. Aligning schedules, information flows, and security frameworks combined with innovative handling techniques and systems would create an efficient intermodal linkage between Sweden and Finland. The cost disadvantages of the extra cargo handling activity related to operating a shipping service between Finland and Sweden for further transport by rail, were raised at the final reference group meeting of the project. Some of the participants thought it would be too expensive today due to loading/unloading costs and related dues and fees in port, but there is an opportunity for these connections in the future. The links would for example be interesting as the sulphur directive becomes effective in 2015 and the cost of shipping is likely to increase as a result, which could open up a market for shorter sea transport links.

The extension into northern Finland has the potential to attract substantial goods flows. Based on available market data and current traffic on the ferry link between Umeå and Vasa, potential goods volumes could account for as much as 20 000 TEU to 50 000 TEU annually. The rail service would also open up the possibility of combining containers with semi-trailers, enabling even higher potential goods volumes. If, for example, Umeå and Vasa operated within the same organisational framework, the implementation might be further facilitated.

Sundsvall has a potential to link with Finland as well; however, there is no existing ferry link to utilise. Sundsvall is developing a logistics platform that integrates the port with the intermodal terminal, enabling efficient transhipment processes and techniques between sea and rail. Sundsvall has existing rail shuttles. Like Sundsvall, Gävle provides an interesting potential of both feeder services and rail shuttles, enabling a geographical extension with the assistance of Short Sea Shuttles. From the basis of their current shipping services and rail shuttle, the estimated annual potential volumes could be between 30 000 TEU and 50 000 TEU.

Stockholm and Norrköping have the advantage of being close to the metropolitan area of Stockholm and the industrially dense Mälardalen, respectively. Both have substantial shipping services to and from countries in the Baltic region of both container and RoRo types. Norrköping has the advantage of an integrated intermodal rail terminal in the Pampus terminal, while Stockholm has the advantage of an extensive shipping network. On the basis of their current shipping services and rail shuttle, estimated potential volumes could be between 50 000 TEU and 100 000 TEU annually. Other potential extensions would be in the southeast of Sweden, e.g., Blekinge, with further connections to the continent, especially Poland.

Besides the hinterland connectivity, there is also the potential to utilise intermediate stops on existing shipping services that already operate in the Baltic Sea region. This alternative would enable additional frequency and would complement both hinterland connections and existing sea connections.

The Short Sea Shuttles have special requirements for fast and efficient transhipment between sea and rail. Most of the ports mentioned above do not fully fulfil those requirements today. There are, however, many techniques available that could be of interest and used to improve these ports.

The estimated potential volumes should not be interpreted as “added” volumes to the existing system of feeder services since most of these volumes are already handled by the respective ports for transhipment. However, the potential goods volumes would constitute a substantial potential for the Short Sea Shuttles and the existing system of rail shuttle services and its associated coordination and a likely concentration to gateway ports. The potential goods flows consist of a combination of transhipment containers and short sea containers, but there are further opportunities associated with the coordination and combination with bilateral goods of conventional RoRo type. Further, increased containerization of cargo implies future increase in volumes for the short sea container shuttles. Table 6 summarises the total TEU per major ports and countries within the region today that could be associated with the Short Sea Shuttle Concept.

Table 6: The Nordic, Baltic and Russian container markets. Source: Nordregio (2013).

COUNTRY	2000	2004	2005	2006	2007
St Petersburg	233 000	773 000	1 119 000	1 450 000	1 682 000
Kaliningrad	20 000	60 000	90 000	115 000	188 000
Russia total	253 000	833 000	1 209 000	1 565 000	1 870 000
Helsinki	376 500	500 000	460 000	420 000	431 000
Kotka	192 000	326 000	367 000	462 000	571 000
Others	360 000	487 500	485 000	540 500	605 500
Finland total	928 500	1 313 500	1 312 000	1 422 500	1 607 500
Göteborg	615 000	736 000	788 000	820 000	841 000
Helsingborg	97 500	99 000	108 000	136 000	200 000
Others	208 500	226 500	232 000	322 500	359 000
Sweden total	921 000	1 061 500	1 128 000	1 278 500	1 400 000
Aarhus	330 000	391 000	396 000	427 000	504 000
Copenhagen	112 500	113 000	125 000	138 000	148 000
Others	65 000	82 500	88 500	95 000	101 000
Denmark total	507 500	586 500	609 500	660 000	753 000
Oslo	138 500	174 000	170 500	170 000	194 000
Larvik	35 500	40 000	42 500	45 000	50 000
Others	322 500	372 000	415 500	423 500	430 000
Norway total	496 500	586 000	628 500	638 500	674 000
Gdynia	188 500	377 000	400 000	461 000	500 000
Gdansk	18 000	41 000	70 000	76 000	94 000
Others	18 500	23 000	27 000	30 000	50 000
Poland total	225 000	441 000	497 000	567 000	644 000
Reykjavik	140 000	146 000	156 000	160 000	160 000
Others	175 000	190 000	200 000	200 000	200 000
Iceland total	315 000	336 000	356 000	360 000	360 000
Klaipeda	40 000	174 000	214 000	232 000	321 000
Lithuania total	40 000	174 000	214 000	232 000	321 000
Riga	85 000	153 000	156 000	160 000	212 000
Ventspils	500	500	1 000	14 500	17 000
Others	2 000	2 500	3 000	8 000	8 000
Latvia total	87 500	156 000	160 000	182 500	237 000
Tallinn	77 000	113 000	128 000	152 000	200 000
Estonia total	77 000	113 000	128 000	152 000	200 000
TOTAL	3 851 000	5 600 500	6 242 00	7 058 000	8 066 50

Source: Based on interviews and website research

One of the largest changes in the figures presented in the table above is that Maersk Line switched their Polish operations from BCT in Gdynia to the deepwater container terminal DCT Gdansk in 2008/2009.

The most likely potential volumes are associated with transhipments to and from the Baltic States and Russia and between Norway, Sweden and Denmark. Depending on the service and market, this potential may differ significantly. The total market, as illustrated in the Table 6 above, constitutes some 8 million TEU annually. These statistics and the container market mainly concern containers originating or designated for inter-continental destinations. The Short Sea Shuttle Concept has the potential to further develop the intra-continental container flows and market segments by utilising existing container services, either direct services or feeder services. This shift of volumes would then most likely be from the RoRo segment to the container segment as more volume is shifted to containers. Three main potential international segments have been identified related to the Short Sea Shuttle Concept:

- 1) For the Norway-Sweden-Denmark route, the potential container volumes could be as much as 100 000-300 000 TEU/year,
- 2) For the Sweden-Finland-Russia connection, annual goods volumes could account for as much as 1 million TEU per year, given the upcoming sulphur directive and its impact on transport costs in general and on shipping in particular,
- 3) Sweden-Baltic states. This is the market segment most difficult to estimate since the hinterland connections that could be utilised are limited. However, we estimate these annual volumes to be less than 100 000 TEU/year.

To summarize, the potential associated with the Short Sea Shuttle Concept is substantial. However, implementation of the concept is a great challenge in many aspects, such as scale, infrastructure, number of actors, and technology. Because of the many different stakeholders involved, a coordinator to facilitate and manage the collaboration and long-term ambitions of a Short Sea Shuttle service is probably needed. Government support at the regional, national and supra-national level could be needed initially.

7.2 Capacity requirements for the shuttles

In order to estimate required potential container volumes to fill up a shuttle to a certain utilisation level, different vessel sizes and departure frequency is played about with in Table 7. As indicated in the table, large volumes are required for vessels larger than 1000 TEU, especially if there will be more than one departure per week. These figures can be compared with available volumes for the Nordic, Baltic and Russian container markets shown in Table 6. The vessel size and the departure frequency, in combination with market analysis including customers' requirements and analysis of competitors at sea and on land, need to be examined in detail for each route to find the suitable set up for the shipping service. These calculations will therefore only serve as guiding principles.

Table 7: Capacity requirement for the Short Sea Shuttles depending on size and frequency.

Vessel capacity (TEU)	Departure frequency	Capacity utilisation	Total number of containers per year
150	1/w	80%	12 480
150	3/w	80%	37 440
350	1/w	80%	29 120
350	3/w	80%	87 360
700	1/w	80%	58 240
700	3/w	80%	174 720
1000	1/w	80%	83 200
1000	3/w	80%	249 600
1400	1/w	80%	116 480
1400	3/w	80%	349 440

The high frequency requirements and a high capacity utilisation of the vessels mean that maximum suitable vessel size of up to 1 000 TEU is suggested on markets with similar size as the Swedish market. Similar recommendations were received from two of the respondents, shown in Table 2. Large economies of scale in shipping imply that too small vessels will have a higher cost per transported load unit. Consequently, too small vessels will have difficulties in reaching the break even for profitability. The lower limitation in size depends on different factors, such as capacity utilisation, volumes, distances, etc. Considering the market potential in Northern Europe, vessel sizes from 350 up to 1000 TEU will be suitable for the Short Sea Shuttles on most routes. However, larger cargo volumes in some ports can allow for larger vessels.

7.3 Availability of infrastructure for increased shipping

Capacity deficiencies are already evident in parts of the Swedish transport system, especially in some part of the railway system and within and around metropolitan areas (Trafikverket, 2012). There are also a few places with capacity problems in the road networks, mainly in the Stockholm and Gothenburg region. These problems are expected to be worse in the future. Both infrastructure managers and freight operators consider the largest capacity and quality problems, in the Swedish railway infrastructure, to be on the tracks that are used by both passenger and goods traffic (Vierth et al., 2012).

Shipping is regarded as one solution, and is therefore often promoted (e.g. European Commission, 2011). The waterways have limited infrastructure costs and high available capacity with very little congestion. Thus, growing transport volumes can be handled by ships, which would relieve the pressure on the land-based infrastructure. Consequently, there is a possibility for shipping to serve as a complement or competing mode to rail and to some extent to road, which demands a large infrastructure investment to increase its capacity (Vierth et al., 2012). Infrastructures at sea and in ports are available for smaller

container vessels in the whole region. The shuttles are suggested to be relatively small, which means that there is no, or very little, need for dredging of widening fairways and port basins, or for additional port equipment.

There are in general no capacity limitations in the number of ships in Swedish fairways; it is primarily a matter of the dredging of shipping fairways in order to allow the passage of larger ships. Compared with land based infrastructure, the costs for partly adjustments of fairways are less costly than infrastructure for railways and roads (Trafikverket, 2012).

There are many ports available along the coasts of the North and Baltic Seas that can serve container vessels the size of a feeder vessel. Only in Sweden, there are 27 ports able to handle containers (CombiPort, 2013) with diverse equipment for loading / unloading and storage and movement of containers between the different traffic modes. The “buyer's market”, which means supply of port capacity exceeds demand, giving the ship operator an advantage over sellers in price and service negotiations. However, even though there is excess capacity on an annual basis, port slots available for an efficient timetable cannot always be guaranteed. The container cranes are often the bottlenecks in the cargo handling activities in port. This is mainly due to the high investment costs of the cranes and the physical restrictions (e.g. quay length, necessary distance between the cranes, etc.), which set the limits of the number of cranes that can serve a vessel simultaneously.

Even though capacity is available at sea and in fairways, many ports face some capacity shortage in gates and in the connecting railway system at peak hours. For example, capacity problems for freight are identified for the harbour track in Gothenburg (Vierth et al., 2012). There are large daily and weekly variations in delivery and collection times of cargo in a port. There are two available options (Styhre, 2010): 1) to invest in overcapacity in order to handle the peaks, which will result in low average capacity utilisation of equipment, or 2) to keep the investment down and the capacity utilisation up, which will result in queues during peak hours. Often there is a combination of the two: some overcapacity is necessary, but will not fully match the highest load peak in order to save costs.

In order to attract cargo to a specific port, its hinterland needs to be well-connected to the port. Road and rail infrastructures, as well as frequent and reliable transport services, including shipping services, are necessary.

7.4 Demand on transport

In a previous study by CombiPort (2013), it was concluded that the main disadvantages of short sea shipping are longer transport time, lower frequency and uneven goods flows, while the advantages are foremost related to lower transport costs for well-established services. Compared to traditional feeder services, the Short Sea Shuttles offer a higher frequency, fewer port calls along the routes and a longer time table commitment from the shipping lines. This will provide a longer planning horizon for the customers and a shorter total transport time with cargo waiting fewer days in port.

Freight transport is highly contextual and different segments serve shippers with quite diverse demand patterns. Main dividers relate to the character of the goods, geographical scope, i.e., whether the transport service is part of a domestic, an intra-European or a trans-ocean transport chain, and willingness to pay for fast transport. Domestic shipping is rather significant (Vierth et al., 2012), but not in the segments of unitised cargo that Short Sea Shuttles aim for. The Short Sea Shuttles focused in this report aim at combining intra-regional flows of goods loaded in containers with flows of containers as part of deep sea shipping, which somewhat limits the scope of transport demands that need to be fulfilled. The demand can be characterised as medium in the scales of demand for speed and low costs. The main difference from the current container feeder services is the demand for stricter schedules, higher frequencies and stability over time.

Like many similar studies, a large survey study carried out in 2012 of large Swedish manufacturing and wholesale companies showed that punctuality is ranked higher than transport time (Lammgård et al., 2013). This indicates that transport time is not as important as being able to plan the transport and get the cargo just-in-time when necessary. Maersk acted on this by launching Daily Maersk, which however offers longer lead time, but significantly increased frequency and reliability for their Europe-Asia routes in 2011 (Maersk Line, 2011). Instead of publishing an optimistic timetable they changed to one that they were sure to meet. The same applies for SJ's trains between Stockholm and Gothenburg with longer transport time in order to increase the chances of arriving on time. Consequently, there is a focus on both punctuality and frequency for the Short Sea Shuttles in order to cope with some of the traditional disadvantages of shipping.

7.5 Stakeholders analysis

Implementing the Short Sea Shuttle Concept does not regard a limited substitution of links in transport chains. On the contrary, it affects a multitude of stakeholders with somewhat diverging interests, and history is full of examples of implementation failures, although the system aimed for seems to provide large improvements. Changing large-scale and complex systems meets a particular strong inertia if it is not changed within the governance of one actor (Woxenius and Lumsden, 1996). It is simply too often the case that the costs and benefits of introducing the change are unevenly distributed between the stakeholders or that decision-making in the different organisations is badly synchronised. It is, hence, somewhat naive to think that large changes come easily; they are possible to implement, but change requires deep knowledge about the pros and cons for each actor involved.

As a complement to the presentation of the features characterising the concept and the SWOT analysis in Chapter 3, this section discusses how an implementation of the Short Sea Shuttle Concept might affect different stakeholders. The actor categories covered are shippers, forwarders, incumbent feeder shipping lines, potential new shipping lines operating shuttles, deep sea shipping lines, ports, rail shuttle operators, road hauliers, infrastructure providers, port cities and, finally, the society at large including external effects for citizens. In this development phase, it is limited to a logical deduction/desktop

study primarily based on the expertise in the research group. The analysis is made in a context of a post-2015 market with SECA regulation in place and, probably, with NECA regulation being implemented, although Russia currently halts the negotiations.

Just as with the railway shuttles, *shippers* and *forwarders*, in their capacity as proxy customers, will benefit from a wider selection of transport services, but even more from an improved transport quality. Better integration and more importantly stability over time will facilitate investments in logistics structures adapted to the services.

At the outset we assume that the shuttle services will be offered by the *incumbent feeder shipping operators* such as Unifeeder, Team Lines and SeaGo Line (Maersk), or as part of the capillary network controlled by the *deep sea shipping lines*. Nevertheless, since the operations will be of another character it might open up for entrepreneurs challenging the incumbents, in this report referred to as *niched Short Sea Shuttle operators*. This has been witnessed concurredly in the Swedish rail shuttle market with several small players (Flodén and Woxenius, 2013). Obviously, the Short Sea Shuttles implies both opportunities and threats for the incumbents, depending on if they will operate themselves or face new competition, but also in the dimension of whether they will use the existing fleet or invest in new vessels in the longer term. In addition, it will require organisational and market investments and a fair amount of new thinking by the staff.

For *deep sea shipping lines* not operationally involved in the current feeder services, it will facilitate a stronger synchronisation of events and a stronger service offer in certain segments just like the railway shuttles have improved the over-all offer. It can also help them to have stable time tables if a set of ports will act as hub ports serving rather well-defined regions. Hence, they can build up their organisation for direct calls in the long-term.

Many short sea RoRo and ferry services resemble Short Sea Shuttles but primarily they serve shippers with an intra-European transport demand and road transport links are often quite long. The *short sea RoRo shipping lines* will, however, face some new competition since they transport containers in their services, but some of their services might qualify to be marketed as Short Sea Shuttles with improved integration with deep sea shipping.

Spontaneously, *rail shuttle operators* might be identified as the actor category most challenged by the Short Sea Shuttles. In a Swedish context, this might apply when a railway shuttle has gained large volumes from an east coast port and transport the containers by rail to Port of Gothenburg or Port of Helsingborg. Currently, this competition is between railway shuttles and feeder operators and the pattern is that rail has taken substantial volumes from the feeder services. On the other hand, Section 7.1 focused on cross-Baltic Short Sea Shuttles coordinated with the railway shuttles adding volumes to the existing railway shuttles. Our view is that the interaction between road and rail where volumes decide which mode is the better, could be replicated with the interaction between railway shuttles and Short Sea Shuttles. Thus, as road is used to build up flows until a railway shuttle is viable and act as backup if the volumes decrease, the railway and Short Sea Shuttles can alternate depending on volumes. This does not apply on a weekly or monthly basis as the Short Sea Shuttles are

expected to be stable over time, but it can at least make shippers more comfortable with a reliable transport service.

Road hauliers are not expected to be very much affected, but a higher frequency will help to smoothen their operations with less significant peaks around feeder ship calls.

A main driver behind this study as well as the development of railway shuttles is that *hub ports* want to secure their hinterland and attract more flows. Volumes are particularly important for attracting direct trans-ocean calls by the main deep sea shipping lines. The most relevant in a Swedish context, is obviously the Port of Gothenburg, but there are aspirations also by the development of Stockholm Norvik.

At the other end of the Short Sea Shuttles, *capillary ports* will benefit from higher frequency and improved coordination with deep sea shipping. Those ports that already have a railway shuttle might not be much affected, but it can attract flows. The main driver for the capillary ports is expected to be better prospects for establishing logistics parks around the ports. As the Swedish ports often are municipality owned, a certain wish to attract blue-collar jobs in the logistics sector can be distinguished.

The infrastructure providers and other authorities with infrastructure planning among their tasks will be positively affected by a more stable offer of transport services. The Swedish public sector has a complicated relationship towards ports since they are often municipality owned and run as companies with profitability goals. Yet they are decisive for employment and attractiveness for industry in a wider region around the ports and, above all, the state is expected to supply the access infrastructure. Quays and cranes are substantial investments, but railways, highways and fairways are much more costly. Municipalities might invest in the roads and tracks at the immediate vicinity of the port, but the major invoices are to be picked up by the state level. It has still proven to be difficult to implement national and even regional strategies regarding ports, partly since politicians at the government and regional levels hesitate to interfere with local politicians.

The *infrastructure providers* are obviously much affected by the traffic modes combined in the capillary and hub ports. Capillary ports with variable volumes and frequent shifts between feeder shipping, rail shuttles and road transport to get to the hub ports obviously create a lot of problems for the infrastructure providers. A more stable situation will obviously help to match the infrastructure to the demand and a higher frequency compared to feeder services will decrease the peak loads around ship calls. In particular *road infrastructure providers*, both at the municipality and state level, will benefit from this as they also have to cater for local passenger traffic. *Rail infrastructure providers* might also see a more stable situation, perhaps most visible if the cross-Baltic Short Sea Shuttles can make the Swedish railway shuttles connecting east and west coast ports more stable over time. When one link for each port is shifted to sea from rail or road, local congestion and demand for land infrastructure capacity will obviously decrease. Finally, the *Maritime administration* will be helped in their priorities of fairway investments and more even demand for their support services such as pilotage.

At the society level, *port cities* will gain from less land traffic and, as mentioned, the logistics parks in the capillary ports will be more attractive if they can be established as stable and high-quality nodes as part of a global container network. For hub port cities, on the other hand, the advantage lay more in the attractiveness for direct calls and quality improvements for the flows in the vicinity of the hub port. For job creation, it might not be advantageous with a more integrated network since most jobs tend to appear where the containers are stuffed and stripped, not where they are transhipped between modes.

The total income for the tax authority is likely to decrease since shipping is less taxed than the other traffic modes. This is, however, not the same as saying that it is economically disadvantageous for the *society at large* since much of the taxes paid by road and rail should be compared with infrastructure and external costs. Used in a proper way, shipping has a clear benefit to require very little infrastructure investments, less energy and with SECAs and NECAs in place also for emissions than other modes. Society's main benefit from the Short Sea Shuttles, however, is like to be increased competitiveness through improved logistics, so decisive for peripheral countries.

Table 8 summarises the relevant stakeholder of the Short Sea Shuttle Concept. Most advantages are likely to come from the increased stability and frequency.

Table 8: Main advantages and disadvantages for the main stakeholders.

Category	Stakeholder	Advantage	Disadvantage
Customers	Shippers	Better integrated service	Prolonged lead time
	Forwarders	Wider selection of services	Others compete for the integration of flows
Transport and terminal service providers	Incumbent feeder shipping line	More business and more stable flows	Challenge by new niche operators
	Niched Short Sea Shuttle operator	New business opportunities	
	Deep sea container shipping line	Improved and more stable capillary network, improved cost efficiency	
	Short sea RoRo shipping line	Can operate as Short Sea Shuttle	New competition in certain segments
	Rail shuttle operators	Increased flows by cross-Baltic shuttles	Competition for flows
	Road hauliers	Less variable demand	
	Hub port	Secure hinterland by better service	
	Capillary port	Less variable flows and logistics park competitiveness	
Infrastructure provider/legislator	Road infrastructure provider	Less regional road transport/congestion and stable planning conditions	
	Rail infrastructure provider	Stable planning conditions	
	Maritime administration	Stable planning conditions and stable demand for services	
Policy makers	Hub port cities	Less local traffic and attractiveness for direct calls	Less containers stuffed and stripped
	Capillary port cities	Employment in logistics parks	
	The society at large	Competitiveness and less infrastructure spending, congestion and emissions	Less tax revenues

8 Conclusions

Efficient short sea shipping is vital for trade and industry in Northern Europe. It is important to find cost-effective solutions for shipping to improve the global availability of goods in Northern Europe and to reduce the environmental impacts caused by the transport industry. The growing importance of shipping has been highlighted in various contexts, for example in the Swedish Transport Administration's capacity investigation from 2012, and in the white paper on transport from the European Commission from 2011. Both reports stress the need to shift larger volumes of cargo from the land-based infrastructure to sea. Consequently, sustainable and well integrated transport services are of great importance in order for the separate parts of the transport system to function cooperatively, and to avoid fragmented or short-term focus on individual solutions. This allows transport buyers to get better global access to their markets and gives them opportunities to better plan their transport activities.

The purpose of this work is to develop and define a container shipping concept, with the focus on transport of cargo within, to and from Sweden. The *Short Sea Shuttle Concept* involves transport of containers between satellite ports and a hub port with fixed schedules, and high reliability and departure frequency. The shuttles can operate between two ports, but additional ports can be added in a string to collect enough cargo as long as the frequency and the transport time are reasonable. This research is limited to transport of maritime containers, but the concept can be applicable to other types of goods and load units. High punctuality is an essential factor for the shuttles, as it allows the transfer of more time-sensitive cargo to sea, which currently is transported by other modes. The increased importance of shipping in a future transport system means that there are great demands on efficiency, sustainability and economic stability. The Short Sea Shuttle Concept is defined as: "*High-frequency short sea liner shipping of standardised load units that is highly integrated into transport chains with functional inland connections.*" A suitable size range of the shuttles for Northern Europe is expected to be approximately 350-1000 TEU. However, larger or smaller cargo volumes in some regions mean that some deviations from this recommendation might be appropriate.

The Short Sea Shuttles will be an integrated part of a longer transport chain, requiring a connection to the existing railway system and deep sea services. This allows transport buyers to get better access to their global markets and facilitates adaptation of their logistics systems and better planning. In the context of Scandinavia this potential would be especially interesting for the extension of existing rail shuttles with sea links connecting countries and regions surrounding the Baltic Sea. An implementation of a system of short sea shipping links will bring preparedness for further capacity problems in railway and road infrastructures and will also open up new markets. The most important aim of the concept is to offer cost-efficient, reliable and sustainable transport for shippers in Northern Europe.

Goods transport is highly contextual and different segments serve shippers with quite diverse demand patterns. The Short Sea Shuttles aim at combining *intra-regional flows* of goods loaded in containers with flows of *containers as part of deep sea shipping*. Implementing

the Short Sea Shuttle affects a multitude of stakeholders with diverging interests. It is assumed that it is most likely that the shuttle services will be offered by the incumbent feeder shipping operators or as part of the capillary network controlled by the deep sea shipping lines. The concept creates opportunities for new business models, including both operational and commercial perspectives.

The most suitable ports for the Short Sea Shuttles are the ones with largest potential volumes, both in the port cities and in the hinterland. Potential volumes include both existing containers that today are transported by other modes (including feeder shipping), but also cargo that is not containerised today, but is likely to be so in the future. Preliminary analysis of market conditions for the implementation of the concept has identified three main potential international segments for the Short Sea Shuttle Concept:

- 1) For the Norway-Sweden-Denmark route, with potential container volumes of 100 000 -300 000 TEU per year;
- 2) For the Sweden-Finland-Russia connection, with potential volumes that could account for as much as 1 million TEU per year;
- 3) Sweden-Baltic state, with annual volumes that could reach up to 100 000 TEU per year.

Despite the large potential benefits the Short Sea Shuttles would bring to the transport system, the concept faces challenges. The significant problems related to shipping are high emissions of air pollutants such as NO_x, SO₂ and PM. Stricter environmental regulations are important to accomplish significant reductions in emissions from shipping, but these need to go hand in hand with a wish to move cargo from land to sea. The advantages of the Short Sea Shuttles are foremost related to lower costs for shippers, available infrastructure and capacity compared with competitive modes, potential lower emissions, and less accidents and congestion. The most important disadvantages identified are start-up risks, high port costs, too low volumes at present and new regulations for shipping.

Thus, the potential associated with the Short Sea Shuttle Concept is substantial, but implementation of the concept is a challenge in different aspects. Future research is suggested to include a case study analysis of the three identified potential routes, from three perspectives: 1) *Logistics*, including suggested time table, ports to call, investigation of major customers' requirement on transit time, frequency, etc. for the shuttle services. 2) *Economic analysis* to in detail investigate costs in a start-up phase and in a steady state, including new regulations and expected future volumes and development of the shipping industry. 3) *Environmental aspects* to compare the environmental performance of the Short Sea Shuttles and the different transport alternatives. Further work would benefit from a close cooperation between researchers and potential operators and other actors in the shipping industry in order to get better information about costs and logistics aspects and to facilitate a future implementation of the concept.

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