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Research Paper

« Connecting Scandinavia through the Fehmarn Belt Link »

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Abstract

This paper concerns the forwarding company KDSB and their investigation of intermodal operational activities in the Northern part of Europe. Due to receiving new contracts by three customers in the Oresund area of Scandinavia, KDSB will enter the freight forwarding business in the region. One customer is located in Malmo, another in Copenhagen and a third at the Hoje Taastrup terminal outside of Copenhagen. These customers have a demand of transportation between the port of Hamburg and their locations. Furthermore, the company have chosen to operate on the new to be constructed Fehmern Belt Link. The construction of the link is to be finalized in 2021, and is expected to change the current flow of freight in the Scandinavian region. In order to conduct necessary investments and strategic decisions, KDSB have evaluated other possible routes and modes. Hence, the new Fehmern Belt Link is being compared with other possible alternatives. An investigation regarding the infrastructure, a performed cost analysis, a market analysis and a setup plan is proposed in the paper.

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1.Introduction

The Oresund region is today connecting the Scandinavian cargo traffic to Europe. This connection means that cargo are transported from Sweden, Norway, Finland and Denmark across Oresund, through the Zealand region, towards Germany and further out in Europe. Hence Oresund, Zealand and also the Jutland region of Scandinavia is of major importance both from the individual municipality level, as well as from a state and European Union (EU) perspective. According to the political partnership called STRING (STRING includes Hamburg & Schleswig-Holstein in Germany, Zealand and the Capital region in Denmark and the Scania region in Sweden), the cargo traffic at the Oresund region has increased with large dimensions during recent times (String, n.d.).

In order to understand the importance of the Scandinavian Oresund region, one first have to have a general understanding of the vital role of the major cities. The prosperity and growth of the cities are essential for the regional development in forms of production, culture, knowledge and establishment of new infrastructure (Femern [1], n.d). By looking at the current amount of inhabitants in the cities, one may receive an understanding of the need for well functional logistic routes. In Sweden, the third largest city is situated in the Scania region, which is located on the opposite side of the sund than Copenhagen. Malmo has approximately 300 000 inhabitants (Malmö stad, n.d.), while Copenhagen has 1,250 000 inhabitants (Denmark, 2014). Other cities of importance in the Oresund is Trelleborg, Helsingborg, Roskilde and Helsingør. These are all connected to each other and the Zealand region by the Oresund bridge link (Wichmann Matthiessen. 2003, p. 31). Looking at vital cities in the northern german region, one can identify Hamburg, Kiel and Lübeck as major centres. Hamburg posseses a population of 1.8 million inhabitans while Kiel and Lübeck together can amount of approximately 450 000 (Femern[1], n.d). By only looking at these mentioned centres and their population, one should understand the importance of infrastructure as a crucial component of the region.

Due to the previously mentioned forecasted increase of capacity (as for example analysed by STRING) further investments in modern infrastructure in the northern european region will be conducted. The first step was to establish a fixed link across the Great Belt in Denmark and another one crossing the Oresund between Denmark and Sweden. A third link is to be constructed in 2021 across the Fehmarnbelt between Fehrmarn in Germany and Lolland in Denmark. This new link will be in the form of a 17,6 kilometers long immersed tunnel (Femern [2], 2014). By establishing a fixed link over the Fehmarnbelt, access between the regional urban areas can greatly be improved (Femern [2] , 2014.) The tunnel between

Fehrmarn and Lolland in association with improvements in the rail network have the chance to change the economic conditions in the region, as well as enhancing the intermodal traffic posibilities (Butler and Madsen, 1997. p.753). Furthermore, Butler and Madsen (1997) constitutes that the Fehmarn link together with the Great Belt and Oresund link, indeed introduces new routes for both the rail and road network in the northern continental part of Europe (Butler and Madsen 1997. p. 752). In the figure below, the reader can identify the plotted Fehmarn belt passage in orange colour between the german city of Puttgarden and the danish city of Rødbyhavn.

Figure: 1, Map of Northern Scandinavia and the Fehmarn belt passage
(source: one society democracy Europe, 2014)

1.1 Introducing The Forwarding Company *KDSB*

Due to the planned new Fehmarn link between Dennmark and Germany, a Scandinavian forwarding company operating within logistics, named KDSB have decided to actively conduct operations on the new route in 2021. The strategic decision to enter the fehmarn link route is due to the receival of three new customer contracts. These mentioned contracts includes transporting lorries between the port of Hamburg to the Oresund area in Sweden and Denmark. Furthermore, the contracts also includes transportating lorries in the opposite direction; from the Oresund region to the port of Hamburg. To be more specific, the contracts involves both delivery and pickup at three different locations in the Oresund area. One contract concerns a customer located in Malmo, one in Copenhagen and another at the intermodal terminal of Taastrup in the outskirts of Copenhagen. These contracts will be further presented in detail in section 5.

Acquiring the contracts and simultaneously having the possibility to receive favourable train schedules on the fehmarn link (due to a early entry on the line), have created a business opportunity. Hence, KDSB have decided to investigate and compare the usage of rail on the new fehmarn belt link with other currently existing routes and modes. By looking into each line (currently existing and being planned) and the existing transportation mode alternatives, KDSB will present a cost and market analysis. Additionally, KDSB will examine potential areas for development of the most appropriate route and apply theoretical analysing-tools such as SWOT analysis.

1.2 Essential Infrastructure in the Oresund & Fehmarn area by 2021.

The infrastructure is vital to understand in order to receive a general grasp of the transportation situation in a area. Furthermore, the authors of the paper believe that the following infrastructural objects and linkages in the northern part of Europe is vital to comprehend. They are vital, due to their role in the strategic decision making of selecting freight routes. The key infrastructual linkages are: the Orresund link, the Great belt link, the Fehmarn belt link and the port of Hamburg.

The Oresund link

Today Denmark and Sweden are connected through Malmo and Copenhagen via the Oresund bridge link. The link was completed in 2000 and contains paralell two-way railway and motorway. In total, the bridge is 1,8 kilometers long across the Oresund channel. The link has resulted in benefits both from a time reducing perspective as well as a reduction in congestions from the previously existing land-sea bottleneck (Wichmann-Matthiessen. 2004, p. 31). Furthermore, Wichmann-Matthiessen (2004) argues that the established link across the Oresund has developed and strengthen the regional integration. However, it is important to communicate that the development has been slower compared to the expectations (Wichmann-Matthiessen. 2004, p. 31). The current freight capacity crossing the bridge is however extensive. Only the capacity by trucks comprimises of 30 000 crossings per month. (Oresundsbron [1], 2014). Prices charged by the tolls vary depending on the frequency of crossings. The standard price per truck and crossing is approximately 564 SEK (Oresundsbron [2], 2014). Since the danish electrified system is 25kw (kilowatt) AV (alternative current electrification), compared to the Swedish 15kw AV, dual-voltage locomotives and trains are required when crossing the Oresund Link (Railway technology [1], 2014). In figure 1 below, the reader can see the location of the Oresund link.

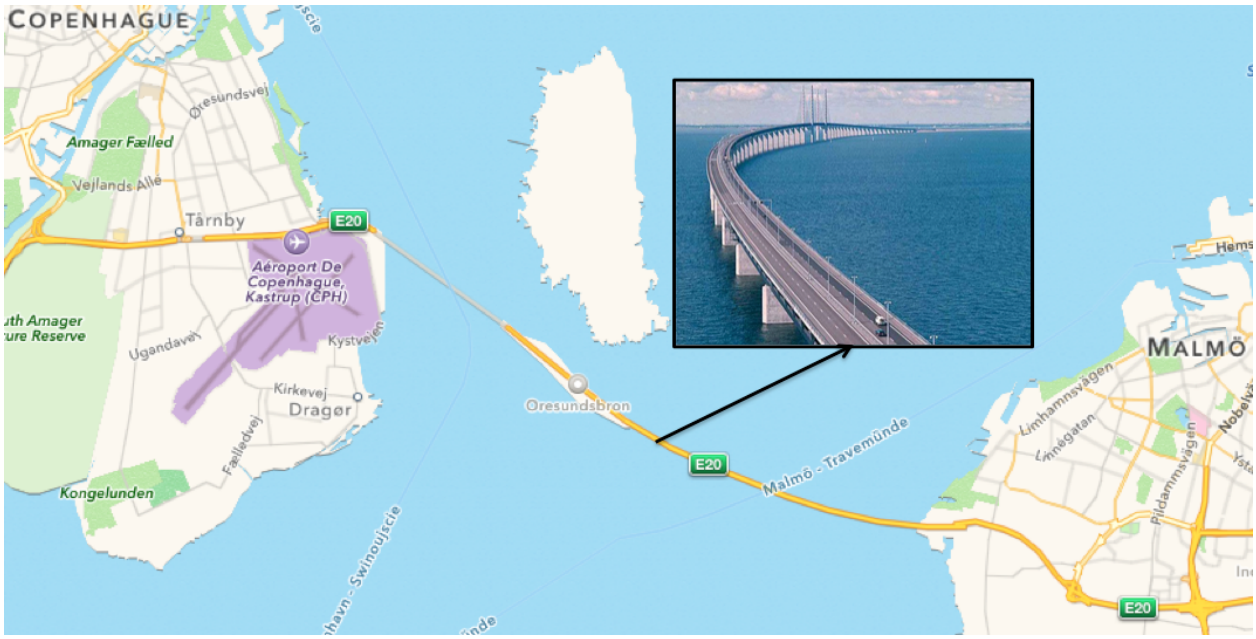


Figure: 2 (Own illustration, google map & picture from Behnam, 2011)

Great Belt Link

The Great belt link connects the Danish Zealand region and the Jutland peninsula through the Funen island. In 1997 the link was completed, including 3 water crossings with two bridges and one tunnel (East-bridge, West-bridge and the Sprogø tunnel). The two bridges and the tunnel have paralell two-way motorway and railways (Storebaelt [1], n.d.). Up till now, the link has increased the north-to-south amount of journeys by 77 per cent. This percentage number includes both passanger and freight traffic. The Scandinavian traffic as a whole have contributed to this high percentage. Hence, the purpose of establishing the Great Belt link has been to connect the entire Scandinavia (not only the danish regions of Zealand and Jutland) with continental Europe through time and cost benefits (Railway technology, 2014). The current price charged for crossing the link is approximately 7500 SEK per train and 1400 SEK per truck (Storebaelt [2], 2014) . Important to mention is that the link offers electrified 25kw AV, which only allows Swedish trains with dual-voltage to be able to access the line (Railway technology [2], 2014). In figure 3 below, the reader can see a visual presentation of the Gret Belt link.

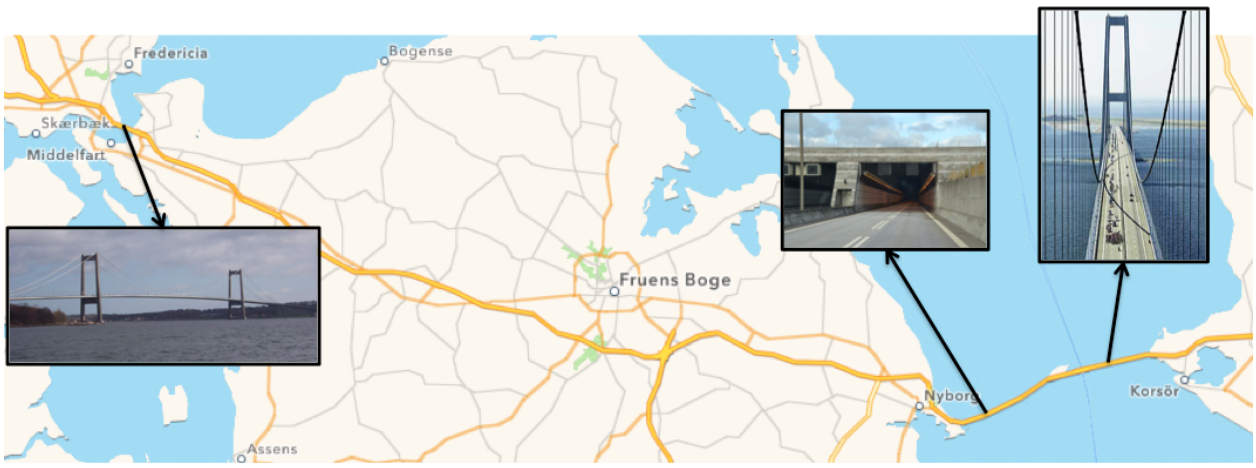


Figure: 3 (Own illustration, google map & pictures from Scanpix, 2005,. Anon, 2010,. and Anon, 2013.)

Fehmarn Belt passage by Ferry

Currently the Fehmarn passage is operated by the ferry line Scandlines between the german region Fehmarn and the danish region of Lolland. To be more specific, the ferries traffic the citites of Puttgarden and Rodby at a frequency of more than 50 times per day. The transit time across the passage is 45 minutes according to the operating schedules by Scandlines. Every truck is advised to stand ready at the ferry terminal minimum 15 minutes prior to departure. Neither reservations nor waiting lists are required. The ferries are able to carry shorter commuting trains but not freight trains (Scandlines 2014). According to Butler and Madsen (1997) the current capacity using the Fehmarn passage by ferries (out of the total capacity between Denmark and Germany) is 12 percent (Butler and Madsen 1997. p. 753). Price per full truck amounts to 2100 SEK and for empty ones 1100 SEK. Hence, the weight is a progressive factor of the ferry price for the route (Scandlines, 2014).

Fehmarn Belt Link

In 2021 the new immersed tunnel will be completed, connecting Scandinavia to continental Europe. This tunnel link will have the length of 17.6 kilometers and a combined rail and road tunnel. The length of the tunnel makes it the longest immersed tunnel in the world (Femern [1], 2014). Furthermore, the fixed link is estimated to reduce the transit time from 45 minutes (current ferry transit-time) to 7 minutes. For passenger trains between Copenhagen and Hamburg, this means a reduction in time of 1,5 hours (3 hours instead of 4 hours). Looking at freight trains, the transittime can be reduced from 6 to 4 hours. From the train perspective, trains can save 160 kilometers of detour by using the Fehmarn Belt link in 2021 instead of travelling through the Great Belt link. Because of these savings in time and distance, the tunnel is a top priority for the European Union (Femern [3], 2014). The crossing will have

electrified rail connection with different systems. The german standard is 15kw AC and the danish is 25kw AC. Therefore, any train using the Fehmarn crossing needs a dual-voltage locomotive much like at the Oresund Link (Railway technology [1], 2014). By connecting Fehmarn and Lolland with a fixed link, the flow of freight is estimated to gradually shift to this new link. Furhtermore, the region of Fehmarn and Lolland is predicted to become enhanced from a economic perspective (Femern [3], 2014). In figure 4 & 5 below, the reader can see the location of the Fehmarn link.

Figure 4 (Own illustration by using googlemap & picture from Scandlines)

Figure 5 (Own illustration by using googlemap & picture from Uhr, 2011)

Port of Hamburg

In the year of 1189, the port of Hamburg was officially established (Port of hamburg [1], 2014). The port is situated on the river Elbe and has a surface area of 7,200 hectares. Furthermore, the port area includes a total road network of 140 kilometer and runs a 304 kilometer long railway (Hamburg port authority, 2014). The port of Hamburg is currenly one of the leading logistic locations in the northern part of Europe. Not only does the port operate within transshipments, but also operates as a logistic hub itself (Port of hamburg [2],2014). The port of Hamburg is today the third largest port with its four containerterminals after the port of Rotterdam and Antwerpen. In order to communicate the extensive amount of operations conducted in the port of Hamburg, the example of the total amount of ships calling Hamburg during 2011 is fitted. During 2011, the amount of 10 106 shipps docked altogether in the port area (Port of hamburg [3], 2014). Looking at the operations during 2013, one can see that a total amount of 9,258,000 TEU containers were handled by the port (Port of hamburg [4], 2014).

In total, approximately 90 rail companies are offering connectings between the port of Hamburg and the hinterlands. These companies contributes to the 200 rail connections that

every day serves the port. The different terminals being a part of the port of Hamburg are equippped with the most modern rail cargo handling facilities. These modern equipments contributes heavily to the smooth function of transshipments between ships and rail.

When describing the port of Hamburg, it is of specific interest to look at the HHLA Container Terminal Tollerort (CCT). From a intermodal perspective, this terminal is the essential part regarding the infrastructure of the port of Hamburg. The CCT terminal handles container traffic, bulk cargo and on-and-off loading on trains. Hence, it play an important role as a service provider for logistic fowarders and rail companies who are operating between the port and the hinterlands (Port of Hamburg [5], 2014). Four berths and eight container gantries are located at the terminal area. These are essential for the handling of post-panamaz sized ships in the port. Due to the scale of operatings concerning transloading trains, the CCT terminal are equipped with 720 metres of rail track as well as three transtainer cranes. The specialized transtainer cranes provides increased efficiency since they manage to handle block trains quikly without any shunting operatings. Hence, one can argue that the port of Hamburg and its CCT terminal is well suited for intermodal transshipments (HHLA, 2014). The rail connecting the terminal with the rail network uses the standard german current system of 15kw AC (Railway technology [1], 2014). In figure 6 below, the reader can see the location of the CCT-terminal in Hamburg.

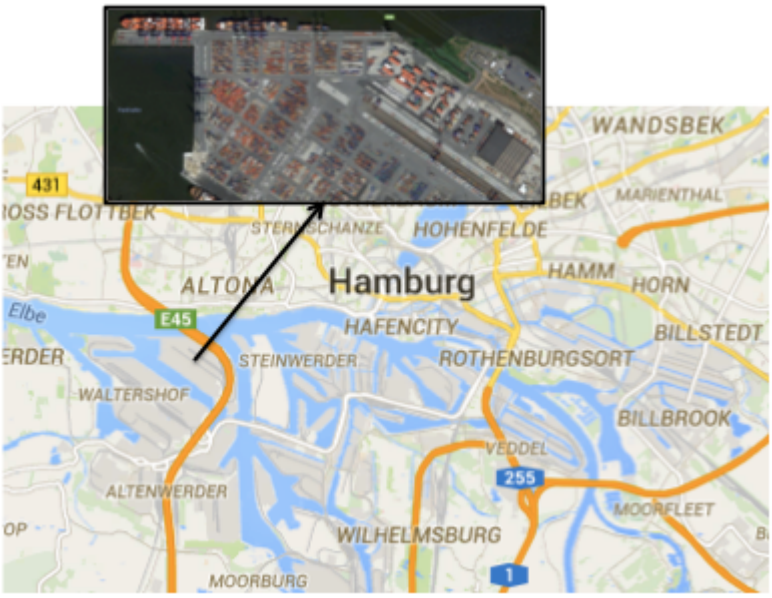


Figure: 6 (Own illustration by combining googlemap picture and)

Høje Taastrup Terminal

The Høje Taastrup terminal is considered an important intermodal terminal in Denmark due to its strategic location. The terminal is located approximately 20 kilometers from Copenhagen (Google Maps [1], 2014) Høje Taastrup together with another 3 terminals (Hirtshals, Esbjerg and Taulov) are connecting the whole railway freight transportation in Denmark. Due to its strategic location, Høje Taastrup terminal has been listed in DB Schenker's investment plan as one part of a sustainable and national freight network for Denmark in future (DB Schenker Rail Scandinavia A/S, 2013). By using terminal operations, freight companies can establish efficient logistics systems. Furthermore, the usage of terminal services such as from the Høje Taastrup terminal can reduce external costs for the society. For example it can lead to reductions of traffic congestions, evironmental impacts and energy consumption (Taniguchi et al., 1999). In figure 7 below, the reader can see the detailed location of the Høje Taastrup outside of Copenhagen.

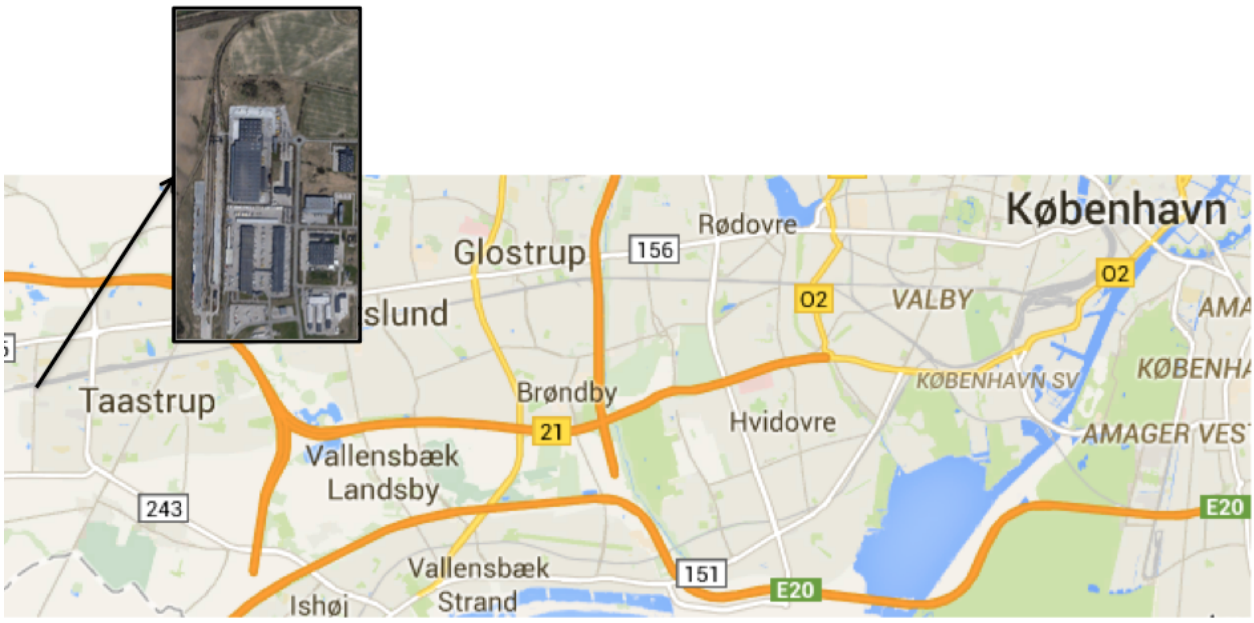


Figure 7 (Own illustration by using googlemap)

2. Purpose of the paper

The purpose of the paper is to evaluate and compare intermodal operational routes between the port of Hamburg and the Oresund area of Denmark and Sweden (both Copenhagen and Malmo) from KDSB's pespective. This will be done by comparing the planned operations through the new 2021 fehmarn belt link route, the current route through the fehmarn passage and by the Jutland Schleswig route. Finally, a cost analys, system setup, market analysis

and an overall plan for implementation will be provided on behalf of the Scandinavian forwarding company KDSB.

3. Limitations

- The calculated train costs in the cost analysis are based on the railway charges in both Sweden and Denmark. For example the electricity price calculated as a usage cost by the locomotives per distance is set by swedish standards, while the rail charge is according to danish prices. Another example is the truck prices, which are calculated according to french prices. The authors of this paper acknowledge that these numbers are not accurate but rather estimations. The reason for the mixed sources is the lack of available data.
- Furthermore, by using Swedish figures regarding for example salaries, the numbers will once again not be perfectly accurate. The danish crown is approximately worth 25 per cent more than the Swedish crown. Hence, the final total cost in the cost analysis will rather be of a general nature. However, this should not affect the comparison level of the various route options.
- The paper is limited to rail and truck modes as well as the usage of roro ferries. Shipping air freight modes are excluded.
- The cost analysis involves only costs and excludes margins. A profitability analysis of the route is excluded from the paper.

4. Current Situation Today: Existing Routes

As mentioned earlier, 12 per cent of the total lorries traffic between Scandinavia and Germany are using the corridor throught the Fehmarn-Lolland passage The lorry traffic on the other route through Jutland (the Jutland-Schleswig line) amounts to 68 per cent of the total traffic. (Butler and Madsen 1997. p. 753). This means that rather a small proportion of the total amount of lorries are currently using the Fehmarn belt passage. Environmental barriers such as the sea, constitute a key barrier for transportation. This barrier contributes to the uneven balance of the flow of goods between the two routes. Furthermore, the mentioned barrier is due to the fact that it involves a slower transporation mode (ferries), which is also considered rather costly and difficult for intermodal shifts (Butler and Madsen 1997. p. 753). Out of the remaining 20 per cent, 17 per cent of the lorries are transported on ferries from southern Sweden to Germany. The rest is being transported on ferry-routes from

Denmark to Germany, such as the Gedser-Rostock ferry line (Butler and Madsen. 1997, p.753).

In order to properly explain the different freight routes between the Oresund region and the port of Hamburg, and at the same time provide a clear structure, the authors of the paper have divided the routes by colours. The reasoning behind this decision is to clarify to the reader regarding what and when a route is discussed and mentioned.

- **The blue route:** Fehmarn Lolland passage between Hamburg-Oresund by Truck
- **The red route:** Jutland Schleswig line between Hamburg-Oresund by Truck.
- **The green route:** Jutland Schleswig line between Hamburg-Oresund, by Rail.
- **The orange route:** New Fehmarn Belt Link between Hamburg-Oresund by Rail
- **The Final Consolidating Route**

Below, in figure: 8, the different routes are visualized by the colours on the map.

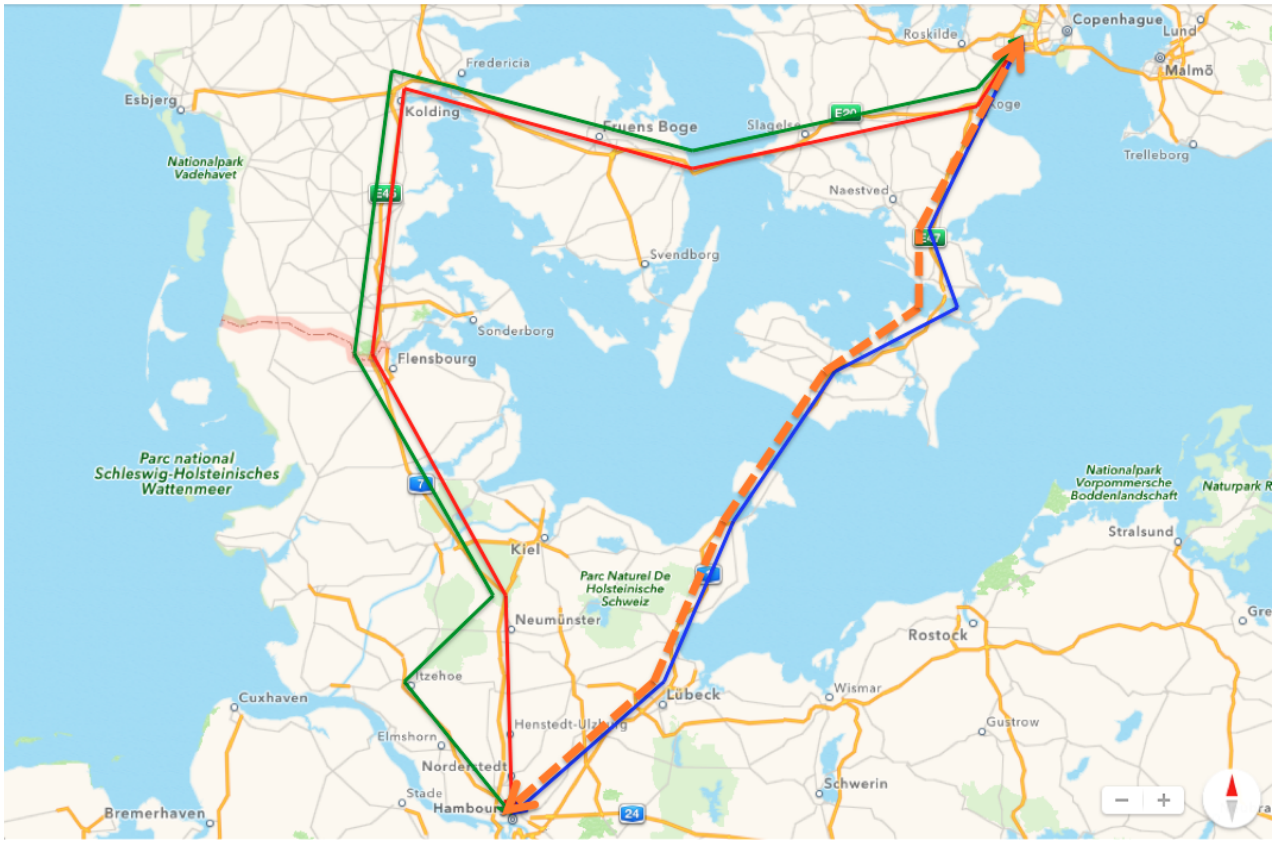


Figure: 8 (Own illustration by using googlemaps)

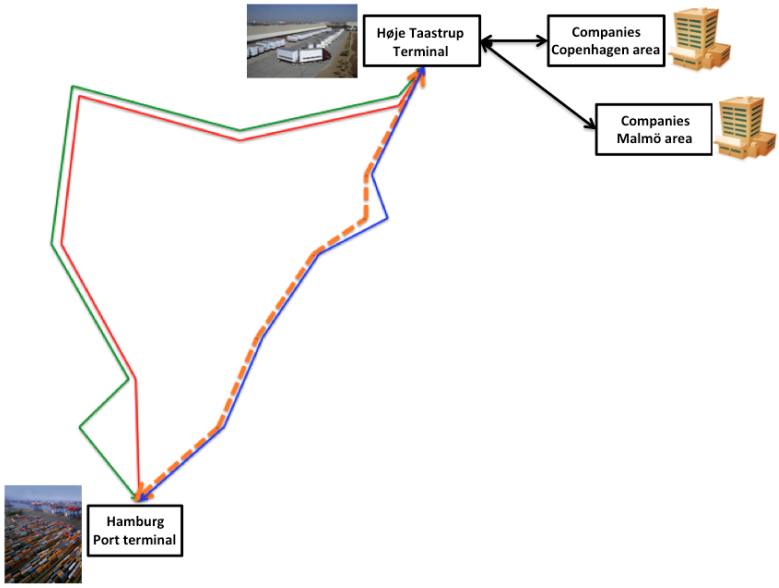
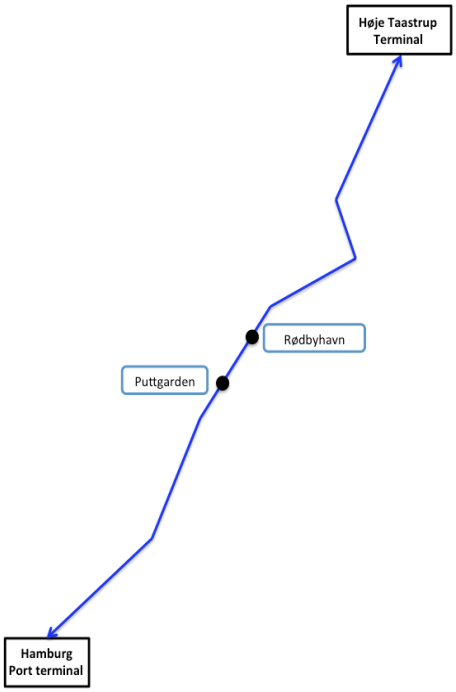


Figure: 9 (Own illustration googlemap & pictures from Objectif terre et hommes, 2011,. Mettler toledo, 2003,. and Chartron, 2010)

4.1. The Blue Route: Fehmarn passage between Hamburg-Copenhagen by Truck

Figure: 10 (Own illustration)



Looking at the first step of the this route, containers from the ships are loaded on trucks in the dry port of Hamburg. Then, the trucks travel by the E47 road to Puttgarden in Germany. In puttgarden the trucks make a stop in order to wait for the ferry to depart across the Fehmarn passage towards Rødbyhavn in Denmark. As earlier mentioned, the transit time by ferry take approximately 45 minutes. When arriving at Rødbyhavn, the trucks continue by the E47 road towards Copenhagen and shifts into E55 in Falster. When arriving in the Copenhagen area, the trucks divert towards the Hoje Taastrup terminal. It takes approximately 4 hours and 45 minutes in total transittime, which also includes expected congestions and time of loading/unloading trucks on the ferry. In total, the trucks travell a distance of approximately 335 kilometers by using this route (Google Maps [2], 2014). It is of importance to also mention that the ferry might be already be full when the trucks arrive to the ferry terminal. Hence, this should be considered since waiting for the next ferry means that precious time can be lost.

4.2. The Red Route: Jutland Schleswig line between Hamburg-Copenhagen by Truck.

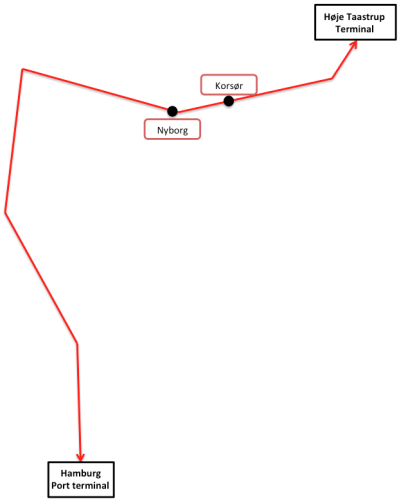


Figure: 11 (Own illustration)

Looking into the red route through the Schleswig-Jutland line, the freight is also transported by the mode of trucks. As presented in the previous part, containers from ships are firstly loaded on trucks in the dry port of Hamburg. Secondly, those trucks are travelling by the E45 road towards Jutland, Denmark. When arriving in Taulov, the trucks shift into the E20 road towards Zealand and Copenhagen. Between Jutland and Zealand, the trucks passes the Great Belt link across Nyborg and Korsor, travelling through the Funen island. The usage of the Great Belt Link implies a bridge fee as earlier stated (Storebaelt [2], 2014). Finally, they arrive in the Copenhagen area where they divert to the Hoje Taastrup terminal. The transittime by road for this route (Schleswig-Jutland line) is approximately 5 hours, and the total distance around 470 km (Google maps [1], 2014)

4.3. The Green Route: Jutland Schleswig line between Hamburg-Copenhagen by Rail.

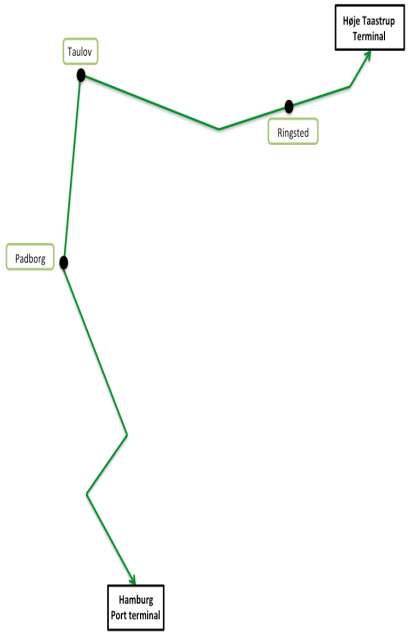


Figure: 12 (Own illustration)

The green route between the port of Hamburg and the Hoje Taastrup terminal uses the Schleswig-Jutland line by the mode of rail. The current railway for freight transported by train is through the Danish cities of Padborg, Taulov and Ringsted (Boysen, 2011). Furthermore, by using the Schleswig-Jutland line, the trains travell across the Great Belt Link between Jutland, the Funen island and towards Zealand. Hence, comparable to the red route alternative, a bridge fee is implied for the crossing. By using rail on this route, the switch poin in Taulov is being used. In Taulov, trains are shiftet into the Jutland-Zealand rail line instead of continuing towards Aarhus. It takes approximately 5 hours from the Port of Hamburg to the Taulov by railway and around 2 hours from Taulov to the Hoje Taastrup terminal (Google Maps [3], 2014 & Google Maps [4], 2014). Hence, the total travel time is about 7 hours and the total distance approximately 480 kilometers long through this route.

Expectations are that the volume tranported through this corridor by rail is to doubble until 2030. The majority of the freight volume travelling the Schleswig-Jutland line is cross border flow between Denmark and Germany, rather than a domestic flow according to a report by the Hanseatic Transport Consultancy (2012). Looking at congestions, some bottlenecks have already appeared in this corridor, which constrains the freight transportation capacity between Germany and the Oresund region (Boysen H. E., 2011).

4.4. The Orange Route: New Fehmarn Belt Link at 2021 By Rail

Figure: 13 (Own illustration)

The new orange route that will be established in 2021 will be using the Fehmarn-Lolland line by the mode of rail. This new line will include transshipment into rail at the CCT-terminal at the port of hamburg. From the port, the trains departing towards Denmark and Copenhagen will travel by the Fehmarnsundbrücke across the Femarn sund. Once the trains embark this location, the crossing of the Fehmarn Belt Link tunnel will start. When arriving in Denmark and Lolland, the trains, the journey continues towards Copenhagen without interuptions. Finaly, the freight trains are diverted to the Hoje Taastrup intermodal terminal outside of Copenhagen. There will be a fee implied for crossing of the Fehmarn belt tunnel. Furthermore, the total traveltime will be aproximately 4 hours and the distance covered reaches 335 kilometers.

This new Fehmarn Belt route will be used by the fowarding company KDSB with start in 2021. The link itself is estimated to have a daily capacity by rail of 78 trains. In total, the travel time for cargo trains between the CCT-terminal at the port of Hamburg and the Danish capital Copenhagen will be reduced by approximately 2 hours (core network corridors, n.d.).

4.5. The Final Consolidating Route

Each routes presented previously are reaching the terminal in Hoje Taastrup from the CCT-terminal at the port of Hamburg. The final route by truck links the the coloured routes arriving at the Hoje Taastrup terminal to the contracted customer A in the Copenhagen area

as well as customer B in the Malmo area. Containers are transloaded on trucks from the train in Hoje Taastrup. Afterwards, the trucks are travelling by road to the explained customers. For customer A the journey take approximately 30 minutes in total. For customer B, the journey takes around 1 hour. The second journey to customer B crosses the Oresund bridge into Sweden, which implies a bridge fee as earlier mentioned. When the trucks arrive to the customers, the containers are delivered and another container (returning one) is being picked up by the same truck. Hence, a reverse logistic system is established between the customers and the up terminal in Hoje Taastrup. The returned container will then be sent back to Hamburg by train on the Fehmarn Belt route with export goods.

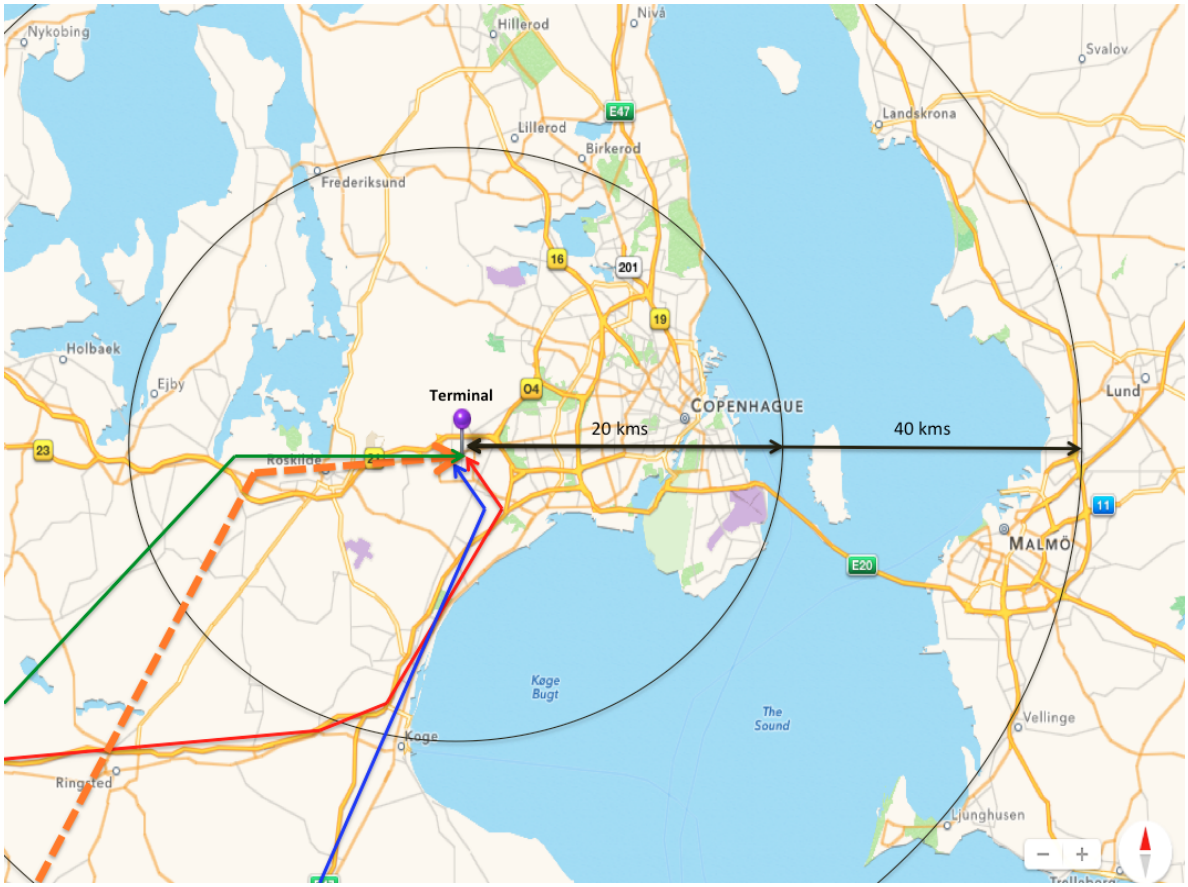


Figure: 14 (Own illustration by using googlemaps**)**

5. The Contracts

KDSB forwarding company has as earlier stated received a contract amounting to 40 units of 20-feet TEU's being delivered per day between the port of Hamburg, the intermodal terminal in Taastrup and the city of Copenhagen and Malmö. The requested product by the client contains only the handling of entire containers by an intermodal solution between the point of origin and the point of demand. Hence, KDSB is not concerned regarding opening

containers, nor distributing single pallets. Furthermore, the customers who has signed the contract is the danish beer company Carlsberg, Customer A in Copenhagen, and Customer B in Malmo. The demanded transittime by the customers is maximum 2 days between pickup and delivery. Additionally, the contracted customers have signed a reverse logistic contract. This reverse part means that when a container is delivered to the customer, another one is picked up, either empty or with export goods with destination port of Hamburg.

Contract 1: Carlsberg

In order to ensure full capacity and filling up the train, KDSB will initiate a long term partnership contract with Carlsberg. This contract will be of similiar nature to the Goteborg-Falköping line between DB Schenker and the Jula company (Bergqvist, and al., 2014). The Carlsberg distribution centre is located in direct vicinity of the Høje Taastrup terminal. Currently, two trains are operating everyday with 28 containers (20ft) each direction, between the distribution centre and the brewery in Fredericia Jutland (Transbaltic, 2012). The main idea would be to transport the beer' containers destined for international trade directly to the port of Hamburg, where they would then be loaded onto ships. A part of the raw material used in the plant as for example empty bottles, would be imported from the port of Hamburg to the carlsberg manufacturing plant in Copenhagen. This import cargo as well as the export one, will be handled by KDSB. 10 TEU's per day will be delivered in the Høje Taastrup Terminal from the port of Hamburg, and 10 TEU's will be transported to the port of Hamburg from the Høje Taastrup terminal. These operations will take place 5 days a week. Carlsberg will operate the receival and the delivery of their containers by themselves. Carlsberg will do this due to the near location of its distribution centre from the Høje Taastrup terminal.

Contract 2: Customer A in Copenhagen

Customer A is located within 20 km around the Høje Taastrup terminal. KDSB will deliver and pick up the containers with its own trucks beng sent from the Høje taastrup terminal. Customer A needs to import 20 containers per day and export 20 container per day, 5 days per week. Two trucks will be needed for operating this operation with 5 round trip each per day.

Contract 3: Customer B in Malmo

Customer B is located within 40 km around Høje Taastrup terminal. KDSB will deliver and pick up the containers with its own trucks from the terminal. 10 containers will be picked up

and 10 will be delivered each day, 5 days a week. Two trucks will also be needed for this customer, and the operations demand 3 round trip each per day.

6. Market Analysis

This part presents an analysis of the current traffic between the port of Hamburg, the Copenhagen area and the Malmo area.

6.1. Identifying the current traffic between the port of Hamburg, Copenhagen and Malmö area

Currently, there are 3 freight trains leaving the port of Hamburg towards Denmark per week and conversely (Port of Hamburg [6], 2014). The rest of the traffic is carried out by trucks. A total of 59 per cent out of the total internatnional flow of lorries passed through the Danish-German border in Southern Jutland, making this crossing the busiest border connection. In total almost 6.000 lorries crossed the border during the 4th quarter of 2010. While 12 per cent of the total border traffic passed by the connection Gedser-Rostock, and Roødby-Puttgarden, which represents approximately 1.200 lorries. This percentage represents a total of approximately 28.800 trucks per year regarding the freight transport operations between Germany and Denmark.(Danish ministry of transport, 2012). Obviously, all this trucks are not container lorries, but a significant part of them are. Once the Fehmarn belt railway line will be opened, the containers may be transported by train instead of truck. Furthermore, the connection will allow to develop the trade between Hamburg and Copenhagen, and some carriers will perhaps start to use containers for their cargoes rather than transporting bulk in conventional trucks. Additionally, rail will be able to provide reduced transport time, which can result in a more agile supply chain for companies. Furthermore, some capacity can be re-directed from the Rostock-Gedser line by ferries onto the Fehrmarn Belt link. For example regardng the cargo leaving Berlin to Denmark, a city which situated relatively close to hamburg (less than 2 hours by train), the new link could be attractive.

At least 30.000 trucks per months went from the Malmo area through the Oresund bridge in 2014 (Oresundsbron, 2014). Some of them travelled to the port of Hamburg Port where they could transload onto shipps. The rail link from the Høje Taastrup terminal next to Copenhagen could instead be used. Due to these reasons, it is reasonable to believe that the freight traffic between Hamburg and Copenhagen will dramatically grow thanks to the Fehmarn Belt link (Femern, 2003). It is the authors of this papers belief that thedemanded

capacity in fhe future will exceed the 3 trains per week currently running between the Port of Hamburg and Denmark.

6.2. SWOT-Analysis

A SWOT analysis is a well suited tool for analysing the market, since it concerns the present operations and the future development for a company or a project. SWOT stands for strengths, weaknesses, opportunities and threats (Humphrey, 2005). In this part, the authors of the paper will use the SWOT analysis to identify the market situation for the traffic on the new fehrmarn Belt Link.

Strengths: compared with the current railway freight transport between Hamburg and the Oresund region, the new Fehmarn tunnel will provide a much shorter route. It will also reduce the transportation time greatly, while simultaneously cut costs. Compared with the road transportation between Hamburg and the Oresund region, the new Fehmarn tunnel route will not only reduce the transittime and cut costs, but it will also have less impact on the environment.

Weakness: the most iminent weakness for this new intermodal solution would be the uncertainty of the new tunnel project. Such cross-border infrastructure project implies high cost and is usually affected by the political decisions from different countries. It is possible that the project can be delayed or even be canceled entirely. The uncertainty of the project will make the investment on new equipements such as trains, wagons an etc more risky.

Opportunities: based on the strengths of the new intermodal solution, it is highly likely that the new intermodal solution will attract the freight transport volumes from the other routes. Based on the freight volume forecast for this corridor presented previously in this report, the freight volume is going to increase greatly. This increase means more business opportunities for the new intermodal solution.

Threats: as the new infrastructure provide a enhanced intermodal solution, many intermodal companies which are operating on the current existing routes, e.g. Kombiverkehr, are likely to shift their operations onto the Fehmarn link. This decision by the competitiors might create congestion and increase the competitions between the intermodal companies. Hence, the margins might be reduced to a more competitive business environment for KDSB:

7. Operations on New Fehmarn Route by KDSB

In this section the load capacity of KDSB's trains as well as the scheduled operations will be presented to the reader.

The Contracted Capacity to KDSB on the Fehmarn Link Route

Due to the established contracts, KDSB will have to carry 40 TEU's back and forth between the port of Hamburg's CCT-terminal and the Høje Taastrup Terminal, 5 days per week. KDSB have decided to size the train according to the demanded capacity by the customer. This decision since it is more profitable due to economies of scale to run a fully loaded train.

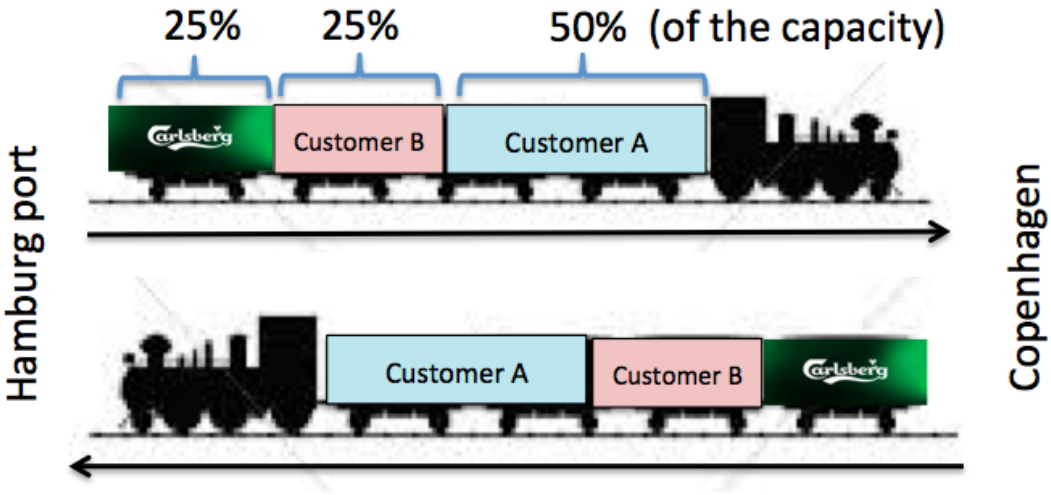


Figure: 15, KDSB's load capacity (own illustration)

KDSB will initiate the operation with a 20 wagons train, each wagons can accomodate two 20ft container, or one 40ft container as presented in section 7.3. To begin, KDSB will start with one train making a round trip per day. By roundtrip, one travel per day per destination (Hamburg, Copenhagen) is undertaken. In the following part, the reader will receive information about the established operational schedule for the train.

Schedule for KDSB's operations on the Fehmarn Link Route

According to the Core Network Corridors organization (n.d.), the new rail link will allow a journey time of 4 hours between Hamburg and Copenhagen (for a freight train). KDSB have decided to run 1 train per day in each directions during the week, without any stop between the two cities: a direct trip. Below the reader can see the undertaken schedule for the intial phase of the freight operations by KDSB:

Distance		Departure terminal		Arrival terminal	
From	To	Loading deadline	Day	Unloading deadline	Day
Port of Hamburg	Høje Taastrup terminal	08:30	Mon to Fri	14:00	Mon to Fri
Høje Taastrup terminal	Port of Hamburg	15:15	Mon to Fri	20:45	Mon to Fri

Figure :16, KDSB's Train schedule (own illustration by Excel)

→ This schedule will allow KDSB's customers to deliver their containers in time, before the loading deadline. Below, one can find the description of the schedule according to a operational point of view :

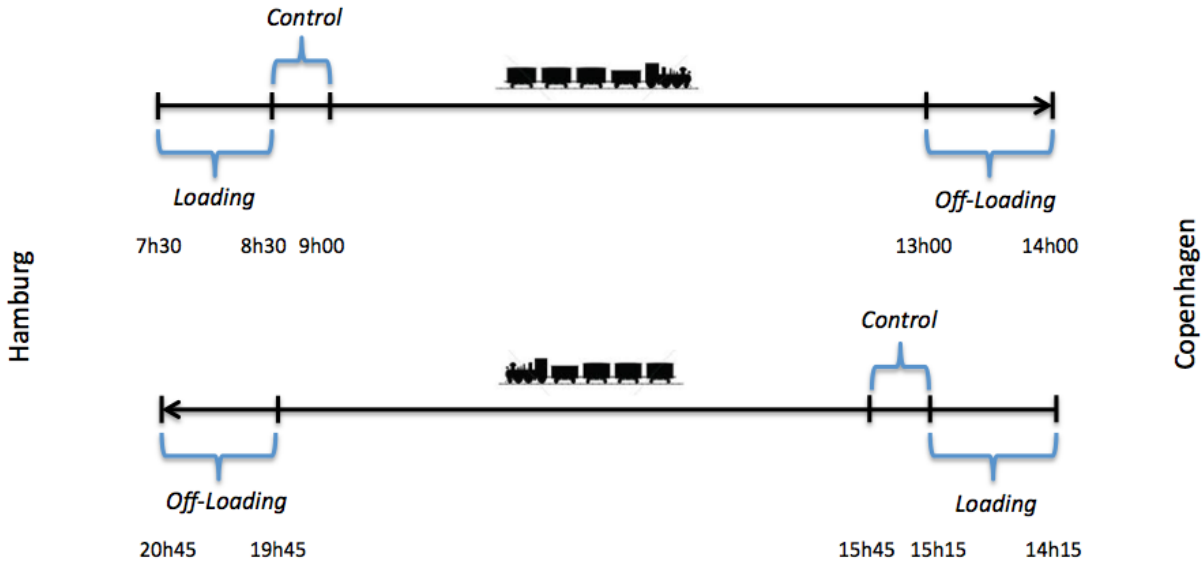


Figure: 17, KDSB's operational schedule (own illustration)

7.1 The Choosen Intermodal Transportation by KDSB

In this part the reader shall receive an understanding of what type of vehicles, locomotives, wagons and containers that has been selected by KDSB for the operations on the Fehmarn Belt Link route.

Regarding the train operations, the EG3100 Two-system locomotive has been suited as the most fitted alternative for the route. The EG3100 model of locomotive is suitable because they are capable of transporting heavy freight. Furthermore, the EG3100 model have a two-system which means that it can handle both 15 kw AV and 25kw AV. Beeing able to handle both types of currents mean that the train is perfectly fitted for operating internationally across different systems. Since Sweden and Germany have a 15kw AV system compared to

Denmarks 25kw AV system, a two-system locomotive such as the EG3100 is a necessity for conducting operations. The locomotive have the maximum speed of 140 kilometers per hour. Due to the fact that KDSB is a young company, the investment capacity is limited and therefore the locomotive are purchased from the secondary-market. Hence, KDSB has agreed to purchase one EG3100 for 10 million SEK. Below in figure 18, the EG3100 is visualised.

Figure: 18, The EG3100 locomotive (Erik's Rail News,1999)

The Lgns-type of wagon has been selected due to the weight capacity (33 tonnes). Furthermore, it is appropriate to select the Lgns-type due to its capability of carrying two 20' TEU containers or one 40' container. For KDSB's operations, this means that two containers can be carried on the same wagon. The Lgns-type of wagon is considerable cheaper compared to other more advanced alternatives. This cost benefit is both from a initial purchase price perspective as well as maintenance costs perspective (100 000 SEK per unit and 0.10/km SEK in maintenance) (Flodén 2011). KDSB have acquired 20 new Lgns-wagons for a total price of 2 million SEK. Below in figure 19 and 20 is the Lgns-wagon visualised.

Figure: 19, Lgns wagon (Modelbahnshop, 2014)

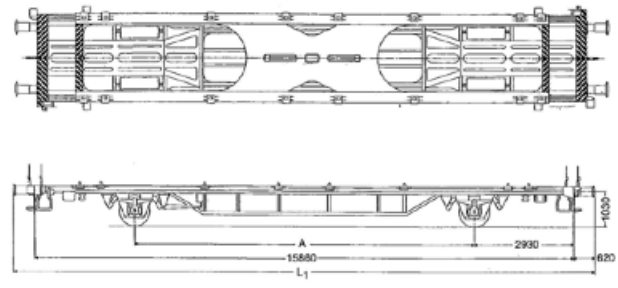


Figure: 20, Lgns Wagon print (Flodén 2011)

The standard container is provided by KDSB's contracted customers. Hence, KDSB have not acquired the containers themselves. The material of these containers are made of steel

sheet and they are equipped with port-lift pockets. Below in figure 21 is the standard container made of steel visualised.

Figure: 21, Standard Steel Container (Transport Information Service, n.d.)

The selected trucks is the Scania G-series with V8 engines. This type of truck is fitted for the routes within copenhagen and across the Oresund to Malmo due environmental and fuel efficiency effects. The trucks will be purhased from the secondary market in order to receive a lower investment cost (Scania [1], 2014). Euro-6 will be the standard of the trucks which is advantaegeous from an environmental perspective as well as approximately 2% more fuel efficient (Scania [2], 2014). KDSB have acquired 4 trucks with trailers for the operations in the Oresund area for a total price of 10 million SEK . Hence the price per truck have been set to 2.5 million SEK each. Below is the Scania G-serie truck with trailer visualised.

Figure: 22, the Scania G-serie truck with trailer (Grabcad, 2012)

7.2 The Choosen Terminal Operators by KDSB

HHLA Container Terminal Tollerort - Port of Hamburg

The container Terminal Tollerort (CTT) has its own container rail station, which went into operation in 2008. As been explained in the infrastructure part of the paper, a total of 720 metres of track and three new transtainer cranes make it possible to handle block trains quickly without shunting (Port of Hamburg [5], 2014). Hence it is a suitable terminal for transshipment and for KDSB's freight operation. The containers will be pick up in this terminal and transload onto the train by HHLA (Hamburger hafen un Logistik) which is the terminal operator. KDSB have a long-term contract with HHLA, which guarantees the favourable train schedules.

Taastrup Intermodal Terminal - DB Schenker

As been described earlier in section 1.2, DB Schenker is the terminal operator of Høje Taastrup terminal (Transbaltic, 2012). Since logistic terminals is vital in intermodal transport, the KDSB forwarding company is in need of a strategically located terminal. Therefore, the Høje Taastrup terminal has been selected by KDSB for its intermodal corridor. KDSB will not own nor operate the Høje Taastrup terminal, but rather purchase the handling service by the external terminal operator DB Schenker. The contracted service by DB Schenker to KDSB includes on and off-loading of trains, transloading service from rail to truck and also storage servie of containers.

8. Costs Analysis

According to Flodén. J (2011), "Cost calculation is not an exact science, and the types of costs included and their estimation can vary between different calculations." The same way of cost calculation for all different lines are used in this chapter to provide the reader with a good base to compare. Therefore, the cost analysis below presents the cost per TEU transported for all the different lines previously described. This cost is calculated on a basis of 19 200 containers transported each year which means 80 TEU per day (40 each travel) during 240 operating days per year. Detailed calculation in available in Appendix n°1.

The blue route: Fehmarn passage between Oresund-Hamburg by Truck

Purchasing costs		**Depreciation Time**
Volvo Trucks and wagons (20 trucks)	50 000 000SEK	10 years
Category	**Fixed Cost**	**Variable Cost**
Interest Loan for trucks&wagons/year (5%)	250 000 SEK	
Payment of trucks & wagons loan/year (10 years)	5 000 000 SEK	
Depreciation cost trucks and wagon/year	5 000 000 SEK	
Total cost all trucks /year (utilization)		34 812 960 SEK
Total cost all trucks /year (utilization+amortization)		45 062 960 SEK
Total Trucks Cost/year (Utilization+amortization)	45 062 960 SEK	
cost per one TEU transported	**2 347 SEK**	

Figure: 23, Cost chart for Fehmarn-Lolland Route by Truck (own illustration by Excel)

In order to obtain an accurate cost per TEU transported, we simulate the purchase of trucks and their financial amortization. Purchasing cost were presented in section 7.3. According to the demand, 20 trucks and wagons are needed, each truck can accomodate two 20ft containers. Trucks' utilization costs are a combination of :

- the number of kilometers traveled (presented in section 4.1)
- Fixed costs (FAQ Logistique, 2011)
- Ferry costs (Scandlines, 2014)
- Variable costs (FAQ Logistique, 2011)

The red route: Jutland Schleswig line between Oresund-Hamburg by Truck.

The costs for this route were calculated by the same way as for the previous route. All the cost involved have the same basis, except that the ferry cost were replaced by the bridge fee according to figures provided by Storebaelt (2014).

Purchasing costs		**Depreciation Time**
Volvo Trucks and wagons (20 trucks)	50 000 000SEK	10 years
Category	**Fixed Cost**	**Variable Cost**
Interest Loan for trucks&wagons/year (5%)	250 000 SEK	
Payment of trucks & wagons loan/year (10 years)	5 000 000 SEK	
Depreciation cost trucks and wagon/year	5 000 000 SEK	
Total cost all trucks /year (utilization)		44 827 200 SEK
Total cost all trucks /year (utilization+amortization)		55 077 200 SEK
Total Trucks Cost/year (Utilization+amortization)	55 077 200 SEK	
cost per one TEU transported	**2 869 SEK**	

Figure: 24, Cost chart for the Jutland Schleswig Route by Truck (own illustration by excel)

The green route: Jutland Schleswig line between Oresund-Hamburg, by Rail.

For the green route, the authors of the paper simulate the purchasing of one train and 20 wagons. The models and price were presented in section 7.3. The various costs associated with the usage of trains, depreciation time and terminals fee are calculated based on informations provided by Flodén. J (2011).

The great belt link charge were defined according to figures provided by European commission (2011).

Purchasing costs		**Depreciation Time**
RS Train	10 000 000SEK	50 years
Lgns Wagons	2 000 000SEK	15 years
Category	**Fixed Cost**	**Variable Cost**
Interest Loan for Train/year (10%)	100 000SEK	
Interest Loan for Wagon/year (10%)	20 000SEK	
Payment of train loan (10 years)	1 000 000SEK	
Payment of wagons loan (10 years)	200 000SEK	
Depreciation cost train	200 000SEK	
Depreciation cost wagon	133 333SEK	
Wage Drivers: 6 drivers		2 088 000SEK
Track Fee		601 536SEK
Track Charge		663 137SEK
Accident Charge		202 176SEK
Electricity		2 546 696SEK
Wagon maint		24 960SEK
Terminal fee Taastrup		4 915 200SEK
Terminal fee Hamburg Port		3 187 200SEK
Great Belt link bridge Approx		3 600 000SEK
Number of TEU per year = 19 200		
Total Train Cost/year		19 482 238SEK
Cost per TEU transported		**1 015SEK**

Figure: 25, Cost chart for the Jutland Schleswig route by rail (own illustration by excel)

The orange route: New Fehmarn Belt Link at 2021 By Rail

The costs for the Fehmern route were calculated by the same way as for the Jutland-Schleswig rail route. All the costs involved have the same basis, except that in this case, less drivers will be needed because of the shorter travel time (345km compared to 480km). The amount of kilometers traveled is lower, and the bridge fee is replaced by a tunnel fee.

Purchasing costs		Depreciation Time
RS Train	10 000 000SEK	50 years
Lgns Wagons	2 000 000SEK	15 years
Category	**Fixed Cost**	**Variable Cost**
Interest Loan for Train/year (10%)	100 000SEK	
Interest Loan for Wagon/year (10%)	20 000SEK	
Payment of train loan (10 years)	1 000 000SEK	
Payment of wagons loan (10 years)	200 000SEK	
Depreciation cost train	200 000SEK	
Depreciation cost wagon	133 333SEK	
Wage Drivers: 4 drivers		1 392 000SEK
Track Charge		446 342SEK
Accident Charge		136 080SEK
Electricity		1 714 122SEK
Wagon maint		16 800SEK
Terminal fee Taastrup		4 915 200SEK
Terminal fee Hamburg Port		3 187 200SEK
Tunnel Charge Fehrmarn Approx		3 600 000SEK
Number of TEU per year = 19 200		
Total Train Cost/year		17 061 078SEK
Cost per TEU transported		**889SEK**

Figure: 26, Cost chart for the New Fehmarn Belt Route by rail (own illustration by excel)

Cost of truck deliveries between Copenhagen and Malmö

According to the demand, the authors of the paper simulate the purchase of 4 trucks. Two of them will be used to operate with customer A in the Copenhagen area, and two of them with the customer B in the Malmo area, as described in the section 5 . The trucks' utilization costs were defined by the same way previously used in this cost analysis. The cost per TEU transported in Malmo include a bridge fee (Oresundsbron, 2014).

Purchasing costs		Depreciation Time
Volvo Trucks and wagons (4 trucks)	10 000 000SEK	10 years
Category	**Fixed Cost**	**Variable Cost**
Interest Loan for trucks&wagons/year (5%)	50 000 SEK	
Payment of trucks & wagons loan/year (10 years)	1 000 000 SEK	
Depreciation cost trucks and wagon/year	1 000 000 SEK	
Total cost truck 1/year (utilization)		750 859 SEK
Total cost truck 2/year (utilization)		750 859 SEK
Total cost truck 3/year (utilization)		1 639 809 SEK
Total cost truck 4/year (utilization)		1 639 809 SEK
Total truck cost 1 /year (utilization+amortization)		1 263 359 SEK
Total truck cost 2 /year (utilization+amortization)		1 263 359 SEK
Total truck cost 3 /year (utilization+amortization)		2 152 309 SEK
Total truck cost 4 /year (utilization+amortization)		2 152 309 SEK
Total Trucks Cost/year (Utilization+amortization)	6 831 336 SEK	
cost per one TEU transported in Copenhagen area	**263 SEK**	
cost per one TEU transported in Malmo area	**897 SEK**	

Figure: 27, Cost chart for truck deliveries to Copenhagen and to Malmo (own illustration by excel)

8.1 Cost comparison

This table gather all the previously presented costs according to the different routes. A time comparison is presented according to the travel time presented from section 4.1 to 4.5.

	Hamburg--> Copenhagen		Hamburg -->Malmö	
	Cost per TEU	Time	Cost per TEU	Time
Jutland- Schleswig operated by truck	3 132SEK	05:30	3 766SEK	06:00
Jutland-Schleswig operated by rail and truck	1 278SEK	07:30	1 912SEK	08:00
Fehrmarn Lolland operated by truck and ferry	3 019SEK	05:15	3 653SEK	05:45
New Fehrmarn Belt Link operated by rail and truck	1 152SEK	04:30	1 786SEK	05:00

Figure: 28, Cost table for comparison (Own illustration)

The two graphs below illustrate the same comparison about time and cost but with a better understandable picture for the reader.

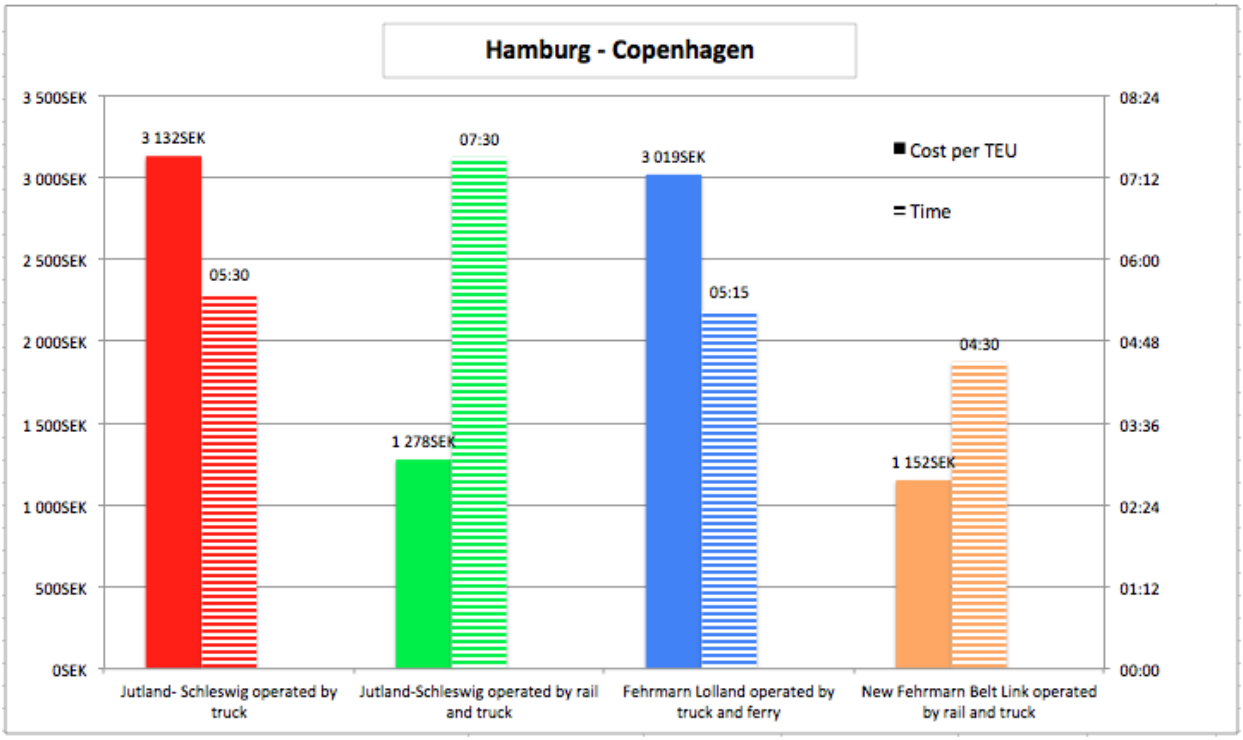


Figure: 29, Cost comparison graphics (Own illustration)

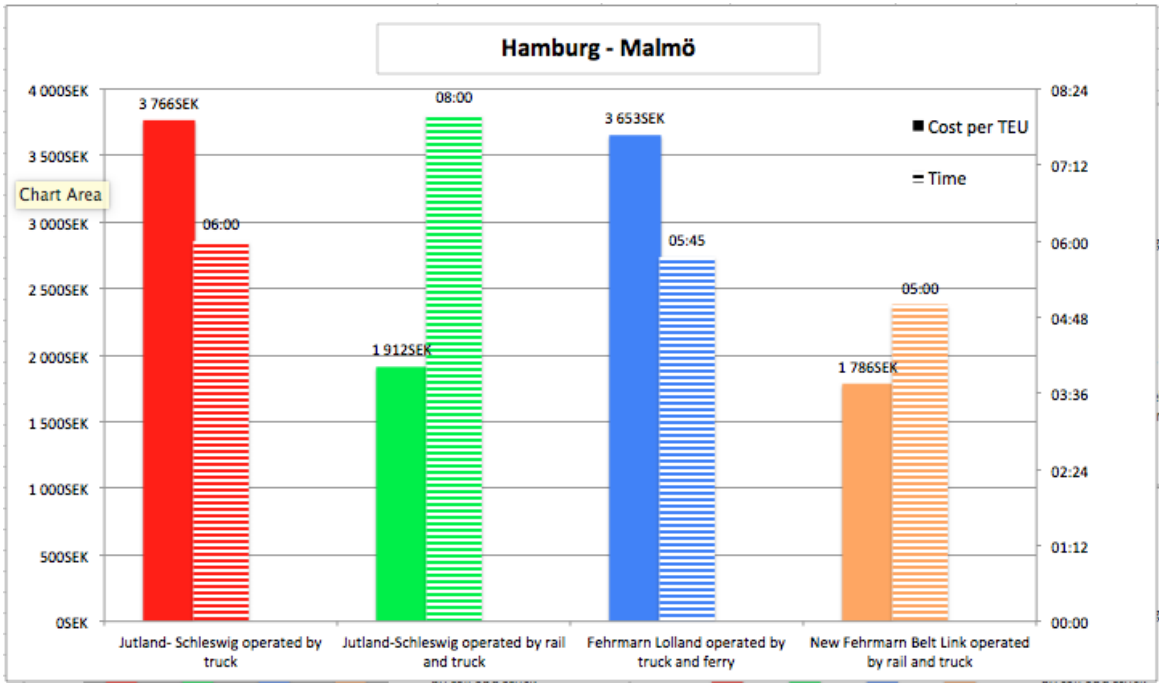


Figure: 30, Cost comparison graphics (Own illustration)

The “green” and “orange” line are the two intermodal ways, combining train and truck. One can easily note that the intermodal solutions allows the forwarding company KDSB to save at least 50% of the cost. This saving in contract to the usage of the unimodal solutions operated by truck (red and blue). The reader should also note that the “orange” proposed solution (new fehrmarn belt) is not only cheaper than the others routes, but also much more time efficient. Comparing costs and time of transportation between Hamburg and Oresund, the results serves as a decision foundation for KDSB regarding what route to choose. KDSB will operate on the orange line, which mean using intermodal system by the new fehrmarn belt. The cost per TEU will be 1150 SEK for Customer A and it will take 4 hours and 30 minutes from Hamburg to the customer. For the customer B, cost per TEU will be 1780 SEK with a transit time of 5 hours. The orange new route is in total 162 per cent cheaper and 16 per cent faster compared to the blue route (same route by truck). It’s in total 10 per cent cheaper and 66 per cent faster compared to the green route (current intermodal solution).

9. Proposed Expansion

Once our forwarding company will be established in this new market, a new challenge will be to think about KDSB’s operational expansion. Each expansion project will depend on the Return on Investment from the first operating period (Phillips,P.P. and Phillips J.J., 2005). If KDSB’s results shows that the business is profitable, KDSB should look to expand the activities. In this case, the first expansion will go through an increase in the train capacity, and if necessary an increase in term of frequency.

9.1 Increased Capacity

KDSB started to operate with a 20 wagons train, this is enough to meet the existing customer demand during the first operating period. But if the demand is increasing, the train size might be changed to a maximum of 36 wagons according to Flodén. J (2011). This means that KDSB are able to almost double the capacity, in order to carry 72 TEU's each travel, or 144 TEU's per day, without any change in the schedule. In addition, the number of wagons in the train may be determined depending on the application. Furthermore, KDSB can choose to add the desired number of wagons, with a maximum of 36 cars. This means that the company can have some flexibility as long as the demand does not exceed 144 TEU's per day. If the demand actually exceed this volume, KDSB will have to introduce changes in terms of frequency of operations (amount of travels).

9.2 Increased Frequency

During the first operating period, KDSB's train is running five days a week. The first step to increase frequency will be to operate 7 days a week, this allows an increase of 40% of capacity. If this increase in capacity is found to be insufficient to meet the future demand, the next step would be to buy and operate a new train. Which involve a new investment, and a doubling of staff numbers, but allows an increase of 100% of the previous capacity. Another challenge will be to get an additional slot in the rail network, in order to operate with a second train.

9.3 Expansion in Figures

	First operating period 1 train 5days/week 20 wagons	1 train 5days/week 36 wagons	1 train 7days/week 36 wagons	2 trains 7days/week 36 wagons
Capacity in TEU/year	19200	34560	52560	105120

Figure: 31, Capacity chart according to the potentials expansions (own illustration)

The figures above shows the capacity in TEU's per year, depending on the option of planned expansion. During the first operating period, 19 200 TEU's will be transported per year, and this can be increased to 105 120 TEU's per year by buying a new train. This however, would would be the most expensive planned solution.

10. Conclusion

The authors of the paper can conclude that the forwarding company KDSB should initiate operations on the Fehmarn Belt link. The intermodal operations for the contracted customers should use this line due to the cost and transit time benefits. By comparing the route with other alternatives, such as the Fehmarn-Lolland passage by truck, the authors can identify a cost reduction of 162 per cent. Since the contracted customers have demanded their goods within a maximum time frame of 2 days, the time reduction of 16 per cent is an additional indication that the orange route is the most fitted choice. When comparing rail operations on the Fehmarn Belt link with the Schleswig-Jutland one, a cost saving of 10 per cent to the new route's advantage can be identified. Furthermore, the 66 per cent in time reduction is another strong determining factor. Due to these figures, the authors strongly believe that KDSB will be further competitive and successful by entering the new Fehmarn Belt link. It can also be seen as a necessity, since this unique opportunity otherwise may be undertaken by competing operators. The authors of the paper strongly believe in benchmarking activities in the forwarding industry when the new link is ready in 2021. Therefore, KDSB should take the initiative and be the first to operate as a forwarder when the link is completed.

The authors of the paper can also anticipate the growth of their market share and a need for expansion. However, from the SWOT-analysis, the risks should be perceived as rather large. A delay of the completion could have devastated impact on KDSB's operations.

Appendix

Appendix n°1 : Detailed calculation

Train : 10 000 000 x 1 = 10 000 000 SEK
(unit price)

Wagons : 100 000 x 20 = 2 000 000 SEK
(unit price) x (nb of wagons)

Wage : 29 000 x 12 x 4 = 1 392 000 SEK/year
(salary) x (nb of month) x (nb of employee)

Track fee : 2,41 x 700 x 240 = 404 880 SEK/year
(SEK/trainxkm) x (distance/day) x (working days/year)

Track charge : 0,0036 x 738 x 700 x 240 = 446 342 SEK/year
(SEK/ton-km) x (train max weight) x (distance/day) x (operating days/year)

Accident charge : 0,81 x 700 x 240 = 136 080 SEK/year
(SEK/train-km) x (Distance/day) x (oeprating days/year)

Electricity : 0,7315 x 0,0189 x 738 x 700 x 240 = 1 714 122,19 SEK/year
(SEK/kwh) x (STA price) x (train max weight) x (distance/day) x (operating days/year)

Wagon maintenance : 0,10 x 700 x 240 = 16 800 SEK/year
(SEK/km) x (distance/day) x (operating days/year)

Terminal fee Hoje Taastrup : 256 x 80 x 240 = 4 915 200 SEK/year
(SEK/load unit) x (load unit/day) x (operating days/year)

Terminal fee Hamburg : 166 x 80 x 240 = 3 187 200 SEK/year
(SEK/load unit) x (load unit/day) x (operating days/year)

Tunnel charge Fehrmarn approx = 7500 x 2 x 240 = 3 600 000 SEK/year
(tunnel fee/travel) x (nb of travel/day) x (operating days/year)

Trucks :

Fixed cost/day = 1528 SEK/day

Variable cost/day = (nb of km/day) x (cost/km)

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