Master thesis

Traffic and Highway Engineering

Rail Freight in northern Denmark

An analysis of the potential for rail freight

Kim Jakobsen

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STUDENT REPORT

School of Engineering and Science.
Department for civil engineering.
Master in Traffic and Highway Engineering.
Thomas Manns Vej 23.
9220 Aalborg Øst.
http://www.byggeri.aau.dk/www.ses.aau.dk

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Kristian Hegner Reinau

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Synopsis:
The objective of the report is to assess the potential of railway freight to and from the North Denmark Region. The potential goods flow is found from sales data from Statistics data. These data have shown to be of poor quality for national trade which is why only the potential for international trade in the region is analyzed. The prospect for the potential to be harnessed is investigated by discussions with local stakeholders in the form of infrastructure managers and an operator.
From the freight flow there seems to be a large potential in transporting heavy shipments by rail to and from the region. However, the discussions show risk in the future of total rail freight shutdown in a large part of the region and difficulty to sustain a stable freight operation in general due to track shutdowns.

Preface

This report is a master thesis produced as the final project during the Master's degree programme *Traffic and Highway Engineering.* The report has been composed in the period between 1 February and 8 June.

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Reading guide

For source references the Harvard method is used, i.e. sources are referred to by name and year in parenthesis. Sources that are used for longer passages of text are situated at the end of the paragraph in question. In cases where only a short passage of text refers to a source, the reference is placed at the end of the sentence in question before the full stop. The full bibliography is found in the end of the report.

Abstract

Europakommissionen har igennem længere tid plæderet for, at en større del af godstransporten skal foregå på skinner. I dens Hvidbog fra 2011 lægges der vægt på, at lastbiltrafikken har for høje emissioner, og at det europæiske vejnet er under stadigt større pres. At føre en større del af godstransporten over på skinner og ad søvejen vil afhjælpe begge disse problemer. Ingen af disse modes har imidlertid fleksibiliteten, som findes ved vejtransport og muligheden for at levere godset til døren. Målet er derfor, at 50% af al gods, der rejser *længere* end 300 km, skal flyttes multimodalt inden 2050. I Danmark er det næsten kun transitgods, som kører igennem Danmark fra Tyskland for at nå Sverige og omvendt, der transporteres på skinner. Især i Region Nordjylland har jernbanegods haft en særdeles lille markedsandel. Så sent som i 2016 viste en rapport ved navn "Fremme af Gods på Banen" fra Trafikstyrelsen, at gods sjældent blev transporteret på jernbanen, fordi omlæsning er dyrt, det er tidskrævende og meget få firmaer har et transportbehov, der er så stort, at de med jævne mellemrum kan fylde et godstog.

I Nordjylland er der i mellemtiden kommet en løsning, der kan inkludere mindre virksomheder i brugen af godstog. DB Cargo Scandinavia og Aalborg Havn har lavet aftale om at oprette en shuttletog-service, hvor firmaer kan bestille godstransporter til forsendelser á ned til 25 ton. I nærværende rapport undersøges potentialet af dette ved brug af købs- og salgsdata fra Danmarks Statistik samt en interessentanalyse af de nordjyske havne, der har havnespor, DB Cargo Scandinavia og Banedanmark.

Det anskaffede data har vist sig at være mangelfuldt ved national handel. Den nationale data indeholder købs- og salgsinformationer og firmaers lokation på postnummerniveau. Dette kunne være et godt belæg for at finde det nationale potentiale for jernbanegods i Nordjylland med en trafikmodel. Mængderne er imidlertid sjældent angivet, hvorfor der udelukkende findes et potentiale i international fragt. Potentialet findes ved at udskille fragtdata for Nordjylland. Import- og eksportmængderne er aggregeret på årsbasis for hver vare og hver destination, så en forudsætning er antaget om, at varer sendes i lige store forsendelser. Potentialet er så fundet ved at dividere forsendelsesmængderne med 12 for at se, hvor mange firmaer der kan benytte jernbanetransport, hvis de konsoliderer deres varer over en måned. Det samme er desuden gjort på ugebasis ved at dividere de angivne mængder med 52. Det antages i øvrigt, at der kun er basis for jernbanetransport for varer, der sendes til import- og eksportlande, der kan nås med jernbane, og som er langt nok væk fra Nordjylland til rentabel jernbanetransport.

Varetypen har også indvirkning på, om der tilvælges jernbanetransport. Af denne grund er frisk fisk sorteret fra eksportdata, men der er ikke fundet basis for at udskille andre varetyper. I stedet kan læseren vurdere potentialet ud fra branchegrupperne, de egnede firmaer indgår i.

Analysen af godsforsendelserne viser, at der umiddelbart er et stort potentiale i at flytte gods med tog til og fra Nordjylland. Interessentanalysen viser imidlertid, at der er problemer for jernbanegods i regionen såvel som hele Danmark. I Vendsyssel skal togtrafikken fra efteråret 2018 styres af det nye ERTMS-signalsystem, og det står

stadig hen i det uvisse, om godsoperatørerne har eller kan skaffe rullende materiel, der kan køre med systemet. Ydermere er der tvivl om, hvorvidt Vendsyssel nogensinde bliver elektrificeret, og om der i så fald vil blive kørt godstog til området. Hvis området blev afskåret fra godstogsoperatørerne, ville Aalborg Havn blive den eneste jernbaneterminal i regionen. Hverken Aalborg Havn, DB Cargo Scandinavia eller de resterende havne er interesseret i dette, da alle parter gerne ser et samspil omkring jernbanegodset imellem havnene og om muligt at samme godstog kan betjene flere af de nordjyske terminaler.

Hele regionen er, ligesom resten af Danmark, påvirket af afbrydelser i skinnenettet. Både operatører og terminalbestyrere er enige i, at afbrydelser, som afskærer terminaler fra det internationale skinnenet, ødelægger kundegrundlaget. De umiddelbare løsninger på problemet er at sikre mulig gennemkørsel ved sporarbejde eller at udbygge skinnenetværket, så der imellem flere lokationer findes alternative ruter.

Contents

1 Introduction

If one drives along the Danish motorways these days, chances are that the speed of the traffic is reduced as many other individuals choose to drive along the motorways too. The traffic may even be at a standstill. This situation happens more and more often as the spare capacity of the motorway network some places is coming to an end and this is a tendency that will most likely continue. Especially the sections Aalborg-Flensburg and Kolding-Copenhagen will suffer from a high rate of traffic. A part of this problem is due to heavy vehicles that take up more physical space, drive at lower speeds and overtakes slowly. In addition to contribute to congestion, heavy vehicles emits carbon dioxide as well as other pollutants due to the predominant use of internal combustion engines. (Vejdirektoratet, 2018)

Transport of goods is one of the reasons for these heavy vehicles. The need for freight transport is increasing and it has proved difficult to have growth in economic wealth without a rise in freight transportation. Furthermore, globalization enables customers to buy products regardless of the distance to the producer. Packages of high value relative to their weight allows for energy inefficient modes like planes and trucks to be used. Companies are able to move production to countries with low wages though the market for their products is far away from the production facilities. (Askildsen, Hovi and Eidhammer, 2013)

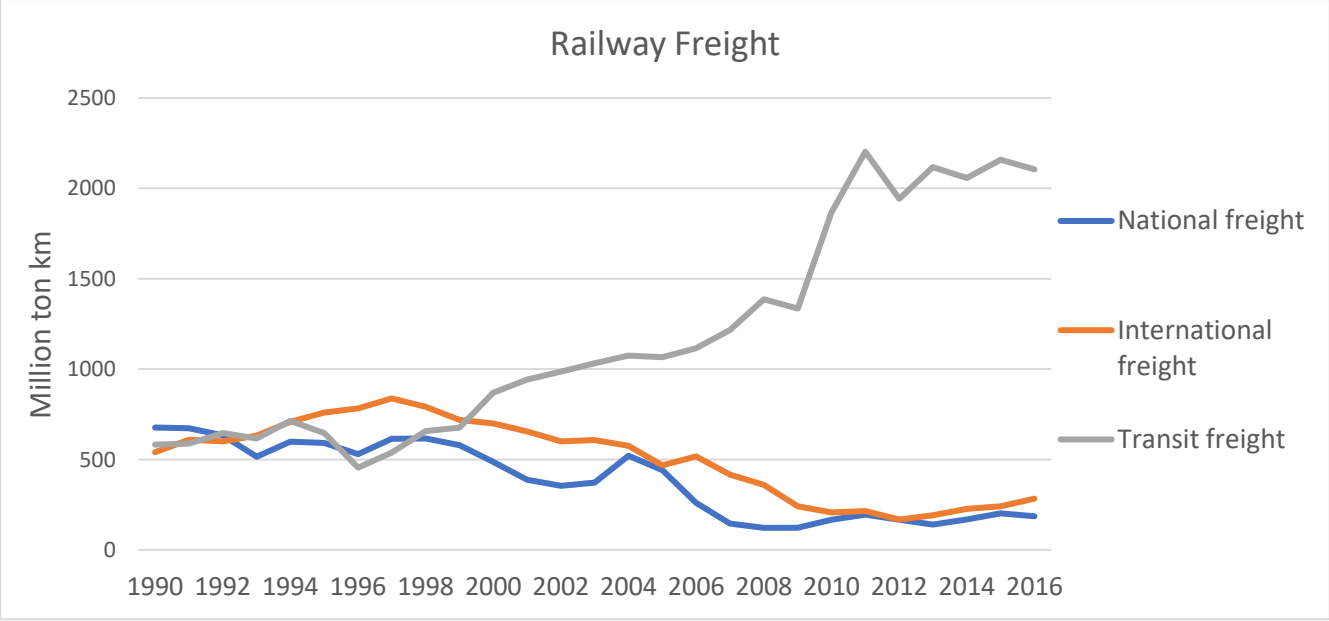

Figure 1: Freight transport on rail in Denmark (Danmarks Statistik, 2017).

These tendencies the European Commission wishes to accommodate to reduce the negative impacts mentioned. The method to do so is not to restrict trade and freight in the union but to promote use of transport modes that are more sustainable as well as to utilize the infrastructure more efficiently. In order to do so multimodal transport, i.e. transport that includes at least two transport modes of which one is not by road. Main haulage of goods should according to the commission be performed by waterways or railways. The concrete goals of the actions are to move the freight transport of more than 300 km from road by 30% before 2030 and 50% before 2050. (European Commission, 2011)

For inland transport, a way to ensure this is to facilitate long distance border crossing rail freighting. The way was partially paved for this by the separation of rail operators from rail infrastructure which was ensured through several directives launched in the 1990's and 2000's (Zunder *et al.*, 2013). In Figure 1 what may be an effect of this can be seen as the national and international rail freight traffic began to decline during this period while transit traffic grew extensively.

International and national rail freight today is insignificant compared to that of road and sea transport and so, rail freight still overall has a relatively small market share as can be seen from Figure 2. In the world of rail freight, Denmark is in many ways merely a stepping stone between Sweden and Germany. Tracks that are part of the Scan-Med corridor give way to a considerable amount of rail freight whereas the residual track sections are primarily used for passenger transport.

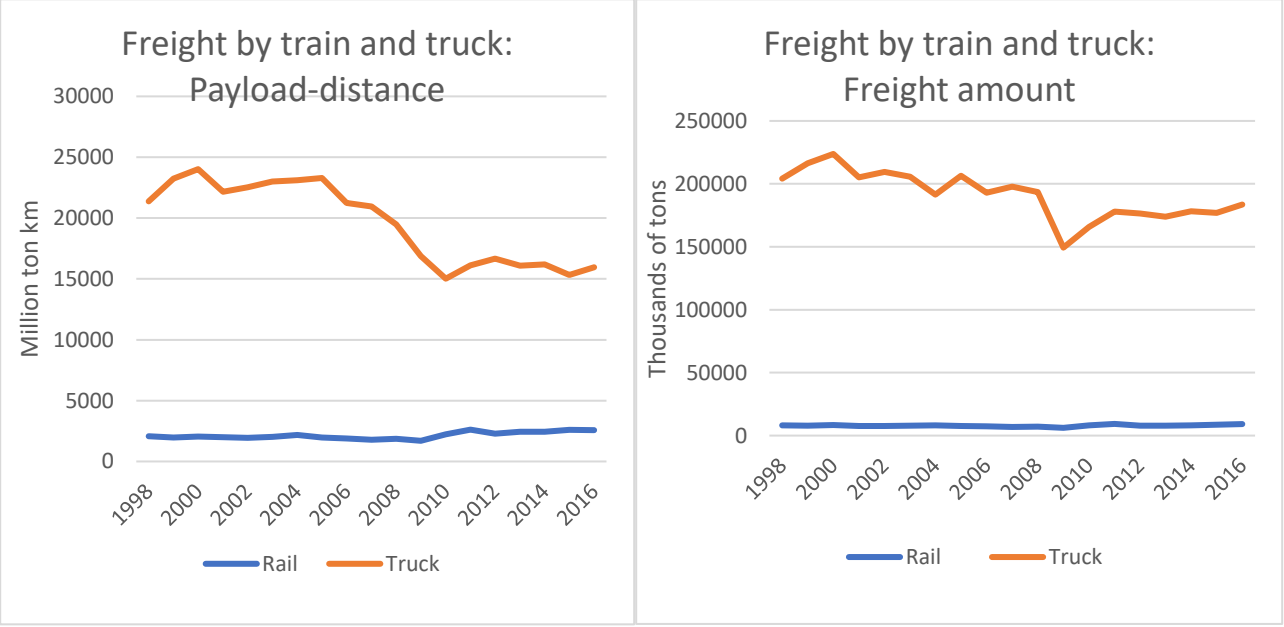

Figure 2: Annual Danish freight amounts for trucks and trains.(Danmarks Statistik, 2018b) (Danmarks Statistik, 2017)

The issue with stagnating international and national rail freight was treated recently in a report by the Danish Transport Authority to promote the use of freight trains. The report stresses that relatively few Danish companies produce or attract an amount of goods that would justify frequent use of whole trains. Moreover, the report

shows that the region with the smallest amount of rail freight at present is the North Denmark Region. Even though the region is the most remote region from the goods demanding capitol of Denmark and it is far from the German border and thus, in theory, would have a potential for rail goods, less than one train a week travels back and forth to the region each week according to the report. (Trafik- og Byggestyrelsen, 2016)

However, since the report was published in 2016, a new concept has reached the region which possibly can prompt more companies to make use of the railway network in the North Region for freight transport. Since 2 February 2017 DB Cargo Scandinavia has operated a shuttle train that offers transport of shipment sizes down to one single container (Port of Aalborg, 2016). This will presumably give rise to far more potential railway freight customers and it encourages one to ask the following question:

1.1 Problem statement

How big is the potential for rail freight transport to and from the North Denmark Region when shipments of down to one container can be shipped ad hoc and which barriers and opportunities are decisive to the rail freight market share in the region?

1.2 Elaboration

The statement consists of two parts:

a) Assuming there are no obstacles for using rail transport, how big are the quantities that could potentially be sent by freight trains to and from the North Denmark Region?
b) To utilize the full potential of rail freight, what needs to be changed for rail freight in the region?

To answer part a and part b is equally vital for the study. The two parts are studied differently, i.e. with a quantitative method and a qualitative method. This will be discussed further in chapter 3, but it is important to clarify that the conclusion depends on both the qualitative interview analysis in chapter 4 and the quantitative freight flow analysis in chapter 5.

2 Theory

In the following chapter the theory of the key elements in rail freight is explained. Freight transport is a broad subject and subjects, that are not directly discussed in this chapter, will be brought up later in the report, e.g. terminal design. However, the theory of the Break-even distance cover many of the issues in rail freight. Firstly though, freight traffic models will be discussed to understand the deselection of these for analyzing method.

2.1 Traffic models

Use of models is central to calculate correct procedures to obtain sustainable freight transport. Freight transport is a complex matter, which means that there are countless procedures in freight operations that can be modelled and each of these operations has a varying number of variables to think of.

Models regarding transportation can be set up in a number of ways depending on the exact problem they are solving and what input is available. These problems can be strictly economical or organizational which means geographical data is not necessarily required as an input. When looking through examples of freight models, though, it is clear that they often handle geographical data because freight is first and foremost about moving goods a given distance. Traditional 4-step traffic models are often used to forecast goods movements and choice of mode. (Monios and Bergqvist, 2017)

Historically the 4-step model is made to calculate passenger movements and it seems that models are often constructed as passenger models and then modified to work as freight models (Ortuzar and Willumsen, 2011). However, transport of passengers and transport of goods are not the same. A person can often perform a trip with just about any transport mode in most cases as long as the time consumption is tolerable, whereas transport of goods has to be thought of as a part of the production line. (Raaschou-Nielsen, 2005)

The demands for transportation is very dependent on the product that is transported. Thus, a model of mixed types of freight must differentiate between the types of goods. Some types of goods have special needs like cooling, ventilation etc. This influence costs and, in some cases, it also restricts the mode choice. (Raaschou-Nielsen, 2005)

Another incredibly complicated matter in transport is organization. The complexity here depends a lot on how the goods are being transported. Direct transport from producer to customer is in this case the simplest case since the producer is the only actor when it comes to transport. The most complicated instance is multimodal transport which is mostly defined as transport that involves several modes of transport from different companies (Monios and Bergqvist, 2017). Multimodal transport is in most cases planned by a freight forwarder which means that the transport decision is often only up to one person and its knowledge as well as its personal preferences. This variable is for instance taken into account in the TAPAS-model from Sweden that seeks to simulate the

outcome of production and transport possibilities along with the decision making of transport agents among other actors. (Holmgren *et al.*, 2012)

According to Tavasszy (2008) freight models have in general become increasingly complex since the first freight models were introduced in the 1970's. Model components were added in the 1980's so that the 4-step model was complete for freight transport and in the 1990's Agent Based Simulation Models, as mentioned earlier, were introduced. More components are requested by Tavasszy to enhance the possible objectives and quality of freight models.

In recent years within the traffic modelling field in Denmark, one of the warmest subjects has been the National Traffic Model. The decision to create a national traffic model was made in 2009, not as a part of a specific project, but as an all-round calculator for traffic projects of significant sizes like the disputed Kattegat bridge connection. The model can give output for a variety of purposes, that being effects of physical changes in infrastructure or economic regulations. Once again, it shows that freight modelling appears to be a more challenging field than modelling of passenger traffic. According to a memorandum freight analysis suffers from lack of data. (Overgård, 2016)

Whereas the Danish National Traffic model has multiple purposes to fulfill, it is also an option to simply model the freight mode choice. That is the purpose of the *Location Analysis Model for Belgian Intermodal Terminals*(LAMBIT). The GIS-based traffic model makes use of an all-or-nothing algorithm to show the preferable mode choice between the cheapest unimodal road route, the cheapest multimodal barge route and the cheapest multimodal rail route. Still, the model is built from large quantities of data, especially cost data from transport companies. (Macharis, Pekin and Rietveld, 2011)

2.2 The break-even distance

What many of these models are used partially to discover is the so called *break-even distance* or the *critical distance* in multimodal transport. This distance marks the threshold of when it will be profitable to change from unimodal transport to multimodal transport. A schematic diagram explaining the principal is shown on Figure 3.

Figure 3: Schematical diagram of the BE-distance. The blue graph denotes the cost of truck transport while the red line denotes the cost of multimodal train transport relative to transport distance. In this case the BE-distance is exactly reached as the graphs intersect at the right-side end of the diagram. Unimodal road transport would be cheapest on shorter distances and multimodal rail transports would be cheaper for longer distances.

The diagram shows the cost of truck transport in blue. When looked upon isolated, main haulage by truck is more expensive than by train which is seen from a steeper main haulage incline for truck transport. A considerable part of the cost of multimodal rail transport though, is from reloading goods between rail and truck at terminals, as well as transporting goods between origin and terminal and likewise terminal and destination.

The European Commission somewhat decided that this distance is around 300 km through its politics (European Commission, 2011). Naturally, this is not exactly true in every instance. It becomes obvious when looking through studies made on intermodal transport that there is great dispute about the actual break-even distance. Janic (2007) argue that intermodal rail transport is only competitive at distances over 600 km and that this is only feasible with economy of scale. Meers, Vermeiren, & Macharis (2014) conducts a review of multiple studies of break-even distances which demonstrates that the distance, that allows for profitable rail freight, differs according to the conditions in each case. The break-even distances in the review ranges from 117 km to 1858 km. Such a gap points to differences in both analyzing methods and case differences.

Regarding methods, there is no standard for performing break-even distance analysis which means that results can only be compared vaguely. One important parameter to use to differ between methods is whether cost of transport or the customer's price is used to compare transport modes. Since the ability to compete with other modes is directly reliant on the price customers need to pay, total price seems suitable to compare competitiveness. (Meers, Vermeiren and Macharis, 2014)

To make matters more complicated, standardization is not only a problem when it comes to methods to measure the BE-distance. The definition of what the BE-distance is differs from study to study as well. Considering a

consignor and a receiver of a good, there will be different ways to decide the competition interface between unimodal road transport and multimodal rail transport from the distance between the two locations. This is because distance between the two locations can be measured as (Kim and Van Wee, 2011):

- Distance as the crow flies
- Shortest road distance between consignor and receiver (door to door deliverance)
- Distance from hub to hub
- Total mutimodal distance, i.e. main haulage by rail and drayage distance

Each definition may apply to different situations, but the missing standardized definition makes it difficult to compare BE-distances. Moreover, a definition that relies on the distance from hub to hub can give the idea that it is only the distance between the hubs in use that is relevant, but the position of companies making use of the hub is important for the competitiveness of the hub.

On Figure 4 two companies that trade back and forth with goods is shown. The companies have the choice to send these goods by unimodal truck transport or by a multimodal solution where trucks transport goods to either of the marked hubs and let trains transport the goods for the majority of the distance and then let trucks transport the goods from the hub to its end location. On Figure 4 the unimodal route is clearly shorter than the intermodal route. For the companies to use the intermodal hubs, they will have to hire trucks to transport the goods in the opposite direction of where the goods need to go. However, drayage is almost always needed when using intermodal hubs.

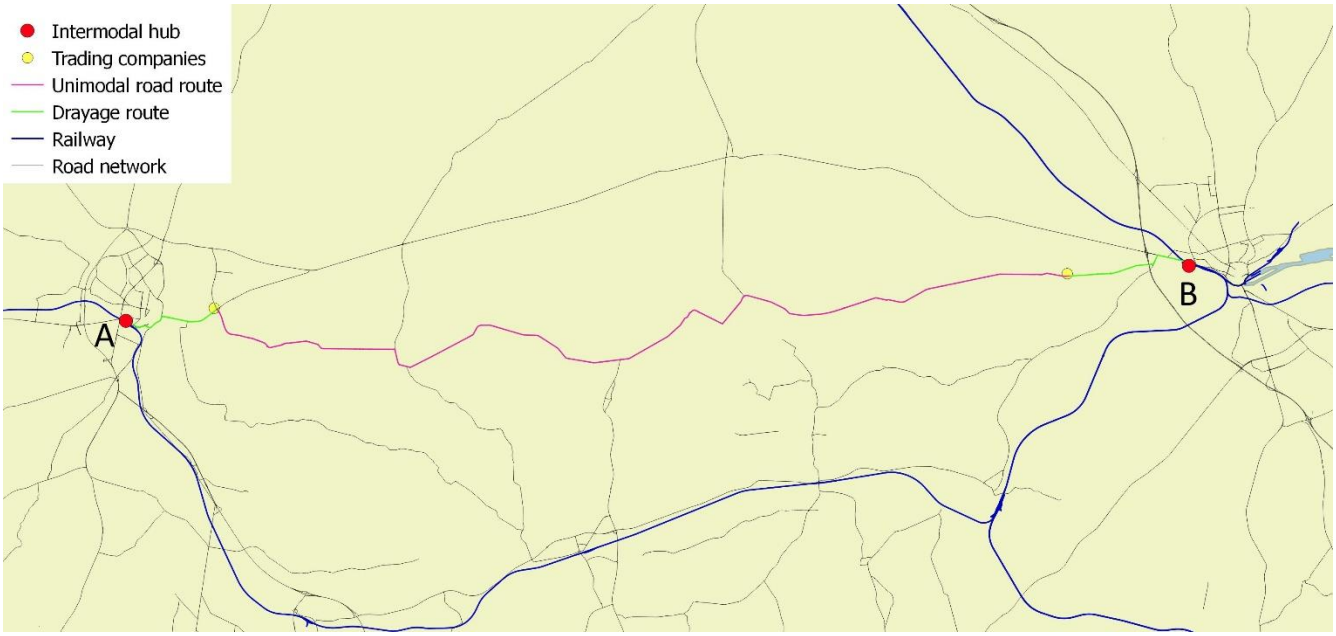

Figure 4: Sketch showing shortest unimodal road route compared to an multimodal route between two locations.

Another set of companies trading goods with one another is shown on Figure 5. These companies are further apart than the first two. The cost for this second set of businesses to use intermodal transport is about as big as

for the first set of companies since the drayage distance is similar and the rail transport distance is the same. However, the second set of companies are more likely to choose multimodal transport, because the distance of unimodal road transport is longer for the second set of companies compared to the first.

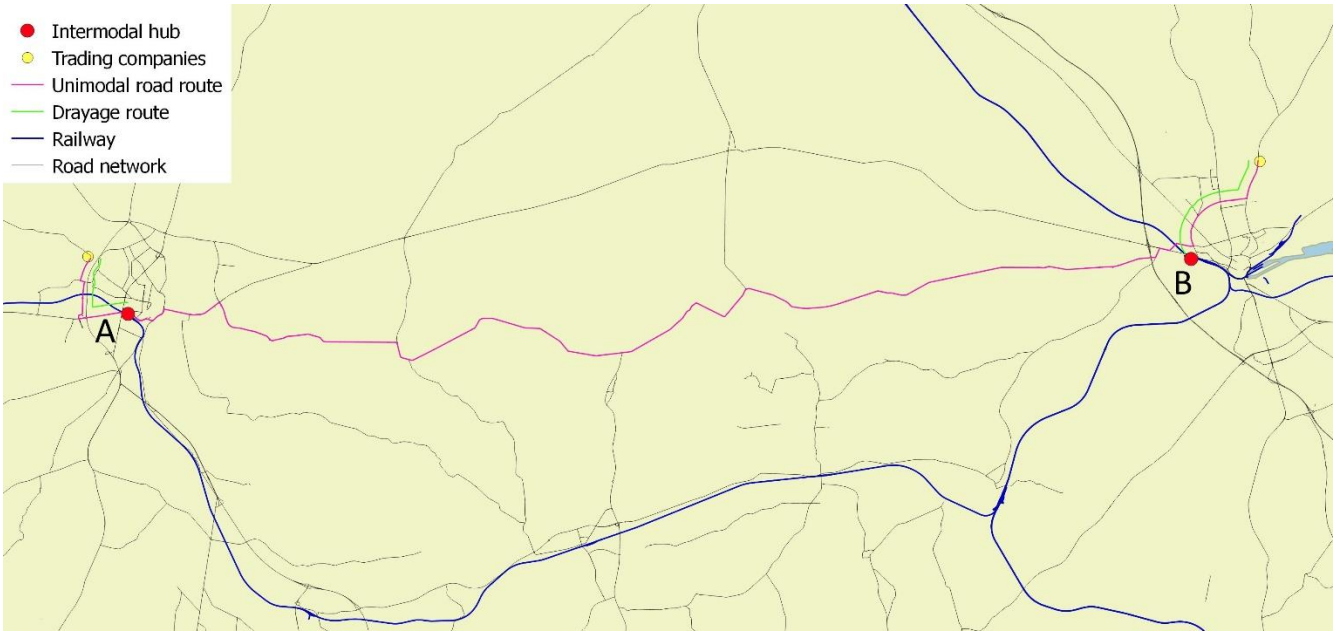

Figure 5: Same case as with Figure 4 but this time drayage between companies and hubs does not happen in the opposite direction of the good's destination.

Figure 6: Examples of market areas. The biggest market potential is found where drayage to/from terminal is in the same direction as the shipment's destination.

This is why the market area of a hub is seldom circular as one might think. The market area, i.e. the area around the hub where businesses make profitable use of the hub, depends on where the main recipient terminals are located. In the cases seen on Figure 4 and Figure 5 the market areas would probably turn out to have a shape as seen on Figure 6. The market area is skewed towards the opposite direction of the way the goods are being sent, because this is where multimodal rail transport is the most competitive with unimodal truck transport. This is just an example though, other variables can have an effect on the market area.(Kim and Van Wee, 2011)

Regardless of whether a standard is found to compare competitiveness of freight modes, it does not seem possible to find a universal break-even distance. However, it is a valuable indicator of new multimodal friendly initiatives. To use break-even distances as an indicator of this, they have to be calculated for each instance. The most important variables to include in such calculations are drayage distance, rail distance, truck distance, terminal location, market area, rates for driving, rail use and terminal handling (Kim and Van Wee, 2011).

These are changeable variables just like the distance. Handling- and drayage cost can be eliminated if goods are moved directly from consignor to receiver. This is only feasible if either consignor, receiver or both have sidings that are linked to the rail network. This solution reduces the break-even distance dramatically. (Trafik- og Byggestyrelsen, 2016)

Where the present limit for profitable rail transport is today varies, it seems, from case to case. To use BE-distances for a Danish problem statement it would thus be appropriate to use a BE-distance from Danish cases. The only observed Danish BE-distances are found in the aforementioned Trafik- og Byggestyrelsen (2016). According to this document rail transport is economically preferable to road transport at distances of more than 450 to 500 km and more than 350 km if the transport route crosses the Great Belt Bridge.

2.3 Infrastructure design

Transporting goods multimodally generates many possibilities of how to construct a full goods transfer. Instead of the simple unimodal truck transport consisting of onloading, main haul and unloading, multimodal transport can consist of countless trip components. In theory freight can be reloaded multiple times on its way from origin to destination but actual reloading from one mode to another demands for the shipment to travel a very long distance and thus reloading at more than two terminals for a shipment will rarely happen (Racunica and Wynter, 2005).

However, to set the record straight, unimodal road transport is not always as simple as it appears from the literature. Terminals are used for unimodal road transport as well to consolidate goods and avoid trucks that drive almost or entirely empty. Danske Fragtmænd for instance have more than 20 cargo terminals located in Denmark (Danske Fragtmænd, 2018). This collaboration between haulers reduces the emissions from road transport as the vehicles are used more efficiently. Further collaboration can reduce emissions just like the use of rail transport. (Palmer *et al.*, 2018)

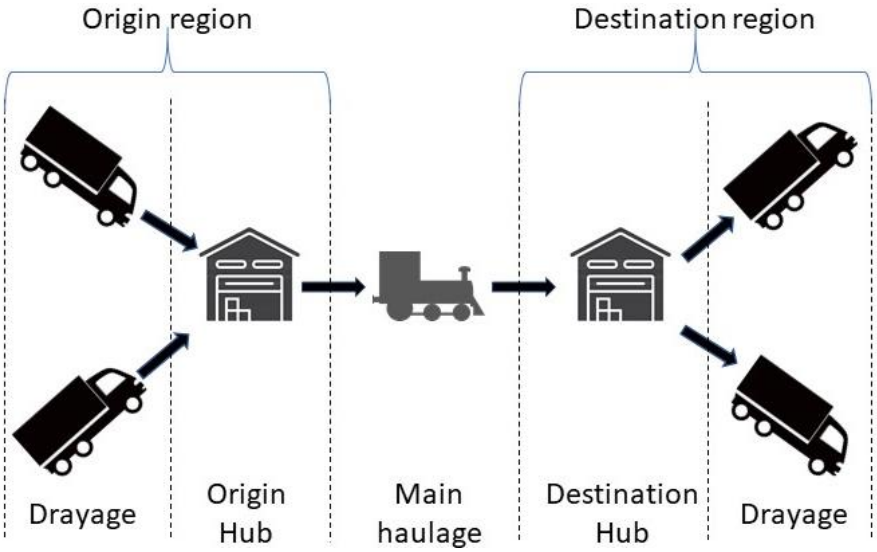

Figure 7: Principal sketch of a direct rail transport where the freight train loads goods on one origin hub and delivers the goods at one destination hub.

The fact that reloading is a considerable part of the transport cost is probably the reason why several authors work with models where only two intermodal terminals come into action(Kim and Van Wee, 2011)(Janic, 2007). The principle is sketched on Figure 7 where drayage is performed between the intermodal terminals and main haulage is only performed between these two terminals. For this type of freight method there is a need of either having sufficient shipments to occupy the capacity of a train at *one* terminal frequently or instead over time consolidate shipments at the terminal and ship less frequently.

The alternative is to make use of several terminals within one region as sketched on Figure 8. On such a freight corridor a freight train can go from terminal to terminal assembling or dissembling the train on the way. The benefits of this solution are that shipments sizes from each terminal are not required to occupy an entire train and, if more terminals within a region offers reloading between truck and train, drayage will be reduced. Total transport time is extended, though, compared to a direct link between two hubs, as a transport corridor requires shunting or loading at more terminals. This is time-consuming so a more direct two-hub system is preferable if possible. (Woxenius, 2007)

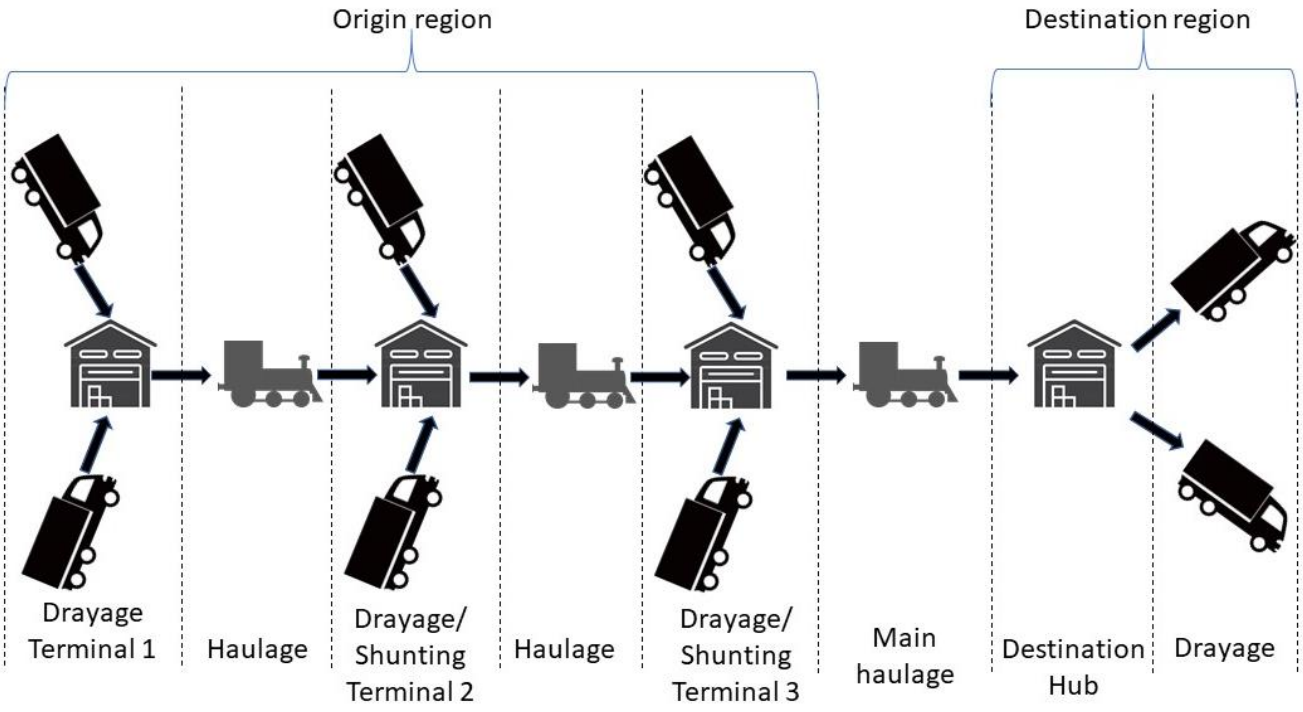

Figure 8: Principal sketch of a corridor solution where the freight consolidate goods on its way through several hubs in the origin zone. The destination zone could as well consist of multiple hubs.

2.4 Types of goods

The emphasis on keeping transport duration at a minimum is justified. There are multiple reasons why time is an important parameter to the road and rail competition interface (Raaschou-Nielsen, 2005)(Reis *et al.*, 2013):

- Return of interest. While goods are being shipped they are an investment with no return. It is in the interest of the shipping company to profit from their product as quickly as possible.
- Insurance premium is costlier for transports that take longer time.
- Faster transport enables companies to quickly react on market tendencies.
- Goods can have an expiration date, e.g. food.

Thus, *Time is money* is a very literal statement in the business of freight and because intermodal transport will in almost every case be slower than unimodal truck transport, the break-even distance will be longer when time costs are included opposed to calculations without time costs (Meers, Vermeiren and Macharis, 2014). Time is here first and foremost the transportation time itself, but other undertakings are time consuming as well:

- Time to order a channel on the rail network (If not a shuttle service is already operating at the desired time)
- Lost time from mismatching rail net channels and transport requirement.
- Punctuality of service.

- Frequency of rail transports.

The time sensitivity differs from commodity type to commodity type. The return of interest increases with the price of the commodity, expiration time differs and demands for shipping time in general depends on the urgency of acquiring the commodity in question.

It has not been possible to find empirical evidence that some types of goods are completely unfit for rail transport because of the transport duration. Stinson et al. (2017) shows, through shipment microdata collected in Arizona, USA, that shipments of sizes below 1500 lb of mass are never shipped by rail while more than 80% of the shipment by rail are heavier than 35,000 lb. The same study shows that freight rail in Arizona is used by far the most for bulk commodities, especially coal. As expected foodstuff is seldomly shipped by train according to the study. More surprisingly manufactured goods like textiles, vehicles, electrical equipment etc. is never shipped by rail in Arizona.

However, rail freight in America is different from European rail freight on multiple parameters. Obviously, the distances between sender and receiver are longer which is suitable for railway transport. The majority of the American rail network is owned by the rail freight operators. Because of this constellation, rail freight operators can allow passenger traffic on certain tracks while other track sections are used solely for freight transport. The American rail freight is thus not assigned to accommodate to the passenger traffic by only operating at night or with multiple stops during daytime. Another derivative of the different ownership is the lesser operating costs per train as the freight operators do not pay fees for use of the rail network. This means that American trains are not forced to consolidate the same amount of goods as European to keep costs down but are freer to choose faster routes. (Clausen and Voll, 2013)

Reis et al. (2013) show a picture similar to Stinson et al. (2017) of the mode split for different commodity types, although railway transport in this case is represented for all commodity types. Again, rail transport has a very small share in the transportation of food stuff with a 1 % share compared to a 95% share to road and 4% to river barge. Reis et al. (2013) state as well that rail transport has the largest share in freight of bulk commodities apart from soil commodities. In Denmark though, bulk is mostly transported by ship and seldomly by rail. In return the share from commodity types seems more evenly distributed on the Danish railways. The most popular commodity type for railway transport is finished metal products while railway transport has no share in mail and packages. (Trafik- og Byggestyrelsen, 2016)

2.5 Externalities of freight transport

As mentioned in chapter 0 the EU-commission substantiate the mode shift mainly because of environmental issues in the freight sector. Diesel driven trucks pollutes with global pollutants like CO^2 and local pollutants like NO_2. Trains are approximately five times more energy efficient than trucks and often this energy is in an electrical form. Electric propulsion is presumably the reason why rail freight has the lowest emission of NOx, particulates and CO compared to road transport, inland waterways and maritime transport. The lesser need for energy is

mainly due to the fact that the rolling- and air resistance for rail transport is much lower per ton freight than it is for road transport. (Hardy and Hardy, 1997)

Regarding form of energy, solutions are being developed to electrify road freight transport. Such solutions can minimize the use of combustion engines and thereby reduce the amount of local pollution and even global emission if the electricity source is environmentally friendly. If we presume the European electrical grid is going to be able to withstand this increase in electricity from the transport sector, taking into account the higher rolling resistance and presuming the electricity is CO_2-netural, the EU-commission's main incentive for moving freight to rail, which is to reduce emissions, is unsupported. However, this is only a thought derived from the fact that Siemens is developing electrical lorries. No other literature on this has been found. (Siemens, 2018)

However, there are other reasons to strengthen the competitiveness of rail freight. These reasons appear when looking into negative externalities other than emissions. According to a study by the Swedish National Road and Transport Research Institute the costliest externality for land transport is deterioration of transport infrastructure. The study takes up two trips of freight transport and the magnitude of the negative externalities when the route is completed with either freight train, truck or ship. The study includes the following externalities for Road, rail and sea transport:

Table 1: The externalities of different modes of freight transportation. (VTI, 2013)

Road	Rail	Sea
Air pollution	Air pollution	CO_2
CO_2	CO_2	NO_x
Noise	Noise	SO_2
Accidents	Accidents	
Congestion	Congestion	
Wear and tear	Wear and tear	

Though wear of infrastructure is the greatest externality in the case of both rail- and truck transport, the impact from freight transport on roads is higher than on railways. (VTI, 2013)

Another type of externality, that is both pointed out in the VTI study the EU commissions white paper from 2011, is congestion. Congestion is a cost for both roads and railways but in the study the size of the problem differs very much between road types. Motorways are in general more congested than other roads and especially if situated near a city. In Denmark the motorway traffic is expected to increase annually with 1,5 % until 2030(Vejdirektoratet, 2016). This development is hard to control with the options available as vehicles can access the road network as they please without having to pay road tolls apart from when passing bridges.

Congestion can be avoided in the case of railways since access to the network is only permitted by Banedanmark when capacity is at disposal. Several railway sections in Denmark are at the brink of their capacity. Railway capacity is first and foremost handed to passenger trains (Banedanmark, 2018)

When speaking of externalities, it is important to clarify that these are costs that are not directly returned by the infrastructure users. Externalities are thus not a direct cost for infrastructure users but a cost for society. As is shown in the Swedish study, the external costs are more or less internalized through taxes and tolls, but it is not certain that these payments are used for the specific externalities and, moreover, it is inefficient use of resources even if they are paid for. According to (CER and UIC, 2015) The externalities of rail freight are six times lower than the externalities of road freight with road congestion excluded. Thus, for the sake of society, railway transport is preferable to road transport. However, another alternative to road transport is found in both inland waterways and maritime transport. To choose between rail and sea transport, based on environmental factors, is not a simple task as the degree of environmental friendliness of sea and rail transport depends on multiple factors like vehicle age, size, propulsion, etc. Electric locomotives, for instance, pollutes far less than diesel driven, especially if the electricity source is environmentally friendly. Ships for freight transport mainly use heavy fuel which entails heavy emissions of particles and NO_x. It is peculiar that accidents are not included as an externality for sea transport. Singular ship transport accidents, like the Exxon Valdez scandal of 1989, can potentially ruin entire eco systems and accidents at sea are thus relevant to include as externalities as well(Peterson *et al.*, 2003). On the other hand, ships do not deteriorate infrastructure and cause congestion like rail and road modes as seen in Table 1. Thus, unless there is clear knowledge of a benefit of moving freight from sea to rail in a specific case, rail freight should only gain market shares from road freight to reduce externalities. (Monios and Bergqvist, 2017)

3 Methodology

Three types of methodology are made use of during the project. A literature review has been performed to investigate the subject of railway transport and explain the necessity of it. During the review it has become obvious that an important factor in the competition interface between multimodal transport and unimodal transport (truck) is the specifications of the terminals handling the cargo. The terminals account for much of the rail transport cost and the terminal managers are important stakeholders in the field of railway transport. The terminals are included in the study through interviews of representative terminal managers along with interviews of other important stakeholders.

The last method is of a more quantitative type. Using Register data bought from Statistics Denmark goods flows from the North Denmark Region is accounted for to see if the region sends or receives shipments suitable for railway transport.

3.1 Literature review

The majority of the literature has been reviewed at the initial period of the study. Because the study has changed in form since its initiation, some of the searched terms, hindsight, seem peculiar. Examples are *rail freight modelling* and *goods movement model*, since it was planned initially to make use of a transport model in the study. Other subjects have been *break-even distance* and simply *rail freight*. Most of the literature has been searched via scopus.com and in some cases the selection of articles has been narrowed down by selecting the most popular, or most cited, articles. Aalborg University library's search engine, Primo, has been used in a similar manner as Scopus.com.

Apart from looking into the research on rail freight, the literature search has also been a measure to learn how the freight business works. For this, Bibliotek.dk has been used extensively for books about freight and newspaper articles on the Danish rail freight situation. Reports about rail freight and administrative papers have been found by Google search and through the websites of the organizations behind them such as Danish governing bodies and the EU commission.

3.2 Stakeholder analysis

As mentioned the choice of the primary method to uncover the rail freight potential initially fell on traffic modelling. Yet, from early investigations it has become clear that the variables that decide the mode of transport are numerous and would be too laborious to cover completely in a study like this. Especially for people outside the business of freight transport it is difficult to point out the relevant issues in a modal shift and thus to build a freight model uncovering the potential of rail

freight. To begin with the thought was that freight flows would primarily be affected by cost and infrastructure, but as mentioned in section 2.1 human factors are important as well and to include these, complex agent-based models would need to be put into use. To avoid looking into the human factors of choosing between road and rail, a model like the Belgian LAMBIT model could have been taken into use. However, both the need for cost data as well as adequate software is a problem for a model to be build. Furthermore, from talks in the beginning of the study, it has become clear that several problems for rail freight in the region are not due to cost- or time differences but are rather organizational and operation management related issues.

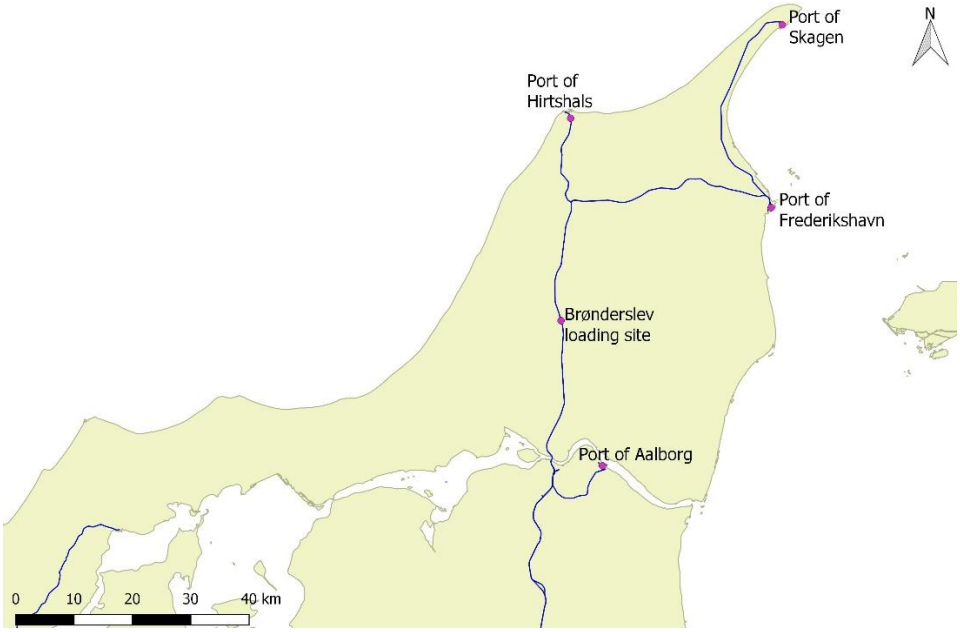

Figure 9: The locations suited for reloading between road and rai freightl vehicles according to Trafik- og Byggestyrelsen (2016).

To account for the rail freight circumstances in the region, a more qualitive method is used along with a quantitative method that will be explained further into the text. The qualitative part of the analysis is a stakeholder analysis. By interviewing the most important stakeholders in the business of rail freight in the region, the circumstances for goods transport by rail will be clarified.

The choice of stakeholders to interview has been made from the fact that a big part of multimodal transport cost is from terminal handling. Along with the operators the terminals provide the rail freight service for local customers and are thus important to the rail freight industry. Also, Trafik- og Byggestyrelsen (2016) shows that there are several loading tracks and terminals in the region but it is not specified which services these loading sites offers. The sites are specified as shown on Figure 9. Apart from the public loading siding at Brønderslev all sites are port tracks. To learn about the port tracks, representatives of Port of Aalborg, Port of Hirtshals and Port of Frederikshavn are interviewed. Attempts have been made to interview representatives from Port of Skagen, but the port management recommend to instead ask local company FF Skagen about the tracks, as FF Skagen uses the port tracks on a regular basis.

Local port representatives were asked questions within four subjects:

a) Design of track facilities.
b) Present rail freight situation.
c) Actions that could improve the use of the facility.
d) Possibilities of collaboration among the ports.

Subject a is to clarify whether the facility could possibly service freight trains, to clarify if the Geo data from Kortforsyningen.dk was up to date and find key elements of the facility. Subject b covers whether rail freight is or is not being handled at the facility, how much is handled or to clarify why the facility is not being used for rail freight handling. Because all terminals are linked to the same main track, it is interesting to know if the stakeholders think a corridor solution, as shown in section 2.3, could be a solution to handle more rail freight in the region or if freight trains should go directly from each origin terminal to the destination area, hence subject d is a part of each interview.

These subjects are chosen as they are assumed possible to be discussed with every port representative and because they presumably cover the question on what the options are for rail freight in the region. This is only partly covered in Trafik- og Byggestyrelsen (2016). Especially the subject on collaboration between ports seems to be neglected by the Danish Transport Authority. For the study it is important to know whether the ports act as a whole collective or autonomously.

In addition to the ports, the intermodal terminal in Taulov is visited. The visit has two objectives:

e) To show an example of a terminal with a high degree of utilization.
f) To interview a rail freight operator and learn what they see as the main issues in the rail freight business.

Objective f is possible because Taulov intermodal terminal is managed by DB Cargo Scandinavia who as well performs rail freight operations in Denmark and is the company behind the shuttle service from Port of Aalborg, which was introduced in section 0.

During the interviews of the port representatives and DB Cargo it has become clear that Banedanmark would be relevant to include in the qualitative analysis. Thus, a representative is interviewed to account for some of the issues that have been uncovered.

There are still many stakeholders that could be included in the analysis, even within the fields of track managers and rail freight operators, but to account for the main issues, the stakeholders at hand are believed to be the most relevant. One could very well call it a case study since it is only an outtake of the stakeholders that has been studied. Although a more deductive method is used as well, the study very much rests on these qualitative methods. Qualitative methods such as a case study should, according to Eisenhardt (1989) only be used to build up hypotheses, but this claim is untrue, Flyvbjerg (2013) states. Flyvbjerg states that even singular case studies can provide scientific knowledge about a general matter if only an appropriate case is chosen and treated contemplative.

The approach of using interviews as an integral part of a study with multiple actors is seen used by Kordnejad (2016), who seeks a way of using railway freight in an urban environment. This implies new intermodal loading techniques that are discussed by a group of stakeholders in the industry. The study at hand likewise seeks to find a potential of rail freight, but instead of a stakeholder meeting, interviews of stakeholders are undertaken separately.

Each interview is conducted personally with use of dictaphone. During the visit, if it is a terminal in question, a trip is performed around the facility to better be able to describe the facility in the analysis. In the case of Port of Aalborg and Taulov terminal the trip is guided. Though the subjects of each terminal interview are the same, individual questions have been prepared before every visit for the conversation to have a better flow. Every interview with the use of dictaphone is transcribed to ensure the quality of the analysis. These transcriptions are accessible through the author of the report, but they are not published along with the report in order to prevent any misuse out of context.

Only in the case of Port of Skagen neither an interview with dictaphone nor a visit to the track facility is performed since it has shown not to be possible. Instead a phone interview is performed with FF Skagen represent Thomas Hansen whose firm makes use of the track regularly.

3.3 Goods flow analysis

The regular size of the potential of rail freight in the North Region is analyzed through goods flow microdata. Initially the idea has been to create a freight model like the Belgian LAMBIT-model and use the data in the model. As already mentioned however, the model would not be able to point out some of the more local issues with rail freight in the region. Instead an analysis is performed on the goods flow data by filtering the data from goods that are not produced in sufficient quantities, goods that are not transported far enough for rail freight to be competitive, i.e. further than the break-even distance.

The data is bought from Statistics Denmark and, because it is sensitive microdata, can only be handled through a remote computer. This limits the choice of software to treat the data to those programs that are installed on the remote computer. The main software used for the analysis is Quantum GIS or QGIS as this is capable of filtering the data as well as presenting the results in the form of maps. Although it has been necessary to make use of R-Statistics as well as Libre Office as QQGIS has proved to have its limitations.

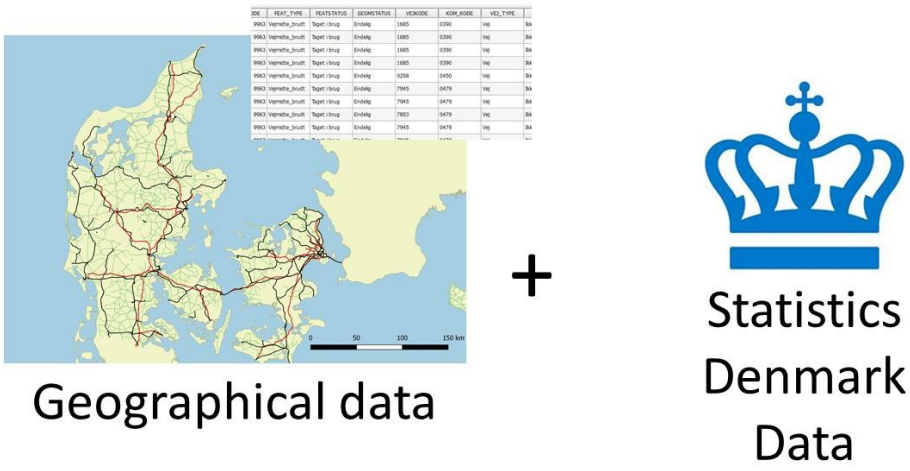

Figure 10: The output of the quantitative analysis is filtered statistics presented with maps that are created with Geographical data.

3.3.1 Register data from DST

The movement of goods is found through five registers. This data cannot be shown directly as it contains microdata about Danish companies. Thus, this report only contains aggregated data in the form of tables, graphs or maps. The five registers are as follows:

VARS – Sales of goods by the industrial sector

VARS shows the sales made by every industrial company. Each company has a CVR number that identifies it in the Central Business Register and in this case works as a key identifier between datasets. The number is encrypted to keep sensitive data about companies anonymous and so the location of the selling/buying companies cannot be estimated without looking into other registers that use the same encryption of data. (Erhvervsstyrelsen, 2018)

Field can be used to filter which items that should not be a part of the study. Field is shown as a number that refers to the Danish Business Authority's register of business fields. By using this register, goods not qualified for railway transport can be sorted from the study.

Part number is used to link the sold commodity to the VARK-register which holds the purchases made by companies in Denmark. By doing this it should be feasible to link the commodities origin with their destinations.

Amount and *Amount text* indicates how much is sold from the company of the commodity. An issue is to decide what the transport need is if for instance the amount of a good is given in *number* since this only says something about the size of the shipment if the commodity description is analyzed. The registers are massive which is why this is not possible

Table 2: VARS-register of goods sold by the Danish industry.

CVR-NR	Field (branche)	Part number (varenummer)	Amount	Amount text
XXXXXXXXXX	XXXXXX	6-10 digits	-	kg, m^3, m^2 etc.

VARK – Purchases of goods by the industrial sector

VARK is a register of all purchases made by the Danish industry. Most items have a unique part number that should also be observable in the VARS register, or in the register UHDI which is explained further on. So, where the VARS register gives the start position of the goods, VARK shows the destination.

The attributes are nearly the same for VARK and VARS but for VARK there is no information about the amount that are bought by each company. This information is available from the VARS-register, but the distribution from the selling company will have to be split evenly between purchasing companies.

This is definitely a source of error, but it is not possible to estimate goods distribution in other ways with the data provided.

Table 3: VARK-register of goods bought by the Danish industry.

CVR-NR	Field (branche)	Part number (varenummer)
XXXXXXXXXX	XXXXXX	6-10 digits

UHDI – International trade

UHDI is a register of Danish international trade. The register is more fulfilled in the sense that a weight is given for all aggregated shipments in kg.

Table 4: UHDI-register of all foreign trade.

CVR-NR	I/E	Country	Weight
XXXXXXXXXX	1: Import 2: Export	Country code	Number of kg's

Another attribute not provided for UHDI is identification of the foreign country company. This is not given in any other way than the country code of which the company resides in. Depending on the size of the foreign country, this entails quite a big source of error on the travel distance of a good. However, for most countries the travel distance is met.

BYSTRA – City sizes and work places

Bystra holds an encrypted address, the municipal address, along with the ZIP-code for each company. The main reason for using this register is to join each company with its ZIP-code on a map. This is the most exact placement allowed by Statistics Denmark to protect companies from having sensitive data revealed about them. If needed data can be shown at a more general level through home municipality. The exact location of each company is protected since the *municipal address* is not a conventional address but a 16-cipher code of letters and numbers that can only be used to link the BYSTRA-register with the FIRA-register.

Table 5: BYSTRA-register linking the encrypted municipal address to the local ZIP-code.

Municipal address (Access address)	ZIP-code	Municipality-code
XXXXXXXXXXXXXXX	XXXX	XXX

FIRA - Accounts statistics on level of workplace

The register shows account details of every Danish work place. The register involves 110 attributes but only three of these are important to the study as shown in Table 6. CVR-NR enables the register to be joined to the registers VARK, VARS and UHDI while the attribute 'Access address' allows for the register to be joined to BYSTRA's attribute *Municipal address*. The function of the register in this study is thus to link sales and purchases with company placement as well as indicating the primary field of business of companies in the UHDI-register.

Table 6: FIRA-register for linking goods information to BYSTRA.

CVR-NR	Access address (Municipal Adress)	Field code
XXXXXXXXXX	XXXXXXXXXXXXXXX	XXXXXX

3.3.2 GIS-data

Whereas geographical data and GIS software would have been essential to build and use a model like the LAMBIT model, the goods flow analysis could might as well be performed with a database management system without mapping functions. QGIS, however, allows to filter data by selecting features on a map. For instance, when only goods shipped to or from the North Denmark Region, relevant zip-code areas can be selected by marking the zip-codes within the region. Furthermore, the results can be presented by maps instead by tables.

The relevant geodata is:

- Zip-code area map by Johannessen (2008) seen on Figure 11.
- Municipal areas by Geodanmark (2018).
- World map by (Sandvik, 2009).

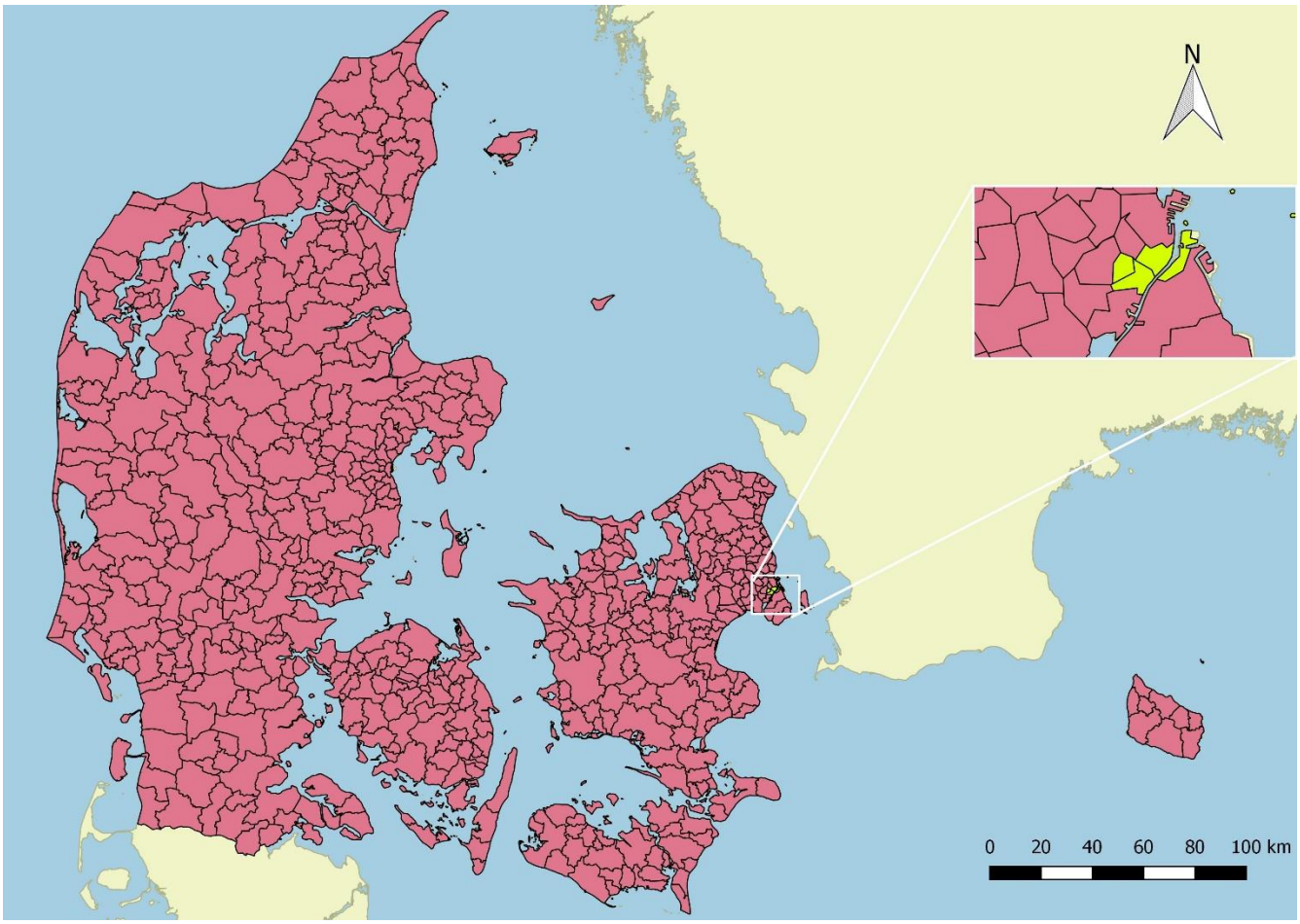

Figure 11: Danish ZIP-code areas used in the study. Yellow areas consist of multiple ZIP-code areas of relatively small size aggregated in central Copenhagen. By aggregating data in ZIP-code

3.3.3 Data processing

As mentioned, the registers containing sales data VARS, VARK and UHDI registers can be linked to the zip-codes found in BYSTRA by first joining BYSTRA with FIRA and then joining each sale register with FIRA. To begin with, the objective is to find what sales and purchases are made from the North Region. On a national level this is done by filtrating the purchases from VARK to only be from the North Region by the use of queries in QGIS, as shown in Figure 12. The filtered data is then joined to the unfiltered VARS-register with the key identifier *part number*. Thus, every purchase in the North Region of national goods is linked to the selling company and the selling company's ZIP-code. A similar procedure is performed for the goods sold from the North Region.

```
SELECT count(distinct'CVRNR'), 'Municipality' WHERE 'Weight'/52 > 25000 FROM 'UHDInorth' GROUP BY 'Municipality'
```

Figure 12: Example of query with the objective to count the companies in each municipality in the region that are capable of shipping more than 25 tons a week.

When it comes to international trade from the North Region, the process is simpler. Both CVR number as well as import/export country is apparent from the register and so the part number is of no use in the processing of international goods. As with the VARS and VARK registers the UHDI data is filtered to include only import/export to/from the North Region. Countries that are suited for export and import by railway transport are filtered by removing them from the aforementioned world map. The remaining countries are used to filter the UHDI dataset from countries that are not thought to be suited for railway transport to and from the North Denmark Region.

3.3.4 Remedy for aggregated data

The microdata has, unexpectedly, shown to contain only aggregated data on shipments. This is an issue as it is not possible to see size of every shipment which is important to know to decide whether the shipment is eligible for rail transport as stated. The procedure of using aggregated annual goods flow microdata is used by Stinson et al. (2017) for a modal choice model covering Arizona. The remedy in this study against the aggregated data is dataset of goods types and the typical sizes of the shipments these are sent in. However, such a dataset is not at hand for this study. The remedy in this study instead is to divide the annual freight amounts by 12 or 52 to see whether the freight flow of the commodity in question would be sufficient to ship by train if it was shipped in equally big shipments monthly or weekly respectively. How big these weekly or monthly shipments must be to travel profitably by train is checked during the interviews.

From this assumption it is feasible to derive a freight amount of shipments that are large enough to be transported by train. However, the region has several ports from where these shipments could as well be transported. There seems to be no remedy to this issue. In the Arizona study such a problem is not present as Arizona is a landlocked state with railway transport being the most environmentally friendly transport mode. In the North Denmark Region, the options for shipping goods by sea are plenty and it does not seem as a preferable solution environmentally from what was learned in section 2.5 to have railway transport take market shares from the maritime transport. This issue will not be resolved and thus the reader will have to have sea transport in mind when examining the analysis in chapter 5 where the data analysis is presented.

4 Stakeholder and infrastructure analysis

In the following chapter the viewpoints on rail freight of different stakeholders are presented to show how the present-day situation is and how they think rail freight could become a more significant part of the transport market in the North Denmark Region. Rail freight terminals are, as mentioned in section 2.2, important stakeholders, since a big part of transport cost is due to terminal handling. Because of this, every port linked to the railway in the North Denmark Region has been analyzed. To put the cases of the ports in perspective, the intermodal terminal in Taulov has been analyzed as well.

The visit at Taulov terminal also serves as an interview with a freight operator. The terminal is run by DB Cargo Service Denmark, a sister company to DB Cargo Scandinavia, which also has made ground for some comments on the situation for rail freight operators.

During the terminal interviews Banedanmark is mentioned several times, which is why an interview with a representative from Banedanmark has been arranged to let the organization answer the critique. During both the interviews with the terminal managers and Banedanmark, issues were partly attributed to political decisions and lack of interest from politicians in rail freight. Unfortunately, it has not been possible to get an interview for the report at hand with relevant politicians about the matter.

4.1 Taulov container port

Located near Fredericia Station, Taulov container port has a significant part of the Danish rail traffic passing close to it every day. Taulov container port is one of three container ports owned by the infrastructure owner, Banedanmark, and it is, track length wise, the largest of these(Banedanmark, 2018). The container port is a siding to the TEN-T-network and the intersection between the eastern railway towards Copenhagen and the northern railway towards the North Denmark Region is situated right next to the terminal which can be seen on Figure 13 (European Commission, 2017). In other words, Taulov container port is a key point in the Danish railway infrastructure.

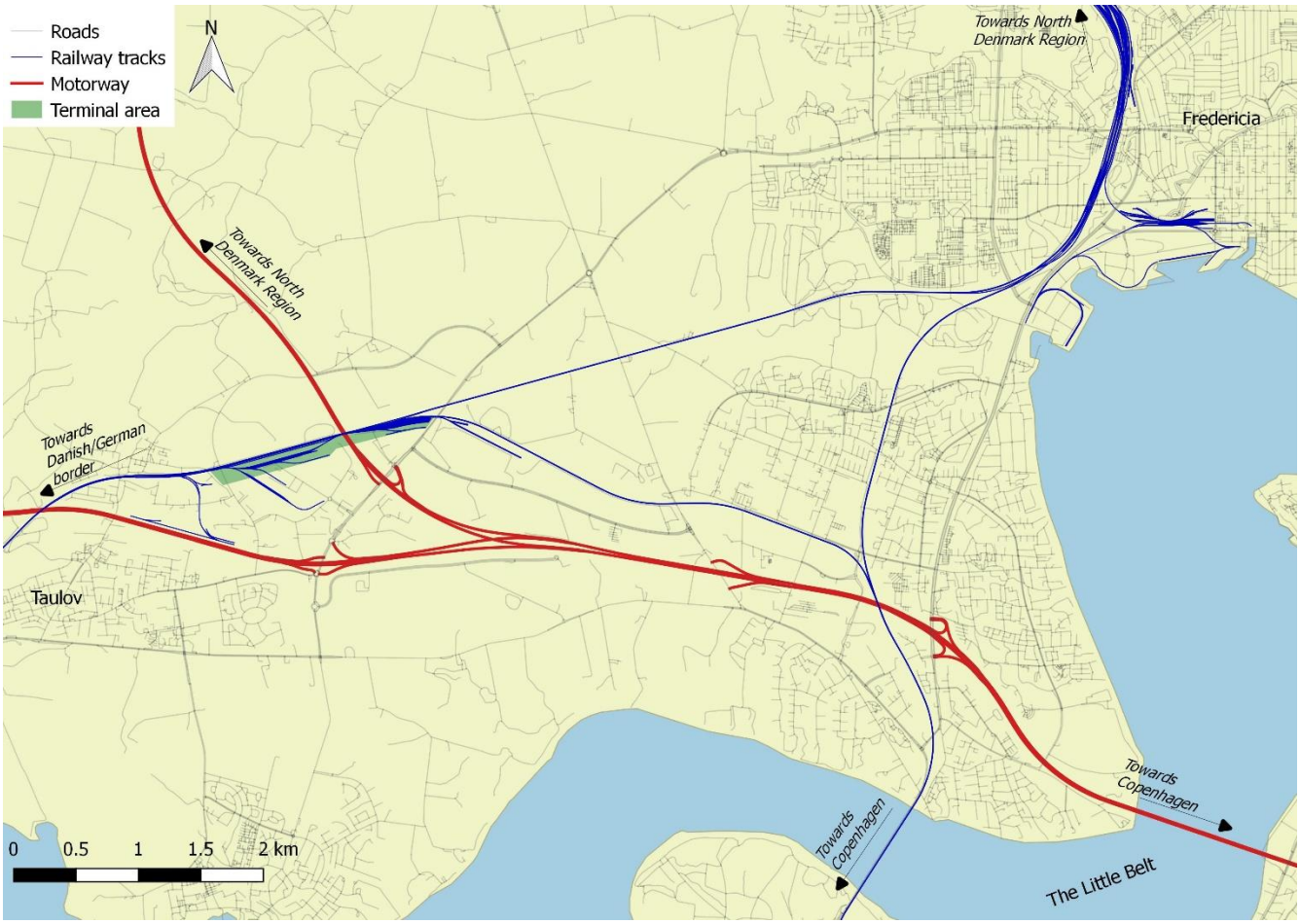

Figure 13: The terminal and its surrounding area where crucial sections of motorway and railway intersect.

This is at least what DB Cargo Service Denmark consider to be the case. DB Cargo Service Denmark manages the terminal and thus leases the buildings and infrastructure from Banedanmark. Though they manage the facility, DB Cargo need Banedanmark to do physical alterations and with the position as terminal manager at Banedanmarks intermodal terminals comes an obligation to receive all freight operators that need expedition. This ensures operability for other rail operators as well as prices that are regulated by the Danish Transport Authority.

Figure 14: Aerial photograph of the terminal area. It is impossible to make use of the unpaved area.

4.1.1 Facility design

The facility is split in two by the section of motorway that connects E20 with the northernmost part of E45. West of the motorway, seen on Figure 14, the actual terminal is placed. A paved platform with tracks on each side allows for reachstackers to load and unload freight trains parked on either of the tracks. From looking at Figure 15 it is worth noticing that these reachstackers are heavy equipment and, depending on the content, the containers carried can be quite heavy as well. This induces very high front axle loads which is why the pavement in the stacking area is dimensioned for a 90-ton axle load, an axle load several times higher than for normal road pavement.

Figure 15: Reach stacker lifting a trailer onto a train car at Taulov intermodal terminal.

The facility east of the motorway is not an actual intermodal terminal in the sense that no loading is taking place. Instead the tracks are used for shunting. Besides reloading, DB Cargo offers shunting as a service. Shunting can be necessary when assembling a trainset with goods delivered to Taulov by truck, but it is also useful for operators to be able to reassemble full length trains. The location of the terminal promotes reassembling. For instance, trains arriving from Continental Europe can have the cars reassembled into trains going north and east.

The capacity of the facility is as of March 2018 reached. According to Trafik- og Byggestyrelsen (2016), status of the facility in 2014 was that 50% of the capacity of 110000 TEU p.a. was used. This shows that the amount of goods handled at Taulov terminal has increased rapidly the last four years and it might be an indicator that railway freight is taking over more market shares in general. Before the terminal in Taulov can take part in this potential upturn, however, the capacity needs to be increased as it is forced to decline customers as it is.

From the maps on Figure 13, Figure 14 and Figure 16 it is clear that the options for expansion are not inexhaustible. Much of the surrounding area has already been occupied by other businesses or infrastructure. According to DB Cargo's representative, Brian Hjortkær, it is more of an advantage than a disadvantage that the terminal is located to other business and infrastructure:

"Here you could actually do business development and have some loading going on. This you have to do near the existing infrastructure(…) It is not Sæby, just to use Nortern Jutland as an example. Perhaps that would not be the right location to place a railway terminal. You have to build it next to existing infrastructure."

- Brian Hjortkær, team leader at DB Cargo Service Denmark (Quote translated from Danish).

The point is that the location is optimal and that it does not make sense to build a terminal in a place with room for expansion if the location does not attract customers. Expansion at the location is possible anyway since a considerable area of the terminal has a surface of unpaved ground. The areas are marked on Figure 14 and Figure 16 and take up about 3 ha of the facility area. DB Cargo Service Denmark would like to see the unused areas utilized, especially since the areas, though they are unpaved, contributes to a higher rent.

A recent extension, that was meant to increase the facility's capacity, is the rail section just south of terminal area 2, seen on Figure 14. The section was finished in 2011 after the facility was granted a part of an appropriation of 66 million DKK. The majority of the funding was spent at the intermodal terminal in Høje Taastrup. With the funding Banedanmark chose to construct the loading area marked as number 2 on Figure 14 along with the rail section south of it. From DB Cargo's point of view this is an upgrade, but they would have appreciated a bigger loading area. (Transportmagasinet, 2011)

"One track and 100 m terminal. Against the fact that a train can be 800 [meters] they have made a terminal that is 100 meters. Does that seem efficient? No, right? But that is what it would amount to."

- Brian Hjortkær, team leader at DB Cargo Service Denmark (Quote translated from Danish).

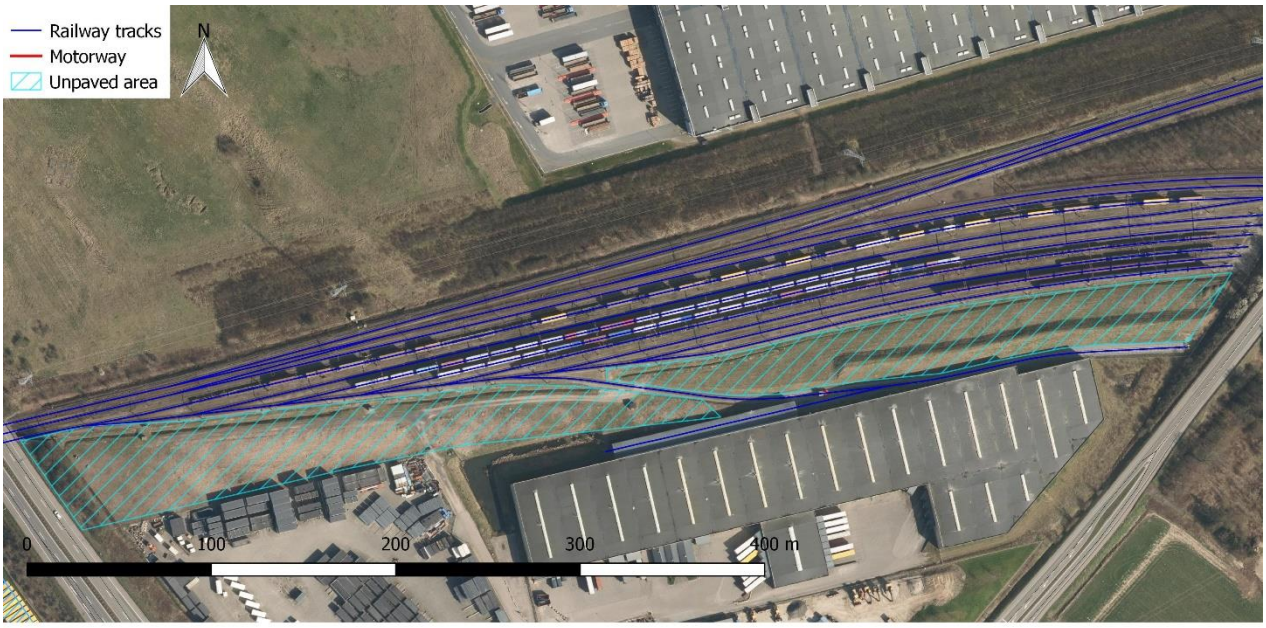

Figure 16: Shunting yard at Taulov placed east of the intermodal terminal and west of Fredericia Shipping's newly established cargo terminal to which freight trains access through Taulov intermodal terminal's main track. Again, the areas that are left unpaved cannot be taken into use before they are paved.

4.1.2 The operator perspective

DB Cargo Scandinavia's activities also includes the freight operation on the rails. The company operates in Denmark and especially between Maschen, Germany and Malmö, Sweden. In Sweden the company has a joint venture with Swedish operator Green Cargo, though this will end during 2018. The joint venture has enabled the two companies to draw on knowledge on each other's home markets allowing Green Cargo to enter the German market and DB Cargo the Swedish.

A new market for DB Cargo Scandinavia is the North Denmark Region, which the company is very focused on. The wagon load service that was introduced in section 0 is a way of establishing an option for smaller companies to make use of rail transport. DB Cargo Scandinavia are aware of the fact that only few Danish companies can produce an amount of goods that is big enough to make use of whole trains regularly. To be able to have the North Denmark Region as a market area, the company is forced to use diesel locomotives. These locomotives are quite old but instead of investing in new rolling stock, DB Cargo Scandinavia has decided to invest several million DKK in prolonging the longevity of the locomotives as it is difficult to know exactly which kind of rolling stock is going to be needed in the future.

"There you have CFL Cargo (…) They make use of some rather old locomotives like us. The operators keep them running, because we do not really know about the signaling system, among others, they [i.e. Banedanmark] are fiddling with. What needs to be built into them? What needs to be built into the locomotives? We have not gotten a clear answer and it just keeps getting postponed."

- Brian Hjortkær, team leader at DB Cargo Service Denmark (Quote translated from Danish).

Brian indicates that ERTMS is not the only thing that complicates planning of future business. The electrification of the railway, north of Fredericia, is another piece in the puzzle. When the railway is electrified, DB Cargo Scandinavia will begin operation with electric locomotives instead of using diesel. This will have the consequence that Port of Aalborg will have to acquire a diesel shunting locomotive for themselves as it is highly unthinkable that the port track between Aalborg station and Port of Aalborg will ever be electrified. Besides that, Brian Hjortkjær implies that one train in the future could potentially stop at multiple terminals in the North Region.

"Imagine in 10 years when ERTMS and catenary systems have reached Aalborg, and all is working. There will not be catenary systems that reach the port. In the long term, Port of Aalborg need to think of it as an option to create its own terminal company that can shunt and manage a terminal. A bit like this place where you have personnel that can do a bit of everything. They will have a small locomotive that drives along their fine port track, picks up and delivers. At the same time, you would set in some efficient trains that just haul up and down because it would maybe be necessary to go further up. One would maybe drive to Hirtshals. Then, you could link some wagons on that train from Aalborg. And We will have 30 electric locomotives. All transit freight is powered by electricity."

- Brian Hjortkær, team leader at DB Cargo Service Denmark (Quote translated from Danish).

To electrify the port track to the Port of Aalborg would not be a sensible decision, socioeconomically, according to Brian Hjortkær. With that said, several decisions regarding rail freight infrastructure seem insensible from the

rail freight operators' view. Both the construction of the intermodal terminals in Hirtshals and Esbjerg are not fully thought through. In Hirtshals the intermodal terminal is located far from the ferry landing. In the case of Esbjerg freight trains have to drive through the city, load and reload far from where the potential ship cargo arrives at a loading site that is not suited for intermodal freight. According to both Brian Hjortkjær and Rasmus Kolind the decision makers have not included the important stakeholders, i.e. the operators first and foremost, before constructing these terminals. According to Brian, however, the operators are told by the decision makers that the operators must show that they can make use of these terminals before new terminals are financed, even though the terminals are useless. Brian Hjortkjær thinks that the funds could be spent much more efficient if the decision of what to fund was given to stakeholders that are more practically involved in rail freight.

4.2 Port of Aalborg

The port of Aalborg began receiving steady traffic of freight trains in 2015 after years of little use of the rail facilities on the site. The new business began after the port track between Aalborg station and the port was acquired by the port from the local municipality. The first regular customer, Captrain, transports tiles for Cembrit's factories in the Czech Republic and Poland to its local businesses in the Aalborg area. In addition to this, DB Cargo has from February of 2017 offered intermodal door-to-door services for shipment sizes down to 25 ton. Thus, the port of Aalborg functions as a hub for local businesses that wish to transport their goods by train.

4.2.1 Facility design

The port is situated east of Aalborg and the Limfjord tunnel which means it is close to the biggest city in the region and its industry while much of the land freight traffic from Vendsyssel passes by right next to it. Just like the terminal in Taulov, the port is situated close to pivotal infrastructure.

By rail the port is accessed by 15 km long port track, which goes from the station in Aalborg to the port. In 2009, when planning began for taking the port track into regular use again, a southwards track section was suggested along the renovation of the existing track. The added section, which is sketched on Figure 17 was supposed to shorten the transport duration for freight trains arriving from and departing to the south by 20 minutes, but it was chosen only to modernize the existing tracks, which means all trains to the port must go through the shunting yard at Aalborg station. (Bro *et al.*, 2009)

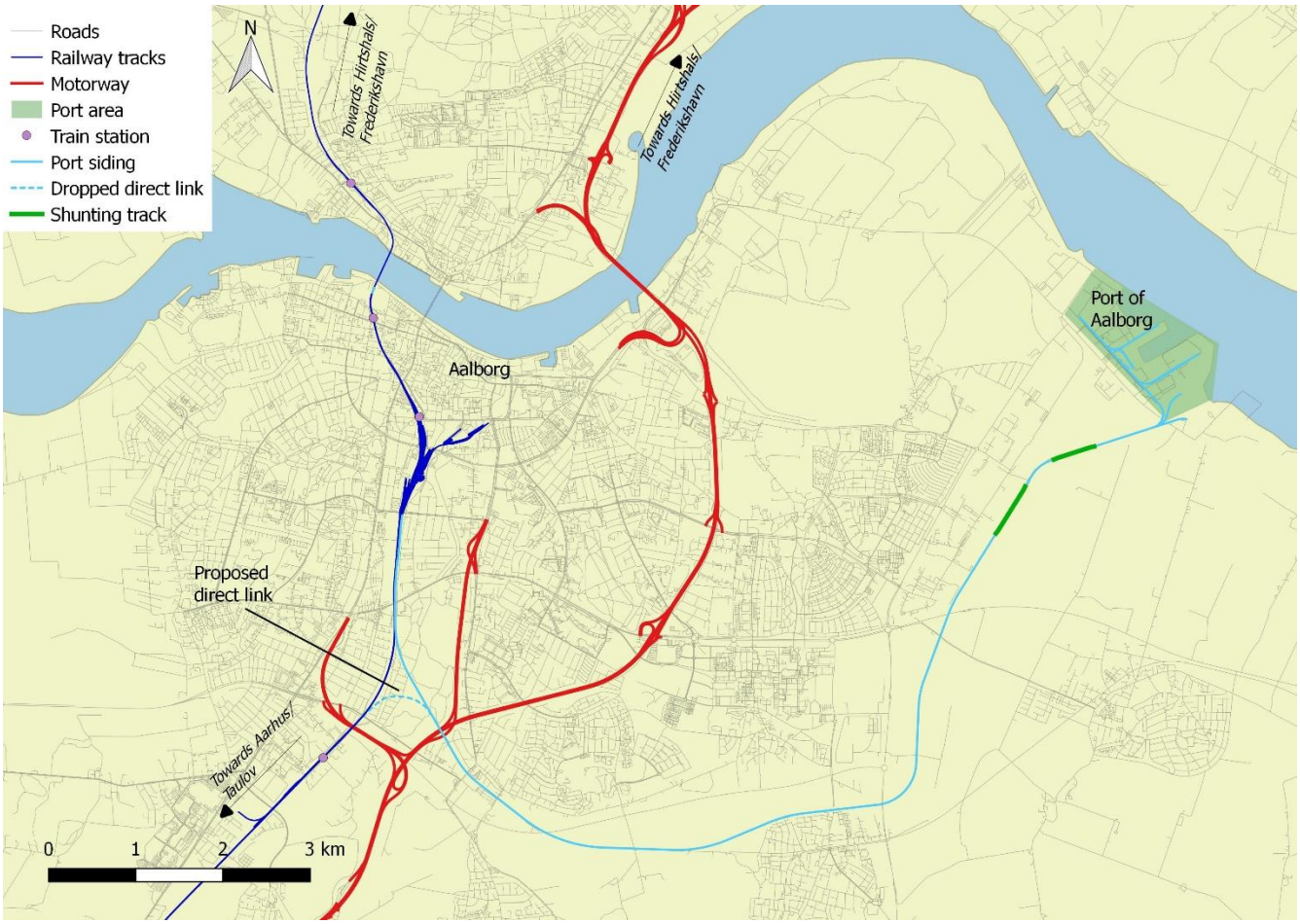

Figure 17: Port of Aalborg and its surroundings.

The Port has multiple track sections for different purposes. On the last part of the 15 km long port track, a siding is located for shunting trainsets as seen on Figure 17. Within the port area there are five sets of loading tracks and a track to turn the trains. Two of the tracks are not open for operation and another has no loading area connected to it. The remaining two tracks each leads to a different terminal. The terminals are shown on Figure 18. So far, only conventional goods are loaded on and off the railway terminals, but the port is capable of handling bulk goods on *Grønlandshavnen* and intermodal container goods at *Kombiterminalen*, though it is not sure whether intermodal goods will be handled at *Kombiterminalen*, since a leaseholder is using the area at the moment.

Of the tracks that are not in use, the port sees a potential with the track that needs a loading area. This track is located relatively far from any constructions which is why it would be well suited for handling dangerous goods. The closed down tracks could in time be taken in use as well, if permission is granted from Banedanmark and if they are prepared and cleaned from asphalt.

According to Brian Hjortkær, who is seeing the port setup from an operator's view, the constellation of the track facilities on the port is very optimal:

"The facility, isolated that is, is an incredible track facility in the case of Port of Aalborg. There are two sidings on the way from the port, upgraded tracks, there has really been put some resources in it. Now, it is all down to some operators and freight forwarders to fall in and show that it is possible to get something going. Port of Aalborg is one of the infrastructure administrators, of the ones in Denmark, that has done the most to promote [rail] freight(…)"

- Brian Hjortkær, team leader at DB Cargo Service Denmark (Quote translated from Danish).

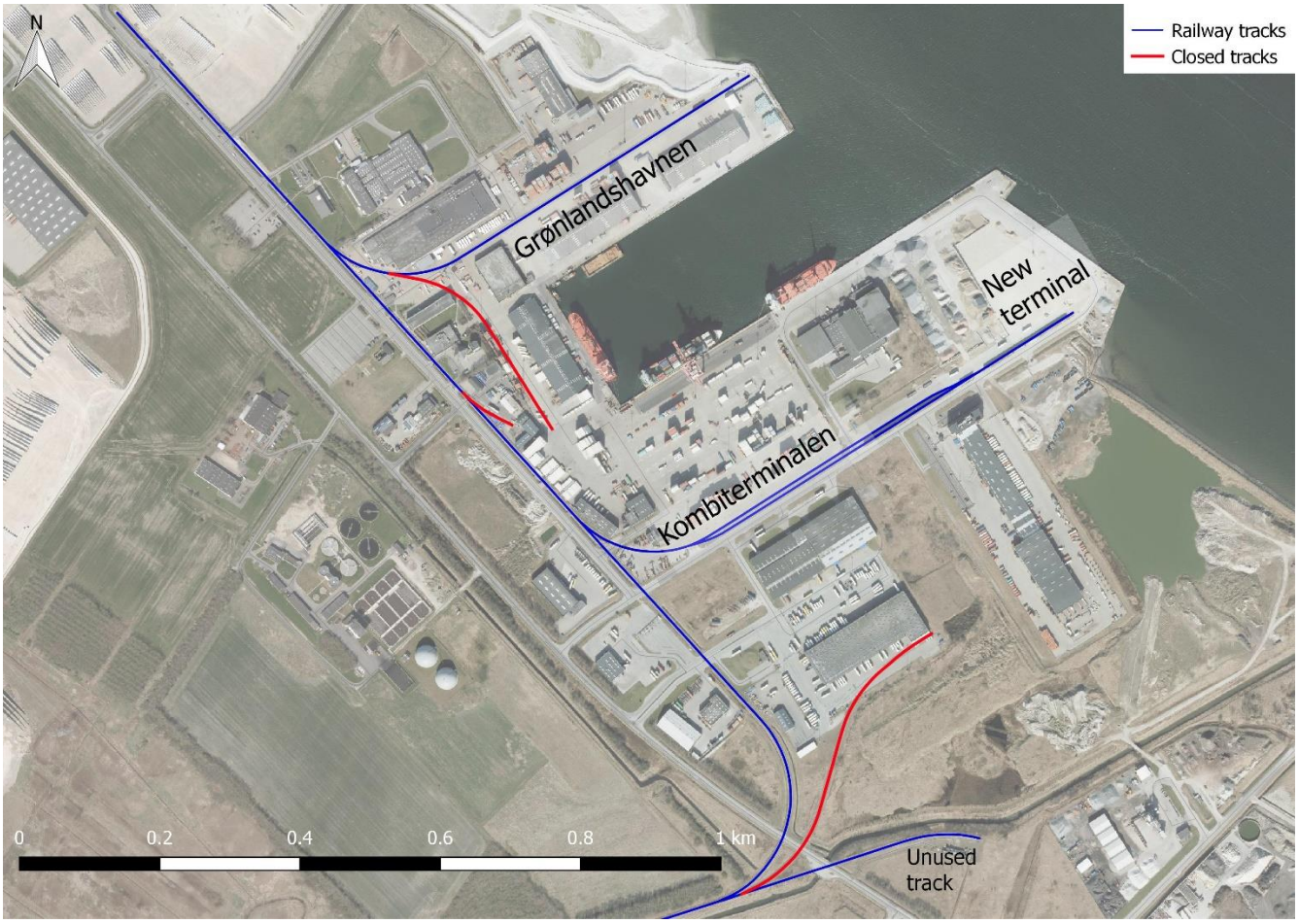

Figure 18: Aerial photo of Port of Aalborg with railway tracks marked.

4.2.2 Present operation

Port of Aalborg is, unlike other ports in the region, a private limited company owned by the municipality of Aalborg. If the company creates an annual profit, the capital is invested into further improving the possibilities

for companies to make use of the port infrastructure. The objective of the port is thus not to make a profit as high as possible for its shareholders, but instead the port seeks to provide a service for the local businesses.

"But the decision [to invest in rail infrastructure] is not made because the case is good, and I do not think [the port of] Frederikshavn will be able to make it that, because it will require really, really large quantities of rail freight. We only do this because we want to create infrastructure. We want to generate opportunities for the companies in North Jutland."

- Rasmus Munk Kolind, Account Manager for Container and Rail, Port of Aalborg (Quote translated from Danish).

This is in accordance with the present use of the tracks. The ships that come into port does not transfer much freight to and from the railway. The port tracks are mainly used by local companies from the area or even leaseholders on the port area. Customers can choose to bring their goods to the hub themselves and load the trains too. In the case of DB Cargo's shuttle trains, this also gives the companies the option to use the rail wagons as temporary storeroom, as shuttle trains that arrive on the port on a Monday stay in the port area until the departure on Thursday and vice versa. DB Cargo offers full intermodal transport solutions as well, including drayage if needed.

4.2.3 Future expansion and collaboration

The frequency of trains could potentially be more extensive. At the moment, the port typically receives freight trains three times a week, two trains Monday and one train on Thursdays. The present capacity of the port is two trains a day, which can be handled at the same time. Thus, the port could potentially scale up the freight train traffic several times from three trains a week to 14 trains a week. However:

"(…) But two trains daily is what we have room for out here. Not to say that is what we are aiming for. We probably strive for more customers to use the [present] setup."

- Rasmus Munk Kolind, Account Manager for Container and Rail, Port of Aalborg (Quote translated from Danish).

Another initiative, which could potentially give rise to more freight handling, would be to make Port of Aalborg the last terminal in a northern railway freight corridor, like the principle shown in section 2.3, in case other ports in the region attracted rail freight customers. Rasmus Munk Kolind does not rule out that this could be possibility but that it is only an option for goods that are not time sensitive. He adds that Port of Aalborg would appreciate if other ports in the region had success with attracting customers regardless of whether the ports would function as a freight corridor. More terminals would hopefully lower the costs for operators and generate a more flexible running of rail freight in the region with the opportunity to have the same personnel service all the terminals as well as utilize the rolling stock more efficiently.

4.3 Port of Hirtshals

Funding granted in 2009 and 2014 recently made construction of an intermodal terminal possible as a part of the Port of Hirtshals. Since June of 2015 the port has been able to reload containers and trailers at their intermodal terminal located south of the port as shown on Figure 19. A total of 33 million DKK was invested from the state to establish the terminal, but so far, the investment has been futile. Only three freight trains have been handled since the opening almost three years ago and these trains merely used the terminal because the tracks to the Port of Aalborg were being renovated.

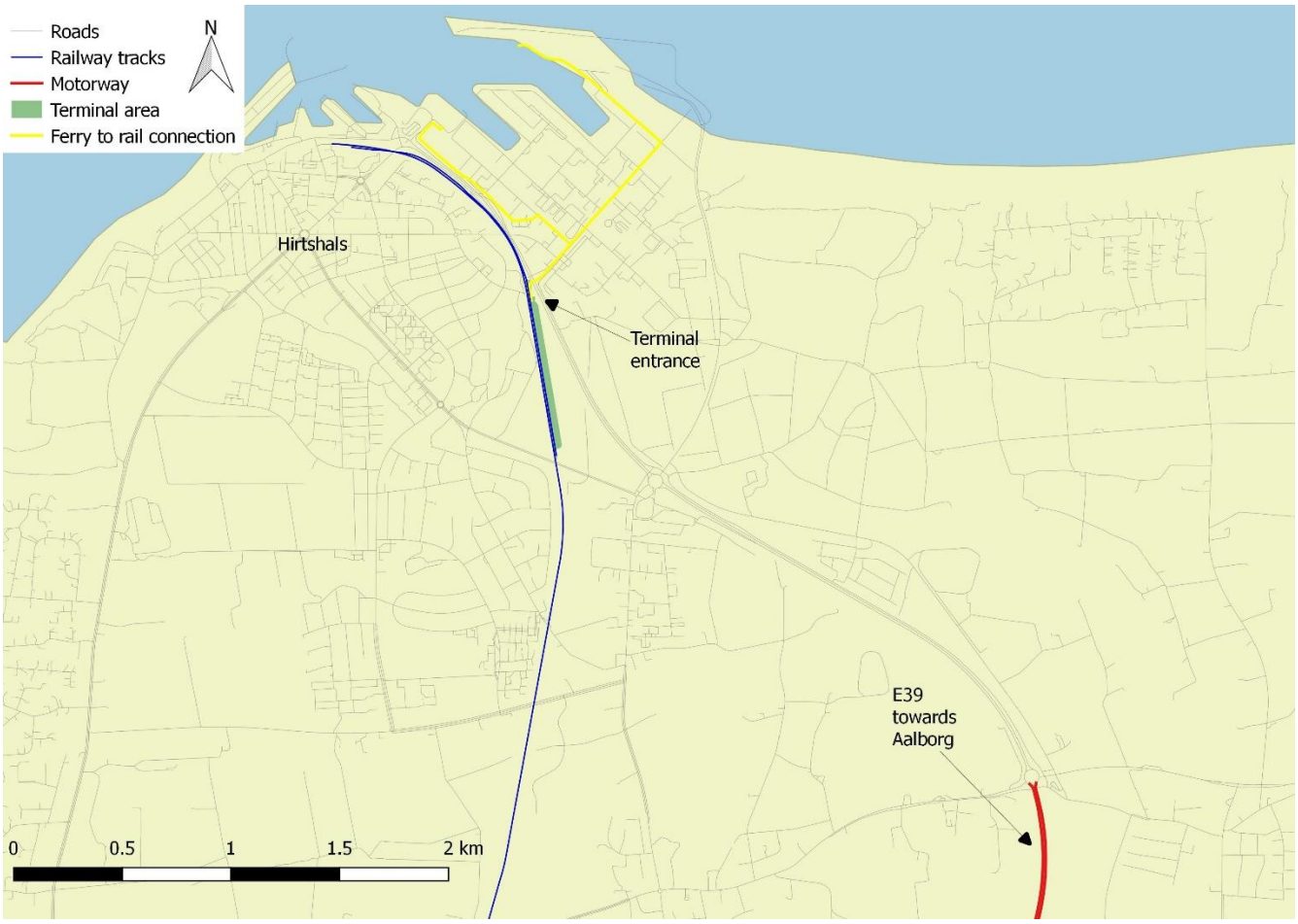

Figure 19: The town of Hirtshals with the port area north of the railway.

4.3.1 Market situation

The terminal is mainly intended for loading *roll-on-roll-off* freight (ro-ro) from ferries arriving at the port and vice versa since most of the freight handled at the port is of this type. According to the CEO of the port, Jens Kirketerp Jensen, the ro-ro freight itself should be a basis for trains to be loaded frequently:

"Today 20 % of the trailers we handle at the port are liftable and 20 % of 140,000 trailers a year actually makes us able to fill up a train three times a week."

- Jens Kirketerp Jensen, CEO at the Port of Hirtshals (Translated from Danish).

The freight that arrives by ship to the port origins from other countries, especially Norway where the port has ferry connections to five ports(Hirtshals Havn, 2018). The intermodal terminal is intended for freight with destination in continental Europe like Duisburg, Germany. If the port succeeds in moving some of the ro-ro units onto freight trains, it will add to the already dominating amount of transit freight moved by freight trains in Denmark that was shown in chapter 1. In this case though, there is potential of mixing the transit freight with local freight from the Hirtshals area.

Still, not a single of these ro-ro units have been loaded onto a train wagon which is why the terminal's loading area is used for parking of ro-ro units for now. To make use of the intermodal terminal, local businesses in the North Denmark Region could potentially send goods via the terminal and thus use it as an intermodal hub. The location of Hirtshals contradicts this as the market area in theory is not circular around the terminal but is skewed towards the opposite direction of where the rail freight is coming from, as explained in section 2.2. This is shown as a principle sketch on Figure 20. The sketch shows a usual market area of an end terminal put onto the map of Hirtshals' location, though the exact shape and size is not known. What this shows is that to be competitive with unimodal truck transport, an inland terminal would be better for local consignors. However, this will be the case for most ports surrounded by open water.

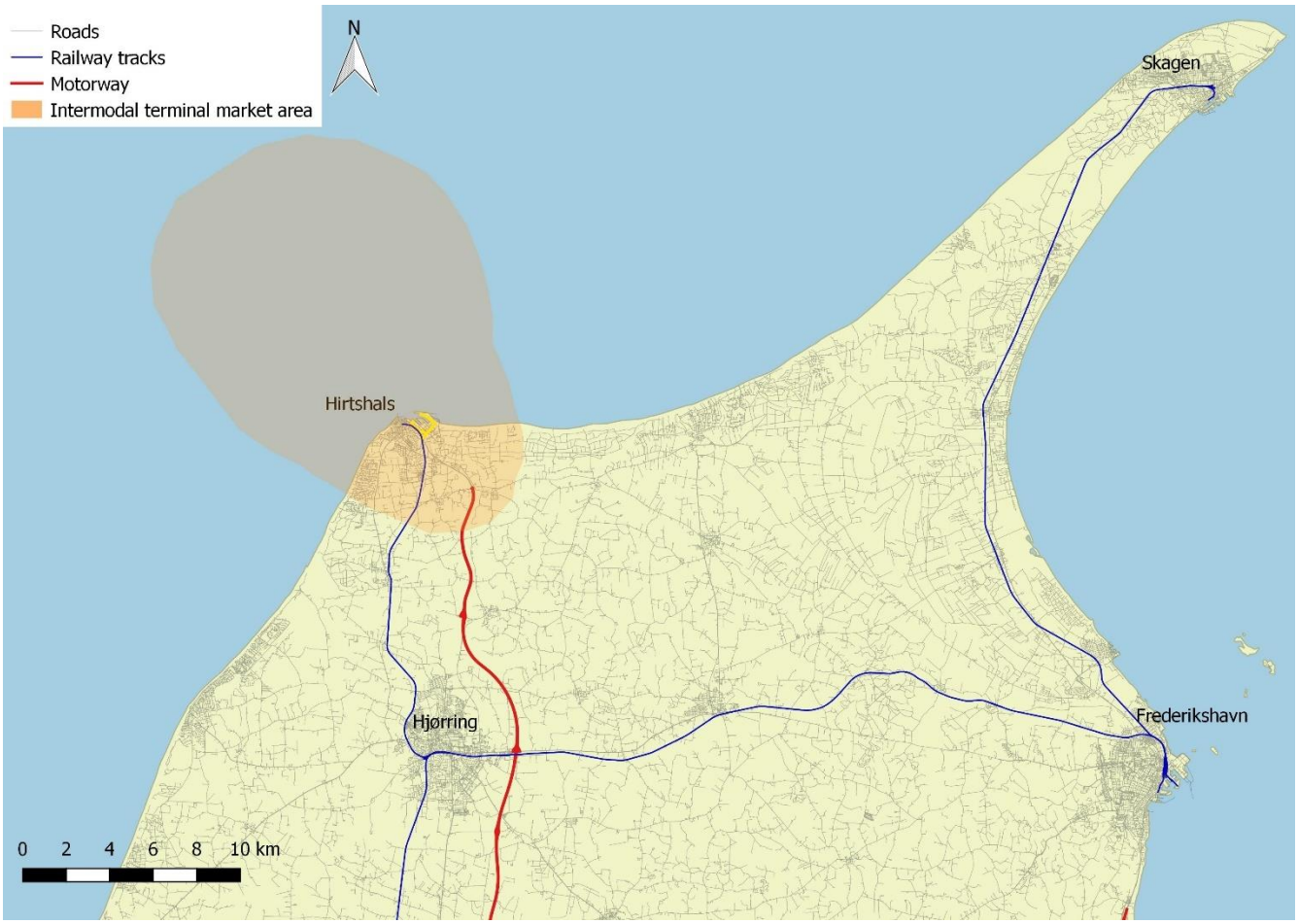

Figure 20: A principle sketch of how the market area is often put around a railway terminal with the majority of the area situated opposite the railway. This is only a sketch, the market area has not been calculated for the terminal.

From this, Aalborg Port seems as a more suitable hub to reload to railway transport but according to Jens K. Jensen the terminal's market area still should in theory cover a major part of the North Denmark Region. Goods that are supposed to go southwards may have to be transported northwards to use the terminal, but they will be free from crossing the Limfjord in a road vehicle which can be time consuming.

4.3.2 Terminal design

Though the terminal is an asset of the port, it is located at a noticeable distance from the ferry ports. The distances from the ferry ports to the terminal entrance is shown with yellow lines on Figure 19. This intermediate distance is between 1 and 2 kilometers naturally makes freight handling costlier than if goods could be loaded directly between ships and trains. However, the terminal is not too far away to be used for container storage which is what the area is utilized for at the moment.

The terminal itself consists of a 675 by 30 m paved loading area next to a siding. This allows the longest allowable trains outside Denmark to be serviced without the need of shunting. Trains for national transport could potentially be longer, but as stated earlier, the terminal is intended for international freight and the railway

network north of Aarhus does not allow for longer trains. The siding lies parallel to the single tracked main track, though access to the siding can only happen by turning trains north of the terminal just before Hirtshals station. This complicates use of the terminal, but because the new signaling system, ERTMS, is planned to be deployed in the North Denmark Region in the near future, a turnout south of the terminal was postponed avoiding setting up signaling there that would be outdated within few years. Though trains need to maneuver forwards and backwards to get to the terminal, the terminal should still be well suited for reloading as actual shunting is not needed due to the length of the terminal.

Figure 21: Hirtshals intermodal terminal today with punctuated lines marking possible future expanisions.

When the ERTMS system is tested and ready for full implementation, it will be possible to have a turnout constructed at the southern end of the terminal, allowing freight trains to enter the terminal without having to turn north of the terminal. This will increase capacity as the terminal will have room for a train being loaded as well as a train standing by north of the terminal. According to Jens Kirketerp Jensen this will double the capacity of the terminal. If necessary, the terminal capacity can be increased further by constructing a track on the east side of the loading area. Along with the additional turnout these tracks can, according to Jens Kirketerp Jensen, quadruple the present-day capacity of the terminal.

4.3.3 Issues

The main reason why there is no prospect of this capacity increase to be necessary, Jens Kirketerp Jensen states, is due to the difficulty in scheduling a train to go from Hirtshals and all the way through Jutland. Passenger trains are given preferential treatment over freight trains by Banedanmark. Driving on the network during night time is an option but it is not possible to reach any distant locations in continental Europe in just one night.

The issue is not about getting a channel on the track between Hirtshals and Aalborg where the railway consists of only one track. The local railway operator for passengers, Nordjyske Baner, have been willing to find a way to allow for freight trains during the day.

Figure 22: Power outputs are available at Hirtshals intermodal terminal for refrigerator trailers and other purposes.

As mentioned earlier the rail network in the area will have ERTMS introduced in the near future. Though it does mean the terminal will be able to invest in a switch to enter loading track from the south end, there is also a possible drawback. When ERTMS is introduced trains without an integrated ETCS system will not be able to operate on the tracks north of Aalborg. Along with the fact that the railway network in the North Region is not yet electrified, the types of locomotives that could potentially be used north of Aalborg is narrowed down. However, initiatives have been made to develop ETCS equipped diesel locomotives at DB Cargo in the Netherlands(IRJ, 2018). If such trains are not implemented for operation in the north region, terminals in Vendsyssel will not be serviced.

This would rule out the option of making a freight corridor as explained in section 2.3. However, Jens Kirketerp Jensen emphasizes that the terminal is designed for loading full length trains and that it seems to only be profitable to ship rail freight directly between one origin terminal and one destination terminal, although it might

be possible to link half a train from Hirtshals with half a train in Aalborg. Furthermore, the time window, in which a freight train from Hirtshals has to reach any destination before the passenger traffic takes up railway channels, is too narrow for additional shunting or loading operations.

4.4 Port of Skagen

At the top of Jutland, where the Danish tracks ends, the port of Skagen manages a track that is used weekly by local fishing company, FF Skagen. The company has made use of railway transport for almost 20 years sending goods by train from Skagen to the port of Aarhus to be reloaded to ships. However, this will change in the near future as FF Skagen has chosen to put an end to the weekly railway freight and instead ship their goods directly from the port of Skagen.

The operation on the track has up until now been taken care of by DB Cargo and the loading and unloading of trains FF Skagen has managed themselves. According to sales director of FF Skagen, Thomas Hansen, the tracks work well for a company to send out their goods, but they are not suited to function as an intermodal terminal with combined transports.

Figure 23: Port of Skagen and its surroundings.

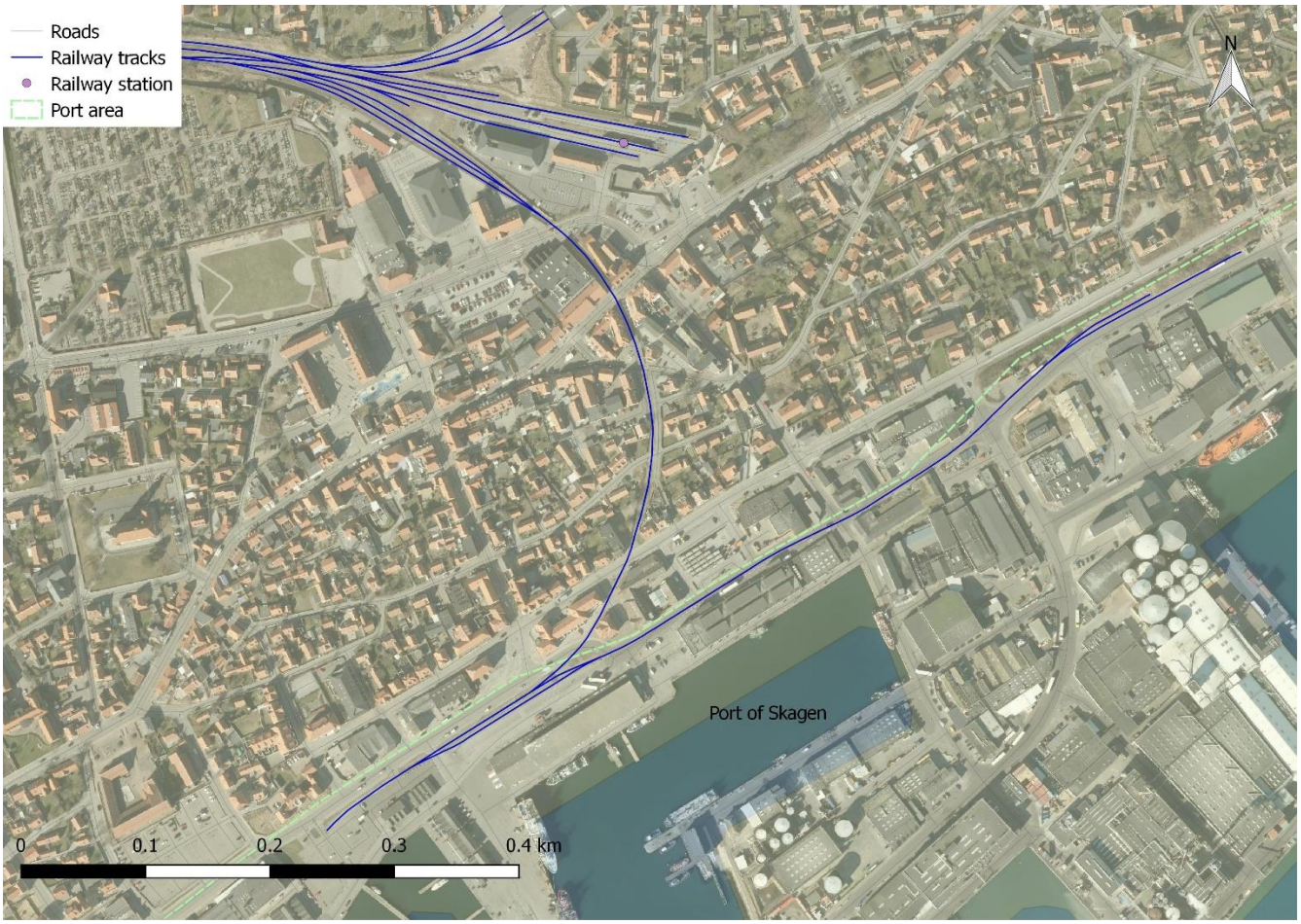

Figure 24: The port tracks next to Skagen station.

The reason why FF Skagen has decided to end their use of the port tracks is mainly due to disruptions in the railway network. This has sparked the choice to change to direct shipping from the port of Skagen which should be cheaper as the goods that were sent to Aarhus by train were shipped from the port of Aarhus anyway. Thomas Hansen adds that he does not see Banedanmark take into consideration the commercial importance of the railway. Banedanmark should adapt better the user needs and not disturb neither freight transport or passenger transport by working at night. If they do not adapt, the customer base will disappear according to Thomas Hansen.

4.5 Port of Frederikshavn

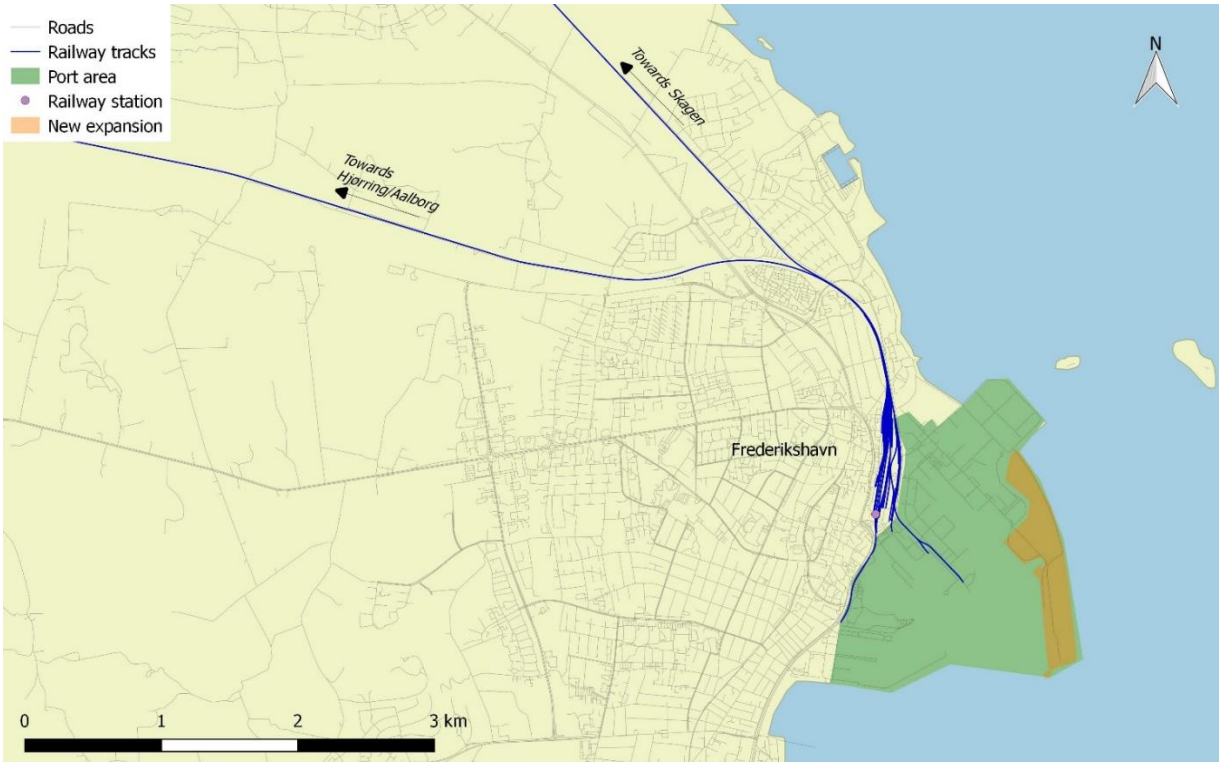

Figure 25: Port of Frederikshavn marked in green and the first leg of its expansion marked with brown. The track layout is in this figure directly taken from Geodanmark (2018) and is, as it shows on Figure 26, not up to date.

Situated on the eastern shore of Vendsyssel the primary traffic of ships arriving at Frederikshavn is ferries from Gothenburg and Oslo as well as a ferry traffic between Frederikshavn and some nearby small islands. Approximately 3910 ferry calls are performed while other ships account for 640 calls. Thus, the port is dealing with a lot of ro-ro traffic like the port of Hirtshals.

On Figure 25 the port is seen situated right next to the center of Frederikshavn. The brown marking on the figure shows the construction site of a new expansion to the port. Most of the newly constructed port area will be leased to the American scrapping company MARS. According to a document from MARS' own website, direct access to the rail network is mentioned as an advantage along with easy access to the motorway(M.A.R.S., 2018). Business development manager from the Port, Bent Lange, sees a potential as well:

"Moreover, we have an agreement with a company, an American company. MARS, M-A-R-S, Modern American Recycling Services, which means it has to do with recycling, primarily of metals, and these need to be exported. Once a structure has been received and processed they are exported (…) but there is a potential, as far as I see, for rail freight there."

- Bent Lange, Business development manager, Port of Frederikshavn (Quote translated from Danish).

Figure 26: The track layout at Port of Frederikshavn is according to the Danish Geo data authority extensive, but a major part of the tracks is closed.

4.5.1 Design of facility

As to whether MARS will make use of the railway access, is still unsure. The area they will be leasing from the port is still under construction and the port's railway network will have to be altered substantially. This is partially due to very restricted options of railway freight options in the port at present. Although geo data from the Danish Geodata Agency shows multiple port tracks, there are only few operative tracks left.

Figure 27: The only port track ready for use at Port of Frederikshavn is the short section of track leading up to the train ferry landing.

Two long stretches of port tracks have been taken out of function and are no longer connected to the main tracks as can be seen on Figure 26. Only the track leading up to the train ferry landing is ready for use as soon as an oil rig at the landing, which can be seen on Figure 27, is moved. Additionally, a track is found south west of the train ferry landing. However, this section has been covered with asphalt and it is partially used as a parking lot, which can be seen on Figure 28. The asphalt and parking lot could easily be removed but even then, the length of the section does not support freight operation to take place:

"It is only 200 m long, which is why I say we do not have any [port tracks] at the port."

- Søren Pilgaard, head of technical department, Port of Frederikshavn (Quote translated from Danish).

Figure 28: The track section shown in green in Figure 26 is covered by asphalt and a parking lot. The tracks show through cracks in the pavement as seen on the picture on the right.

The potential of handling rail freight at the port of Frederikshavn instead depends on whether new tracks will be constructed in the future. In case MARS or any other client on the port area require it, the port has planned how to construct new port tracks that will lead to the area that is under construction.

"It is laid out for railway tracks that area (…) The areas up here are registered[for railway tracks], which means you cannot build on them, but it is not in our mind to invest the necessary millions without having a reason to do it."

- Søren Pilgaard, head of technical department, port of Frederikshavn (Quote translated from Danish).

4.5.2 Future potential

Whether there will be need for tracks or not is thus up to M.A.R.S. and other companies situated on or near the port area. Seen from the port's perspective, the potential is there, especially because of the amount and type of goods that will need to be exported from the port's new area.

Bent Lange and Søren Pilgaard share the view that a transport corridor could be established through the ports of North Region Denmark. The way they see it, freight trains could consolidate wagons as they move from Port of Skagen. Freight wagons from Port of Hirtshals could perhaps be attached at Hjørring station before the train would continue southward, maybe with a stop in Aalborg to collect more wagons. This solution is probably appropriate for time insensitive goods like scrap metal from M.A.R.S., but the question is whether goods from Hirtshals for instance will not be too time sensitive for such a solution.

4.6 Brønderslev loading site

As it is pointed out as a possible location for reloading from road vehicle to train, the loading site in Brønderslev has been examined. Apart from Trafik- og Byggestyrelsen (2016) no documents mentioning the site have been discovered. Instead a visit has been paid to the site.

The loading site is situated right next to the station in Brønderslev. Though geo data of the Danish track layout shows five side tracks next to the station there are only two tracks left of which one is in a poor condition as seen on Figure 29, Figure 30 and Figure 31. The track that is in a proper condition has a length of approximately 300 m but only about 70 m of this track has a paved surface situated next to it. From the examination of Taulov intermodal terminal it is known that track section with no paved loading areas are of little use. This means that only two or three rail cars would be able to be serviced at the site without having to perform shunting. Shunting might be possible if either the track in poor condition or one of the through-going tracks is taken in use. Overall the facility seems ill-suited for loading of freight carriages because of the low capacity and the requirement for shunt movements.

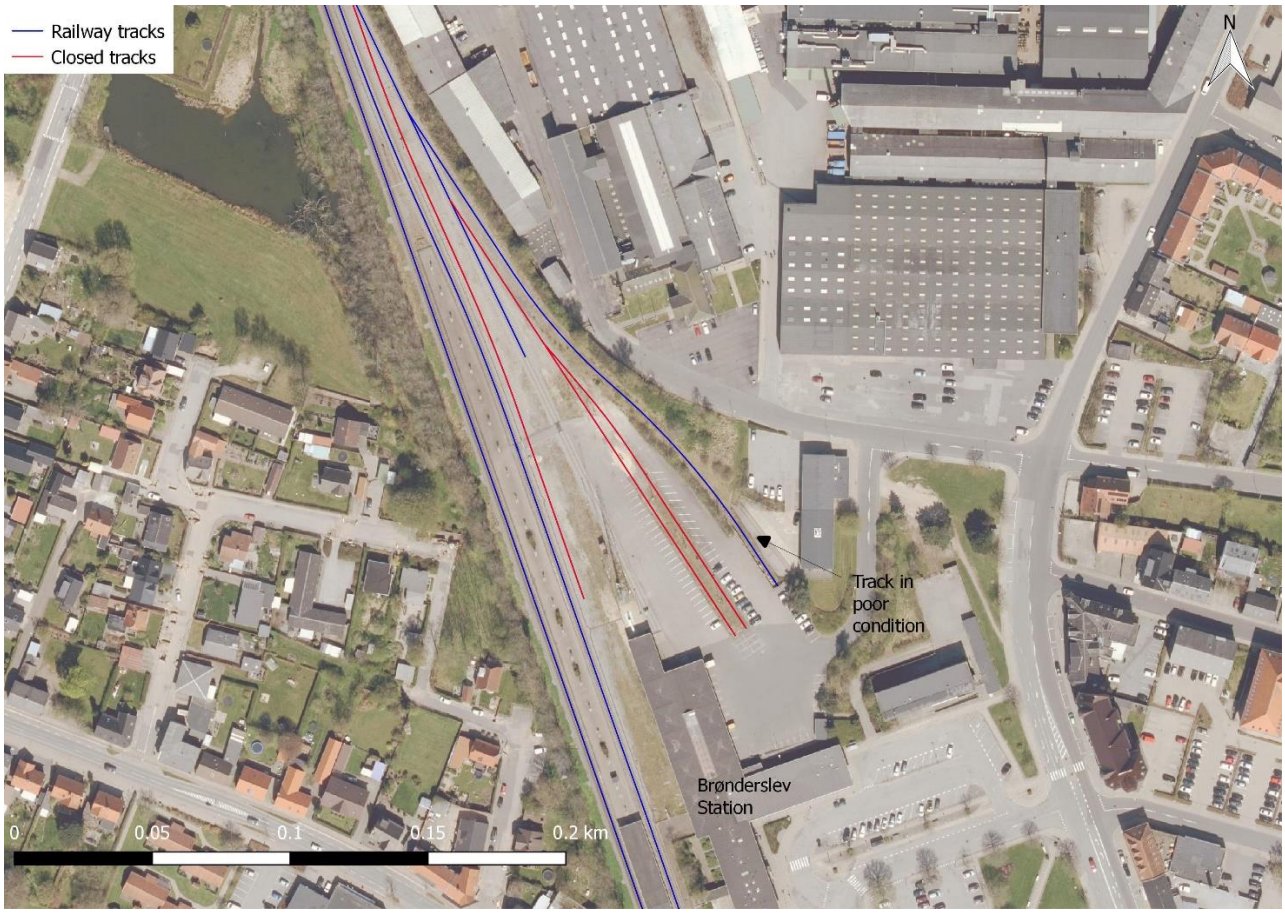

Figure 29: The track layout at Brønderslev loading site.

Figure 30: Brønderslev Public loading site, which is included in the overview of loading sites in section 3.2. Only one track is open and it is no longer a transversal that runs parallel to the track. Instead the siding can only be accessed from one direction and the loading area is of poor quality.

Figure 31: The unpaved area was, according to historic aerial photos, track bed for two sets of tracks that have now been removed.

4.7 Banedanmark

In the preceding sections Banedanmark received considerable critique from both operators, companies and port representatives. To answer some of the criticism and whether the conditions for rail freight in the North Region will be better in time, key account manager Alex Skovly Nielsen from Banedanmark has been consulted.

Two issues have been identified about sidings from the port and terminal interviews:

- Sidings are closed because Banedanmark do not maintain them. Sidings could give more options for rail freight according to Brian Hjortkær of DB Cargo Service Denmark.
- Standards for sidings are higher than necessary. The loading track at Hirtshals intermodal terminal is for instance dimensioned for a speed of 80 km/h which is far beyond the speed trains will be moving on the track.

Sidings are closed, Alex Skovly Nielsen explains, because operators lost interest in them after rail freight was no longer subsidized:

"In the beginning of the noughties DB, Railion, DSB Freight or whatever their name was back then, drove with two wagons to this siding and two wagons to that siding and drove to Randers and Hobro and all the locations with customers who wanted a wagon or two. (…) And I think it was in 03 or 04 they simply said "Stop! Now we simply clear this up, because there is no profit in it and we are not subsidized anymore."."

- Alex Skovly Nielsen, key account manager at Banedanmark (Quote translated from Danish).

Small sidings with relatively small amounts of goods output, such as Brønderslev public loading site, shown in section 4.6 is an example of this. However, Alex Skovly Nielsen agrees that there in some cases could be a potential in opening some sidings. Unfortunately, Banedanmark does not have the funding to open sidings as the renovation work is costly and because maintenance costs will increase in general because of this.

In the matter of siding standards, new sidings, as the one at Hirthals intermodal terminal, are subject to the Danish standards that only allows new rail constructions, like switches and sidings, to be capable of speeds of at least 80 km/h. That is just how it is, and it needs to be like that, according to Alex Skovly Nielsen. Thus, new tracks that are dimensioned for lower speeds than 80 km/h will not be constructed, but in some cases, it is possible to make use of tracks of lower quality. Existing sidings that are out of operation can be leased by private businesses as long as they agree that they are fully responsible for any maintenance and operation on the leased siding.

Also, in Hirtshals, a big concern was the implementation of ERTMS. The signaling system will be put into service at latest in the end of 2018 and function as a test section along with some sections in eastern Denmark before the system is implemented in the rest of the country (Ingeniøren, 2018). Using ERTMS on the tracks north of Aalborg does not mean that train traffic will be banned from the tracks, ERTMS is installed in the trains driving on the local trakcs, but both Brian Hjortkær of DB Cargo and Jens Kirketerp Jensen of Port of Hirtshals have shown

concern whether freight locomotives exist that have the correct form of ETCS installed. Alex Skovly Nielsen admits that the situation is difficult in the North Denmark Region.

“Northern Jutland is also impeded by these eight weeks where the railway is closed, and it is impeded by the fact that we are now establishing signaling system only in Northern Jutland. Aalborg will not be affected by it, but Hirtshals will be affected, Frederikshavn will be affected by it, FF [Skagen] will be affected by it. For now, there is no solution to this, but remedies to solve the problem are in the making."

- Alex Skovly Nielsen, key account manager at Banedanmark (Quote translated from Danish).

What seems to be the most predominant issue, is the complete shutdowns of rail infrastructure. Banedanmark has received a lot of critique for shutting down the main track from Hobro to Langå for two months during the summer of 2018. To find solutions to the disruptions, a field panel has been formed with Banedanmark, operators, ports etc. One of the main discussions is on why both tracks on a double tracked railway must be closed during trackwork. The short answer from Alex Skovly Nielsen is costs. On multiple occasions the problem has showed up that construction work needs to be performed on crucial track sections and it is often a lot cheaper to close both tracks on a double tracked railway. He adds that the problem is far from only being local to the North Denmark Region. On every location where the railway network does not offer an alternative route, total abruption in train traffic can occur if it is not possible to have one track open at all times. Even on the tracks, that are part of the Scan-Med corridor, there is a possibility of shutdowns. Slagelse station for instance will be undergoing construction in 2019, which will cause shutdowns of the tracks for a total of 23 days. This will cause a complete halt of rail transit freight between Sweden and Germany which is why remedies are being examined to keep the corridor open.

“But why not just make a track like the one you just mentioned where you simply just put a track in a switch in one end and the other and then lay a track where you drive through at 10 km/h? And when construction of the station is finished you remove the whole thing and move it to Slagelse where you repeat the procedure. There are suggestions about that too, and it has been discussed for years whether it was a possibility to do all that, but the simplest and easiest thing to do is to close the station (…)”.

- Alex Skovly Nielsen, key account manager at Banedanmark (Quote translated from Danish).

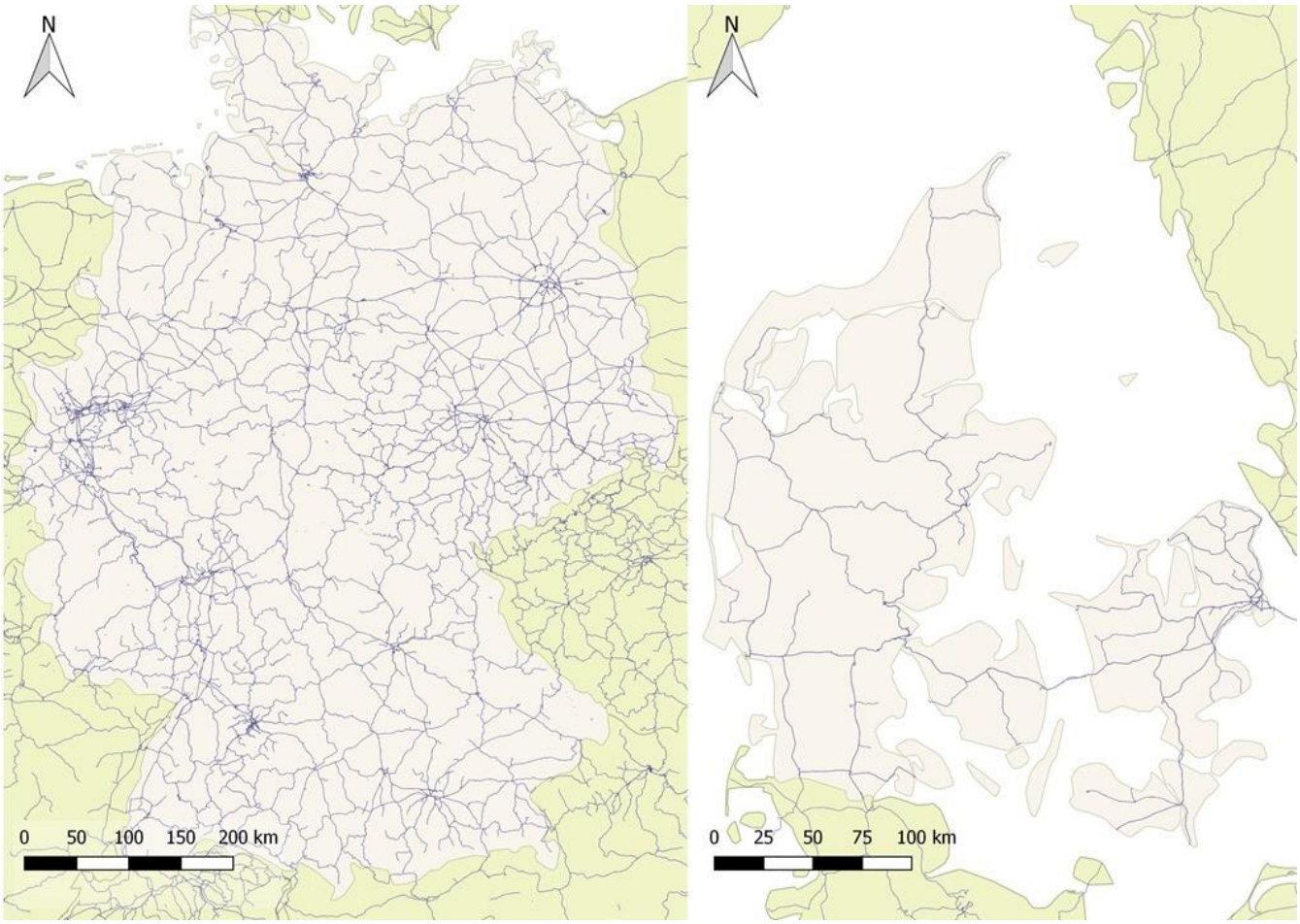

Figure 32: The German railway network is seen to the left and the Danish network to the right. According to the dataset used the density of railway in Germany is 119 m/km² of land area compared to a density of 56 m/km² in Denmark.(Mapcruizin, 2014)

Boiled down the problem is in the density of the Danish railway network. Very few places in the network there will be an alternative to a closed track. A train with starting position in Aalborg and destination in Copenhagen for instance only have on route to choose from. In a country like Germany the rail network, which can be seen on Figure 32, is denser, and there will in almost any case be an alternative route to a closed track for a freight train to drive on.

4.8 Summary and results of stakeholder analysis

The objective now is to summarize the general viewpoints among the stakeholders of the survey and interpret under what conditions rail freight can take place in the North Region.

Among the terminal representatives' viewpoints on rail freight, there are multiple similarities. In every instance there is an urge to provide the users of each facility with as many options as possible. The terminals are willing to cooperate to create as many options for customers as possible and in order to make the rail freight solution as flexible as possible. It is often a puzzle to make rail transportation more profitable. The logistics of drayage and the cost of moving empty rail wagons around call for several options to work with as well as goods flows in every direction.

"Then you would be able to use the same trains, you could maybe use the same wagons, maybe the same engine drivers, shunt personnel and such. That would decrease costs for the operator. It may well be a step back in the beginning for us[Port of Aalborg], but in the long run it would be a major advantage if more train transport got under way in general."

- Rasmus Munk Kolind, Account Manager for Container and Rail, Port of Aalborg (Quote translated from Danish).

Bent Lange from Port of Frederikshavn suggests that cooperation could lead freight routes with trains going from port to port, i.e. Skagen, Frederikshavn, Hirtshals and Aalborg in that order, collecting wagons on the way. Jens Kirketerp and Rasmus Munk Kolind are more reluctant to this idea because shunting at several destinations would increase cost and transport time, though it is more of a decision for the operators, they say. DB Cargo Scandinavia does not rule out to operate more terminals during a trip to the region. If the railway is electrified to Hirtshals and customers are willing to use the facility, DB Cargo Scandinavia will probably have electric trains picking up carriages along the track in Vendsyssel and shunt the wagons at Aalborg station instead of Port of Aalborg. To provide service with modern electric locomotives north of Aalborg may be a pipedream as Banedanmark's representative, Alex Skovly Nielsen, has doubt that electrification will ever continue further up than Aalborg.

In the case of Port of Frederikshavn, the fact that there are not any tracks, that qualifies for reloading at present, makes cooperation amongst the ports a thing that will only be possible in the future where Port of Frederikshavn may have a loading track. Port of Skagen has a loading track in operation but it is not suited for loading combined transports like the terminals in Hirtshals and Aalborg.

When asked about improvements for the rail freight business, varying suggestions comes up from the terminals. The railway north of Aalborg is noticeably only single tracked, which Søren Pilgaard from Port of Frederikshavn has pointed out. This naturally reduces the capacity but according to Søren Kirketerp from Port of Hirtshals it is possible to agree on letting freight trains through to Aalborg with local passenger train operator and track administrator NJB.

To Jens Kirketerp a bigger concern is the implementation of the new European Rail Traffic Management System, ERTMS. The system will be implemented north of Aalborg in the end of 2018 at latest(Ingeniøren, 2018). The local passenger trains have the technology required to drive using the system, but there seems to be confusion about what needs to be done to allow freight trains to drive with the version of ERTMS used in Denmark. This problem is not a local one. Freight operators are forced to prolong the use of older locomotives in their fleets because they are uncertain what kind of materiel they need to drive with the new signaling system. According to Alex Skovly Nielsen of Banedanmark it is an unfortunate situation which will affect the ports north of Aalborg, but not the Port of Aalborg itself. He adds that Banedanmark is seeking a solution to the problem at the moment.

Brian Hjortkjær of DB Cargo finds too that Banedanmark sometimes does make it difficult for rail freight to improve its market share. As a terminal manager DB Cargo struggles with a facility, where the lot is not efficiently used, and as an operator more possibilities from the infrastructure is desired. Specifically, DB Cargo wish for more side tracks openings to be able to load and unload on more locations. In Hirtshals they have a different complaint regarding side tracks. The side track at the intermodal terminal is dimensioned for trains to run at 80 km/h which is not necessary. Jens Kirketerp from the port cannot comprehend why the standards for sidings need to be so high.

Regarding new sidings Banedanmark replies that there is a ruleset and that there is no prospect of letting new sidings be constructed from gentle standards. Existing sidings that are no more maintained by Banedanmark can meanwhile be leased to companies who wish to make use of them and maintain them at their own risk.

The issue that seems to have the greatest consequences is track shutdowns. In eight weeks in the summer of 2018, Banedanmark will perform track renewal between Langå and Hobro. During the time it will not be possible to use the rail section, which will separate the North Denmark Region from the rest of the Danish rail network. Brian Hjortkær Rasmus Kolind and Jens Kirketerp all emphasize that it is difficult to convince potential rail freight customers that rail freight is a profitable choice of mode when the security of supply is as poor as it is. Moreover, both DB Cargo Scandinavia and Port of Aalborg dread the loss of customers who will be difficult to win back.

Such a customer is FF Skagen, which has weekly trains going between Aarhus and Skagen and has chosen to discontinue their use of the railway for freight transport as a consequence of the disruptions in the rail network. Instead they will begin to ship their goods directly by sea from the Port of Skagen. The decision not only rests on the oncoming disruption but according to sales director, Thomas Hansen, on multiple reasons, the main reason being the 13 months long disruption in rail traffic in the region in 2012 and 2013 because a ship collided with the train bridge that crosses the Limfjord. In recent years disruptions has cost his company 5,5 million DKK because of the extra cost of sending their goods by truck to Aarhus. According to Thomas Hansen the length of the disruption is mainly due to incompetence from Banedanmark and the way that he sees it, the biggest hindrance for rail freight is Banedanmark.

Shutdowns of track section is something Banedanmark tries to avoid, Alex Skovly Nielsen states. Unfortunately remedies to ensure track admittance, even to a restricted degree, is often much costlier than shutting down track sections entirely. Furthermore, the vulnerability cannot be fixed solely by securing track admittance during

work on the tracks, as track closedown can happen by accident. In these cases, alternative routes for freight trains would be useful but the Danish network does not allow for this in many cases.

In short, the discoveries can be listed like this:

- The largest freight terminal in Taulov could potentially handle more freight if the terminal area was utilized more efficiently.
- The Port of Frederikshavn does not at present have the facilities to handle rail freight.
- Port of Skagen's port track is only suited for companies that are located on the port area.
- The ERTMS signaling system will hinder operation with the rolling stock that is presently being used in the area by companies like DB Cargo.
- Sidings are closed down in many cases. More open sidings would entail better circumstances for rail freight according to DB Cargo..
- New sidings are constructed from unnecessarily high standards.
- Shutdowns in the rail network, planned or immediate, damages the reliability and reputation of rail freight.
- Political decisions are made without the consent of the relevant stakeholders.

From the analysis it is clear that there are unanswered questions about the future of rail freight in Vendsyssel. Though Port of Skagen and Port of Hirtshals potentially could ship goods by rail, it looks as if rail freight north of Aalborg will pause indefinitely with the implementation of ERTMS. This makes Port of Aalborg the only terminal in the region. In few years it will be possible to transport goods to and from the local station by electrical locomotives, which will add to the environmental friendliness of the rail freight transport to the region. Though it is not known how big the market area for the port is, there is a basis for serving customers far up I Vendsyssel as well as a customer basis south of the Limfjord, all due to its inland location. All in all, Aalborg has an edge over other terminals that is grounded in more than just a shuttle train service.

The other main observation is that rail freight is vulnerable to accidents and track work in general. To ensure that there always is a way for rail freight to leave or reach a location, there needs to be a parallel track that can take over as freight route when the usual route is shut down. In the case of the North Region there are no parallel tracks north of Langå. To create an alternative route, the obvious choice would be to establish a track between Aalborg and Thisted as shown on Figure 33. Such a track would cause the North Region to be less vulnerable to track work between Langå and Aalborg.

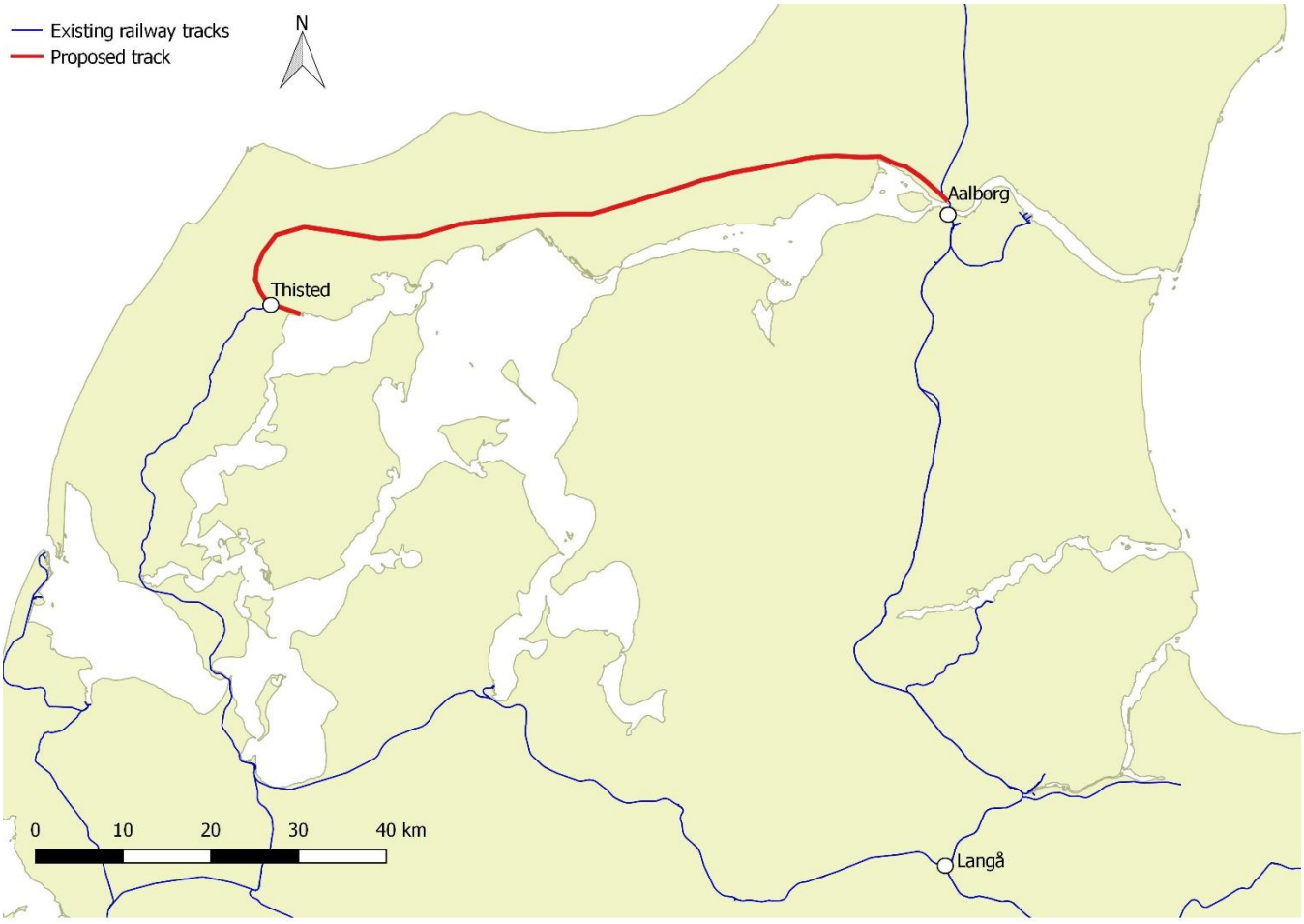

Figure 33: Example of new railway track section that would provide an alternative route in case of a shutdown of the section between Aalborg and Langå.

5 Register analysis

The stakeholder analysis has sketched out the situation for rail freigt in the North Region. The analysis has shown how goods can potentially move through the region, but the question of how much goods could potentially be moved to and from the region still stands. In the following chapter the potential will be examined with the aid of register data as explained in section 3.3. Though methodology is primarily explained in chapter 3, a part of this chapter will explain the approach to the data as the further use builds on some of the information learned in chapter 0. As a consequence of Statistics Denmark's regulations some intermediate and final results, that the reader may expect to be presented with, cannot be shown. This is to protect the anonymity of companies in the study.

5.1 Register analysis

From analyzing the quality of the registers, it is apparent that national good flows are impossible to determine from the registers. This is due to the quality of the registers VARS and VARK that were introduced in section 3.3. The VARK-register, which shows purchases by Danish companies, does not contain data of the amount of the goods bought, at least not measured in weight. However, data about the amount is a part of the VARS-register, which shows data on sales made in Denmark. From the VARS-register the good amounts should then have been decided and the flows should have been determined from where the buying company was relative to the selling. Unfortunately, data on amounts in the VARS-register has shown to be very inconsistent. Around 75% of the rows in the dataset contains no information on weight of the goods.

Additionally, the fact that the VARK-register does not show the amounts of commodities bought by each company has shown to give further problems. The VARK-register shows which companies that buy the commodities shown in the VARS-register, but since VARK does not show amounts, it is impossible to know how to distribute the sold goods found in VARS.

On account of these issues it has been chosen to only include international freight flow in the analysis.

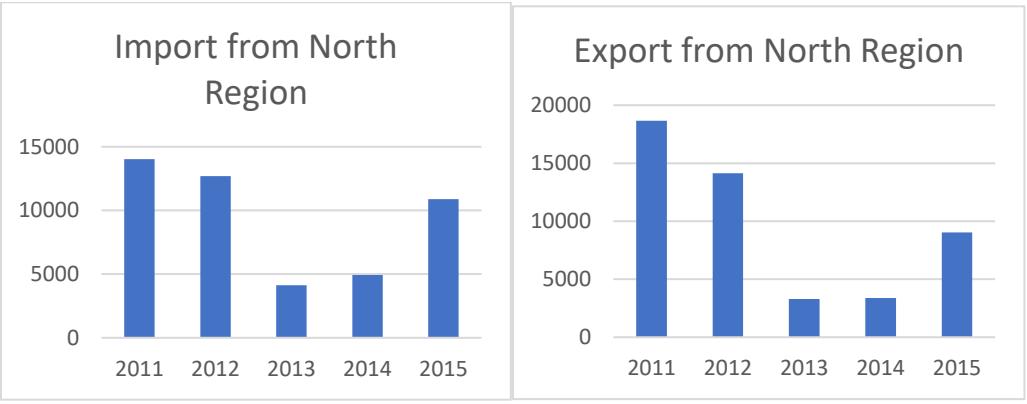

Figure 34: Import and export amounts in 1000's of ton in the North Region according to UHDI data.

This leaves only UHDI as a usable register. The newest UHDI-dataset from 2015 is used for the analysis as this is the newest register and it is thought to correspond best with future trade in the region. However, the annual import and export from the North Denmark Region has been scrutinized as can be seen from Figure 34. From the figure there are clearly fluctuations from year to year for both import and export. 2013 and 2014 saw only a fraction of the traded mass from the years prior and 2015. It seems data is missing, at least for 2013 and 2014, but missing data could be a problem for every year. Unfortunately, this does harm the integrity of the dataset.

5.2 Shuttle service as benchmark for potential

The UHDI-register may not contain data on each individual shipment size, but the data on the aggregated export amounts and import amounts is very consistent. For every type of commodity imported/exported the annual amount of it and to/from which country it has as destination/origin is shown in the register. Then, to address the problem of unknown shipment sizes, an assumption is made that all commodities, that could potentially make use of DB Cargo's wagon load service, import or export the commodities on a regular basis in shipments of approximately equally large sizes. For it to make sense to use the shuttle service each shipment should, according to Rasmus Munk Kolind of Port of Aalborg, be of at least 25 ton. The shuttle service, as mentioned in the introduction, is available for one-off shipments, which means there is no demand for the shipments to happen on a regular basis. Shipment by train could be send weekly, monthly, annually etc. The pace at which companies would use the service would then simply be down to the export/import to/from a given country and how the company orders/sends goods. To find the potential with different shipping frequencies, the annual export/import for each commodity for each country is divided by 12 to see the monthly potential while the weekly potential is found from dividing the aggregated shipment sizes by 52.

To clarify, here is an example: In the data a company is seen to have an annual export of a commodity to France. The aggregated weight of these goods, specifically for France, is 500 ton. If the company was to use the shuttle service on a monthly basis to send its goods to France, they would on average send 41,7 ton, which according to Rasmus Munk Kolind should be enough for the railway solution to be profitable as opposed to trucks. Though the service can potentially be provided weekly, the company's shipments would thus be 9,6 ton and thus under the threshold of 25 tons. Of course, shipment sizes vary, and the aforementioned company probably will maybe have to alternate between transport modes depending on the situation.

Two other assumptions need to be made to use this approach. Firstly, the commodities exported from the North Region may have several recipients in each country. In the example mentioned before, the export to France may have to be transported to several locations within France. In most cases, this would mean that the rail wagon with the commodities would have to be redistributed from a French terminal by truck. If each buying company in France do not require enough goods for an entire container, conventional railway would probably be the only way to redistribute the goods to trucks. This will hardly be a problem though, as conventional freight is the only rail freight type handled at the Port of Aalborg so far.

Secondly, some goods are better suited for railway transport than others. Light, time sensitive and high value-goods are less suited for railway transport as opposed to goods of heavy weight that can stand hold-ups, like coal or gravel, yet there is no apparent literature for which any commodity railway transport is given up. Thomas Hansen of FF Skagen, however, claims that fresh fish cannot be transported by rail. Goods that are not suitable for rail transport can be separated from the export data since these data contain the field code of the producing company, this is not the case with the import data. (Trafik- og Byggestyrelsen, 2016) (Reis *et al.*, 2013)

5.3 Selection of import/export countries

The potential of sending and receiving goods by train depends on geography, infrastructure and amounts. Rail freight can well be a part of a multimodal freight chain and function as a transport mode to international ports, but it has been chosen in this study to assume that the main potential in railway transport is found with goods that has destination or origin in a location that is accessible by land vehicles. This means that Australia, North- and South America as well as pacific islands are excluded from this study as they are only accessible by water or air.

Africa is excluded from the study as well. From Figure 35 and Figure 36 it is evident that neither export or import to and from Africa is high. The reason for the continent to be excluded from the study though, is the limited options for rail transport to and within the continent. (The Telegraph, 2016)

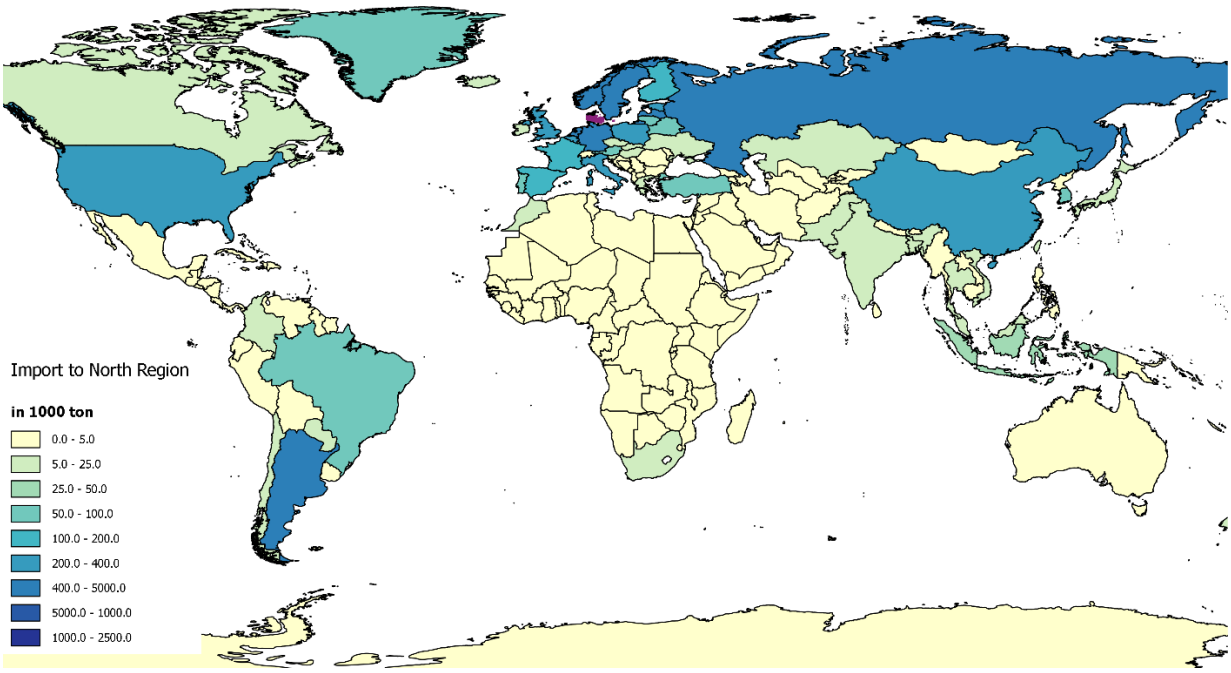

Figure 35: The total amount of import to the North Region divided into origion countries.

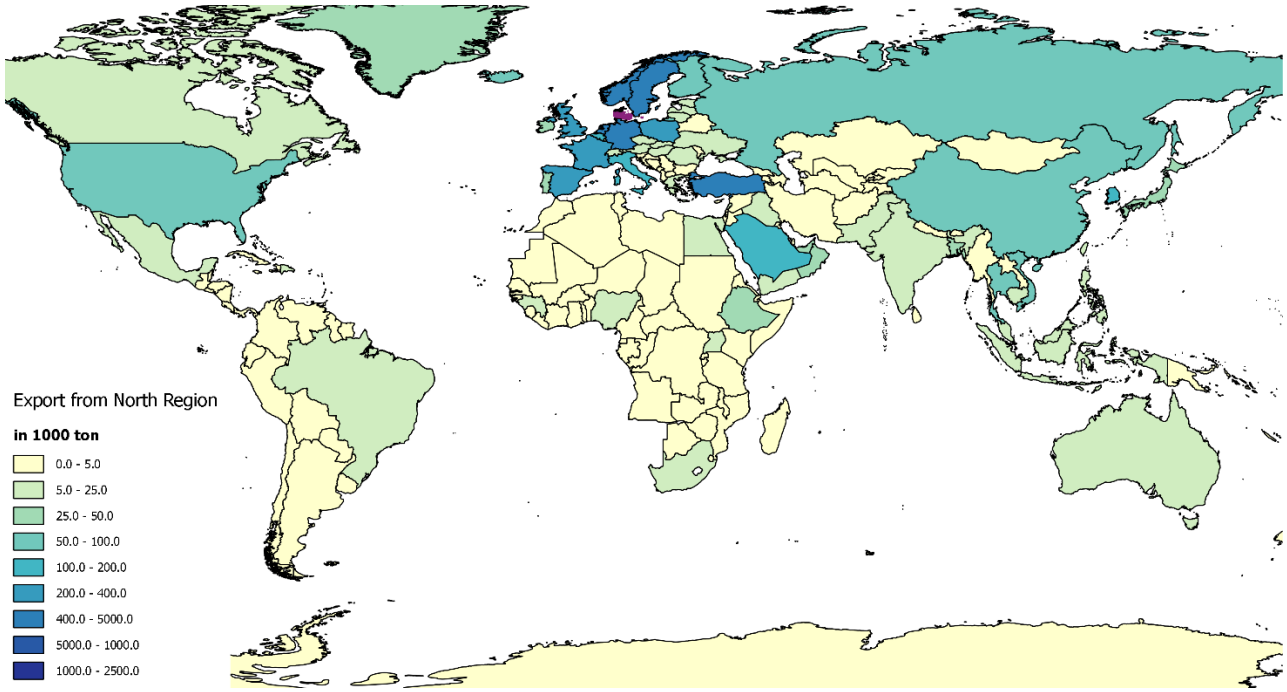

Figure 36: The total amount of export from the North Region divided into receiving countries.

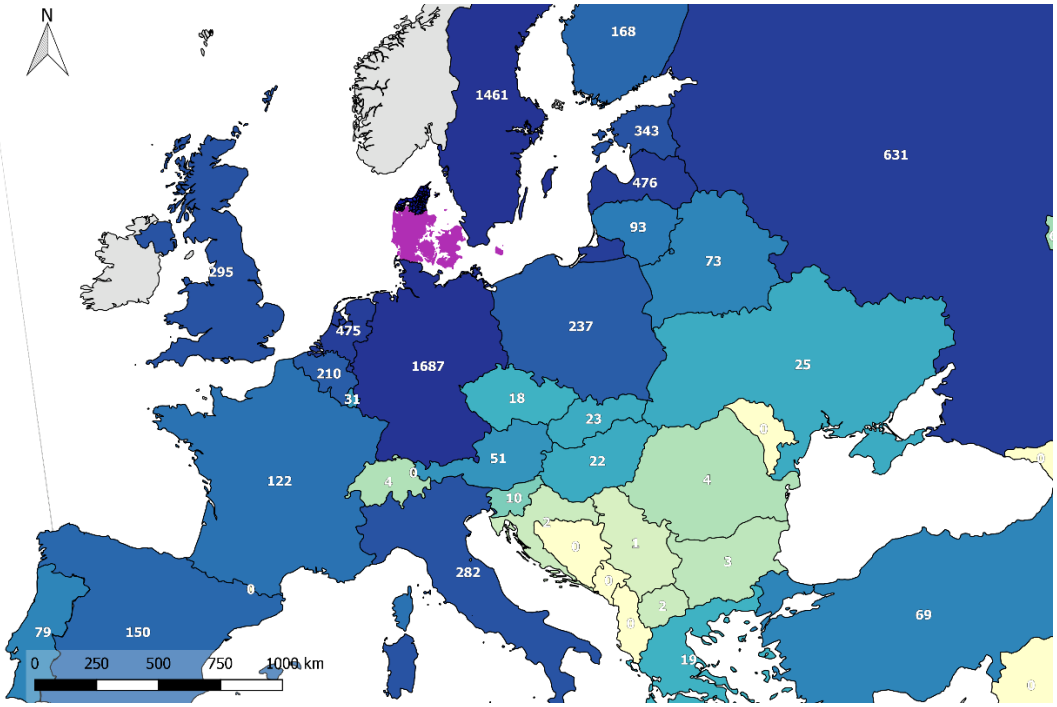

Figure 37: Total import to North Denmark Region from Europe.

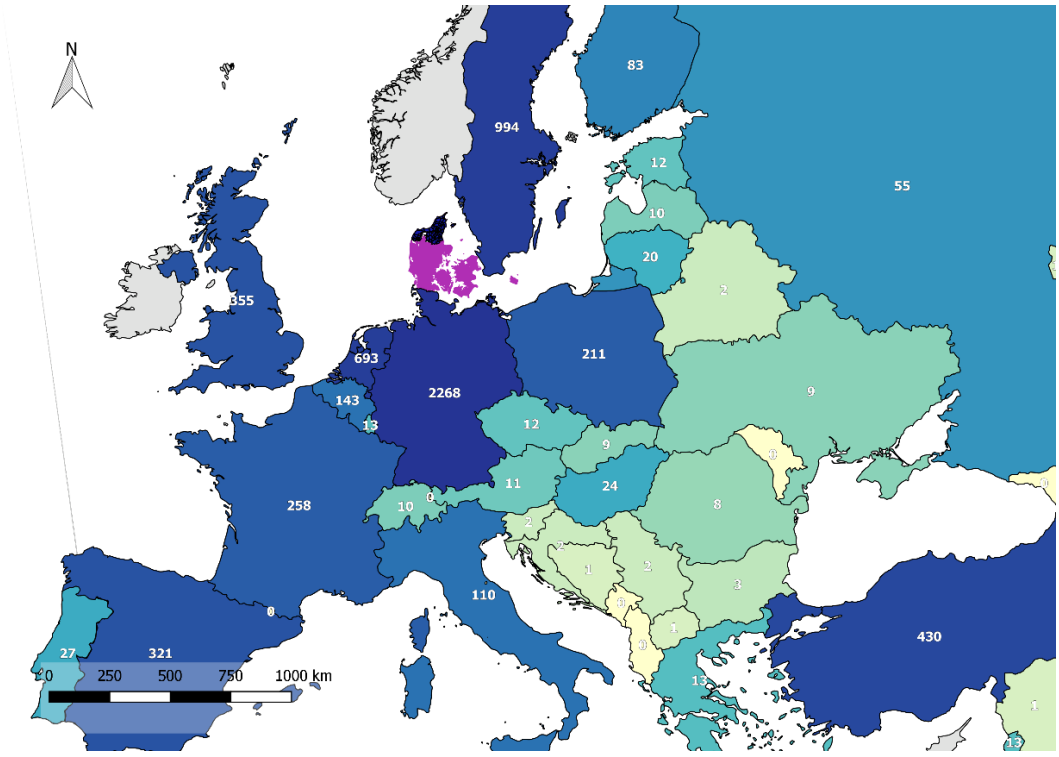

Figure 38: Total export to Europe from North Region Denmark.

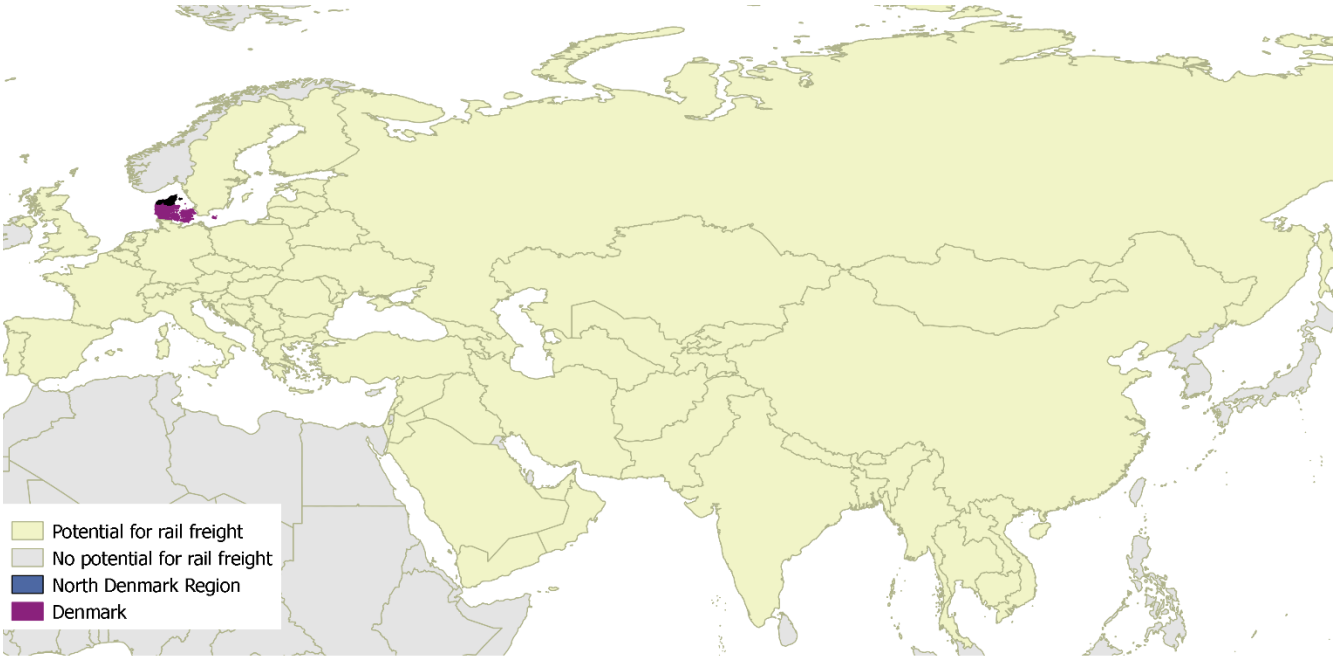

Figure 39: Countries that are selected as eligible for railroad freight.

Remaining is Europe and Asia. The countries that the region exports the most to is situated in Europe so there is still much potential, it seems, for railway transport. Countries such as Germany, Sweden and Norway, that are geographically close to Denmark, trades extensively with the region as can be seen from Figure 37 and Figure 38. The issue in transporting goods by rail to these is whether the breakeven-distance is reached and thereby if rail transport is more profitable than truck. These distances vary quite a lot, but a qualified guess is to follow Trafikstyrelsen's distance of 450 km. This is roughly the distance from Aalborg to Hamburg, Germany, which would mean it is profitable to transport goods by train between most of Germany and the North Denmark Region. Sweden has the second biggest part of export from the North Denmark Region. The country is easily accessed by ferry for trucks from Port of Frederikshavn to Gothenburg, but even from Gothenburg many locations, like Stockholm and Malmö, are far away by truck. Germany and Sweden could then probably be areas to send and receive goods by train. Norway, on the other hand, does not seem as the best contender for railway freight. There are multiple ferry options from Northern Jutland to Norway, rail freight would have to drive a very long distance to reach any location in Norway and vice versa. Thus, Norway is excluded from the data, but this does not exclude transit goods to and from Norway to go through the North Denmark Region.

Island nations like Japan, Ireland and Faroe Islands is removed from the dataset as well. Similar to this, South Korea is removed as it is assumed to be impossible to transport goods through North Korea, which is also removed from the data set.

What is left can be seen on Figure 39.

5.4 Types of export goods

From a Danish perspective the potential in changing transport mode is mostly in the export since this is the case where the Danish companies are in charge of distributing the goods. Fortunately, this is also the case in which the goods types can be decided from the six-cipher field code assuming the company that produces the goods primarily produces the commodity in question.

The Danish field register works on multiple levels. It is split into:

Main groups: All Danish business fields split into 99 groups – accounts for the two first ciphers in the field code.

Group: Sub group of "Main group" – Accounts for third and fourth cipher in the field code.

Subgroup: Sub group of "Group" – Accounts for fifth and sixth cipher in the field code.

Among the companies that could on average export goods by train monthly there are 123 different six-cipher field codes, i.e. subgroups, in the dataset. Most of these field codes are only represented with one company, so Main groups or groups probably gives a better overview of the data though there are a few types of businesses in the region that are well represented as seen on Figure 40.

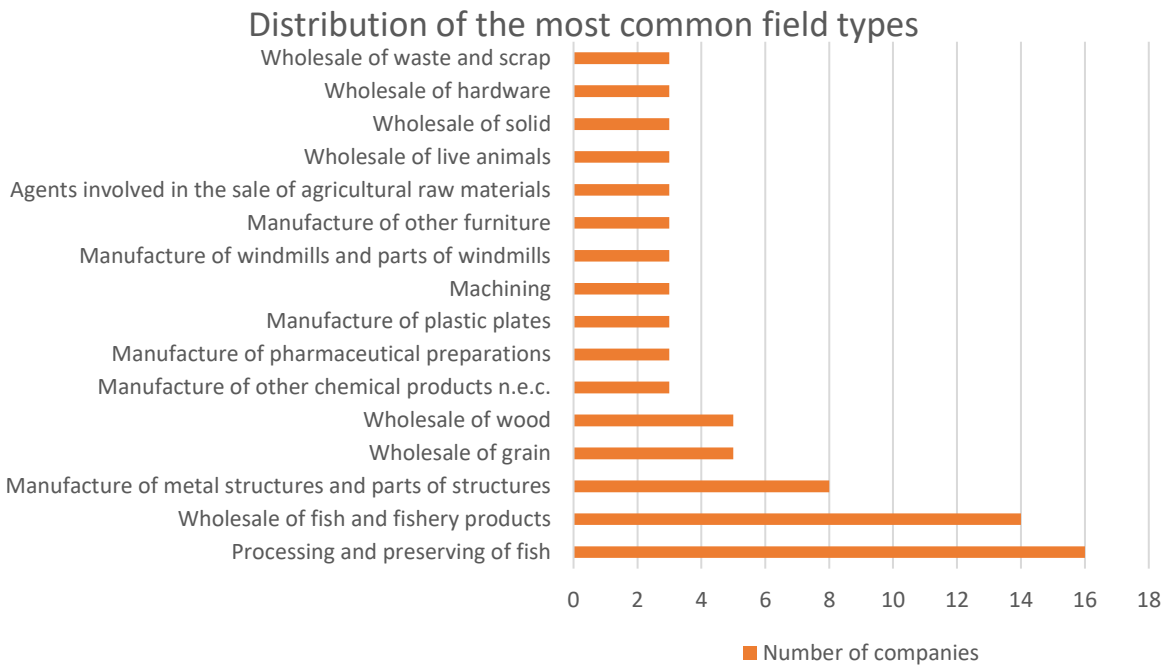

Figure 40: The most common types of businesses that ship enough goods to make use of the wagon load service on a monthly basis.

It seems there is a significant quantity of fishing related companies in the region. Companies that mainly produces commodities that contain fresh fish should be taken out of the export dataset as shipping by rail will be difficult with these goods. To remove the companies that produce fresh fish, entries with field codes of main group 3 as well as field code 10.20.20. Entries with field code 10.20.10 is not removed from the dataset since this is associated with businesses that produce fish meal which has already proven suitable for rail freight by FF Skagen.

Following this removal of unsuited business fields there are no obvious indicators of what types of goods or companies that should not be seen as potential for railway transport in the region, though companies that are located close to a terminal will have less costs for drayage.

5.5 Results from register analysis

Following the removal of shipments unsuited for rail transport the final results of the register analysis are shown in this section. As mentioned before the results are unfortunately affected by the regulations of data use by Statistics Denmark. Values shown in tables and figures from are required to be made of aggregated values from at least three companies to ensure sensitive data about singular companies are not leaked. This regulative is referred to as “the rule of three”.

5.5.1 International distribution of potential railway goods

As was expected from the analysis, the potential of rail freight is mainly found in goods that are transported within Europe. When only including companies that import or export goods amount sufficient for weekly use of rail freight transport, the goods flow have a distribution as seen on Figure 41 and Figure 42. The countries shown on the maps with potential of railway freight are potential destinations or origins of railway freight as at least three companies from the North Region either export to or import from these countries. Countries that have less import or export partners are not shown due to the rule of three.

Assuming the shipments are sent less frequently, i.e. monthly, the number of companies capable of consolidating the needed freight amount increases. The number of countries with a potential to send and receive goods by rail to and from the region also increases as can be seen from Figure 43 and Figure 44. Once again, the rule of three prevent some potential locations of being pointed out.

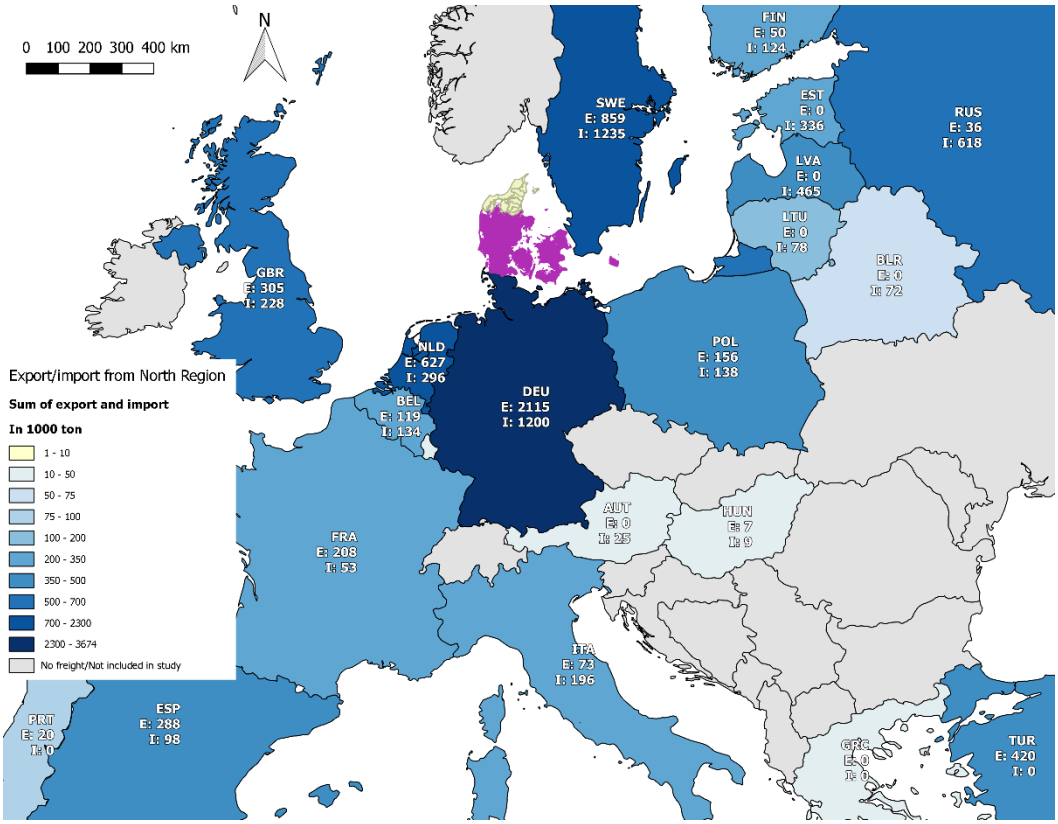

Figure 41: Potential amounts of import and export to different countries by rail on a weekly basis. E: Export amount – I: Import amount.

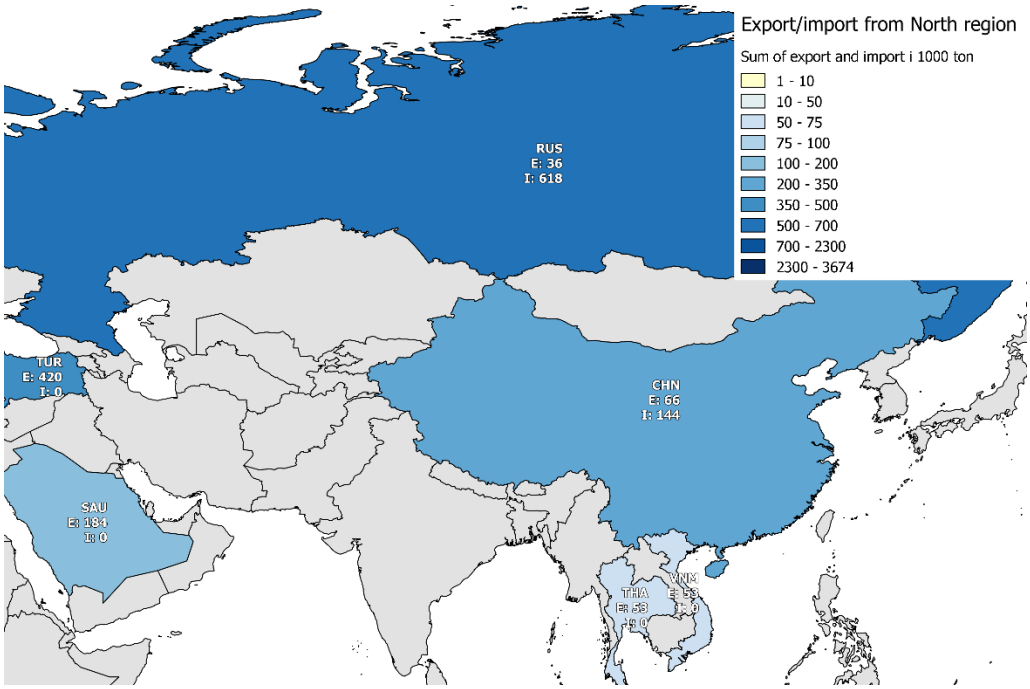

Figure 42: Potential amounts of import and export to different countries by rail on a weekly basis. E: Export amount – I: Import amount.

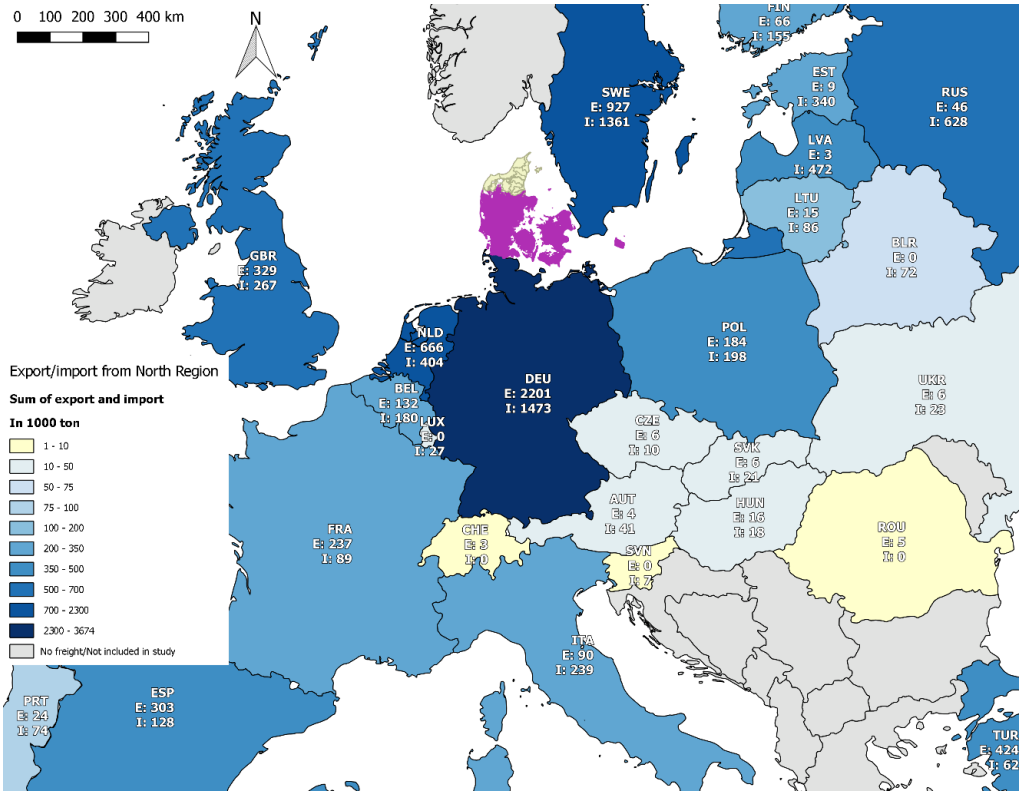

Figure 43: Potential amounts of import and export to different countries by rail on a monthly basis. E: Export amount – I: Import amount.

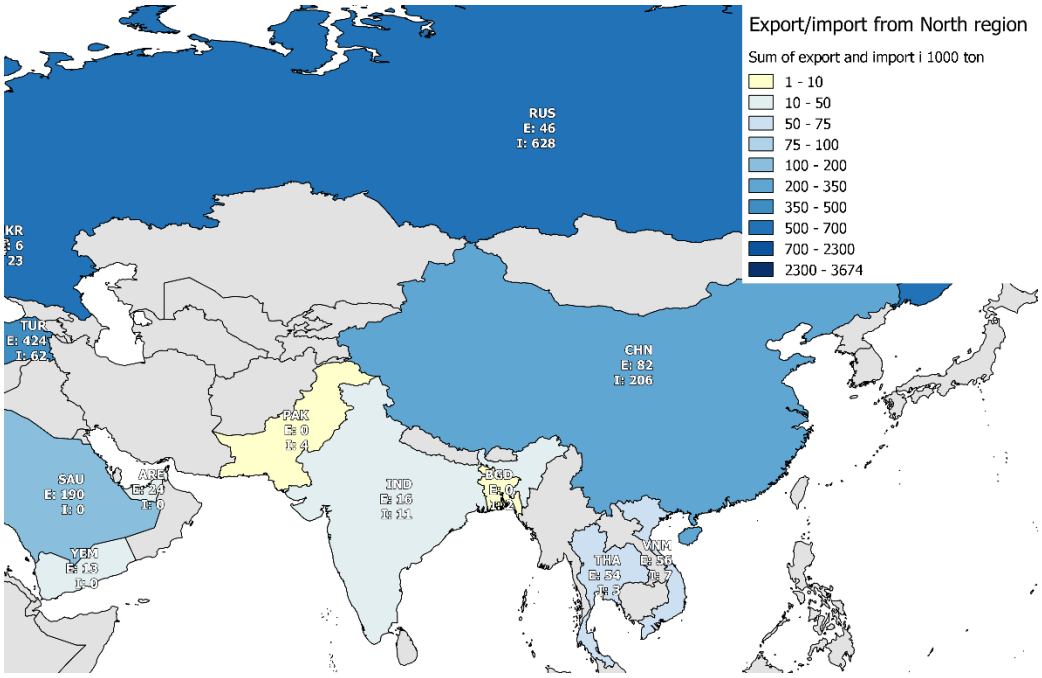

Figure 44: Potential amounts of import and export to different countries by rail on a monthly basis. E: Export amount – I: Import amount.

5.5.2 Distribution of potential within region

Table 7: Number of companies eligible for rail freight

Freight type and shipment frequency	Number of companies
Weekly export	104
Monthly export	195
Weekly import	172
Monthly import	311

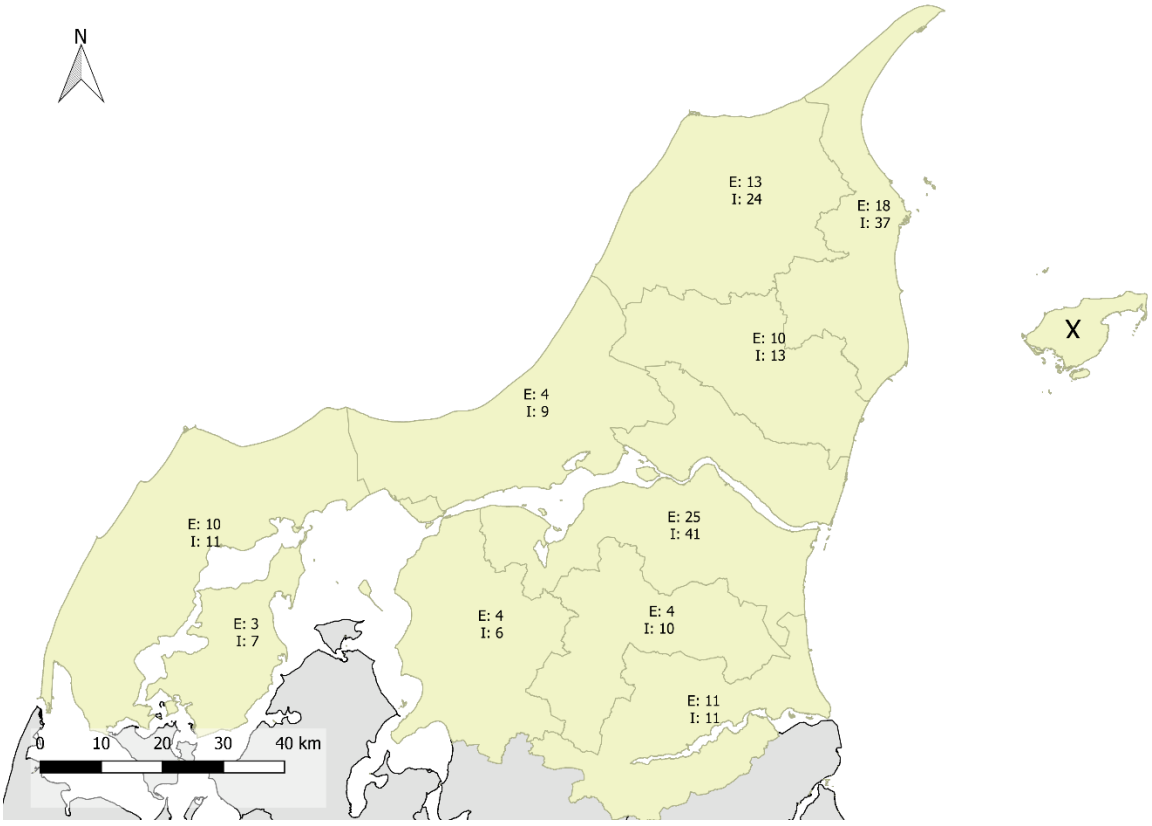

Figure 45: Companies eligible for use of wagonload service on a weekly basis. E: Export companies. I: Import companies.

The companies that are capable of shipping adequate amounts to the countries in section 5.5.1 amount to the numbers seen in Table 7. From looking at Figure 45 it appears that companies that could make use of the single wagon service on a weekly basis are distributed all across the region, but there is a slightly bigger concentration of such companies around Aalborg and between Hirtshals and Aalborg where, according to chapter 0, there is a chance of loading goods onto trains. From Figure 46 it appears that with a shipment frequency of one month the picture is somewhat the same, only with more companies able to make use of the shuttle train from DB Cargo.

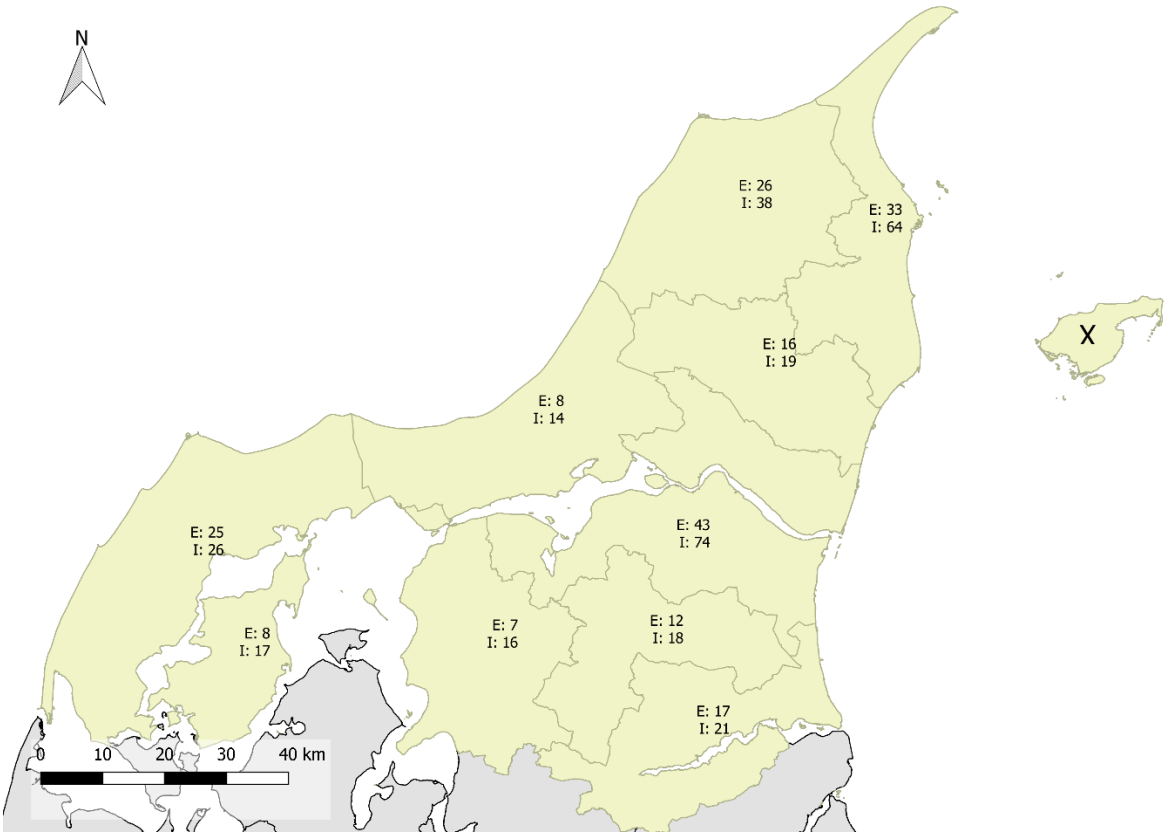

Figure 46: Companies eligible for use of wagonload service on a monthly basis. E: Export companies. I: Import companies.

The distribution of the companies shows a potential that is allocated throughout the region. The output of the respective companies varies though, so a small number of companies eligible for rail freight does not necessarily mean a small potential of rail freight to ship or receive. Figure 45 and Figure 46 show this for weekly and monthly shipment frequencies respectively. The aggregated amounts for the whole region for different shipment frequencies and freight type is shown in Table 8.

Table 8: Aggregated weight of goods that could potentially be transported by wagonload service.

Freight type and shipment frequency	Annual weight for North Region (1000 ton)
Weekly export	5819
Monthly export	6212
Weekly import	5672
Monthly import	6649

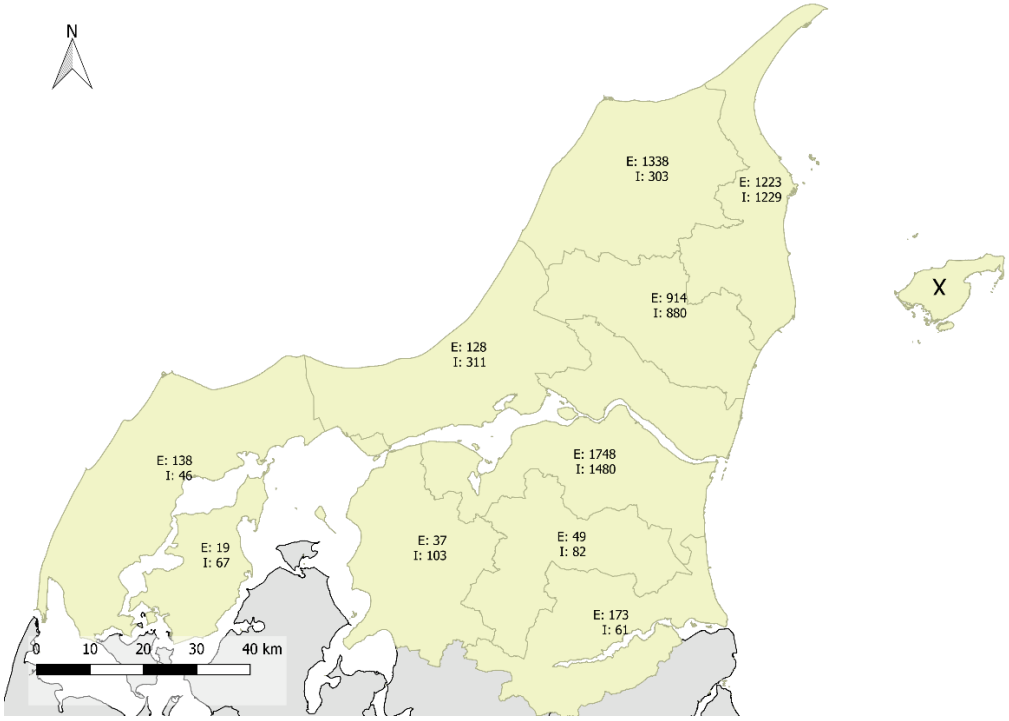

Figure 47: Aggregated import (I) and export(E) eligible for weekly use of wagonload services.

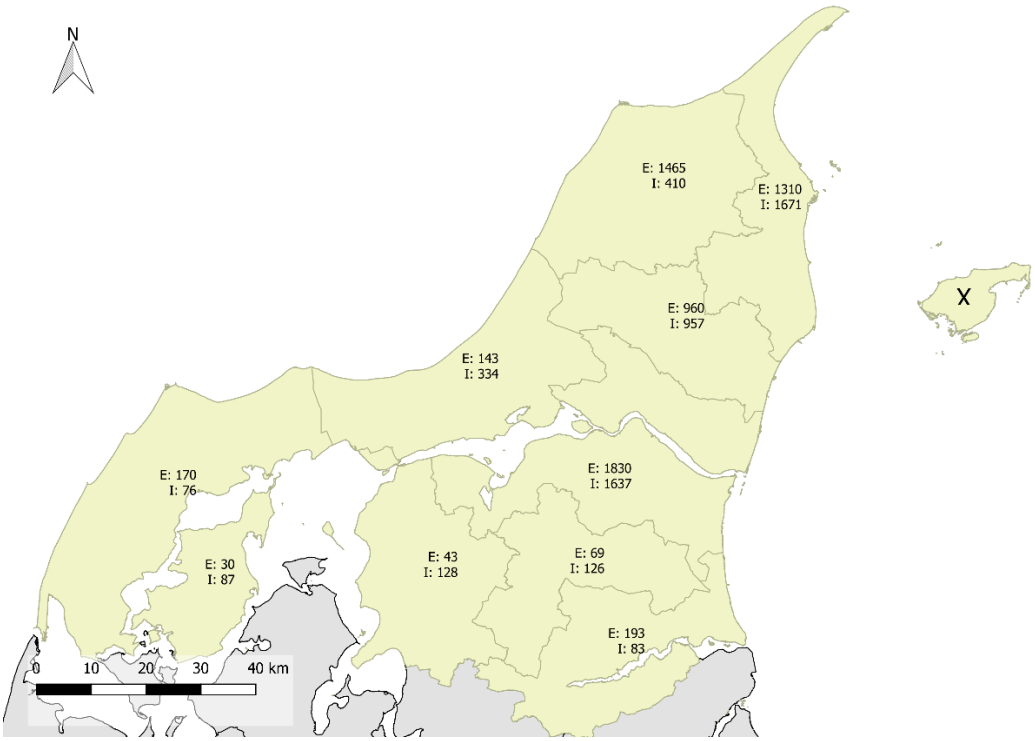

Figure 48: Aggregated import (I) and export(E) eligible for monthly use of wagonload services.

From Table 7 and Table 8 it appears that though there is a considerable difference in the number of companies eligible for rail freight when assuming a monthly shipment frequency rather than a weekly, the difference in aggregated weight between the two frequencies is relatively small. Additionally, from comparing the aggregated weights in Table 8 with the total import and export for 2015 in Figure 34, it seems the companies with a potential for weekly rail freight shipments account for more than half of the total import and export in the region. This is the case even though the UHDI register for 2015 counts 4336 companies in the region in total.

These amounts of goods are, from the assumptions made, eligible for rail freight, however, they are as well possibly eligible for sea transport. The objective of this study is not to show the potential of moving freight from sea to rail but from road to rail. It is not impossible from the data at hand to decide what goods at present is moved by sea and thereby leave out this from the study. However, according to Statistics Denmark the three largest ports in the region, Port of Aalborg, Port of Aalborg Portland, Port of Hirtshals and Port of Frederikshavn, combined exported/imported goods were as shown in Table 9. These values are noticeably smaller than the values seen in Table 8. This shows that there are probably multiple companies that are suited for import or export of railway freight and do not to make use of the local ports for transportation.

Table 9: (Danmarks Statistik, 2018a)

Export/Import	Annual weight (1000 ton)
Export	2796
Import	4074

5.5.3 Business fields

To conclude the business fields eligible for rail freight export are examined. This insight is only possible to acquire from the export data since the import data does not state what type of business the commodity in question was imported from. The businesses are distributed on a main group level as was explained in section 5.4 and can be seen on Figure 49 and Figure 50. The companies shown in the figure are the 195 companies that could potentially use rail freight as frequently as every month.

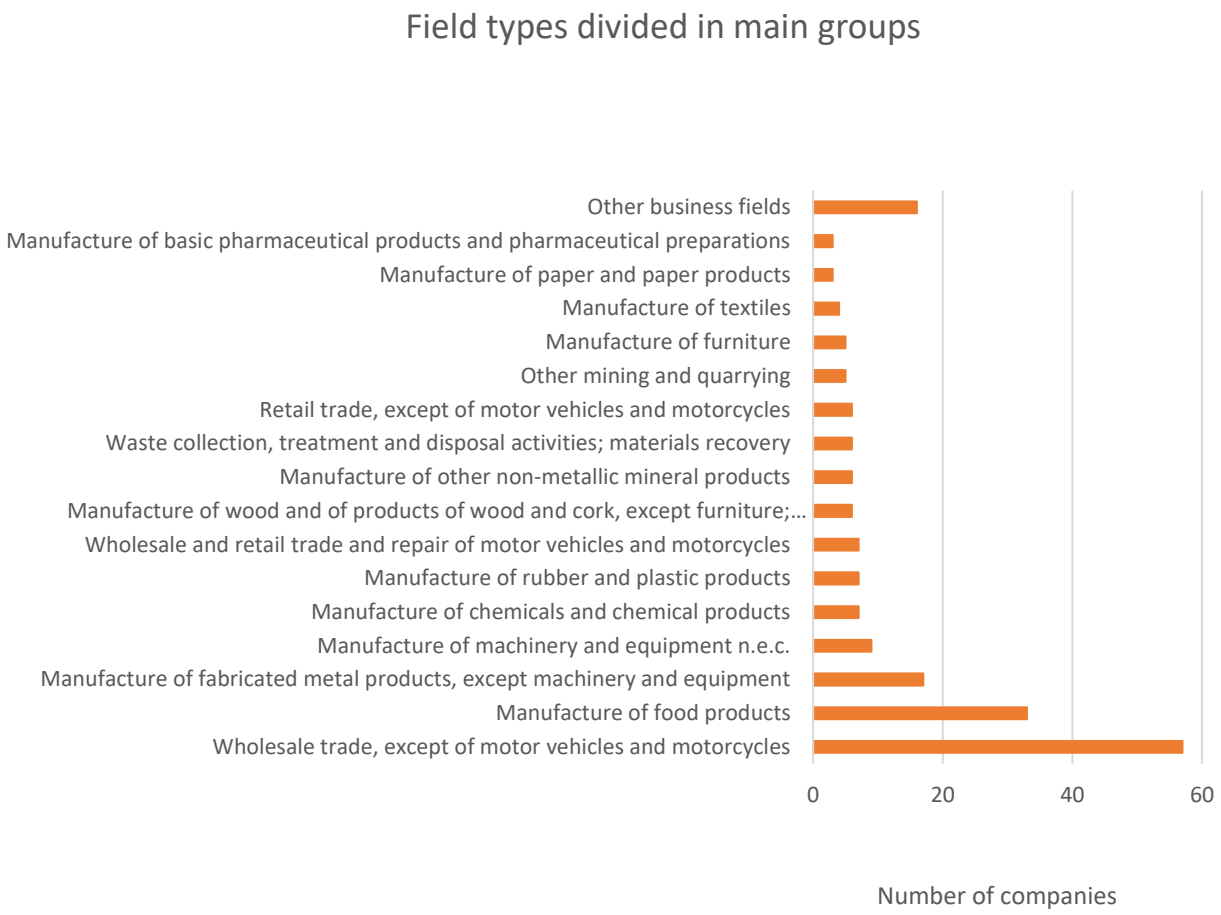

Figure 49: The eligible companies for monthly shipments divided into main field groups and number of companies.

The distribution of fields shows that 57 of the companies are in wholesales. This covers quite a big range of commodity types like agricultural goods, computer hardware, fuel etc. (Danmarks Statistik, 2007). It is difficult to say whether these goods are overall suited for rail transport. The second largest main group in Figure 49 is *Manufacture of food products*. In section 2.4 evidence was found that this commodity type is rarely well suited for rail transport, but this varies from food to food.

Of the residual main groups, it mostly seems there should be a potential to ship them by rail. Metal products and machinery could very well consist of mainly heavy goods well suited for railway transport. The five companies that are in the business of furniture manufacturing, however, are from experience not expected to choose rail freight to ship their products. This commodity type is singled out along with letters and packages in Trafik- og Byggestyrelsen (2016) as being traditionally transported by road. However, no reason for this is stated, and compared to the other main groups this group has a small output of goods.

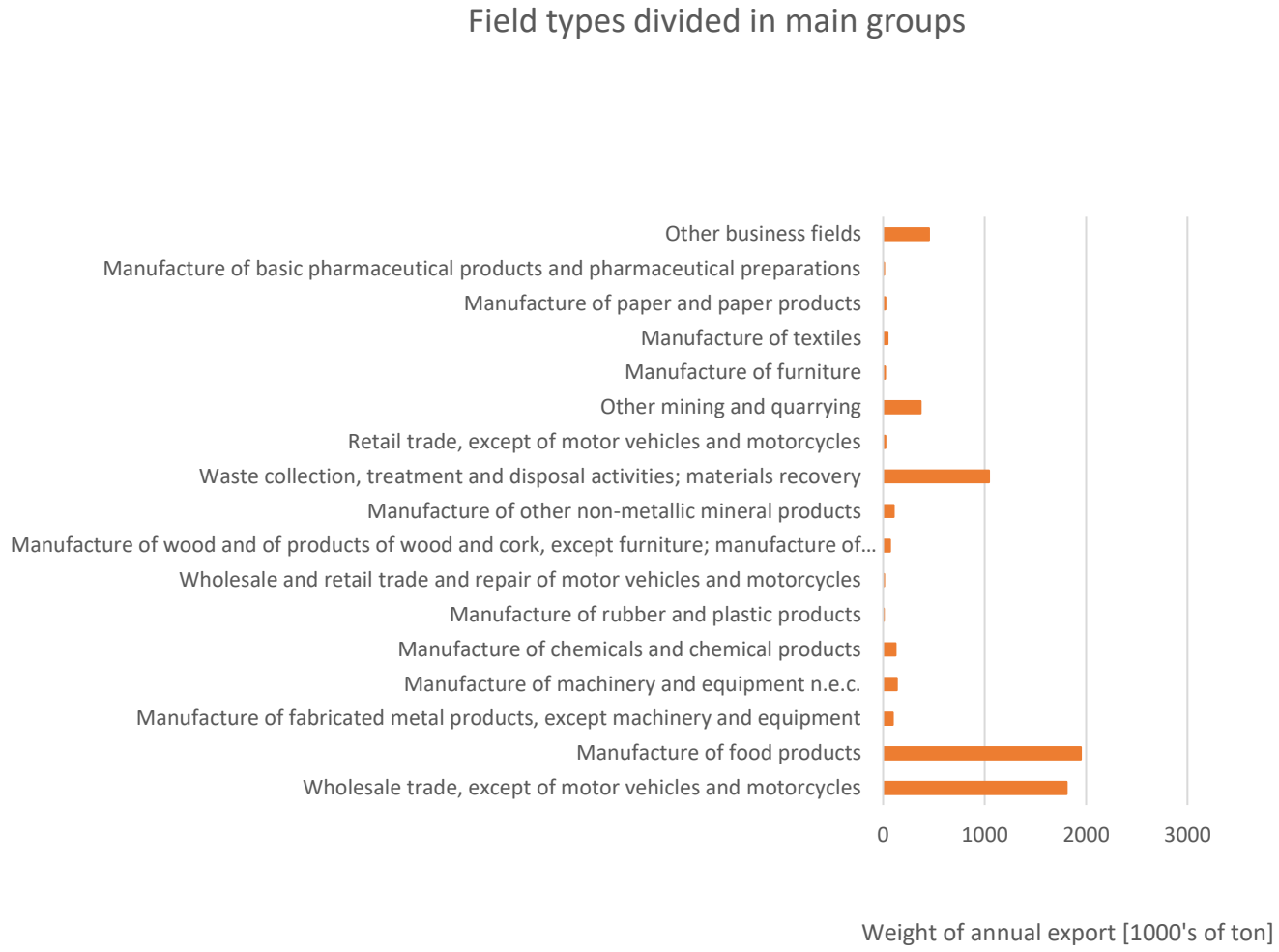

Figure 50: The eligible companies for monthly shipments divided into main field groups and weight of goods.

Though the register analysis shows an immediate potential for wagonload rail transport, it is only partly shows if further rail freight is possible in the North Region. The stakeholder analysis in chapter 4 showed that there are barriers for rail freight at present and that this problem will possibly enhance in the near future. However, the argument that there are not enough large shipments to and from the region to support the use of rail transport does not seem to be valid.

6 Conclusion

There may be a potential for national freight transport to and from the North Denmark Region, but unfortunately the national freight flow data has relatively few records on the amounts of goods that are sold within Denmark. Without any indication of the weight of a commodity, it is impossible to find the potential for rail freight. The potential is probably limited in any way since few locations in Denmark are at distance from the North Region that would make rail transport significantly cheaper than road transport.

The foundation for analyzing the potential in international rail transport to and from the North Region is fortunately better, as information about weight is available for almost all commodities imported and exported to the region. The North Denmark Region is home to several companies that ship or receive amounts of goods that are eligible for rail freight when exclusively considering the weight of the commodities. With the offer of shipping down to 25 ton ad hoc and not having to fill up a full-length train, the market for rail freight in the region seems to include up to nearly 200 companies assuming a monthly shipment frequency. If goods that require transport overseas are excluded, this amount is still larger than the amount of goods that are handled at the major ports in the region. This shows that there still might be a very large market for rail freight going in and out of the region without the need for rail freight to acquire market shares from oversea shipping.

When analyzing the primary fields of business that transport sufficient goods, whole sale and food stuff are amongst the most frequent fields in the region. Though there has been no indication of any specific commodity type that is absolutely unsuited for rail freight other than fresh fish and parcels, rail freight is typically time-consuming compared with road transport, especially wagonload transport.

Unfortunately, the data used to analyze the potential does fluctuate quite a bit from year to year. The data analyzed is from 2015, which is the newest data. The preceding two years, 2013 and 2014 show much lower export and import amounts, while 2011 and 2012 show higher. No answers to why this is the case have been found and thus the integrity of the data analysis is questionable.

The study of freight flow does not include transit freight. However, there is a substantial amount of ro-ro traffic from Norway and Sweden that travels by Ferry to Hirtshals and Frederikshavn to reach destinations in continental Europe. The trailers could potentially be reloaded to freight trains, at least in Hirtshals, before they are moved by rail to an intermodal terminal in continental Europe.

Though the potential seems to be present for further rail freight in the North Region, several obstacles are in the way of using the full potential in rail freight. The region has as of 2018 two terminals suited for combined rail freight in Hirtshals and Aalborg. The intermodal terminal at Port of Hirtshals is not used for rail freight operation at the moment and has only been used three times in total. Port of Aalborg receives up to three freight trains a week from operators Captrain, who ships whole trains through the port, and DB Cargo Scandinavia, who operates

a shuttle train that allows for ad hoc shipments by local companies around Aalborg. Port of Aalborg has capacity for two freight trains a day which means it is still possible to increase the operation.

Port of Frederikshavn has at present only one functioning track, which leads to a train ferry landing, and is thus not suited for loading truck goods onto train carriages. However, rail freight from the port is seen as a real opportunity by the Port of Frederikshavn as its new expansion of the port area perhaps will attract customers that are interested in shipments by rail. Port of Skagen has for many years been a destination for weekly whole freight trains because of the local company FF Skagen's use of rail transport for their fish meal. The port tracks are deemed only suitable for loading freight trains for companies on the port area by FF Skagen. The weekly transport will end during 2018 because the company is unsatisfied with numerous disruptions in the rail network that has happened before and are planned due to track modernizing.

Disruptions in the rail network is regarded as a major problem as well by Port of Aalborg, Port of Hirtshals and DB Cargo Scandinavia. The severity of the problem is due to the fact that customers of the rail freight operators are forced to find other means of transportation during a track disruption, which can be costly. This supposedly discourage potential rail freight customers from shipping their goods by rail. Banedanmark is blamed for these disruptions as they are responsible for a functioning track and for planning of maintenance and track improvements. Banedanmark is aware of the problem but sometimes see no other way than to close tracks when alterations are to be made to the tracks. Additionally, unforeseen mishaps can happen, like collapses of rail infrastructure, which will again possibly close down whole regions of rail network. The issue is in the fact that the Danish rail network has several sections of tracks that offer no alternative route. There is only one route to the rail network in the North Region.

Disruptions in the rail network happens throughout the Danish rail network but for the North Region specifically, another issue is luring. The ERTMS signaling system is to be implemented north of Aalborg, which means only locomotives with ETCT installed will be allowed to access the network. In the short run, this could mean no freight locomotives can access the network as it is unclear whether diesel locomotives with correct ETCT exist. In the long run, the question is whether the tracks north of Aalborg will ever be electrified. If the tracks are only electrified to Aalborg station, the question stands as to whether it will be profitable to have ETCT-equipped diesel locomotives running only to operate north of Aalborg.

If this is not the case, Aalborg will be the only hub in the North Region for rail freight. It is not clear the how far the market area for Port of Aalborg as a railway hub stretches. The market area is most likely skewed towards north, but the cost of drayage might be too high for distant companies to use Port of Aalborg as a hub. Some of these companies could make use of Port of Hirtshals, if access to this terminal will continue to be possible. Port of Hirtshals and Port of Aalborg could, according to DB Cargo, then make up a regional rail freight corridor which would probably help to consolidate freight to fill up freight trains on a regular basis. The concept could include Port of Frederikshavn and Port of Skagen but more stops means that the goods will have to travel for a longer time. In any way, all stakeholders in the study agree that more rail freight in the region will lead to a less rigid

system and a more effective organization as rail operators will be able to serve several terminals with the same equipment.

7 Further work

In this study the question of whether there is a potential in rail freight in the North Denmark Region has been treated on a general level. This is what the data at hand allowed for. Some issues in the rail freight sector need to be accounted for to give a clear picture of the situation. Now, with a clearer picture, new subjects to study has come to the surface.

A model for modal choice, strictly based on cost, is still an option to study the potential of rail freight in the North Region. Without proper freight flow data though, an actual amount of goods cannot be specified as eligible. Instead the model could show which specific areas in Denmark and the world rail freight to and from is eligible. Another purpose with such a model could be to define the market areas of Port of Aalborg and Port of Hirtshals. This would show whether or not additional terminals are needed to serve the region or if Port of Aalborg could work as intermodal terminal for the whole region, in case rail freight operation north of Aalborg came to a halt. The model output could be compared to customer data from operators to see if the market area is utilized fully.

Prior to such a model there is a need to investigate the functionality of the Danish railway loading sites. In the study at hand it was found that Port of Frederikshavn is not suited for railway freight though the Danish Transport Authority reported it had a port track. This is maybe the case for other sites in Denmark. To evaluate the functionality of each terminal and compare the terminals, parameters would have to be established on describing the functionality. Capacity measured in TEU is already used but other specifications, like loading equipment, maximum axle pressure, shunting facilities etc. would also be relevant.

Regarding the disruptions due to maintenance, alterations or accidents in the rail network it seems urgent to find technical methods to ensure that rail freight customers are not isolated from international rail freight. When it comes to planned disruptions, temporary tracks are an option and there may be methods to make use of these more with less costs. Alternatively, more permanent tracks parallel to the existing ones, like the new high-speed track between Copenhagen and Ringsted, could be constructed to make rail freight less vulnerable to accidents and other track disruptions. In the case of the North Region, a link between Thisted and Aalborg would offer an alternative route to Vendsyssel and Aalborg, when the section between Langå and Aalborg is out of function.

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