Intermodal corridor Amsterdam – Central/Eastern Europe

(Cornwell, 2020)

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Preface

This research was conducted by four students from the Amsterdam University of Applied Sciences. The students who executed the research have an aviation operation, an aviation engineering or a logistic background. The research was initiated by the department of Engineering of the Amsterdam University of Applied Sciences as part of the students Minor called Future Proof Airport Seaport Logistics. A special thanks to Mr R. Rhode of TMA and Mr G. de Witt of Samskip who provided the students with valuable information presented in this report.

Management summary

Noord West Connect, NWC, is an industry organization who brings intermodal solution to the province of Noord Holland with the aim of reducing road transport kilometres. Currently there are only a few international intermodal corridors starting from Amsterdam. To explore the possibilities of enlarging NWC's network the following main question has been formulated: *How can NWC create a larger network by outlining new potential corridors, establish a single new corridor and realizing this in their current network?*

The Ruhr area, in Germany, is a saturated market with already many intermodal connections with the Netherlands. Industry experts advised to research the Czech Republic, Poland and the United Kingdom for a possible intermodal connection with Amsterdam. With failing trade negotiations between the EU and the UK, long waiting lines for the Channel Tunnel are expected to occur which will delay cargo going through the tunnel. An intermodal solution from Amsterdam to the UK could offer a time and money saving alternative to the Channel Tunnel problem. Other possibilities to start an intermodal corridor with are Southern Poland and Eastern Czech Republic. These areas are dominated by production industries and have a lot of trade with Western Europe. Much of the cargo transported between these areas and Western Europe is done by road. When researching these areas, one learns that Ostrava and Gliwice both offer a suitable intermodal terminal with a lot of production around them. Also, there is no existing corridor between the Netherlands and these cities. The preferred intermodal choice for this corridor is a connection by train, due to there simply not being a convenient waterway to those areas. Rail transport is faster than inland shipping, and an intermodal rail connection is calculated to be 4.7 hours faster than truck transport between Amsterdam and Gliwice. For a connection to the UK, Felixstowe is the most desirable. Felixstowe has the largest container port in the UK and is geographically closely located to Amsterdam compared to other UK ports, which results in a relatively short travel time by shortsea. With numerous train connections sprouting out into the UK, the Port of Felixstowe offers an excellent hinterland network. Shortsea Amsterdam – Felixstowe could be a feasible corridor to begin a connection with. When choosing for the preferred terminal in Ostrava, METRANS Container Terminal Ostrava Senov, transport costs are €213.14 lower than transport costs by lorry per TEU. The METRANS Container Terminal Ostrava Senov has the preference due to their larger container storage capacity and a longer freight train handling track. The calculations are based on a freight train of 50 TEU. In reality, the freight trains are expected to carry more than 50 TEU, thus resulting in a greater cost advantage when increasing TEU capacity on a train. The maximum allowed freight train length on this corridor is 650 meters, allowing the train to carry a little over 100 TEU. When looking at demand in TEU and a balanced cargo flow, it can be concluded that Amsterdam – Ostrava has the most balanced cargo flow out of the researched corridors. Calculations based on the TEU availability in the region the two cities are located, show that there is a negative balance of 4318 TEU between Noord-Holland and Moravian Silesian, the region in CZ where Ostrava is situated. For every TEU coming from the Moravian Silesian region to Noord-Holland there is 0.9 TEU send back to the Moravian Silesian region from Noord-Holland. This is by far the closest TEU balance of all researched regions and is of no issue since the hinterland area of the TMA terminal Amsterdam is close to the Netherlands largest container handling province, Zuid-Holland. Beneficial is that there are no existing rail corridors yet with Ostrava. The advised route is TMA Amsterdam - METRANS Container Terminal Ostrava Senov, CZ. This single new corridor is recommended to enlarge the NWC network and could be integrated in NWC's current network.

(Boston.com, 2010)

Abbreviations

AT	Austria
BRI	China’s Belt and Road Initiative (the New Silk Road)
BY	Belarus
CBS	Central Bureau for Statistics
CZ	Czech Republic
Czechia	Czech Republic
DE	Germany
ECJ	European Court of Justice
EFTA	European Free Trade Association
EU-27	All European Union Members as of February 1st, 2020
EU-28	All European Union Members as of January 1st, 2020
EU	European Union
GDP	Gross Domestic Product
GNP	Gross National Product
HVA	University of Applied Sciences Amsterdam
IT	Italy
Kmph	Kilometre per hour
LoLo	Lift-on Lift-off
LT	Lithuania
mm	Millimetre
NL	the Netherlands
NWC	Noord West Connect
PL	Poland
R&D	Research and Development
RoRo	Roll-on Roll-off
SI	Slovenia
SK	Slovakia
UK	United-Kingdom

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1 Introduction

Noord West Connect, NWC, is an industry organization backed by the Dutch government to bring intermodal solutions to the North West province of Noord Holland. NWC works together with Lean and Green, which is also a nation-wide transport industry organization who has the same aim as NWC: "going off-road". NWC is creating new intermodal connections, advising companies to make the switch to intermodal transport and bringing the industry together to innovate new intermodal solutions. All with the aim to reduce the transport kilometres on road and with the desired impact to reduce the CO2 emitted by road transport. Intermodal transport means using more than one modality to complete an itinerary of a container from A to B. A lot of companies are oblivious to the benefits of the modal shift for their operation. NWC is convincing companies to make the modal shift and together with shippers, creates intermodal networks connecting Noord-Holland. Modal shift is the term for the change of modalities, for example from road transport to using rail transport instead.

At this moment it is unclear where in Europe the possibilities lie to go "off-road". The Noord West Connect project is expanding their intermodal network starting in Amsterdam, but there are not many international intermodal connections yet. It is unclear where major cargo flows are situated between Amsterdam and potential new areas in Europe. Since most transport within Europe is transported via road (European Comission, 2018) and as the roads get more congested and the pressure on the infrastructure increases, an intermodal product offers the ability to go off-road and be of no annoyance to other road users and most importantly avoids the road transport issues. Figures from the Dutch Department of Statistics show that the total yearly driven kilometres by heavy road users, such as lorries, has increased with over a billion driven kilometres since 2013 (Centraal Bureau voor Statistiek , 2020). With offering corridors with a frequent and reliable schedule as well as fast transit times and a cost attractive product, NWC is convincing sector partners to make the switch.

The minor group who has taken the challenge of Noord West Connect consists of four students from the Amsterdam University of Applied Sciences. Bram van der Heijden and Stan Geestman who have an Aviation Operations background. Freek Sybesma has an Aviation Engineering background and Tim Azoulay has a Logistics background. For the minor group, this challenge tackles a lot of new and unexplored fields. The minor group is unfamiliar with the subject of intermodal transport and therefore this will be a challenge for itself.

2 NWC project

This chapter highlights the questions and goals needed to succeed in the research. In 2.1 the problem statement is outlined. In 2.2 the main question is presented and in 2.3 the sub questions are given. Furthermore in 2.4 the project objectives of the research are presented.

2.1 Problem statement

NWC has asked the research group, NWC 1, to research possible new connections from Amsterdam and provide an overview of potential new intermodal connections. The aim is to present an overview of cargo flows with potential new areas of interest, delivering a new corridor starting in Amsterdam and a thorough validation, including transit times, operating costs, etc. of the proposed corridor (detailed indication see 2.4 project objectives). To contribute to NWC's vision of more intermodal transport the research question to investigate the possibilities of a new corridor goes as follows: *How can NWC create a larger network by outlining new potential corridors, establish a single new corridor and realizing this in their current network?*

To answer the main question, a logical structure has been applied in this report. Chapter 3 defines the research areas for potential new corridors. Chapter 4 dives deeper in the defined regions and hubs thereof and results in suitable intermodal terminals for setting up a new corridor. Chapter 5 elaborates on realizing a corridor between the terminals defined in chapter 4, including the feasibility of this corridor. Chapter 5 will be validation and results of the chosen corridor. Furthermore, recommendations and conclusion are provided.

To provide NWC with a detailed single new corridor a few measures have been taken to keep the research group form distraction. The research excludes a financial overview, as well as calculations on possible reduced emissions by this new corridor. Furthermore, the impact on road use and safety thereof will not be part of the report. The research focusses solely on setting up a corridor and the feasibility of the corridor in terms of demand in cargo volumes, transit costs and transit times.

2.2 Main question

How can NWC create a larger network by outlining new potential corridors, establish a single new corridor and realizing this in their current network?

2.3 Sub questions

2.3.1 What does the NWC network look like today and what are the possibilities for expansion?

2.3.1.1 What are the current hubs within NWC, their trajectories and operators?
2.3.1.2 Which countries are of interest for setting up a new corridor?
2.3.1.3 What are the existing connections with the countries of interest?

2.3.2 Which terminals and modalities should be used for the NWC expansion?

2.3.2.1 Which terminal(s) should be used for the United Kingdom?
2.3.2.2 Which terminal(s) should be used for Poland?
2.3.2.3 Which terminal(s) should be used for the Czech Republic?
2.3.2.4 Which modality should be used for North West Connect expansion?

2.3.3 How can NWC realize the potential corridor?
2.3.3.1 Which of the corridors has the most potential for NWC and why?
2.3.3.2 Will the corridor be feasible?

2.4 Project objectives

The main objective of this report is delivering a well-researched corridor, hat is feasible and is of an academic standard. The sub questions created are there to support the main question and to find out which corridor could be created. Providing the report with detailed corridor lengths, travel times per modality, operating costs and a demand balance of the desired corridor should give a clear indication of the feasibility of this corridor. Furthermore, a map of the new corridor will be provided along with information of the desired terminals in the regions where the corridor will start or end. The possible competition for the new corridor will also be discussed.

2.5 Minor study plan adjustments

The original Minor Study Plan, MSP, consists out of outdated methodology, theoretical framework and objectives. It was structured and created with different sub questions and a different main question. The MSP has stayed the same for the most part. Only the main questions and sub questions have been updated.

3 Noord West Connect Network Potential for Expansion

Chapter 3 consists out of 3 sub questions. 3.1 will discuss the current network, including the current hubs and trajectories operated from Amsterdam. 3.2 will elaborate on the countries of interest, outlining the importance and potential of certain countries. Also, it is made clear why these countries have been chosen and others not. Paragraph 3.3 will elaborate on the existing connections with the countries described in paragraph 3.2.

3.1 Current NWC entire network

What are the biggest hubs and trajectories within the NWC region?
In 3.1.1 the corridors NWC uses at the moment are listed and analysed. Hubs that are frequently being used are also inspected. Finally, NWC currently biggest operators are given and given a little background information.

3.1.1 Hubs within the NWC network

The NWC network contains nine hubs in the Netherlands (NL) (Table 1).

Table 1. NWC hubs

NWC hubs		
Amsterdam	Hasselt	Velsen
Beverwijk	Ijmuiden	Zaandam
Harlingen	Lelystad	Zwijndrecht

(Sjoerdsma, 2020; Azoulay, 2020)

The Port of Amsterdam is the fourth largest port of Europe in terms of cargo handled. Thanks to its geographical location in the North-Western European mainland, it is often used as a hub between Europe (EU) and the UK (Port of Amsterdam, 2020). From the Port of Amsterdam, NWC has 38 different corridors reaching 10 different countries.

The Port of Amsterdam has been investing in projects improving the sustainability of the port. For example, in 2017 they invested 10 million in green projects which are expected to be finished in 2021. The port also offers lower handling rates for more environmentally friendly ships. Within the port there are multiple initiatives to facilitate an energy transition and a circular economy. (energy transition) This includes things as: generating energy with windmills and sun panels, recycling and attracting the use of renewable fuels and materials. (Offshore Energy, 2018)

Another large port in the NWC area is the Seaport of IJmuiden, whose operations mainly consist out of inland shipping to and from Rotterdam, Frankfurt am Main and shortsea to and from Newcastle (Sjoerdsma, 2020). The Harbour of IJmuiden is trying to grow, noticeable by a project like the construction of the new Ijmuiden sea lock. This sea lock will be the world largest sea lock and should enable the harbours around Amsterdam to better compete against other EU ports. (Rijkswaterstaat, 2020)

The largest Dutch port is the Port of Rotterdam. Currently, there is a large cargo stream between the NWC region and Rotterdam. The Port of Rotterdam is used as a hub and the transported goods are often sent to various locations within the EU. Creating a direct corridor between the Port of Amsterdam and its destinations without the use of Rotterdam as a hub could save the Port of Amsterdam both time and money while simultaneously reducing emissions. The Port of Amsterdam and the Port of Velsen are the most used ports in NL to transport to the Port of Rotterdam, sending 63 and 41 ships per week respectively. (Sjoerdsma, 2020)(Appendix 1)

3.1.2 Trajectories within the NWC network

NWC operates in the region of North-Holland. The largest NWC hub, Amsterdam, is connected by train, inland shipping and (short)sea. Most of the Port of Amsterdams cargo is transported between Amsterdam and EU cities. The Velsen hub only uses (short)sea and inland shipping on NWC corridors. The third most used NWC hub is the Port of Ijmuiden, with their most frequent destination being the Port of Rotterdam from where the cargo is distributed to all over the world. Last year the Amsterdam – Duisburg corridor was opened and there has been consistent cargo flows between the cities ever since. Another destination that is often being transported to from Amsterdam is Zwijndrecht. This is another Hub that can be used to transport all over Europe and the most frequent destination for goods leaving Amsterdam by Rail. (Samskip, 2020; Sjoerdsma, 2020)

3.1.3 Operators/Transporters within the NWC network

There are multiple operators that make use of different terminals within the NWC network. The ones that see the most use are the TMA Logistics terminals in Amsterdam and Velsen. These two terminals make up for over 19% of all used terminals within the NWC network in terms of frequency. The most frequently used terminal that is not operated by TMA is United Stevadores Amsterdam, which is used 40 times in a week. This low compared to the 66 of the TMA Terminal Amsterdam. (Sjoerdsma, 2020)
All of the operators NWC works with can be seen in table 2. Off these partners, the ones NWC cooperate the most with are TMA which operates 320 corridors in a week and BCA intermodal which operates 140. (Sjoerdsma, 2020)

Table 2. Operators in the NWC network

Operators in the NWC Network		
BCA Terminal	Eimskip	SCS Multiport
Container Terminal Beverwijk	Lineas Intermodal	Seacon
CTVrede-Steinweg B.V.	MCT Lucassen	TMA Logistics TST
DB Cargo Netherlands	MEO	Sun Line
DFDS Ferries	Samskip	

(Sjoerdsma, 2020; Azoulay, 2020)

TMA Logistics is an operator mostly based in North-holland. They own multipurpose terminals in Amsterdam, Beverwijk and Velzen. They have corridors extending to eastern Europe and China. They also operate over Shortsea with countries such as the UK, Sweden and Finland. (TMA LOGISTICS, 2020)

BCA intermodal is an operator specialised in barge transport between the Netherlands, Belgium, Germany, France and Switzerland. BCA operates mostly from Amsterdam and transports containers throughout all of Europe. (Organisatie, 2020)

3.2 Countries of interest for the NWC expansion within Europe

The NWC network currently only exists of countries within Europe and 71 percent of Dutch export went to EU-28 members in 2019. To expand the network, most would assume to tap into the largest existing cargo flows, for the Netherlands being Germany and the United Kingdom with both having a 7 percent bilateral cargo flow with the Netherlands (CBS, 2019). These countries are expected to already have multiple cargo corridors but due to the sheer size of the cargo market, there might be room for more corridors. The portential of Germany, specifically North Rhine-Westpahlia, has been researched in chapter 3.2.1. The potential of the United Kingdom alongside the opportunities of the

Brexit are explained in chapter 3.2.2. A second option is to investigate upcoming markets with demand for a trade corridor but who are underserved. These countries have no to litte cargo corridors with the Netherlands. It might be harder to set up a corridor with these countries, since the corridor being a pioneer, but the corridor will be one of the first between the countries offering the corridor time to strengthen its market position. Two of these upcoming countries are Poland and the Czech Republic, described in chapter 3.2.3 and 3.2.4 respectively.

3.2.1 North Rhine-Westphalia, Germany

The trade relation between the Netherlands and Germany is one of the largest bilateral trade relations in Europe, and the largest bilateral trade relations for the Netherlands. The Netherlands and Germany traded close to €193 billion worth in goods in 2019. (Table 3) (RVO, 2020) Dutch – German trade is responsible for 23% of Dutch exports and 18% of Dutch imports in. (CBS, 2019)

Table 3. Trade between the Netherlands and Germany in billion Euro

Trade Netherlands-Germany 2019		
		Amount (in billion €)
Total import		78,6
Top 5 imports	Road based vehicles	8,5
	Electronic devices	6,5
	Medicine and pharmaceuticals	4,0
	Various machinery	3,9
	Specialized machinerey	3,6
Total export		114,4
Top 5 exports	Fruit and vegetables	6,0
	Electronic devices	5,9
	Telecommunications devices	5,1
	Medicine and pharmaceuticals	5,0
	Various industrial products	4,9

(RVO, 2020)

Detailed by region, North Rhine-Westphalia contributes the most to the trade between the Netherlands and Germany. North Rhine-Westphalia contributed to 33,6% of trade between the two countries in 2019 by importing 42,95 billion Euros worth of goods from the Netherlands and exporting 20,49 billion Euro worth of goods to the Netherlands in 2018.

53,9% worth of goods exported from the Netherlands to North Rhine-Westphalia is transported by truck. This means that although there is still a large portion of the transport sector which can be transformed from trucking to intermodal transport, close to half of the transport is already being done by rail and inland shipping combined. Duisburg, located in North Rhine-West, expended her cargo flow to China massively over the past years as the result of the China's Belt and Road Initiative (BRI) (Koningkrijk der Nederlanden, 2019). BRI, also called the New Silk Road, is a colossal Chinese project creating a vast network of railways, energy pipelines, highways and streamlined border crossings boosting China's global economic links (Chatzky & McBride, 2020). Part of the BRI is the Duisburg-China connection, with 30 Chinese trains arriving every week in Duisburg's inland port. Duisburg inland port is considered the largest inland port in the world and is becoming Europe's central logistics hub with 80% of trains from China making Duisburg their first European stop, using the northern silk road. Rail freight between Chongqing (China) and Duisburg (Germany) is almost twice as expensive as shipping, but only takes 12 days instead of 45. Air freight is *at least* twice as expensive as rail freight but takes on average five days.

Although expected to becoming Europe's central logistic hub, Duisburg is struggling with a problem. For every two full containers arriving in Europe from China, only one full container heads back the other way, and the port only earn a fifth of the fee from empty containers. Even though this 2:1 ratio has been an increase from the old ratio of 4:1, it might decrease again. One of the main European products heading to China is powdered milk, which is a result of low trust in domestic brands following the 2008 milk powder tragedy (BBC, 2010). If that trust returns, even fewer containers might be heading east from Duisburg. (Oltermann, 2018)

Combining the info that 53,9% of Dutch exports to North Rhine-Westphalia is done by truck with the fact that North Rhine-Westphalia is the Netherlands largest trade partner, it is safe to assume that there is a well-established intermodal transport network in existence and therefore otiose to research the possibility of an additional cargo corridor on this route.

Furthermore, both Rens Rhode from TMA logistics (Rhode, 2020) and Gerard de Witt from Samskip (Witt, Interview Samskip, 2020) dissuade researching additional cargo corridors between Amsterdam and North Rhine-Westphalia, stating that the market was already saturated. Rens Rhode advised to investigate South-Poland and Gerard de Witt recommended to research a possible corridor between Amsterdam and the Czech Republic. Furthermore, both interviewees forewarned of a possible surge in cargo transport demand between the port of Amsterdam and the UK as the result of the Brexit on January 1st, 2021.

This concludes that bilateral trade between the Netherlands and Germany will be excluded from this report from this point on. This conclusion is based on the conversation with Rens Rhode and Gerard de Witt.

3.2.2 United-Kingdom

The trade in goods, measured by volume, between the UK and the EU in 2016 consisted of the following modal split; 75% by maritime shipping and 25% by transport through the Channel Tunnel. 95% of the goods transported through the Channel Tunnel were transported by lorries, over 1.6 million (Statista, 2020), on a special rail bound shuttle service and 5% with the use of direct rail (European Parliament, 2018).

The UK has officially left the European Union on 31 January 2020 and entered a transition period, scheduled to end on 31 December 2020. Meaning that starting 1 January 2021, the UK will no longer be subject to ECJ jurisdiction outside of the EU. This so-called Brexit, short for British exit, will result in the end of tariff-free trade with other EU members. (European Movement International, 2020) (Amadeo, 2020) (Owen, et al., 2020)Currently, all matters concerning the operation of the Channel Fixed Link are supervised by an Intergovernmental Commission set up by the Treaty of Canterbury (United Nations, 1988), signed between France and the UK in 1986. Starting January 1st, 2021, EU law will no longer apply to the UK, leaving the legal status of the Treaty of Canterbury in uncertainty. This means that the Treaty of Canterbury needs to be amended to govern the operation of the Channel Tunnel (Merrick, 2020). To ensure the safe and efficient operation of the Channel Tunnel, the EU has offered a Council mandate empowering France to negotiate an amended to the Treaty of Canterbury. Interoperability rules will be amended so that the Intergovernmental Commission can be maintained as the safety authority competent for the application of EU law within the Channel Fixed Link. France is not allowed to sign the amended treaty without approval of the ECJ. This will mean that, if this proposal is accepted, all relevant law will be applied both on the French and UK side. (European Council, 2020)

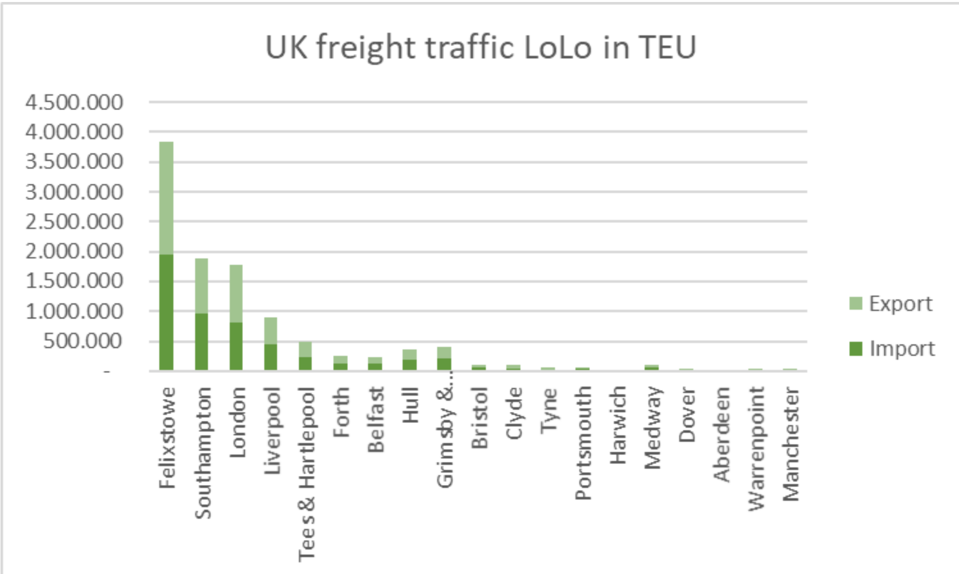
The Prime Minister of the UK, Boris Johnson, has opposed the Council mandate as he has insisted that the ECJ will not have remit in the UK after the completion of the Brexit (Merrick, 2020). Even if France was willing to reach an agreement outside the ECJ's future jurisdiction, it would require EU permission, "creating considerable political and time constraints". (European Council, 2020).

Furthermore, every EU member state will have a vote and veto over the deal, making negotiations more complicated for the UK and a no-deal more likely (European Movement International, 2020).

Without an agreement to the amended of the Treaty of Canterbury, disruptions in the operations of the Channel Tunnel are expected. Already, 27 lorry parks have been proposed all over England with the purpose of holding goods traffic until formalities and additional paperwork has cleared British customs. The disruption could leave up to 7.000 trucks delayed for days, waiting to cross the Channel (Walton, 2020). Exporters are expected to face two-day delays to reach France with 70 per cent of trucks not ready for new checks to cross the Channel – including up to half on the busiest Dover-to-Calais route and in the Channel Tunnel. (Merrick, 2020)

The prospect of the Channel Tunnel becoming impaired by political dissension, possibly remaining long after the Brexit due to bureaucratic slowness, gives competitors of the Channel Tunnel the chance to acquire a larger part of the cargo market. Instead of transporting goods to and from the EU using the Channel Tunnel, intermodal transport can be used. By utilizing short sea transport between the UK and ports closely located to the UK, such as the Port of Amsterdam, the Channel Tunnel disruptions can be avoided.

All major UK ports combined exported 106,691 thousand tonnes to the EU and imported 307,651 thousand tonnes from the EU by maritime shipping in 2019 (Appendix 2). The 18 UK ports that handled Lift on lift off cargo, LoLo, combined exported 5,345,756 TEU to the EU and imported 5,331,120 TEU from the EU in 2019 (Appendix 3). Bulk and Roll on Roll off cargo, RoRo transport will be excluded since the goal of this project focusses on container (LoLo) transport. The ports of interest are ranked by their number of TEU imported and exported from and to the EU. Four UK ports are responsible for 78.7% of TEU's handled, with Felixstowe alone handling 36.0% of maritime TEU (Appendix 3) (Figure 1).



**To calculate TEU, estimations have been made. Containers between 20' and 40' are estimated to be 1.5 TEU and containers above 40' are estimated to be 2.525 TEU.*

Figure 1. Amount of LoLo freight in the UK (gov.uk, 2020; Geestman, 2020)

Although the Brexit expectantly being beneficial for the shift to intermodal transport, the end of tariff-free trade with EU members by leaving the EFTA is expected to damage the overall cargo flow. Tariffs and costs of national market access regulations (Table 4) will be implemented for the UK if the UK and EU are not able to reach a deal regarding trade (European Movement International, 2020).

Table 4. Import tariffs for the UK

Tariffs to the EU	
Product	Tariff
Cars	10,0%
Chemicals and pharmaceuticals	4,6%
Aerospace	7,7%
Capital goods and machinery	1,7% to 4,5%
Food, beverage and tabacco	15,0% to 30,0%

(European Movement International, 2020; Geestman, 2020).

On Chrismas Eve 2020, the UK and EU came to an agreement for trade and cooperation. The UK preserves free movement of goods, services, capital and people. This also means that there will be no no tarrifs on goods between the EU and the UK (Matthijs, 2020). Since the UK left the custom union of the EU, a series of new customs and regulations have been implemented. These new custom rules and regulations are expected to delay Channel Tunnel operations. Advised is to strengthen the trade connection between the Port of Amsterdam and British ports while Channel Tunnel operations are disrupted. The Port of Amsterdam can offer a shortsea connection for transporters to and from the UK to help these transporters avoid Channel tunnel disruptions. 25 percent of total import and export between the UK and the EU goes through the Channel tunnel. The disrupted state of a corridor responsible for a quarter of UK-EU transport is a once in a lifetime opportunity for other UK-EU corridors to start or expand.

3.2.3 Poland

As the Polish economy emerged after decades of state control, industries where privatized and market-based competition was introduced. Within a few years, Polish GDP and living standards started increasing significantly and haven not stopped since. Poland was one of the fastest growing economies worldwide before the 2008 crises and has been *the* fastest growing economy in Europe between the 2008 economic crisis and the Covid-19. (McKinsey&Company, 2015)

This rise in Polish GDP has been achieved just as some Asian countries, like China did as a manufacturing power. No other sector has as much impact as manufacturing, in generating jobs. Even though manufacturing is declining as a share of the global economy, a select group of major manufacturing nations are still expanding their share of global exports. This group of countries includes China, South Korea, the Czech Republic and Poland. Exports from manufacturing account for 33 percent of GDP in Poland. (Sharma, 2017) This is partially caused by the relatively cheap labour, with the minimum Polish wage being less than a third of the minimal Dutch wage. (Table 5)

Table 5. Minimum national wage table

National Minimum Wage			
Country	2020-S2 (€)	2010-S2 (€)	Annual increase (%)
Poland	583	318	8,37
Czech Republic	546	311	7,53
Netherlands	1680	1416	1,86
United Kingdom	1583	1169	3,54
Ireland	1707	1462	1,68

**The annual increase (%) has been based on the past 10 years.*

(Eurostat, 2020; Geestman, 2020)

Exports from Poland to the Netherlands have grown over 76 percent between 2010 and 2018, booking the seconds highest growth after China's 90 percent. (CBS, 2019)Poland is well connected to the Netherlands by train, truck and the numerous ports in the north of Poland. The port of Gdansk, being Poland's largest port, has transported 50 million tons of cargo in 2018. With their strategy to tap into the rail freight traffic between China and Europe, which is booming due to the BRI, in combination with expending their hinterland connection, the port of Gdansk is forecasted to double their transported cargo by 2030. (Railfreight, 2019)Their focus has been on deep-sea traffic rather than short-sea connections that could link the European hinterland. The port of Gdansk is planning to establish a direct rail link to the Belarussian city of Minsk, which has a direct connection to China due to the BRI. Currently, cargo departing from Minsk reaches Gdansk either via the rail link trough Warsaw or via the Lithuanian port of Klaipeda, which is also Gdansk largest competitor in the Baltic sea (Figure 2). The total cost of a feeder slot and inland transport to Minsk via Gdansk is 15 percent lower compared to Klaipeda. Due to the lower costs at Gdansk and establishing a direct rail link to Minsk, the port of Gdansk will be able to attract more cargo. (Landa, 2019) (Railfreight, 2019)

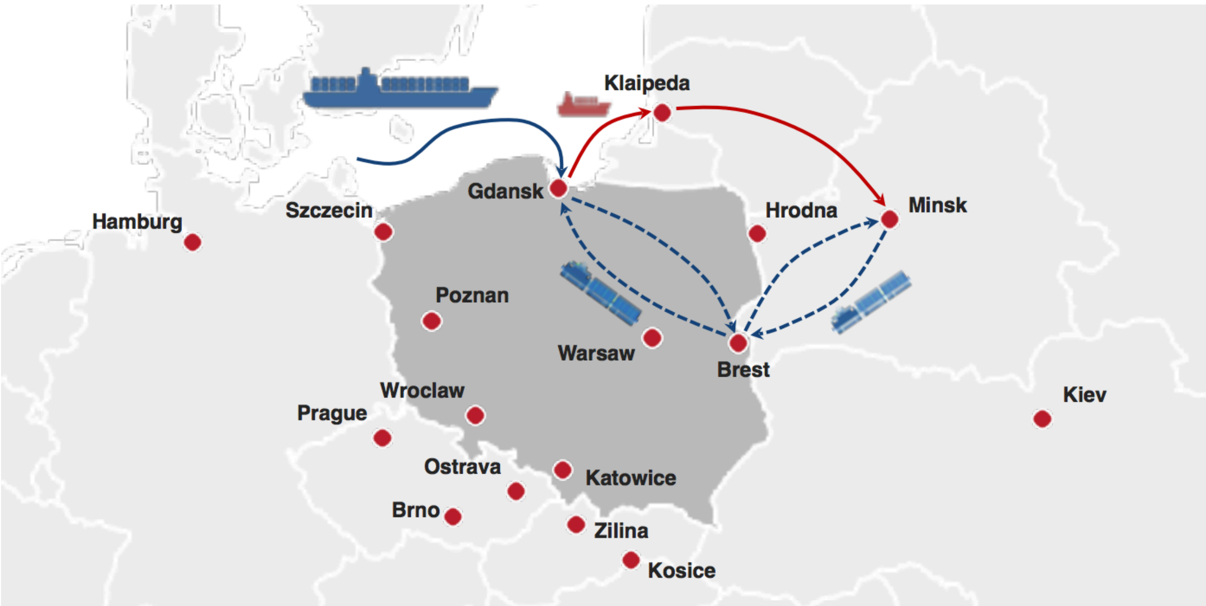


Figure 2. Routes Gdansk to Minsk (Railfreight, 2019)

Furthermore, Gdansk is expending their connection to the hinterland by preparing a direct rail link to Zilina in Slovakia to shorten the route that currently runs via Warsaw and Katowice. This direct rail link is part of the Polish National Railway Programme (Ministry of Infrastructure and Construction Poland; Centre of EU transport, 2017). This same programme aims to increase the Gdansk hinterland connection by rail to the Czech Republic, Slovakia, Belarus and Poland from 33 percent to 50 percent. By shortening the route between Gdansk and Zilina and using their existent direct rail link to Czech Republic's Ostrava, the port of Gdansk hopes to compete with the German port of Hamburg (Figure 3). In costs, the port of Gdansk claims to be 30 percent cheaper on the route to Ostrava and anywhere between 20 to 50 percent cheaper to Zilina compared to Hamburg (Landa, 2019). A downside of the Polish rail network is the maximum speed of rail freight traffic, which is only 30 kmph. In comparison, Germany allows a maximum speed up to 50 kmph for rail freight (Osowki, 2019) and the Netherlands up to 95 kmph (Prorail, 2020). (Railfreight, 2019)

Figure 3. Routes Gdansk to hinterland (Railfreight, 2019)

Due to the well establish ports in the north of Poland, a new cargo corridor between North Poland and Amsterdam will not be researched further. The relatively slow train connections from northern Polish ports to their hinterland, specially to southern Poland and the Czech Republic, gives the port of Amsterdam the opportunity to compete with the Polish maritime ports for the cargo flow of the Czech Republic and southern Poland. It could even be possible for the port of Amsterdam to compete with the port of Klaipeda for the cargo of Minsk.

To take a part of the cargo market share from Poland, the port of Amsterdam could establish a direct rail network to southern Poland. This rail network could even be extended from southern Poland to Minsk, supplementing the Amsterdam-Polish corridor with cargo originating from China. The Amsterdam – Duisburg route, connecting Amsterdam to China, takes 12 days from China to Duisburg. This 12-day journey consist of 10.000 kilometres travelled China to the Polish-Belarusian border city, Brest in five-and-a-half-days and 1.300 kilometres travelled from Brest to Duisburg in six days (Oltermann, 2018). A transit in Duisburg could be skipped by traveling Amsterdam-Poland-Brest (Belarus) -China.

3.2.4 Czech Republic

Like Poland, the Czech Republic benefits from its upcoming economy and low internal wages. Czech minimum national wages are comparable to that of Poland (Table 6). Although having low wages, Czechia has a skilled labour force excelling in manufacturing. By being a relatively cheap manufacturing power, compared to other EU countries (Table 6), combined with their central location in Europe meaning their products have the potential to reach their European customers faster than products from other major manufacturing countries such as China and South Korea, Czechia takes in a strategic trade position.

Table 6. Minimum national wage table

National Minimum Wage			
Country	2020-S2 (€)	2010-S2 (€)	Annual increase (%)
Poland	583	318	8,37
Czech Republic	546	311	7,53
Netherlands	1680	1416	1,86
United Kingdom	1583	1169	3,54
Ireland	1707	1462	1,68

**The annual increase (%) has been based on the past 10 years.*

(Eurostat, 2020; Geestman, 2020)

Most Czech export value in 2018 went to Germany, 32.4 percent. 6,0 percent got exported to Poland, 4,6 percent to the UK and 3,1 percent to the Netherlands. Their three main export product classes are all classes which generally can be easily transported in containers and therefore are suitable for transport by rail and/ or inland shipping. These classes are:

- Machinery and transport equipment 58%
- Manufactured goods chiefly by material 15%
- Miscellaneous manufactured articles 12%

(Czechtrade, 2020)

Due to being landlocked, Czechia must rely on transport by road, rail and inland shipping in to reach seaports of other countries. The port of Hamburg has traditionally been a cargo hub for the Czech Republic and Slovenia. In 2018 over 480.000 TEU were transported on hinterland services between the Czech Republic and the port of Hamburg, of which approximately 450.000 TEU, or 120 trains weekly, whereby rail (Port of Hamburg, 2020). The port of Rotterdam also has a connection to the Czech Republic using the METRANS shuttle, although transporting only a fraction compared to the port of Hamburg. (Port of Rotterdam, 2017) The METRANS shuttle has 11 train pairs per week between the port of Rotterdam and the Czech destinations of Prague and Česká Třebová. Česká Třebová, located between Prague and Ostrava, launched a weekly rail service to Xi'an in China as part of the BTI in March 2019 and added a second weekly departure in September 2019. This connection to China adds an interesting cargo hub to the Czech Republic to connect with the port of Amsterdam. (Railfreight, 2020)

The Port of Amsterdam is advised to exploit the dependability on seaports from the Czech Republic. Due to being landlocked, the Czech Republic heavily relies on seaports from other countries to import and export their goods out of Europe. Outside of goods originating from and destined for the Czech Republic, Czechia's BTI connection makes the Czech Republic a hub for Chinese import and export products. By starting a route from Amsterdam to the Czech Republic, the Port of Amsterdam is able to benefit from both the Czech's dependability of seaports as Czechia's BTI connection.

3.3 Existing connections with the countries of interest

The Amsterdam port region has lots of potential to become a logistic hub. This is due to its strategic location near the North Sea and Rhine, has a good connection with the Dutch rail network and the Amsterdam metropolitan region. This offers a lot of opportunities for the future, like new jobs, new connections and economic growth. The port of Amsterdam wants to take full advantage of these opportunities by combining the benefits of the three strong centers of the Amsterdam metropolitan region: the international logistics function (international hub), the high-quality regional industry (industrial hotspot) and the service center of Amsterdam (metropolitan center).

The Port of Amsterdam is the perfect location for transshipment of goods between Europe and the United Kingdom. Trains and barges arrive at the port, cranes transferring containers and other goods onto short sea vessels with as destination the UK. Due to large terminals from operators like TMA logistics it is possible to achieve fast transfer times to and from the United Kingdom. With a crossdocking station located in the port of Amsterdam, cargo coming from lorries and trains can be unloaded and loaded onto different short sea vessels quickly and efficient.

To know where the gaps are it is important to know where logistic operators are going currently. As discussed in chapter 3.2.1 there are a lot of cargo streams going from Amsterdam to the Ruhr and south-Germany, this area is really saturated with trains and boats already arriving there. With the port of Rotterdam and the port of Amsterdam as main supplier, cargo streams are well organized, and it is difficult to create a new corridor to this region.

With the upcoming economy, low wages and large manufactures facilities, eastern Europe, with focus on South Poland and Czech Republic, is a far more interesting location to set up a new corridor. With only a few direct connections, there is a lot to improve logistically speaking. The upper region of Poland is well connected with Amsterdam and the United Kingdom via the port of Gdansk. This is a good option to transport containers. In the overview below (table 7) all the connections via rail with different operators between Amsterdam and PL/ CZ are shown.
(Samskip Poland Rail schedule, 2020)

Table 7. connection between Amsterdam and Poland/Czech Republic by rail

Amsterdam connection to PL and CZ by rail							
Destination	Route					Operator	Frequency
PL	Amsterdam, NL	Duisburg, DE	Poznan/Kutno, PL			Samskip	6
	Amsterdam, NL	Kijkhoek, NL	Duisburg, DE	Poznan, PL	Warsaw, PL	Kombiverkehr eu.NETdirekt+	
	Amsterdam, NL	Kijkhoek, NL	Wroclaw (Silesia), PL			DB railnet	7
	Amsterdam, NL	Kijkhoek, NL	Köln, DE	Leipzig, DE	Poznan, PL	DB railnet	
CZ	Amsterdam, NL	Kijkhoek, NL	Duisburg, DE	Lovosice, CZ		Kombiverkehr eu.NETdirekt+	
	Amsterdam, NL	Duisburg, DE	Prague, CZ			Samskip	3
	Amsterdam, NL	Kijkhoek, NL	Köln, DE	Leipzig, DE	Lovosice, CZ	DB railnet	

(Samskip Poland Rail schedule, 2020)

As seen in the table above Table 7 there are a lot of stopovers in this cargo stream, via these hubs' containers can be switched between trains and trucks but switching modality means time-delay for the concerning corridor. More stopovers mean more time is required to get from A to B and that costs extra money.

A direct route between Amsterdam and Poland/Czech Republic will lower logistics costs, shipper and logistics companies can also benefit from shorter transit times. This makes rail even more competitive compared to road transport. In contrast with inland shipping, rail transport is expected to match road transport in terms of on-time-performance.

All the connections are visualized in the figure below (Figure 4). Duisburg is one of the biggest in-land cargo hubs of Europe, so almost all the cargo trains departing from Amsterdam go through Duisburg. The marshalling yard Kijfhoek located near the port of Rotterdam and Dordrecht is a large hub used by operator DB cargo, the area is used for shunting rail units. From Kijfhoek there are a lot of connections with hubs in Germany, due to the fact that DB cargo is a German rail freight operator and the largest in Europe.

Figure 4. route network Amsterdam to south Poland/Czech Republic with different operators
(Samskip, 2020; Sybesma, 2020)

In the figure above (Figure 4) you can see that there are not many rail connections between south Poland and Czech Republic. The route south-Poland to Czech Republic is operated mostly by truck, because of the short distance between the two countries it is cheaper to send a truck instead of a whole freight train. This results in few European logistics companies who operate on this route with freight trains. Only the hubs in Wroclaw/ Katowice have a connection with Ostrava, Czech Republic, Katowice is a transit hub to the north of Poland, especially to the port of Gdansk and Gdynia.

There is a large gap via rail transport between these countries as you can see in the figure above (Figure 4), Czech Republic and Poland are building a new rail route in collaboration with the European union, between Prague and Wroclaw, this shortens the travel time between the two cities with 3,5 hours. Constructing the new route should be ready by the year 2050. (The Czech high-speed rail project for Central Europe, 2018)

4 Terminal and modality choice for the Noord West Connect expansion

For the new corridor in the NWC network, there has to be a connection between the United Kingdom and Poland/Czech Republic. there are several connections between these countries but not many of those are direct trains. The port of Amsterdam is used to transship the cargo from train to boat. The departing/arrival terminal in Amsterdam is TMA logistics terminal, this transshipment terminal is facilitated with a suitable train track and a docking station for short sea vessels. From this seaport, short sea vessels are departing frequently to the United Kingdom. Also, TMA logistics terminal is known by NWC, so it would be convenient to use this terminal because of the existing agreements.

In Chapter 4.1 the decision for the regions and terminal in the United Kingdom is explained. In chapter 4.2 the choice of the region and terminal in Poland is clarified and in chapter 4.3 the tradeoff is made for the regions and terminal in Czech Republic. Chapter 4.4 is about the choice of modality.

4.1 Terminal choice for the United Kingdom

The UK consists out 4 countries and of 12 regions. The largest economies are found in the regions with the largest cities. The Greater London region for example is responsible for 20% of the country's Gross national product, GNP, while the second largest region, the North West, is accountable for 7% of the GNP (Rijksoverheid , 2020). Manchester, Liverpool, Blackpool and Lancaster are major cities making up the region of North West England. The striking thing about the UK compared to many other countries is that their major ports aren't bound to big, urbanized areas. As chapter 3.2.2 describes the largest ports in the UK and with 75% of all cargo entering the UK is transported over water this is a massive take of the total trade between the UK and other countries.

Felixstowe is the largest port of the United Kingdom in terms of TEU's and the most potential for a connection to Poland and or Czech Republic via Amsterdam. 36% of the country's container trade is handled at the port of Felixstowe (Appendix 4). In terms of tonnage Felixstowe ranks as 7th largest port in the UK. This is mainly explanatory due to the fact that Felixstowe handles more containerized products and Ro-Ro trailers than other UK ports (Department of Transport, 2018). Felixstowe is geographically close to Amsterdam so transport times will be relatively short. Another benefit it has, that it is well connected with the so called "Golden Triangle" of Britain, an area situated in the heart of England where many high street brands and online retailers' distribution centres are located

The port of Felixstowe has three intermodal rail terminals with 14 inland destinations in the UK and 72 daily arrival and departures. Operators of the terminals are Maritime transport, Freightliner Ltd and GB RailFreight. (Port of Felixstowe, 2020). The port of Felixstowe is capable of handling a million TEU via rail annually. The three rail terminals which are responsible for the handled rail freight are; Northern rail terminal, Central rail terminal and the southern rail terminal. These terminals have many connections throughout the country, see figure 5. The rail connection to London is missing, however, options for last mile transport by road are open. It takes a 2-hour drive from the Port of Felixstowe to the London city centre for example.

Figure 5. Map of intermodal rail connections from Felixstowe per operator
(van der Heijden, 2020; Port of Felixstowe, 2020; Maproom, 2020)

Port of Felixstowe consists out of three maritime terminals. The trinity terminal, Berths 8&9 and Dooley Ro-Ro terminal for trailers, see Table 8. The terminals, as the harbour itself are 24h, seven days a weak operational. These terminals are capable of handling deep-sea vessels as well as handling short sea vessels. Felixstowe offers shortsea connections to a number of destinations such as Rotterdam, Le Havre, Hamburg, Zeebrugge and Antwerp (Shortsea schedule, 2020). The current short sea connection with Rotterdam is operated by Dfds Seaways and consists out of Ro-Ro goods. This is of no competition with the corridor being set up between Amsterdam and Felixstowe as this corridor will consists out of containers only. However, currently there are a few connections to the United Kingdom from Amsterdam. There are shortsea vessels departing from Amsterdam to Hull, Tilbury, Boston and Northfleet. Operated by shippers as Samskip, Seacon, TST-sunline and SCS Multiport (Sjoerdsma, 2020). The ports they are sailing to are rather small and have minimal intermodal solutions from there onwards. However, they are well situated and connected to the UK's national highway's, so suitable for last mile transport by road. To make a true new intermodal connection to the UK and its hinterland, Felixstowe would be optimal. Depending on the demand this could be a better intermodal solution. If the demand is insufficient it would become hard to compete with the sailing vessels mentioned above and one of those destinations would be preferred. Seacon, who's sailing to Boston and Northfleet in the UK can be neglected since they solely operate with Bulk cargo and do not possess Shortsea container vessels. So, Tilbury or Hull would then be a competititor on that route.

Since there is no real difference, other than size, of the two container terminals, both the Trinity terminal as well as Berths 8&9 are suitable for setting up the corridor. The trinity terminal is closer to the Northern and Central rail terminal whilst Berths 8&9 are closer to the Southern rail terminal. All three rail terminals offer the same destinations, only differ in frequencies, so all are suitable for making the connection with the hinterland.

Table 8. Terminals in the Port of Felixstowe

Terminals in the Port of Felixstowe			
Terminal	Length	Stack capacity	Reefer capacity
Trinity terminal	2,354m	96,000 TEU	1,600
Berths 8&9	920m	44,000 TEU	300
Dooley Ro-Ro terminal	208m	850 trailers	NA

(Port of Felixstowe, 2020)

Felixstowe is not the only port in England with potential. Other contenders for the new corridor are Southampton and London. The port of Southampton is of its geographically inconvenient position a less desirable port to make a connection with. The port has also a large amount of passenger traffic due to many cruise liners operating from this port. With four cruise terminals a yearly 1.9 million passengers use the port of Southampton (Associated British Ports, 2020). Although it handles a large number of passengers annually it also handles a considerable amount of TEU's as well. In 2019 the port of Southampton handled just a little under 1.9 million TEU's which is good for 17.6% of the total TEU's that enter the UK (Appendix 4) The Port of Southampton has 2 rail freight terminals with connections to large cities like Leeds, Manchester and Liverpool. The port only has 9 direct connections, which has a negative impact on the connections it can offer to complete the corridor that is aimed to be created (Genesee & Wyoming , 2020)

Another less desirable port is the port of London. It ranks 3rd in terms of handled TEU's annually, around 1.7 million units. In terms of tonnage, it does better and scores 2nd largest of the UK. This is the result of the many dry bulk terminals in the port. The port of London does have a different structure as Felixstowe and Southampton. The port of London is stretched out along the Thames and not concentrated at a single location and therefore most container handlings are performed in the DP World London Gateway terminal. This terminal is located at the opening of the Thames near Southand-on Sea. C R O Ports Dartford and Stanton Grove are two terminals who handle containers but are of a less significant size compared to London Gateway terminal. Also, London gateway offers less train directions than Felixstowe but is closer to one of the largest metropolitan regions in Europe. It does have the advantage that it is well suited for inland water transport, the disadvantage is that the possibilities of inland shipping starting on the Thames is limited. Therefore, Felixstowe is a more convenient candidate for setting up a corridor with Amsterdam.

Felixstowe has the most rail connections, many years' experience with handling containers and has the best infrastructure to handle huge number of containers. Felixstowe is the most versatile when talking about last mile transport. Southampton and London are also possible; however, Felixstowe offers more possibilities and is the most preferable for making a corridor with Amsterdam work.

4.2 Terminal choice for Poland

Poland is strategically positioned between Western Europe, bordering on Germany, and Russia, and it has access to the Baltic Sea. It thus enjoys the advantages of proximity to attractive consumer markets in the EU, Russia, Ukraine, Turkey, and the Middle East. Thanks to accelerated infrastructure development in recent years, Poland has an opportunity to help local industry grow to serve neighboring markets more effectively. Textiles and apparel, furniture, and fabricated metal products are among Poland's most fragmented industries. Skilled labor and supplier networks are concentrated in traditional regions

As to be seen in the map op Poland with the intermodal terminals (figure 8), one of the main drawbacks of the Polish intermodal market is a lack of loading facilities in some regions and overcapacity in others, in the south of Poland there are a lot of intermodal terminals and in the north and east there are few.

4.2.1 Potential regions

Poland is a large country and consist out of 16 regions. To be able to find a suitable terminal, first the suitable region will be discussed.

Northern half of Poland

Poland is only connected with water on the north side of the country. The northern regions have benefits when it comes to cargo exporting and importing because of the large seaports located in the north of Poland. There are four big seaports, two near de city of Gdansk: Gdansk and Gdynia. And two in the upper west region: Szczecin and Świnoujście. Said in paragraph 3.2.3 the focus is not on the northern part of Poland, because of the connection with the seaports.

Southern half of Poland

The southern half of Poland does not have a good connection with the seaports in the north, because of bad road and rail connections and long distances. A truck takes almost six hours to get from Katowice to the seaport of Gdansk, and then the cargo has to be loaded on a ship to be shipped to western Europe. It is a lot faster to put the container directly on a train from south Poland to western Europe.

In the map of Poland below (figure 6) the goods transported abroad via road are shown and in the other map (figure 7) the amount of TEU transported per region via intermodal road transport is visualized. Currently almost all the inland cargo transport happens with the use of a truck. These figures are made from calculations from road transport only. With these figures it is possible to see where the big cargo streams of trucks are coming from or going to. These figures are helping to choose a region for setting up a new corridor. If the two figures are merged and compare the different regions (only the one in south Poland), it is noticeable that Dolnośląskie (Lower Silesia) with the capital of the province: Wroclaw, śląskie (Silensia) with the capital of the province: Katowice, and Lodz province with the capital of the province: Lodz are the three largest provinces in the south of Poland in cargo transportation.

Figure 6. Goods transported abroad via road in thousand tonnes (2019)
(Transport activity Poland, 2019; Sybesma, 2020)

Figure 7. TEU transported per region via intermodal road transport (2019)
(Transport activity Poland, 2019; Sybesma, 2020)

Lower Silesia

Lower Silesia is an industrial region in Poland. Two of the most important branches are the automotive and electro-mechanical. There are also a lot of IT companies operating in the region.

In the south of lower Silesia there is an area called the Black triangle. The area is known for its natural resources and mineral deposits, and had traditional glass, ceramics, and textiles industries. the Turów Coal Mine is still operational and produces over 30 million tons of lignite per year.
(EC Europe, 2013)

Lesser Poland

The Lesser Poland province has developing high-tech and motor industries, the region preserves traditional sectors as metallurgy, heavy chemicals, mining, metal, tobacco and food industries. The largest companies located in Malopolska are BP Polska SE (fuel), Philip Morris International (tobacco), Coca Cola, Grupa Azoty - Tarnów (chemical industry), Synthos SA (chemical industry), Comarch (IT solutions), Can Pack SA (packaging industry), Vistula group (fashion) and Wawel SA (chocolate and sweets). Other big companies are Motorola, MAN, Delphi, Valeo, IBM, Electrolux, Shell and Capgemini.
(EC europe Lesser Poland, 2013)

De Lesser Poland province with capital Krakow has two intermodal terminals. The two terminals have no facilities like cranes and can't handle long trains because of the limitation in train track length. So, this region is also not suitable for the new route.

Silesia

In Silesia the most important industries are mining, iron, lead and zinc metallurgy, power industry, engineering, automobile, chemical, building materials and textile. In the past, the Silesian economy existed almost only of coal mining. Nowadays, car manufacturing is becoming a more predominant industry in Silesia. A few big companies operating out of Silesia are: Fiat Auto-Poland in Bielsko-Biała, GM Opel in Gliwice, and FCA Powertrain Polska. The biggest Polish steelworks, Huta Katowice is situated in Dąbrowa Górnicza. Other foreign investors are IBM, Unilever, Rockwell, Capgemini, Deloitte, Vattenfall and ABB.
(EC Europe Silesia, 2013)

Lodz

Lodz province is located in de centre of poland, but close to the large producing provinces in the south. It is home to many international companies like Nordea Bank, Sandoz, Infosys or Hewlett-Packard. The largest Polish companies in this province are Pelion SA (pharmacy - trade), JTI Polska (tobacco), Indesit (household appliances), Spoldzielnia Mleczarska Łowicz (food industry) and Grupa Paradyż (building materials)
(EC europe Lodz, 2013)

Preferred region

It is obvious that the northern half of Poland is not being used in the route of the new corridor, because of the large seaports located on the north coast. Lodz is a good option, because of the many international companies, but is located in the center of Poland and has good rail and road connections with the large seaports. Most of de cargo will go via ship.

The south of Poland has a lot of labor-intensive production of goods. Which is perfect to transport to western Europe. De Lesser Poland province with capital Krakow has two intermodal terminals equipped with almost no facilities. So, this region is also not suitable for the new route. Lower Silesian and Silesian are both suitable for the new route because of the big capital cities Wroclaw and Katowice and because of the large factories where goods are produced are located in the region. This makes it perfect for the new corridor.

4.2.2 Desired terminal

Terminal concentration can be found in several parts of Poland. There are around 40 intermodal terminals across the country. The regions around Poznan and Katowice have five terminals each, while Tricity and Łódz have four terminals each. Wroclaw and Warsaw have three terminals, and then there are a few close to small cities or between two big cities. The map of Poland below (Figure 8) shows that there are enough facilities on the Polish Baltic seashore, in the central part of the country and in the south. At the same time, other regions only have a few terminals or none at all. The most undeveloped region in terms of intermodal facilities is northeastern Poland. The region has only two intermodal facilities.

Figure 8. Map S3 Intermodal terminals Poland (Agora, 2020)

In the table (Table 9) below the amount of TEU loaded in intermodal terminals is stated. (in thousand TEU). The terminals with a red star are located in Silesia and the terminal with the black star is located in lower-Silesia. All these terminals are one of the largest in transshipment of containers in Poland. So, it is sensible that the new corridor is going through these terminals to load and unload goods.

Table 9. The amount of handling of intermodal terminals in the years 2020-30 in thousand TEU

Type of container terminals	Location	Up to 2020	Up to 2025	Up to 2030
Transit terminals	Małaszewicze	90	180	270
	Medyka	40	80	120
	Sławków *	40	80	120
	Trakiszki	50	100	150
Main terminals	Gliwice *	140	280	400
	Kraków	30	150	270
	Kutno	120	240	360
	Poznań	120	240	340
	Warszawa	140	280	420
	Wrocław *	130	260	370
Local terminals	Dąbrowa Górnicza *	70	150	250
	Brzeg	70	150	230
	Mława	40	70	90
	Kielce	30	50	60
	Koluszki	30	50	60
	Lublin	40	70	90
	Małkinia	40	70	90
	Suwałki	40	70	90
	Swarzędz	80	190	270
	Szczecinek	40	70	90
	Swiecie	20	35	50
	Tarnów	20	35	50
	Rzepin	40	70	90
	Total	3060	5280	7300

(UIC freight department, 2020)

There are two intermodal terminals in Gliwice, Container terminal Gliwice and Gliwice Terminal PCC, they are both located on a train track. Container terminal Gliwice is located directly alongside the highway A1, so it is good access to the hinterland for possible last mile transport. The facility covers 65.000 square meters, with two loading train tracks with a length of 410 meters each, and one railway crane. The terminal has a storage capacity of 1.800 TEU and an annual handling capacity of 128.000 TEU.

Gliwice Terminal PCC is also a good option due to the fact that it's one of PCC intermodal's hubs. PCC is a large intermodal operator who has another hub near Wroclaw. The facility covers 50.000 square meters of operating areas and 4 railway tracks 650 meters each. It has a handling capacity of 150.000 TEU per year and has two railway cranes. The hub is located 35 kilometers from Katowice. It would be convenient to use the PCC terminal Gliwice for the new corridor, because it has longer loading train tracks. With longer rail it can handle longer trains that results in more cargo handling. It also has two cranes instead of one, this means it can load and unload twice as fast.
(Terminal Kontenerowy Gliwice, 2020)

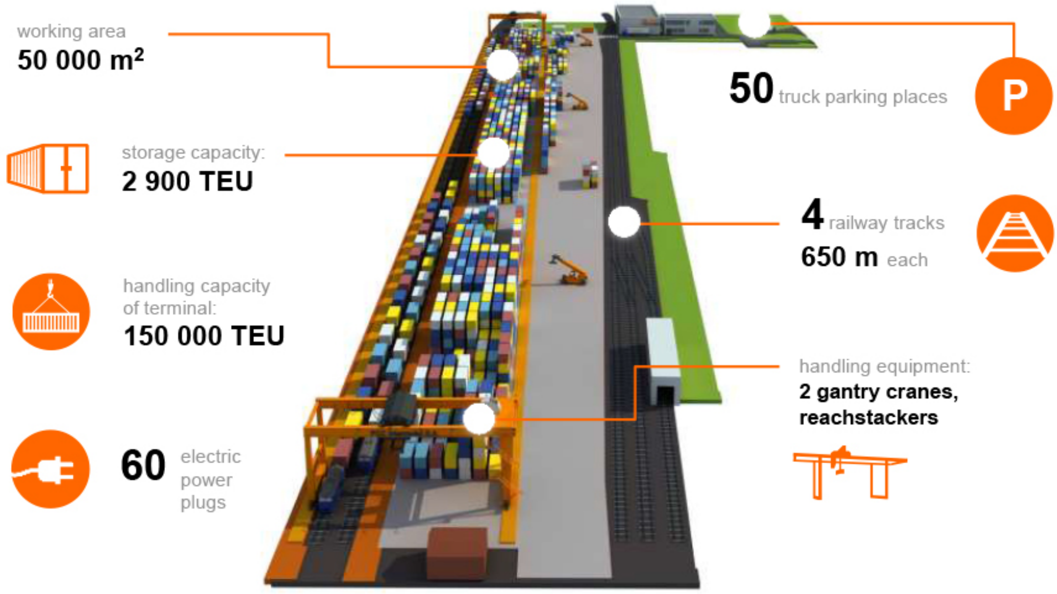


Figure 9: PCC intermodal terminal Gliwice services
(PCC intermodal terminal Gliwice, 2020)

In Wroclaw there are 3 intermodal terminals. All three terminals are located outside of the city of Wroclaw. The Kąty Wrocławskie Rail terminal already has good rail connections with the seaport of Gdansk and Gdania operated by Maersk and also has a connection with the Port of Rotterdam operated by Hupac. The Dutch company Schavemakers Logistics has a direct route between Kąty Wrocławskie Rail terminal and Moerdijk in the Netherlands. This terminal is already saturated with operators, so it is not suitable for our corridor.
(Schavemaker logistics, 2019)

Wroclaw Siechnice is a small terminal with less operators arriving there. It has almost no facilities like cranes and power plugs. This terminal is not suitable for the new corridor.

Brzeg Dolny Terminal PCC is the best option, because of the large operator PCC intermodal, they also have a direct rail connection with Gliwice. The facility in Brzeg Dolny covers 28.000 square meters of operating areas and 4 railway tracks long for 650 meters each. It also has a handling capacity of 110.000 TEU per year. The hub is located 55 kilometers from Wroclaw. (PCC intermodal Terminal Brzeg Dolny, 2020)

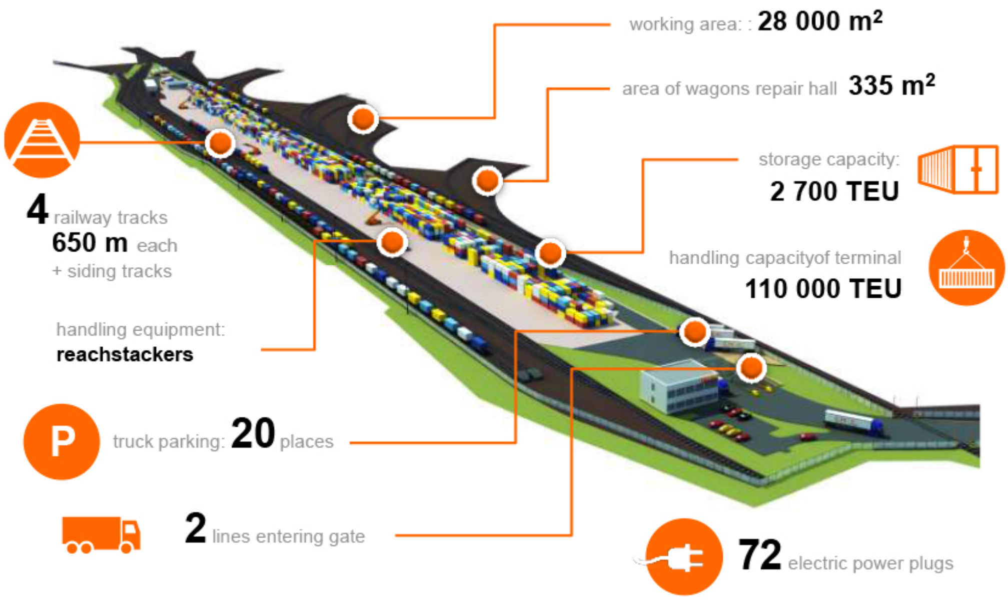


Figure 10. PCC intermodal terminal Brzeg Dolny services
(PCC intermodal Terminal Brzeg Dolny, 2020)

4.3 Terminal choice for the Czech Republic

Chapter 4.3 gives an explanation how a specific terminal in the Czech Republic is chosen as a candidate for the expansion of the NWC network. First off, chapter 4.3.1 explains the national transport flow which gives an insight in import and export by region and trade between specific regions. Chapter 4.3.2 gives an insight in existing rail corridors within, from and to the Czech Republic. Chapter 4.3.3 compares to previous two chapters to identify a region in the Czech Republic with a high cargo flow but without and intermodal corridor. The same chapter offers potential terminals within the promising region whom can potentially be used for a new NWC corridor.

4.3.1 National transport

The intermodal split of national cargo transport in the Czech Republic consists out of 0.13 percent inland shipping, 7.3 percent rail and 92.6 road. When eliminating intra-regional cargo flow, Czechia's national modal shift changes to 0.3 percent inland shipping, 20.1 percent rail and 79.7 percent road. (Appendix 5) The majority of national transport, 75.7 percent, is intra-regional transport. Interregional transport consists of two clusters of regions, one located in Bohemia and one located in Moravia. (Appendix 6). The Bohemian cluster consists of Prague, Central Bohemian, South Bohemian, Plzen, Usti nad Labem, Liberec, Hradec Kralove and Pardubice with Central Bohemia as hub. The Moravian cluster consists of Vysocina, South Moravian, Olomouc, Zlin and Moravian-Silesian. The Moravian cluster shows no clear hub, although Vysocina is only part of this cluster because of the cargo flow density it has with South Moravian (Figure 11). Notable cargo flows are Usti nad Labem to Pardubice, 4.806.420 tonnes, and Hradec Kralove to Pardubice, 3.077.970 tonnes. The two clusters are connected by Central Bohemian. (Sydos, 2020)

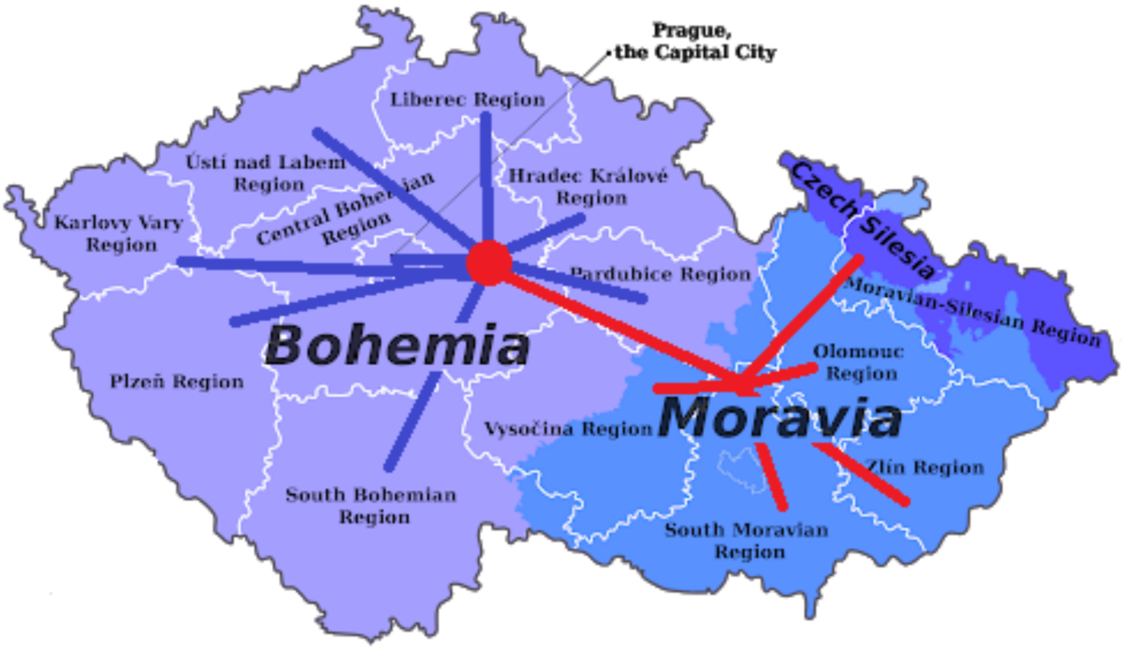


Figure 11. Interregional transport clusters. Bohemian cluster displayed in blue and Moravian cluster displayed in red. (FeelingEurope, 2020; Geestman, 2020)

4.3.2 Inland shipping

Czechia utilizes 16 intermodal terminals, mostly located in the regions Usti nad Labem, Prague and Ostrava. Of the 16 intermodal terminals, two can handle inland shipping (Figure 11) (appendix 7).

Figure 12. intermodal terminals Czech Republic. Marked yellow if able to handle barge. (Agora, 2020)

Inland shipping only makes up 0.13 percent of Czech national cargo flow and is limited to the regions of Prague, Central Bohemian and Usti nad Labem. Using Czech operators only, inland shipping contributed to 0.216 percent of cargo flow between the Czech Republic and the Netherlands in 2019 (Appendix 7). Inland shipping using Czech operators between the Czech Republic and Poland was not existent in 2019, although has existed in the past. Inland shipping between the Czech Republic and the United Kingdom is geographically not plausible. Furthermore, only the intermodal terminals Marianska skala and Mělník Labe are capable of handling barge (Apendix 7) (Agora, 2020). (Sydos, 2020)

Table 10. Inland shipping into and from the Czech Republic in 2019 in percentage

Inland shipping into and from the Czech Republic 2019			
Country	Import	Export	Total
Netherlands	0.307%	0.095%	0.216%
United Kingdom	0.000%	0.000%	0.000%
Poland	0.000%	0.000%	0.000%

(Sydos, 2020; Geestman, 2020)

4.3.3 Rail

Currently, there are 195 freight trains a week departing on both ends running from the Czech Republic, operated by six intermodal transporters (Appendix 9). METRANS, operating the majority of Czechia's continental freight trains (Table 11), uses Prague and Česká Třebová as inland HUB's to export to sea HUB's abroad (METRANS, 2020). Intermodal train connections between the Netherlands and the Czech Republic are limited, and only running nine times a week, to Rotterdam –

Prague and Rotterdam – Česká Třebová (Appendix 9). Both cities are in the Bohemian part of the Czech Republic meaning there is no Dutch rail connection to Moravia.

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Table 11. CZ continental cargo flow rail.

Czech Republic continental cargo flow rail		
Operator	Frequency	International frequency
RCA CSKD	32	0
METRANS	121	95
MAERSK	6	6
Adriakombi	14	14
Bohemiakombi	20	20
Alpe Adria	2	2

(Geestman, 2020; Cosmos, 2020; METRANS, 2020; METRANS, 2020)

Rail transport within the Czech Republic, amounting to 20.1 percent of Czechia's interregional transport, centres around Usti nad Labem with four major cargo streams:

1. Usti nad Labem → Pardubice 19.1 percent
2. Usti nad Labem → Central Bohemia 16.1 percent
3. Central Bohemia → Usti nad Labem 6.8 percent
4. Karlovy Vary → Usti nad Labem 5.7 percent

(Appendix 10) (Sydos, 2020)

The only Dutch port connected by rail to the Czech Republic is Rotterdam. The regions connected to Rotterdam within the Czech Republic, Prague and Pardubice, have a relatively small cargo flow with the Moravian regions Moravian-Silesian, Zlín and Olomouc flow. These three regions make up for 30.6 percent of Czechia's national cargo flow. Most of the cargo flow between these regions is transported by truck (Table 12). The cargo flow from Prague to these three Moravian regions is especially small, contributing to only 0.38 percent of Czechia's national cargo (Appendix 10).

Table 12. Intra-regional transport Czech Republic

Intra-regional transport CZ				
Rail				
Region of unloading				Total
Region of loading	CZ071	CZ072	CZ080	
CZ010	35.08	6.99	52.60	94.67
CZ053	9.39	394.15	314.60	718.14
Road				
Region of unloading				Total
Region of loading	CZ071	CZ072	CZ080	
CZ010	330.80	87.75	298.91	717.46
CZ053	578.51	88.61	376.28	1043.41

(Sydos, 2020)

There is no direct rail connection between the Netherlands and the Moravian regions of the Czech Republic. The Czech regions with a direct rail connection to the Netherlands have a small cargo flow, mostly transported by truck, to the Moravian regions. Because the Czech Republic is landlocked, it is dependent on seaports outside its own border. The rail connection from Rotterdam to the Bohemian part of the Czech Republic only has nine bilateral freight train departures a week, out of the 137 international bilateral freight train departures with European terminals. Most of these connections, 96, are with German terminals. Poland is planning to modernize their rail network to create a direct connection between the port of Gdansk and Ostrava, Moravian-Silesian, to increase their market share. The largest region with neither a direct connection to the Netherlands nor has a high cargo volume flow by rail to one of these direct connections is Moravian-Silesian (Appendix 10). Moravian-Silesian makes up 16.0 percent of national cargo flow (Table 13) or 30.6 percent when counting Zlín and Olomouc as hinterland connections. Ostrava is the largest city within the Moravian-Silesian region and the third largest in the Czech Republic, both by size and population (Table 13)

Table 13. Interregional rail transport CZ

Interregional rail transport CZ			
Region		Total	Percentage
CZ042	**Usti nad Labem**	16,011.14	64.0%
CZ020	**Central Bohemian**	7,941.37	31.8%
CZ053	**Pardubice**	7,283.42	29.1%
CZ080	**Moravian-Silesian**	3,999.20	16.0%
CZ041	**Karlovy Vary**	2,685.09	10.7%
CZ032	**Plzen**	1,994.95	8.0%
CZ071	**Olomouc**	1,966.80	7.9%
CZ010	**Prague**	1,846.37	7.4%
CZ072	**Zlín**	1,686.45	6.7%
CZ064	**South Moravian**	1,347.31	5.4%
CZ052	**Hradec Kralove**	1,235.77	4.9%
CZ031	**South Bohemian**	928.02	3.7%
CZ063	**Vysocina**	807.68	3.2%
CZ051	**Liberec**	268.06	1.1%

(Sydos, 2020)

Ostrava has three intermodal terminals within 40 kilometres: Ostrava Senov, Ostrava-Paskov and Koprivnice. Neither of these intermodal terminals are connected to inland shipping (Appendix 11).

Intermodal terminal Ostrava Senov, located in the North-East of Ostrava, is equipped with four 45-ton reach stackers, three 12-ton reach stackers and one RTG KALMAR crane. Their capacity is 8.000 TEU. The terminal area is 100.000 square metres and the stacking area is 65.000 square meters. The terminal has 1.000 meters of handling tracks. The opening hours are Monday-Friday 07:00 hour to 18:00 hour (METRANS, 2020) (Port of Antwerp, 2020)

Intermodal terminal Ostrava-Paskov, located in Paskov, is equipped with three 45-ton reach stackers and one 46-ton reach stacker. Their open-air warehousing capacity is 2.400 TEU and their warehouse handling area is 31.000 square kilometres. 20', 30', 40'and 45' ISO containers can be handled here. The terminal has three handling tracks, each 270 meters long. Furthermore, the terminal is located six kilometres from the Staříč relief yard with a capacity of 600 TEU and 280 meters of available rail. (PKPcargo, 2020)

Intermodal terminal Koprivnice, operated by ARGO BOHEMIA s.r.o., is the smallest of the terminals located near Ostrava. The terminal is located 36 kilometres South-West of Ostrava in the city of

Koprivnice. The terminal is equipped with one PD 38 gantry crane and one PB 35 side loader. Their storage capacity is 400 TEU (Argo Group).

Terminal Koprivnice is the least preferable terminal out of these three since it is located the furthest from Ostrava, has the lowest storage capacity and the lowest amount of terminal loading equipment.

Existing intermodal corridors from terminal Ostrava-Paskov and terminal Ostrava Senov are:

- Ostrava Senov <> Česká Třebová. Six times a week. Operated by METRANS
- Ostrava-Paskov <> Hamburg. Twice a week. Operated by RCA CSKD
- Ostrava-Paskov <> Prague. Ten times a week. Operated by RCA CSKD

(METRANS, 2020) (Cosmos, 2020)

Preferred terminal Czech Republic

Both the Ostrava-Paskov Terminal in Ostrava-Paskov and the METRANS Container Terminal in Ostrava Senov are suitable to be used for an Amsterdam – Czech connection. The travel time from Amsterdam to the Ostrava-Paskov Terminal by rail is only minutes shorter than compared to the METRANS Container Terminal. Both terminals have the handling tracks to handle a 650-meter train, which is the maximum allowed freight train size on the Dutch – Czech route and are capable to store containers. The METRANS Container Terminal in Ostrava Senov is preferred to be used due to their larger capacity but both terminals are suitable.

4.4 Modality choice

For transport between Poland, the Czech Republic and the Dutch North-west region, there are four modalities to choose from: air, road, rail and inland waterways. During this chapter, the connection Amsterdam-Prague, CZ and Amsterdam-Katowice, PL are compared in time, relative costs and advantages. These routes are chosen since these are two optional corridors that represent transport to both the Czech Republic as to Poland. (Bureau Voorlichting Binnenvaart, 2020)

Airplane

Using an airplane to fly the goods from Amsterdam to Prague or Katowice would be 3 times as expensive as compared to a HGV40 and over 10 times as expensive per km compared to using a train or ship (Goor, 2015). The biggest advantage an airplane has over the other modalities is its speed. Using an airplane would take only 3 hours and 45 minutes to fly to Katowice and just short of 1.5 hours to Prague but will take additional time to get the airplane ready before take-off, such as getting the cargo loaded into the plane and checking the content of the cargo. (Rome2rio, 2020)
Activities such as loading the airplane and checking the documents, combined with the major increase in price, make this an unreasonable modality to use for the transport of most goods.

Inland shipping

The routes Amsterdam-Prague and Amsterdam-Katowice are 1178 km and 1251 km long respectively by inland shipping (Appendix 12). The route between Amsterdam and Prague is 1178 km and Amsterdam-Katowice is 1251 km by ship. The nearest city reachable by ship is Pardubice, this is still around 300 km from Katowice (binnenvaart, 2020). Due to the poor waterways between Amsterdam and Katowice, it is advised to use rail or tuck on this route. The biggest advantage of inland shipping is the relatively high capacity of inland ships. A standard barge ship can transport up to 208 TEU (Konings, 2009). A freight train can roughly transport 100 TEU assuming a single wagon carries 2 TEU (Prorail, 2020). The price of inland shipping is also relatively low compared to train and trucks

(Table 14) (Goor, 2015). The most common ship for inland shipping is a “dry cargo carrier”. This ship sails at about 14 knots (26kmph) when loaded (Young, 2015). Assuming the ship moves at 26 kmph it can be estimated that it takes approximately 45 hours to Prague from Amsterdam and 52 hours (48 hours by inland ship plus 4 hours by truck when operating non-stop) to Katowice from Amsterdam.

Truck

By road it would be when departing from Amsterdam 880 km to Prague and 1191 km to Katowice (Appendix 13). The maximum speed for a truck on the motorway in the Netherlands, Germany, Czech Republic and Poland is 80 kmph (Appendix 14). When able to drive the maximum speed all the time, a truck will take around 22 hours and 45 minutes to drive to from Amsterdam to Prague when taking in conisation that a truck driver can only drive up to 9 hours a day and must take 45-minute break every 4 and a half hours (Department of Transport, 2020). From Amsterdam to Katowice takes roughly 15 hours (non-stop). Adding the 11 hours of rest and a 90-minute break would make the total trip time 27 hours and 30 minutes. It is important to note that truck can easily get stuck in traffic which would prolong travel time. The other modalities do not have this problem but have other calamities that make them inconsistent, such as harsh weather.

Shortsea ship

A possible route to move cargo is for it to be transported from Amsterdam to Felixstowe by shortsea (3.2.2 and 4.1) (Appendix 15). This route is approximately 250 km by sea and should take around 9 hours depending on the ship. The only alternative is using the Channel Tunnel Between dover and Coquelles near Callais. Long queue times and possible British political decision make it a suboptimal choice for transporting to the UK (3.2.2). (Young, 2015)

Freight train

The rail connection between Poland and Amsterdam is feasible to use. From Amsterdam to Prague it is 1005 km by rail and from Amsterdam to Katowice it is 1178 km(3.2.3)(Appendix 16). The maximum speed for freight trains within Europe varies from country to country, this is caused by difference in rails, locomotives, laws and regulations (Table 15). There are multiple models of trains that travel in the Netherlands, Poland, Germany and the Czech Republic. The fastest freight train in Europe goes around 160 kmph (Josef, 2020). The European commission plans to create a rail network within Europe where high-speed trains can be used. At the moment these high-speed train lines are mostly concentrated in Germany, France, Spain, and Italy, but these are not well connected to each other (European Court of Auditors, 2018). High speed trains reach speeds of 200-360 kmph making the travel time between Amsterdam and Frankfurt only 1-2 hours, from Frankfurt there is only about 580 km left for Prague (CER, 2016) (World Region Europe, 2020). The innovation for these passenger trains will improve the rail networks as these need to be able to handle faster trains. Faster rail networks are expected to benefit freight trains as well, as they are expected to be able to drive faster on the improved rails. The maximum size for trains in The Netherlands is 650 metres but is going to increase to 740 metres. In Germany, the Czech Republic and Poland the maximum size is already at least 740 metres (Figure 11). (Troche, 2005)

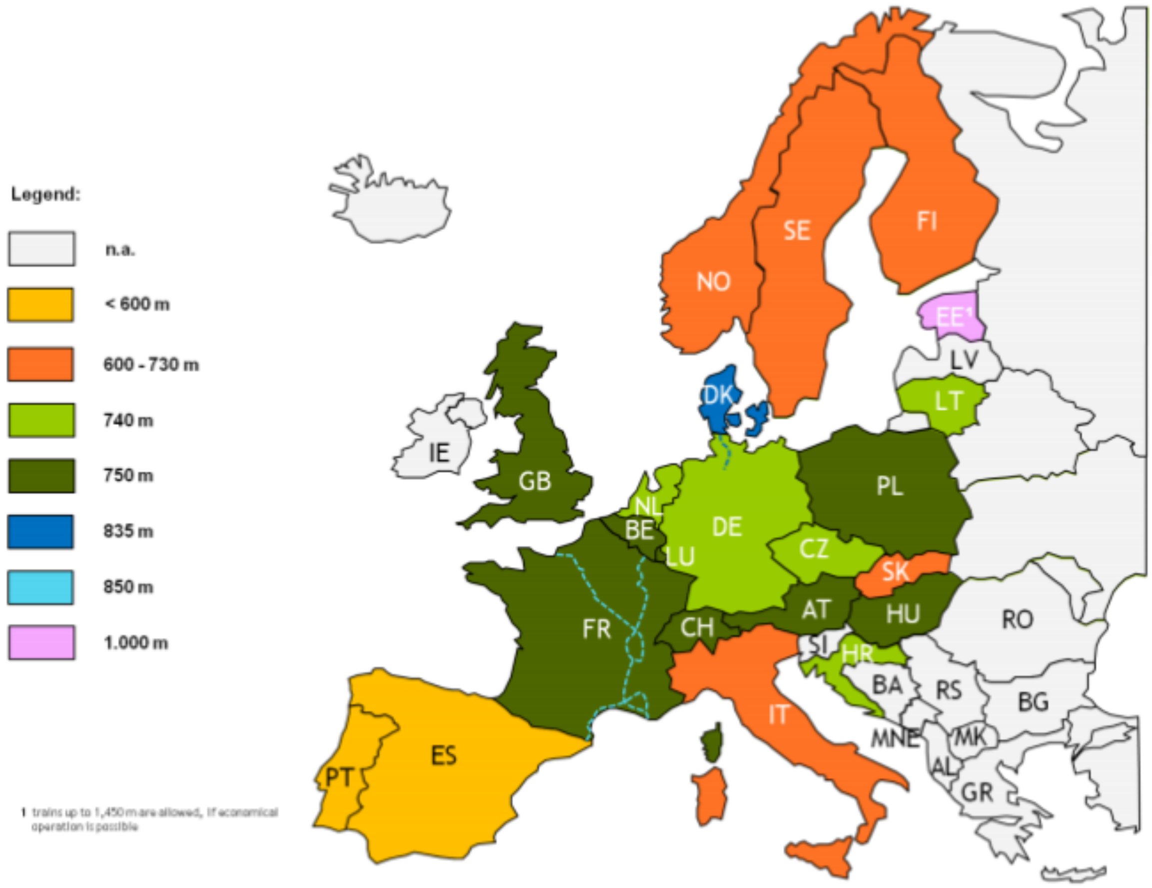


Figure 11. max. Train size (CER, 2016)

Table 14. Relative price index between modalities

Relative price index between modalities					
Modality	Cost per km (index)	Distance Katowice, PL to Amsterdam, NL in km	Distance Prague, CZ to Amsterdam, NL in km	Relative price index with distance Katowice	Relative price index with distance Prague
Road	100	1191	880	100	100
Rail	23	1178	1005	22.7	26.3
Inland shipping	7	1251	1178	7.4	9.4

(Azoulay, 2020; Goor, 2015)

Table 15. Average speed for rail freight per country in kmph

Average speed kmph rail freight traffic new NWC network	
Country	Average speed in kmph
Czech Republic	77.8
Germany	60
Netherlands	60
Poland	31.7
Gdansk, PL	19

(Geestman, 2020; European court of auditors, 2016; FR8HUB, 2020; RFC7, 2017; Leijen, 2020)

Train transport should roughly cost 22.7 percent of the transport costs of trucks on the Katowice leg and 26.3 percent on the Prague leg (Table 14) (Goor, 2015). The time difference between train and truck is almost 10 hours in favour of the train transport for the bilateral route Amsterdam-Katowice (Table 18, Table 19). This is a result of the many mandatory stopovers for truckdrivers. A negative of for train transport is that the cargo is more likely to get damaged compared to that of other modalities.

Due to the major speed difference and therefore time difference between inland shipping and the other modalities combined with the fact that there is no waterway from Amsterdam to Katowice, further research into the benefits of inland shipping is stopped from here one. This leaves rail with the best modality prospect other than transporting goods by road. Rail is a lot cheaper and has roughly the same travelling time as road, if not faster, for travel distances of further than 24 hours away.

5 Realization new NWC corridor

This chapter goes into detail why a specific route is or is not chosen and ends with an advice for the best corridor out of the researched routes. To best corridor is a trade-off between operating costs, demand, existing routes and terminal capabilities. This chapter discusses the feasibility of the corridors in terms of cost in chapter 5.1, demand in chapter 5.2 and competitive advantage in chapter 5.3. Chapter 5.4 concludes the best corridor choice.

5.1 Corridor cost

To validate the rail corridor, the rail corridor must have a cost and/ or time benefit over road transport. Chapter 5.1 explains the calculations made to compare a rail corridor to road transport between two terminals in both cost and travel time. This chapter begins with the route distance and route travel time between different potential terminals, followed by the accompanying costs of these routes. Chapter 5.1.6 compares the cost between the two modalities and chapter 5.1.7 closes chapter 5.1 by explaining the best route(s) based on transport cost, transport time and terminal capabilities.

5.1.1 Route Distance

The route distances are calculated from terminal to terminal and listed in the table according to the city wherein the terminal is located (Appendix 19). Distance by road (Table 17) has been calculated using the Google Maps tool and picking the shortest route between the addresses from the terminals (Appendix 20). Distance by rail (Table 16) has been calculated using the Rome2rio tool. Because two terminals, the HHLA Container-Terminal Hamburg and TMA Logistics Terminal Amsterdam, are not found using the Rome2rio tool, alternative locations have been used in combination with the distance and direction to the original location (Appendix 21).

Table 16. Distance in kilometre by rail

Distance in kilometre by rail (shortest route)											
Terminal	Amsterdam, NL	Duisburg, DE	Hamburg, DE	Prague, CZ	Česká Třebová, CZ	Ostrava-Paskov, CZ	Ostrava Senov, CZ	Gdansk, PL	Gliwice, PL	Brzeg Dolny, PL	Siechnice, PL
Amsterdam, NL	0	208	488	1032	1131	1383	1386	1231	1165	948	989
Duisburg, DE	208	0	366	848	998	1200	1203	1097	1035	815	907
Hamburg, DE	488	366	0	661	834	1046	1050	883	831	610	678
Prague, CZ	979	845	653	0	177	379	383	965	476	370	339
Česká Třebová, CZ	1131	995	834	177	0	202	206	906	298	216	197
Ostrava-Paskov, CZ	1383	1197	1036	379	202	0	6	739	126	234	214
Ostrava Senov, CZ	1387	1200	1039	383	206	6	0	736	129	236	217
Gdansk, PL	1230	1097	893	965	906	747	744	0	654	514	495
Gliwice, PL	1138	1045	830	486	298	126	137	654	0	194	175
Brzeg Dolny, PL	948	815	600	370	216	296	206	514	194	0	41
Siechnice, PL	989	907	641	339	197	198	204	495	205	41	0

(Rome2rio, 2020; Geestman, 2020)

Table 17. Distance in kilometre by road

Distance in kilometre by road (shortest route)											
City	Amsterdam, NL	Duisburg, DE	Hamburg, DE	Prague, CZ	Česká Třebová, CZ	Ostrava-Paskov, CZ	Ostrava Senov, CZ	Gdansk, PL	Gliwice, PL	Brzeg Dolny, PL	Siechnice, PL
Amsterdam, NL	-	217	471	899	1,055	1,214	1,211	1,241	1,164	985	1,019
Duisburg, DE	219	-	372	728	884	1,063	1,060	1,060	996	856	851
Hamburg, DE	469	370	-	643	756	874	868	781	809	640	665
Prague, CZ	898	726	649	-	168	342	347	836	407	271	272
Česká Třebová, CZ	1,060	879	755	176	-	187	192	696	230	218	185
Ostrava-Paskov, CZ	1,215	1,074	876	350	187	-	14	620	85	249	205
Ostrava Senov, CZ	1,209	1,069	870	354	191	15	-	619	81	245	202
Gdansk, PL	1,187	1,063	783	837	746	622	616	-	553	461	468
Gliwice, PL	1,136	997	797	412	234	85	81	544	-	207	164
Brzeg Dolny, PL	985	837	637	272	217	250	246	458	208	-	58
Siechnice, PL	998	851	659	274	186	207	202	470	164	58	-

(Google Maps, 2020; Geestman, 2020)

5.1.2 Rail travel time

Rail travel time has been calculated by dividing the distance of the route (Table 16) by the speed limit of the routes (Table 16). Freight trains have different speed limits in the Netherlands, Germany, Poland and the Czech Republic (Table 15). Assumed is that the average speed of the freight train in each country is the national speed limit for freight trains of that country. Since there is no exact data of the distance is travelled by rail in each country, assumptions have been made on distance travelled by rail in each country by eye based on the route calculated by the Road2rio tool (Appendix 22). The transport does not enter any other country outside the Netherlands, Germany, Poland and the Czech Republic. No national borders are crossed if the departure and arrival destination are located in the same country. In reality, freight trains will have a longer travel time as delays are unavoidable. This increases the cost per TEU over rail. Furthermore, it is assumed that the train drives non-stop.

In the calculations, the following abbreviations have been used:
D_{rail} = route distance rail based on Table 16 in kilometre
P_{CZr} = percentage of route covered in CZ by rail based on Appendix 22
P_{DEr} = percentage of route covered in DE by rail based on Appendix 22
P_{NLr} = percentage of route covered in NL by rail based on Appendix 22
P_{PLr} = percentage of route covered in PL by rail based on Appendix 22
S_{CZr} = speed over rail in CZ based on Table 15
S_{DEr} = speed over rail in DE based on Table 15
S_{NLr} = speed over rail in NL based on Table 15
S_{PLr} = speed over rail in PL based on Table 15
T_{rail} = travel time route by rail in hours

The travel time by rail is based on the following calculations:

$$\sum \left(\frac{D_{rail} * P_{CZr}}{S_{CZr}}\right) + \left(\frac{D_{rail} * P_{DEr}}{S_{DEr}}\right)\left(\frac{D_{rail} * P_{NLr}}{S_{NLr}}\right)\left(\frac{D_{rail} * P_{PLr}}{S_{PLr}}\right) = T_{rail}$$

Travel times by rail can be found in Table 18. These travel times are calculated from point to point.

Table 18. Travel time by rail

	Travel time by rail in hours										
City	Amsterdam, NL	Duisburg, DE	Hamburg, DE	Prague, CZ	Česká Třebová, CZ	Ostrava-Paskov, CZ	Ostrava Senov, CZ	Gdansk, PL	Gliwice, PL	Brzeg Dolny, PL	Siechnice, PL
Amsterdam, NL	0.00	3.47	8.13	16.48	18.12	20.83	20.88	39.94	25.80	18.77	19.58
Duisburg, DE	3.47	0.00	6.10	13.69	15.29	18.09	18.14	35.99	23.57	16.49	18.36
Hamburg, DE	8.13	6.10	0.00	10.72	12.94	15.48	15.53	32.24	20.28	13.20	14.67
Prague, CZ	15.63	13.64	10.59	0.00	2.28	4.88	4.92	35.24	6.74	7.51	6.88
Česká Třebová, CZ	18.13	15.25	12.94	2.28	0.00	2.60	2.64	41.71	4.57	5.81	5.30
Ostrava-Paskov, CZ	20.83	18.05	15.33	4.88	2.60	0.00	0.08	38.11	2.36	5.42	5.75
Ostrava Senov, CZ	20.89	18.10	15.38	4.92	2.64	0.08	0.00	37.90	2.42	6.35	5.84
Gdansk, PL	39.91	35.99	32.62	35.24	41.71	38.52	38.33	0.00	34.39	27.06	26.06
Gliwice, PL	25.21	23.80	20.25	6.74	4.57	2.36	2.58	34.39	0.00	6.12	5.52
Brzeg Dolny, PL	18.77	16.49	12.98	7.51	5.81	6.85	5.54	27.06	6.12	0.00	1.30
Siechnice, PL	19.58	18.36	13.86	6.88	5.30	5.33	5.48	26.06	6.47	1.30	0.00

(Geestman, 2020; European court of auditors, 2016; FR8HUB, 2020; RFC7, 2017; Leijen, 2020; Rome2rio, 2020)

5.1.3 Road travel time

Road travel time has been calculated by dividing the distance of the route (Table 16) by the speed limit of the routes (Table 23). Assumed is that the average speed of the route is the national speed limit for trucks on motorways. The motorway speed limit in the Netherlands, Germany, Poland and the Czech Republic is all 80 kmph. The transport does not enter any other country outside the Netherlands, Germany, Poland and the Czech Republic. In reality, trucks will have a longer travel time as traffic jams are unavoidable and the real route will not exclusively be driven on motorways. This increases the cost per TEU over road.

The travel time calculation is based on a single driver. Using more drivers for a single truck will decrease the travel time at the expense of an increase in hourly costs due to higher labour costs. Road travel times include mandatory breaks according to EC law. These law state that:

- The truck driver must take a 45-minute break when driving between 4.5 and 9 hours straight.
- The truck driver must take a 11-hour break after a working day.
- A working day should not exceed 9 hours of driving.

The exceptions to these rules regarding reducing rest time and extending travel time have not been used, since they cannot be used daily.

All calculations are based on a heavy goods vehicle with the ability to transport between 3.5 and 40 tons (HGV 40).

The average HGV40 speed in Europe is 60 kmph except for Germany. The average HGV40 speed in Germany is 70 kmph.

In the calculations, the following abbreviations have been used:
D_{road} = route distance road based on table 17 in kilometre
D_{DErd} = route distance road in Germany based on Appendix 22
S_{EUrd} = Average HGV40 speed Europe
S_{DErd} = Average HGV40 speed Germany
AT_{road} = active travel time by road in hours
T_{road} = travel time route by road including mandatory breaks in hours

The travel time by road is based on the following calculations:

$$\sum \left(\frac{D_{road}}{S_{EUrd}}\right) - \left(\frac{D_{road} * D_{DErd} * S_{DErd}}{S_{EUrd}}\right) = AT_{road}$$

$$If\ AT_{road} => 4.5\ and < 9\ hours, then$$
$$\sum (AT_{road} + 45\ minutes) = T_{road}$$

$$If\ AT_{road} => 9\ and < 13.5\ hours, then$$
$$\sum (AT_{road} + 11\ hours\ and\ 45\ minutes) = T_{road}$$

$$If\ AT_{road} => 13.5\ and < 18\ hours, then$$
$$\sum (AT_{road} + 12\ hours\ and\ 30\ minutes) = T_{road}$$

$$If\ AT_{road} => 18\ and < 22.5\ hours, then$$
$$\sum (AT_{road} + 23\ hours\ and\ 30\ minutes) = T_{road}$$

Table 19. Travel time by road of an HGV 40 in hours using a single driver

Minimal Travel time by road in hours (single driver)											
City	Amsterdam, NL	Duisburg, DE	Hamburg, DE	Prague, CZ	Česká Třebová, CZ	Ostrava-Paskov, CZ	Ostrava Senov, CZ	Gdansk, PL	Gliwice, PL	Brzeg Dolny, PL	Siechnice, PL
Amsterdam, NL	0.00	3.41	7.93	26.06	28.33	42.37	42.33	42.89	30.49	27.36	27.87
Duisburg, DE	3.44	0.00	6.06	22.39	25.12	28.74	28.69	28.53	27.70	24.47	24.39
Hamburg, DE	7.90	6.04	0.00	21.12	23.09	26.01	25.16	23.47	24.31	21.40	21.78
Prague, CZ	26.05	22.36	21.21	0.00	2.80	6.45	6.53	26.43	7.53	5.27	5.28
Česká Třebová, CZ	28.40	25.04	23.08	2.93	0.00	3.12	3.20	23.35	3.83	3.63	3.08
Ostrava-Paskov, CZ	42.39	28.91	26.04	6.58	3.12	0.00	0.23	22.08	1.41	4.15	3.42
Ostrava Senov, CZ	42.30	28.83	25.19	6.65	3.18	0.25	0.00	22.07	1.35	4.08	3.37
Gdansk, PL	42.04	28.83	23.96	26.45	24.18	22.12	22.02	0.00	20.97	8.43	8.55
Gliwice, PL	30.06	27.72	25.03	7.62	3.90	1.41	1.34	20.82	0.00	3.45	2.73
Brzeg Dolny, PL	27.36	24.19	21.36	5.28	3.62	4.17	4.10	8.38	3.47	0.00	0.97
Siechnice, PL	27.56	24.39	21.69	5.32	3.10	3.45	3.37	8.58	2.73	0.97	0.00

If Distance/maximum speed is between 4.5 and 9 hours, add 0.75 h SUM ((Distance/ maximum speed)+0.75)
If Distance/maximum speed is between 9 and 13.5 hours, add 11.7 SUM ((Distance/ maximum speed)+11.75)
If Distance/maximum speed is between 13.5 and 18 hours, add 12. SUM ((Distance/ maximum speed)+12.5)
If Distance/maximum speed is between 18 and 22.5 hours, add 23. SUM ((Distance/ maximum speed)+23.5)
Assumed there is one truck driver
was the ability to drive the average speed of 60 kmph in Europe excluding Germany
was the ability to drive the average speed of 70 kmph in Germany

(Geestman, 2020; Nathan, 2017; RFC7, 2017; Google Maps, 2020)

5.1.4 Rail travel cost

Rail travel costs are based on the operating cost of a 25-wagon train (Table 20) combined with the distance and travel time of the rail route (Table 17) (Table 18) (table 15). A single wagon is a 40' container or 2 TEU, a 25-wagon train is 50 TEU. Assumed is that the cost for rail transport will not be affected by labour costs to the same extent as road transport. The necessity to differentiate labour cost between countries is therefore lessened. The type of locomotive used, impacts the cost per hour and per kilometre. Out of the two locomotive options given, electric and diesel, the electric variant has been chosen as it does not burn fossil fuels and is both cheaper per hour and per kilometre. The only variable of operating a train in different countries is the rail access charge. The rail access charge is, unlike the operating cost per hour and per kilometre, based on a 25-wagon train. (Table 20). (TransTools3, 2016)

Table 20. Rail average operating cost per wagon on a 25-wagon train

Rail average operating cost per wagon on a 25-wagon train					
Country	Type	Cargo	€/hour	€/km	€/km rail access charge
Czech Republic	Electric	Non-container	€ 14.23	€ 0.25	€ 3.37
		Container	€ 14.59	€ 0.25	€ 3.37
	Diesel	Non-container	€ 14.23	€ 0.27	€ 3.37
		Container	€ 14.59	€ 0.27	€ 3.37
Netherlands	Electric	Non-container	€ 14.23	€ 0.25	€ 2.40
		Container	€ 14.59	€ 0.25	€ 2.40
	Diesel	Non-container	€ 14.23	€ 0.27	€ 2.40
		Container	€ 14.59	€ 0.27	€ 2.40
Poland	Electric	Non-container	€ 14.23	€ 0.25	€ 4.90
		Container	€ 14.59	€ 0.25	€ 4.90
	Diesel	Non-container	€ 14.23	€ 0.27	€ 4.90
		Container	€ 14.59	€ 0.27	€ 4.90
United Kingdom	Electric	Non-container	€ 14.23	€ 0.25	€ 1.45
		Container	€ 14.59	€ 0.25	€ 1.45
	Diesel	Non-container	€ 14.23	€ 0.27	€ 1.45
		Container	€ 14.59	€ 0.27	€ 1.45
Germay	Electric	Non-container	€ 14.23	€ 0.25	€ 2.56
		Container	€ 14.59	€ 0.25	€ 2.56
	Diesel	Non-container	€ 14.23	€ 0.27	€ 2.56
		Container	€ 14.59	€ 0.27	€ 2.56

(TransTools3, 2016)

In the calculations, the following abbreviations have been used:

C_{rail} = *cost rail route*
D_{rail} = *route distance rail based on table 16 in kilometre*
P_{CZr} = *percentage of route covered in CZ by rail based on Appendix 22*
P_{DEr} = *percentage of route covered in DE by rail based on Appendix 22*
P_{NLr} = *percentage of route covered in NL by rail based on Appendix 22*
P_{PLr} = *percentage of route covered in PL by rail based on Appendix 22*
S_{CZr} = *speed over rail in CZ based on table 15*
S_{DEr} = *speed over rail in DE based on table 15*
S_{NLr} = *speed over rail in NL based on table 15*
S_{PLr} = *speed over rail in PL based on table 15*
T_{rail} = *travel time route by rail in hours*
TC_{rail} = *hourly cost over rail based on Table 20*
DC_{rail} = *distance cost over rail per kilometre based on Table 20*
AC_{CZr} = *access cost per kilometre of rail in CZ based on table Table 20*
AC_{DEr} = *access cost per kilometre of rail in DE based on table Table 20*
AC_{NLr} = *access cost per kilometre of rail in NL based on table Table 20*
AC_{PLr} = *access cost per kilometre of rail in PL based on table Table 20*

The rail travel cost Table 21 is based on a 25-wagon train. The type of locomotive used is electric and the type of cargo used is a container. The rail travel costs are given per wagon, the equivalent of two TEU, and are based on the following calculations:

$$\sum (D_{rail} * P_{CZr} * AC_{CZr}) + (D_{rail} * P_{DEr} * AC_{DEr})(D_{rail} * P_{NLr} * AC_{NLr})(D_{rail} * P_{PLr} * AC_{PLr}) + T_{rail} * TC_{rail} + D_{rail} * DC_{rail} = C_{rail}$$

Table 21. Travel cost by rail per wagon based on a 25-wagon train

Travel cost by rail per wagon based on a 25 wagon train											
City	Amsterdam, NL	Duisburg, DE	Hamburg, DE	Prague, CZ	Česká Třebová, CZ	Ostrava-Paskov, CZ	Ostrava Senov, CZ	Gdansk, PL	Gliwice, PL	Brzeg Dolny, PL	Siechnice, PL
Amsterdam, NL	€ -	€ 120.79	€ 284.02	€ 598.04	€ 655.81	€ 794.69	€ 796.82	€ 1,045.45	€ 811.01	€ 614.27	€ 640.84
Duisburg, DE	€ 120.79	€ -	€ 213.95	€ 493.29	€ 575.47	€ 690.49	€ 691.62	€ 905.79	€ 734.73	€ 535.88	€ 596.86
Hamburg, DE	€ 284.02	€ 213.95	€ -	€ 384.82	€ 482.20	€ 600.31	€ 602.26	€ 774.17	€ 617.71	€ 418.94	€ 465.47
Prague, CZ	€ 567.21	€ 491.61	€ 380.17	€ -	€ 67.22	€ 213.49	€ 215.29	€ 841.12	€ 278.57	€ 256.35	€ 234.85
Česká Třebová, CZ	€ 656.04	€ 573.80	€ 482.14	€ 99.60	€ -	€ 113.89	€ 115.69	€ 911.78	€ 180.41	€ 174.79	€ 159.36
Ostrava-Paskov, CZ	€ 794.75	€ 688.82	€ 594.51	€ 213.49	€ 113.89	€ -	€ 3.60	€ 809.02	€ 83.76	€ 174.01	€ 172.93
Ostrava Senov, CZ	€ 797.05	€ 690.66	€ 596.46	€ 215.29	€ 115.69	€ 3.60	€ -	€ 806.69	€ 85.76	€ 190.95	€ 175.60
Gdansk, PL	€ 1,044.60	€ 939.22	€ 820.52	€ 889.84	€ 983.77	€ 876.48	€ 872.25	€ -	€ 777.63	€ 611.87	€ 589.26
Gliwice, PL	€ 792.34	€ 741.97	€ 616.90	€ 282.38	€ 180.41	€ 83.76	€ 91.37	€ 777.63	€ -	€ 172.55	€ 121.36
Brzeg Dolny, PL	€ 614.27	€ 535.88	€ 411.80	€ 256.35	€ 174.71	€ 219.90	€ 166.47	€ 611.87	€ 172.64	€ -	€ 36.66
Siechnice, PL	€ 640.90	€ 596.86	€ 440.01	€ 234.85	€ 159.36	€ 160.17	€ 164.77	€ 589.26	€ 182.43	€ 36.66	€ -

(Geestman, 2020; European court of auditors, 2016; FR8HUB, 2020; RFC7, 2017; Leijen, 2020; Rome2rio, 2020; TransTools3, 2016)

5.1.5 Road travel cost

Road travel costs are based on the operating cost of a HGV40 with a single driver (Table 22) combined with the distance and travel time of the road route (Table 23) (Table 19) (Appendix 22). A single truck lorry is 40', the equivalent of 2TEU. Road transport costs are notably affected by labour costs and differ due to the wage gap between different countries. Due to the difference in labour cost, the operating costs of the route are based on the operating costs of the departing country. Hourly costs include labour cost, depreciation, and insurance. Cost per kilometre includes fuel, repairs and maintenance, tire wear, toll and the (Eurovignet Table 22). Assumed is that truck drivers are not paid during their mandatory rest. The hourly costs and costs per kilometre are based on diesel prices of 2010. Diesel prices have, on average of CZ, DE, NL, UK, and PL, risen by 3.15 percent between 2010 and 2020. The increase in diesel price has not been adjusted for the calculation. (TransTools3, 2016)

Table 22. HGV 40 operating cost

HGV 40 operating cost		
Country	€/hour	€/km
Czech Republic	€ 19.46	€ 0.39
Netherlands	€ 35.22	€ 0.37
Poland	€ 17.65	€ 0.33
United Kingdom	€ 30.79	€ 0.42
Germay	€ 33.63	€ 0.39

(European Commision, 2020; TransTools3, 2016)

Table 23. Diesel price litre

Diesel price Litre including VAT		
Country	2010	2020
Czech Republic	€ 1.106	€ 1.000
Netherlands	€ 1.066	€ 1.340
Poland	€ 0.908	€ 0.980
United Kingdom	€ 1.450	€ 1.330
Germay	€ 1.073	€ 1.130
Average	€ 1.121	€ 1.156

(TransTools3, 2016; Autotraveler.ru, 2020)

In the calculations, the following abbreviations have been used:
C_{road} = *cost road route*
D_{road} = *route distance road based on table 16 in kilometre*
T_{road} = *travel time route by road in hours*
TC_{road} = *hourly cost over road based on table 22*
DC_{road} = *distance cost over road per kilometre based on table 22*

The road travel cost (Table 24) is based on a HGV40 of 40'. The operating cost of the departing country have been used (Table 22). A single driver has been used. The road travel costs are given per lorry, the equivalent of two TEU, and are based on the following calculations:

$$\sum (D_{road} * DC_{Road}) + (T_{road} * TC_{Road}) = C_{road}$$

Table 24. Travel cost by road per 40'lorry based on a HGV40

Travel cost by road one HGV40 (single driver)											
City	Amsterdam, NL	Duisburg, DE	Hamburg, DE	Prague, CZ	Česká Třebová, CZ	Ostrava-Paskov, CZ	Ostrava Senov, CZ	Gdansk, PL	Gliwice, PL	Brzeg Dolny, PL	Siechnice, PL
Amsterdam, NL	€ -	€ 208.10	€ 451.69	€ 862.14	€ 1,011.75	€ 1,164.23	€ 1,161.35	€ 1,190.12	€ 1,116.28	€ 944.62	€ 977.22
Duisburg, DE	€ 207.28	€ -	€ 352.10	€ 689.05	€ 836.71	€ 1,006.13	€ 1,003.29	€ 1,003.29	€ 942.71	€ 810.20	€ 805.47
Hamburg, DE	€ 443.91	€ 350.21	€ -	€ 608.60	€ 715.55	€ 827.24	€ 821.56	€ 739.22	€ 765.72	€ 605.76	€ 629.42
Prague, CZ	€ 637.88	€ 515.70	€ 461.01	€ -	€ 119.34	€ 242.93	€ 246.49	€ 593.84	€ 289.11	€ 192.50	€ 193.21
Česká Třebová, CZ	€ 752.95	€ 624.38	€ 536.30	€ 125.02	€ -	€ 132.83	€ 136.38	€ 494.39	€ 163.38	€ 154.85	€ 131.41
Ostrava-Paskov, CZ	€ 863.06	€ 762.90	€ 622.25	€ 248.62	€ 132.83	€ -	€ 9.94	€ 440.41	€ 60.09	€ 176.87	€ 145.62
Ostrava Senov, CZ	€ 858.79	€ 759.35	€ 617.99	€ 251.46	€ 135.67	€ 10.66	€ -	€ 439.70	€ 57.39	€ 174.03	€ 143.49
Gdansk, PL	€ 734.95	€ 658.17	€ 484.81	€ 518.24	€ 461.90	€ 385.12	€ 381.41	€ -	€ 342.40	€ 285.44	€ 289.77
Gliwice, PL	€ 703.37	€ 617.31	€ 493.48	€ 255.10	€ 144.89	€ 52.38	€ 49.90	€ 336.83	€ -	€ 128.17	€ 101.54
Brzeg Dolny, PL	€ 609.88	€ 518.24	€ 394.41	€ 168.41	€ 134.36	€ 154.79	€ 152.32	€ 283.58	€ 128.79	€ -	€ 36.04
Siechnice, PL	€ 617.93	€ 526.91	€ 408.03	€ 169.65	€ 115.17	€ 128.17	€ 125.07	€ 291.01	€ 101.54	€ 35.97	€ -

(Geestman, 2020; RFC7, 2017; TransTools3, 2016; Google Maps, 2020)

5.1.6 Transport cost comparison

Travel cost has been compared by subtracting the travel cost by rail (Table 23) from the travel cost by road (Table 24).

In the calculations, the following abbreviations have been used:
C_{road} = cost road route in Euro based on table 24
C_{rail} = cost rail route in Euro based on table 23
C_{dif} = cost difference in Euro

$$\sum C_{road} - C_{rail} = C_{dif}$$

Table 25. Operating cost difference road minus rail in 2 TEU

Cost difference road minus rail (in 2TEU)											
City	Amsterdam, NL	Duisburg, DE	Hamburg, DE	Prague, CZ	Česká Třebová, CZ	Ostrava-Paskov, CZ	Ostrava Senov, CZ	Gdansk, PL	Gliwice, PL	Brzeg Dolny, PL	Siechnice, PL
Amsterdam, NL	€ -	€ 87.31	€ 167.67	€ 264.10	€ 355.93	€ 369.53	€ 364.53	€ 144.67	€ 305.27	€ 330.35	€ 336.38
Duisburg, DE	€ 86.49	€ -	€ 138.15	€ 195.76	€ 261.23	€ 315.64	€ 311.67	€ 97.50	€ 207.98	€ 274.32	€ 208.61
Hamburg, DE	€ 159.89	€ 136.25	€ -	€ 223.78	€ 233.36	€ 226.93	€ 219.30	€ -34.96	€ 148.00	€ 186.82	€ 163.95
Prague, CZ	€ 70.67	€ 24.10	€ 80.84	€ -	€ 52.11	€ 29.44	€ 31.19	€ -247.28	€ 10.53	€ -63.85	€ -41.64
Česká Třebová, CZ	€ 96.91	€ 50.58	€ 54.16	€ 25.42	€ -	€ 18.94	€ 20.69	€ -417.39	€ -17.03	€ -19.94	€ -27.95
Ostrava-Paskov, CZ	€ 68.30	€ 74.08	€ 27.74	€ 35.13	€ 18.94	€ -	€ 6.34	€ -368.61	€ -23.67	€ 2.87	€ -27.31
Ostrava Senov, CZ	€ 61.74	€ 68.68	€ 21.53	€ 36.17	€ 19.98	€ 7.05	€ -	€ -366.99	€ -28.37	€ -16.92	€ -32.11
Gdansk, PL	€ -309.65	€ -281.04	€ -335.72	€ -371.60	€ -521.87	€ -491.36	€ -490.85	€ -	€ -435.23	€ -326.44	€ -299.49
Gliwice, PL	€ -88.97	€ -124.67	€ -123.42	€ -27.28	€ -35.53	€ -31.38	€ -41.46	€ -440.80	€ -	€ -44.38	€ -19.82
Brzeg Dolny, PL	€ -4.39	€ -17.64	€ -17.39	€ -87.93	€ -40.35	€ -65.11	€ -14.15	€ -328.29	€ -43.85	€ -	€ -0.63
Siechnice, PL	€ -22.97	€ -69.95	€ -31.98	€ -65.19	€ -44.19	€ -32.00	€ -39.70	€ -298.25	€ -80.89	€ -0.69	€ -

When rail is cheaper
When road is cheaper

(Geestman, 2020; European court of auditors, 2016; FR8HUB, 2020; RFC7, 2017; Leijen, 2020; Rome2rio, 2020; TransTools3, 2016; Google Maps, 2020)

The cost difference between road and rail is especially apparent when transporting from NL to CZ and PL by rail and when transporting from CZ and PL by road (Table 25). This difference is partially caused by the lower truck operating cost when departing from either PL or CZ (Table 22). Furthermore, transport by road being cheaper in PL is partially caused by the speed difference in modality types. In PL, HGV40's are allowed to drive 80 kmph on motorways and on average drive 60 kmph over the entire route (Appendix 15) where freight trains only travel 31.7 kmph on average. This speed difference increases the cost of freight train transport in PL since it is both slower and, due to the operating cost per hour, more expensive. (Table 20)

Transhipment costs are comparable per modal type (TransTools3, 2016). This means that there will not be a difference in transhipment cost per TEU for rail and road. Therefore, transhipment cost is exempt from the calculations to calculate the cost benefit of rail over road.

5.1.7 Route potential based on cost and travel time

The operating costs of a 25-wagon freight train are lower on all bilateral routes including Amsterdam, NL with the exclusion of Gdansk, PL (Table 25) (Table 26). Although transport using a rail corridor is cheaper compared to using road transport on these routes, it is important to note again that terminal costs and last mile transport costs are excluded from the calculations. The three researched bilateral routes having the largest cost difference per TEU between rail and road transport are:

- Amsterdam, NL <> Česká Třebová, CZ
- Amsterdam, NL <> Ostrava-Paskov, CZ

- Amsterdam, NL <> Ostrava Senov, CZ

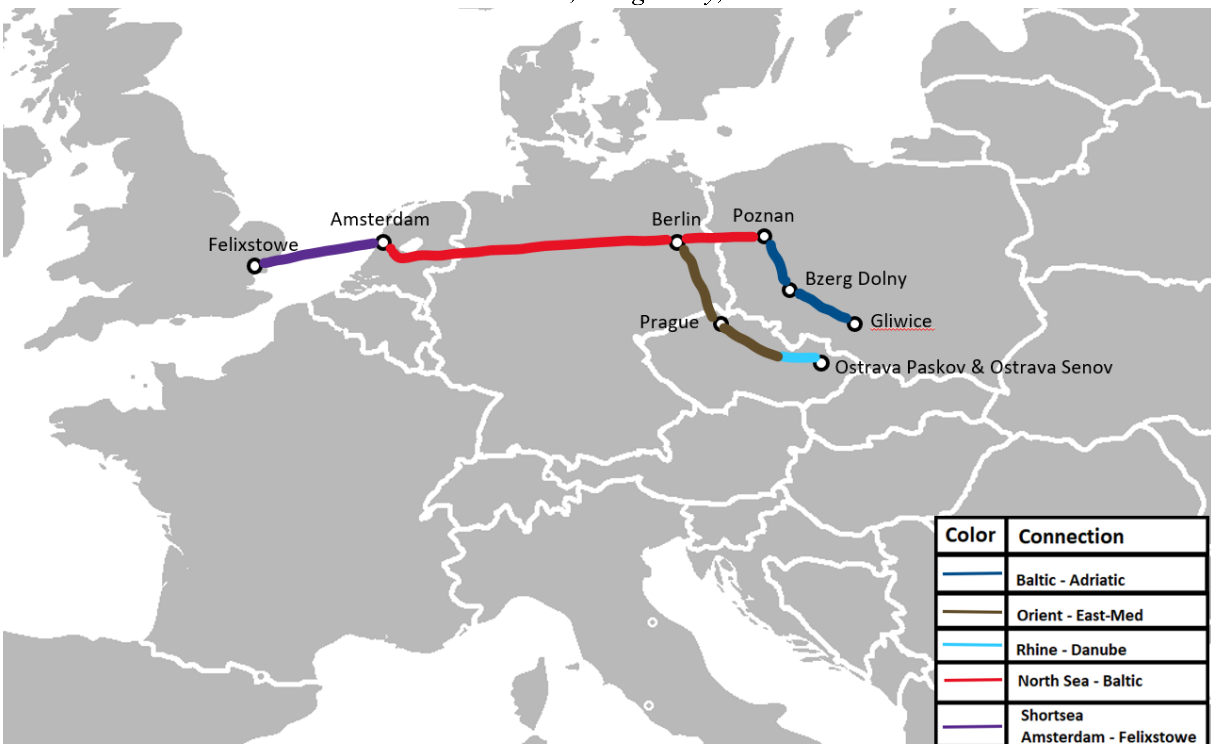
Table 26. Cost benefit rail over road per TEU

Cost benefit rail over road average travel time (per TEU)						
Route start to end				Cost road (lorry)	Cost rail (wagon)	cost difference (TEU)
Amsterdam, NL	Česká Třebová, CZ	Amsterdam, NL		€ 1,764.70	€ 1,311.86	€ 226.42
Amsterdam, NL	Ostrava-Paskov, CZ	Amsterdam, NL		€ 2,027.28	€ 1,589.45	€ 218.92
Amsterdam, NL	Ostrava Senov, CZ	Amsterdam, NL		€ 2,020.14	€ 1,593.87	€ 213.14
Amsterdam, NL	Ostrava-Paskov, CZ	Brzeg Dolny, PL	Amsterdam, NL	€ 1,950.98	€ 1,582.97	€ 184.01
Amsterdam, NL	Ostrava Senov, CZ	Brzeg Dolny, PL	Amsterdam, NL	€ 1,945.26	€ 1,602.04	€ 171.61
Amsterdam, NL	Prague, CZ	Amsterdam, NL		€ 1,500.02	€ 1,165.26	€ 167.38
Amsterdam, NL	Hamburg, DE	Amsterdam, NL		€ 895.60	€ 568.04	€ 163.78
Amsterdam, NL	Brzeg Dolny, PL	Amsterdam, NL		€ 1,554.49	€ 1,228.54	€ 162.98
Amsterdam, NL	Siechnice, PL	Amsterdam, NL		€ 1,595.15	€ 1,281.74	€ 156.71
Amsterdam, NL	Gliwice, PL	Amsterdam, NL		€ 1,819.65	€ 1,603.35	€ 108.15
Amsterdam, NL	Duisburg, DE	Amsterdam, NL		€ 415.39	€ 241.58	€ 86.90
Amsterdam, NL	Gdansk, PL	Amsterdam, NL		€ 1,925.07	€ 2,090.06	€ -82.49

(Geestman, 2020; European court of auditors, 2016; FR8HUB, 2020; RFC7, 2017; Leijen, 2020; Rome2rio, 2020; Google Maps, 2020; TransTools3, 2016)

These operating costs merely give an indication which routes would have the largest cost benefit of rail compared to road (Table 26). The bilateral routes with the largest cost benefit are all between NL and CZ. The relatively low average speed of freight trains in PL (Table 15) increases operating costs between NL and PL. Bilateral routes between NL and PL are competitive to road but would require higher load factors on freight trains compared to NL-CZ routes to reach the same cost benefit of using an intermodal corridor. (TransTools3, 2016)

Figure 12. Potential corridor via Amsterdam to Felixstowe, Brzeg Dolny, Gliwice and Ostrava- Paskov and



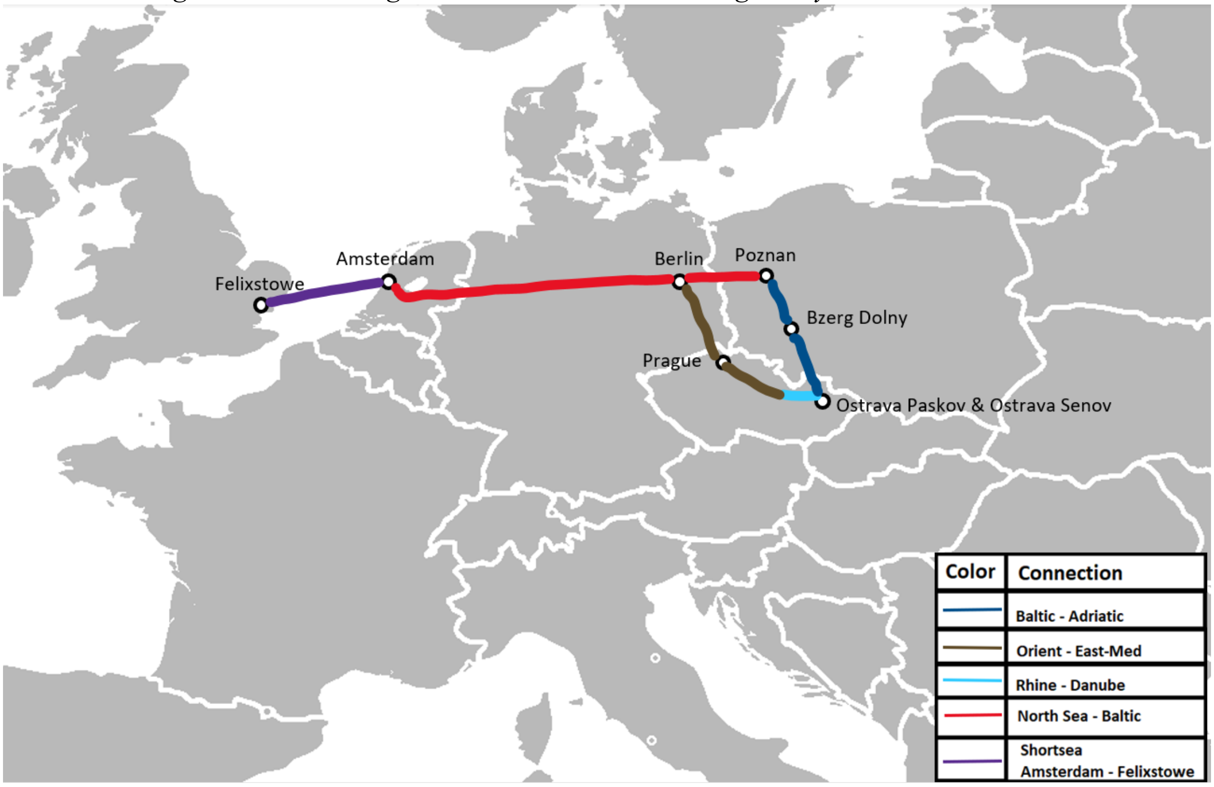
(European Commision, 2020; Webstockreview, 2020; Azoulay, 2020)

Outside bilateral routes, it is possible to operate a rail route with multiple stops while still having lower operating costs compared to that of a HGV40. This could be done to increase the load factors on the freight trains. Potential multiple stop routes are:

- Amsterdam, NL > Ostrava-Paskov, CZ > Brzeg Dolny, PL > Amsterdam, NL
- Amsterdam, NL > Ostrava Senov, CZ > Brzeg Dolny, PL > Amsterdam, NL

Although using multiple stops is expected to increase load factors, it would also increase operating times and therefore operating costs.

Figure 13. The triangle between Amsterdam, Bzerg Dolny en Ostrava



(European Commision, 2020; Webstockreview, 2020; Azoulay, 2020)

Outside of the cost benefit, intermodal transport has a massive time benefits over road transport, halving operating times on the routes:

- Amsterdam, NL <> Ostrava-Paskov, CZ
- Amsterdam, NL <> Ostrava Senov, CZ

Although these operating times are based on terminal-to-terminal transport and not on door-to-door transport, it is safe to assume that intermodal transport would still have time benefit as last mile transport on both ends combined would not take nearly as much as the 43 hours which initially have been saved by transporting intermodal. (Table 27)

When comparing operating costs by rail between the Port of Amsterdam and their competitor the Port of Gdansk, rail transit costs to Amsterdam are less then 10 percent more expensive to southern Polish and Czech cities while being approximately 30 percent faster. This is mainly caused due to the low average speeds freight trains reach in Poland (table 15). If Gdansk uses road transport to southern Poland and the Czech Republic, they can offer a travel time which is on par with Amsterdam to the Czech destinations and less than half to the southern Polish destinations while having less than half the transit cost (Table 25) (Table 27).

Table 27. Time benefit rail over road excluding transfer time in hours

Time benefit rail over road excluding transfer time minimum travel time (h)						
Route start to end				Time road (h)	Time rail (h)	Time difference (h)
Amsterdam, NL	Ostrava-Paskov, CZ	Brzeg Dolny, PL	Amsterdam, NL	73.89	45.01	28.87
Amsterdam, NL	Ostrava Senov, CZ	Brzeg Dolny, PL	Amsterdam, NL	73.77	45.99	27.78
Amsterdam, NL	Ostrava-Paskov, CZ	Amsterdam, NL		84.77	41.65	43.11
Amsterdam, NL	Ostrava Senov, CZ	Amsterdam, NL		84.63	41.76	42.86
Amsterdam, NL	Česká Třebová, CZ	Amsterdam, NL		56.73	38.95	17.77
Amsterdam, NL	Gliwice, PL	Amsterdam, NL		60.55	51.01	9.54
Amsterdam, NL	Brzeg Dolny, PL	Amsterdam, NL		54.72	37.53	17.19
Amsterdam, NL	Siechnice, PL	Amsterdam, NL		55.43	39.16	16.27
Gdansk, PL	Prague, CZ	Gdansk, PL		52.88	70.47	-17.59
Gdansk, PL	Česká Třebová, CZ	Gdansk, PL		47.53	83.41	-35.88
Gdansk, PL	Ostrava-Paskov, CZ	Gdansk, PL		44.20	76.63	-32.43
Gdansk, PL	Ostrava Senov, CZ	Gdansk, PL		44.08	76.23	-32.15
Gdansk, PL	Gliwice, PL	Gdansk, PL		41.78	68.79	-27.01
Gdansk, PL	Brzeg Dolny, PL	Gdansk, PL		16.82	54.13	-37.31
Gdansk, PL	Siechnice, PL	Gdansk, PL		17.13	52.13	-34.99

(Geestman, 2020; European court of auditors, 2016; FR8HUB, 2020; RFC7, 2017; Leijen, 2020; TransTools3, 2016; Rome2rio, 2020; Google Maps, 2020)

5.1.8 Transfer time terminals

The loading and unloading time at terminal are assumed to be the same, it takes 5 hours to load 25 containers on a train, that is 50 TEU. Short sea shipping takes 12 hours to load or unload a ship with a 27.000 dead weight tonnes and IWW takes 11 hours to dispatch a medium-sized vessel with a loading capacity of 1.350 tonnes. (Table 28) (TransTools3, 2016)

Table 28. Terminal transfer time per modality

Terminal transfer time per modality		
Container 40'	Transfer time	
	Total (h)	per TEU (h)
HGV 40	0.5	0.25
Rail	5.0	0.10
IWW	11.0	NA
Sea	12.0	NA

(TransTools3, 2016)

Rail time based on 25 units of 20 tons each (50 TEU)
IWW and Sea transfer time is based on a full load. Due to the difference in loading capacity, transfer time per TEU for these modalities are unknown

5.2. Corridor Demand

To be able to validate the corridor that's being created, an essential aspect of the feasibility should be discussed. The demand on the new corridor is of utmost importance to make this corridor work and stand out against transporting goods by road. To be able to present a realistic image of the cargo flows between the Netherlands, Poland, Czech Republic and the United Kingdom, the following has been done:

Every product is divided in product categories called: Harmonized system, in short, HS. There are around 5,300 product descriptions with headings and subheadings organized in 99 subchapters, which is named as a HS-2 heading (United nations , 2017). An example of a common HS-2 heading is: *Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television* which has the product code 85. This chapter is than again divided into HS-4 headings which range from 8501 – 8548. Every subheading is repeatedly labelled with another layer of subheadings called HS-6 and thereunder there is even an HS-8 and a HS-22 code. To be able to make a realistic estimate of the TEU's travelling between these four countries the 5 product categories most traded between them in terms of value have been put into Excel. Data gathered from the ICT Trade Map data base, which sources information from Eurostat, is able to provide an accurate and detailed trade value for the HS-2, HS-4 and HS-6 product codes. Of course, there is a huge difference between a country's top 5 most traded product categories in terms of value and in terms of tonnage. ICT Trade map only supplies it's HS-4 codes with detailed information in terms of tonnage. As one can imagine, to collect all data from HS-2 and HS-4 codes manually is such an extensive process that due to time restrictions is impossible to conduct. With every HS-4 code could range up to 48 subheadings, but with an average of around 20 subheadings this would mean that roughly 2000 subheadings should be analysed and entered in excel by hand. To simply this process only the top 5 product groups of bilateral trade between two countries have been selected. The tonnage of every HS-4 code has been calculated and put into a table (Table 29). (Appendix 23-34)

Table 29. Import from the Netherlands to Poland

NL import from PL						
Product code	product type	Value in USD thousand	percentage of total	Tonnes	Max loading weight 2 TEU	TEU
85	Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television . . .	$ 1,338,296	13%	67575	25	5406
84	Machinery, mechanical appliances, nuclear reactors, boilers; parts thereof	$ 1,167,984	11%	100831	25	8066
94	Furniture; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings; . . .	$ 880,193	9%	172960	25	13837
27	Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral	$ 849,316	8%	NOT CON	25	0
87	Vehicles other than railway or tramway rolling stock, and parts and accessories thereof	$ 801,080	8%	88412	25	7073
	Other	$ 5,126,552	50%	437430	25	34994
	Total	$ 10,163,421	100%	867208		69377

(van der Heijden, 2020; ITC trade map, 2019)

To be able to calculate the number of TEU moving between country's the assumption of 25 tons for a 40-foot container has been made. This assumption was based on an industry expert saying: *"De benadering die wij veelal hierin hebben is een gem. tonnage per geladen container/trailer (24-25t voor een 45' container of huckepack trailer"* (Witt, Correspondance , 2020). In this statement he is saying they assume a weight of 24-25t for a 45' container. This has been adjusted in the research to 25 tons for a 40' container. 40' containers usually have a higher maximum loading weight than 45' containers, but due to the different size, stowage and load factors of goods, the calculations have been continued with 25 tons for a 40' container. To calculate the final amount of TEU's per category and the remaining amount of TEU's the following calculations where applied:

$$T_{teu} = \frac{T_{ton}}{M_c} * 2$$

$$T_{tonR} = \frac{\sum T_{ton}}{\sum T_{vt5p}} * (100\% - \sum T_{vt5p})$$

Abbreviations used in the formula's:
T_{teu} = Total TEU's
T_{ton} = Total tonnes
M_c = Maximum loading weight containers
T_{tonR} = Total tonnage remaining products
T_{vt5p} = Total value top 5 products

It is not always possible to transport certain goods in containers, for example for HS-2 code 27 *Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes* (Table 29). The organisation for economic co-operation and development, OECD has a list of transport modes per product group (OECD, 2020). This list was used to distinguish non-containerized product groups from containerized product groups. When calculating the tonnage of the remaining products no extra measures have been taken to exclude the non-containerized goods out of the calculations. This due to the fact that the majority of non-containerized goods are dry bulk or liquids which are usually heavy products. Considering the top 5 products often are high in value rather than high in weight, the calculation of the total tonnage of the remaining goods, based on the top 5 most valuable product types, will counterbalance this effect and therefore it will be unnecessary to take extra measures into account to calculate the total exchange in TEU (Table 30).

Table 30. TEU's exchanged in 2019

2019 cargo flow (TEU)					
Export	Import				
	UK	PL	CZ	NL	TOTAL
UK		46702	16594	35550	98846
PL	98896		173221	69377	341493
CZ	32142	107222		19118	158481
NL	97380	123005	31020		251405
TOTAL	228418	276929	220834	124044	1700450

(van der Heijden, 2020)

5.2.1 United Kingdom

Detailed information was provided by the United Kingdom Department of Transport per port in the UK. Therefore, it was quite easy to assume the amount of TEU's arriving in the port of Felixstowe which made up 36% of all arriving containers in the UK. Applying this 36% ratio, as mentioned in chapter 4.1, on the total of imported and exported containers to and from the UK, this will result in around 118,000 TEU's. This makes up just over 3% of all containers handled in the port of Felixstowe. Considering the ratio mentioned in chapter 3.2.2 it can be estimated that most of these TEU's will be transported by shortsea.

5.2.2 Poland

Unlike the UK, Poland did not have such detailed information per port or terminal. Instead, a document uploaded by the Polish Bureau of Statistics gave detailed insight in goods transported by road per Voivodship, which means region, in 2019. The ratio in transported goods per region will give useful insight in the cargo flows within Poland, caused by the dominant role road transport has in

Poland. Of all international goods transported in Poland 70% is transported by lorry. This makes using these figures and ratio's as a base for assuming the TEU per region realistic. The TEU's per region in Poland are shown in Table 31.

Table 31. Voivodship balance of goods road transport 2019 and TEU's

Voivodship balance of goods road transport 2019 (x thousand tonnes)					
Region	export	import	total	balance	Total TEU's
Dolnośląskie	12,475	8,855	21,330	3,620	79,990
Kujawsko-pomorskie	3,686	2,522	6,208	1,164	23,281
Lubelskie	2,741	1,920	4,661	821	17,479
Lubuskie	6,177	4,455	10,632	1,722	39,871
Lódzkie	5,465	5,299	10,764	166	40,366
Malopolskie	4,860	4,332	9,192	528	34,471
Mazowieckie	8,589	9,730	18,319	-1,141	68,699
Opolskie	2,860	2,401	5,261	459	19,729
Podkarpackie	2,904	1,860	4,764	1,044	17,866
Podlaskie	2,124	1,455	3,579	669	13,422
Pomorskie	2,979	1,951	4,930	1,028	18,488
śląskie	13,391	12,422	25,813	969	96,802
świetokryzkie	1,842	1,433	3,275	409	12,282
Warminsko-mazurskie	1,799	1,797	3,596	2	13,485
Wielkopolskie	10,875	10,243	21,118	632	79,195
Zachodniopomorskie	6,995	4,470	11,465	2,525	42,995
Total	89,762	75,145	164,907	14,617	618,422

(van der Heijden, 2020; Transport activity Poland, 2019)

The calculations made to calculate the TEU per region:

$$T_{teupr} = \sum \frac{I_r + E_r}{T_I + T_E} * T_{teu,PL}$$

Abbreviations used in formula
T_{teupr} = Total TEU per region
I_r = Import per region
E_r = Export per region
T_i = Total import per region
T_e = Total export per region
$T_{teu,PL}$ = Total TEU Poland

Having calculated the amount of TEU's per region, it is now interesting to highlight the Voivodship of Dolnośląskie, Lower Silesian and Śląskie, Silesian as mentioned in chapter 4.2.1. These are the preferred regions to start a corridor with and they both combined are responsible for 28,6% of the countries handled TEU's originating from the UK, CZ, and NL. The voivodship of Lower Silesian where Brzerg Dolny is situated and Silesian where Gliwice is located have a significant amount of TEU's and is therefore suitable for creating a corridor with the three above mentioned countries. It can be said with enough confidence that plenty of demand will be available in these regions.

5.2.3 Czech Republic

A Czech transport database gave insight in the domestic cargo movement of the Czech Republic. The database provided tables with domestic trade per region and the modality split of this trade. It can be assumed that the domestic trade between regions corresponds with the distribution of international trade per region in the Czech Republic. This due to the fact that regions that receive heavily international trade, these goods also have to distribute it to other regions as well as within its own. The same goes for the Netherlands for instance, the province of Zuid-Holland, where the Port of Rotterdam is located and a lot of international trade is received, has the highest international road trade as well as the highest domestic road trade. The same goes for the second largest and third largest provinces, Noord-Brabant and Limburg. They are both second and third largest in international road trade as well as in domestic road trade. Having concluded this, the three regions of interest discussed in chapter 4.3 and their trade volume, modality split and total TEU's divided per region are shown below. (Table 32)

Table 32. Goods traded between regions and modality split 2019

Goods traded (thousand tonnes)							
Region	Modality	Import in tonnes	percentage	Export in tonnes	percentage	total	total TEU per region
Moravian Silician	Rail	8517.4	13.7%	9212.5	14.8%	124655	46102
	Road	53814.0	86.3%	53111.4	85.2%		
	IW	0.0	0.0%	0.0	0.0%		
Zlin	Rail	1187.2	5.8%	551.9	2.8%	39927	14767
	Road	19322.2	94.2%	18866.2	97.2%		
	IW	0.0	0.0%	0.0	0.0%		
Olomouc	Rail	1259.4	3.4%	1215.2	3.1%	75405	27888
	Road	35374.3	96.6%	37556.3	96.9%		
	IW	0.0	0.0%	0.0	0.0%		

(van der Heijden, 2020; Sydos, 2019)

The Moravian Silesian region where Ostrava is situated, the preferred destinations to create a corridor with, is good for 12% of the national cargo flow. When adding up the hinterland regions of Zlin and Olomouc, combined they are responsible for 24% of the national cargo flow. This translated into TEU's it will also receive 24% of the incoming TEU's traded between the CZ, NL, UK and PL. The same calculation has been applied here as has been applied in the part about Poland, above. It has to be said that the Central Bohemian region and Prague region together are responsible for almost 22% of the total TEU's moved in the Czech Republic. However, as motivated in chapter 4.3 these where not the preferred regions to make a corridor with. Remarkably the modal split of the Moravian Silesian, Zlin and Olomouc regions lean heavily towards road transport and no inland water transport. Rail transport is only a small part of the total modal split but could be increased when creating a new corridor with Amsterdam. There is at least enough demand to make a connection work.

5.2.4 The Netherlands

Although it is clear that the region and port in the Netherlands already were preselected, it is essential to look at the demand for intermodal transport within the Noord West Connect region to complete the overview of the demand for TEU's per country and region. As mentioned in the part of the Czech Republic, the three provinces with the largest road cargo volume domestically also have the largest road cargo volume internationally. The province of Noord-Holland ranks third when combining the total international road trade and the total international barge trade. However, the volume available in Noord-Holland will not be the only volume that could potentially go through the Port of Amsterdam. Due to the compact size of the Netherlands, Amsterdam has a huge domestic hinterland area where a lot of volume could be passed via Amsterdam. Being neighbours with the province of Zuid-Holland, having the largest international trade volume, and not that far away of the province of Noord-Brabant, having the second largest international trade volume, it is to be expected that volumes will be added from those two as well. Furthermore, volumes coming from Eastern Europe that will pass via Amsterdam as the research suggest will also be added and will assure that enough volume is available to start a corridor from Amsterdam.

5.2.5 Inter-regional demand

In every single region of interest there has been proven enough demand for a corridor, but how is this between the certain regions. In the table below (Table 33) the TEU balance between regions is visualized.

Table 33. TEU balance between regions of interest and their hinterland (H = Hinterland)

Region trade balance	
Region	TEU balance
Noord-Holland - Moravian Silesian	(4318)
Noord- Holland - Silesian	(55018)
Noord- Holland - Felixstowe	(76001)
Noord-Holland + H - Moravian Silesian	228897
Noord Holland + H - Silesian + H	115762
Silesian - Moravian Silesian	50700
Felixstowe - Moravian Silesian	71683
Felixstowe - Silesian	20983
Felixstowe - Moravian Silesian + H	54128
Felixstowe - Silesian + H	(59007)

(van der Heijden, 2020)

Hinterland Noord-Holland: Zuid-Holland, Noord-Brabant
Hinterland Moravian Silesian: Zlin, Olomouc
Hinterland Silesian: Lower Silesian

These results are very intriguing due to the fact that not a single inter regional connection would have a balanced cargo flow. It has to be noted that these figures are TEU's transported by road, rail and inland water shipping. It can be that there is a large difference between modality in terms of trade balance. For instance, it could be that TEU's transported by rail between Noord-Holland and Moravian Silesian is more in balance than shown in the table above (Table 33). It can be concluded from this table that the most balanced cargo flows of all modalities combined is the one between Noord-Holland and Moravian Silesian. Although it is an unbalanced cargo stream it is quite easy to balance this connection by adding some demand from the province of Zuid-Holland with its hinterland volume. Industry expert, Gerard de Witt, has said the following: *"Ja of in ieder geval dat je weet dat er ofwel gebalanceerd is ofwel dat er voldoende volume is en dan wellicht niet helemaal gebalanceerd maar dat je op je strong legs zeg maar, dus je money making leg dus vanuit polen je export leg dat je daar zorgt dat je volle bezetting hebt en dat je bepaalde kosten die je niet op je weak leg dus in dit geval polen import leg gecoverd kunt krijgen. Dat je die kosten wel kunt dragen op je strong leg."* He basically says, and is using South-Poland as an example, is that on one leg you need a strong money-making leg to be able to afford a weaker leg back. In this case, the leg Ostrava - Amsterdam is the strong money-making leg and the leg Amsterdam – Ostrava is the weaker leg. Although being the weaker leg of the two, it is nowhere to being weak. For every TEU send to Noord-Holland from Moravian Silesian, Moravian Silesian receives 0.9 TEU back. This is very close to a balance and therefore a strong connection to create a corridor with.

5.3 Competiting routes

The preferred corridor will use a rail connection between Ostrava and Amsterdam and a shortsea connection between Amsterdam and Felixstowe. It is important to keep an eye on the current and potential competitors. Competitors in this chapter are defined as alternative route options to get cargo from PL and CZ to the UK and vice versa. Examples are the Channel Tunnel (chapter 3.2.2) and the Port of Gdansk. (chapter 3.2.3).

Currently, 25 percent of UK-EU cargo goes through the Channel Tunnel. The Brexit will nullify current laws and regulations regarding Channel Tunnel. Unless clear new laws and regulations regarding Channel Tunnel operations are accepted by both the British government and the EC before the start of 2021, massive disruptions in the Channel Tunnel operations are expected causing trucks to be delayed for up to a couple of days. Rens Rhode, CFO TMA Logistics, said during his interview with NWC1: *"Het gaat nu waarschijnlijk met zeilenwagen, maar straks met Brexit krijg je wachtrijen bij Calais. Dus dan is een terminal gebruiken zoals Amsterdam, dan heb je het voordeel dat je in een keer het hele douanedocument kan regelen. Het duurt 18 uur om aan te komen in Engeland, dus dan heeft Engeland ook al 18 uur de tijd om de douanepapieren de regelen en dan kunnen de containers gewoon door zonder wachttijden."* (Rhode, 2020). This is interpreted as shortsea being favourable after the Brexit as time can be saved by checking the transport documents all at once at the Port of Amsterdam, instead of having to check all the transport documents separately from each truck. Long queues, sometimes even days long, are expected to occur at both Channel Tunnel ends as the result of this extra paperwork. The Port of Amsterdam can offer a shortsea connection for transporters to and from the UK to help these transporters avoid Channel tunnel disruptions.

An existent rail cargo corridor from CZ to a seaport is the route Hamburg, DE - Prague, CZ. This corridor transports 450.000 TEU yearly which translates to approximately 120 freight trains a week. Due to this existing connection, the Port of Amsterdam is advised against starting a route to Prague. There is a rail link between Hamburg, DE and Ostrava, CZ of two freight trains weekly. Since the Port of Hamburg has limited room to grow, it is unexpected that the Hamburg, DE – Ostrava, CZ rail route will grow significantly (chapter 3.2.4). Furthermore, the water level of the river Elbe which connects the Port of Hamburg to the sea is sometimes too low for ships to sail through. Shortsea travel time at 14 knots is 41 hours from the Port of Hamburg to the Port of Felixstowe, were the travel time from the Port of Amsterdam to the Port of Felixstowe is only nine hours. (Rotterdam, 2015).

Another seaport aiming to expand their share of the PL and CZ transport market is the Port of Gdansk. This port is the largest port in PL in TEU handled and offers direct shortsea connections to multiple ports in the UK. The Port of Gdansk is planning to establish a direct rail link to the Belarussian city of Minsk, which has a direct connection to China due to the BRI. Currently, cargo departing from Minsk reaches Gdansk either via the rail link trough Warsaw or via the LT port of Klaipeda. Furthermore, PL is modernizing their rail network which could raise their maximum speed limit for freight trains. If PL can increase their maximum freight train speed, the Port of Gdansk could offer a faster rail connection to southern PL and CZ terminals and therefore increase their market share, possibly at the expense of the market share of the Port of Amsterdam. Currently, the rail route Amsterdam, NL - Gliwice, PL takes 26 hours were the rail route Gdansk, PL – Gliwice, PL takes 34 hours (Table 17). Furthermore, the Port of Amsterdam offers a shorter route to the port of Felixstowe by shortsea compared to the Port of Gdansk to the Port of Felixstowe, nine hours compared to 82 hours at 14 knots (Ports, 2020). Due to the better geographical location of Amsterdam compared to that of Gdansk, the Port of Amsterdam is expected to still offer a shorter route in time to UK ports despite PL efforts to shorten their hinterland travel time by rail.

5.4 Corridor Choice

Using the calculations based on a 25-wagon freight train, it can be concluded that rail transport has a lower route cost per TEU compared to road transport using a HGV40 on a number of routes. All the routes are either going to or starting from Amsterdam. The departing/arrival terminal in Amsterdam is TMA logistics terminal. This intermodal terminal is facilitated with a train track and a docking station for short sea vessels. From this terminal, shortsea vessels are departing frequently to the United Kingdom. The pick-up/drop-off location is situated in the southern part of Poland or in the Czech Republic. All the terminals in the destination countries are examinate and checked for suitability to accommodate these large freight train and if they have enough facilities to handle the trains and trucks efficiently.

For the calculations for the cost and travel time of the road transport the assumption is made that the trucks drive 70 kmph in Germany and 60 kmph in the rest of Europe. Traffic congestion is common in European countries, costing logistic companies a lot of money because of the time delay.

Travel time by rail from Amsterdam to Gliwice is almost 26 hours and Amsterdam to Brzeg Dolny close to 19 hours (Chapter 5.1.2, Table18). This is shorter than from Gliwice and Brzeg Dolny by rail to the largest seaport in Poland, Gdansk, with respectively taking 34 hours and 27 hours. This is due to the fact that in Poland has some of the slowest average freight train speeds in Europe with the rail connections to Gdansk being notoriously slow averaging merely 19 kmph. So, if a container must go from south Poland or the Czech Republic to Great Britain it is het way faster to send it via a freight train corridor to Amsterdam and then by shortsea to Felixstowe than to send it to the Port of Gdansk first and then load in on to a shortsea vessel.

For the calculations, 25-wagon freight trains are used to get to the operating cost per TEU. In practice, a locomotive can pull over 50 wagons with just a little bit more consumption in power. So, when a train is longer than 25 wagons it becomes cheaper to transport a container. Normally a locomotive in the Netherlands can carry around 50 wagons.

The direct route Amsterdam - Brzeg Dolny, PL – Amsterdam is a corridor which is cheaper to operate by rail than by road with the costs difference of €162.98 per TEU. Based on a train with 25 wagons for a bilateral route. This cost is exclusive terminal handling costs and with a train with 25 wagons.

The route Amsterdam – Ostrava-Paskov, CZ - Brzeg Dolny, PL – Amsterdam has a cost difference per TEU of €184.01 for this triangle route. It means that the costs per TEU transported via rail is €184.01 lower than when it is done via road transport.

Amsterdam - Česká Třebová, CZ – Amsterdam is the most cost reducing route to the central part of Czech Republic. This is an already existing route via the Port of Rotterdam, but it is an excellent choice to use because of the high demand in cargo volume.

If rail would be used on the route Amsterdam – Gliwice, PL – Amsterdam instead of road, transit costs will be reduced with €108,15 per TEU on a return trip. To reach the same cost savings per TEU compared to Amsterdam – Ostrava Senov, PL – Amsterdam, the freight trains on the PL route will need a higher load factor.

The route with the highest price margin is the route Amsterdam - Ostrava-Paskov, CZ – Amsterdam, with a cost difference per TEU of €218.92 for a return trip. Next is the route Amsterdam- Ostrava-Senov, CZ- Amsterdam with a cost difference of €213,14. These two destinations are located in the region Moravia-Silesia with Ostrava being the capital city. The corridor to Ostrava has the largest cost difference between modalities and therefore is the best option for a modal shift. Furthermore, Ostrava currently has no corridor with the Netherlands.

Another good reason to choose for Ostrava is because China has a direct rail connection with the Czech Republic. The trains coming from Xi'an arriving at Ceska Trebova, a small place between Ostrava en Prague. This cargo must be transhipped to the rest of Europe. Ceska Trebova is located in the hinterland of Ostrava, so Ostrava can take advantage of this corridor. Now that the location of the corridor is clear, a terminal to load and unload the containers must be chosen. Both terminals in Ostrava are possible, Ostrava Paskov terminal and the METRANS Container Terminal Ostrava Senov. In the next chapter the discission for the terminal is explained.

6 Discussion

How can NWC create a larger network by outlining new potential corridors, establish a single new corridor and realizing this in their current network? That is the main question this study is based on. The result of this study shows that Amsterdam has the potential to become a logistic hub between the United Kingdom and Poland/Czech Republic. The port of Amsterdam acts like a transhipment seaport for cargo coming from southern Poland and the Czech Republic. In South Poland, there are two potential terminals: PCC Intermodal Terminal Gliwice and PCC Intermodal Terminal Brzeg Dolny. The two terminals in the Czech Republic are located near Ostrava: the Ostrava Paskov Terminal and the METRANS Container Terminal Ostrava Senov.

Despite these promising results, questions remain unanswered about terminal handling costs. The terminal handling costs are not factored in the calculations due to the scarcity of data and complexity of these costs. The assumption in this report has been made that terminal costs are the same at each terminal.

Questions about last-mile transport remain unanswered. The final kilometres before arrival to the client must be executed over road. The effects of last-mile transport are excluded from this research, since this research focusses setting up a terminal-to-terminal corridor and not door-to-door transport.

The costs saved by using a rail corridor to the Czech Republic are higher than that of Poland (Gliwice and Brzeg Dolny), hence why the choice is made to fully focus on the corridor to the region Moravia-Silesia in the Czech Republic. These costs are based on a train with 25 wagons. This is large setback for the focused regions in Poland because this is a high potential region with no direct connection to the port of Amsterdam. When the trains get longer than 25 wagons and if terminal charges are included in the calculation, Poland is expected to be a good option for a rail corridor but to confirm this a follow up research is needed.

Although the costs saved by using rail instead of road are between 3.2 and 6.4 percent higher on the route Amsterdam-Ceska Trebova than Amsterdam-Ostrava, the route Amsterdam-Ceska Trebova is not recommended since their as already the Dutch intermodal route Rotterdam-Ceska Trebova and the projects goal is to find a completely new Dutch corridor.

The Route Amsterdam-Prague is avoided due to the well-established Hamburg-Prague intermodal corridor which would be a challenge to compete against.

Both the Ostrava-Paskov Terminal in Ostrava-Paskov and the METRANS Container Terminal in Ostrava Senov are suitable to be used for an Amsterdam – Czech connection. The travel time from Amsterdam to the Ostrava-Paskov Terminal by rail is only minutes shorter compared to the METRANS Container Terminal. Both terminals have the handling tracks to handle a 650-meter train, which is the maximum allowed freight train size on the Dutch – Czech route. Both terminals are capable to store containers. The METRANS Container Terminal in Ostrava Senov is preferred to be used due to their larger storage capacity.

If contract negotiations with the METRANS Container Terminal are unsuccessful, the option remains to choose the Ostrava-Paskov terminal.

The results of setting up a corridor to eastern Europe is further supported by the idea of big logistic operators like Samskip who are looking into the possibilities in using the Port of Amsterdam as a transhipment port for eastern Europe and the United Kingdom.

Both Poland and the Czech Republic are modernizing and expending their rail network. Train connections will be improved between western Europe and Poland in the coming years. Currently, freight trains in Poland only reach average speeds of 31.7 kmph, resulting in long travel times between the Czech Republic and southern Poland to the seaport rich region of northern Poland, which is located at the Baltic sea. If this rail connection becomes faster, more cargo is expected to go to the seaports of Poland and then be loaded on a ship. This new rail line between the seaport of Gdansk and Ostrava mentioned is expected to be ready in the year 2050 (Chapter 3.2.3).

7 Conclusion & recommendation

Concluding this research by answering the main question: *How can NWC create a larger network by outlining new potential corridors, establish a single new corridor and realizing this in their current network?* Based on NWC1 research, a TMA Terminal Amsterdam, NL – METRANS Container Terminal Ostrava Senov, CZ rail corridor is advised to enlarge the NWC network. This single corridor has been validated in terms of cost and demand. This corridor reduces transport cost with €213.14 per TEU for a return trip, based on a 25-wagon freight train, when opting for rail transport instead of road transport. The cargo flow balance, based on the regions where the TMA Terminal Amsterdam, NL and METRANS Container Terminal Ostrava Senov, CZ are situated, is 0.9 TEU from Noord-Holland, NL to Moravian Silesian, CZ for every 1.0 TEU from Moravian Silesian, CZ to Noord-Holland, NL. Based on minimum travel time, a freight train would take 14 hours and 19 minutes less for a retour trip than a truck. Unlike the Czech container terminals in Prague and Ceske Trebova, the METRANS Container Terminal Ostrava Senov has no frequent international train connections as of now, meaning that there are no direct international rail connections the Port of Amsterdam has to compete against.

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