Progress towards Federated Logistics through the Integration of TEN-T into A Global Trade Network

Deliverable 1.4

Simulation based impact of new trade routes on TEN T and disadvantaged region v1

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Glossary of terms and abbreviations used

Abbreviation / Term	Description
BRI	Belt and Road Initiative
CAREC	Central Asia Regional Economic Cooperation
EAEU	Eurasian Economic Union
FTA	Free Trade Agreement
GDP	Gross Domestic Product
INSTC	International North–South Transport Corridor
IWW	Inland Waterway
LNG	Liquefied Natural Gas
NSR	North-South Route
NSTR	Nothing Significant to Report
NWP	North-West Passage
OECD	Organization for Economic Cooperation and Development
PEP	Primary Entry Point
TEN-T	Trans-European Transport Network
TEU	Twenty-foot Equivalent Unit
VOT	Value of Time
WCM	World Container Model

1 Executive Summary

Since 2014, the European Union has taken on a leading role in further expanding and improving the quality of the transport networks of the European Union. The EU's long-term TEN-T policy belongs to the world's vanguard in terms of ambition, geographical scope and network density. Further advancing the EU's leadership in global transport flows and logistics starts with establishing a sound and fundamental understanding of the impact on the TEN-T network of global transport and geo-economic trends. In order to achieve this, Task 1.2 performs a strategic analysis of the most relevant emerging trade routes which are expected to gradually change global transport patterns, and a simulation of their potential impacts on the TEN-T. This relates to the intercontinental rail freight connections between China, Russia and Europe (Belt and Road Initiative) and the Middle East and Northeast Europe (International North-South Corridor).

The findings of Task 1.2 are published in two deliverables: D1.4 (present document) and D1.5. This report establishes the baseline scenario (year 2019) for the three new tade routes. The second report will explore the 2030 and 2050 simulations and link the usage of the corridors to changes in the disadvantaged regions (e.g. accessibility, economic growth, population).

For Eurasian rail freight transport, rail services coming from China and arriving at the European border in 2019 overwhelmingly used Malaszewicze as principle entry point (PEP). The 200.000 TEU per year coming from China translated into some 55 trains per week. About 12% of this flow branched off towards Lodz. Some 23% went to Hamburg and some 44% went on to Duisburg. Smaller flows went to Liege, Ghent, Tilburg and Madrid. Export flows also travel in the opposite direction, but to a lesser extent.

For the International North-South Corridor, we see a current potential of over 86.000 TEU, which could increase to 125.000 TEU in 2030 and 206.000 TEU in 2050. It remains to be seen how long it will take for these volumes to be realised if the route is completed. Only a fraction of the cargo is related to Europe. This concerns 8.500 TEU if the route would be opened right now, which could increase to 13.500 TEU in 2030 and 24.000 TEU in 2050. The corridor is therefore most interesting as a European trade route if European trade can be combined on INSTC trains with Russian cargo.

Regarding the Arctic Route, we have found that its greatest potential lies in the transport of raw materials that come from this region, especially energy-related raw materials. In 2019, approximately 6 ships per week arrived in Europe from this region. Russia has plans to more than triple the amount of raw materials extracted by 2030. However, Russia also plans facilities to be able to process the raw materials on its own soil, so that transport to Europe will no longer be necessary. It is therefore not expected these commodity flows to increase, thus keeping the impact on the European TEN-T network negligible.

NOTE: For completeness, we have included at the end of this report (as Annex) the full "Preliminary Analysis on Europe's Disadvantageus Regions" from the perspective of the EGNT evolution taking into account the impact of those "new routes" along with Tent-T Synergies and intercontinental freight flows as contributors.

2 Introduction

2.1 New trade routes and their implications

Since 2014, the European Union has taken on a leading role in further expanding and improving the quality of the transport networks of the European Union. The EU's long-term TEN-T policy belongs to the world's vanguard in terms of ambition, geographical scope and network density. Further advancing the EU's leadership in global transport flows and logistics starts with establishing a sound and fundamental understanding of the impact on the TEN-T network of global transport and geo-economic trends. In order to achieve this, Task 1.2 consists of a strategic analysis of the most relevant emerging trade routes which are expected to gradually change global transport patterns, and a simulation of their potential impacts on the TEN-T.

The EU-China rail connection has been experiencing strong growth, yet the long-term economic viability and competitive neutrality of this rail connection needs to be addressed. Also, the route's competitive position vis-à-vis other modes is subject for analysis, which should involve the rapid expansion of intra-Eurasian rail connections and rail freight services, especially between China, Russia and Central Asian countries.

Concerning the Arctic sea route, it is estimated that sea ice is declining at a rate of 12.8 percent per decade. The response to the effects of climate change in the Arctic is done through two strategies, mitigation and adaptation. Whereas mitigation involves the reduction of greenhouse gas emissions, the adaptation strategy concerns the adjustment to the actual or future changing climate conditions. The goal of adaptation is not only to reduce vulnerability to the new conditions (such as sea-level rise and extreme weather events), but also to take the opportunity to profit from any potential benefits that may arise. Within the Arctic Region, potential benefits relate to the new opportunities emerging for shipping activities and natural resources extraction. Arctic sea traffic by cargo ships, passenger ships, offshore vessels and fishing vessels as well as the mining activities in the region are expected to intensify in the near future. The possibilities from fossil fuel extraction are more controversial, as additional exploitation of fossil fuels is bringing extra greenhouse gasses in the atmosphere (and essentially opposing the mitigation strategy for global warming). In any case, climate change impacts the Arctic, bringing new challenges and opportunities for the EU and its TEN-T network.

The International North–South Transport Corridor (INSTC) is a 7,200-km-long multi-modal network of ship, rail, and road routes for moving freight between India, Iran, Afghanistan, Armenia, Azerbaijan, Russia, Central Asia and Europe. The objective of the development of the corridor is to increase trade connectivity between major metropolitan regions such as Mumbai, Moscow, Tehran, Baku, Bandar Abbas, Astrakhan, Bandar Anzali, etc. Dry runs of two routes were conducted in 2014, the first was Mumbai to Baku via Bandar Abbas and the second was Mumbai to Astrakhan via Bandar Abbas, Tehran and Bandar Anzali. The objective of these trials was to identify and address key bottlenecks. The results showed transport costs were significantly reduced. Other routes under consideration include via Kazakhstan and Turkmenistan.

The impacts of new trade routes developments, although ricocheting positively onthe EU economy and its social development, may be different for the various EU regions. In particular, disadvantaged regions may benefit from specific opportunities by filling up historical gaps, if properly managed. This deliverable analyses the impacts of the new trade routes on the TEN-T and European disadvantaged regions (see annex for a full exploration). This includes predicted flow changes for the European corridors with a focus on 2030 and 2050 time horizons. Some ideas of leveraging the role of intermodal nodes, in particular the inland ones covering comprehensive logistic activities supporting local developments, are elaborated as well.

Belt and Road Initiative analysis

In the analysis of the Belt and Road Initiative, information about its viability and its environments is collected and brought together. Information on the status of, and further plans for the initiative (e.g. expansion of rail connections and rail freight services), bottlenecks, transport costs, data on the use of the Belt and Road Initiative and prognoses (if available) for the future, competing lines and how they are used, and other relevant topics are included. Both subjective and objective data are utilized in the strategic analysis, where the long-term economic viability, competitive neutrality of the rail connection, and competitive position of these routings in relation to other modes have been researched.

Northern Sea Route analysis

In the analysis of the Northern Sea Route information about the Route and its environments is brought together, including the status of and further plans for the Route (e.g. expansion or adaptation because of melting ice caps), bottlenecks, transport costs, data on the use of the Route and prognoses (if available) for the future, competing routes/lines and how they are used, and other relevant topics. Arctic sea traffic by cargo ships, passenger ships, offshore vessels and fishing vessels, as well as the mining activities in the region are expected to intensify in the near future. This brings possibilities but also challenges related to greenhouse gases. Both subjective and objective data are used in the analysis, where the long-term economic viability, competitive position of the Route in relation to other modes and climate challenges are researched.

International North-South Trade Corridor analysis

In the analysis of the International North-South Trade Corridor, information about the Corridor and its environments are brought together. This includes information about the status of and further plans for the corridor (e.g. expansion of connections and services), bottlenecks, transport costs, data on the use of the corridor and prognoses for the future, competing corridors/routes and how they are used, and other relevant topics. Both subjective and objective data will be used in the analysis, where the long-term economic viability and competitive position of the Corridor in relation to other routes are researched through a simulation model.

A potential trade route that is not included in the present analysis is a possible rail tunnel connection between Spain and North Africa (as discussed in Position Paper 1). This still seems to be a relatively distant prospect and therefore less relevant for impact simulation. The findings of Task 1.2 are published in two deliverables: D1.4 and D1.5. The present report establishes the baseline scenario (year 2019) for the three new tade routes. The second report will present the 2030 and 2050 simulations and will link the usage of the corridors to changes in the disadvantaged regions (e.g. accessibility, economic growth, population).

2.2 Mapping PLANET Outputs

Purpose of this section is to map PLANET's Grant Agreement commitments, both within the formal Deliverable and Task description, against the project's respective outputs and work performed.

Table 2-1 Adherence to PLANET's GA Deliverable & Tasks Descriptions

PLANET GA Component Title	PLANET GA Component Outline	Respective Document Chapter(s)	Justification
DELIVERABLE			
D1.4 Simulation based impact of new trade routes on TEN T and disadvantaged regions	Simulation based impact of new trade routes on the TEN-T and disadvantaged regions	Ch. 6, 7, 8	The respective chapters bring forward the results from the baseline (2019) analysis of the impact of new trade routes on the TEN-T network.
TASKS			
ST1.2.1 Preparatory activities	ST1.2.1 Preparatory activities for the simulation will build upon the scenarios formulated in Task 1.1 in order to detail the research questions for applying the Panteia Terminal Hinterland Model.	Ch. 3, 4	The respective chapters develop the methodology and infrastructure analysis that are required for carrying out the simulation (using the Panteia Terminal Model), further building upon the scenarios identified in T1.1.

3 Methodology

Following the strategic analysis, the impact of these new trade routes on the TEN-T network is analysed. This shall be primarily done by carrying out a simulation. The simulation will predict the future transport flows between China and Europe, taking into account the new trade routes, and the effect of these transport flows on the European network. Particular attention is paid to the impact of the three emerging routes on disadvantaged regions in Europe.

The scenario simulation will be carried out delivering the volumes per current and emerging trade routes, for the year 2030 and 2050 for all the TEN-T corridors. Deepsea port volumes, hinterland terminal volumes, and freight flows will be determined using the model, giving insights in terms of modal split, external costs (emissions, noise, congestion, accidents) and transport costs. The analysis of corridors will take into account specific product levels to allow impact of technologies (T1.4) such as 3D printing on the international flow of some products Based on the simulation results, potential up- or downgrades of existing TEN-T infrastructure will be identified, as well as missing links and the potential locations of hubs.

The findings of Task 1.2 are published in two deliverables: D1.4 and D1.5. The present report establishes the baseline scenario (year 2019) for the three new tade routes. The second report will present the 2030 and 2050 simulations and will link the usage of the corridors to changes in the disadvantaged regions (e.g. accessibility, economic growth, population).

The simulation is carried out using the **Panteia Terminal Model**. This model utilizes input from the **Panteia World Trade Model**, the **Panteia NEAC Model**, as well as any other useful models (e.g. the World Container Model). Moreover, the simulation will be carried out with close support from NEWOPERA, who has extensive experience in such modelling exercises through the application of the **Traffic Attraction Zone Model** run in 2014 with traffic projection up to 2050. This model is particularly suited for investigating the impact of emerging routes on disadvantaged regions in the areas around the routes. Documentation on the Traffic Attraction Zone Model provided by NEWOPERA has been used to build the simulation.

3.1 Simulation approach

The simulation follows the traditional model approach, using trade driven volumes, fixed sum mode choice and modelling the present-day. The modelling steps are:

1. Create a transport network covering Europe and China, now and in future, including the trade routes between Europe and China. This step forms the core of the strategic analyses of the three emerging trade routes with which task 1.2 commences.
2. Develop an O-D matrix with trade data between European and Chinese regions
3. Calculate the transport costs between the European and Chinese regions
4. Develop forecasting scenario’s for 2030 and 2050 for the trade, transport network and transport costs
5. Calculate the transport flows between the European and Chinese regions for the forecasting scenarios and calibration of the results.
6. Calculate the impact on TEN-T based on different scenario’s
7. Calculate the impact on the disadvantaged regions

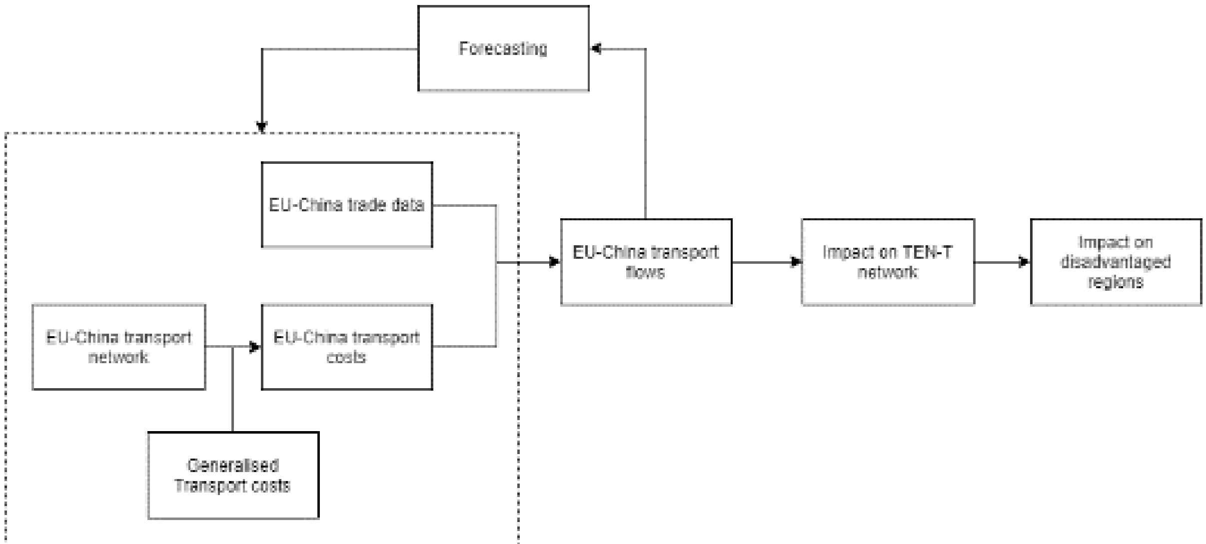


Figure 3-1: Task 1.2 modelling steps

The steps are ‘work in progress’ and will be further developed as the modelling process progresses. Initially, a simple model will be built with a number of links and simple costs as a proof of concept. Based on this, the model will be slowly extended on different parts. For example, more nodes will be added, more cost parameters will be included or the path-finding algorithm will be more detailed.

3.2 Description of the models

The following models will be used in Task 1.2:

Terminal Model (Panteia)

The Terminal Model is a flexible transport model offering extensive policy and scenario evaluation options. In its core, the terminal modal calculates transport costs and time between regions for various modes of transport and different commodities. It uses a complex networks (road and intermodal, including transhipment points) including associated transport cost to establish transport costs from a particular location within the study area (municipality level) to any other area within or outside Europe (NUTS-3 level).

Over the years, the Terminal Model has been used in various projects, including modal shift potential, analysing sea port catchment areas, impact of different train lengths on intermodal transport costs and the evaluation of changes to certain transport routes. The model is written in python.

NEAC Model (Panteia)

NEAC is a European freight flow database and a multimodal transport model, all in one package, designed for analysing medium to long-distance traffic flows. It was developed in-house by Panteia, combining inputs and experience from a long series of European transport studies. As a highly detailed and flexible system, it has extensive policy and scenario assessment capabilities.

NEAC combines data inputs from a very wide range of trade, transport and infrastructure databases to support a pan-European multimodal model. The model follows a classical approach using detailed multimodal networks to model route and mode choice. It allows a wide range of scenarios and impacts to be analysed. NEAC-10 models traffic flows as multimodal chains describing the transport of a commodity from its region of production, via transhipment locations to the region of consumption. NEAC-10 has been used extensively for modelling TEN-T networks and corridors. It can model traffic flows at link level.

World Trade Model (Panteia)

WTM (World trade Model) is an input-output model of the world economy. It describes deliveries from sector I in country c to demand category j in country c. This model is used to predict trade flows between countries per sector, for example the (development of the) deliveries of the mining industry in Saudi Arabia to another country, for example Pakistan, or the deliveries of the metal industry in China to France.

World Container Model

In order to analyse possible shifts in future container transport demand and the impacts of relevant transport policies, the World Container Model (WCM) was developed. This strategic model for the movement of containers on a global scale was developed at TNO in partnership with the Delft University of Technology and TML. The model excels at combining a consistent description of worldwide trade flows, container flows and transportation services on a global scale, combined with a port and multimodal route choice model.

The multimodal route and port choice procedure is conducted using an improved logit choice model that considers overlaps between alternative routes in the network. The model considers transport times, tariffs, and time sensitivity of goods. It describes yearly container flows across the world's shipping routes through 437 container ports around the world, based on trade information to and from all countries, taking more than 800 maritime container line services into account. The model distinguishes between import, export and transshipment flows of containers at ports, as well as hinterland flows.

The model was calibrated against all available port throughput statistics. Scenario analyses done with the model included the effect of low speed shipping, increase of land-based shipping costs, major infrastructures such as the Trans-Siberian rail line and the opening of Polar shipping routes. The model is being applied for the European Commission's Trans-European Networks programme and the Rotterdam Port Authority, to develop long term forecasts.

Traffic Attraction Zone model

The Traffic Attraction Zone model takes the nodes and their localization are the focal point of the analysis. Nodes play a major role in the implementation of corridors and networks not only because they are an integrated part of the network infrastructure - as entry or exit points of the networks, or places for transhipment or marshalling yards - but also because they are the centres of organisation of transport.

Nodes are indeed places of "interface":

- Between modes;
- Between spatial levels; Global; Continental (European); National; Regional; Urban levels;
- Between types of actors; transport operators and representatives of institutions.

Results are presented based on relevant objectives that are broken down at national, regional and local levels, pointing out major contextual differences. This is done in such way as to allow for application to a more diffuse level of the transport network. In doing so, the objectives have also been derived:

- not only in tons (segmented by bulk/containers and products);
- but also in tons per threshold of distance, not only 300Km but also 600Km, and even for intervals of 100km recalling that if a global figure for modal shift is given, this must also be interpreted in

terms of absolute value for transport; different thresholds allow more progressive approaches for modal shift and consolidation of flows;

- and also in Tons-Kms, which is often the most relevant indicator for analysis of modal share and impact of transport on environment.

In doing so, a whole database of transport has been reconstructed based on the distributional patterns of population and activities across Europe. The global result appears consistent with the EU Statistical Pocketbook figures, although it is well known that basic statistics of transport are not always homogeneous across countries. The ETIS Plus database is used for transport across Europe as well as CAFT for trans Pyrenean and trans Alpine, and SITRAM database for France.

The model takes into account detailed operation costs for modes, with distinction between feeding trains to nodes and two types of trains for transports between core nodes (long trains of 1.000T, and trains of 500T). This differentiation allows for explicating the impact of the use of long trains upon capacity use.

3.3 Scenario development

Scenarios offer insights into possible future developments. Scenarios can be used to gain insights into the most likely direction the future will take, but you can also use scenarios to gain insights into what the future will look like when certain choices are made. The scenario method consists of a number of steps, the first of which is a description of the system under investigation and the factors influencing it, followed by an outline of the development possibilities and a justification of a given decision situation. As a result, many potential images of the future are obtained.

The advantage of scenario analysis is the possibility of examining the effects of decisions in changing circumstances. Scenario planning is an important tool for identifying risk factors and areas of uncertainty with regard to certain developments. A scenario analysis usually consists of a business-as-usual scenario and other scenarios that focus more on specific possible developments. The table below contains a preliminary list of possible scenarios for Task 1.2. It is possible that in the course of this study the number of scenarios will be expanded. Each scenario will be simulated for 2030 and 2050, the results of which will be presented in the next deliverable. Nevertheless, the scenarios were preliminary identified already in order to allow for a progressive development of the project.

Table 3-1 Overview of the preliminary scenarios used in task 1.2.

Year	Scenario type	Reference scenario (2019)	Assumptions		
			Exogenous developments	**Rail scenario**	**Disadvantaged Regions (DR)**
2030	High	*Business-as-usual*	*High growth*	*High investment*	*High progress in DR*
	Low		*Low growth*	*Low investment*	*Low progress in DR*
2050	High	*Business-as-usual*	*High growth*	*High investment*	*High progress in DR*
	Low		*Low growth*	*Low investment*	*Low progress in DR*

3.3.1 Reference scenario

This scenario, also referred to as the business-as-usual scenario, assumes that there will be no significant change in the trade patterns, so that normal circumstances can be expected to continue unchanged. The assumptions for the economic and demographic growth from the reference scenario will be used as a basis to develop more specific scenarios. The reference (or baseline) scenario takes the year 2019 as its basis, and is presented in the next chapter.

Specific scenarios, as will be used in the 2030 and 2050 simulations, are developed based on a set of assumptions described below. *Exogenous* factors will affect the (railway) transport economy but take place in a broader context. *Rail* developments are taking place within the railway sector and economy and are therefore expected to affect route choices even when all exogenous factors remain stable.

3.3.2 Specific scenarios

Exogenous developments

The reference scenario will be complemented by a high and a low scenario. The High scenario combines relatively strong economic growth with relatively strong population growth; the low scenario combines moderate economic growth with limited demographic development. These two variants provide insight into the bandwidth within which the future is likely to take place.

Rail scenario

Europe has always been strongly committed to rail freight transport. In this scenario, rail freight transport is highly efficient and attractive. Low costs due to economies of scale, an extensive rail network, infrastructure investments, fast trains and efficient terminals, among other things, contribute to many shippers opting for rail freight transport instead of other modes of transport. In this scenario, the Eurasian rail route (and to a lesser extent the North-South Route) will be used much more intensively for trade between Asia and Europe. This scenario includes:

- Lower transport costs by rail
- Decrease in transport time
- Efficient border crossings
- More terminals connected in Europe and China
- More efficient rail terminal operations

In addition to a scenario in which railways are used more intensively for freight transport, a situation in which this does not happen is also being considered. In this situation, no further modal shift to intercontinental rail takes place. This provides insight into the consequences of underdevelopment of rail freight transport.

Disadvantaged regions scenario

Eastern Europe is the gateway for rail transport to and from Asia. In this scenario, considerations must be given in case the disadvantaged regions develop very strongly which is a likely scenario. This involves infrastructural development on the one hand, and socio-economic development on the other. From this analysis, key hubs for china-europe rail transport can be identified, which can serve as a starting point to develop more centralized or local strategic management initiatives. A low development scenario in these regions is also considered. Disadvantaged regions will be analyzed in the next deliverable together with the 2030 and 2050 scenarios.

4 Infrastructure analysis

4.1 Belt and Road Initiative

As set forth already, by far the most important railway corridor between Western Europe and China, now and in the foreseeable future, runs through Poland, Belarus, Russia and Kazakhstan. Trains typically carry up to 41 high-cube containers of 40 ft., making up for trains of approximately 565 m. As a rule, the trains do not exceed the total number of 41 *containers*, of any type or size, due to Chinese government subsidy regulations in conjunction with infrastructure capacity in the EU. However, for the long haul through the Eurasian Economic Union (EAEU) countries – in effect Belarus, Russia and Kazakhstan – where freight trains often exceed 1.000 m, combining trains is common use.

Under normal circumstances, lead times from terminals in inland China to Duisburg stand at 15 to 16 days or slightly less, which would allow for a time saving of some 14 days compared to ocean for the overall transport. However, currently experienced delays are seen to increase lead times to 18 to 19 days or even more. These partially capacity-related issues are a driver towards considering and testing possibilities for using alternative stretches. In the next sections, this is examined in more detail.

4.1.1 The main corridor

From the Polish-Belarusian border, two routes are available. The first proceeds to Moscow and from there to Yekaterinburg, where the corridor is split up with the most important leg transiting Kazakhstan towards the Chinese border, and an alternative leg transiting Siberia and reaching China either via Mongolia or via the Russo-Chinese border. The second route diverts at Minsk, transits Southern Russia and then crosses into Western Kazakhstan, from where it also proceeds to the Chinese border. Over two thirds of rail freight between China and Europe is forwarded via the Russia-Kazakhstan route, with only small portions via alternative routes.

Break of gauge takes place on the Polish-Belarusian border (Malaszewicze/Brest or alternative EU-EAEU border crossings) and on the Kazakh-Chinese border (Dostyk/Alashankou; Khorgos) or, for the Trans-Siberian route, the Russo-Chinese (Zabaykalsk/Manzhouli) or Mongolian-Chinese border (Erenhot). Customs procedures also take place on these border crossings, with Russia, Belarus and Kazakhstan being members of the Eurasian Economic Union (EAEU) customs area and Mongolia being aligned to it.

The essential milestones (both westbound and eastbound) are thus:

- Assembly/arrival of the goods at European rail terminals, such as Duisburg, Hamburg or Tilburg;
- Brake of gauge, transhipment and customs procedures at Malaszewicze/Brest;
- Brake of gauge, transhipment and customs procedures at Dostyk/Alashankou or Khorgos;
- Arrival/assembly of the transports at Chinese rail terminals, such as Chongqing, Chengdu, Wuhan, Xi’an or Yiwu.

Figure 4-1 The main Europe-China railway corridor ©Panteia

European sections, terminals and transhipment points

The most important start and end point for trains to and from China is the inland port of Duisburg, which at the time of writing handles some 120 trains per month in either direction, and in the same area the inland port of Neuss. Other important departure and arrival points include the port of Hamburg, Railport Brabant (Tilburg) and, in Central Europe, Łódź (Łódź Special Economic Zone) and Budapest. Apart from the logistic rationale, not all European rail terminals are able to handle trains to and from China due to the capability requirement of communicating with information control systems used by the Chinese intermodal operators who organise the transport process. A number of Western European destinations, including the port of Amsterdam as of March 2018, are serviced through Duisburg rather than directly.

The trains reach the Polish-Belarus border at Malaszewicze/Brest, where break-of-gauge transhipment and customs procedures take place. Traditionally, westbound trains were transhipped in Malascewicze, whereas eastbound trains were transhipped at Brest. However, nowadays operators can decide on which side of the border the transhipment takes place.

The Malaszewicze/Brest border crossing is identified by all stakeholders as the first and foremost bottleneck, notably for westbound transport. Ideally, transhipment and customs procedures would take some 18 hours for an entire train (this is the official aim of the Belarus Railways), but in practice this may last for 2 to 3 days or even longer. This, combined with the notorious difficulties of the busy European railway network, causes many trains to arrive with serious delay at their Western European destinations and leads to rescheduling issues and congestion at the most important arrival terminals.

Estimations of current infrastructure capacity at the border crossing (e.g. availability of cranes and tracks at the terminals) stand at some 10 trains per day (loaded with 80 TEU). Also, current regulations between Poland and Belarus allow for a maximum of 12 border crossings per day. Thus, in terms of infrastructure, the border crossing may already be operating at its maximum capacity.[2]

The Malaszewicze/Brest border crossing: essential logistic procedures

For westbound trains, handling procedures typically resemble the following path:

- Belarusian railways run the train to a Belarusian railway terminal
- Belarusian customs control
- Border control on two sides of the border
- Shunting across the border to Polish customs – typically carried out by Belarusian railways
- Shunting to Polish terminal for transhipment – carried out by one of two Polish shunting operators
- Operator picks up train

For eastbound trains, procedures are slightly different:

- Rail operator runs the train to a Polish terminal
- Shunting to Polish customs station
- Border control on two sides of the border
- Shunting by Polish operator across the border to Belarusian terminal
- Transhipment and customs at Belarusian terminal
- Taking over by Belarusian railways

As will be detailed in the next paragraph, border procedures are generally very time-consuming. Also, the time needed for border procedures can deviate due to logistics processes of operators (choice of terminal, trucking operations between terminals, loading and unloading in addition to transhipment, storages, train composition) or incorrect documents. It therefore seems fair to conclude that infrastructure limitations coincide with suboptimal administrative procedures and organisation.

Poland intends to invest some 55 million euros in the facilities on the Polish side of the border over the coming years, aiming to increase capacity and enable the use of 750m trains and higher axle loads. Another 40 million of investment is depending on the construction of a third railway bridge (broad gauge only) and additional tracks across the border jointly with Belarus. Terminals on the Polish side are privately owned, whereas Belarusian facilities belong to Belarusian Railway. Ideally, infrastructure investments would be accompanied by optimisation of procedural management and communication between parties on both sides of the border, initiatives for which are being started as well. Options for improvement are being considered by multiple stakeholders, but, as we will see, partially depend on customs regulations. One possible option could be a limitation of loading and unloading operations at the border terminals, in order to focus on essential border handling (transhipment and legal procedures). Also, optimising shunting procedures of empty wagons in the border area is considered.

2 www.belint.de/material/belintpresentation.pdf

The Eurasian Economic Union

The Eurasian Economic Union (EAEU) is an economic union in the Northern Eurasian hemisphere, which entered into force in 2015. It currently consists of Russia, Kazakhstan, Belarus, Armenia and Kyrgyzstan, with possible prospects for deeper cooperation or accession for others. Notably, this may concern Tajikistan, Azerbaijan, Mongolia, Moldova and Turkmenistan.

The EAEU has an integrated market of some 183 million people, with considerable combined economic output. It features free movement of goods and people and envisages gradual integration of markets, although the process seems to have slowed down. Common policies are in place in a number of fields – including customs, transport and foreign trade and investment. Free trade agreements exist with a number of countries, including Moldova, Uzbekistan and Vietnam.

As the Chinese BRI initiative is expected to bring considerable investments to the Central Asian region, the EAEU is regarded by some observers as an unfortunate – or even inferior – competitor. However, from a transport perspective, the Eurasian customs union removes a number of technical and customs obstacles for the Silk Road Economic Belt, and can thus be regarded complementary to Chinese aims. In May 2018, a Free Trade Agreement (FTA) was signed between the EAEU and China.

thediplomat.com/2018/01/remember-the-eurasian-economic-union/

www.cer.eu/sites/default/files/pb_eurasian_IB_16.3.17_0.pdf

Obviously, another option might be bypassing Malaszewicze/Brest altogether, possibilities for which are being examined by a number of market parties. One such possible option would run from Poland through Lithuania, entering the broad-gauge system at Šeštokai, and rejoin the main corridor at Minsk. Infrastructure capacity on this route is relatively limited, however, thus rendering it unsuitable for large numbers of trains in the foreseeable future. Currently, the Polish and Belarus governments are also considering a second border crossing north of Malaszewicze (Czeremcha/Vysokolitovsk) for border crossing. Another potential bypass transits Ukraine, possibly departing from Budapest or Bratislava and changing to broad gauge at Dobrá/Chop. Recently a plan was conceived by the Austrian, Slovak and Russian railways to construct a broad-gauge freight railway line from nearby Košice to Vienna. According to the plan, construction would start in 2024 with operational status to be reached in 2033.[3]

Brest-Dostyk sections, terminals and transhipment points

The route from Poland, via Belarus and to Moscow has well-developed (electrified) infrastructure, albeit with different systems and the aforementioned break of gauge. Belarus and the Russian Federation are parts of the EAEU customs union and apply the same standards for rail operations. Therefore, border procedures at the Russian-Belarusian border are driven by technical and staff management matters rather than by cargo clearance.

An upcoming cargo hub is Minsk, where considerable investments are seen to take place in i.a. the China-Belarus Industrial Park, which is expected to increase and diversify the country's production

3 www.railjournal.com/index.php/freight/austria-backs-broad-gauge-extension-to-vienna.html?channel=527&utm_source=Email_marketing&utm_campaign=IRJ_Rail_Brief_Feb_28_2018&cmp=1&utm_medium=HTMLEmail

output. The hub's connection to the intercontinental corridor will be improved simultaneously, with Duisport, among others, investing in rail freight facilities.[4] As such, Minsk could become an example of creating added value along the corridor.

Moscow, next to being a central hinge for intercontinental rail freight, is of increasing importance as a destination – and to a lesser extent point of departure – for rail freight from China. For certain commodities, this may cause a slight loss for Northwest European deep-sea ports, as cargo to and from the Russian market may otherwise be transhipped there, onto and from shortsea services connecting with Baltic ports. The number of rail freight services from China to Moscow now stands at over 10 trains per week and is seen growing, with tariffs at around $4.000 per forty feet unit.

Trains from Western China into Kazakhstan can use two border crossings. First, the traditional border and transhipment facility at Dostyk/Alashankou is handling the vast bulk of intercontinental trains, with procedures being led by Chinese operators. Second, the new facilities at Khorgas are projected to handle increasing volumes, especially for trade to and from Central Asia, the Caucasus and Turkey. From the Chinese-Kazakh border, lead times to Brest/Malaszewicze are stable at 8 to 10 days, covering between 1.000 and 1.100 kilometers per day. The busiest station of departure in China is Chongqing, with over 10 trains per week, followed by Chengdu, Wuhan, Yiwu and others.

Freight trains destined for the EU typically carry 41 forty-foot units, making up for trains of approximately 565 m. Although in both the EAEU countries and China longer trains of over 1.000 m are operated, the European railway system, including the Malaszewicze/Brest border crossing are equipped for trains <750 m. According to stakeholders, both lead time and border handling might be improved by bundling all shipments on shuttle trains between Dostyk and Brest, rather than handling all trains from Chinese and European points of departure on an ad-hoc basis. This, however, would have to be administrated by the Chinese intermodal operators.

Between Moscow and China, parts of the route are single-track. Although the use of very long trains is common, and two parallel routes are available, future bottlenecks on these stretches cannot be excluded. The Russian and Kazakh railway authorities have indicated to the researchers that upgrades are being considered, but no decisions have been taken yet. According to the stakeholders, however, particularly Kazakhstan is keen to play an active role in further implementation of BRI.

4.1.2 Alternative corridors

Routes that are complementary to the one described above are still being used primarily for domestic and intra-continental transport between China, Russia, Central Asia and the Middle East. As already noted, for the main corridor an alternative for traversing Kazakhstan is the Trans-Siberian route, starting at Yekaterinburg and reaching Northeast China over Russian territory at the Manzhouli/Zabaykalsk border facilities, or via Mongolia at Erenhot. A parallel route to the Trans-Siberian railway is the Baikal-Amur line, which is primarily used for domestic freight transport. In 2017 it was announced that the Russian Federation plans to invest $43 billion over the next five years to upgrade its railway infrastructure. This includes the Baikal-Amur and Trans-Siberian routes, and connectivity projects to the Baltic and Black seas [5]. Apart from improving domestic rail freight and passenger transport, it is unclear what the effects on intercontinental rail freight will be.

A completely different corridor is seen running through Kazakhstan and other Central Asian countries and connecting Western China to the Caucasus region, Turkey, and ultimately Central Europe. A central

[4] www.wiwo.de/unternehmen/handel/neue-seidenstrasse-duisburger-hafen-will-china-geschaefte-ausbauen/21125382.html

[5] www.rbth.com/business/2017/03/02/russia-europe-asia-transport-corridor-712173

connecting hub is the port of Baku (Azerbaijan), from where rail ferries reach the ports of Aktau (Kazakhstan) and Turkmenbashi (Turkmenistan). Considerable infrastructure investment takes place on either side of the Caspian Sea. On the Caucasus side, the newly constructed Kars (Turkey)-Tiflis (Georgia)-Baku (Azerbaijan) Railway extends the corridor into Turkey. The line then connects to the Trans-Anatolian railway, running from Eastern Turkey to Istanbul, where the double track Marmaray rail tunnel links Asia to Europe. However, the ferry connection over the Caspian Sea and the relatively poor rail infrastructure in Southeast Europe continue to constitute a bottleneck.

Potential advantages of the southern route are the availability of an alternative corridor in conjunction with bypassing Russia. The latter is considered beneficial from a perspective of international interdependency, and avoids the trade sanctions in place between the European Union and the Russian government. However, a considerable number of stakeholders believe both the longer lead time compared to the northern route and the additional costs of the aforementioned rail ferries will forbid economic feasibility of the route in the foreseeable future. Also, political stability along the southern route has been questioned. According to a number of stakeholders, disadvantages of the southern corridor add to the case for using ocean freight between this part of the world and China. Notwithstanding these considerations, Chinese decision-makers have indicated to the researchers that the southern route is primarily regarded in strategic rather than commercial terms and has their attention.

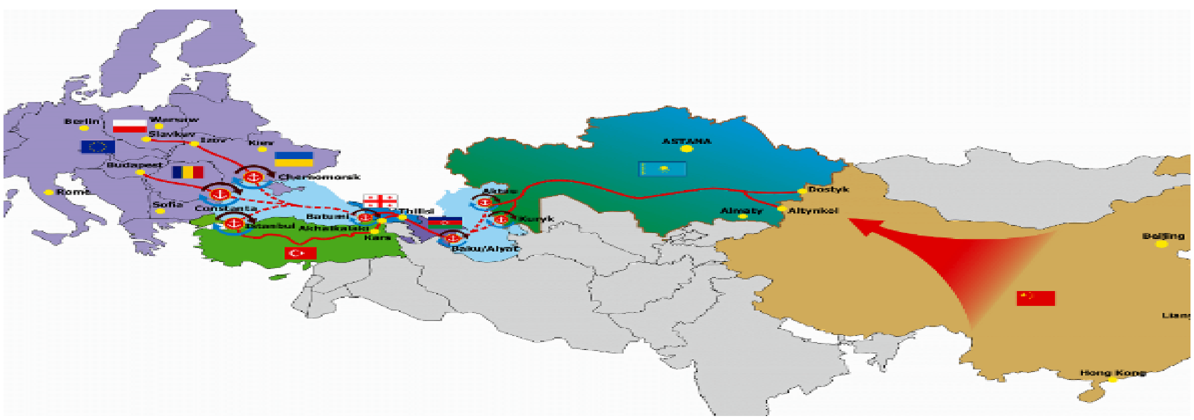


Figure 4-2 The Southern or Middle Corridor ©Trans-Caspian International Transport Route

Daily services exist between Western Europe (i.a. Duisburg, Rotterdam) and Istanbul, some of which call at Budapest[6], with lead times of around 5 days. Alternatively, part of the route from Western Europe to Istanbul may be covered by road. Services to Teheran are offered, too. A first service to China via Turkey and the Caspian is under consideration, and might grow to 3 services per week. However, large-scale uptake of the southern route has not been witnessed so far.

4.1.3 EU railway hubs and transit to and from China

Volumes and number of trains on the Silk Road are rising, but not very stable. Connections change rapidly, and only few connections have been served without interruption (Duisburg, Hamburg, Tilburg).

According to market intelligence still 80%-85% of the trains are passing the Brest-Malaszewicze border crossing, 7% the Kaliningrad route and 7% the other mentioned routes. The routes from the Middle Corridor via the Caspian Sea are not mature enough to offer stable fixed connections.

6 www.railcargo.nl/railscout

Northern border crossings versus central border crossings

The most obvious route (less kilometers, best infrastructure, best transfer facilities, less handlings, less politics involved, best connected to Western Europe) is the Brest - Malaszewicze border crossing. All other Polish, Baltic, Russian (Kaliningrad) borders are alternatives, which are elaborated because of the delays in Brest – Malaszewicze & operators always like to have alternatives, either in transport modes or in transport routes.

The second bundle of border crossings are in Slovakia and Hungary. From these border crossings, Central Europe may be best served. Here, there is the Kosice broad gauge connections best placed, with most connections and facilities. These border crossings serve the regional market of Austria, Czech Republic, Slovakia and Hungary.

Figure 4-3 Intercontinental rail freight transit through Poland

Transit through Poland

For the reference year 2018, 3.055 trains to and from China crossed Poland (transit), via the East-West and West-East line from Rzepin/Oderbrucke – Terespol/Brest. With a the daily average of c.a. 8 intermodal trains both ways.

The number of transit trains is presented on the map below:

- The red line represents transit on the New Silk Road (total is 3.055+58+80);
- The blue line represents transit of automotive (Czech Republic to Russia – Skoda/Volkswagen via Belarus and Slovakia to Russia – Kia/Hyundai) (less relevant).

It also shows the growing importance of the Kuznica –Bruzgi border crossing, as 1/6 of the transit trains are using this route. For cost/time calculations, however, the exact border crossing is of minor importance.

The route Rzepin/Oderbrucke – Terespol/Brest aligns with the the TEN-T corridor Nord Sea-Baltic and is currently totally renewed to allow 160km/hour operations for passenger trains on the section German border – Warsaw and 100km/hour operations for freight trains over the whole Polish stretch of the corridor.

Transit trains Slovakia – Czech Republic – Germany

Another possible route to reach Western Europe is through Slovakia and Czech Republic. On this route, the infrastructure is advanced (double track, electrified). As Slovakia and Czech Republic have the same infrastructure, safety and energy systems, only the German-Czech border requires locomotive changes. However, the growing congestion along national and international corridors in the Czech Republic does not allow much more freight traffic. The congested Prague – Ostrava line is already the busiest line in Central and Eastern Europe.

Transit trains Hungary - Austria – Germany

A third route to reach Germany is via Hungary and Austria. Again, the infrastructure from the Ukrainian border westwards is according standards (double track, electrified). Still, locomotive changes are required on the Austrian-Hungarian border. The drawback of this route is that it involves much more kilometers compared to the direct route via Poland. Moreover, this route passes via Ukraine, which is considered sub-optimal.

Number of China trains per hub

In this paragraph the number of trains per hub are indicated. Determining the number of trains per hub proved to be a difficult exercise due to the following factors:

- Many trains/services are launched and only a few are stable and run over the subsequent years;
- Many ad-hoc trains are organized – this has to do with the Chinese incentive systems of subsidizing Silk Route trains. The system subsidizes each individual train, also ad hoc trains and the Chinese platforms are rewarded by the ministry of transport for each Silk Road train;
- A train service has many fathers, and all promote the service. Like: the Chines platform, the local hub/terminal the train operator, the logistics service provider. As all these parties claim the train, it is difficult to interpret the actual numbers and not to double count.

Silkroad Hubs

Although many cities received China trains, only a few receive these trains over a period of several years, for reasons mentioned above. According to market intelligence, the following cities received regular services from China in 2020.

- Duisburg – 35 services per week (around 30% of the China trains to Europe)
- Hamburg – no exact number available, but apparently most cargo is car transport (70% cars)
- Neuss – 3 services to Xi'an (normal and express) via Kaliningrad-Poland border crossing
- Genk / Belgium
- Liege
- Vienna – 1 train per week (Xi'an) – through connection to Milan via Brest
- Milan (see Vienna)
- Budapest
- Bratislava
- Slavkov
- Tilburg
- Lodz
- Poznan.

Example of the RTSB network

The Rail Transportation Service Broker (RTSB) is a mayor player on the Silk Route and their network is most likely similar to the network map and connections of other mayor operators.

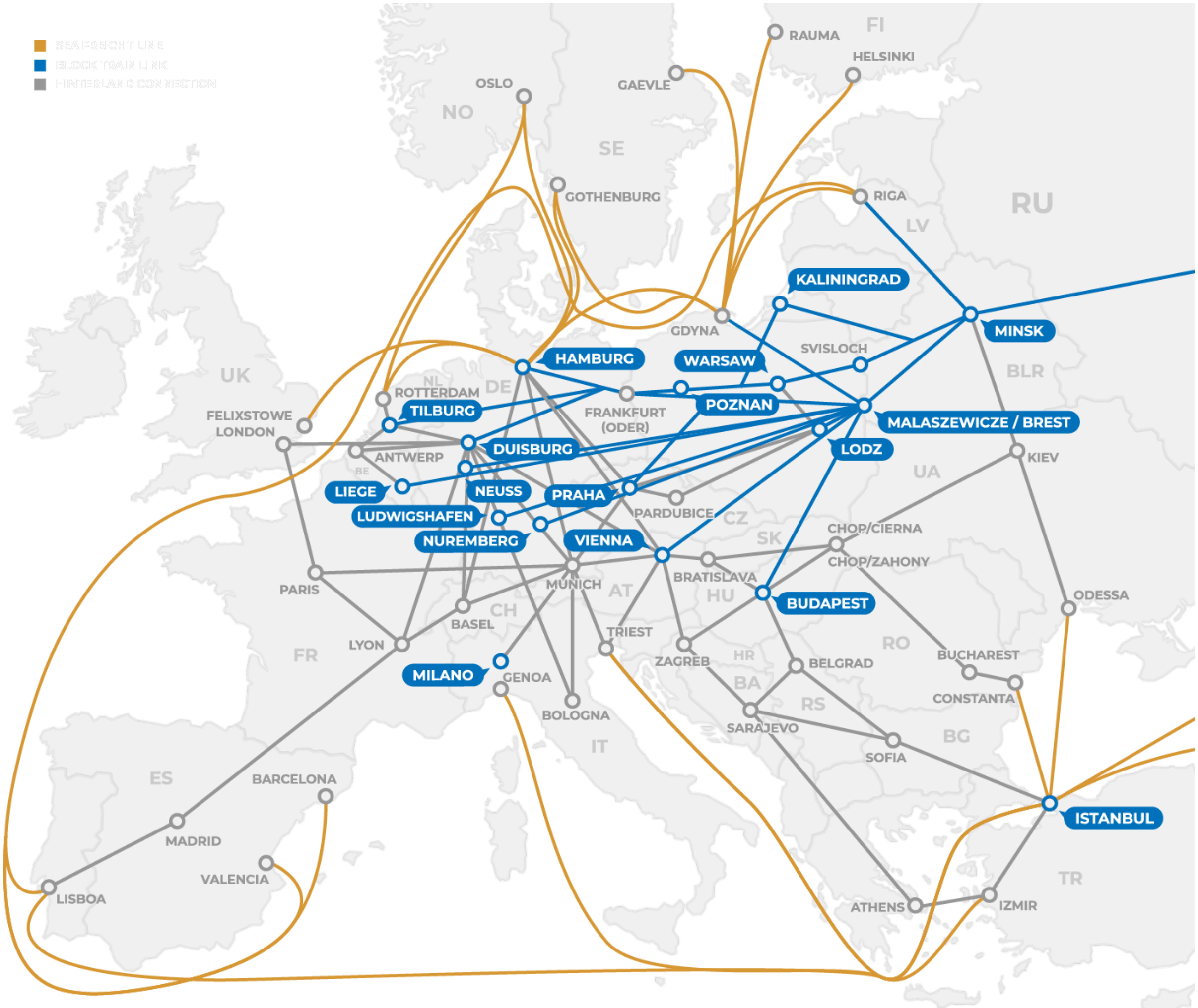


Figure 4-4 RTSB Network, but many other operators have a more or less equal map

What is important to learn from this map, is that Poland is the central transit country; and even Vienna and Budapest are served via Poland. Moreover, it shows that still the majority of the destinations are in Germany, and secondly in Poland. Central and Southern Europe are only marginally connected.

4.1.4 EU Border crossings

The following section provides an overview of all possible border crossings for the China trains to enter the European Union. The overview provides an indication of number of trains per day or week, the caracteristics of the border crossing and infrastructure, the relative advantage of using this border crossing (and disadvantage) and the future developments. In Annex 1, information on infrastructure development, including border crossings, is further expanded.

Malaszewicze-Brest

State: Currently, this crossing serves 9 trains in both directions per day (China trains). Although this is the main border crossing, the service level is still not considered optimal (delays, but heavy investments in infrastructure extension are ongoing – additional border bridge, customs facilities, tracks).

Advantage: This is the biggest border crossing point with all facilities on the main corridor. The main corridor (TEN-T standard) is double track, electrified and currently upgraded to 100km freight services in Poland. Also, this serves the shortest route to the main markets and with most intermodal services connected, and targets the logistics hubs in Middle Poland and North West Europe (Hamburg, Duisburg, Netherlands).

Disadvantage: Facing delays, operators are looking for alternatives. The rail infrastructure on the Polish territory is facing detours, as the main line is renewed, but this will be finished in 2022.

Future: This will continue to be the most convenient border crossing, even with all its issues. No additional handlings other than the gauge change (like shipping), shortest to the main EU markets (Germany, Benelux) and UK. It is next to border crossing investments, also the corridor is upgraded.

Secondary Polish border crossings (Sestokai, Bruzgi/Kuznica, Svisloch/Siemianowka, Visoko-Litovsk/Czeremcha)

State: Currently, Kuznica only receives 1 train per direction per day, on average. The other border crossings are used ad hoc and not permanently staffed, so customs have to be organized. The transfer equipment is limited, no transfer crains available.

Advantage: It is an alternative in cases when the main border crossing at Malaszewicze is congested.

Disadvantage: Secondary lines, so additional diesel locomotive needed, no proper transfer equipment in place, no customs services or other border services like veterinary & customs brokers.

Future: The Polish government announced investments in January 2021 to improve the infrastructure on the secondary border crossings (around 70 million euros). However, these invesments will not improve the infrastructure to such extent that the facitilities will match Malaszewicze. These border crossings will be always a second best option; the investments will be huge if it want to compete with Malaszewicze, not only at the border but also the tracks from Warsaw to the border. The connections both on Belarus and Polish sides of the border are mostly not electrified and are single-track. So additional locomotives are required, and less capacity on these lines will hinder the operations.

Kaliningrad – ferry to Germany (Mukran, Rugen port)

State: Currently, the services had been increased to 2 to 3 trains per day. From Kaliningrad, cargo is put on shortsea to Port of Mukran (Sassnitz) and further by train to Hamburg.

Route: Minsk – Lithuania (no stops, as trains to Kaliningrad are exempted from any Lithuanian control) – Kaliningrad.

Advantage: On these route, no track changes are needed.

Disadvantage: Kaliningrad is promoted because of the delays in Malaszewicze, however it is not a preferred route as it involves additional handlings (instead of 1 transfer in Malaszewicze, it involves a transfer in Kaliningrad (train-ferry) and Mukran (ferry – train)) and organization of the ferry. Such represent optimal conditions, but in less optimal conditions, the cargo is firstly put in stack either in

Kaliningrad or Mukran if the connection is not available and thus involve additional handling, costs, time, and administration.

Future: Kaliningrad will be most probably a secondary option, as described above. The costs of the additional handling will always be a limiting factor. Transport routes are mostly guided by the costs factor.

Kaliningrad / Grodno (Poland)

State: With the continuously rising popularity of rail transportation between Europe and China, there is a need for alternatives to the traditional route taking through the Polish-Belarusian border. Currently, 6 to 7 trains are taking this route via Kaliningrad - Grodno. Among others the express train from Xi'an to Neuss links through Kaliningrad with a lead time of only 14 days.

Route: The Kaliningrad-Grodno route is running via Belarus – Lithuania – Kaliningrad to Poland by rail.

Advantage: Kaliningrad is on the wide gauge track to Russia, so only gauge change at the Polish-Kaliningrad (Russian) border is required.

Disadvantages: The Polish side of the border is not electrified, therefore, diesel traction is required in the first leg in Poland.

Future: the Kaliningrad-Grodno route is operated as a secondary border crossing in Poland.

Klaipeda (Lithuania) & Riga

State: Only limited use, 1 train per week.

Advantage: The trains run without changing gauge to the Baltic ports. From here, the cargo is transferred to short sea. The border crossing between the Russia/Belarus and the Baltic states is quite smooth.

Disadvantage: Short sea connections from the Baltic states are limited. Again, an additional transfer is needed, from short sea port to final destination. Moreover the Baltic ports are quite dislocated from the main markets in Western Europe and the Baltic region does not have such a big industry or logistics hub to attract these trains by itself.

Future: Although this connection is already promoted for years and has a good reputation and transfer time (from Kazakhstan to Baltic ports in 9 days), the connection never picked up. Therefore, it is not expected that it will fly in future either.

Kaunas (RAIL BALTICA)

State: Not yet in use, and it might take years before the Rail Baltica is constructed to its full potential. In particular, the Polish stretch is important to be upgraded from the single, not electrified infrastructure to double track electrified.

Advantage: Kaunas is on the wide gauge track to Russia on the crossroad with the Rail Baltic normal gauge railway line into Poland. Currently, both the terminal and Rail Baltic line are constructed.

Disadvantage: Customs procedures are done at the Lithuanian/Russian border, and changing wagons at the terminal. Therefore, two stops are required.

Future: this could be a potential competitor of Malaszewicze, as the infrastructure is spot on and seamless transport is foreseen on the TEN-T corridor. But for the moment it takes years to build the line upto TEN- standards. When fully constructed, it will be a top of the bill terminal and railway line into Poland and part of the TEN-T corridor, including corridor standards.

Slavkov (endpoint broad gauge in Poland)

Advantage: longitudinally, Slavkov is halfway Poland, and from here trucking could be organized to central European countries (Czech Republic, Slovakia, Austria, Southern Germany). The terminal is well prepared to handle more China trains, having terminal craines and reachstackers.

Disadvantage: limited intermodal rail services are connecting Southern Poland to the South. Most connections are to Hamburg and the Ruhr area. The latter has a better connection via Brest. Moreover, all Central European countries also have the ambition to become a Silkroad hub, and these could also be served via the Slovakia/Ukrainian border.

Future: Southern Poland is an industrial centre, less a manufacturing centre. This attracts less imports and exports from China. If intermodal normal gauge trains from the West are regularly connected to the terminal, this terminal has a chance, otherwise, the Slavkow terminal will only have a regional function (hub).

Kosice (Slovakia) – Ushorod (Ukraine)

State: Broad gauge route on Slovak territory to transshipment terminal: the East Slovakia Steelworks (VSŽ), south west of Košice, via Trebišov to Uzhgorod. The Slovakian part of the broad gauge is single track but electrified. Currently few trains per week take this border crossing.

Advantage: the terminal has huge transfer capacity to transship from broad to normal gauge and is well connected on the Slovakian rail network. Via the Metrans intermodal network. Kosice has the advantage that it is already well served by intermodal trains, as Kosivice is part of the Metrans intermodal network, Kosice is in the hard land of the Slovak industry with many car factories and supply industry.

Disadvantage: all Central European countries have also the ambition to become a Silkroad hub, and these could also be served via Hungarian border. Moreover, Ukraine is not a preferred partner by Russia, so transport via Ukraine could be easily disrupted. Although, it is said that this will not influence the rail connections.

Future: This may be a promising regional hub, as Eastern Slovakia is far from the Western European markets. Kosice is an industrial centre, including car factories – which could be served easily by train from China.

Figure 4-5 Broad gauge track route Kosice

Dobra-Cierna/Chop (between Slovakia and Ukraine)

State: Currently no (or very limited number of) intercontinental trains.

Advantage: Huge capacity, both at border terminal and on the Slovakian rail network.

Disadvantage: All Central European countries have also the ambition to become a Silkroad hub, and these could also be served via Kosice and Hungarian border. Moreover it is not connected to an intermodal network, as the number of China trains do not justify regular intermodal trains Kosice is better place, having an industrial backyard and intermodal connections as described above.

Future: as Kosice is better placed, it looks like that Dobra-Cierna/Chop will be only a second best border crossing to Kosice.

Broad gauge railway line to Vienna – extension of the Kosice broad gauge line

State: Currently not yet in construction phase – it is a pipeline project.

Future: Unclear prospects for realization. No EU funding will be granted (because broad gauge is not TEN-T standard, so no EU grants are possible) and the political will from the EU is missing. The national governments of Slovakia and Austria, nor Russia, will not invest in a greenfield project of more than 6 billion Euros. Moreover, Slovakia is not promoting it anymore and the railway line would be constructed in Slovakia. The economic crisis in Russia will not help, as Russian Railways (RZD) should also be one of the investors.

This project has been ‘talk of the town’ between 2010 and 2016, but recently, there is not that much progress.

Zahony (Hungary) - Chop (Ukraine)

State: Currently, about 2 China trains per week, both from Jinan and Changsha to Budapest. Over the past 10 years, much of the network in the Záhony area has been rebuilt, and many of the transshipment facilities improved. The Ukrainian crisis resulted in a loss of traffic but some commodities are still crossing the border, and free capacity may be attractive when other trans-loading points, such as near Terespol on the Poland-Belarus border, become saturated. However, Budapest is currently also served once a week from China via Poland and Slovakia.

Disadvantage: All Central European countries also have the ambition to become a Silkroad hub, and these could also be served via the Slovakian border.

Future: It may be promising as regional hub, as Hungary is far from the Western European markets to become a real alternative. Even Austria is easier to reach via Slovakia.

Ukraine (Dornashti) – Romania (Vadul-Siret)

This connection is not used for China trains. The Romanian market is served via other routes/modes, like the port of Constanta of via road/rail from Western Europe.

Romania – Georgia and beyond

Rail ferries / shortsea shipping via the Silk Road to the Georgian port of Poti and Constanta in Romania.

This connection has been abandoned for years. Train wagon ferries are outdated and had stopped running years ago, although from time to time it is discussed to reopen the service. Alternatively, short sea shipping could be introduced to fill the gap over the Black Sea. However, no regular China trains are foreseen in the coming years that would use the “middle route’ via Kazakhstan-Azerbaijan-Georgia-Romania. The number of handlings (Aktau, Baku and Poti and Constanta) and border crossings (Kazakhstan, Azerbaijan, Georgia, Romania/EU) are challenging in terms of time, organizational, and financial requirements.

Bulgaria – Turkish border

State: This is the border crossing for the so called Middle Route trains (China – Caspian Sea – Turkey – EU). The route is being considered and announced from time to time, but currently not in use.

Advantage: This route avoids Russia and could therefore be interesting for products falling under the Russian import ban like agriculture products. Moreover there are no transshipment issues as both side of have normal gauge track.

Disadvantage: The number of transshipment handlings: wagon/ferry (Aktau /Black Sea) – ferry/ship (Baku) and the normal/broad gauge transshipment (Georgian-Turkish border) and border crossings (Kazakhstan, Azerbaijan, Georgia, Turkey, EU) is challenging timewise, organizational wise and financially. The border crossings are more difficult than the borders between Kazakhstan, Russia and Belarus as these countries are part of the customs union (so only checks at the China/Kazakhstan and Belarus /Poland border), whereas the countries on the Middle Route have all their own customs control.

- Timewise – as the route face many handlings and each handling cost at least 1 day and a border crossing costs also at least 1 day, many additional days are added on this route. Moreover, the infrastructure on parts of the route (Turkey, Georgia) allow only low speed due to mountainous area.

- Organizational wise – Each handling and border crossing need extra service from the logistics service provider: organizing the border documents; organizing the customs clearance; organizing the transfer handlings; and checking afterwards whether all cargo is still on the train.
- Financial – All the additional organizational services, as mentioned above, bears additional costs, which can be avoid by taking the Russian route.

Future: Unless the Russian option is closed, this route will be only attractive for very limited volumes. It is planned that this route be part of the North-South route: India-Chabahar-Iran-Turkije-Bulgaria. All these route are 'nice to talk' about, but face significant challenges such as the lack of economic background, cargo flows, tough infrastructure development conditions, hostile countries. Therefore, it is unlikely that this route will develop soon, unless there is huge pressure, and financial aid from China, Russia or India.

4.2 Arctic sea route

Another potential trade lane that has recently attracted more attention is the Arctic sea route. With receding sea ice, the Arctic route could perhaps accommodate ocean freight connections between North-East Asia and North-West Europe at considerably shorter transit times (perhaps even up to one week) compared to the traditional Suez Canal route. Accessibility for intercontinental shipping will greatly depend on exact ice conditions, which could vary from partly accessible during certain months of the year, to permanently accessible. Accessibility, in principle, however, still is a far cry away from commercial viability of regular services. Ice and weather conditions, combined with only thinly spread seaports along the route, require special vessels, experienced crews, and entail greater risks for cargo. Also, environmental regulations might become more strict as shipping movements increase, whilst the Russian Federation levies passage fees in exchange for maintaining its necessary fleet of icebreakers. Higher fuel prices might help determine economic viability of transit flows.[7] However, since container services oftentimes increase their utility through cargo exchanges in intermediate ports of call absent in the Arctic passage, the overall viability of the Arctic Route for East-West trade must not be overestimated.

The Arctic area itself, on the other hand, is expected to see significant economic development. This pertains to the exploration of mineral resources previously shielded from man by permanent ice and fisheries, and perhaps also forest. While only covering 6% of the earth's surface, currently 25% of global gas extraction and 10% of global oil extraction already takes place in the polar region. With that, it is estimated that the region exhibits approximately 20%–30% of the world's undiscovered and recoverable gas reserves, and 5%–13% of the undiscovered and recoverable oil reserves. Although the world may be gradually transitioning to renewable energy sources, substantial interest by commercial parties for oil and gas extraction activities in the region remains in the near future. Next to hydrocarbons, the Arctic region holds vast quantities of nickel, gold, bauxite, zinc, copper, lead, iron, platinum, phosphates and other rare earth minerals; key resources for myriad industries in the advanced economies. Coal mines are found here as well. Most mineral extraction in the Arctic takes place in Northwest Russia, but with 110 operating mines, a fair share of mining activities takes place in the European Arctic as well. Fishing stocks in the subarctic waters, then, will likely expand northward with the receding of sea ice, even as subarctic land regions may shift from permafrost to forestry and perhaps other forms of agriculture. In all, although economic development will undoubtedly compete with environmental concerns, economic development of the Arctic will lead to increased transport flows that stand aloof from major East-West

[7] UK govt review

transit services. This will include marine traffic of many sorts (e.g. tankers, offshore industry vessels, fishing vessels, general cargo ships, passenger ships, etc.), but also land infrastructure, all connecting the polar region to markets. Indeed, the EU is already considering expanding the TEN-T network to its northern fringes, whilst Norway and Finland are planning construction of the Arctic Railway, connecting the Arctic deep sea port of Kirkenes to the Finnish railway network.[8] Doubtless, other Arctic states, including Russia, will also expand their land transportation networks to the area.[9]

4.3 International North-South Route

North-South corridors may complement the more prominent East-West corridors. The North-South International Transport Corridor is to connect Northern Europe to the Persian Gulf. As we have seen, some of the CAREC corridors also display a North-South orientation.

The North-South Corridor starts in Finland and travels through Russia to the Caspian Sea, where it splits into three routes. The western route traverses Azerbaijan, Armenia to western Iran; the central route uses ferries to transport cargo across the Caspian Sea to Iran; and the eastern route runs through Kazakhstan, Uzbekistan and Turkmenistan to eastern Iran. From the Iranian ports of Chabahar and Bandar Abbas, maritime connections to the west coast of India may augment the corridor.

The agreement establishing the North-South Corridor was signed by Russia, Iran and India in 2000. In later years, 11 other countries joined the project: Armenia, Azerbaijan, Belarus, Bulgaria (observer status), Kazakhstan, Kyrgyzstan, Oman, Syria, Tajikistan, Turkey and Ukraine, aiming at making it a key infrastructural integration factor in the vast expanse of Eurasia. The route, which is due to become operational, could shorten transit time from South Asia to St. Petersburg from some 6 weeks to only 3 weeks. Although the corridor entails (at least) 3 border crossings with their respective customs proceedings, intensifying economic cooperation within the region – through India's accession to the Shanghai Cooperation Organization, and a possible free trade agreement between India and the Eurasian Economic Union – may strongly further the uptake of the corridor. A major bottleneck in the corridor is the 200 km railway stretch between Qazvin (North-West Iran) and Astara (just across the Azerbaijan border). The connection was projected to become operational in 2017. In March of the same year, the dual-gauge cross-border section was completed.

[8] The Finnish railway network was constructed with a 1.524mm track gauge, considered interoperable with the 1.520mm gauge in use in the former USSR.

[9] https://climate.nasa.gov/vital-signs/arctic-sea-ice/; Overland et al. (2013) Future arctic climate changes: adaptations and mitigation time scales. *Earth's Future*, 2 (2), pp. 68-74; European Environment Agency (2017). The Arctic environment: European perspectives on a changing Arctic; CBS Maritime (2016) Arctic shipping: Commercial Opportunities and Challenges. The Arctic Institute Center for Circumpolar Security Studies. Washington DC; Meng et al. (2017) Viability of transarctic shipping routes: a literature review from the navigational and commercial perspectives, Maritime Policy & Management, 44:1, pp. 16-41; Acrtic Shipping – Commercial Opportunities and Challenges (2016). Copenhagen Business School.

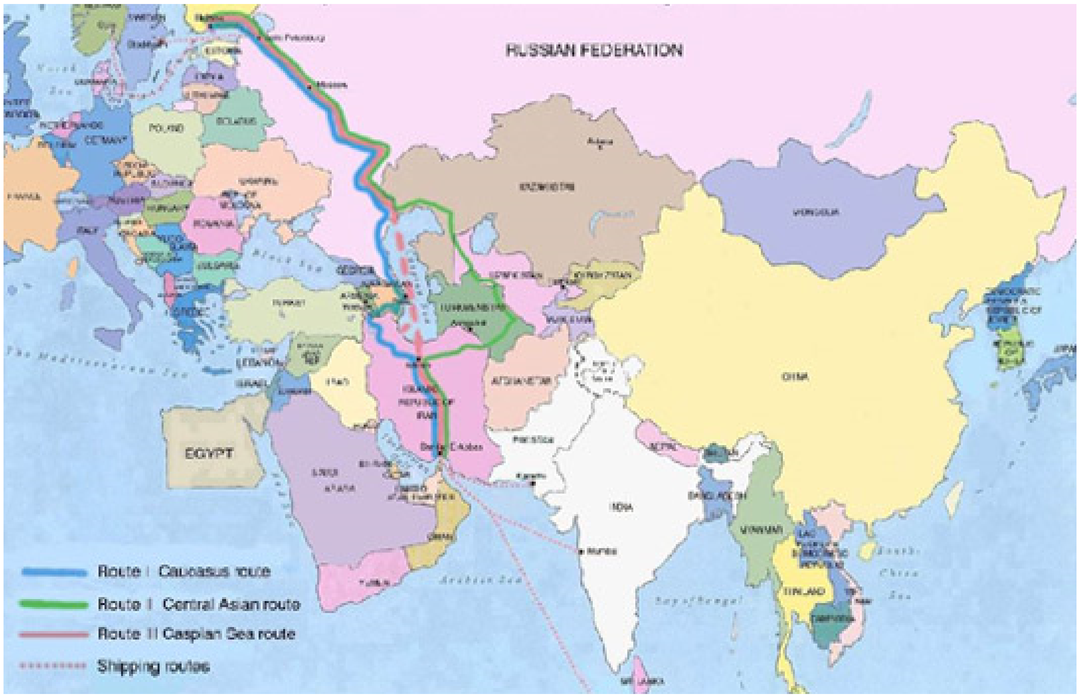


Figure 4-6 The different branches of the North-South Corridor (http://www.tcts.ir).

A spur off the eastern route is being constructed from Uzbekistan into Afghanistan. The seventy-five kilometres of single 1,520 mm gauge unelectrified line, completed in 2011, connects Mazar-i-Sharif with the rail-connected freight terminal at Hayratan on the Afghan side of the Uzbek border. Studies are being undertaken for the construction of further lines from Mazar-i-Sharif west to Herat (with connections to Iran) and east to Shirkhan Bandar (for Tajikistan). These lines would create a rail corridor through the north of Afghanistan, enabling Tajik and Uzbek freight to reach the Persian Gulf ports by rail without passing through the other country or Turkmenistan.

In 2016, development of the Port of Chabahar in South-East Iran, and a 600 km railway connection between the port and Iran's main railway network at Zahedan, were announced. From Zahedan, rail connections to i.a. Turkmenistan, and road connections into central Afghanistan exist.[10] Thus, the Northern Europe-Persian Gulf Corridor would gain additional traction.

[10] The route through Chabahar allows India to avoid the political, practical and security problems of transiting Pakistan, and provides a geopolitical counterbalance to the nearby Chinese-backed and managed port at Gwadar in Pakistan which is at the end of a developing land transport corridor from China.

Figure 4-7 The future Chabahar-Zahedan-Zaranj-Delaram trade corridor (RAILNEWS).

5 Belt and Road Initiative reference simulation

Eurasian rail freight has rapidly been increasing since 2015. With sea freight rates soaring as a result of the Corona crisis, Eurasian rail freight is becoming more popular than ever. The ceiling and speed of development after the Corona crisis is still unclear and is influenced by a number of factors, such as the following: rapid infrastructure development; the mainstreaming of Eurasian rail freight; the reduction of subsidies from China-Europe block trains; the relocation of production to Eastern Europe; and the strong growth of the Chinese economy. In addition, a number of background trends factor are important as well, such as the emergence of the physical internet and the greening of transport, and the need to reduce the risk of using only sea transport when there are no other apparent reasons to favour rail, as demonstrated by the recent Suez problem.

To better deal with these uncertainties, a model-based analysis is needed to inform policymakers about future flows of goods under different circumstances. This chapter therefore presents a macro model for analysing intercontinental freight transport chains. This model is applied to intercontinental rail transport between Europe and China, for the baseline year 2019.

5.1 Model specification

5.1.1 Route choice criteria and function

The assumption is that the shippers have knowledge about the two main trade route alternatives between China and Europe. The choice of the route is based on a logit function (Dios, Ortuzar & Willumsen, 2011), where the route choice depends on the probability of the route based on the generalized transport costs:

$$P_{r=} \frac{e^{-\mu Cr}}{\sum \in CS^{e-\mu C_h}}$$

where P_r is the probability of the route r ; C is the generalized transport costs, CS is the choice set of routes and μ the logit scale parameter. In our situation, the choice set of routes always consist of two options, one via sea and one via rail. The generalized transport costs for sea and rail is as follows:

$$c_{rm} = \sum_{l \in r} c_l + \sum_{n \in r} S_n + A_e + v_g * \left(\sum_{l \in r} T_l + \sum_{n \in r} t_n \right)$$

where the total costs C of route r for mode m is based on c_l, the total costs of transport on the links of route r, the transhipment costs S of the nodes n along the route; A_e the attractiveness of European principal entry node; T_l, the transport time over de links; t_n, the transhipment time in the nodes; and v_g, the value of the transport time (VOT) for commodity type g.

The node attractiveness parameter A_e captures the variable costs of the nodes categorized as principle entry nodes. It includes the hidden costs such as personal preferences of shippers, service quality, fuel costs congestion costs, quality of hinterland links, etc. These costs are not included in the transhipment costs of the nodes but do play a role in the node preference of decision-makers. The attractiveness parameter is unknown and will need to be estimated.

The VOT parameter V_g refers to the shipper's preference for faster modes of transport. For high-value or perishable goods, shippers are often willing to pay a premium for shorter transport times. Since VOT values vary greatly between studies, the VOT parameter is partly estimated.

5.1.2 Route choices

The choice set is based on two separate networks, one for Eurasian sea transport and one for Eurasian rail transport. Each network consists of Principal Entry Points (PEP), i.e. nodes with a direct connection to China. Connections between the PEPs are based on existing port rotation schedules and rail services between the continents. The PEPs are connected to the hinterland through hinterland connections. A simplified hinterland network is chosen for China, consisting only of road transport. For the European hinterland, a detailed intermodal network consisting of road, inland waterway and rail links is used. If hinterland transport is intermodal, other terminals are visited besides the PEP.

Per network, the route is determined based on dijkstra's shortest path algorithm. A shortest path based on the lowest generalised costs is generated between every OD pair in the dataset. Given the example network in Figure 5-1, two shortest paths are added to the choice set. One for rail (O – R1 – R2 – D) and one for sea (O – S1 – S2 – S3 – D). In the case of the rail network, last mile transport directly from rail terminal R2 to destination node D has a lower costs than the intermodal option R2 – S3 – D. Likewise, in the sea network, intermodal transport from S2 with barge to S3 and finally with truck to D has a lower costs than directly from S2 to D, and is thus chosen.

Finally, the probability of the sea route versus the rail route is determined for a certain O/D pair and commodity type based on the logit function. The probability threshold is set at 10%, meaning that probabilities under 10% are set to 0.

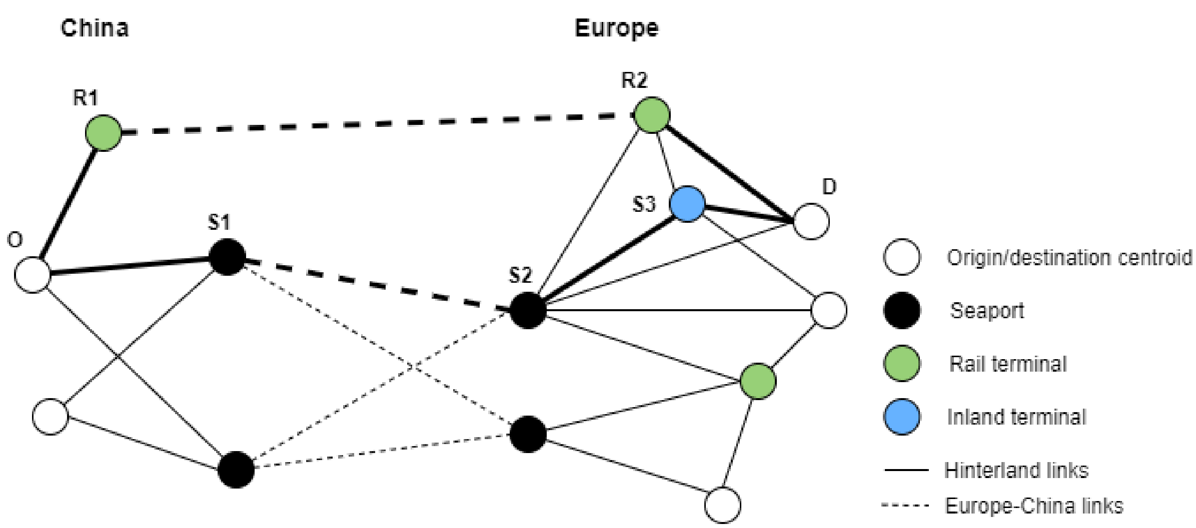


Figure 5-1 Example of PLANET's model for simulating intercontinental transport chains

5.2 Data

5.2.1 O-D matrix

The trade data used as input from the model is collected from four sources: Comext database from Eurostat, UNCTAD trade database, Chinese customs data and Eurostat data on European road freight. The Comext database is used as a basis to construct the O/D-matrix. This database contains trade data between different EU countries and China in values and containerised tonnes for level 164 level-3 NSTR commodity types.

Data from the year 2019 is chosen to construct the OD-matrix since it is the most recent year with reliable data on standard trade patterns between Europe and China. In 2020, there were major disruptions to traditional trade flows due to the COVID pandemic.

For simplicity, the data is aggregated to the 10 NTSR level-1 commodity groups. Furthermore, within each commodity group, five levels of commodity values are distinguished. The levels range from 'very low' value goods with a value of 5 €/kg or lower, to 'high value' goods, with a value of 20 €/kg and higher. Keeping a distinction between commodity values is important because it allows taking into account the time-sensitivity of certain goods within a commodity group. For example, the commodity 'Electrical machines and appliances' has a value of 19.9 €/kg, whereas the value for 'Furniture' is 3.3 €/kg. Both products fall under NSTR level-1 commodity group 9, but Electrical machines and appliances are much more time-sensitive and more likely to travel between China and Europe via rail than furniture.

Data for non-EU countries in Europe[11] are added to the O/D-matrix taken from the UNCTAD database. UNCTAD trade data is only available in values, thus ratios from Comext dataset are used to convert this data in the same format.

Next, the O/D matrix is disaggregated from the country level to the regional level. For Europe, country level data is split into NUTS3 using Eurostat's road freight dataset, road_go_ta. The origin and destination of road freight is generally a good indication of the locations of consumption and production. For non-EU countries, the population of administrative regions comparable to NUTS3 are used to disaggregate country-level data. Population data is collected from various national sources.

For China, country-level trade data is broken down to the province-level. China consists of 31 provinces. To achieve this, Chinese customs data is used that is publically available. This datasets contains trade data between Chinese provinces and other countries in values and HS commodity type. This data is converted to NSTR commodity types and used to distribute the trade data in the O/D-matrix across the Chinese provinces.

5.2.2 Network

The network consists of a set of transport links between all Chinese provinces and NUTS3 regions in Europe. Transport within Europe and China occurs via hinterland links which transport cargo from the regions to the seaports or rail terminals. Intercontinental transport takes place via rail and maritime container services between the seaports and rail terminals in China and Europe.

[11] This is done for Albania, Bosnia-Herzegovina, North-Macedonia, Montenegro, Switserland, Serbia, Norway and Kosovo

5.2.2.1 *Eurasian rail network and costs*

The Eurasian rail services are based on the statistics published by the Eurasian Rail Alliance Index[12]. Rail services are selected with a westbound flow of at least 1.500 TEU in 2019, which is equal to approximately one train every two weeks. This has resulted in a selection of 24 rail services between China and Europe. Rail terminals and the rail services in between them are shown schematically in Figure 5-2.

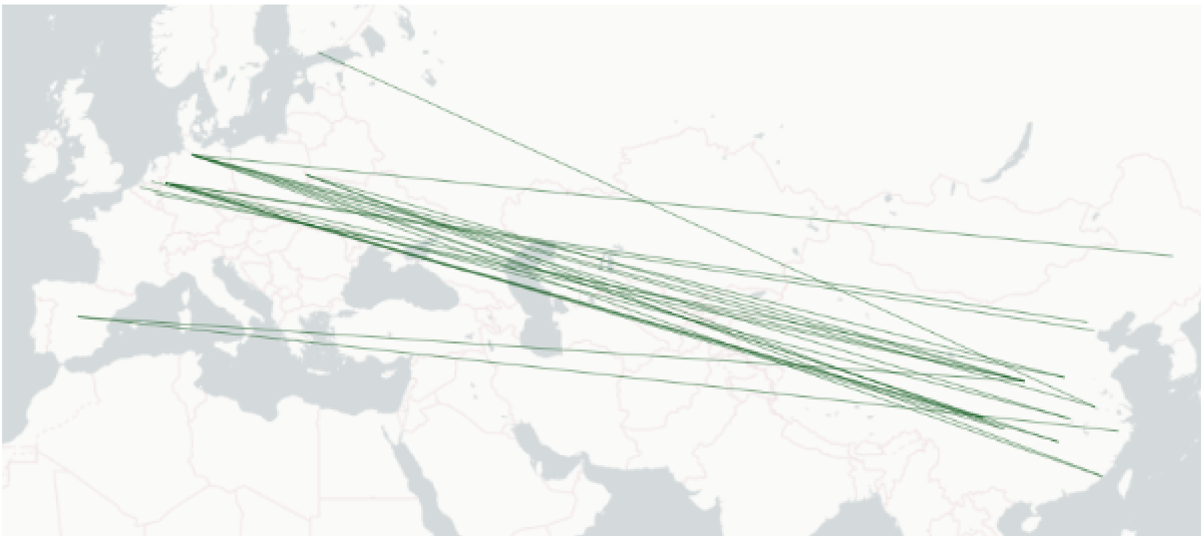


Figure 5-2 Eurasian block train services used in the simulation model.

In the literature, information is available on certain Eurasian rail services (see Vinokurov et al., 2018, Feng et al., 2020, Besharati et al., 2017, and Jiang at al., 2018), but not for all regularly used ones. Therefore, a costs model for Eurasian Rail Freight was developed to estimate the costs and time of the missing rail services. This model contains cost figures of rail freight transport through Europe, China and Central Asia, such as traction costs, shunting costs, overhead costs and wage costs, as well as transhipments costs and waiting costs at the border crossing points and the different load factors for eastbound and westbound trains. For transport through Central Asia, the freight forwarders fees published by the Joint stock company United Transport and Logistics Company – Eurasian Rail Alliance (UTLC ERA) are used.

Table 5-1 below shows the costs per FEU on selected lines as calculated by the model and as reported in the literature. For services where a benchmark number is available in the literature, the model produces consistent results.

With the Eurasian Rail costs model, a tool available to estimate the rail costs for various rail services according to various scenarios is available. In this way, one can understand the impact of different measures, such as speeding up the gauge changes at the borders or an improved loading factor, but also the cost of a new rail service.

[12] See https://index1520.com/en/

Table 5-1 Results of the costs model for Eurasian Rail Freight, compared to benchmark data

Origin	Destination	Transport costs ($/FEU) (without subsidy)	
		Eurasian rail costs model	Literature benchmark[13]
Chongqing	Duisburg	10.184	8.500-10.182
Chengdu	Lodz	9.632	9.400-10.557
Zhengzhou	Hamburg	9.847	9.453-10.500
Yiwu	Madrid	11.795	13.800
Chengdu	Tilburg	10.110	n/a
Zhengzhou	Liege	9,973	n/a
Beijing	Duisburg	10,444	n/a
Harbin	Hamburg	10,129	n/a
Chengdu	Tilburg	10.110	n/a

5.2.2.2 *Maritime network and costs*

The maritime sea freight network used in the simulation model is shown schematically in Figure 5-3. Sea freight services are offered much more frequently than Eurasian rail services, with the main shipping liner operators running services between the Chinese and European ports multiple times a week.

[13] Based on Vinokurov et al. (2018), Feng et al. (2020), Besharati et al (2017) and Jiang at al (2018)

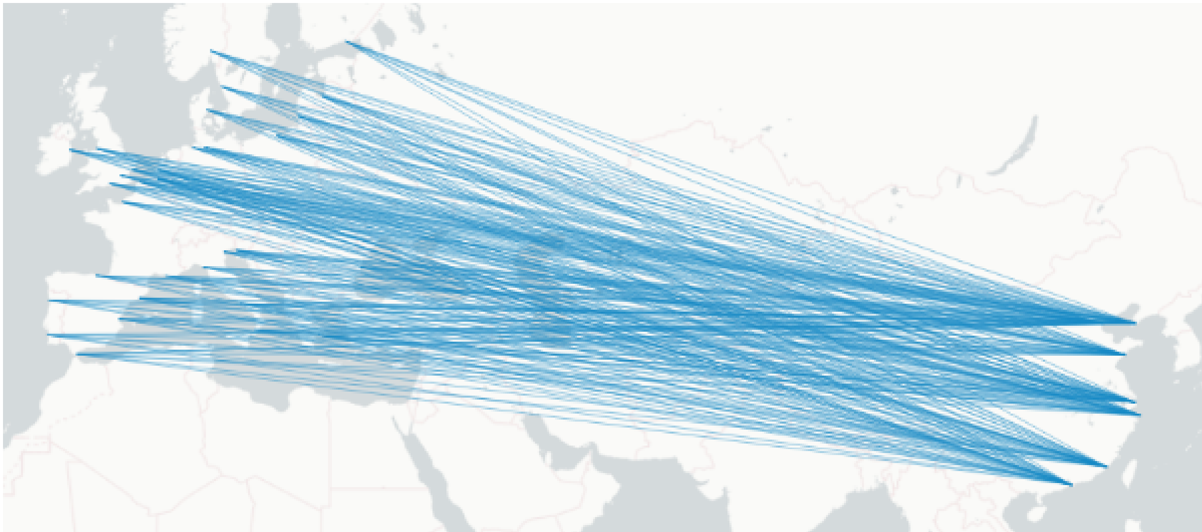


Figure 5-3 Martime sea freight services used in the simulation model.

Costs for maritime services are based on an updated version of Panteia's Liner Shipping Model (Newton et al, 2014). This model calculates the costs of container services, taking into account rotation characteristics such as port calls and vessel dimensions. Using this model, the costs per TEU per sea basin [14] was calculated. Any differences in costs within a sea basin are corrected for by the node attractiveness parameter A_e, because certain ports have lower port dues, better hinterland connections or are part of more rotation schedules.

5.2.2.3 *Hinterland network and costs*

Costs for European hinterland transport are based on the costs models for different modalities owned by Panteia. These models are updated on a yearly basis using publicly available sources (such as Eurostat and network statements) and surveys and include a wide variety of costs components, such as:

- For rail: labour costs (driver wages incl. social costs and reimbursed expenses); capital costs (lease of locomotive and wagons, reserve material); traction costs; access charges; other costs (insurance, repairs and maintenance, shunting, overhead, waiting); and the load factor.
- For inland waterways (IWW): Labour costs (crew wages incl. social costs and reimbursed expenses); capital costs (costs of depreciation, interest cost of vessel); fuel costs; other costs (insurance, repairs and maintenance, overhead); ship dimensions; waiting times for locks and bridges and the load factor.
- For road: labour costs (driver wages incl. social costs and reimbursed expenses); capital costs (costs of depreciation and interest cost of vehicle); fuel costs (including excise duties); other costs (insurance, road tax, repairs and maintenance, tire costs, overhead); toll costs; load factor and resting times.

[14] Liner shipping rotation schedules between Europe and Asia are often organized per sea basin and thus operated by the same vessel type. ba Baltic Sea, North Sea, Mediterranean Sea, Adriatic Sea, Black-sea

For China, a simplified hinterland network is sufficient, consisting of road transport from the centroid of each Chinese province to the Chinese ports and terminals. Costs for road transport in China is set at €0.65 TEU/km (Wen et al. 2019) with a speed of 41.6 km/h (Tavasszy, 2011)

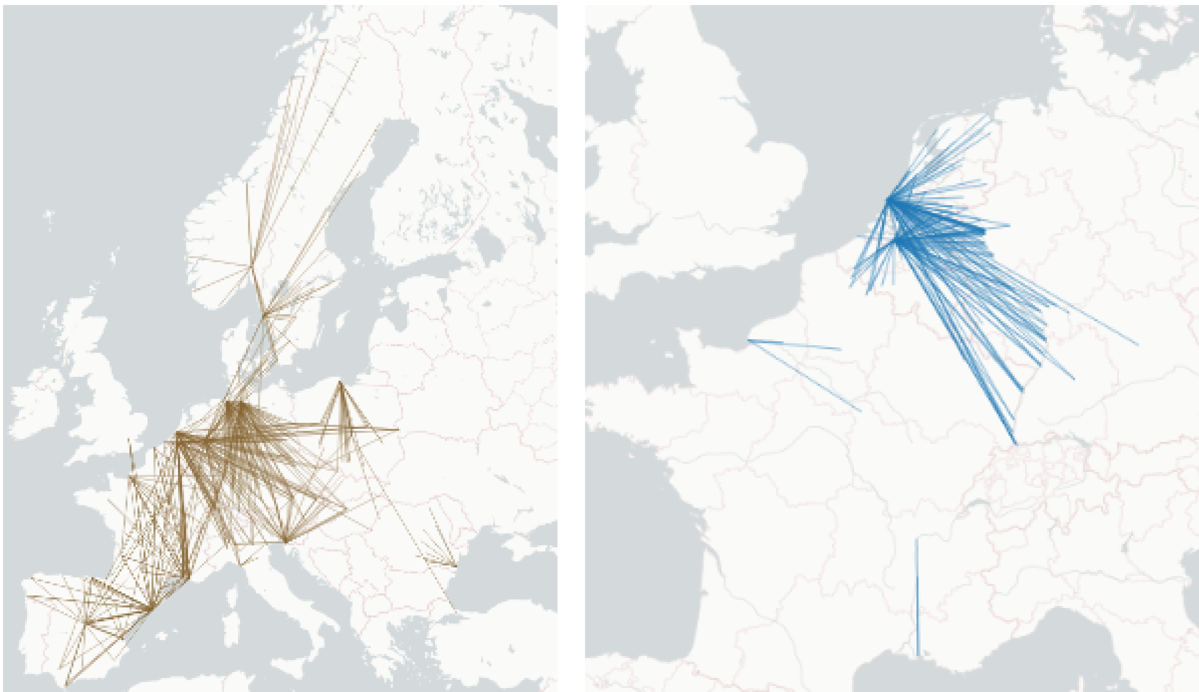


Figure 5-4 Rail (left) and barge (right) services used in the model to simulate hinterland

5.2.2.4 ***Transhipment***

In order for the cargo flows to go through the nodes, the network consists of transhipment links. The transhipment links depend on the available hinterland and intercontinental connections within a node. For example, Hamburg is connected to China via rail and maritime services, and connected to the hinterland via rail and road.[15] Rotterdam is connected to China via maritime services and offers road, rail and barge transport to its hinterland.

[15] Hamburg also offers hinterland connections by barge. However, with a modal share in hinterland transport of 2.6%, volumes are too small to be considered in the model.

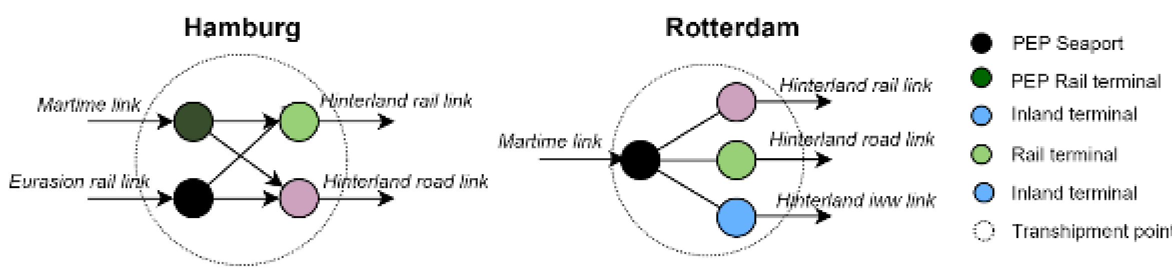


Figure 5-5 Transshipment links in Hamburg and Rotterdam integrated into the network

Cargo handling costs that are incurred when cargo units need to be unloaded or loaded in a different mode of transportation are shown in Table 5-2. Handling costs are set at €45 per TEU for maritime ports and €32.5 for inland terminals. Maritime ports are usually heavily congested and thus a higher costs and dwelling times are assumed. Dwell times of containers on deep sea container terminals are set at an average of 5 days for vessel – truck and vessel – rail transfers and 4 days for vessel – barge transfers (Rodrigue & Notteboom, 2009). Dwell times in inland terminals are set to an average of 2.5 days for transfers to truck, based on information received from the Rail Service Centre Rotterdam. Transfers from rail to rail or barge are set to 3 days, assuming that intermodal services are sometimes not perfectly synchronized and that is it sometimes necessary to wait before the next service departs. Most maritime terminals are offering free storage of around five days and inland terminals of around 3 days, therefore no additional storage costs for containers is considered.

Table 5-2 Cargo handling costs for transfers between different modes of transportation

Transfer type	Dwelling time [days]	Transhipment costs [€/TEU)
Vessel – truck	5	45
Vessel – rail	5	45
Vessel – barge	4	45
Rail – truck	2.5	32.5
Rail – barge	3	32.5
Rail – rail	3	32.5
Barge - truck	2.5	32.5

5.2.2.5 *Value of time*

A major cost component of transport between China and Europe is related to the costs of transport time. Customers are willing to pay a premium for transport if it reduces the amount of time the goods are in transport. When goods are in transit, the cargo owners cannot sell or utilize the goods. Cargo owners cannot use the capital invested in the goods to do other business. Goods in transit thus 'freezes' capital, which cannot be used for further investments. This makes quick transport especially attractive for high value and time sensitive goods.

In addition, companies usually have buffer stock of goods at destination warehouses in order to accommodate variation in demand by costumers. Complex and very long supply chains interfere heavily with the commercial activities frustrating the quick market response If lead times can be brought to a minimum, so can also the costs for warehousing decreases. Transport time also matters if the depreciation of goods is taken into account. Goods such as fruits and vegetables can spoil quickly. The market can also change when goods are in transit. Technologies can become obsolete or goods can go out of fashion, which can be prevented by a faster transport.

The shorter transport time is the main argument for which carriers prefer rail transport over transport by ocean-going vessel between China and Europe. For a realistic simulation of the goods flows, it is therefore crucial to include the time factor in the transport costs.

Although transport time can have a great deal of influence on the choice of modality, there is still considerable uncertainty as to how much time really costs. Tao and Zhu (2020) provide a meta-analysis of value-of-time (VOT) studies. They find that VOT can range somewhere in between 0.016 to 7,300 dollars per hour per ton. Nevertheless, the general consensus is that high-value commodities tend to have higher VOTs than lower value commodities. This leads to that inland shipping is often used to transport goods with a low VOT, while air freight is used for goods with a high VOT.

Chen et al (2017) use an average of 150 €/TEU/day for transport from Heifei to Hamburg. Wang (2015) uses 50 €/FEU/day for low time sensitive cargo and 200 €/TEU/day for high time sensitive cargo. In a model on international maritime container shipments, Tavasszy et al. (2011)[16] uses a value of time of 85 €/TEU per day.

Others base the VOT on a percentage of the cargo's value. Modelling transport between Shanghai and Hamburg, Zhang & Schramm (2020) uses a VOT of 1% of the cargo's value per day for good with low time-sensitivity such as bulk products and raw material, and 2% for goods with a high time sensitivity, such as complex manufactures and perishable goods. Lu et al. (2019) use the example of transport between Beijing and Berlin to find out for which regions the costs of rail transport is lower than sea transport. In their model, they estimate the value of time based on an annual interest rate of 6%, which translates to a value of time of around 0.016% of the cargo's value per day.

Davydenko et al. (2012) base the VOT on NSTR commodity type which are computed by a model on international maritime container shipments. The VOT values range from 1 €/day/tonne for raw materials (NSTR commodity type 2, 6 and 7) to 8 €/day/tonne for machinery and consumer goods (NSTR commodity type 9).

Table 5-3 Different VOT used in various sources.

Source	VOT [€/day/TEU][17]

[16] Tavasszy, L., Minderhoud, M., Perrin, J. & Notteboom, T. (2011). A strategic network choice model for global container flows: specification, estimation and application. Journal of Transport Geography, 19, pp. 1163-1172.

[17] Values from sources are converted to €/day/TEU, using the following conversion factors: 1 $ = 0.85 €, 1 TEU = 10 tons. For Zhang & Schramm (2020) and Lu et al. (2019), a low value container of 10.000 €/FEU and a high value container of €200.000 is chosen, based on https://transportgeography.org/contents/chapter5/intermodal-transportation-containerization/container-shipping-costs-value/

Zhang & Schramm (2020)	€ 42.5 - € 850
Lu et al. (2019)	€ 1 - € 18
Chen et al (2017)	€ 153
Tavasszy et al. (2011)	€ 85
Wang (2015)	€ 50 - € 200
Davydenko et al (2012)	€ 10 - € 80

This makes it clear that many different interpretations of the VOT exist. Because the values shown in Table 5-3 vary greatly, it is uncertain if the values that are used can be applied to different areas or at different scales. A solution to achieve an accurate representation of the VOT is to let the model partly estimate the VOT. Panteia uses the value of the goods to denote the VOT, as has been done in most studies. A distinction between five categories of commodities is made, from very low to very high, and divide the goods between these groups according to the value per kilo. Next, each category is assigned a VOT, which corresponds to the values from the previous studies. It is important that the categories and values have a logical interval between them. In this way, the results cannot be steered too much by using specific category boundaries. The likelihood of a realistic representation of the freight flows is therefore larger. The categorisation of the commodity value and corresponding VOT as shown in Table 5-4 was found to provide realistic base year results that corresponded to the observed transport flows between China and Europe.

Table 5-4 Categorisation of commodity value and corresponding VOT estimated by the model

VOT-category	Cargo value [€/kg]	VOT [€/day/TEU]
Very low	0 – 2.5	10
Low	2.5 – 5	20
Medium	5 – 10	40
High	10 – 15	60
Very-high	15 +	80

5.2.2.6 ***Node attractiveness***

The model is further refined and calibrated using the node-specific attractiveness parameter A_e for the European PEP. The generalized costs function does not take into account qualitative aspects that determine node choice of shippers, such as the quality of the hinterland connections per node or shippers preferences. The attractiveness parameter reflects these qualitative costs and is determined through model calibration. This parameter is used to explain the difference between the observed and the calculated values of the model.

The estimation of the port attractiveness parameter is done through an iterative process, where the model results are compared to the observed values. For the base year, 2019 is chosen, the year for which the most recent data is available. For port transhipment values, data from Eurostat is used. The mar_go_qm dataset contains data on the incoming and outgoing throughput in TEU per European port for the base year. These transhipment values are corrected for transhipment to short sea. The share of transhipment in the overall port throughput per port were derived from Mueler et al. (2020) and Pastori (2015). For transhipment in rail PEP, throughput at rail terminals from the Eurasian Rail Alliance Index is used.

In the first iteration of the model, all nodes received the same attractiveness value. The results of the model are then compared to actual transhipment volumes. Based on this, the weight of each node is adjusted, depending on how far away the throughput is from the actual throughput. In this way the model automatically adjusted the weight of each node. Eventually the model converged to a realistic weight per node, as shown in Figure 5-6.

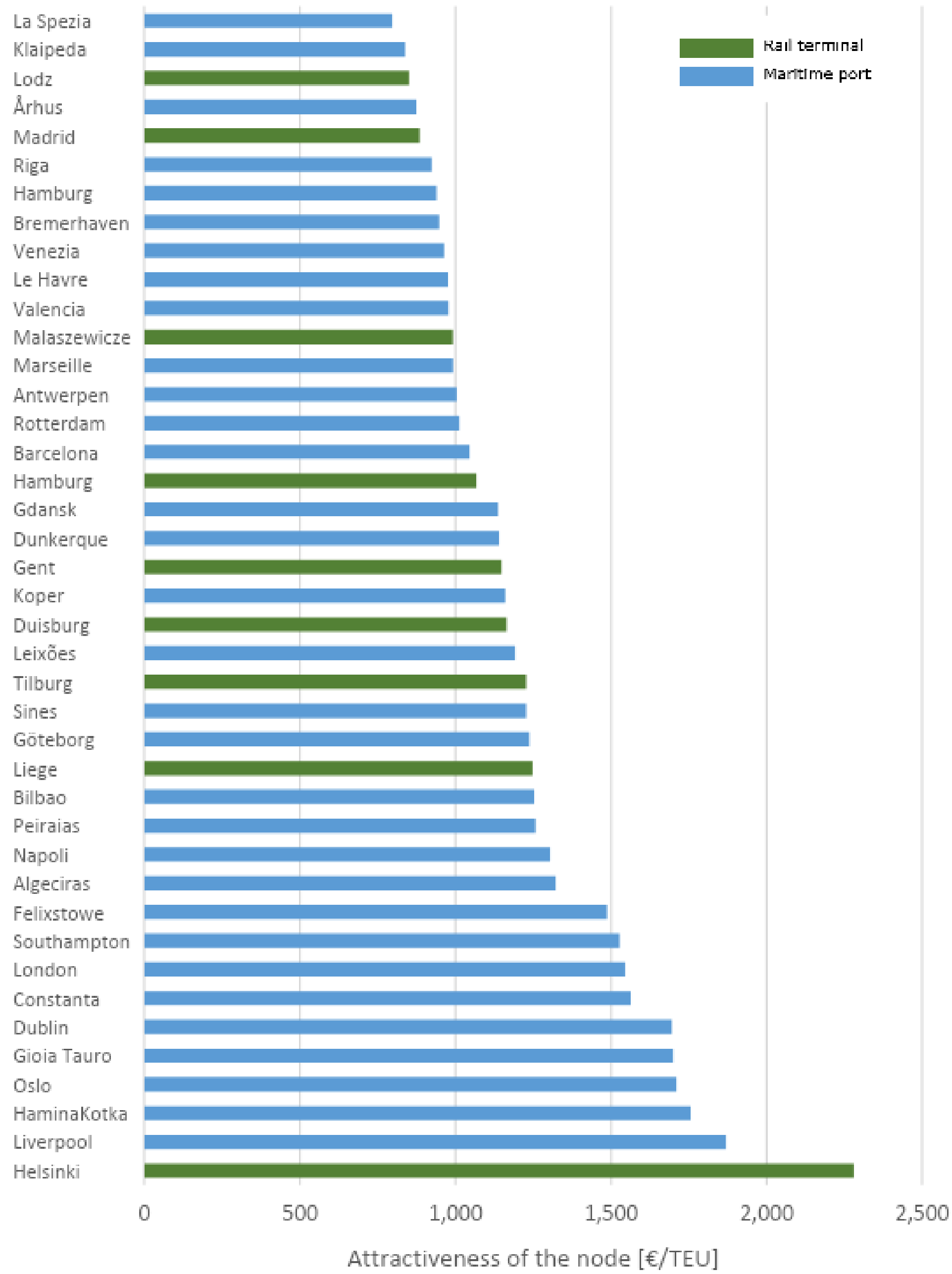


Figure 5-6 Estimation of the node attractiveness parameter in the model

5.3 Results

5.3.1 Overview

Table 5-5 provides an example of the model output for transport between two Chinese provinces, Shanghai and Chongqing, and Berlin. The freight costs[18] include all costs of intercontinental transport, hinterland transport and transhipment costs. While rail transport is often quoted as being four or five times more expensive than sea transport, when the entire intermodal journey is taken into account, rail transport is twice to three times as expensive. When the VOT is taken into account, the transport costs are much closer together.

Table 5-5 Freight costs for sea and rail transport between Shanghai – Berlin and Chongqing - Berlin

	Mode	Freight costs, excl. VOT [€/TEU]	Freight costs incl. VOT (low - high cargo values) [€/TEU]
Shanghai province - Berlin	Sea	1289	2523 – 5583
	Rail	4037	5243 – 6043
Chongqing province – Berlin	Sea	1806	3195 – 6336
	Rail	3731	4837 – 5638

The routes that are chosen belonging cargo flows in the example Table 5-5 are shown in Table 5-6. In this example, rail is used for hinterland transport within Europe, but road and IWW transport are also possible. While the sea routes pass through the same seaport, the land routes use different terminals. This is due to the different block train services between the European and Chinese terminals. The Eurasian rail Alliance Index shows that in 2019, Chongqing operates trains to Duisburg and Malasewicze mainly. The Heifei terminal near Shanghai, on the other hand, serves Hamburg.

Table 5-6 Route choice for sea and rail transport between Shanghai – Berlin and Chongqing - Berlin

	Mode	Routes
Shanghai province - Berlin	Sea	Shanghai province – Heifei rail terminal – Hamburg rail terminal – Berlin rail terminal – Berlin
	Rail	Shanghai province – Shanghai port – Hamburg rail terminal – Berlin rail terminal – Berlin
Chongqing province – Berlin	Sea	Chongqing province – Shenzhen port – Hamburg port – Hamburg rail terminal – Berlin rail terminal – Berlin
	Rail	Chongqing province – Chongqing rail terminal - Malaszewicze rail terminal – Großberen rail terminal – Berlin

[18] During 2020 and 2021 prices of sea freight and rail freight container rates have risen sharply. We assume that these are temporary fluctuations in the market and that in the longer term the prices will normalise to the levels they were before the corona crisis. Since this model makes a projection for 2030 and 2050, such temporary fluctuations are less relevant.

Coincidentally, in this example, the same route is chosen for all the different cargo values. But it is possible that a different route is chosen depending on the cargo value. This is for example the case for transport to the Alpine region. Mediterranean ports are preferred to North Sea ports as the cargo value increases, because the travel time via some shipping lines visiting the Mediterranean ports are shorter.

The model simulates all cargo on the network based on the freight costs between all pairs of Chinese provinces and European NUTS3 regions. Table 5-7 provides an overview of the total trade between Europe and China for the 2019 base year as simulated by the model. After calibration, the model estimates around 320.000 mln TEU cargo is transported via Eurasian rail, which is about 3.7% of all containerised trade between Europe and China. As a result, the total volumes are almost equal to the volumes realised.

Table 5-7 Comparison of observed volumes for 2019 and modelled container flows (in million TEU)

	Observed		Model	
	Sea[19]	Rail[20]	Sea	Rail
Import	5.67	0.19	5.66	0.20
Export	4.14	0.11	4.15	0.12

The model simulation confirms that rail freight is hardly interesting for low or medium valued goods, as shown Table 5-8. These type of goods account for 70% of the total goods between China and Europe. With current prices for Eurasian rail freight these goods are unlikely to travel by rail, even if the value of time is considered. Eurasian rail freight is most interesting for commodities with a higher cargo value. Such commodities include vehicles or parts of vehicles for assembly, apparel and clothing, in particular luxury goods, consumer appliances and electrical machinery. Approximately 5% of all high value commodities are simulated to travel by Eurasian rail, and 25% of all very high value goods.

Table 5-8 Modeled total TEU transported China – Europe per rail and sea for different cargo values

	Cargo value [€/kg]	Sea [mln TEU]	Rail [mln TEU]
Low and medium value	< 10	7.06	0
High value	10 – 15	1.97	0.12
Very high value	15 >	0.70	0.25

5.3.2 Europe

Figure 5-7 shows per country the amount of containers shipped by Eurasian rail. The largest trade partner for China by Eurasian rail freight is Germany, with a total of 75.000 TEU, or 23% of all Eurasian rail freight. The combination of a good connection with China via Duisberg and Hamburg and the large trade volumes

[19] Sum of total TEU sea transported is based on the containerised tonnes between Europe and China from Comext and UNCTAD converted to TEU's
[20] Sum of total TEU rail transported is based on the Eurasian Rail Alliance index

in high-value goods between these countries make Germany the most attractive trading partner for China for Eurasian rail transport.

After Germany, there is considerable rail transport with Poland (45.500 TEU) and the Netherlands (43.300 TEU). Poland's favourable location in particular ensures relatively low transport costs for rail transport compared to sea transport. The Port of Gdansk is usually at the end of container ship rotations, which means that sea transport to Poland can take up to five days longer than to North Sea ports. The Netherlands has more competition from sea transport, but the high volume of trade in high-value goods with China means that much of the trade is still attractive for land transport. Switzerland is also an attractive trading partner via rail transport, mainly due to the high volume of exports of high-value goods to China.

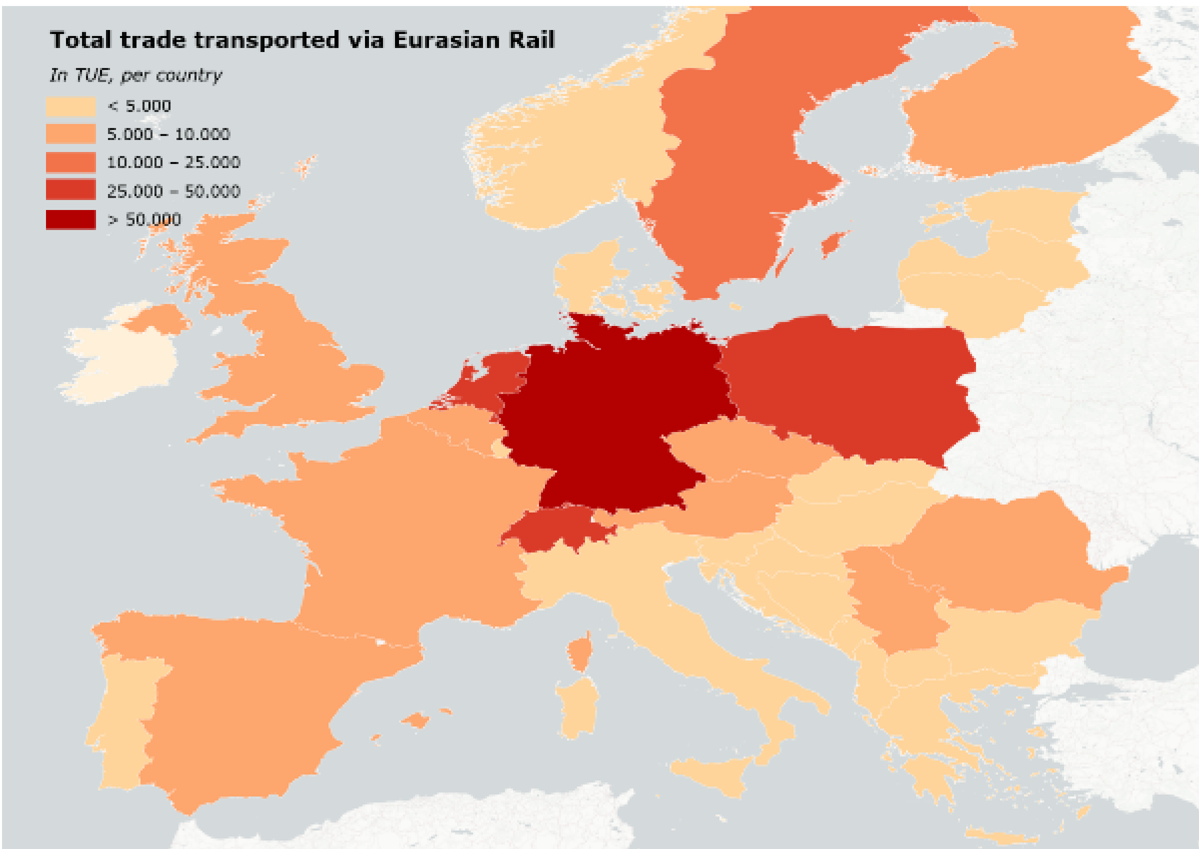


Figure 5-7 Modelled container flows from and to Europe via Eurasian rail, per country

The routes along which the model directs the trade flows correspond closely to the actual transport flows. After comparing the modelled flows with the actual flows, it shows that for import to Europe, the correct PEP was chosen by the model 88% of the time. For export, this percentage is 75%.

The lower level of accuracy of the export flows is indicative of the imbalance in import and export flows between Europe and China, but also between countries in Europe. For example, Poland imports in total 142.000 TEU in high value goods from China, while it only exports 9.000 TEU. From this, 40.000 TEU are imported from China and 5.000 are exported to China by rail. The remaining cargo is transported by sea.

Such trade imbalances are also observed for the Netherlands, United Kingdom, Spain and France, and to a lesser extent for Germany. For the countries in Scandinavia and Switzerland, by contrast, exports of higher-value goods exceed imports, with the exception of Denmark.

This situation corresponds with practice, where demand via rail for imports is much higher than the demand for exports. Carriers have difficulty filling the eastbound trains and often do so with goods that are not necessarily time-bound. The imbalance makes it challenging to keep intermodal services viable. An intermodal service is best most effective when the same amount of freight is flowing in both directions. But due to the geographical disparity of import and export of high value goods with China, carriers need to source cargo from a larger hinterland to combine it into a viable service to avoid transport with empty containers. Figure 5-8 shows the import and export per terminal. In 2019, some terminals offer more balanced connections than others.

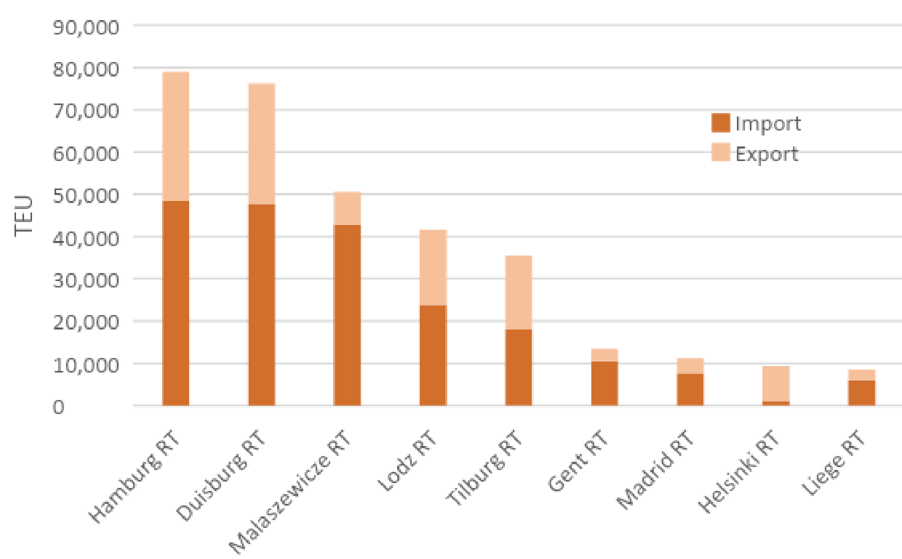


Figure 5-8 Modelled total TEU transhipped via Eurasian rail per major rail terminals

5.3.3 Difference in freight rates

Figure 5-9 shows the costs difference between Eurasian rail freight and sea freight across Europe, for low-value and high-value commodities. For the lowest-value goods, i.e. goods with a value of less than 2.5 euros per kilo, Eurasian rail transport to Europe is substantially more expensive for all regions. The cost of rail freight is around 90% more expensive than sea freight for the regions close to the seaports, up to around 60% more expensive in the interior of Europe.

As the value of the goods increases, the cost differences between rail and sea transport also change. Looking at the other extreme, i.e. goods with a high cargo value of more than 20 €/kg (

Figure 5-10), for large parts of the European inland, rail transport is more advantageous than maritime transport. Inland Europe, regions along the Baltic Sea, the north of the Balkans and regions close to a PEP, such as Madrid, the Ruhr and Helsinki, rail transport costs is approximately 1% to 5% lower. In central and western Poland, costs are up to 5% to 10% lower. Switzerland and southern Sweden also stand out. These regions have no PEP, but do have fast intermodal connections with the PEP for rail, Duisburg and Hamburg. Rail freight to the terminals in Tilburg, Ghent, Liege and Hamburg is somewhat less attractive due to the short distance to the nearest seaports and thus the lower sea freight rates.

Figure 5-9 Cost difference Eurasian rail / maritime, goods with value under 2.5 €/kg

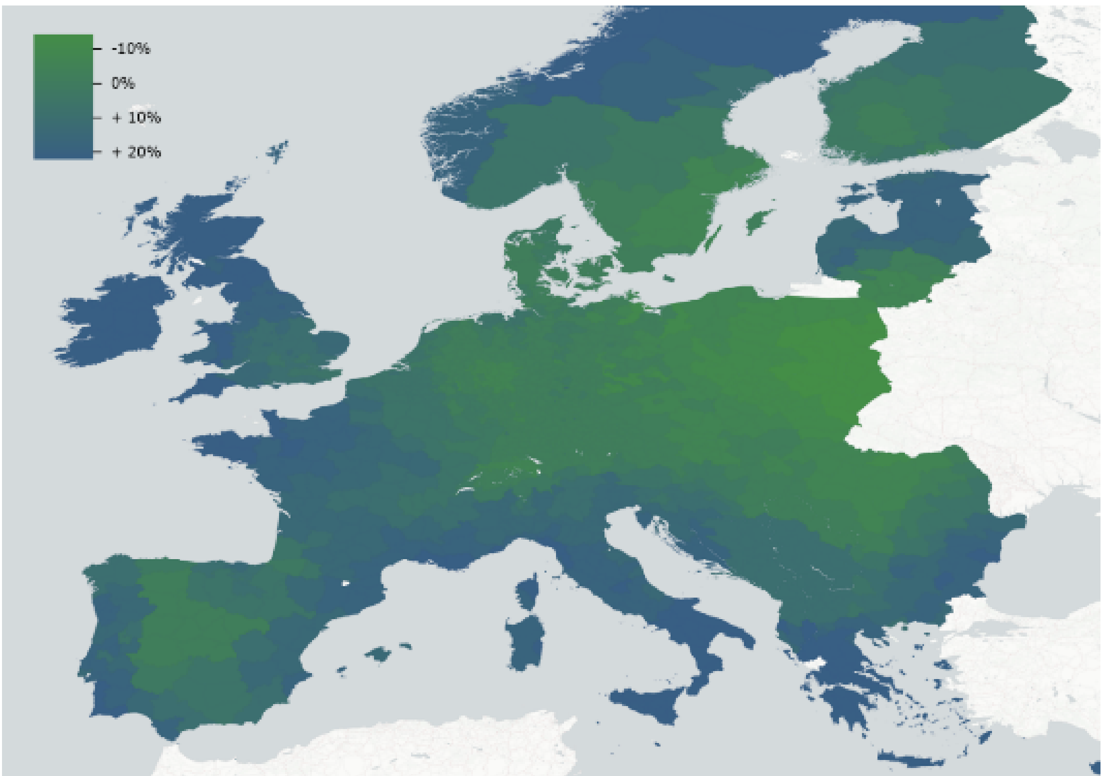


Figure 5-10 Cost difference Eurasian rail / maritime, goods with value more than 15 €/kg

5.3.4 China

Figure 5-11 shows per the modelled amount of containers shipped by Eurasian rail. A similar pattern as in Europe is visible in China. The regions with the most transport to Europe are either close to a rail terminal (such as Chongqing, Chengdu and Zheijang), have high trade volumes (such as Shanghai and Guangdong) or the nearest port is at the beginning of a container ship rotation, making the distance by sea long (such as Beijing, Tianjin and Jilin).

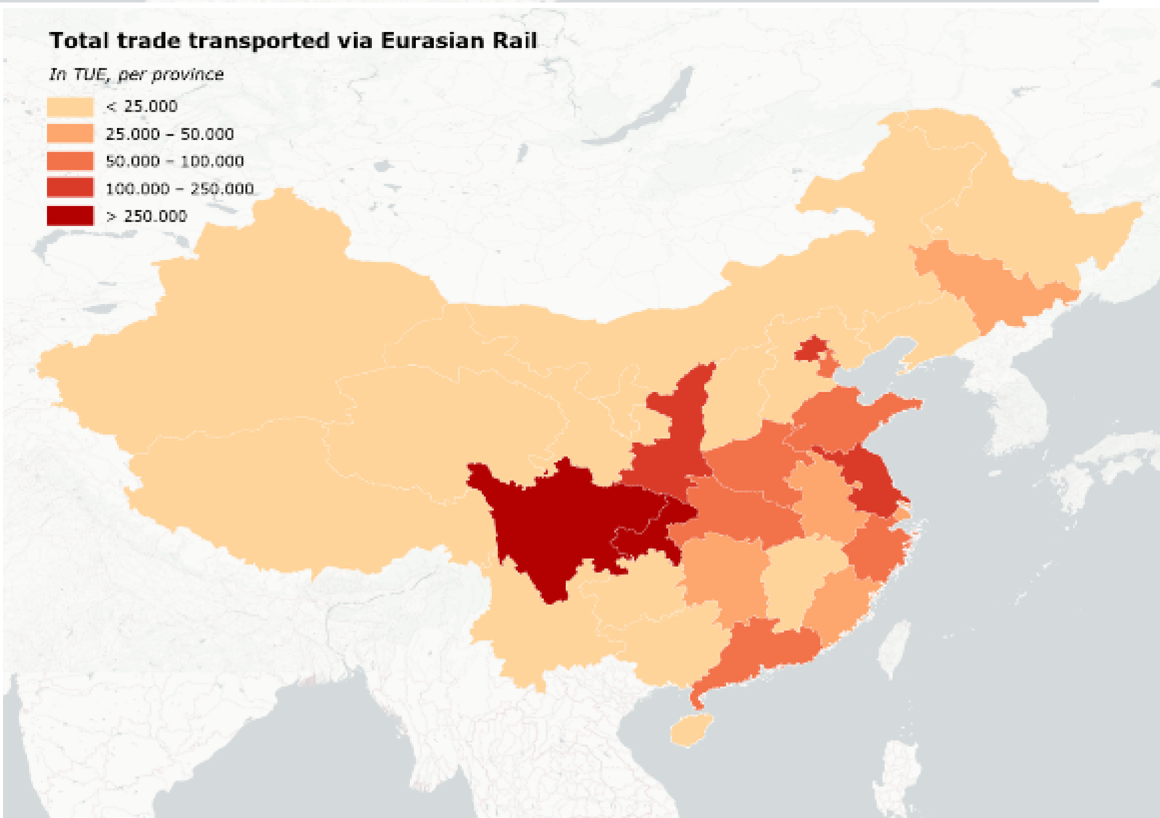


Figure 5-11 Modelled total TEU transported from and to China via Eurasian rail, per province

5.3.5 Network impact

The rail services coming from China and arriving at the European PEP are shown in Figure 5-12. For the base year 2019, only Malaszewicze is included as the border point because this is where by far the most trains from China arrive. The 200,000 TEU per year coming from China translates into about 55[21] trains per week. About 12% of this flow branches off towards Lodz. Some 23% goes to Hamburg and some 44% goes on to Duisburg, of which about half has Duisburg as its destination and the rest goes on to Liege, Ghent, Tilburg and Madrid. The export flows travel in the opposite direction, but to a much lesser extent.

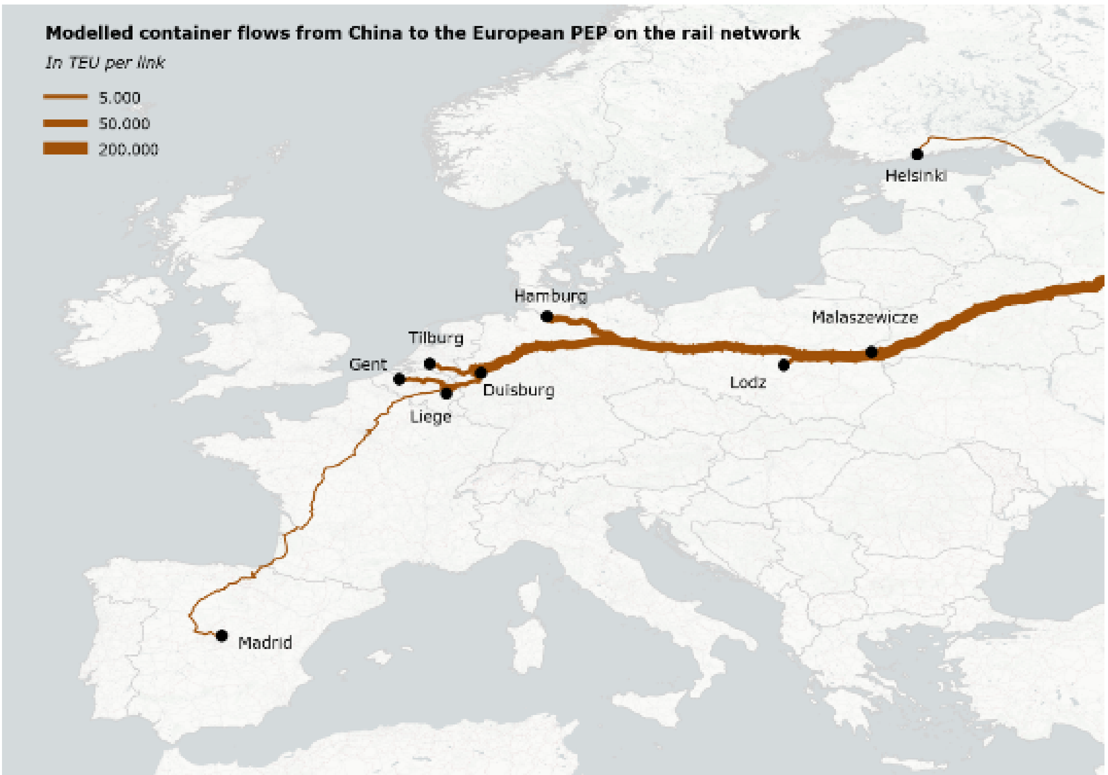


Figure 5-12 Modelled container flows from China to the European PEP on the rail network

[21] Assuming 70 TEU per train

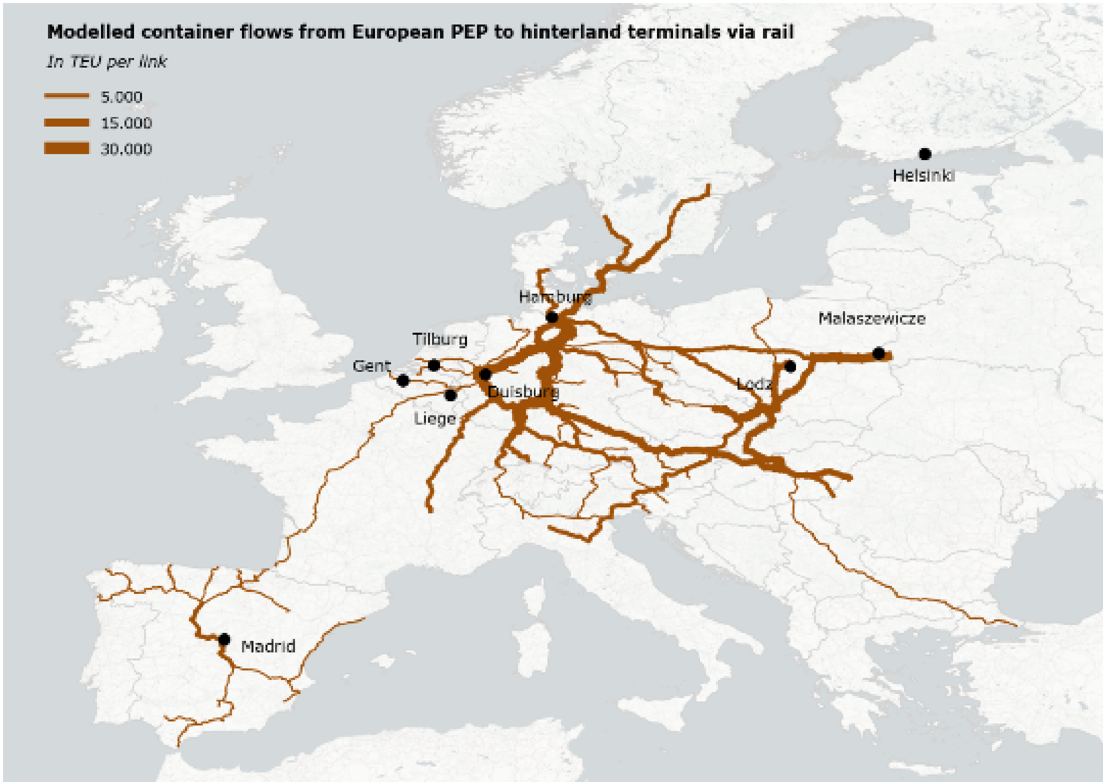


Figure 5-13 Modelled container flows from European PEP to hinterland terminals

The simulated last mile flows from the European PEP to the NUTS3 regions are shown in Figure 5-13 and Figure 5-14. For the hinterland flows, the simulation assumes an all-or-nothing distribution for the mode choice of the hinterland transport. This means that rail transport is typically chosen for distances above around 300 kilometre if a shuttle connection is available. This is a simplification of the network that significantly reduces the computational complexity of the model when calculating the EU-China container flows. While this simplification slightly overestimates rail transport and slightly underestimates road transport, the links with the most flows remain more or less unchanged.

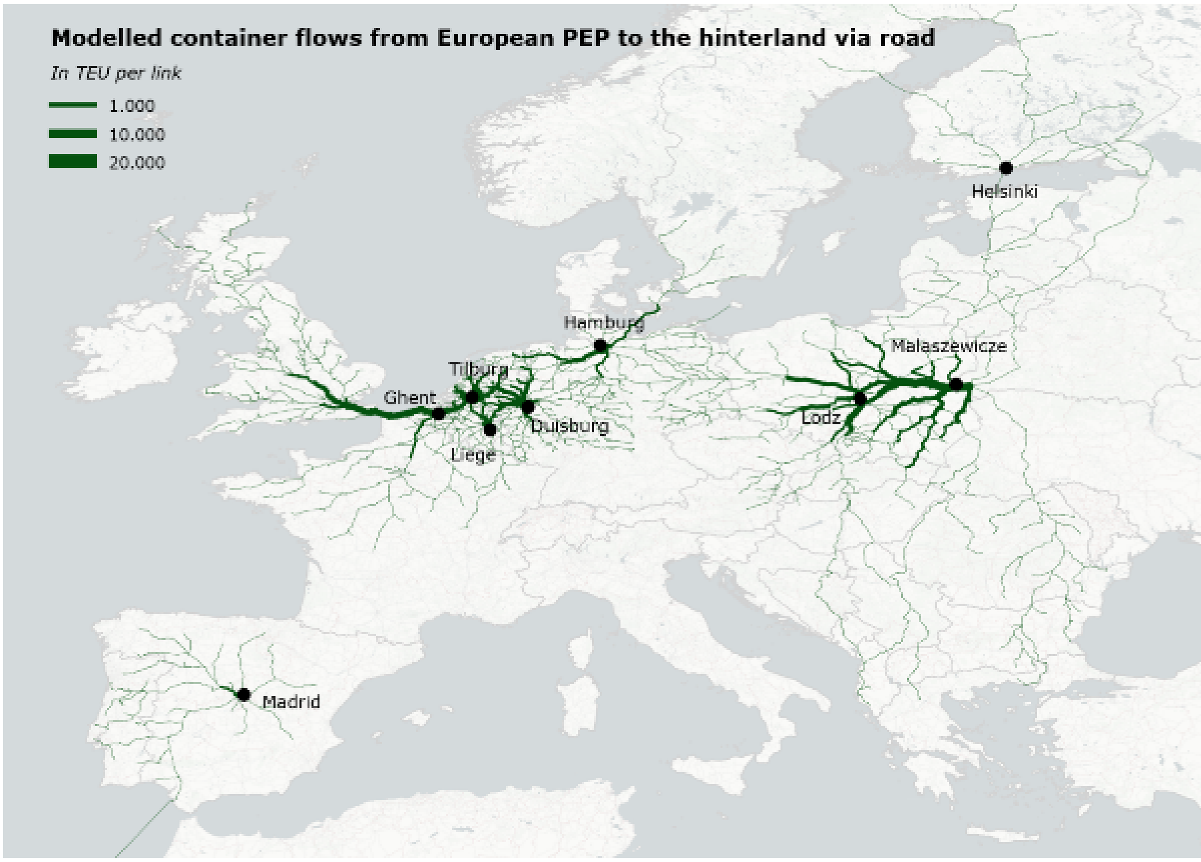


Figure 5-14 Modelled container flows from European PEP to the hinterland via road

The biggest pressure on the network are the China trains going from Malaszewicze to Hamburg and Duisburg. This part of the network is part of the North-Sea Baltic corridor. This involves between 30 and 50 trains per week.

The hinterland transport by rail has a much lesser impact on the network. The biggest flows take place between Hamburg and Frankfurt, between Hamburg and Duisburg and from Warsaw to the Czech Republic and Hungary. This involves between 5 and 8 trains per week.

For road transport, the roads around are the PEP have the highest concentration of container flows. Table 5-9 Truck departures per week per PEP. shows the truck departures per day from the PEP. At most terminals the flows spread quickly, so that only the access roads have to handle such volumes. For example in Tilburg, Hamburg and Duisburg, half of the trucks travel north while the other half goes southward. Specific routes with high volumes of traffic are the E30 from Malaszewicze to Warsaw (25 trucks per day) and the route from Ghent to London via the Channel Tunnel, of some 17 trucks per day on average.

Table 5-9 Truck departures per week per PEP.

PEP	Truck departures [per day][22]
Malaszewicze RT	68

[22] Assuming 1.5 TEU per truck and terminal operating times of 6 days a week

Duisburg RT	56
Tilburg RT	39
Lodz RT	32
Hamburg RT	28
Gent RT	23
Liege RT	13
Madrid RT	9
Helsinki RT	3

5.4 Conclusion

This chapter presents a transport model for modelling the container flows between Europe and China. The model accurately models the sea/rail distribution of rail and sea transport for the base year 2019 of up to 99% after calibration. The model is calibrated using the transhipment numbers in the European PEP. Comparing the modelled flows with the actual flows, it shows that for import to Europe, the correct PEP was chosen by the model 88% of the time. For export to China, this percentage is 75%. This difference in accuracy between the export and import flows is due to the inherent geographical imbalance of trade between China and Europe, both between the continents and between China and different countries in Europe. Import flows follow more the logic of the market (i.e. lowest freight costs and shortest time), while export flows is more based on the availability of goods for transport.

A key component of the model is the value of time parameters. Without taking into account the value of time, transport by sea between China and Europe would be cheaper under all circumstances. The value of time is based on existing literature and partly determined through calibration. Using the value of time for calibration was necessary, because using the values used in previous studies on Eurasian rail freight would significantly overestimate the potential of Eurasian rail freight. As such, this model also provides input for other macro transport models that use the value of time.

The model shows that Eurasian rail transport for the base year 2019 is only suitable for higher-value goods with a value of more than 10 euro per kilo. Reduced rail freight rates, quicker rail transport and a decrease in the trade imbalance of higher-value goods may make Eurasian rail transport more attractive in the future. The model also shows that Eurasian rail transport is most suitable for (i) regions with a high production of higher-value goods, or (ii) regions that are far away from a seaport, or (iii) regions that are near seaports with a long transport time to the destination, for example because many port calls are made in between. Based on this model, the future transport flows in 2030 and 2050 and their impact on the TEN-T network will be analysed using different scenarios.

6 North-South route simulation

The primary purpose of the International North-South Transport Corridor (INSTC) is to increase the connectivity between India, Iran, Russia and Azerbaijan, and in the longer term, other Central Asian countries and the Gulf States. Europe, while not directly part of the INSTC, is located on the edge of the corridor. Europe could therefore benefit from this route if it were invested in it.

This is in particular true for the countries located in the Baltic Sea region. The distance by sea from the Baltic Sea region to India and the Gulf States is relatively large compared to the other parts of Europe. Thus making land transport via the INSTC between these regions an option. For example, a multi-modal journey from India to Finland can be completed in 22 to 25 days. By comparison, a journey by sea takes approximately between 35 and 40 days. As Klaipeda is also connected to the Russian rail network, the Baltic States can also be reached by land in a similarly short time. And from Klaipeda, Poland and Sweden can be reached quickly by short sea.

The INSTC consists of three main routes. The western route runs through Azerbaijan, while the eastern route passes through Turkmenistan and Kazakhstan, and the central route crosses the Caspian Sea. The shortest of the three routes is the western route, and therefore theoretically also the fastest and most attractive for transport to Europe. However, the missing Qazvin-Rasht-Astara rail link in Iran means that this route cannot yet be fully utilised. With the opening of the Qazvin and Rasht section in 2019 and the completion of the Astara rail terminal in the same year, a major step towards a continuous rail connection between Russia and Iran had been taken. But the delay in completing the last section, the 130km link between Rasht and Astara, remains a thorn in the side. Mid 2021 there is still much uncertainty about whether and when this link will be completed[23].

Regardless of whether this link is completed, the EU must anticipate developments outside Europe that may affect trade flows to and from Europe. These kinds of developments can change the way cargo enters and leaves Europe and therefore the pressure on the European network. The aim of this chapter is therefore to investigate the potential on the INSTC in terms of transport volumes in the event that the western rail route is completed. Based on the current trade volumes between the countries on the INSTC and a cost comparison between sea and land transport, we map the current and future potential until 2050. This way, we gain insight into the expected volumes from and to Europe via this route, and thus the expected impact of this route on changing trade flows from and to Europe.

6.1 Methodology

To gain insight into the future volumes on the INSTC, we use a simple transport model consisting of the following steps.

1. Establish a trade matrix between the countries
2. Determine the transport costs for sea and land transport between the countries
3. Calculate the transport volumes between the countries based on the transport costs
4. Determine future trade volumes based on expected growth in trade between countries

[23] https://www.railfreight.com/corridors/2021/07/06/the-iranian-missing-link-on-the-russia-india-corridor-do-we-miss-it/

Each of these four steps is explained in more detail below.

6.2 Trade between the INSTC countries

The geographical scope of the model is the countries for which trade via the western INSTC route is most interesting, namely Estonia, Latvia, Lithuania, Finland, Sweden, Poland and Russia located on the northern side of the route, and Iran and India located on the southern side of the route. The trade matrix consisting of the trade flows between these counties is constructed from different data sources, as shown in Table 6-1.

Table 6-1 Datasets used to construct the trade matrix for the main countries on the INSTC

Dataset	Description and application[24]
COMEXT	Trade between selected European countries, total trade and containerized trade, in tonnes and in EUR, for NSTR 3-digit goods classification
UNCTAD	Trade between Russian and India & Iran, in USD. COMEXT data is used to convert UNCTAD data to containerized trade for different commodity values. Regional GDP data from the Russian State Statistics Service is used to derive the GDP from the Moscow and St. Petersburg province and its catchment area, i.e. its bordering regions
OECD	GDP forecast for 2030 and 2050 for OECD countries.

In total, over 9 million tonnes is traded between the selected countries on the INSTC in 2019[25]. Russia is the most important trading partner on the northern side of the corridor, accounting for 70% of all north-west flows. On the southern half of the corridor, India is responsible for 88% for all trade flows. The largest trading partners are India and Russia, trading around 5,5 million tonnes and accounting for 59% of all trade between the selected countries. Trade between the European countries and Iran is limited due to the sections imposed by the EU against Iran. Only 30 thousand tonnes, or 3% of all Iranian INSTC related trade, is between these regions.

Table 6-2 Total trade (1000s tonnes) between northern and southern countries INSTC, 2019

	India	Iran	Total
Russia	5.444	1.035	6.478
Baltic Sea countries	2.729	30	2.759

[24] To process the data, a conversion rate of 1 $ = 0.84 € is used to covert dollars to euro's. Conversion to TEU is made by assuming 1 TEU = 10 tonnes.

[25] The year of 2019 is taken as the starting point for the analysis as it is the most recent year with trade data reflecting standard international trade patterns. Although trade data for 2020 is available, trade figures in this year are distorted due to the corona pandemic.

In comparison, 125 million tonnes was transported between China and the EU in 2019[26]. Thus, the total trade between the countries on this route is much smaller than the trade between the countries on the New Silk Road.

The future growth in trade are based on the GDP projections by the OECD (OECD, 2018). The forecasted trade between countries is derived by taking the average GDP growth of both countries. The highest economic growth is expected for India, the largest trading partner of all the countries in the corridor. GDP in India is expected to almost double in 2030 compared to 2019. By 2040 and 2050, India's expected GDP growth will have levelled off, but will remain much higher than the other economies. Russia, the second largest trading partner of the countries in the corridor, is experiencing the lowest GDP growth, with a growth per decade of below 10%.

6.3 Transport costs on the INSTC

Transport costs for sea and land transport were calculated based on a generic cost function which includes the freight costs and the value of time. The transport costs between the most important nodes on the INSTC, i.e. Stockholm, Gdanks, Helsinki, St Petersburg, Klaipeda and Moscow on the north side of the corridor, and Bandas Abbar and Mumbai on the south side, are included. First- and last mile haulage between these nodes and are equal for sea and rail, and therefore omitted from the model.

[26] Figures from on COMEXT data

Figure 6-1 Sea route alternative to the International North-South Transport Corridor.

The possible routes between these nodes are shown in Figure 6-1 for sea and Figure 6-2 for rail. For sea, liner shipping companies offer different options to go to the Baltic sea. On the most common routes between the Arabian Sea and the Baltic Sea, containers are transhipped twice. The first transhipment takes place at Algeciras or at one of the North-Sea ports, such as Rotterdam or Hamburg. From there, the cargo is taken to Gdansk in the Baltic sea, where it is further distributed via short sea to the various ports in the Baltic region. For Moscow, hinterland transport from St. Petersburg to Moscow is considered.

The rail route starts at Mumbai, from where the containers are transported by short sea to the port of Bandar Abbas in Iran. There, the containers continue their journey on a block train. Via Tehran, the route goes to Astara at the Iranian and Azerbaijani border, where there is a changeover to the Russian rail gauge. Via Astrakhan the block train goes to Moscow, where the route branches off to the north towards St Petersburg and Helsinki, or westwards to Klaipeda. From Klaipeda the container can continue by short sea to Stockholm or Gdansk. Latvia and Estonia are not included as a separate destination but are served from Helsinki or St Petersburg.

Figure 6-2 Western route of the International North-South Transport Corridor.

Transport costs, transhipment costs and mode-specific costs used in the calculations are shown in Table 6-3. The costs are derived from Panteia's intermodal transport costs model, which data is partly publicly available via Panteia (2020). Shipping distances are calculated from https://sea-distances.org. Road and rail distances are calculated based on google maps. The costs of time determined for commodity groups based on the cargo value and derived from Belt and Road Initiative reference simulation and shown in Table 6-4.

Table 6-3 Costs paramters used to calculate the generalised transport costs

Parameter	Value	Unit
Transport costs		
Maritime costs	0.021	€/km/TEU
Maritime speed	22	Km/h
Short Sea costs	0.047	€/km/TEU
Short Sea speed	28	Km/h
Rail costs	0.175	€/km/TEU
Rail speed	35	Km/h

Hinterland transport costs	0.3	€/km/TEU
Hinterland transport speed	42	Km/h
Transhipment costs		
Transhipment costs Sea	75	€/handling
Transhipment time Sea	5	days
Transhipment costs Rail	35	€/handling
Transhipment time Rail	4	days
Mode-specific costs		
Rail waiting costs	0.6175	€/hour
Gauge change costs	120	€/TEU
Customs costs	50	€/TEU
Suez canal fee	50	€/TEU
Port dues	20%	of total capital costs

Table 6-4 VOT parameter based on the commodity value

VOT-category	Cargo value [€/kg]	VOT [€/day/TEU]
Very low	0 – 2.5	10
Low	2.5 – 5	20
Medium	5 – 10	40
High	10 – 15	60
Very-high	15 +	80

Based on the costs parameters, the transport costs is calculated for each route for the five different type of commodities. The freight costs for different commodity values are shown in Table 6-5 for trade with India and in Table 6-6 for trade with Iran.

Table 6-5 Freight costs (incl. VOT), different cargo values transported from/to India along the INSTC

		Sea	Rail
From	To	Freight costs [€/TEU]	Freight costs [€/TEU]
Mumbai	Helsinki	1261 - 3965	1842 - 3182
Mumbai	Klaipeda	1182 - 3750	1803 - 3008
Mumbai	Stockholm	1214 - 3838	2154 - 3944

Mumbai	Gdansk	977 - 3516	1976 - 3688
Mumbai	Moscow	1535 - 4215	1538 - 2647
Mumbai	St. Petersburg	1246 - 3926	1665 - 2830

Table 6-6 Freight costs (incl. VOT), different cargo values transported from/to Iran along the INSTC

		Sea	Rail
From	To	Freight costs [€/TEU]	Freight costs [€/TEU]
Iran	Helsinki	1261 - 3965	1516 - 2254
Iran	Klaipeda	1182 - 3750	1527 - 2269
Iran	Stockholm	1214 - 3838	2023 - 3632
Iran	Gdansk	977 - 3516	1868 - 3399
Iran	Moscow	1587 - 4637	1262 - 1908
Iran	St. Petersburg	1246 - 3926	1389 - 2092

Using a logit function, it is possible to determine the likelihood of either the sea route or the land route being chosen depending on the commodity value and the trade partners. The green colour in Table 6-7 and Table 6-8 indicates that land transport is a viable option for this commodity type on this specific connection. The probability of carriers choosing rail for this connection is greater than 66%. The orange colour refers to that both rail and sea transport is a viable option. The probability for rail is between 33% and 66%. Red indicates that sea transport will most likely be chosen by the carrier. The chance of rail transport being chosen is less than 33%.

Table 6-7 Likelihood of choice for sea or land route to/from India, depending on commodity value.

From	To	Very low	Low	Med	High	Very high
Mumbai	Helsinki					
Mumbai	Klaipeda					
Mumbai	Stockholm					
Mumbai	Gdansk					
Mumbai	Moscow					
Mumbai	St. Petersburg					

Table 6-8 Likelihood of choice for sea or land route to/from Iran, depending on commodity value.

From	To	Very low	Low	Med	High	Very high
Iran	Helsinki					
Iran	Klaipeda					

Iran	Stockholm					
Iran	Gdansk					
Iran	Moscow					
Iran	St. Petersburg					

Trade to Moscow is the most attractive for all commodity groups. This is partly due to the short distance by rail, but mainly because transport by sea to Moscow requires another 700 km hinterland leg. This is a major cost factor, as hinterland transport is relatively expensive. Gdanks is the least attractive for transport by rail. This is on the one hand because another short sea leg is needed from Klaipeda, and on the other hand because Gdanks can be easily reached via deep sea.

6.4 Transport volumes on the INSTC

The total trade on the INSTC can be derived by applying the probability of a certain mode and commodity group to the trade data. A correction to the data is made by assuming that a minimum share of full containers of 65% is required on each connection. Based on this, we can calculate what the potential of the INSTC is, if the western route will be used. The results are shown in Figure 6-3 and Figure 6-4.

The figure shows that the current potential of the route is 86 000 TEU. In other words, if the route were in operation in 2019, there would be potential for 86 000 TEU to be transported on the route annually. This is equivalent to a total of over a thousand trains a year[27], or about 20 trains a week. The bulk of this is trade between India and Russia, particularly trade to the Moscow region, some 78% of the total trade on the INSTC. Trade between Russia and Iran amounts around 11.000 TEU, or 12% of the total trade on the INSTC. Transport to and from European countries on the INSTC takes place almost exclusively with India and amounts to over 8.500 TEU. This shows that the volumes to Europe, representing 10% of the total trade, are only a small portion of the total potential on the route. The low volumes do not make it likely that separate block train services from the south of the corridor to European destinations are set up. The greatest potential of the INSTC is to combine Europe-related cargo with other cargo flows on the corridor. For example, cargo from Helsinki or Klaipeda bound for India is transported to Moscow together with other cargo destined for Russia. In Moscow, the cargo destined for India is transferred to another train with Russian goods going to India

[27] 80 TEU per train is assumed

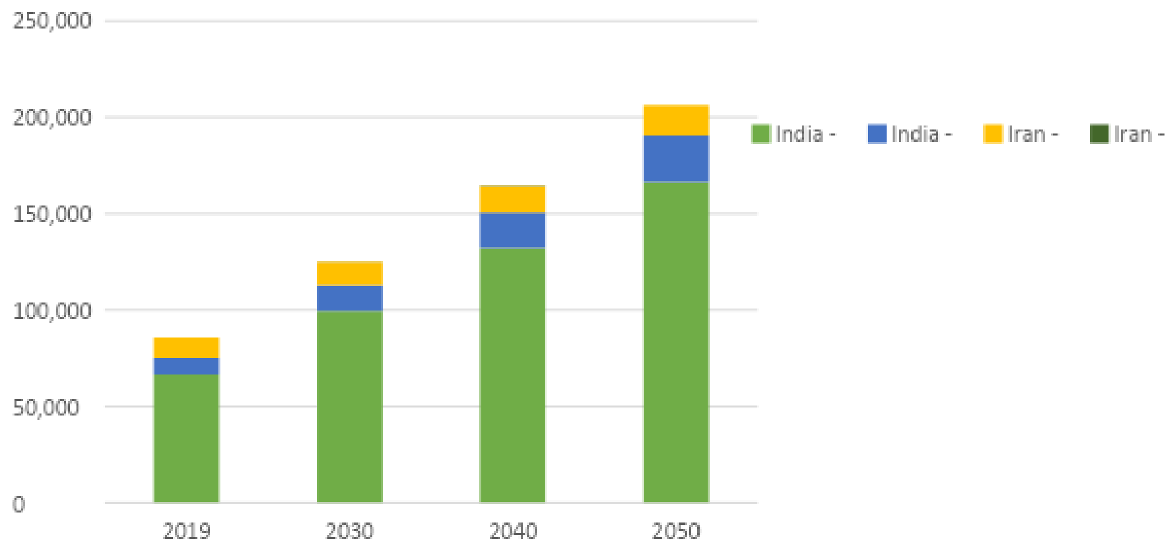


Figure 6-3 TEU potential International North-South Transport Corridor, 2019 – 2050

Figure 6-4 Trains per week potential International North-South Transport Corridor, 2019 – 2050

By 2050, the potential could be over 206.000 TEU per year, which is equal 2.500 trains per year or 50 trains per week. One eighth of this, or 24.000 TEU, has a European origin or destination. This concerns 6 trains per week running over the INSTC. With these volumes, it becomes more interesting to set up a dedicated regular block train from Helsinki or Klaipeda to Bandas Abbar. But at the same time, the predicted volumes in 2050 do not come close to the volumes running on the New Silk Road. With a total volume in 2019 of 300.000[28] TEU, or 72 trains per week, this route is currently much more heavily used.

[28] Eurasian Rail Alliance Index, https://index1520.com/ [accessed on 31-07-2021)

6.5 Conclusion

This chapter investigates the potential in terms of transport volumes on the INSTC in the event that the western rail route is completed. Based on a simple transport model, we see a current potential of the route of over 86,000, which could increase to 125,000 TEU in 2030 and 206,000 TEU in 2050. It remains to be seen how long it will take for these volumes to be realised if the route is completed. It always takes a number of years before transporters actually switch from sea to rail transport.

Only a fraction of the cargo is related to Europe. This concerns 8,500 TEU if the route would be opened right now, which could increase to 13,500 TEU in 2030 and 24,000 TEU in 2050. The corridor is therefore most interesting as a European trade route if European trade can be combined on INSTC trains with Russian cargo. The total potential of the route may increase slightly if Gulf States and Pakistan are included or rail costs are lowered due to more efficient customs and border crossing procedures.

7 Artic Sea Route analysis

7.1 Introduction

This Chapter analyzes the current freight flows from the Arctic region to Europe. To do so, it firstly elaborates on the ship traffic flows going from the Arctic to Europe mainly through the Northern Sea Route area. Secondly, it provides details on the quantity of commodities carried by ships and on the destination of these flows in Europe. Ultimately, it highlights traffic on other Arctic areas as well as the transit flow that crosses the region.

The Arctic presents three main routes that are used by vessels to navigate through the region: the Northern Sea Route or “NSR”, extending on the East of Novaya Zemlya and following the coastline of the Russian Arctic from the Kara Sea, along Siberia, to the Bering Strait; the Northwest Passage or “NWP”, running along the coast of Northern Alaska and the Canadian Arctic Archipelago and the Transpolar route, which will cross the North Pole once ice conditions allow it.

7.2 Current freight flows

7.2.1 Northern Sea Route area

The NSR is the shortest route linking Europe and the Asia-Pacific region[29]. Between 2016 and 2019, 8329 separate voyages took place on the NSR. Throughout these years, the number of vessels working on the NSR increased by 58%,[30] due to both a rise in internal traffic on the NSR and a growth in destination shipping by LNG carriers and tankers working between the Kara Sea and European ports.[31] The percentage of destination shipping voyages on the NSR gradually increased from 2016 to 2019: in 2016, destination shipping formed 12% of all voyages, while in 2019 it almost doubled to 23%.[32] Similarly, the volume of cargo transported on the NSR also grew, from 7.5 million tonnes in 2016 to 31.5 million tonnes in 2019, due to transport of liquid hydrocarbons for export, primarily to the European market.[33]

While traffic on the NSR is increasing, it should be noted that the route is still not a commercially viable alternative for the Suez Canal, (the principal route connecting the Mediterranean Sea to the Indian Ocean). Reasons for this are due to the physical characteristics of the NSR itself. Firstly, the seasonality of the NSR impedes continuous passage: the route is often available only between May and October, and icebreakers are nonetheless needed during this period to break floating ice layers that remain in summer. Secondly, the usage of icebreakers-accompanying ships is necessary yet quite expensive, and in any event only vessels with the ice-class can travel across the Arctic area. Furthermore, due to ice conditions, the navigation time is not proportionally shorter compared to the one in the Suez Canal. Lastly, the water along the NSR is sometimes too shallow to be navigated by large container ships, causing problems to vessels operating on the route.[34] As a consequence, despite its closeness to Europe, the NSR is still only viable in a small scale for research and development, and it is still quite disadvantageous when compared to the benefits of the Suez Canal.

[29] https://nordregio.org/maps/sea-routes-and-ports-in-the-arctic/
[30] number of voyages increased from 1705 to 2694, or by 58% (Gunnarsson, 2021)
[31] increase in destination shipping between SW Kara Sea and European ports (by LNG carriers and gas condensate tankers
[32] Gunnarsson (2021)
[33] Gunnarsson (2021)
[34] https://biznesalert.com/the-northern-sea-route-wont-replace-the-suez-canal/

From the standpoint of resources transported, energy plays a major role in shipping along the NSR. Even though offshore exploration activities in the Arctic are still significantly limited, the considerable developments in the production of LNG close to the Yamal and Gyada peninsula are responsible for a remarkable increase in traffic.[35] Currently, LNG tankers and tankers are the most common types of vessels crossing the region, followed in a very small portion by containers, icebreakers, general cargo and bulk carriers.[36] Between 2016 and 2019, most of the cargo transported consisted in liquid hydrocarbons: LNG, gas condensate and crude oil, and was exported to European markets[37]. In 2019, 254 shipments of LNG were brought from Sabetta, (where the Yamal LNG gas project is located), by 23 LNG carriers to foreign markets and 41 shipments of gas condensate by 6 tankers.[38]

As for the projects taking place in the Arctic region, Yamal LNG produces 16.5 MT/y of LNG, while the Arctic LNG-1, 2 and 3 projects are estimate to have a capacity of 40 MT/y. The Obskiy LNG project has also an important capacity, most notably 4.8 MT/y.[39] It is also noteworthy to mention Gazprom's Novy Port project which, in 2019, produced 7.7 million tonnes of crude oil. Together with the production of Yamal LNG, (18.4 million tonnes of crude oil), these projects account for 26.1 million tonnes of crude oil, which translates into 80% of cargo volume on the route.[40]

Aside from energy resources, the NSR does not host significant traffic flows carrying other commodities. In 2019, general cargo vessels, fishing vessels, bulk carriers and containers formed a negligible portion of vessels crossing the area[41], largely overpowered by tankers.

On the Bering Sea and Strait, crossed by the NSR, bulk carrier logged the highest number of hours of operation within all other non-fishing vessels active in the area, followed by the operations of container ships[42]. Between 2014 and 2015, the Bering sea hosted 51,142 segments by non-fishing vessel most commonly in the form of bulk carriers (20,120) and container ships (15,228).[43] However, aside from the carriage of supplies such as construction material and supplies for the construction of ports along the route,[44] it is difficult to quantify the volumes of resources extracted from the area and shipped along the NSR. Raw materials such as minerals and timber are exported on a regular basis, but normally their quantity is so small as to not have appreciable effects on markets.[45] Excluding palladium and gem-quality and industrial diamonds, (of which Arctic Russia is responsible for, respectively, 40% and 20% of the world's total production),[46] vermiculite, copper, phosphate minerals and bauxite are the most common minerals, produced in quantities below 6% of the world's total production.[47]

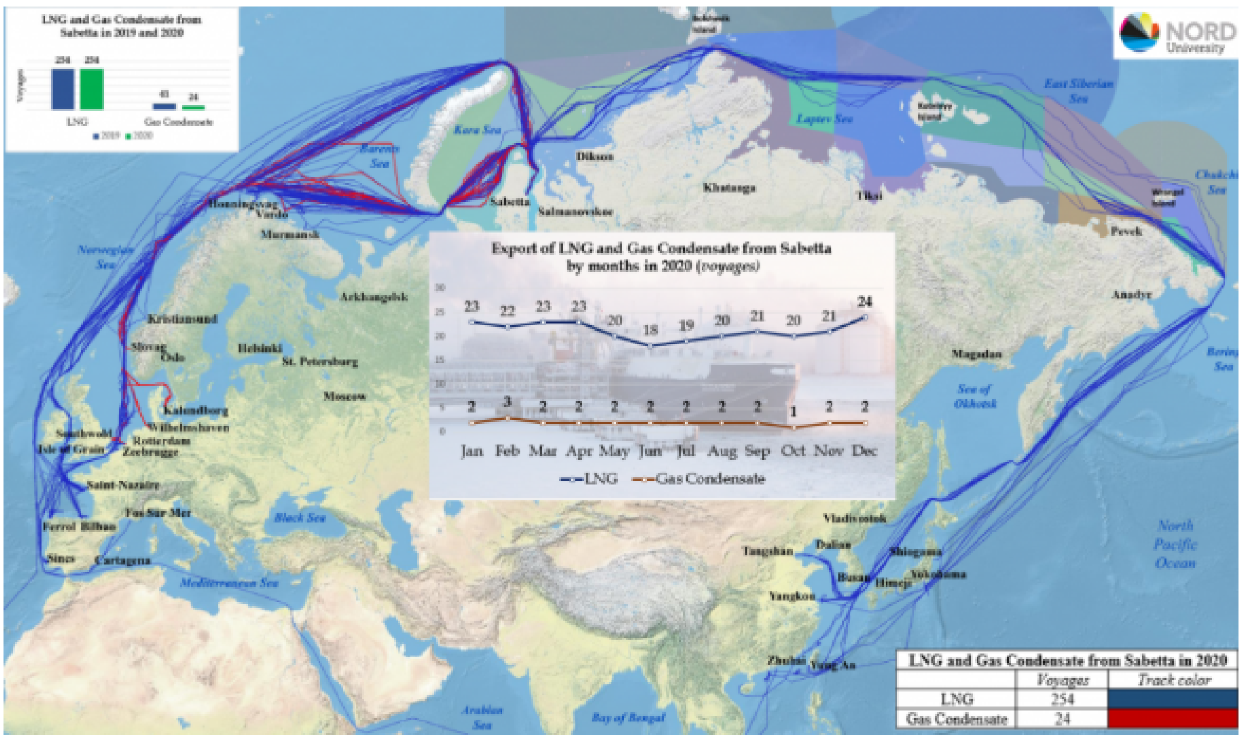
Special mention should be given to the traffic taking place in the Barent Sea, crossed by the NSR, primarily consisting in fishing activities. This area, crossed both by the NWP and the NSR, hosts considerable maritime traffic in the form of fishing vessels. Here fishing activities predominated, contributing to over 95 of vessel activity in the area[48]. The region encompasses hundreds of fish species relevant for commerce, such as salmon, cod and pollock[49]. Barents capelin stocks, shared between

[35] https://www.ispionline.it/en/pubblicazione/oil-and-natural-gas-exploitation-russian-arctic-29947
[36] https://arctic-lio.com/powerbi-2/
[37] Gunnarsson (2021)
[38] Gunnarsson (2021)
[39] https://www.ispionline.it/en/pubblicazione/oil-and-natural-gas-exploitation-russian-arctic-29947
[40] https://www.highnorthnews.com/en/cargo-volume-northern-sea-route-remains-stable-32m-tons-2020
[41] https://arctic-lio.com/powerbi-2/
[42] https://www.frontiersin.org/articles/10.3389/fmars.2019.00573/full
[43] https://www.uaf.edu/caps/our-work/arctic-ocean-transit-project-files/increased-maritime-traffic-in-the-arctic-paper-final-9Dec2019.pdf
[44] Gunnarsson (2021)
[45] https://www.smithschool.ox.ac.uk/publications/reports/ssee-arctic-forecasting-study-november-2011.pdf
[46] https://www.ssb.no/a/english/publikasjoner/pdf/sa84_en/kap3.pdf
[47] https://www.ssb.no/a/english/publikasjoner/pdf/sa84_en/kap3.pdf
[48] https://www.frontiersin.org/articles/10.3389/fmars.2019.00573/full
[49] https://arctic.ru/resources/

Norway and Russia, provide over 65,000 tonnes of fish, while herring reaches a quota up to 1,600,000 tonnes.[50]

7.2.2 Arctic shipping to Europe

The last years have seen a rise in destination shipping from the Arctic region to Europe. Between 2016 and 2019, trips from NSR to European ports increased from 78 voyages a year to 287.[51] Such growth is due to the increase in shipments of LNG from Yamal LNG to ports in Europe for unloading, transshipments and return voyages to the port of Sabetta.[52] It is estimated that in 2019, out of the 18.8 mln tonnes of LNG extracted and exported from Yamal LNG, 15.6 mln tonnes were sent to Europe,



(accounting for almost 60% of Russia's total exports). The COVID-19 crisis brought a decrease in demand

Figure 7-1 Traffic flows crossing the NSR and terminating in Europe ©NSR Information Office

from Europe, which impacted the quantity of LNG exported in 2020. In 2020, exports of Russian LNG decreased up to 10.7 mln tonnes, (a -10.6% tear-on-year decline)[53]. European companies also performed considerable activity for domestic shipping on the NSR, with 23 companies making 269 voyages from 2016 to 2019. Most of these vessels were general cargo, bulkers and heavy lift carriers providing support for offshore drilling activities and dredging services.[54]

The map above showcases where traffic flows crossing the NSR terminate in Europe. Notably, most traffic flows crossing the NSR carry, as a commodity, energy-related resources such as LNG and gas condensate. For what concerns LNG, destinations are normally Honningsvag in Norway, Rotterdam in The

[50] http://www.access-eu.org/modules/resources/download/access/Deliverables/D3-71-NOFIMA_final.pdf p 16
[51] Gunnarsson (2021)
[52] Gunnarsson (2021)
[53] https://www.hellenicshippingnews.com/russian-lng-exports-a-year-in-review/
[54] Gunnarsson (2021)

Netherlands, Zeebrugge in Belgium, Dunkerque and Saint-Nazaire in France, Bilbao and Ferrol in Spain and Sines in Portugal. Most of these destinations are large-scale LNG terminals that receive the resources extracted from Sabetta and other LNG and Gas Condensate plant projects. In the following paragraph, a series of information on the quantities of resources received by each port, as well as its strategic relevance for commercial traffic flows, is provided.

The Port of Honningsvaag in Norway is utilized as a transshipment point for LNG. Its most important operator is Novatek, Russia's largest independent natural gas producer.[55] In 2018, 16 LNG reloading operations were carried out within the transfer operations of Novatek's Arctic Yamal project. In 2019, 21 reloading operations took place each month between January and June, with each shipment accounting for about 80,000 tons of LNG.[56] In total, between November 2018 and June 2019, more than 120 loads of LNG were transferred from specialized Arc7 tanks to conventional LNG carriers.[57] Honningsvag is increasingly acquiring importance as Novatek utilizes it as a temporary terminal for ship-to-ship transshipment, while it realizes its LNG transshipment and storage facilities on the Kola and Kamchatka Peninsula. Within the 278 voyages undertaken by LNG and Gas Condensate carriers from Sabetta, respectively 10 LNG carriers voyages and 1 Gas Condensate carrier were directed to Honningsvag's transshipment point.[58]

The Gate terminal Rotterdam is a large scale onshore facility located at a distance of 2520 nautical miles from Sabetta.[59] The total throughput of LNG in 2020 was 6.2 million tonnes, decreasing from the 7.1 million tonnes in 2019. Furthermore, in 2020 the Gate terminal received 5.8 million tonnes of incoming LNG.[60] It is estimated that out of the 278 voyages made by LNG and Gas Condensate carriers from Sabetta in 2020, respectively 26 LNG carriers voyages and 8 Gas Condensate carriers were directed to the Gate terminal.[61] The Rotterdam terminal is an important sorting facility for LNG, which is then regasified at the Gate to be distributed across European nations either through underground pipelines or by loading it onto vessels and trucks.[62]

The Zeebrugge LNG Terminal is a large scale onshore facility located at a distance of 2550 nautical miles from Sabetta.[63] Between 2016 and 2017, the port served as a stopover for many cargo vessels transporting prefabricated LNG modules and other project cargo from construction yards in China and Indonesia to Sabetta.[64] For what concerns LNG shipping destinations, statistics show that in 2020, out of the total 254 voyages of LNG carriers from Sabetta, 62 of them were directed to Belgium.[65] Apart from sorting LNG, traffic flows also reach Zeebrugge for its unique infrastructure for loading small LNG ships. In fact, differently from Rotterdam, the particularity of Zeebrugge lays in its role for small-scale LNG use, which makes it a strategical hub for alternative fuel for ships and long-haul trucks.[66]

The Dunkerque LNG import Terminal and Montoir-de-Bretagne LNG Terminal are two large scale onshore facilities located along the French coast. Statistics show that out of the total Russian exports of LNG in 2018 per million ton 1.1% was directed to France,[67] making it the European country with the most significant quantity of Russian LNG import amount. In addition, out of the total 254 voyages made by LNG

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[55] https://www.offshore-energy.biz/bw-tulip-completes-8th-sts-lng-transfer-of-honningsvag/
[56] https://www.highnorthnews.com/en/nine-million-tons-russian-lng-will-be-reloaded-norwegian-waters-during-2019
[57] https://www.highnorthnews.com/en/novatek-and-tschudi-group-return-norways-honningsvag-transfer-lng
[58] https://arctic-lio.com/nsr-shipping-traffic-export-of-lng-and-gas-condensate-from-sabetta-in-2020/
[59] https://www.spf.org/_opri_media/news/2.Mr.MikhailBelkin_Rosatomflot.pdf
[60] https://www.portofrotterdam.com/sites/default/files/facts-and-figures-port-of-rotterdam.pdf
[61] https://arctic-lio.com/nsr-shipping-traffic-export-of-lng-and-gas-condensate-from-sabetta-in-2020/
[62] https://www.portofrotterdam.com/en/doing-business/logistics/cargo/lng-liquefied-natural-gas/lng-terminal
[63] https://www.spf.org/_opri_media/news/2.Mr.MikhailBelkin_Rosatomflot.pdf
[64] Gunnarsson (2021)
[65] https://arctic-lio.com/nsr-shipping-traffic-export-of-lng-and-gas-condensate-from-sabetta-in-2020/
[66] https://www.gti.energy/wp-content/uploads/2018/12/6-6-Pieterjan_Renier-LNG17-Paper.pdf p 8
[67] https://www.oxfordenergy.org/wpcms/wp-content/uploads/2019/11/Russian-LNG-Becoming-a-Global-Force-NG-154.pdf p 27

carriers from Sabetta in 2020, 58 went to France,[68] Both terminals are highly performing: in 2018, the Dunkerque terminal received five cargoes in just one month, (achieving a record number in one single month[69]); while Montoir-de-Bretagne recorded great numbers when, in the same year, it received 13 LNG carriers in one month and 3 LNG cargo transshipment in just one week,[70] As for the importance of the two terminals, they both serve significant purposes for shunting LNG. Dunkerque receives much LNG because of its considerable annual regasification capacity, which reaches 13 billion m3 of natural gas and satisfies 20% of France and Belgium's gas demand[71]. Differently, Montoir-de-Bretagne is very important for its option of transshipping consignments between LNG carriers,[72] facilitated by its favorable geographical location and meteorological/nautical conditions.[73]

The Bilbao LNG Terminal and Mugardos LNG Terminal in Ferrol are two large scale onshore facilities located in Spain. In 2020, of the total 254 voyages made by LNG carriers from Sabetta, 30 of them reached Spain.[74] Both Terminals are highly efficient, making them congenial hubs for receiving LNG. With regard to Bilbao, in the last years the Terminal has seen a rise in the quantity of LNG received. In 2019, the main supplier of natural gas for domestic, commercial and industrial consumption in Bilbao, Bahía de Bizkaia Gas (BBG), received 53 LNG consignments, 19 more than in 2018.[75] In addition, the Operator reported a rise of 95% in (un)-loading activities at the regasification terminal compared to 2018. By the end of 2019, the facility in Bilbao had received 67 vessels and unloaded 4.2 million tons of fuel, (including both LNG and Gas condensate). BBG reported that this figure accounts for 12% of the whole 2019 throughput in the Port of Bilbao.[76] Differently, during 2019 the Mugardos Terminal performed 20 ship discharges, an increase of 54% compared to 2018. By the end of the year, 2.22 million cubic meters of LNG (14,874 GWh) reached the facility's tanks,[77] with a consequential increase in regasification work. Importantly, Mugardos will be run only with green power through ambitious plans that would bring 100% renewable energy to the facility[78].

Sines LNG Terminal is a large scale onshore facility located in Portugal. In 2017, 55% of the LNG entering Portugal was carried to Sines, forecasted to grow nearing 70% of the LNG entering the country[79]. These projections were confirmed in 2019, when the Terminal received more than 4 million tons of LNG, recording the highest number since its opening in 2004. The quantity of handled LNG has increased year by year, with a 44.5% growth compared to 2018.[80] Out of the total carriers carrying LNG from the Russian Arctic to Europe in 2020, 6 vessels reached Portugal.[81]

7.2.3 Other Arctic Areas

The Arctic region is also crossed by the NWP and the Transpolar route. However, these routes are of smaller significance for the EU in that they do not present considerable traffic flows reaching European

[68] https://arctic-lio.com/nsr-shipping-traffic-export-of-lng-and-gas-condensate-from-sabetta-in-2020/
[69] https://www.offshore-energy.biz/frances-dunkirk-lng-to-receive-record-number-of-cargoes-in-july-plans-45-day-maintenance/
[70] https://www.elengy.com/en/news/news/press-releases/315-a-streak-of-records-at-the-montoir-de-bretagne-lng-terminal-in-august.html
[71] https://www.offshore-energy.biz/frances-dunkirk-lng-to-receive-record-number-of-cargoes-in-july-plans-45-day-maintenance/
[72] https://www.nantes.port.fr/en/nantes-saint-nazaire-port/port-facilities-and-activities/montoir-de-bretagne
[73] https://www.elengy.com/en/news/news/press-releases/280-lng-trans-shipment-at-the-montoir-de-bretagne-lng-terminal-from-an-arc7-ice-class-lng-carrier.html
[74] https://arctic-lio.com/nsr-shipping-traffic-export-of-lng-and-gas-condensate-from-sabetta-in-2020/
[75] http://gasprocessingnews.com/news/increased-activity-at-bilbao-lng-plant.aspx
[76] https://www.offshore-energy.biz/spains-bbg-reports-throughput-spike-at-bilbao-lng-terminal/
[77] https://www.offshore-energy.biz/reganosa-mugardos-lng-terminal-2019-activity-jumps/
[78] https://www.offshore-energy.biz/mugardos-lng-terminal-to-only-use-green-power/
[79] https://www.ren.pt/en-GB/media/comunicados/detalhe/rens_liquefied_natural_gas_terminal_in_sines_welcomes_its_500th_ship
[80] http://www.ngvjournal.com/s1-news/c7-lng-h2-blends/portugal-port-of-sines-completed-first-natural-gas-bunkering-operation/
[81] https://arctic-lio.com/nsr-shipping-traffic-export-of-lng-and-gas-condensate-from-sabetta-in-2020/

countries. Traffic in the Canadian Arctic, crossed by the NWP and, partly, by the Arctic bridge, (a route connecting Canada to Norway but of minor importance for European interests), has almost tripled between 1990-2015.[82] The predominant vessels using the NWP are bulk carriers and general cargo ships,[83] although the Passage is increasingly being used by tug/supply and tourism ships.[84] However, the strong presence of pack ice limit exploratory activities along the NWP.[85] Differently, the Transpolar Route is a future route that shall become available over the years, while ice in the Arctic melts. Estimates forecast that the Route crossing the Arctic Ocean will become available around mid-century.[86] The Route is expected to cross the North Pole, which will have benefits both for what concerns shortening journey times and allowing ships to navigate through the Arctic in international waters.[87]

7.2.4 Transit Freight Flows

Transit shipping in the Arctic region occurs mainly through the NWP and the NRS. These routes are used to connect the Pacific and Atlantic Oceans as an alternative to the Panama and Suez canals, even though the latter remain the main arteries of ship traffic flows.[88] For what concerns the NWP, in 2019 most vessels that traversed it were cutters, cargo ships and cruise vessels.[89] Although vessels crossing the NWP have traditionally been small ships, glacier retreat is favoring the passage of larger passenger vessels.[90] Differently, for what concerns the NRS transit shipping only covers a minority of trips: even though voyages of a transit nature grew from 8 in 2016 to 14 in 2019, they still form only 0.4-0.8% of yearly trips taking place along the NSR.[91] This is most likely due to lower fuel prices, encouraging the usage of safer traditional shipping routes, as well as the imposition of U.S. sanctions against Russia, making transit along the NSR less profitable.[92] The majority of the transit voyages taking place on the NSR (47 out of 51) carry general cargo between Asian Pacific ports, (China, Japan and South-Korea), and European ports, (Nordic countries, Germany, UK, Netherlands and France). Importantly, the Bering Sea and Strait have seen an increase of transit traffic of 250% from 2008 to 2015, (from 220 to 254 transits annually), primarily thanks to the destination shipping for the Yamal LNG project.[93]

7.3 Freight flows in 2030 and 2050

By 2030 and 2050, traffic in the Arctic region is forecasted to grow. Two main factors will work as propulsors for such rise. Firstly, on the one hand, the discovery of economic resources in the area represents attractive investments and warrants an increase in commercial operations.[94] The increase in activities dedicated to the extraction and export of natural resource activities will dictate a rise in activity levels and, consequentially, in traffic. Operations that will be particularly subject to grow are LNG export from Russia and sealift to support mining activities in Canada. On the other hand, melting glaciers will open new waterways, contributing in ships being seasonally rerouted through the Arctic in place of other

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[82] https://nordregio.org/maps/sea-routes-and-ports-in-the-arctic/
[83] https://www.arctictoday.com/more-vessels-are-traveling-longer-distances-in-canadas-northwest-passage/
[84] https://www.enr.gov.nt.ca/en/state-environment/73-trends-shipping-northwest-passage-and-beaufort-sea
[85] https://www.smithschool.ox.ac.uk/publications/reports/ssee-arctic-forecasting-study-november-2011.pdf
[86] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/634437/Future_of_the_sea_-_implications_from_opening_arctic_sea_routes_final.pdf .
[87] https://www.researchgate.net/publication/348780990_Arctic_Shipping_Trends_2050#pf16
[88] https://www.researchgate.net/publication/348780990_Arctic_Shipping_Trends_2050#pf16
[89] https://www.spri.cam.ac.uk/resources/infosheets/northwestpassage.pdf
[90] https://www.oceaneconomics.org/arctic/arctic_transport/transits.aspx
[91] Gunnarsson (2021)
[92] https://www.oceaneconomics.org/arctic/arctic_transport/transits.aspx
[93] https://www.uaf.edu/caps/our-work/arctic-ocean-transit-project-files/increased-maritime-traffic-in-the-arctic-paper-final-9Dec2019.pdf
[94] https://www.thearcticinstitute.org/complexities-arctic-maritime-traffic/?cn-reloaded=1

transoceanic routes, with a rise in transit traffic.[95] Overall, projections suggest traffic increasing over baseline levels by 2030: the most likely scenario forecasts a growth in vessel traffic at an average rate of 2.58% annually, with 124 extra vessels operating by 2030.[96] Shipping along and from the Artic is expected to increase at an average 6% per year, both thanks to ice reduction and increases in industry activity.[97]

7.3.1 Destination freight flows

The Arctic oil and gas industry will continue to sustain destination shipping for approximately 20 years. Afterwards, a decline in destination shipping and a rise in domestic shipping are expected to be seen.

In the near future, destination shipping will be sustained by the continuous operation of the LNG projects carried out in the Arctic region. The Yamal and Gyda peninsula have proven fruitful for establishing plants for the production of LNG: the Yamal LNG and Obskiy LNG projects are forecasted to have a total capacity of approximately 60 MT/y of LNG by the late 2020s – early 2030s.[98] In particular, Yamal LNG should have a capacity of 17,6 mln tons LNG and a life-span of 2014 – 2040. Projections suggest that other significant Arctic projects will also survive until 2040. Novoport Oil Deposit should have a capacity of 8,5 mln tons crude oil and a lifespan of 2014 – 2035; Arctic LNG-2 should come with a capacity of 16,5 mln tons LNG and a life-span of 2022 – 2045 and, lastly, TRANSNEFT – Arctic should have a capacity of 45 mln tons crude oil and a life-span of 2020 – 2040.[99] However, while these projects widen the number of vessels operating on a commercial basis in the region, it should be noted that the rate of growth in the oil and gas sector is not expected to surpass 0.5% per year increase in production, with natural gas production following a similar trend.[100]

In the longer-run, destination shipping along the NSR will be replaced by domestic traffic. At present, destination shipping on the NSR concerns direct transport of LNG from the Yamal plant to European and North-Eastern Asian ports. Once Novatek completes its transshipment and storage facilities for LNG on the Kola and Kamchatka Peninsula, domestic voyages along the NSR will increase while destination shipping voyages will be reduced. Both terminals should start operations in 2023. Meanwhile, the temporary ship-to-ship LNG transshipments currently taking place in Honningsvag will be replaced by the same services offered in closer sites, (such as on the Kildin Island close to Murmansk),[101] increasing domestic voyages at the detriment of international travels. Furthermore, so far destination shipping along the NSR has greatly profited from shipments with project cargos for large-scale Russian Arctic energy and mining projects on heavy lift carriers. However, Russia is increasingly accelerating its own LNG project development, which might render the expertise of foreign companies for construction and shipment of prefabricated modules redundant. In this scenario, destination shipping will become less important, replaced by Russia's domestic shipping across its own manufacturing facilities.[102]

Aside from the oil and gas industry, other activities might also impact destination shipping. The rise in the amount of large coastal mineral mines, discovered as a result of the increase in demand for mineral resources, will bring a growth in the volume of extraction and mining activities.[103] Furthermore, the warming of the oceans will have a weight on fishing activities, even though its consequences are yet to be seen. The rise of temperatures will certainly change marine ecosystems, which might result in a

95 https://www.cmts.gov/downloads/Arctic_FAQs_for_External_Partners_2019.09.25.pdf
96 https://www.cmts.gov/downloads/Arctic_FAQs_for_External_Partners_2019.09.25.pdf
97 https://www.smithschool.ox.ac.uk/publications/reports/ssee-arctic-forecasting-study-november-2011.pdf
98 https://www.ispionline.it/en/pubblicazione/oil-and-natural-gas-exploitation-russian-arctic-29947
99 https://www.spf.org/_opri_media/news/2.Mr.MikhailBelkin_Rosatomflot.pdf
100 https://www.smithschool.ox.ac.uk/publications/reports/ssee-arctic-forecasting-study-november-2011.pdf
101 Gunnarsson (2021)
102 Gunnarsson (2021)
103 https://www.smithschool.ox.ac.uk/publications/reports/ssee-arctic-forecasting-study-november-2011.pdf

reduction of fish population sizes and their increased vulnerability to other factors, (such as invasive species). In addition, intensive commercial activities in depleted fishing areas might destroy habitats and bring about the loss of habitat-forming activities, (such as corals and seaweed).[104] On the other hand, estimates suggest than an increase in temperatures in a specific area would result in a consequential increase in phytoplankton, allowing the bottom of the food chain to flourish and attracting fish species to certain regions areas where there is more food.[105] Certain kinds of fish might be migrating towards the North, moving fish stocks and catch potential and, consequentially, more fishing activities to the Arctic.[106]

7.3.2 Transit freight flows

For what concerns transit traffic, the increase in temperatures and melting glaciers will keep opening new Arctic routes and lengthen the shipping season in the Arctic reason. Ice conditions along the NSR and NWP, which sometimes impede traffic to vessels with moderate ice strengthening, will increasingly ameliorate, easing traffic and congestion on both routes.[107] It is estimated that, by 2030, the temperature rise will result in the open-water period increasing of 6 weeks by 2025, reaching 9, 5 and 6 weeks for the NSR, the NWP and the Transpolar Route. As a consequence, costs to transit in the Arctic will decrease with the reduced need for the usage of icebreaker escorts, resulting in more traffic in the area. In addition, by 2050 the Transpolar Route should become available as a way to cross directly the Arctic without the need to circumnavigate any land.[108]

7.4 Conclusion

The greatest potential for the Arctic lies in the raw materials that come from this region, especially energy-related raw materials. In 2019, approximately 6 ships per week arrived in Europe from this region.

Russia has plans to more than triple the amount of raw materials extracted by 2030. However, Russia at the same time plans facilities to be able to process the raw materials on its own soil, so that transport to Europe will no longer be necessary. It is therefore not expected these commodity flows will increase exponentially, thus keeping the impact on the European TEN-T network negligible.

[104] https://business.esa.int/sites/default/files/Arctic_fishing_MacKenzie_110312.pdf
[105] http://library.arcticportal.org/1671/1/Arctic_Opening%2C_opportunity_and_risks_in_the_High_North.pdf
[106] https://www.thearcticinstitute.org/complexities-arctic-maritime-traffic/?cn-reloaded=1
[107] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/634437/Future_of_the_sea_-_implications_from_opening_arctic_sea_routes_final.pdf
[108] https://www.researchgate.net/publication/348780990_Arctic_Shipping_Trends_2050#pf16

8 Conclusions

For Eurasian rail freight transport, rail services coming from China and arriving at the European border in 2019 overwhelmingly used Malaszewicze as principle entry point (PEP). The 200.000 TEU per year coming from China translated into some 55 trains per week. About 12% of this flow branched off towards Lodz. Some 23% went to Hamburg and some 44% went on to Duisburg. Smaller flows went to Liege, Ghent, Tilburg and Madrid. The export flows travel in the opposite direction, but to a lesser extent.

The model shows that Eurasian rail transport for the base year 2019 is only suitable for higher-value goods with a value of more than 10 euro per kilo. Reduced rail freight rates, quicker rail transport and a decrease in the trade imbalance of higher-value goods may make Eurasian rail transport more attractive in the future. The model also shows that Eurasian rail transport is most suitable for (i) regions with a high production of higher-value goods, or (ii) regions that are far away from a seaport, or (iii) regions that are near seaports with a long transport time to the destination, for example because many port calls are made in between. Based on this model, the future transport flows in 2030 and 2050 and their impact on the TEN-T network will be analysed using different scenarios.

For the International North-South Corridor, we see a current potential of over 86.000 TEU, which could increase to 125.000 TEU in 2030 and 206.000 TEU in 2050. It remains to be seen how long it will take for these volumes to be realised if the route is completed. Only a fraction of the cargo is related to Europe. This concerns 8.500 TEU if the route would be opened right now, which could increase to 13.500 TEU in 2030 and 24.000 TEU in 2050. The corridor is therefore most interesting as a European trade route if European trade can be combined on INSTC trains with Russian cargo.

By 2050, the potential could be over 206.000 TEU per year, which is equal 2.500 trains per year or 50 trains per week. One eighth of this, or 24.000 TEU, has a European origin or destination. This concerns 6 trains per week running over the INSTC. With these volumes, it becomes more interesting to set up a dedicated regular block train from Helsinki or Klaipeda to Bandas Abbar. But at the same time, the predicted volumes in 2050 do not come close to the volumes running on the New Silk Road. With a total volume in 2019 of 300.000 TEU, or 72 trains per week, this route is currently much more heavily used.

Regarding the Arctic Route, we have found that its greatest potential lies in the transport of raw materials that come from this region, especially energy-related raw materials. In 2019, approximately 6 ships per week arrived in Europe from this region. Russia has plans to more than triple the amount of raw materials extracted by 2030. However, Russia at the same time plans facilities to be able to process the raw materials on its own soil, so that transport to Europe will no longer be necessary. It is therefore not expected these commodity flows will increase, thus keeping the impact on the European TEN-T network negligible.

For what concerns transit traffic, the increase in temperatures and melting glaciers will keep opening new Arctic routes and lengthen the shipping season in the Arctic region. As a consequence, costs to transit in the Arctic will decrease with the reduced need for the usage of icebreaker escorts, resulting in more traffic in the area. In addition, by 2050 the Transpolar Route could become available as a way to cross directly the Arctic without the need to circumnavigate any land.

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Annex 1 – Preliminary Analysis of Disadvantaged Regions

Synergies TENT and intercontinental freight flows

Document Summary Information

Grant Agreement No	860274	**Acronym**	PLANET
Full Title	Disadvantaged Regions Synergies TENT and intercontinental freight flows (Contribution to WP.1.2 and WP.3.2 for the parts of NEWO competence)		
Project URL	www.planetproject.eu		
Work Package	ST1.2 and ST3.2		
Responsible Author	Franco Castagnetti, Silvio Beccia (NEWO)		

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1 Glossary of abbreviations used

Abbreviation / Term	Description
BRI	Belt and Road Initiative
B2B	Business To Business
B2C	Business To Consumer
CTR	Container
EGNT	European Green Network
ERDF	European Regional Development Fund
ESF	European Social Fund
ERMTS	European Rail Traffic Management System
ICT	Information & Communication Technology
NSR	Northern Sea Route
SSR	Southern Sea Route
TEN-T	Trans-European Transport Network
TEU	Twenty feet Equivalent Unit
TSI	Technical Standard for Interoperability

2 Summary

This document looks into two major topics:

- **<u>Disadvantaged Regions</u>** in the perspective of EGNT evolution especially taking into account the impact of “new routes” mainly the West-East route, the Artic route and the North-South route. The Disadvantaged Regions are identified on the basis of GDP per capita gap versus European average.
- **<u>Synergies TENT and intercontinental freight flows</u>** contributing to EGNT evolution.

Although, as per PLANET’s project segmentation those two topics belong in different WPs (WP1 and WP3), there is significant overlapping:

- **The relevance of new routes on disadvantaged regions** is relevant in providing the frame and contents to EU Network simulation.
  In the picture below – representing the largest definition of “disadvantaged countries” (Structural Funds 2014-2020 - ERDF and ESF eligibility – updated regulation to be applied in 2022-2028 will show reassessed detailed maps by beginning 2022) the new routes are represented in schematic way.
  Potential impacts of “Recovery Fund” has not been addressed so far.

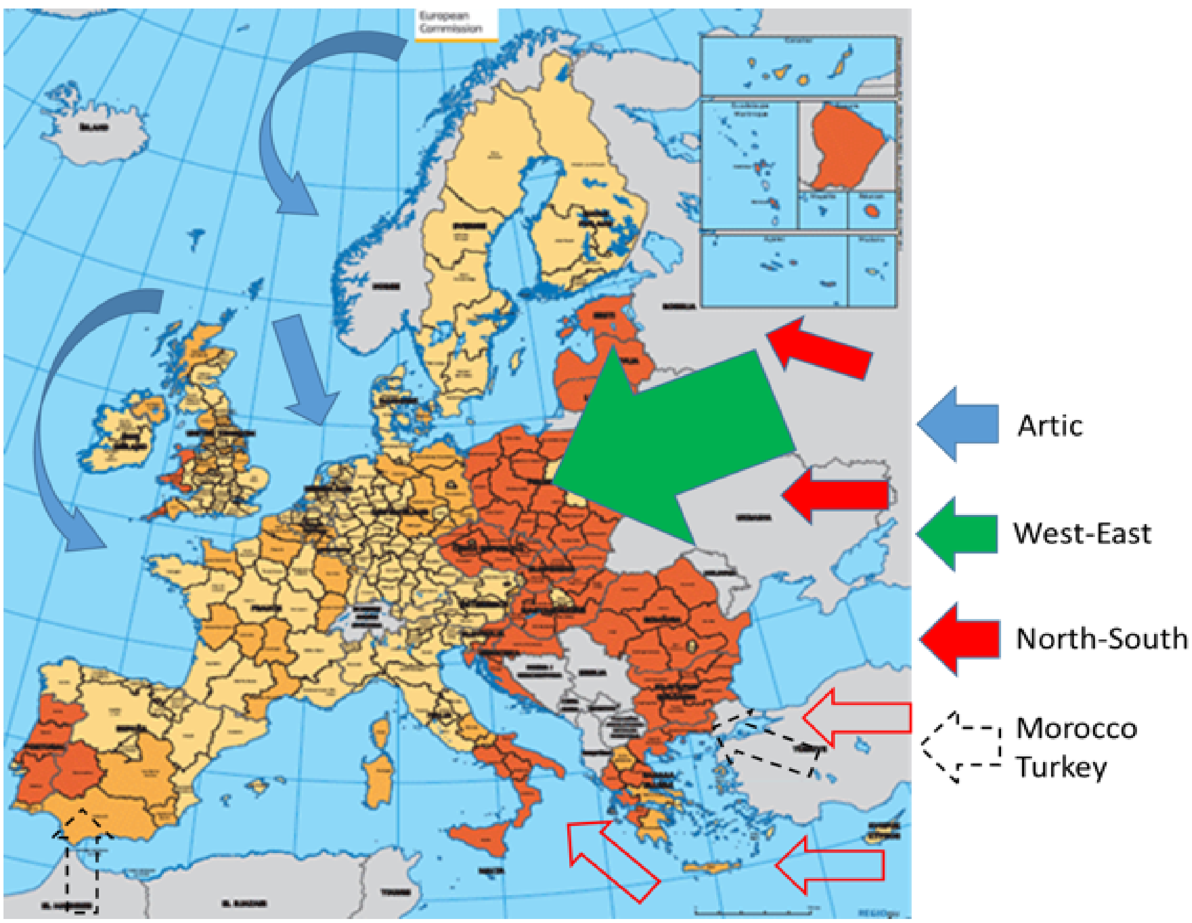

Fig - “New routes” and EU Disadvantaged regions - source Structural Funds 2014-2020 - ERDF and ESF eligibility and NEWO elaboration about new routes

The most relevant is the West-East route supporting the booming traffic with China.
The Artic route may have future development as well as the North-South route.
The North-South route can be expected to have different sub-routing options. They may be partially overlapping with the West-East routes, with the Turkey route and with the Mediterranean existing route.
Additional routes are: the Turkey route whose development is at present limited by Marmaray Tunnel underneath the Bosporus and the Morocco route which is depending on a future Gibraltar tunnel.

- **The progressive growth of freight rail transportation is fundamental in the EGNT perspective.** Rail is relevant in its role in a co-modal transport system for providing sustainable transport overland before/after the sea transport segment.
  A number of Priority TEN-T projects are already addressing the issue of increasing the role of rail. Nevertheless, the targets' review may be required considering the traffic shifts related to the new routes. It is even more relevant for addressing the rail adequacy to new challenges when important intercontinental exchanges, as in the West-East route, are already taking place by rail.
  In particular it is paramount to speed up completion of actions targeting 2030, recovering apparent delays, in order to reach the desired targets. A point of future attention is to move the overall design from a network built as a sum of corridors supporting the modal shift, to the EGNT integrated network approach supporting co-modality,
  In targeting developments, the systemic approach is key and the SWOT, or other similar planning methodologies, can support such coordination.
- The document provides some evaluations about how the increasing trade volumes reveal **the needs of reinforcing infrastructural actions for capacity expansion both of track lines and of inland terminals**.
  About the lines tracks, some considerations tackle the general point of bringing to conclusion the modernization projects already ongoing. Special focus is to be attributed to the most congested lines while other considerations tackle exemplary situations such as, for instance, bottlenecks and potential new lines.
  Inland terminals are a major point of attention. Considerations tackle both their density and their role together with the expansion of their functions to more valuable logistics operations. Gateway solutions can contribute to streamline traffic while freight village solutions can address a combination of operations spanning from industrial park, free zone, multichannel distribution hub up to city logistic centre. A specific support to the seaports in the development of rail traffic, can be the establishment of dry port solutions capable of enabling collaboration between seaports and inland terminals.
- **The Eastern EU entry points in the West- East route are a specific challenge.** They are facing a vertical growth of new transit traffic with the opportunity to capturing additional value leveraging synergies.
  In fact, in the West-East entry regions all the items summarized in the above bullets have a special relevance.
  In particular, the need of infrastructural investments supporting transhipment and removing bottlenecks can be combined with smart logistics solutions with significant benefits for the local economies.

The contents of this document is structured in modules in order to allow the possibility of moving individual elements into other project's documents consistently with the official deliveries commitments.

This document does not tackle other key topics constituting key objectives of the PLANET project.

Of course, the ICT applications in their numerous evolving facets are fundamental for EGNT targets and for increasing the rail relevance, but other documents relating to specific Project's WPs will address these topics much better than any effort in trying to contribute here.

It is worthwhile to mention that, if ICT is relevant for the freight transport evolution, it is even more so when dealing with logistics. Therefore, the ambitions to expand the inland terminals' role from transport to logistics, rely strongly on the capability of upgrading ICT evolutions and applications.

In the reference section is reported a list of documents, partially coming from previous researches operated by NewOPERA and directly or indirectly influencing the evaluations elaborated in this document. Other reported documents are the result of the research carried out for completing this contribution. Web sites are not reported in the reference chapter but only in specific notes inside the text description of this document.

1. Definition and identification of EU Disadvantaged Regions

a. Regulation - period 2014–2020

The regional policy of the European Union, called Cohesion Policy, aims at improving the economic well-being in the European Union and also to avoiding regional differences removing economic, social and territorial disparities. Significant part of EU's budget is allocated to this policy. More than 32% of the EU budget 2014-2020 has been allocated to financial instruments supporting Cohesion Policy. These funds are managed between the European Commission, the Member States together with local and regional institutions.

In the 2014–2020 funding period, money has been allocated between regions depending on the classification:

- “more developed" - with GDP per capita over 90% of the EU average
- “transition" - between 75% and 90%
- "less developed" - less than 75%

By far the largest amount of funding has been dedicated to the regions designated as “less developed”. This includes about all the regions of the new member states in Eastern territories, Southern Italy, Greece and Portugal, and some areas in Spain).

The Cohesion Policy, as shown in the below picture, has set 11 thematic objectives supporting growth for the period 2014-2020.

The following periods continue according to the same principles with the appropriate updates.

Fig x: Regional policy priorities (https://ec.europa.eu/regional_policy/en/policy/how/priorities/)

Regional policy projects in less developed regions are supported by three European funds:

- European Regional Development Fund (ERDF); investment from the ERDF will support all 11 objectives, but 1-4 are the main priorities for investment.
- European Social Fund (ESF); main priorities for the ESF are 8-11, though the Fund also supports 1-4.
- Cohesion Fund; the Cohesion Fund supports objectives 4-7 (evidence of priority 7 = Promoting sustainable transport and improving network infrastructures) and 11.

The target territories of individual funds, as can be seen in following maps, are slightly different.

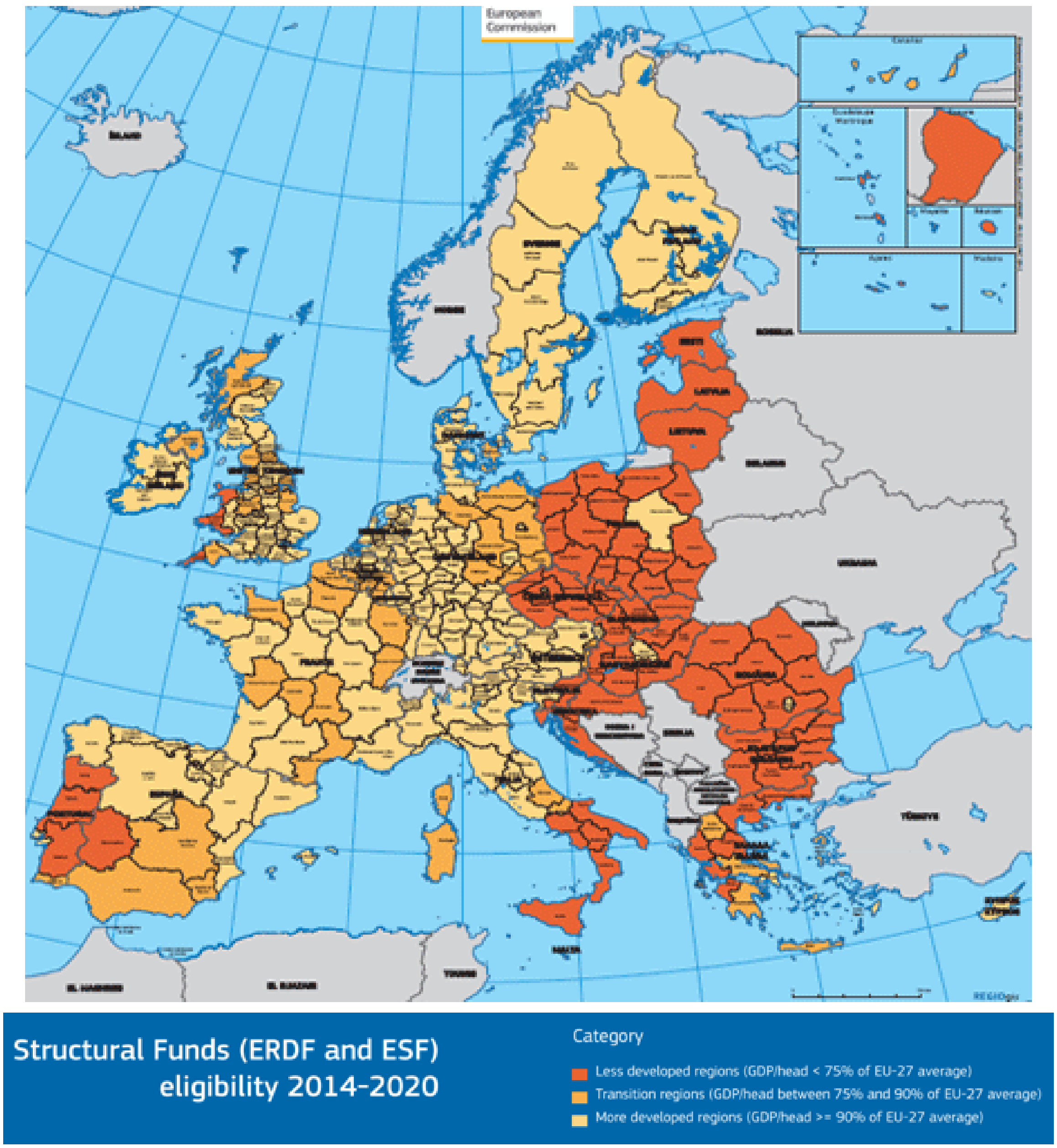

Fig: Structural Funds 2014-2020 (ERDF and ESF) eligibility
(https://ec.europa.eu/regional_policy/en/policy/how/is-my-region-covered/)

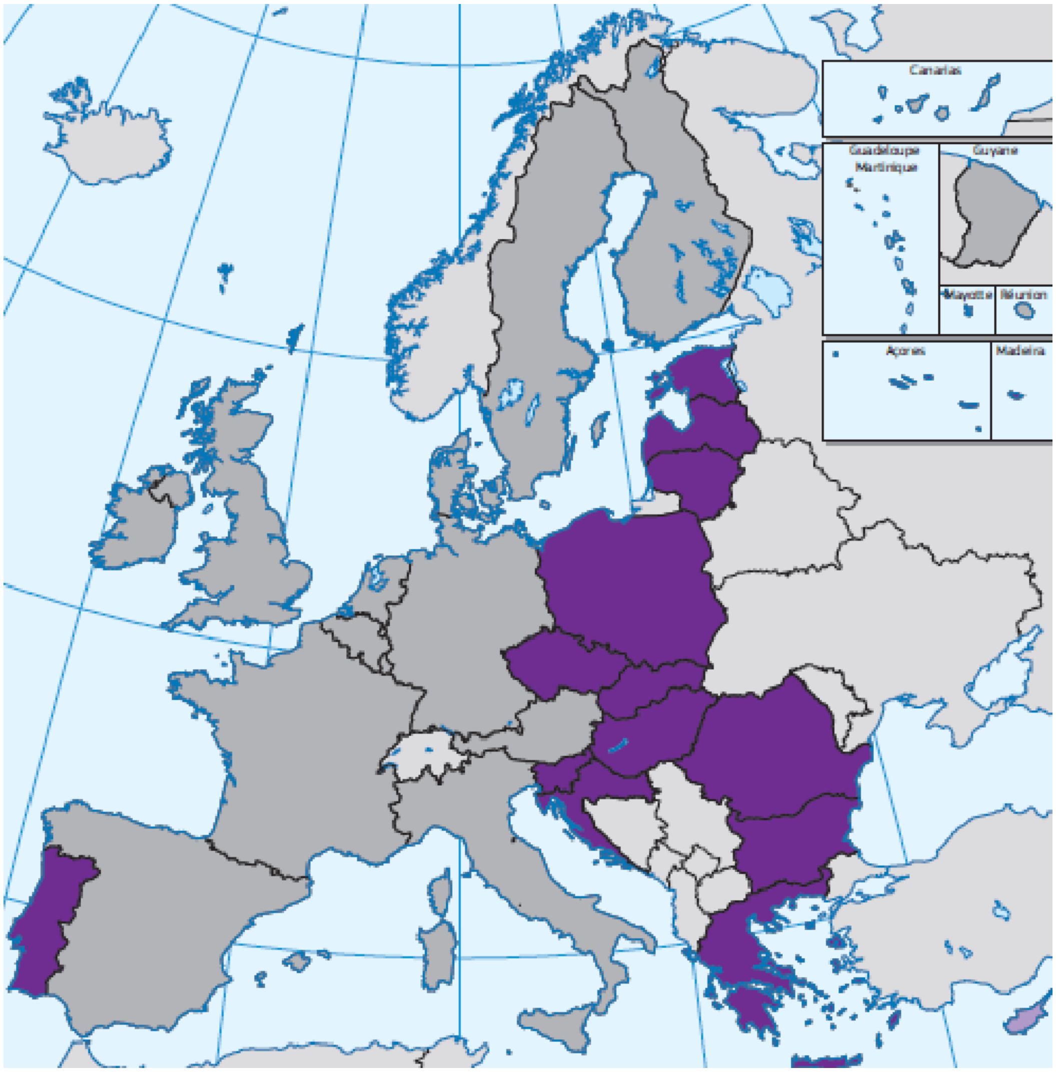

Fig: Cohesion Fund eligibility 2014-2020
https://ec.europa.eu/regional_policy/sources/what/future/img/elig_1420_Mar12_CF_0810_A4P20_M.pdf

Significant amount of fund has been allocated to infrastructures and transport in the period 2014-20 and policy continuity is expected in the following years. Climate actions and sustainable growth are the key policy words. In particular the funding includes over 3.900 km of new or reconstructed railway lines (https://ec.europa.eu/regional_policy/en/policy/how/stages-step-by-step/strategic-report/).

"For the 2014-2020 period, the Cohesion Fund concerns Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia and Slovenia.

The Cohesion Fund allocates a total of € 63.4 billion to activities under the following categories:

- Trans-European Transport Networks, notably priority projects of European interest as identified by the EU. The Cohesion Fund will support infrastructure projects under the Connecting Europe Facility;
- Environment: here, the Cohesion Fund can also support projects related to energy or transport, as long as they clearly benefit the environment in terms of energy efficiency, use of renewable energy, developing rail transport, supporting intermodality, strengthening public transport, etc. (https://ec.europa.eu/regional_policy/en/funding/cohesion-fund/)".

In addition to EU programs, national development programs may exist, partially targeting the same objectives and with specific local focus.

b. Regulation - year 2021

In the final steps of period 2014-2020 a revision process has been undertaken in order to incorporate possible improvements in the following period. In particular the evaluation of the existing rules was conducted in 2019. In second half of 2020 an extensive consultation – a "fitness check" - was conducted of all stakeholders on the draft text, including Member States, regional and local authorities, business associations, interest groups, individual companies, and citizens contributing to the updating of Regional Aid Guidelines.

The "fitness check" showed that the environmental and energy rules have to improve environmental protection and achieve the objectives of the Energy Union. However, they needed to be further adjusted in light of new technologies and novel support types, as well as recent environmental and energy legislation.

The rules also needed to be aligned to future challenges, in line with the Commission's priorities. In particular, State aid can contribute to the European Green Deal, as well as to the EU's Digital and Industrial Strategies.

While completing the updating process of the rules to the next 2022-2027 period, published in April 2021, to provide predictability and legal certainty, the Commission has prolonged in a Regulation and in a Communication the validity of these aid rules until the end of 2021.

A bridging period is in particular necessary to the individual Countries for the identification of territories matching the revised criteria as in the revised Regional Aid Guidelines to be implemented starting year 2022. The revised maps needs to be formalized within 2021.

c. Regulation - period 2022–2027

The European Commission, as published on April 29, 2021, has officially adopted revised EU "Regional Aid Guidelines", adjusting the rules under which Member States can grant State aid to companies in order to support the economic development of disadvantaged areas in the EU.

It can be important to underline that the Regional Aid Guidelines are the first set of State aid rules that are revised following the announcement of the "European Green Deal" and the "European Industrial and Digital Strategies". The Commission included in these guidelines specific provisions to facilitate support in the context of the Just Transition Fund (JTF) in line with cohesion principles. The JTF is one of the pillars of the Just Transition Mechanism to be implemented under the cohesion policy to contribute addressing the social, economic and environmental consequences that may accompany the ambitious objective of the transition towards a climate neutral Union by 2050.

The revised Guidelines include adjustments to reflect experience from the application of the previous rules, as well as to reflect the updated focus of EU policy priorities.

In general and in particular in the perspective of Planet project, the key elements to of the revised Guidelines can be the following:

- Increased overall regional aid coverage to 48% of the EU population (previously 47%) and updated list of assisted areas based on the latest available Eurostat statistics on GDP (2016-2018) and unemployment (2017-2019).
- Unchanged criteria of the assignment criteria for assisted areas, which have proven to work well in the previous period. At the same time, Member States have increased flexibility to assign additional areas as for instance ones which are facing particular transition challenges.
- Increased maximum aid intensities to support the European Green Deal and Industrial /Digital Strategy objectives by enabling additional incentives for investments in the disadvantaged areas of the EU. Paying attention to the scope of each of the thematic guidelines there are possibilities to combine different kinds of aid for same investments.
- Additional aid intensity bonuses: for outermost regions, for border areas, for Just Transition Areas in the most disadvantaged areas and for those experiencing a population loss.
- Small and medium-sized enterprises (SMEs) maintain higher maximum aid intensities than large enterprises.
- Validity of regional aid maps for the period 2022-2027, to be defined by individual countries within 2021, will have a mid-term review in 2023 based on updated statistics.
- Clarification of some terminology and targeted changes in light of the European Green Deal and the EU's Industrial and Digital Strategies. For example, the sectorial scope of the Guidelines was updated also taking into account better potential contribution to the green and digital transition.

The potential impact of “Recovery Fund” has not been addressed so far.

2. TEN-T Network and Disadvantaged Regions

d. The TEN-T Network

The Trans-European Transport Network (TEN-T) policy addresses the development of a Europe-wide network of railway lines, roads, inland waterways, maritime shipping routes, ports, airports and railroad terminals.

The infrastructure network consists of two layers:

- **The core network** prioritizes the most important links and nodes of the TEN-T to be fully operational in 2030. The core network links main nodes and routes, taking into account major traffic flows. The objective of the core network is to cover the EU territory so that each member state could be integrated in it. There are more links and nodes in the densely populated parts of Europe and where most freight traffic is concentrated.
- **The comprehensive network**, to be completed by 2050, will develop accessibility to all EU regions by feeding into the core network. The great majority of European citizens and businesses will be within 30 minutes in travel time from the feeder network. Once the core network is implemented at horizon 2030, with the focus shift to the implementation of the comprehensive network, the regional and local territorial integration becomes the prevalent objective. The regional and local networks, which are functional to the territorial distribution of activities must then be connected to the core network through major nodes of the core network. For this reason the definition of the comprehensive network will be largely depending upon regional or local actors together with EU authorities.

Fig: TEN-T freight network
https://ec.europa.eu/transport/infrastructure/TEN-Tec/TEN-Tec-portal/site/maps_upload/TEN-T_modes/EU_A0Landscape2019_freight.png

As said above, both layers include all transport modes: road, rail, air, inland waterways and maritime transport, as well as intermodal platforms.

The Transport Corridors are the main axes of the infrastructure network. The corridors approach manages the coordinated development of the infrastructure and the traffic within the core network. Covering at least 3 Modes, 3 Member States and 2 Cross border sections, the corridors are major players for guaranteeing co-ordination and transparency. The co-ordination implies several actions in terms of financial, technical and organizational efforts to overcome barriers due to the multinational ownership of the corridor.

Within the Core Network, Freight corridors according to the principle of The Regulation (EU) No. 913/2010 have been defined by linking the main industrial and port regions in Europe.

The pictures below highlights:

- the rail freight network and the individual corridors
- the internal waterways network

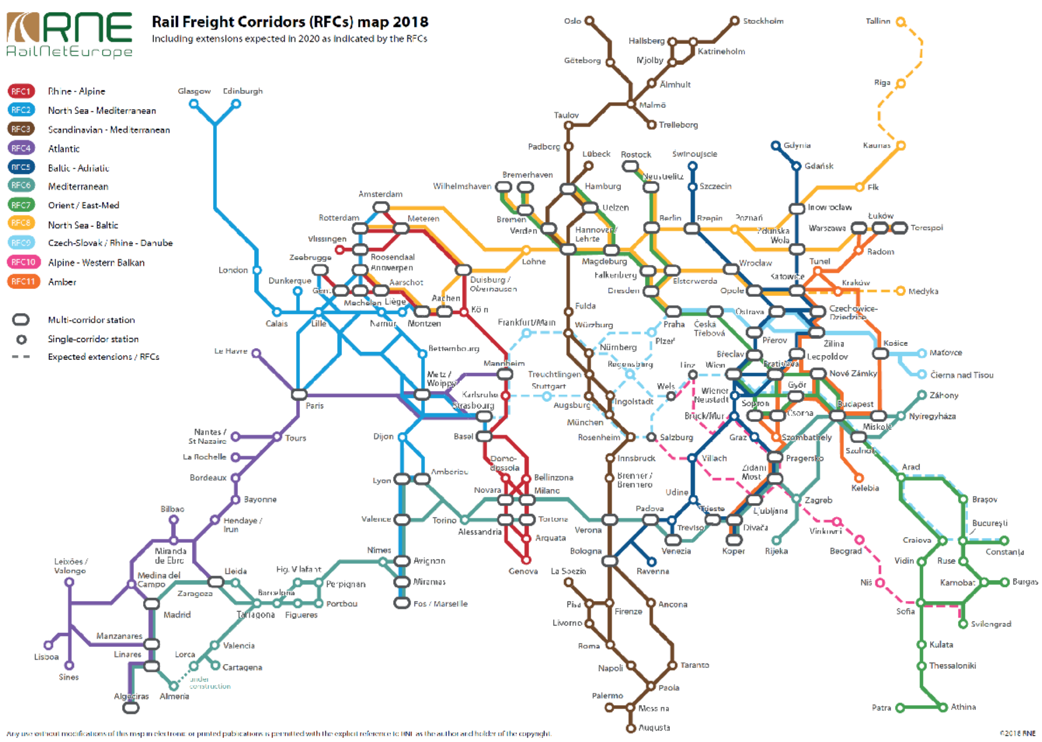

Fig x: TEN-T Corridors and Rail Freight Corridors
http://ec.europa.eu/transport/infrastructure/TEN-Tec/TEN-Tec-portal/map/maps.html
file:///C:/Users/Silvio/Downloads/RFC-MAP-2017.pdf

Fig: EU internal waterways network – source https://ec.europa.eu/transport/infrastructure/TEN-Tec/TEN-Tec-portal/site/maps_upload/TEN-T_modes/EU_A0Landscape2019_freight.png

e. Relevance of the transport terminals as nodes in the transport network

As anticipated a relevant aspect of the freight network together with the connecting lines dimension and the intersection points, is the deployment of nodes where handling activities both for transportation means and for loads (unit load and less then unit load) are performed.

Accessibility of nodes is different in different territories.

The nodes' network is covering the EU territory according to where freight traffic is concentrated.

This is also true when looking at nodes in a time perspective towards 2050.

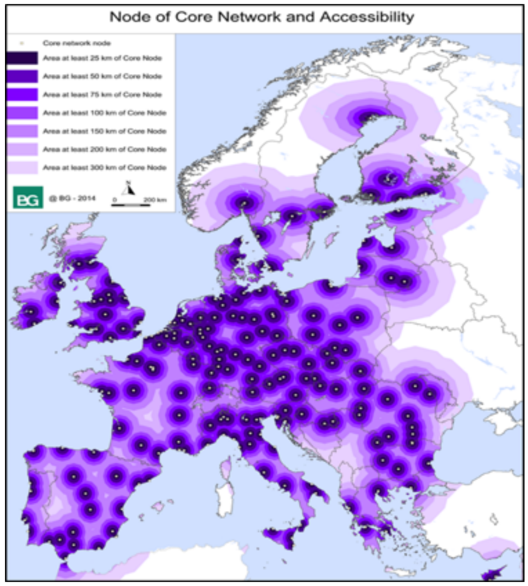

Fig: Accessibility of Core Nodes – Source; BG Group for NewOPERA 2014 - Road Map 2030/2050 - Towards the implementation of the comprehensive network: derived infrastructure development

In the following table the traffic in tons going through nodes at 2050 is projected based on the existing network planning.

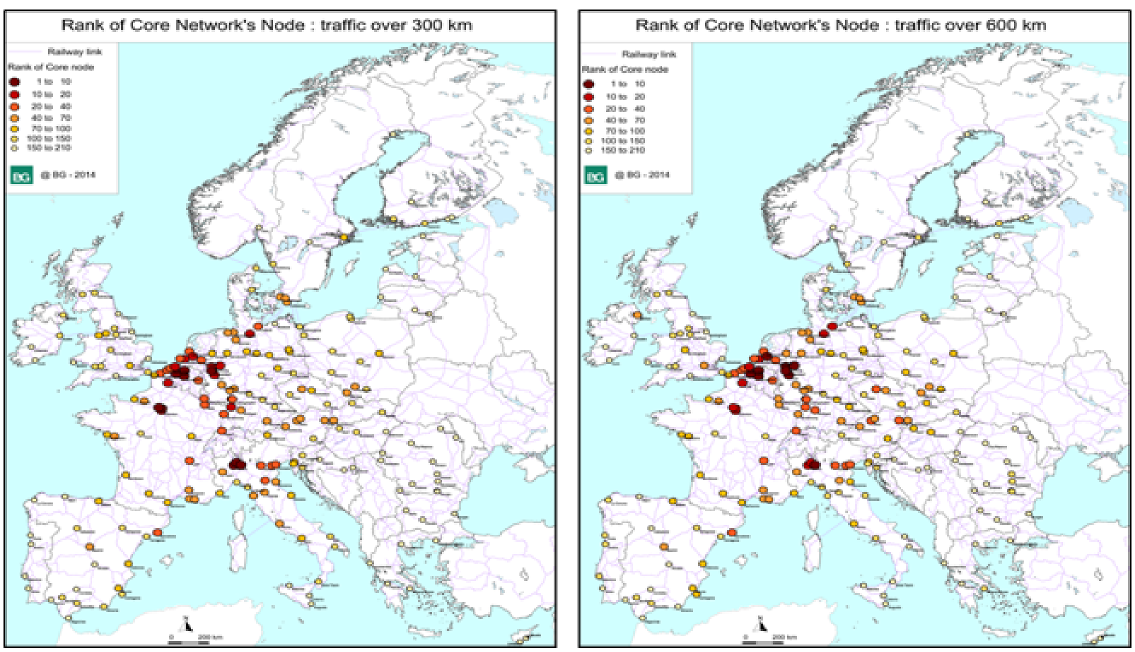

Fig: Network of Core Network Nodes, Continental traffic - Source; BG Group for NewOPERA 2014 - Road Map 2030/2050 - Towards the implementation of the comprehensive network: derived infrastructure development

f. Exemplary TEN-T projects in Disadvantaged Regions

The TEN-T planning has been segmented in the period 2014-20 in 30 Priority Projects (or axes), most of which are still in progress. This planning has strong EGNT imprinting. "Of these 30 key projects, 18 are railway projects, 3 are mixed rail-road projects, 2 are inland waterway transport projects and one refers to Motorways of the Sea. This choice reflects a high priority to more environmentally friendly transport modes, contributing to the fight against climate change (https://ec.europa.eu/inea/ten-t/ten-t-projects/projects-by-priority-project)". The priority projects so appear highly consistent with the EGNT principles of co-modality. Also High Speed Rail project are included as the may be beneficial for freight as well.

In the following there are short descriptions of rail and sea projects involving Disadvantaged Regions, selected with focus on

- West-East route
  - 6 - Railway axis Lyon-Trieste-Divača/Koper-Divača-Ljubljana-Budapest-Ukrainian border
  - 17 - Railway axis Paris-Strasbourg-Stuttgart-Wien-Bratislava
  - 22 - Railway axis Athina–Sofia–Budapest–Wien–Praha–Nürnberg/Dresden
  - 23- Railway axis Gdańsk–Warszawa–Brno/Bratislava-Wien
  - 27 - Rail Baltica - axis: Warsaw-Kaunas-Riga-Tallinn-Helsinki

- Portugal and Greece.
  - 3 - High-speed railway axis of southwest Europe
  - 8 - Multimodal axis Portugal/Spain-rest of Europe
  - 16 - Freight railway axis Sines/Algeciras-Madrid-Paris
  - 19 - High-speed rail interoperability in the Iberian Peninsula
  - 21 - Motorways of the Sea

I. Projects involving the West-East route and Eastern countries

The West-East route is coincident with Belt and Road Initiative (BRI) or Silk Route. In following paragraphs, there are pictures and information regarding this route as well as the other "new" route.

Priority Project 6 - Railway axis Lyon-Trieste-Divača/Koper-Divača-Ljubljana-Budapest-Ukrainian border

"The railway axis from Lyon to the Ukrainian border is the main east-west passage south of the Alps, connecting the Iberian peninsula with the eastern part of Europe and beyond. The 1,638 km long railway axis is an important high capacity east-west rail axis crossing the Alps between Lyon and Turin. It touches upon four Member States (France, Italy, Slovenia and Hungary), linking important urban areas. It will also deliver an important increase in transport capacity, thus allowing a modal shift from road to rail to be realized in the sensitive mountainous regions it crosses" (https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-6).

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Fig x Priority Project 6 - Railway axis Lyon-Trieste-Divača/Koper-Divača-Ljubljana-Budapest-Ukrainian border
(https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-6).

Priority Project 17 - Railway axis Paris-Strasbourg-Stuttgart-Wien-Bratislava

"The railway axis Paris-Strasbourg-Stuttgart-Wien-Bratislava is an east-west oriented axis crossing very densely populated areas in the centre of Europe. It touches upon four Member States: France, Germany, Austria and Slovakia" (https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-17).


Amsterdam
Den Haag
Rotterdam
Arnhem
Enschede
Osnabrück
Hannover
Münster
Magdeburg
Eindhoven
Duisburg
Antwerpen
Kassel
Halle
Leipzig
Wroclaw
Düsseldorf
Köln
Bruxelles/Brussel
Dresden
Erfurt
Jena
Lille
Liège
Aachen
Charleroi
Koblenz
Frankfurt am Main
Praha
Luxembourg
Mannheim
Nürnberg
Reims
Saarbrücken
Brno
Paris
Metz
Baudrecourt
Karlsruhe
Regensburg
Nancy
Stuttgart
Strasbourg
Augsburg
Linz
Wien
Bratislava
München
Freiburg
Salzburg
Basel
Dijon
Innsbruck
Graz
Bern
Maribor
Bolzano
Ljubljana
Zagreb
Clermont-Ferrand
Lyon
Trieste
Bergamo
Brescia
Novara
Verona
Venezia
Milano
Padova
Torino
Priority Axis n° 17
TEN-T Railways
0 75 150 300
km
Cartography: TEN-T EA, May 20
© EuroGeographics 2001 for the administrative bounda

Fig x: Priority Project 17 Railway axis Paris-Strasbourg-Stuttgart-Wien-Bratislava – (https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-17)

Priority Project 22 - Railway axis Athina–Sofia–Budapest–Wien–Praha–Nürnberg/Dresden

"The project links eastern Member States through a major railway axis. Completing the axis will improve connectivity between all the networks on the basis of common standards.

This axis is the only connection from southeastern Europe (and Greece) to the heart of the EU.

Some sections have been already completed - in Germany, Czech Republic, Hungary and Greece - and works on the remaining ones will start only after 2013" (https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-22).

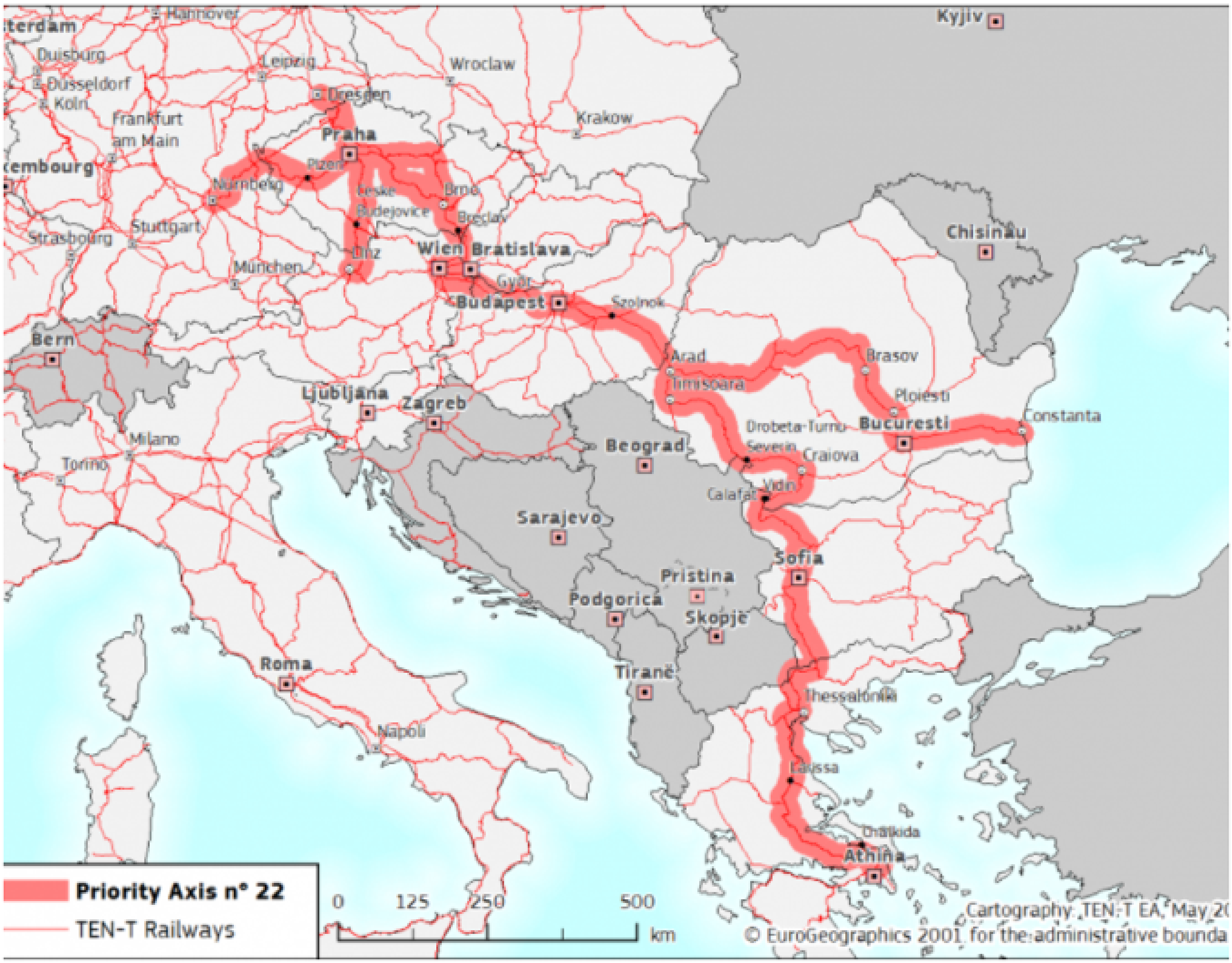


Fig x: Priority Project 22 - Railway axis Athina–Sofia–Budapest–Wien–Praha–Nürnberg/Dresden (https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-22)

Priority Project 23- Railway axis Gdańsk–Warszawa–Brno/Bratislava-Wien

"This axis mainly involves modernization and upgrading of the rail route - part of the former pan-European transport corridor VI identified at the Crete (1994) and Helsinki (1997) conferences - which connects Gdańsk via Katowice and Žilina to Bratislava and through a western branch via Brno to Vienna. The corridor was identified as a multimodal north-south axis to create a complex multimodal transport system for goods and passengers with the port of Gdańsk, rail and roads. The axis touches upon four Member States: Poland, the Czech Republic, Austria and Slovakia. Its western branch passes through Brno, the second largest city of the Czech Republic, while its eastern branch passes through Žilina, a city of growing importance with regard to automotive production in Slovakia, to the country's capital Bratislava. The modernization of the rail lines and the construction of container terminals for example at Gdańsk and Sławków/Katowice should generate better conditions for the development of effective intermodal transport. The works will allow increased speeds on the rail network: 160 km/h for passenger trains, up to 250 km/h for some sections in Poland and 120 km/h for freight trains in general. They will also reinforce the attractiveness of rail, enabling a modal shift from road to rail" (https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-23.

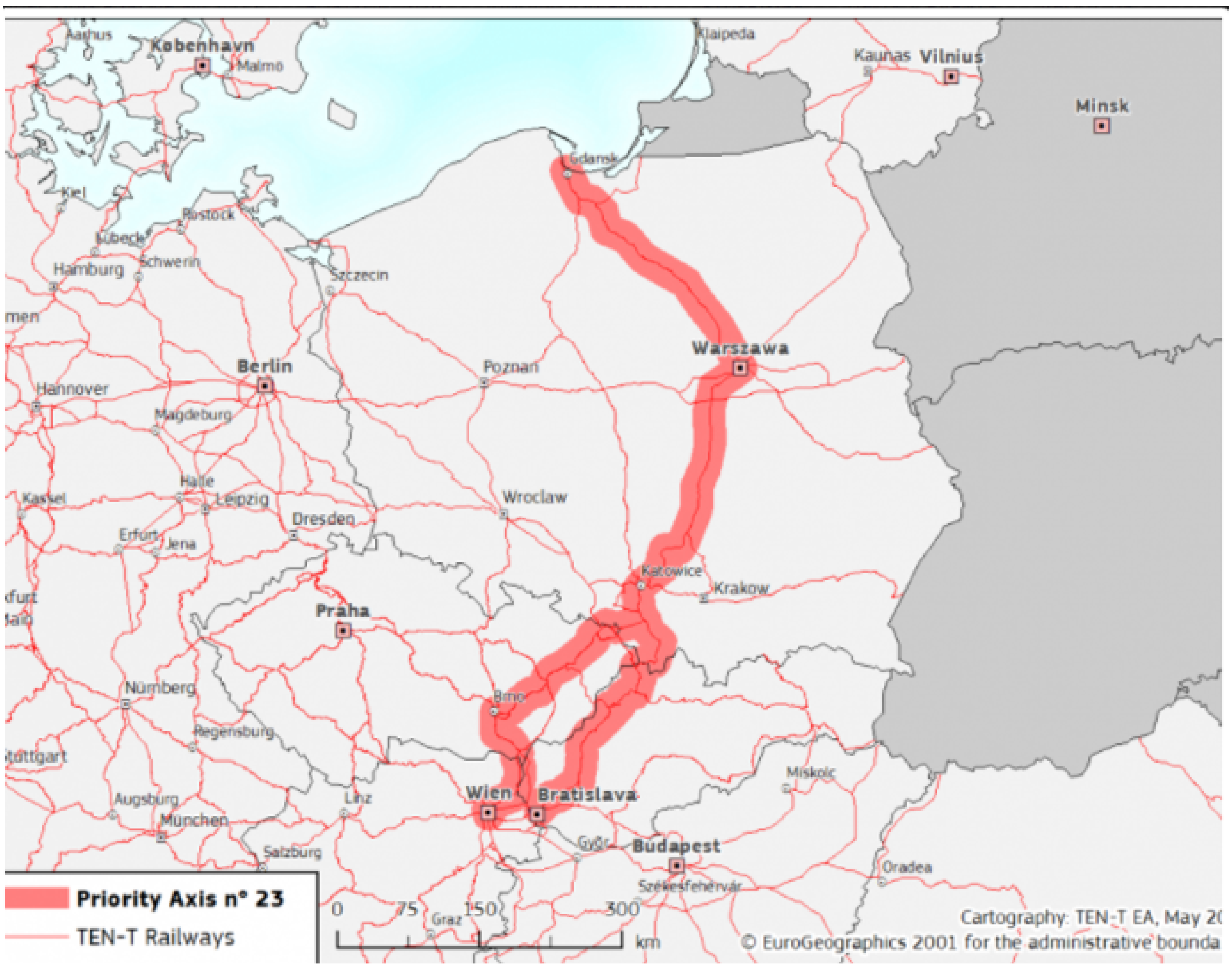


Fig x: Priority Project 23- Railway axis Gdańsk–Warszawa–Brno/Bratislava-Wien https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-23

Priority Project 27 - Rail Baltica axis: Warsaw-Kaunas-Riga-Tallinn-Helsinki

"Rail Baltica is a strategic and sustainable rail project linking four new EU Member States of the EU - Poland, Lithuania, Latvia and Estonia - as well as Finland. In addition, it is the only rail connection between the three Baltic States themselves to Poland and the rest of the EU. To the north, Helsinki is connected by rail ferry services across the Gulf of Finland which can form a "bridge" to the countries of the Nordic Triangle (PP12). The length of the current track is approximately 1,200 km by the most direct existing route from Tallinn to Warsaw. A variety of track and operating systems are currently in use: single and double track, electrified and non-electrified (of which single track non-electrified is the most common system). The line passes through a variety of different terrain - urban areas such as the cities of Białystok, Kaunas and Riga, and rural areas such as in the Podlaskie region of northeast Poland and southern Lithuania, as well as northern Latvia and the south of Estonia. "Rail Baltica" also connects three major Baltic seaports: Helsinki, Tallinn and Riga and has a short rail connection to a fourth – Klaipeda" (https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-27).

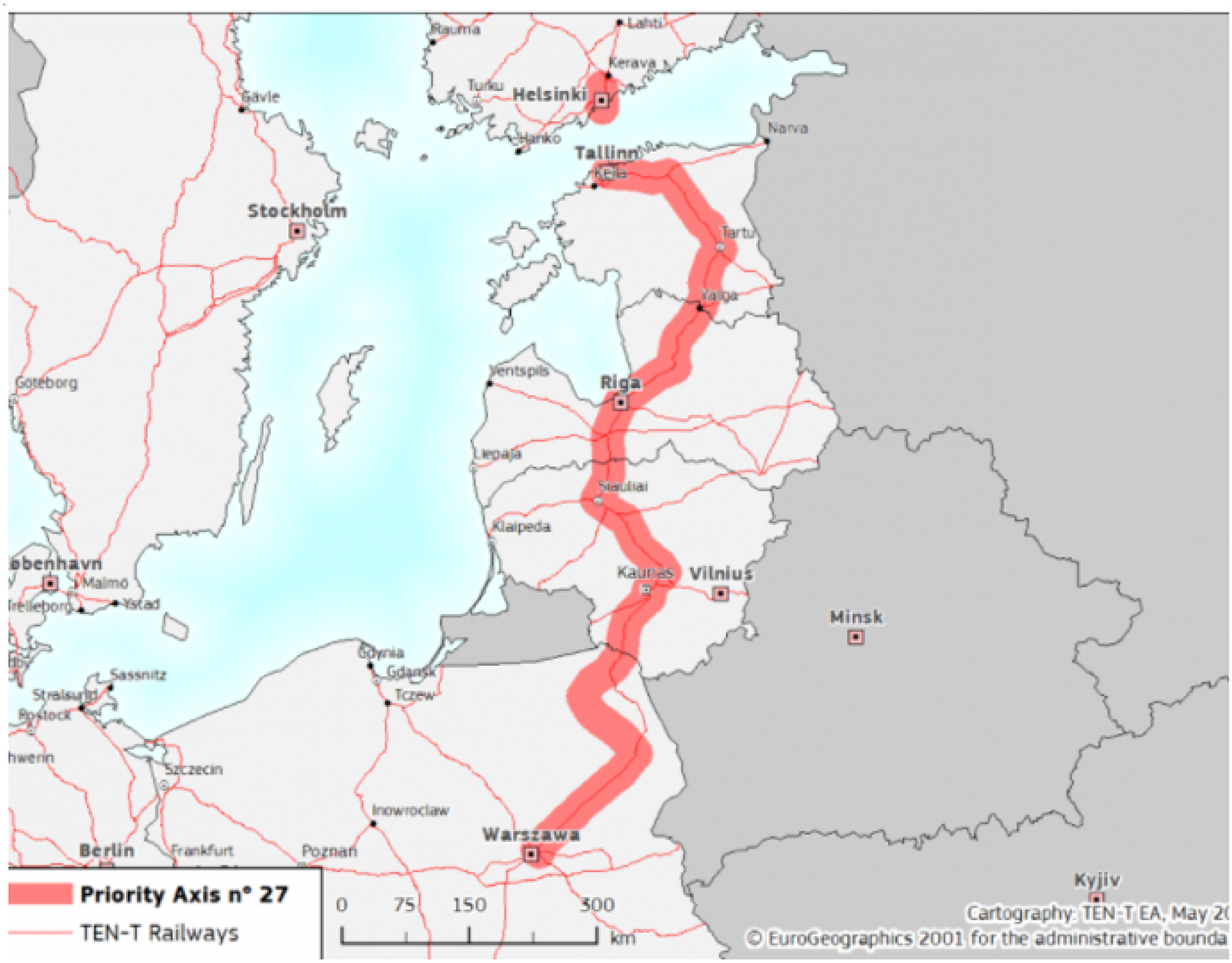


Fig x: Priority Project 27 "Rail Baltica" axis: Warsaw-Kaunas-Riga-Tallinn-Helsinki https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-27

II. Projects involving Portugal and Greece

Priority Project 3 – High-speed railway axis of southwest Europe

"The high speed railway axis of southwest Europe is a key project that ensures the continuity of the rail network between Portugal, Spain and the rest of Europe. It consists of three branches:

Mediterranean branch: Madrid-Barcelona (operational) – Figueras-Perpignan (completed) – Montpellier-Nimes (French high speed network)

Iberian branch: Madrid-Lisboa-Porto

Atlantic branch: Madrid-Valladolid (operational) - Burgos-Vitoria-Bilbao/San Sebastian-Dax-Bordeaux-Tours (Paris)"

(https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-3)

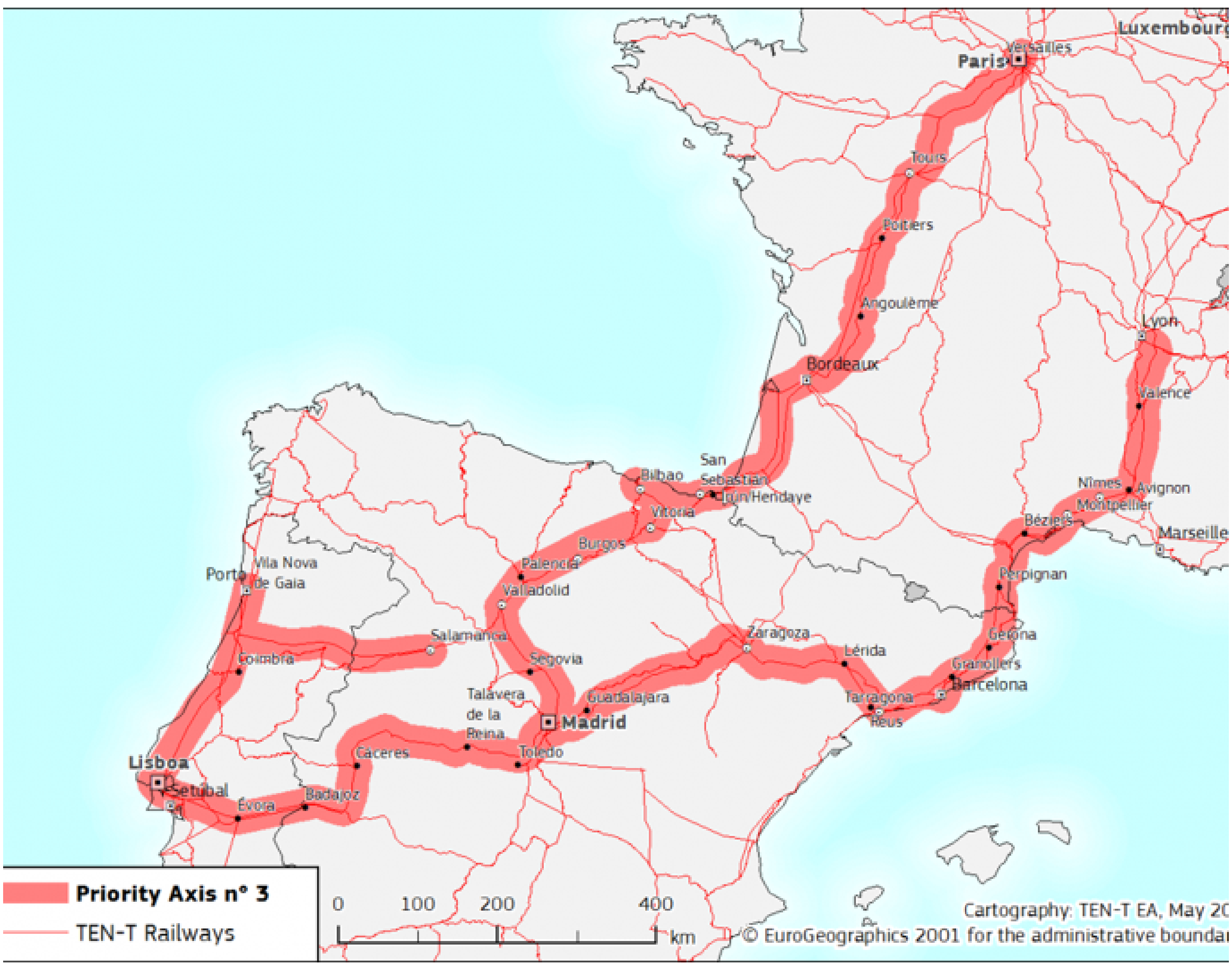


Fig x Priority Project 3 – "High-speed railway axis of southwest Europe"- (https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-3)

Priority Project 8 - Multimodal axis Portugal/Spain-rest of Europe

"This axis reinforces some of the key modal corridors linking Portugal and Spain, thus contributing to the improvement of connections between the centre of the EU and its peripheral regions, and the strengthening of the Iberian peninsula's position as a western European gateway.

It includes sub-projects aiming at improving routes across the Spanish-Portuguese border, linking Spanish cities such as Valladolid, Seville, Vigo and La Coruña with Portugal's principal sea ports and airports and its large urban centres - Porto and Lisbon in particular. As part of wider infrastructure investments, it complements existing rail, road, maritime and air routes in the west of the Iberian peninsula, and will connect the main Portuguese and Spanish sections of the trans-European transport network. Among the sub-projects is included the construction of the new Lisbon airport.

The motorway infrastructure has been completed in Portugal and close to completion in Spain.

The rail infrastructure will still require the removal of bottlenecks (around €1.1 billion is still needed), and is being implemented with polyvalent sleepers (unless direct UIC gauge is used) since the aim of PP08 is to lead towards interoperable lines.

Overall, the axis involves the construction of 2,265 km of new motorways, upgrading of 1,067 km of conventional rail lines, and the upgrading and construction of Atlantic ports and a key airport."

(https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-8)

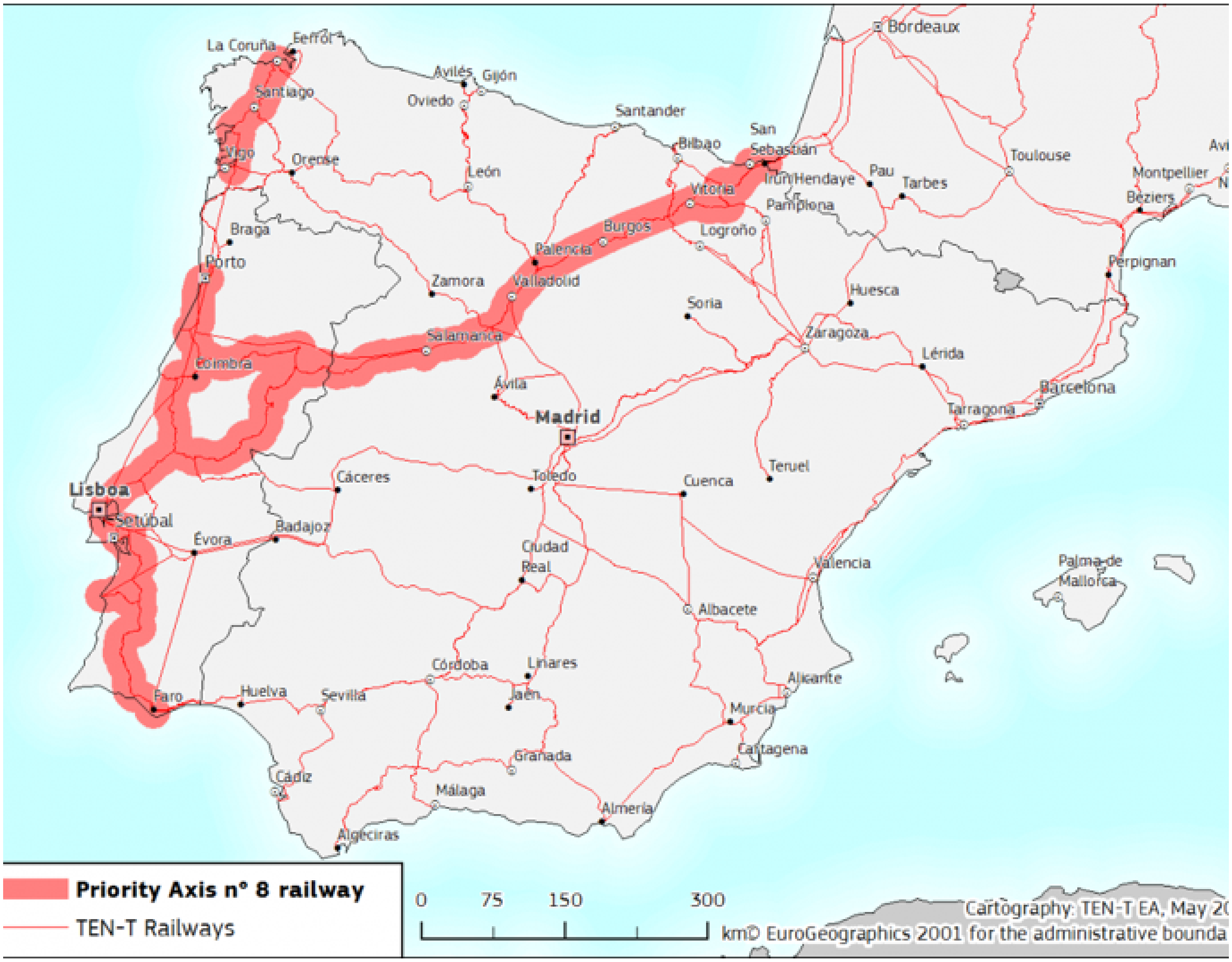


Fig x - Priority Project 8 "Multimodal axis Portugal/Spain-rest of Europe" rail component
(https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-8)

Priority Project 16 - Freight railway axis Sines/Algeciras-Madrid-Paris

"The project aims to develop a high capacity freight railway axis linking the two key ports of Algeciras in southern Spain and Sines in southwestern Portugal with the centre of the EU.

So far, these infrastructures have been mostly used for transshipment or transfer to road, but were not suitable to be efficient terminals due to the lack of an adequate rail connection.

In Portugal, the line links the three logistic platforms of Sines, Poceirão and Elvas/Badajoz. In Spain, it reaches a major port (Algeciras) and the main logistics platform (PLA.ZA).

The scheme also involves the construction of a new high capacity rail link for freight across the Pyrenees, connecting the French and Spanish networks, in order to provide freight flows with a rail access to the entire TEN-T.

The rail access route to the ports will be built with interoperable sleepers so as to allow operations in Iberian gauge in the first stage (coherent with the freight rail network in Spain and Portugal), but ready for the future conversion to UIC "European" gauge. The project also includes the construction of a long distance tunnel through the Pyrenees, in order to eventually link it with the branch of the Grand Projet du Sud-Ouest towards Toulouse.

Several possible alignments are under consideration for this link, which will complete a European trade route from Portugal and Spain to the rest of Europe on which significant future traffic growth is forecasted. The construction of this new line, in European gauge, is expected to enable rail to achieve a 30% share of the land transport market in the Pyrenees. As a direct result, this infrastructure will foster rail traffic between Lisbon, Setúbal, Sines and Algeciras, central Spain and the rest of Europe."

(https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-16)

Fig x Priority Project 16 "Freight railway axis Sines/Algeciras-Madrid-Paris" – source

(https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-16)

Priority Project 19 - High-speed rail interoperability in the Iberian Peninsula

“This project involves the construction and the upgrading of high performance lines and the installation of dual-gauge (polyvalent) sleepers, third rails or axle-gauge changeover stations on the Spanish and Portuguese high speed rail networks, in order to make them fully interoperable with the rest of the trans-European rail network.

The project will provide high speed rail access to the biggest cities of Spain and Portugal and will target five corridors: Madrid-Andalusia, northeast, Madrid-Levante/ Mediterranean, north/northwest corridor, including Vigo-Porto, and Extremadura. The project will be implemented in compliance with Directive 2008/57/EC on interoperability, and will incorporate ERTMS (European Rail Traffic Management System).

The project will allow the creation of a fully interoperable high speed rail network on the Iberian peninsula connected to the rest of Europe. Moreover, the higher availability of the conventional rail network for freight traffic will contribute to the development of trans-European rail freight corridors.”

(https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-19)

Fig x Priority Project 19 "High-speed rail interoperability in the Iberian Peninsula" - Source (https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-19)

Priority Project 21 - Motorways of the Sea

"PP21 on Motorways of the Sea (MoS) builds on the EU's goal of achieving a clean, safe and efficient transport system by transforming shipping into a genuine alternative to overcrowded land transport. The concept aims at introducing new inter-modal maritime-based logistics chains to bring about a structural change to transport organization: door-to-door integrated transport chains. It will also help to implement the policy initiatives on the European maritime space without barriers, the maritime transport strategy for 2018 and will positively contribute to greenhouse gas (CO2) reductions which is of paramount importance in the context of climate change.

Motorways of the Sea taps on the huge potential of maritime transport as the backbone of international trade. In Europe, this capacity has not yet been fully exploited. Motorways of the Sea, which are based upon successful shipping routes, are designed to shift cargo traffic from heavily congested land networks to where there is more available spare capacity – the environmentally friendly waterways. This will be achieved through the establishment of more efficient and frequent, high-quality maritime-based logistics services between Member States."

(https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-21)

Fig x - Priority Project 21 "Motorways of the Sea" – source (https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-priority-project/priority-project-21)

3. New global routes intersections with Disadvantaged Regions

a. Geographical identification of new global routes

The Freight Corridors serve all EU countries and the global routes in scope as identified in below pictures:

- West-East route

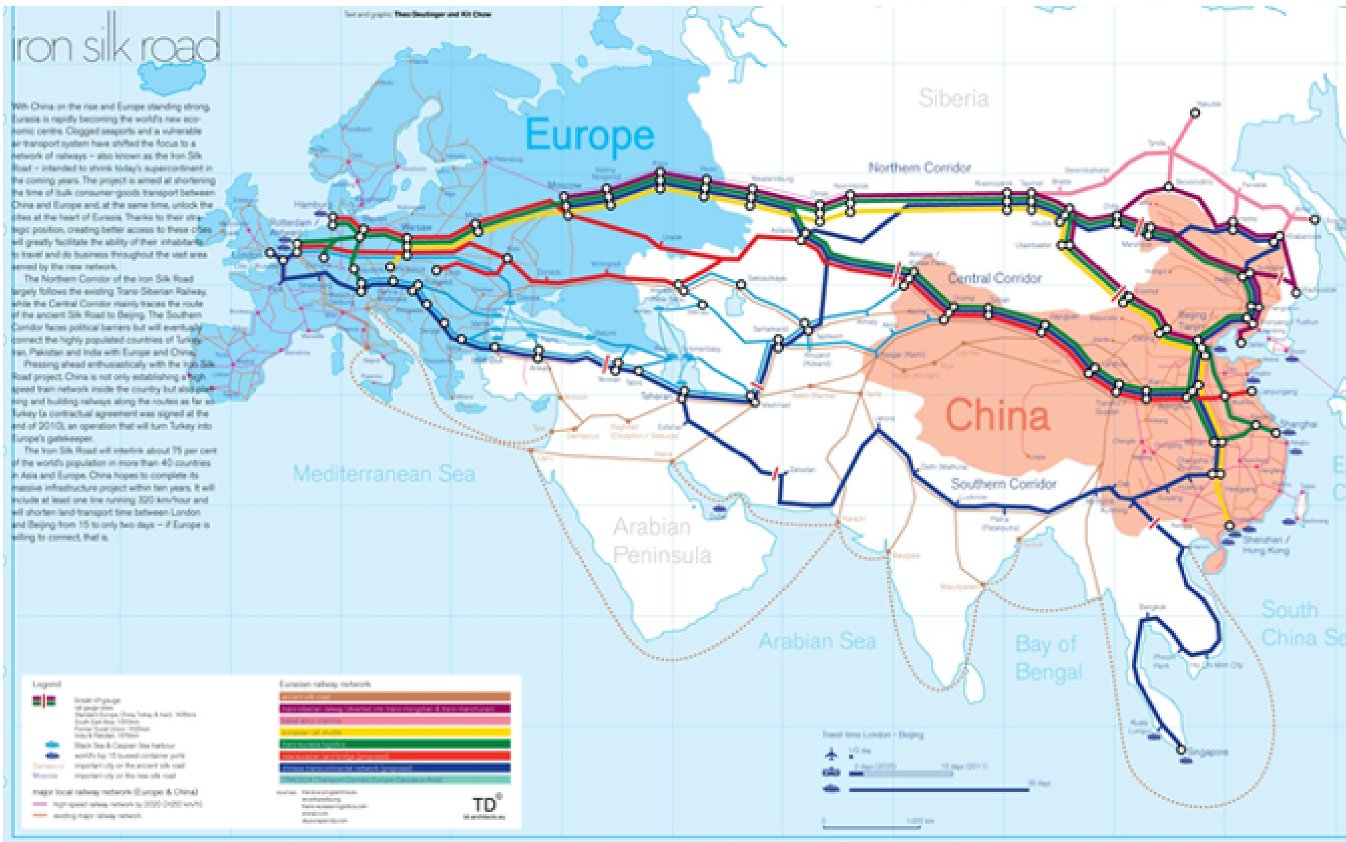


Fig x xx source

- Artic route

Fig x xx source

- North-South route

Fig x x source

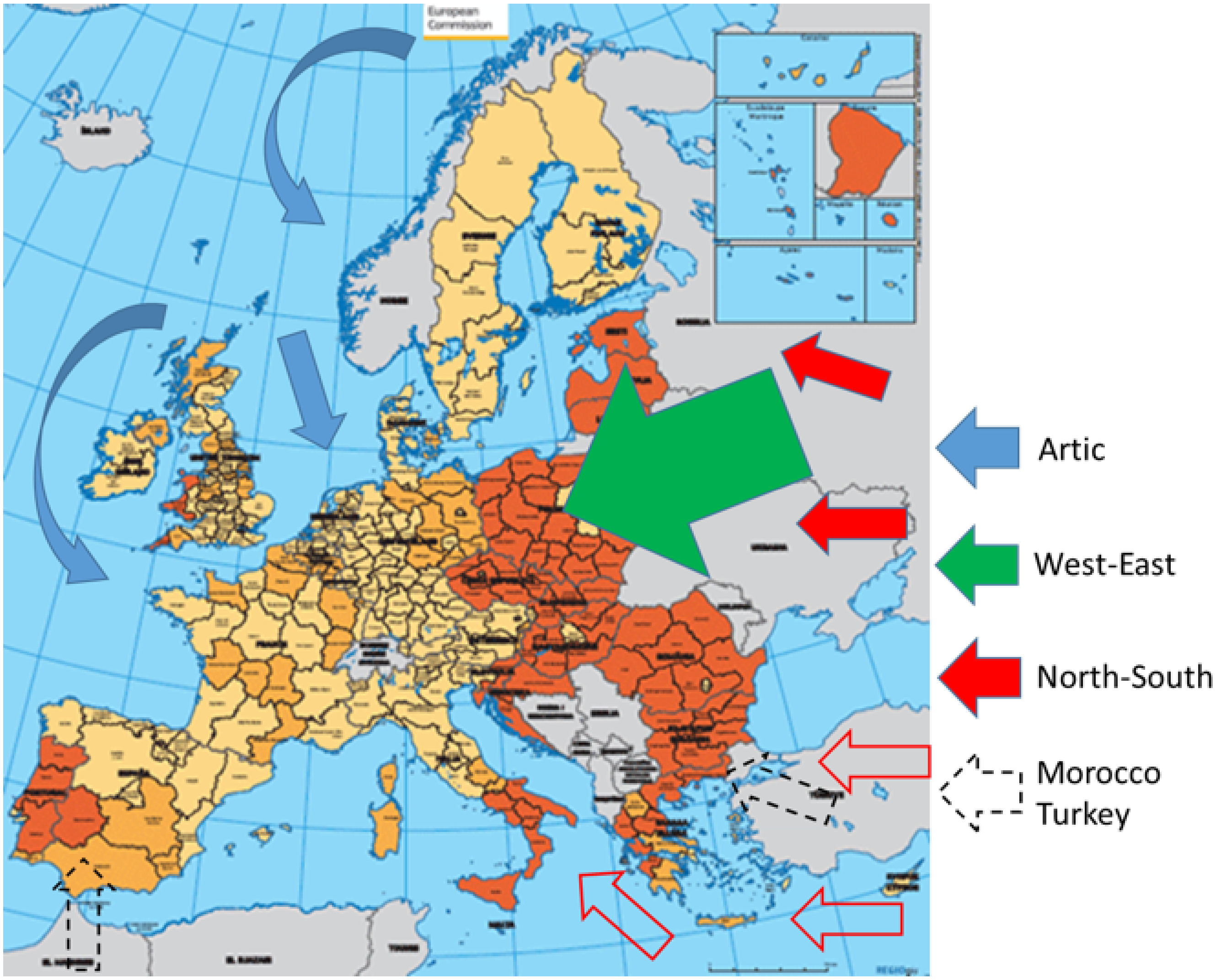


Fig - "New routes" and EU Disadvantaged region - source Structural Funds 2014-2020 - ERDF and ESF eligibility and NEWO elaboration about new routes

b. Global routes intersections with TEN-T corridors

The global routes interact with most of TEN-T corridors potentially contributing, especially for West-East route (Artic route and North-South route may imply some lightly negative implications), to bring benefits to the economies of disadvantaged territories.

Possible future routes such as Morocco, Turkey and Balkan countries, not yet in EU, are basically included in the following notes being new territories potentially relevant especially in a long term perspective.

	West-East route	Artic route	North-South route	Other «new» routes	
				Morocco	Turkey
RFC 1 Rhine-Alpine		BNLL	I		
RFC 2 North Sea-Mediterranean		BNLL, F	F		
RFC 3 Scandinavian-Mediterranean		DK, D, N, S, FIN	I		
RFC 4 Atlantic		F, E, P		E	
RFC 5 Baltic-Adriatic		D, PL	I, SLO, HR		
RFC 6 Mediterranean	H		E, F, I, SLO, HR	E	
RFC 7 Orient/East-Med	BG	D	GR, BG		BG
RFC 8 North Sea-Baltic	PL, LT, LV, EW	BNLL, D, PL, LT, LV, EW			
RFC 9 Czech-Slovak/Rhine-Danube	SK, CZ, RO		BG		
RFC 10 Alpine-Western Balkan			BG		BG
RFC 11 Amber	PL, SK, H		SLO		

Fig x: Freight corridors and countries as "entry points" (in red Countries included in Cohesion fund eligibility) - source NewOPERA elaboration 2020

In the following paragraphs the intersections of the routes in scope with the corridors in the Disadvantaged Regions are highlighted. This is done by zooming maps of corridors going through the countries eligible according to the Cohesion Fund 2014-20 with focus on entry areas.

Of course, being all the network interrelated, each impact in a defined section can bring effects on the entire system. Nevertheless the following paragraphs tackle the territories more directly involved by new routes.

No consideration is made in these pages about likelihood of traffic simple crossing the area or capturing additional value added.

I. West-East route

The West-East route is the most significant route impacting on Disadvantaged Regions because of

- Highly articulated connections with TEN T
- Wide interested territories and lines serving large areas
- Significant volume of fast growing traffic also in the short as well in a medium/long term perspective
- Global investments already in place and still ongoing even if only partially mirroring the huge investments taking place outside Europe, especially in China

The interactions include corridors with different story and operations in place. In fact while

- North Sea-Baltic Corridor
- Mediterranean Corridor
- Rhine Danube Corridor

have a relatively consolidated management, Amber Corridor is relatively younger and still less structured with regard to several aspects.

As a result, all the Eastern Countries have significant implications from the development of the various alternatives of West-East flows. All the routes' alternatives will be interested even if it can be assumed that the flow intensity and the time development may by different.

The list of involved countries named Disadvantaged Regions includes:

- Lithuania
- Latvia
- Estonia
- Poland
- Slovakia
- R Ceca
- Hungary
- Romania
- Bulgaria

The Maps showing the interested corridors and countries are represented in the following pictures.

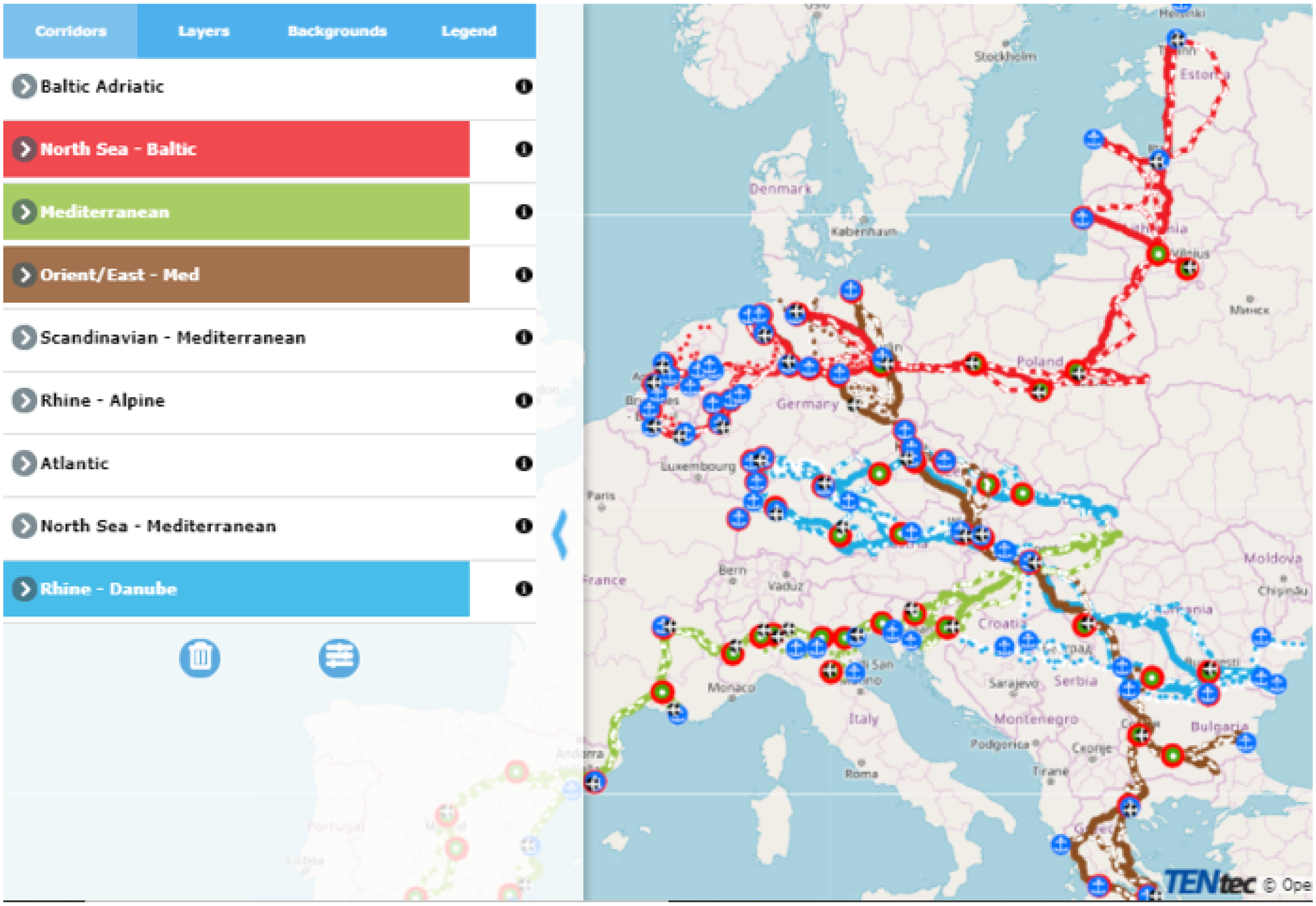


Fig x; Mediterranean Corridor 6, Orient-East Med Corridor 7, North Sea-Baltic Corridor 8, Rhine Danube Corridor 9, interacting with West-East route - source https://ec.europa.eu/transport/infrastructure/TEN-Tec/TEN-Tec-portal/map/maps.html

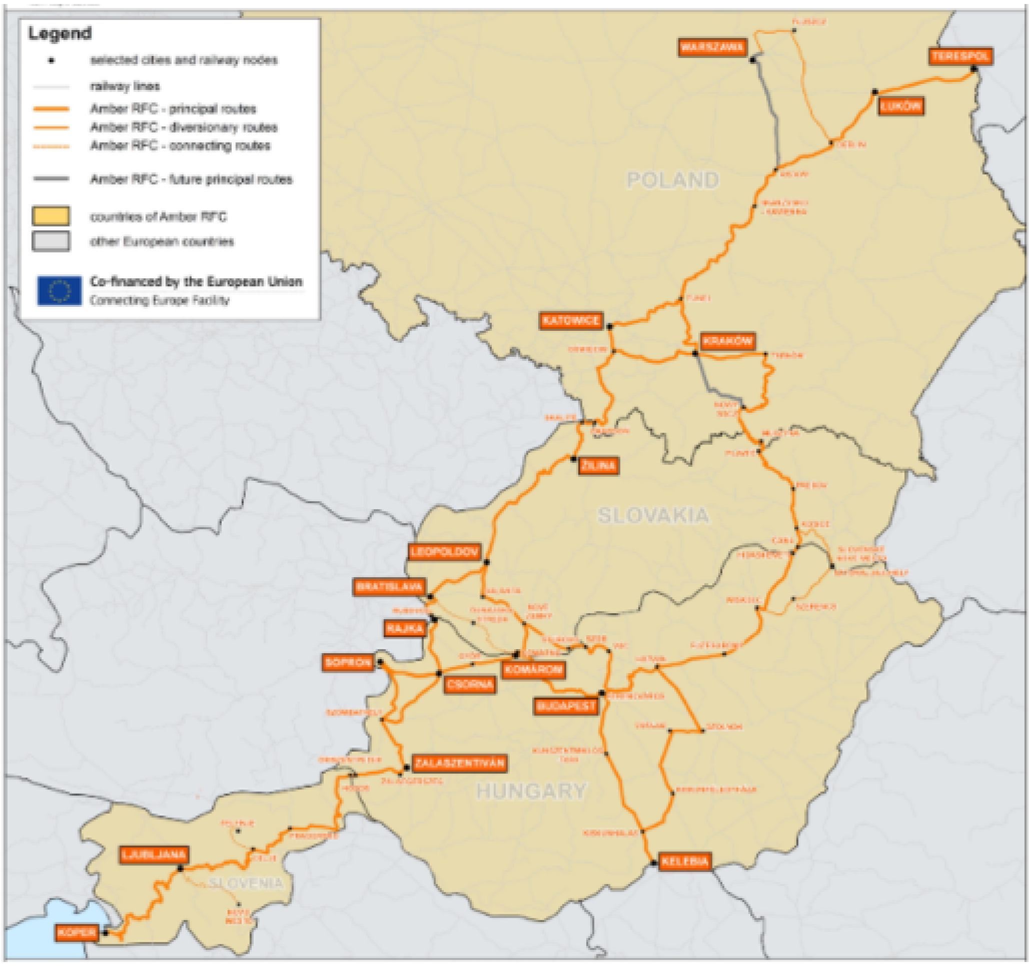


Fig x : AMBER Corridor 11 interacting with West-East route - source https://rfc-amber.eu/

II. Artic route

The Artic route is supposed to potentially involve all corridors connecting sea ports of the Atlantic Ocean and the Nordic Sea. Volume shifts may be relatively small somehow reducing entry of goods in Southern and Eastern ports while Northern ports would have traffic increase.

With a big number of Corridors involved, the list of related Disadvantaged Regions includes:

- Portugal
- Poland
- Lithuania
- Latvia
- Estonia

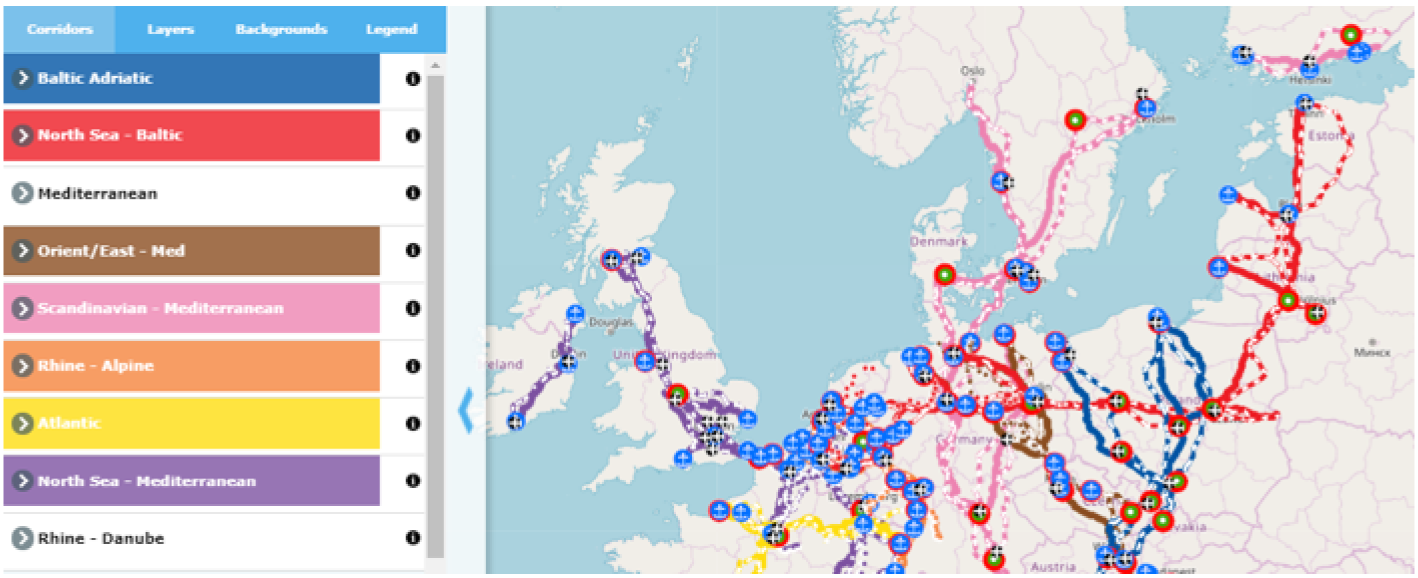


Fig x; Rhine-Alpine Corridor 1, North Sea - Mediterranean Corridor 2, Scandinavian Mediterranean Corridor 3, Atlantic Corridor 4, Baltic Atlantic Corridor 5, Mediterranean Corridor 6, Orient-East Med Corridor 7, interacting with Artic route - source https://ec.europa.eu/transport/infrastructure/TEN-Tec/TEN-Tec-portal/map/maps.html

III. North-South route

The North-South route is supposed to potentially involve all countries with ports in the Mediterranean and Black Sea. So it is involving the biggest number of Corridors. Volume shifts may be relatively small somehow reducing entry of goods in Southern and Eastern ports.

The list of related Disadvantaged Regions is relatively long and includes:

- Slovenia
- Croatia
- Hungary
- Bulgaria
- Greece
- (Italy)

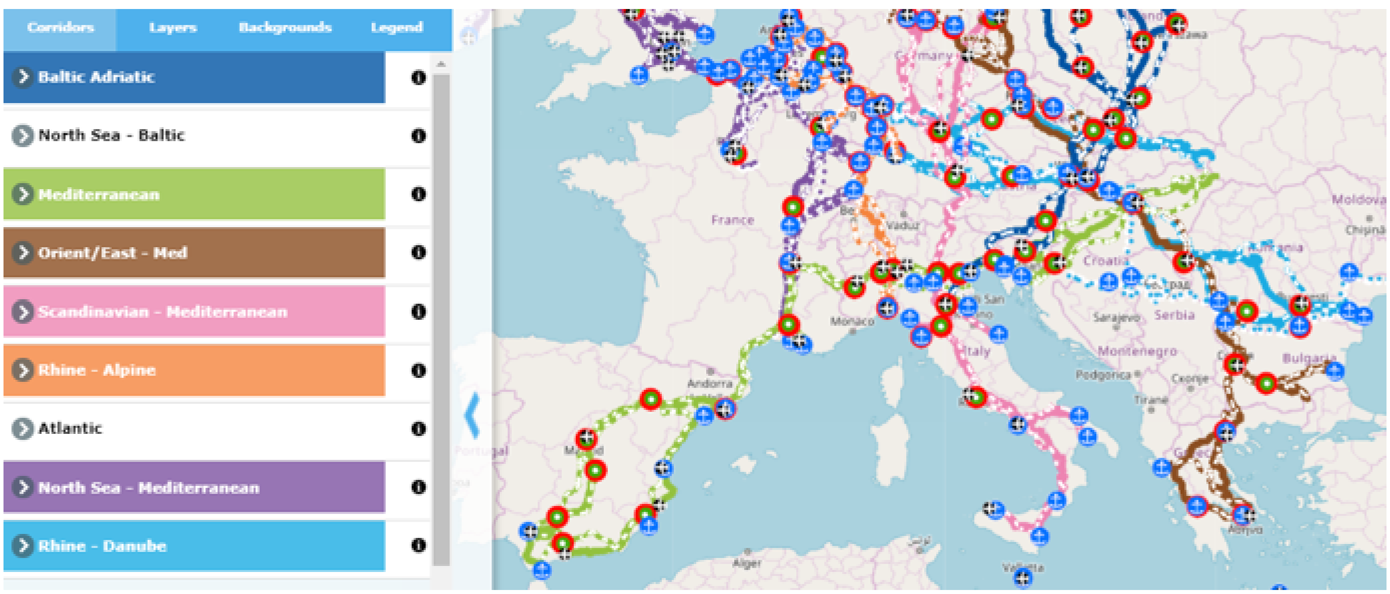


Fig x; Rhine-Alpine Corridor 1, North Sea - Mediterranean Corridor 2, Scandinavian Mediterranean Corridor 3, Baltic Atlantic Corridor 5, Orient-East Med Corridor 7, North Sea-Baltic Corridor 8, Rhine Danube Corridor 9, interacting with North-South route - source https://ec.europa.eu/transport/infrastructure/TEN-Tec/TEN-Tec-portal/map/maps.html

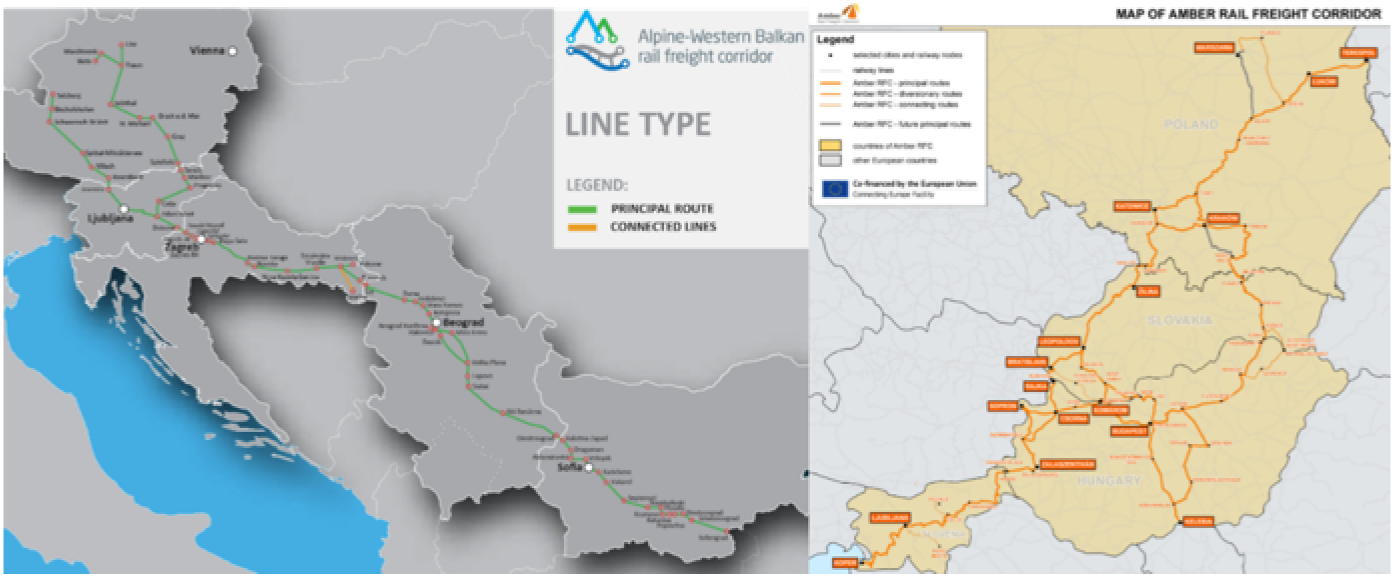


Fig x : Alpine-Western Balkan Corridor 10, AMBER Corridor 11 interacting with West-East route - source https://www.rfc-awb.eu/detailed-map/ , https://rfc-amber.eu/

IV. Other “new” routes

The Turkey route is included in the consideration about West-East route as partially related to the same territories being one of the several options, even with different volume and time perspective.

The possible developments of Morocco route would have main implications for Spain as EU entry country and less directly for Portugal.

4. Rail infrastructural initiatives and connecting nodes in the West-East route

There are several nodal infrastructures connecting EGNT in the West-East route. They are different for a number of elements.

In the following pages, the most significant are reported with main information about current status and the plans under development. When available, information regarding lines are reported as well, especially with reference to local situations.

The different nodes may be classified according to several categories of features. The most relevant for the purpose of this document seem to be

- mode as primary category – including rail and sea, with additional considerations about transport technologies
- location as secondary category – within EU and outside EU boundaries, with further segmentation about countries

The alternative classification option considered is the sub-routing (basically the corridors) of which the nodes are part, but this would require to identify a number of potential sub options allowed in the network.

With the adopted segmentation, the network is identified as self-contained individual entity and transport resource It is the primary tool for allowing traffic with a number of multiple choices while the transport flow enter the network.

The following description privileges the "entry" perspective, since the import looks at present economically more relevant.

In general the "exit" perspective may imply similar considerations, due to the need of balancing the traffic which encourages to have the same pattern both ways. When available, specific notes about differences existing between traffic in and traffic out, have been reported.

a. The rail mode

The rail mode is at present the most relevant mode in West-East route for a number of reasons and by far the one with biggest growth expectations.

As most of the traffic is containerized, the container transshipment is the most effective technology both for short lead-time and unit load handling costs. The investments in automation and modern cranes are increasing handling efficiency. Several terminals have completed recent investments or have development plans in place, including storage space, track lines, handling and other equipment. Investments include also ICT which is an issue of particular relevance on this paper.

For bulk material, the cargo transshipment (instead of unit lad transshipment) represents a relevant challenge. The cargo transshipment is managed in same locations of containers' transshipment, at least in the most important nodes. This operation is executed either with generic or specific equipment.

The attention of this research is focused on unit load transshipment as the most relevant and the fast growing traffic segment.

The main locations are grouped by country and with distinction of two geopolitical clusters:

- Transshipment nodes within EU
- Transshipment nodes outside EU.

In fact the handling operations can be performed on both sides of EU boundaries and similar competitive behavior can be recognized between the most advanced examples (Malasczewicze in Poland and Brest in Byelorussia).

Some limited info are also reported about other rail technologies. In fact, exchange bogies technology exists even if it has a marginal role. While dual/multiple gauge technology is not at all significant.

For individual geographical localization of nodal points both in EU and when available along the West-East route, for technical reasons, it is possible to consult "Rail facilities portal". The Rail Facilities Portal is the successor of "Rail freight locations" portal, initiated and authorized by the European Commission (https://railfacilitiesportal.eu/).

I. Transshipment nodes within EU

Poland

Malasczewicze is the most important EU entry point and inland traffic node in the West-East route.

See case study highlighted in the following sections.

The impact of the re-opening by the end of 2019 in the close area "The border crossing at Czeremcha – Wyskolitowsk needs to be evaluated. This will be an intermodal bypass north of Malaszewicze" (https://www.railfreight.com/intermodal/2019/03/05/polish-city-of-lodz-to-become-rail-freight-hub/).

The Logistics Centre **Medyka-Żurawica** is located at the border crossing Medyka-Mościska. The centre boasts comprehensive infrastructure, offers comprehensive service support, including handling, unloading and loading of goods for railway and car transport, warehousing and storage, sorting, packing and crushing, as well as changeover for wagons holding cargos which cannot be transferred or otherwise handled. (https://www.pkpcargo.com/en/what-we-do/terminals)

PKP PLK (Polish rail infrastructure Company) is investing relevant money in this border facility. Some works have already been completed. "Thus, PKP PLK upgraded the tracks on the Medyka – Mostyska-II crossing on the Ukrainian border. The project facilitated longer and heavier freight trains and enabled an increase of speed. The company will continue the modernization of this junction by track upgrades close to the **Medyka** intermodal terminal. The works will cost 91 million Zlotys (about 21.2 million Euros) and will last until 2023" (https://www.railfreight.com/policy/2019/01/24/poland-to-add-new-tracks-near-malaszewicze-terminal/).

Poznań-Franowo:"the latest PKP CARGO's intermodal investment project is the Poznań-Franowo terminal, located at the junction of major transport routes. The terminal is the largest freight station in

Wielkopolska, the size of its yard reaching 20,000 square metres, and the track system totaling 1,570 running metres in length. The terminal's handling capacity is 60,000 containers" (https://www.pkpcargo.com/en/what-we-do/terminals).

In December 2013, the container terminals in PKP Cargo was opened. In July 2015, the expansion of the terminal began (https://pl.wikipedia.org/wiki/Pozna%C5%84_Franowo).

In Slawkow near Katowice a container Euroterminal has been constructed at the turn of the century. "This facility has been set as a substitute for a 1520 mm new line that has been planned in the 70s between Ludin (UA) and Dresden. The project has been completed as far as Slawkow, but never beyond, because of the cost of crossing the Silesian range mountains and also the reluctance of the Polish authorities then facing the Solidarnocs upheaval. This wide gauge Polish branch of the soviet network is only single track, but has quite ample capacity (and huge Russian loading gauge allowing double-stacking of containers), as the traffic for which it has been built - delivering iron ore and sulphur to the Polish heavy industry - has been considerably reduced since the fall of the Wall.... It is Diesel operated, but should be electrified in a not too distant future" (https://euterminal.pl/en/about/).

"The terminal at Sławków is also operative, but it is currently only used for traffic between Poland and Ukraine. "Due to political tensions between Russia and Ukraine, rail freight traffic to and from China via Sławków does not exist at the moment." But could represent an alternative in the future should the political situation improve. (https://www.railfreight.com/intermodal/2019/03/05/polish-city-of-lodz-to-become-rail-freight-hub/?gdpr=accept)

Fig: Slawkow network and large gauge arrival point (LHS Rail line) – source https://euterminal.pl/en/about/

Fig: Slawkow near Katowice cargo transshipment equipment - source
https://euterminal.pl/en/64-2-2-2-2-4-2/

Fig: Slawkow near Katowice unit load transshipment equipment - source
https://euterminal.pl/en/64-2-2-2-2-4-2/

Slovakia

Slovakia is strategically located between the two continental transport platforms. It is the EU country where broad gauge (1,520 mm) and narrow gauge (1,435 mm) have the most significant common presence with the highest penetration of broad gauge inside EU. Leveraging this peculiarity, it has transshipment facilities both at the border with Ukraine and inside the country.

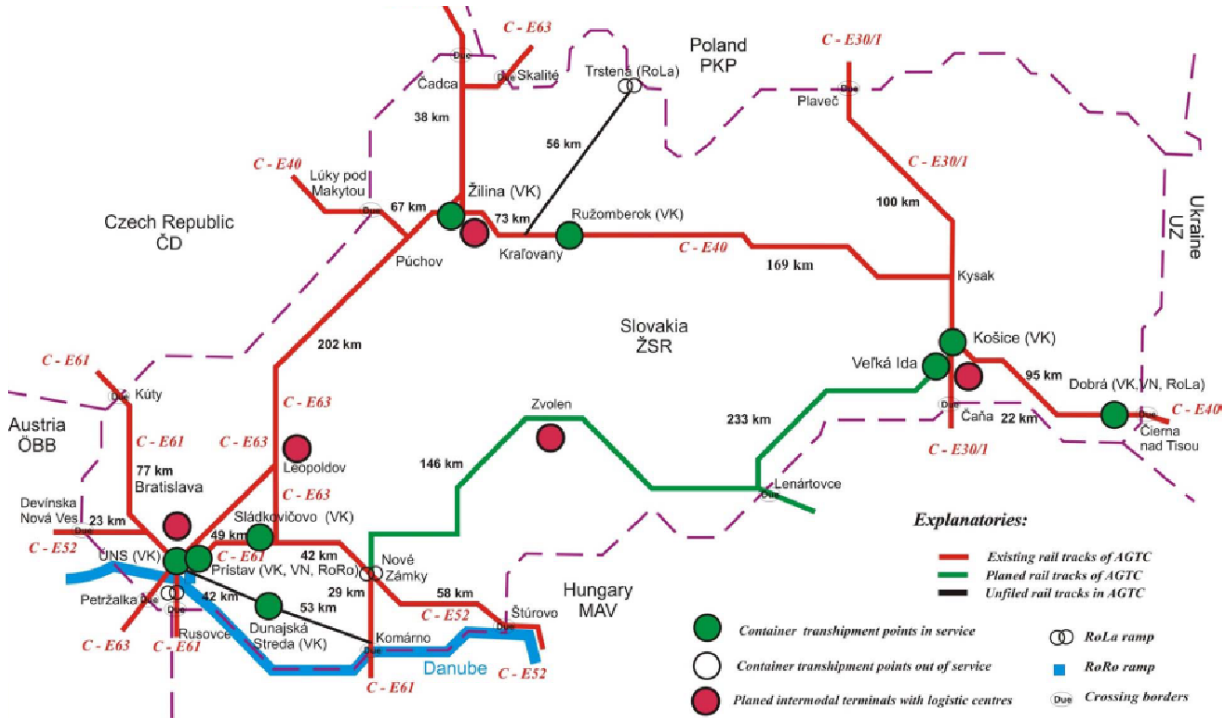


Fig: Future intermodal terminals - source Ministry of Transport, Construction and Regional Development of the Slovak Republic - Intermodal transport infrastructure in the Slovak republic - priority axis No 3 of Operational program Transport (plan 2013 targeting main execution by 2015)

The **Dobra** container transport terminal – DOBRÁ CTT – is situated close to the border near the big international terminal of Čierna nad Tisou. It operates two gantry cranes for trans loading containers, with a daily loading capacity of nine complete container trains. Currently, this terminal has ninety per cent free trans loading capacity, explained the Slovakian government. With an annual trans loading capacity for 200,000 containers, the terminal could become a major logistics centre in eastern Europe.

https://www.railfreight.com/specials/2018/12/04/slovakia-has-plenty-space-to-become-transit-hub-on-new-silk-road/ https://euterminal.pl/en/about/

The **Košice** terminal is situated where the broad gauge currently ends. The government is supporting a major upgrade of the facilities in Košice with the construction of a new intermodal terminal and the global logistics and industrial park (GLIP). "We will work on further joint steps in order to boost the status of Košice region and Slovakia as a transit country", Košice regional governor Rastislav Trnka was quoted in News Now, a Slovak media site. He added that "Košice region offers enough rail transport capacity, including a higher rail transport speed than Poland and Hungary" (https://www.railfreight.com/specials/2018/12/04/slovakia-has-plenty-space-to-become-transit-hub-on-new-silk-road/).

Fig: Intermodal Terminal Košice - Special inland intermodal terminal of type rail – road combined with rail – rail type with European gauge track and broad gauge track - source Ministry of Transport, Construction and Regional Development of the Slovak Republic - Intermodal transport infrastructure in the Slovak republic - priority axis No 3 of Operational program Transport

There are projects in other locations: in **Žilina** a new intermodal terminal will be constructed, as well as in **Leopoldov**. In **Bratislava**, a tri-modal terminal will be built. "The Slovakian ministry wants to make Slovakia an alternative choice of transit after Poland. It is, in every sense, preparing to be the logistic hub on the New Silk Road. With such government support the country will become very important in the near future"

(https://www.railfreight.com/specials/2018/12/04/slovakia-has-plenty-space-to-become-transit-hub-on-new-silk-road/).

Hungary

One of the largest intermodal terminal in Eastern Europe will be built in **Fényeslitke, close to Záhony, on an area of 85 ha,** for € 50 mio with high ambitions in international railway logistics. The investment is operated by a private company, the East-West Intermodal Logistics Service Ltd (controlled by the Rahimkulov family). The terminal will be able to handle up to 500,000 TEUs per year - almost doubling the country's domestic intermodal capacity.

The new terminal will provide capacities to handle increased traffic volumes between the EU and China as alternative to other border crossings with traffic issues avoiding delays. Services include operations both on standard and broad gauge.

"The maximum capacity is going to be 1 million TEU/year, following the development of the railway infrastructure.

The terminal operating software will be able to connect with customers online and to real-time monitoring tracking the position of containers during transit.

The storage area of the terminal has an independent crane track, on which only 1 crane operates, which can later be expanded with additional cranes. The railway crane tracks are 850 m long. The terminal has 3 separate railway crane tracks, which are also suitable for receiving 740 m long trains approved in Europe. The cranes have a load capacity of 45 Mt.

During the first phase each railway crane track will have one crane, which can be upgraded later to two cranes per track. The cranes will also be capable of handling 45” containers and cranable semi-trailers as well as non-craneable semi-trailers with special solution. The terminal will have 4 mobile container loading vehicle, 5 terminal tractors and 10 terminal semi-trailers.” https://eastwestil.com/en/terminal-2/

“The terminal will provide a full range of logistics services and when the operations starts, it will offer customers 15,000 square meters of leasable warehouse space. On the available unbuilt areas, an additional 500,000 square meters of warehouse, assembly or production plant can be established if required” (https://dailynewshungary.com/the-largest-intermodal-railway-terminal-in-europe-is-being-built-on-the-new-silk-road-in-hungary-video/).

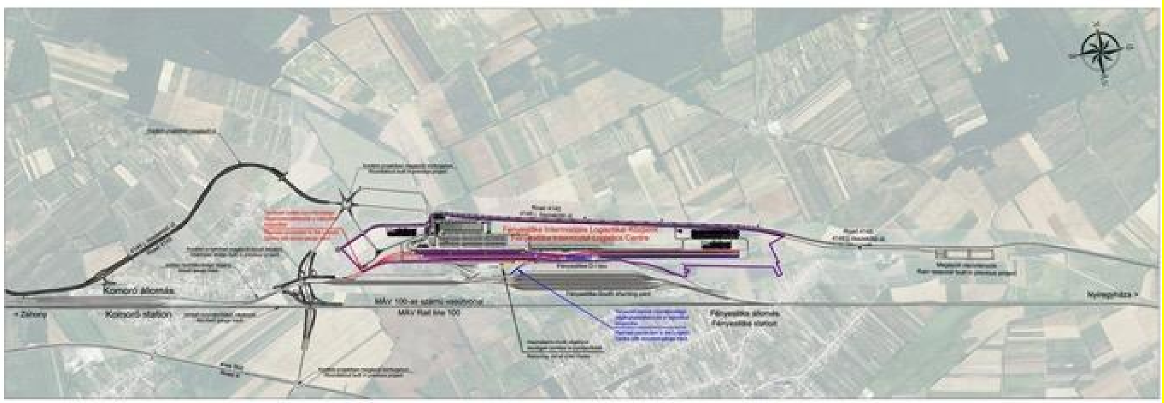


Fig: Design of future terminal in Fényeslitke, Hungary (close to Záhony border) source https://www.railfreight.com/railfreight/2021/01/27/tenfold-increase-for-eurasian-rail-freight-traffic-through-hungary/?gdpr=accept

Záhony is the Hungarian entry point serving the Budapest hub – From Budapest a number of regular trains reach Balkans, Austria and afterwards Germany and Switzerland, Italy (source https://www.railcargo.com/en/network/eurasia/jinan-budapest)

Fig: Hub role of Budapest terminal – source
https://www.railcargo.com/en/network/eurasia/jinan-budapest

II. Transshipment nodes outside EU

Byelorussia (BY)

Brest (facing Małaszewicze in Poland) - Brest terminal is operated by The Belintertrans-Germany GmbH (BITG) is a company of the Belarus Railway (BCh) state enterprise with offices in Friedrichsdorf near Frankfurt. It is incorporating with all state railway companies of the CIS, in particular with the Russian Railway RZD.

It is the "most significant reloading and gauge conversion station in Europe" http://www.belint.de/material/belintpresentation.pdf

"The service package includes:

- Consolidation of cargo in Brest,
- Shunting services
- Re consignment to diverse places/countries of destination (CIS, EU, Central Asia, Caucasian region)
- Multi-modal solutions to on-carriage to the final point of unloading (Link between rail, road and sea)
- Handling of dangerous goods / temperature-controlled goods
- Bonded warehouse services with bonded licenses with EU & Eurasian Union
- Custom Clearance Services"

(http://www.belint.de/material/belintpresentation.pdf).

Fig: Brest terminal transshipment - source (http://www.belint.de/material/belintpresentation.pdf)

Ukraine (UA)

Chop (no significant transshipment facilities?) (facing Záhony in Hungary and Dobra in Slovakia)

The station is an important transportation hub and gateway to Ukraine. There are two border checkpoints: Strazh for Slovakia and Druzhba for Hungary. The station serves passengers and freight trains.

https://en.wikipedia.org/wiki/Chop_railway_station

Ukraina (UA) (facing Romania border)

Ukraine – Break-of-gauge 1,435 mm (4 ft 8 1⁄2 in)/1,520 mm (4 ft 11 27⁄32 in). Crossings at Vicşani, Valea Vişeului and Câmpulung-la-Tisa (including bogie conversion systems). Dual gauge (4 rail) track exists between Tereseva (Ukraine)/Câmpulung-la-Tisa - Sighetu Marmaţiei - Valea Vişeului, going back into Ukraine. Crossings are not electrified) https://en.wikipedia.org/wiki/Rail_transport_in_Romania.

Moldova (facing Romania border)

Moldova – Break-of-gauge 1,435 mm (4 ft 8 1⁄2 in)/1,520 mm (4 ft 11 27⁄32 in). Crossings and bogie changers exist at Ungheni (Moldova) and Galaţi-Reni. No voltage issues (None of the tracks of the Moldovan Railways are electrified). Daily passenger service to Chişinău from Bucharest. Multiple daily services from Iaşi.

https://en.wikipedia.org/wiki/Rail_transport_in_Romania

https://en.wikipedia.org/wiki/Calea_Ferat%C4%83_din_Moldova

Russia

Chernyakhovsk/Kaliningrad - "DB Cargo Logistics together with Kaliningrad Railway, a regional branch of Russian Railways (RZD), GEFCO Russia and Novik Logistik are considering to launch the new rail services between China and the European Union by using the intermodal terminal in Chernyakhovsk for container transshipment. This facility is owned by Russian company Novik Logistik and it has a convenient location. It is situated on the midway from Lithuanian border to Kaliningrad and connected with the European gauge railway (1,435 millimetres) to the Polish network via the Zheleznodorozhny – Skandawa border crossing. On the Polish side, Skandawa border station is linked to Poznań, an important hub for New Silk

Road rail freight connections, and other junctions across Poland" (https://www.railfreight.com/beltandroad/2019/11/28/db-cargo-focuses-on-kaliningrad-route/).

See also "Kaliningrad" in the following paragraphs as a major sea mode option.

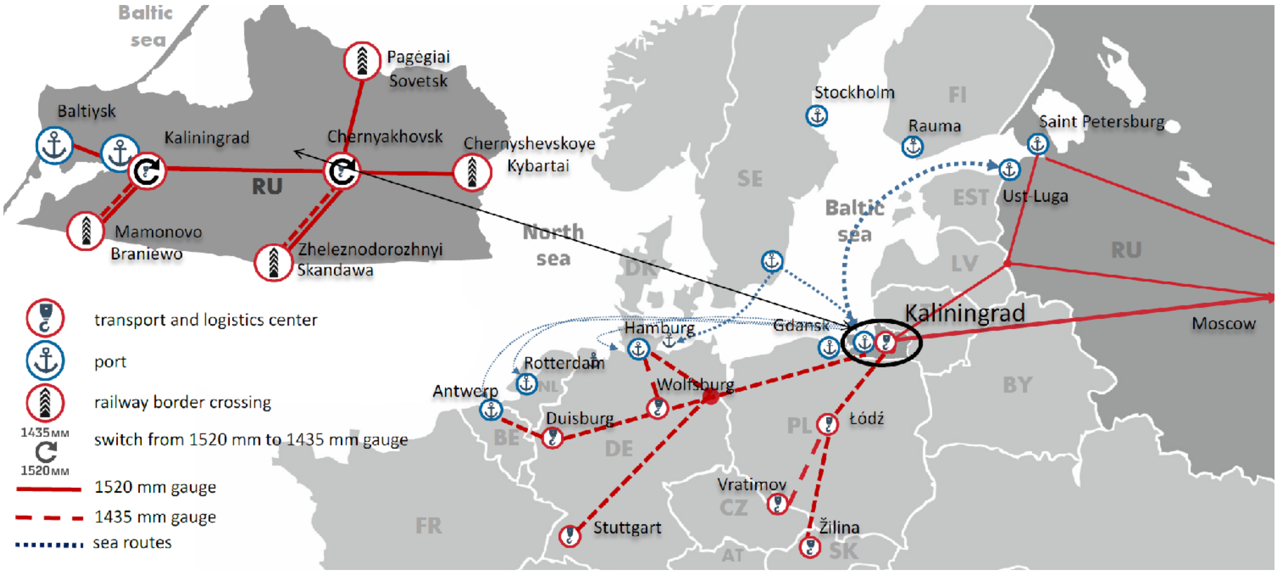


Fig: Chernyakhovsk/Kaliningrad traffic routes – source European Commission, Analysis of the potential of the development of rail container transport market in Poland - 2019

III. Exchange bogies

Bogies exchange facilities, from North to South are operated at:

- Sestokai (LT) at the Lithuanian/Polish border.
- Brest-Litovsk (BY) at the Belarus/Polish border (+ Talgo).
- Mostika (UA) and Zurawica (PL) at the Ukraine/Polish border.
- Chop (UA) at the Slovakian- Ukraine border, which is also active for the traffic to Hungary as it is close too from the Hungarian border in Zahony.

IV. Dual/multiple gauge

No significant application is reported in relationship to the freight traffic in scope.

b. The sea mode

In the Sea mode solutions the freight traffic arrive by rail in ports of neighboring countries and are loaded on ships for going to EU countries. The traffic can be by ferry boats and/or by container vessels.

This container vessels solution is available as alternative for reaching isles such as Great Britain Ireland and Iceland, but also the Nordic countries. This solution is overall expected to have lower potential than overland.

I. Sea mode – ferry boats

Finland

There are two gauge changing facilities in Finland (former Russian empire, hence 1524 mm gauge) for the traffic with Sweden: one is in Tornio, the other in Turku, the latter linked via a ferry-boat to Stockholm. None of them can be of significant interest for the Asian- European transit traffic.

Germany

A huge transfer facility exists in Mukran (D). It was built around 1980 by the former DDR to avoid transiting through Poland, also for strategical reasons, because both the former East German regime and the Soviet Union were not trusting the behaviour of the Polish authorities in case of war. This hub in Mukran is linked with Russia by ferry-boat, but the level of traffic is now much lower than in the old days of the Warsaw pact. In late ’90 Extensive refurbishment has been executed especially for passengers. The regular ferry link between Sassnitz and Russian Ust-Luga (via Baltiysk) as well as the transporting of railway wagons of the Russian broad gauge has been in operation since 2012**.** **(**https://www.mukran-port.de/company/history.html)

Ukraine

In the communist era existed a ferry-boat between Illichevsk near Odessa (UA) and Varna in Bulgaria on the Black Sea where a bogie exchange facility has been established. The traffic has been always very limited.

II. Sea mode – container vessels

Russia

Kaliningrad “Sea port (KSCP JSC) – is the largest enterprise of the Western and unique ice-free Russian port on the Baltic Sea. It is situated in the Southeast part of the Baltic Sea in Pregel river water mouth in Special economic zone of Russia – the Kaliningrad region. The port with its location on the junction of the trans-European transportation corridors (Baltic-Adriatic Corridor and North Sea Baltic Corridor) indicates on the formal integration of the region into European transportation system.

Fig: Kaliningrad location – source https://www.bing.com/maps?q=kaliningrad+wikipedia&form=ANNTH1&refig=b55a7e38e3754156b190e9715e5e3d49&sp=2&qs=AS&pq=kaliningrad&sk=LS1&sc=8-11&cvid=b55a7e38e3754156b190e9715e5e3d49

Terminals are located in inner harbours (Volnaya and Industrialnaya) of the Kaliningrad city and connected with the Baltic sea by navigation canal 43 kilometers long, from 80 to 150 meters wide and from 9 to 10,5 meters deep ”http://www.worldportsource.com/ports/commerce/RUS_Port_of_Kaliningrad_1533.php#:~:text=The%20Port%20of%20Kaliningrad%20container%20complex%20includes%20two,The%20port%20also%20contains%20two%20oil%20terminal%20berths).

The port has direct rail connections well integrated in terminal lay out. Trains can reach the port consistently with the Byelorussian allowed length of 910 m. (https://www.ferrovie.info/index.php/it/archivio/archivio-news-2018/13-treni-reali/5060-ferrovie-la-russia-aggira-l-ostacolo-della-polonia-sulla-via-della-seta).

“The Port of Kaliningrad container complex includes two roll-on/roll-off berths, and all berths have two rail tracks. The Port of Kaliningrad's State Fishery Port has about 10 thousand square meters of container sites. The port also contains two oil terminal berths” (http://www.worldportsource.com/ports/commerce/RUS_Port_of_Kaliningrad_1533.php#:~:text=The%20Port%20of%20Kaliningrad%20container%20complex%20includes%20two,The%20port%20also%20contains%20two%20oil%20terminal%20berths).

Most of the transit traffic in Russian ports in Baltic Sea, is handled in Kaliningrad. (https://seanews.ru/en/2020/12/16/en-container-traffic-via-baltic-basin-ports-down-1-2-in-november-2020/).

Other Russian Baltic basin sea ports, relevant for import-export, are Ust-Luga, Primorsk, St. Petersburg, Vyssotsk.ù.

St. Petersburg is in particular competing as an option for the Northern route (Vladivostok and Trans-Siberian regions) for bypassing delays and other issues in Byelorussia transit (https://it.sputniknews.com/economia/201805136003255-russia-aggira-ostacolo-polonia/).

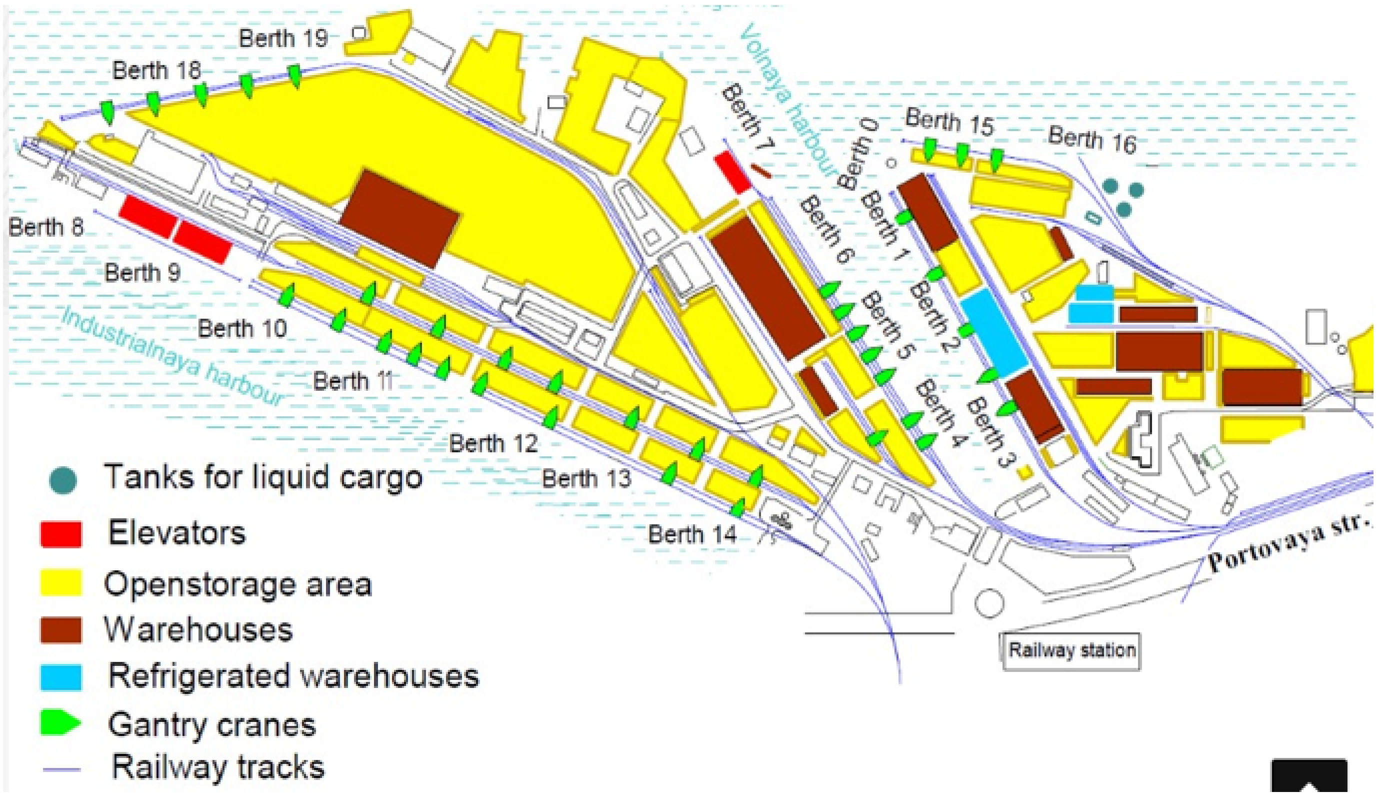


Fig x : Kaliningrad port lay out source http://kscport.ru/index.php/en/about/port-profile/port-layout

5. Exemplary rail infrastructural initiatives in Romania and Bulgaria

a. Romania

The recent facility in **Oradea**, has been realized by Intermodal Vest a joint venture of two major European rail freight operators - P&O Ferrymasters and the Transmec Group's. Its proximity to the Romania-Hungary border provides fast access to the wider rail network from the west into the Balkans, Turkey and Bulgaria (https://www.railfreight.com/corridors/2016/11/01/new-terminal-widens-gateway-to-eastern-europe/).

The teminal in **Curtici**, also close to the Hungarian border has similar target in connecting Turkey to Europe (https://www.railfreight.com/beltandroad/2020/06/18/rail-cargo-group-launches-new-china-connections-via-turkey-to-europe/).

The aspiration of Romanian entry point from China is depending upon:

- Constraints in Russia (for example restriction to imports and transit for certain type of goods)
- Wider use of Marmaray Tunnel underneath the Bosporus opened to freight traffic in October 2019

See the chapter Transshipment nodes outside EU for information about Moldavia border.

b. Bulgaria

By 2030 the European Union may launch a new "Aegean Sea – Baltic Sea" Corridor. The proposal has been presented at RailFreight Summit in Poznan in September 2020 (https://www.railfreight.com/intermodal/2020/09/10/will-the-aegean-baltic-corridor-become-part-of-the-ten-t-network/).

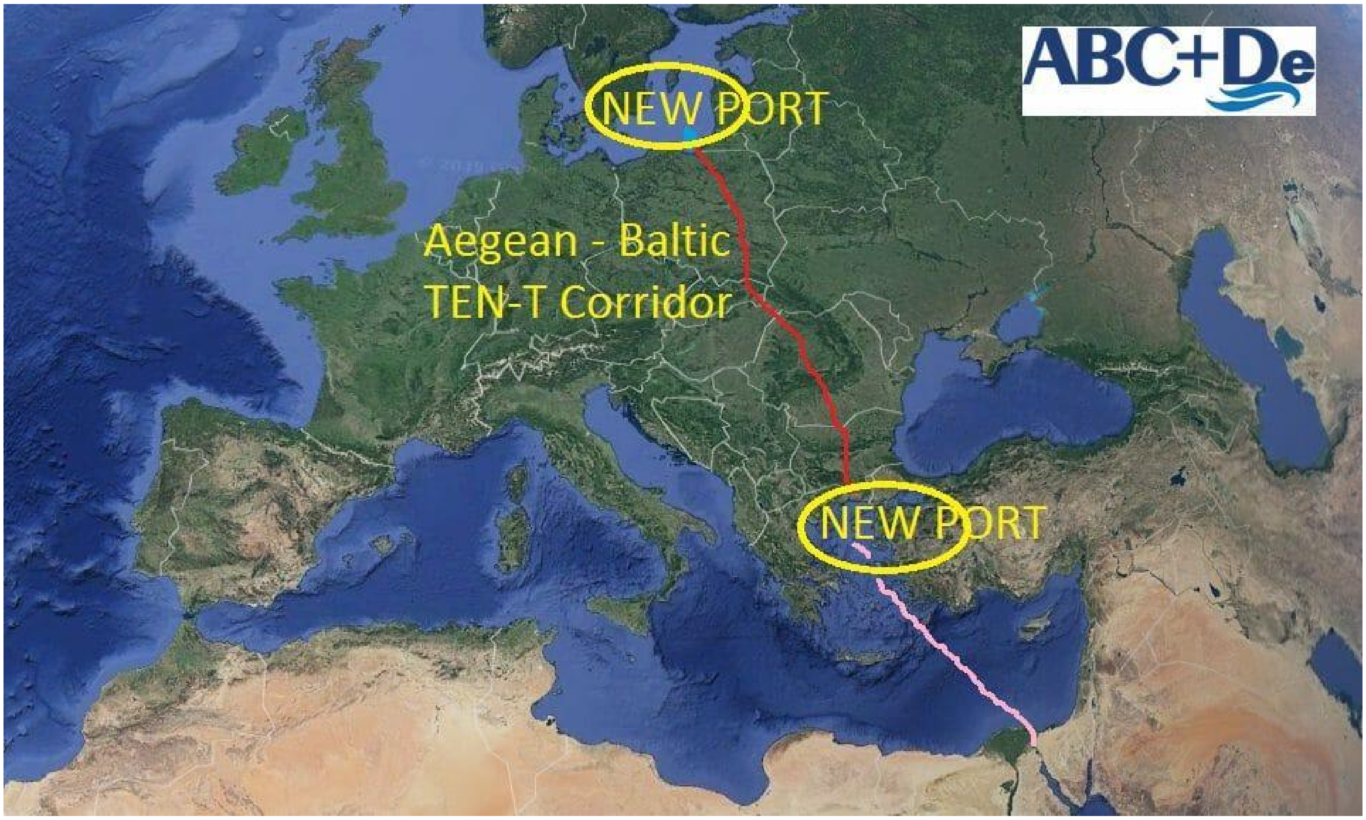


Fig x - Possible future TENT Corridor "Aegean – Baltic" – source https://www.largeinfraprojects.eu/tent-corridor/

The corridor by a new railway connection from Greece via Bulgaria, Romania, Hungary, Slovakia, and Poland to the Baltic Sea, is developed as a shorter way for freight running from Asia or Eastern Africa via the Suez Canal to Northern Europe. Now, the vessels from Suez go through Gibraltar and then head northward.

The proposed seaports on both ends of the transport artery are Ismara port in Greece and Vistula port in Poland. Ismara port is located in Western Thrace, between the existing harbours of Alexandroupoli and Kavala. Vistula port is placed near the delta of a river of the same name, a few kilometres Eastward from Gdańsk.

In addition, a series of multimodal centres on the route should be established.

6. Exemplary rail infrastructural initiatives in Portugal and Greece

Portugal and Greece are both countries with a strongly sea oriented transportation system and are at their early stages of development of rail transportation.

Nevertheless, the developing integration of inland network and the opportunity to better link sea and land in co-modal setting is inspiring evolutions of which the initial steps are already progressing.

a. Portugal

Infrastructural initiatives supporting development of co-modal transportation have their focus on the ports. The European Commission (EC) strongly support infrastructural development and push for ambitious targets.

"The Portuguese and Spanish governments should increase their budgets for rail and port infrastructures. This is the recommendation of the European Commission. The institute considers the Portuguese ports as potential European import hubs due to its geographic location on the Atlantic coast. In this light, it has criticized the lack of investment in port and railway infrastructure" (June 2019 - https://www.railfreight.com/policy/2019/06/19/eu-wants-spain-and-portugal-to-push-infrastructure-investments/).

Focal topics are the ports and their rail connections with the international rail links with the Spanish network for taking advantage of the upgrading of such infrastructure in the Pan-European railway corridors in 2030 perspective.

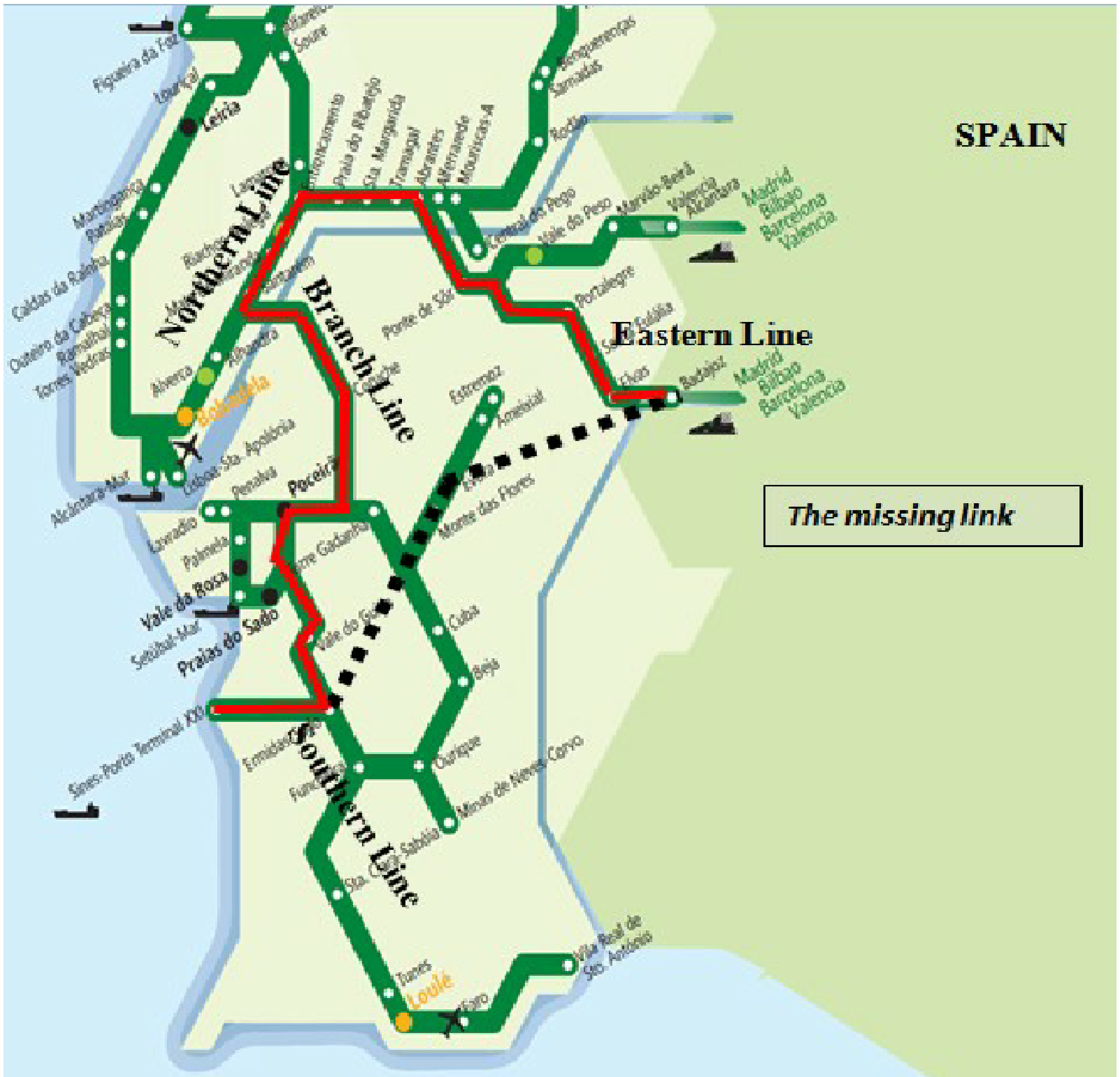


Fig x – Main infrastructures in Portugal - source https://www.railfreight.com/policy/2019/06/19/eu-wants-spain-and-portugal-to-push-infrastructure-investments/

The most important projects include (https://www.railfreight.com/railfreight/2019/01/16/portuguese-government-presents-2030-rail-investment-plan/ and https://www.railfreight.com/policy/2019/06/19/eu-wants-spain-and-portugal-to-push-infrastructure-investments/ and https://www.railfreight.com/business/2017/10/04/improved-railway-connections-for-port-of-setubal/);

The new rail connection between Lisbon and Porto. A high-speed connection will be constructed for passenger services, reserving the current rail track for cargo trains.

A new bridge above the Tagus river to shorten rail service time between Lisbon and the regions of Alentejo and Algarve (South), thereby developing an Atlantic corridor on the Portuguese coast.

Other projects include a rail tunnel in Alcantara to connect Cascais and Cintura and electrification of the remaining non-electrified railway network; a direct rail track between Sines and Grandola will be constructed to avoid the slopes of the Santiago do Cacem mountains and facilitate the traffic of heavy freight trains; further, upgrades will be done towards rail safety, noise reduction,signaling and telecommunication system improvement.

Port projects include improving rail connections for Port of Setubal with the objective to electrifying the railway connections, developing new incoming and outgoing railway tracks and construcing a new connection between the port and the stations of Praias-Sado and Setubal Mar; other examples are the port terminals of Tersado, Sadoport, Somincor and Sesimbra

b. Greece

"Currently, the focus lies on sea transportation, but it would be beneficial to turn the attention towards rail. The brand new rail service connecting the port of Thessaloniki and the dry port of Sofia is a good way to start" https://www.railfreight.com/corridors/2020/12/01/greek-government-calls-for-investments-railway-still-underdeveloped/).

"It is essential to note down that Greece's railway network is part of the Orient/East-Med corridor of the TEN-T network. As part of this corridor, it sees many EU oriented investments with the latest one effected in July 2020, reaching the amount of 2,2 billion euros. This specific financial boost is aimed at reinforcing the railway cross-border links and the connections to ports and airports. For example, some projects that will benefit from the funding budget are the railway section between Alexandroupoli-Pythio, which are the object of further development, and the construction of a high-speed rail line between the port of Kavala and Thessaloniki. Both projects will take place in Northern Greece.

Additionally, on 27 November the first train connecting the port of Thessaloniki and the dry port of Sofia made its initial voiyage. The trip which lasted sixteen hours will be the first among several test trips that will take place until mid-January 2021. The route will include weekly roundtrips which will optimize the services between the two cities and improve connectivity in the Balkan peninsula generally. Nevertheless, there is still space for implementing more changes. For instance, apart from the connectivity between inland destinations which leave to be desired, Greece lacks something equally fundamental: the freight terminals that facilitate transshipment and multimodal transport are not very much developed. Currently, the country has only two central terminals in the ports of Piraeus and Thessaloniki respectively. At the moment, all attention is focused towards the Thriasio multimodal freight station in Athens which is estimated to upgrade the rail freight services significantly. The project will be completed in 2021. Simultaneously, there are hopes for a corresponding investment in Thessaloniki, with nothing being definiteyet" (https://www.railfreight.com/corridors/2020/12/01/greek-government-calls-for-investments-railway-still-underdeveloped/).

7. EGTN developments & TEN T Synergies - intercontinental freight flows

The new routes interacting with TEN T in the perspective of EGTN will privilege more sustainable modes. Sea and Rail look the “natural” modes for intercontinental flows (even if some new road service from/to China are under development). Nevertheless, it is important that also EU internal transport segments proceed according to the same sustainable principles.

This continuity in sustainable approach is consistent with coordinated efforts to bring benefits to Disadvantaged Regions when traffic flows are defined:

- Finding their Origin/Destination in the Disadvantaged Region
- Just crossing the Disadvantaged Region having elsewhere their Origin/Destination.

When the traffics have their Origin/Destination in the Disadvantaged Region the benefits are mainly related to the reduced

- Costs for the
  - new more competitive connections
  - additional industrialization improvements because of new opportunities and traffic volumes
- Impacts on environment (in general) due to
  - implying reduction of ton*km/mile a
  - modal shit with higher use of more sustainable modes.

Regarding modal shift in a co-modal perspective, the intermodal traffic can be expected to increase its share.

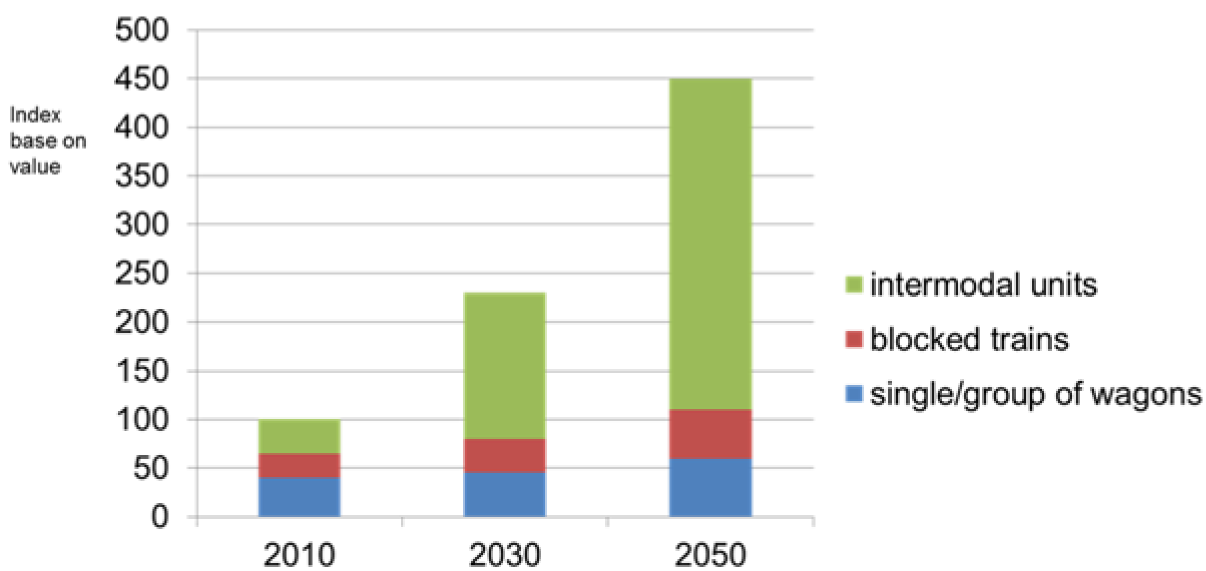


Fig x – source NewOPERA – SPIDERPLUS project - 2015

Intermodal traffic looks week in disadvantaged regions while the rail freight share is in general higher, at least in Eastern countries, than the European average.

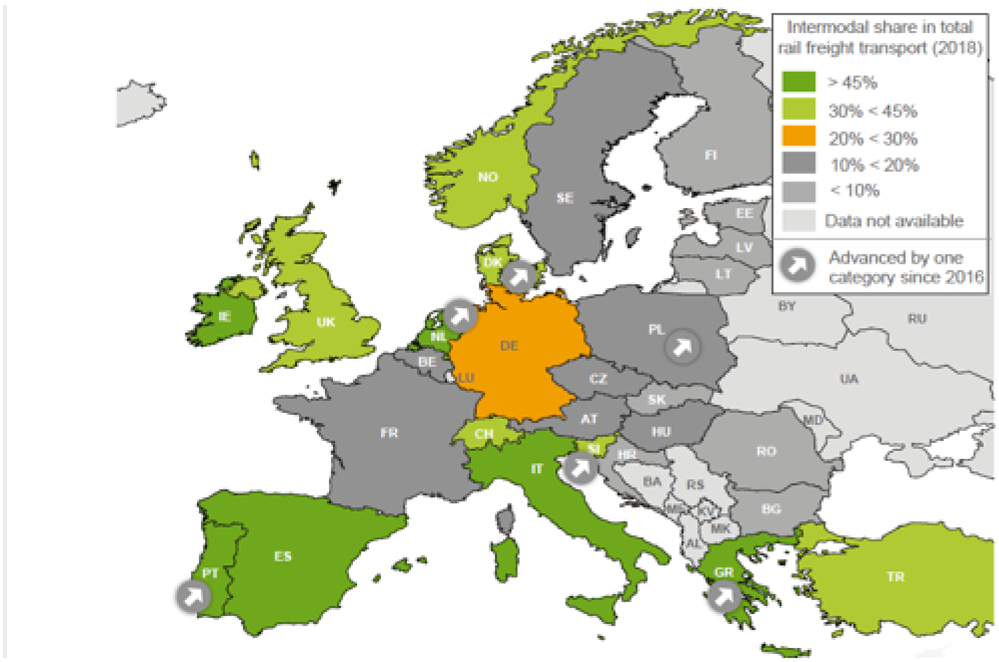


Fig x intermodal rail freight transport in Europe in % of rail freight tkm in 2018 – source UIC freight department, 2020 report on combined transport in Europe, November 2020

	ROAD	RAIL	INLAND WATERWAYS	PIPELINES
EU-28	73.3	16.5	5.8	4.5
BE	72.4	10.1	15.3	2.2
BG	54.8	17.9	24.0	3.2
CZ	70.5	25.9	0.0	3.5
DK	80.6	10.5	-	8.9
DE	71.4	17.3	8.6	2.8
EE	55.6	44.4	-	-
IE	99.1	0.9	-	-
EL	98.1	1.8	-	0.1
ES	90.7	4.9	-	4.4
FR	84.2	10.1	2.3	3.4
HR	64.7	17.7	5.6	12.1
IT	81.3	12.8	0.0	5.9
CY	100.0	-	-	-
LV	24.3	69.2	-	6.5
LT	32.8	65.6	0.0	1.7
LU	88.3	5.9	5.8	-
HU	59.3	30.7	4.6	5.5
MT	100.0	-	-	-
NL	46.8	5.6	42.3	5.3
AT	58.4	28.4	2.6	10.7
PL	69.6	21.9	0.0	8.4
PT	84.1	13.8	-	2.1
RO	41.5	29.5	26.8	2.3
SI	64.5	35.5	-	-
SK	53.5	27.7	3.1	15.7
FI	72.4	27.3	0.3	-
SE	69.8	30.2	0.0	-
UK	85.6	9.1	0.1	5.3

Fig x : modal split of freight transport on land by country - data 2017 – source Statistical pocket book 2019

The service level can improve because of accessibility developments and frequency of train/ships, also in synergy with transit traffics.

a. The role of transport nodes for maximizing benefits

When the traffics just crosses the Disadvantaged Regions having elsewhere their Origin/Destination, the benefits can be identified in the additional activities to be performed in the connecting facilities (either internal and/or costal) and in the activities supporting the transport segments and the logistics activities.

For better exploiting the derived benefits it is important to coordinate the territory planning according to principle already experienced in “similar” situations supporting both inbound and outbound flows.

In such perspective the physical nodal points connecting line segments in the transport network have a key role for contributing to the developments in the areas they serve both for transit ("Close to Port" or Close to Transshipment") and distributing goods in related traffic attraction zones ("Close to market").

The highest potential in EGNT perspective may derive from the combination of the above mentioned situations applying co-modal principles. The idea behind the traffic attraction zone connectivity/accessibility to EGTN in the favored regions, but more so in the Disadvantaged Regions is the shortening of the two dimensions of SPACE and TIME which constitute the service variables of Transport and Logistics. The Nodes in the traffic attraction zones are fulfilling a geographical role of bringing the manufacturing factories nearer to the Ports for their intercontinental trades or nearer to the market for the distributions to the consumers whichever applicable. This approach contributes in EGTN perspective to reduce the mileage both in the primary transport legs and in the final one to origin/ destination as well as in optimizing co-modal roles. But the two variables of SPACE and TIME, in order to produce their maximum benefits, have to be managed in combination. So in addition to geography resolving the physical accessibility to/from the Traffic Attraction Zones one has to perform and fulfill the comprehensive service dimension related to complex and long Supply Chains full of gaps and problems to be overcome. In this respect the Nodes assume a pivotal role in EGTN providing all types of accessibility both physical and virtual.

These are the places where different barriers such as:

- Language
- Administrative/Financial
- Technology
- ICT and infomedia
- Management
- Economy of scale
- Handling and Engineering

just to cite few, can be overcome.

The Role of logistics is complementing and supplementing Transport legs by delivering Values towards the completion of the Supply Chain transactions.

Having focus on the West-East route, it is important to put attention to the transshipment functions of nodes for the rail traffic when entering EU territory because of gauge difference. That creates the need of train stop that can be combined with other operations in the same area and/or routing optimization. The entry points in the EU can be also a privileged location for administrative procedures and other indirect activities dedicated to the cargo and to the transport means.

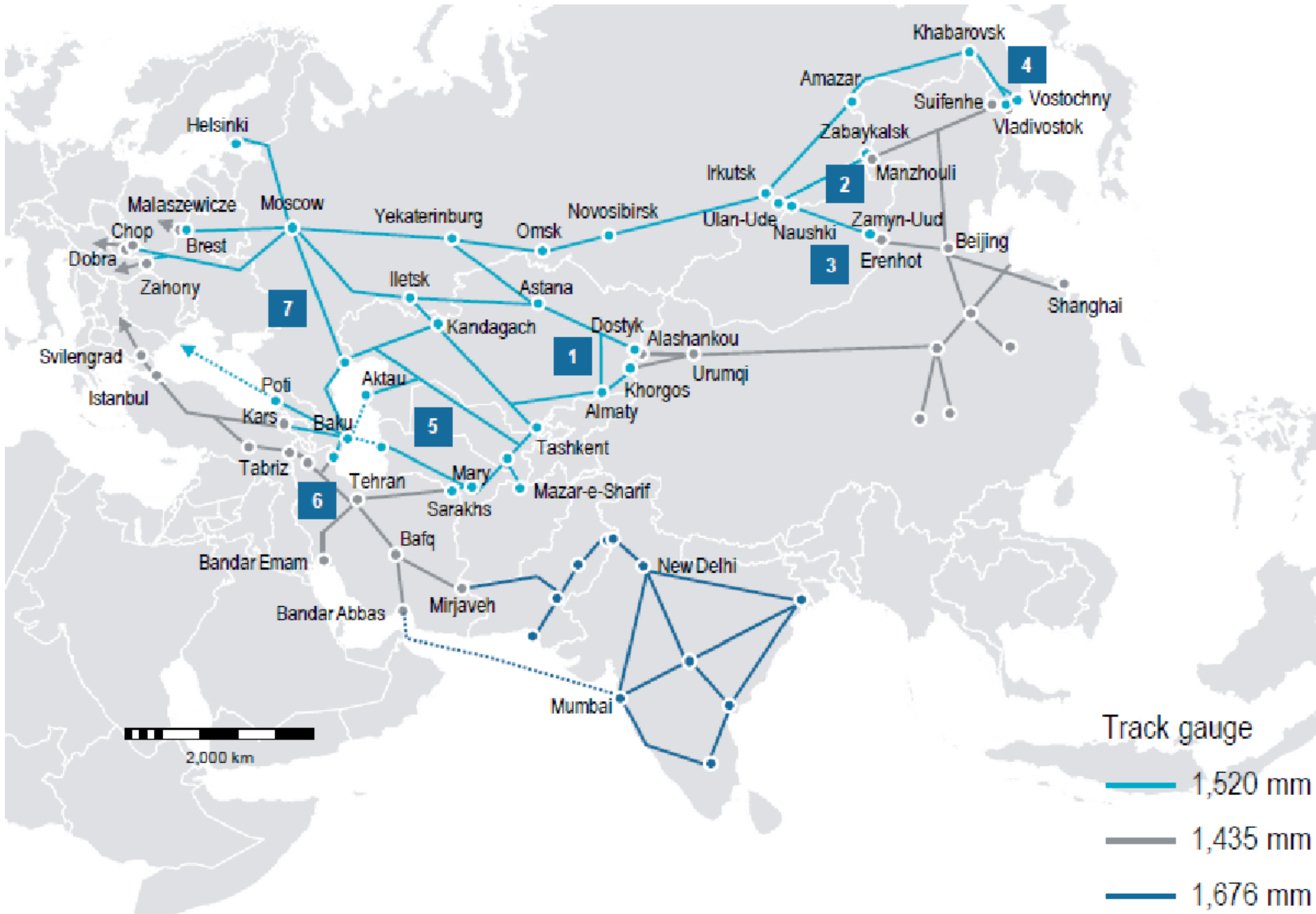


Fig x Gauge in different territories – source UIC & Roland Berger - Eurasian Rail corridor 2017

While the focus of the above and following considerations remains, the benefit to industrial sectors and the general regional economies, a relevant impact is with the transport industry.

An example of this can be the PKP CARGO Group performance. PKP CARGO Group was established in 2001 and soon became the leader in freight transport in Poland and the second largest operator in the European Union.

PKP CARGO debuted on the Warsaw Stock Exchange in 2013.

b. Models of inland terminals development

The development models, with focus on inland nodes more potentially involved in the West-East route, have been grouped according to the following categories:

- Dry ports
- Gateway/hubs
- Freight villages

Some highlights about each model are summarized in the following paragraphs.

The different models are not in alternative as the different functions can be consolidated, as appropriate, in individual locations according to local territory potential and local governance.

The development of new functions does not require necessarily to add facilities in new locations, but to develop, where possible, infrastructure and services enhancement aiming to the defined targets.

Nevertheless the infrastructure in terms of terminals shows relative low density in large territories included in the Disadvantaged Regions.

Similar considerations about infrastructural density can apply to transport lines including both rail and infrastructures waterways.

I. Dry ports

The "dry port" model is a good example of solutions for maritime traffic where available space in sea ports is in short supply. In fact a sea port is putting the sea in contact with land surface and is equivalent to a very busy cross road where continuous traffic flows are transiting. The idea behind the Dry Ports is to allow continuous uninterrupted traffic flows through the sea ports towards hinterland destinations.

While managing such a space constraint the dry port can support smarter operations in term of long/medium distance connections as well as logistics functions including urban logistics.

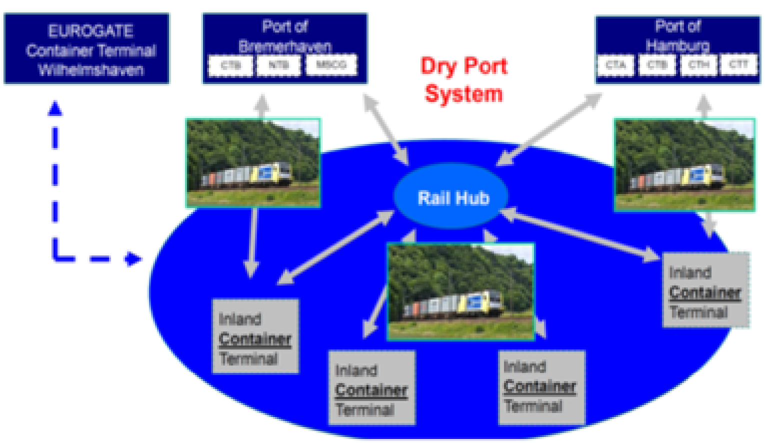


Figure x: Dry Port system supporting Bremerhaven and Hamburg – Source: TIGER project, 2013

The Dry Ports in addition to be able to absorb high volume traffic in an industrial way and by so doing decongest the Sea Ports, can fulfill additional logistics and distribution functions such as Customs, Health

Phytopathology controls, Handling & deconsolidation, Repacking, City & return logistics, Last mile deliveries, improving greatly the accessibility to the World Commercial Network and therefore to EGTN.

Examples of hypothesis of applicability of the dry port model may be Costanza and Gdynia, as well as any other sea port location contributing to EGTN development even in not Disadvantaged Regions.

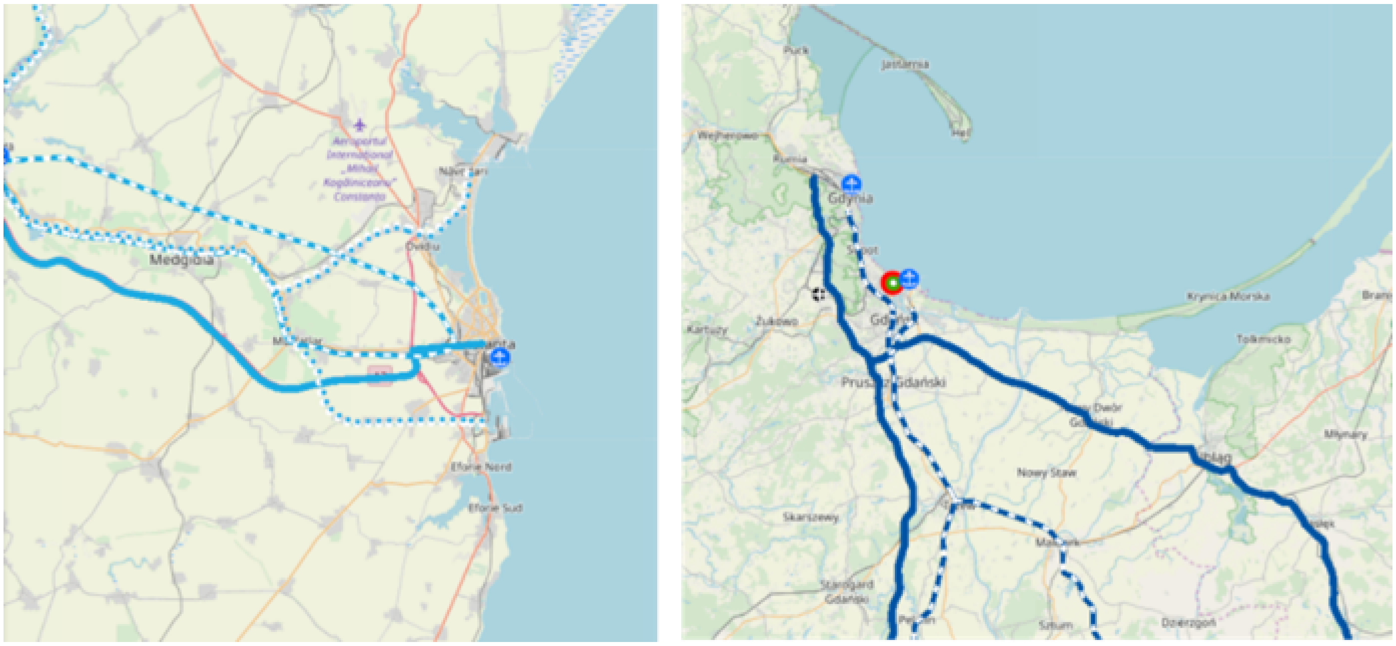


Fig x : Costanza and Gdynia as examples of Ports in Disadvantaged Regions where developed dry port functionalities – source https://ec.europa.eu/transport/infrastructure/TEN-Tec/TEN-Tec-portal/map/maps.html

II. Gateways/Hubs

The "gateway/hub" model is another solution with internal intermodal terminals allowing to reassemble traffic segments according to the different traffic lines. It is also appropriate for achieving synergies between traffics of different nature (for instance traditional traffic with containerized traffic). Places where multi corridors meet are natural nodes for such gateway/hub functions, but other locations may be also interesting depending upon specific local situations.

In the pictures below there are

- Visual representation of the model
- Examples in Budapest and Warsaw as corridors intersections in Disadvantaged Regions.

The examples have been selected choosing big urban areas where potential synergies can be found also with the "freight village", model including metropolitan logistics functions.

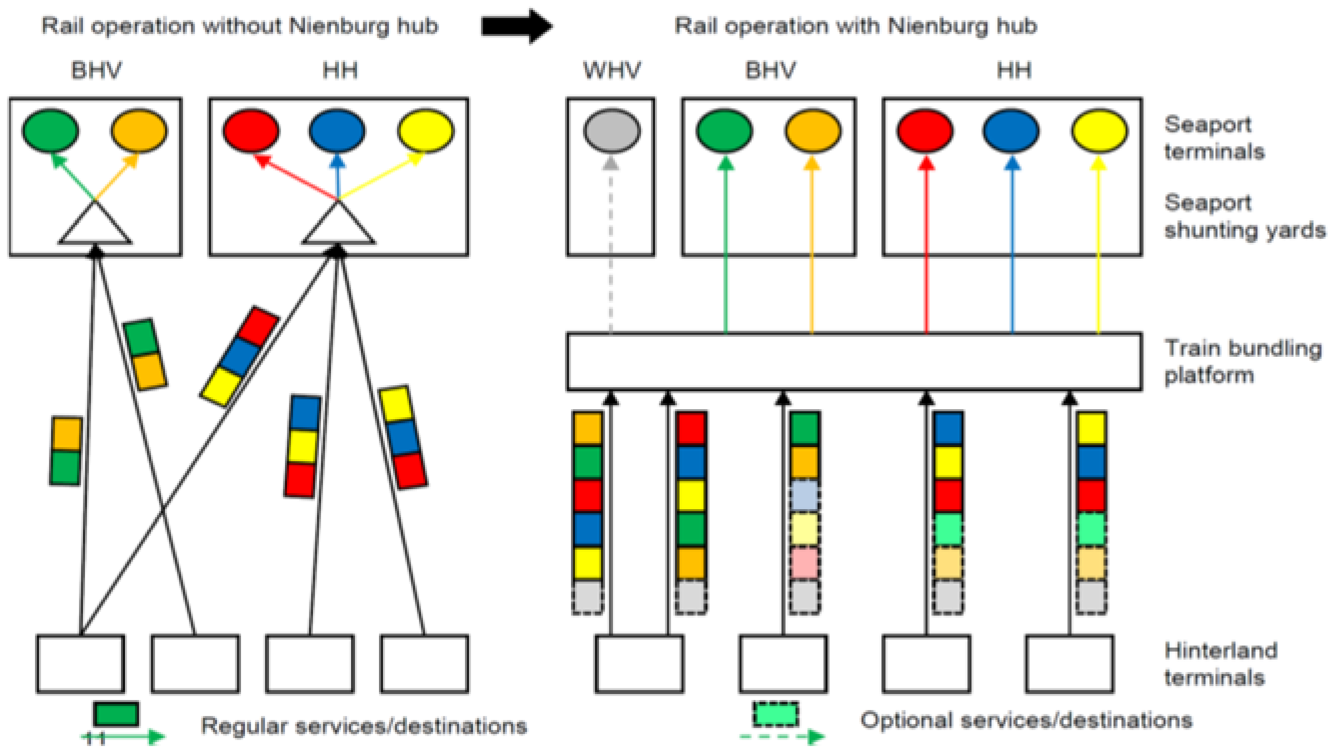


Fig x : Gateway/Hub model applied in Nienburg – Source: TIGER project, 2013

Fig x: Warsaw and Budapest as examples of corridors' interactions in Disadvantaged Regions - https://ec.europa.eu/transport/infrastructure/TEN-Tec/TEN-Tec-portal/map/maps.html

III. Freight Villages

The “freight village” model is a solution close to the industrial park model, capable to hosting value added activities in distribution/collection centers up to light manufacturing facilities. It is appropriate for “free zone” policies and in general for relocation of industrial activities (for instance near shoring) encouraged also by new offerings of infrastructures and services. Of course also existing logistics operations can consider the opportunity to move in better locations reducing mileage and improving accessibility to EGTN

Locations becoming inbound/outbound nodes driving significant new traffic flows, developing new European logistics roles. An exemplary experience to underline is, at the beginning of this century in the BeNeLux area, the development of European Collection/Distribution Centers. This development was based on a dedicated market research which results indicated that this region was the most favored one in the whole of Europe from a Transport Logistics stand point. Similarly it may now happen in Eastern Countries.

As anticipated while commenting the “dry port” and the “gateway/hub” models, the logistic functions can support also urban distribution. This is in general an EU guideline under development in H2020 projects for mobility aiming at facilitating CO2 reduced footprint and service developments better supporting co-modality. This is an extension of the "zero mile" principle in co-modal perspective aiming at minimizing transport legs and road mode in most sensitive areas because of population density such as urban areas. It may be applied also in Disadvantaged Regions in proper comprehensive approaches.

As can be observed in the picture below, several locations in “Disadvantaged Regions” in Eastern countries are emerging since few years as most desirable logistics locations. They are attracting investments for qualified building to be dedicated both to logistics and to industrial parks.

The cost of labor and other incentive policy are of course supporting this evolution. Also taxation may be part of such policies. As a consequence some Distribution Centers for e-commerce have been located in Eastern countries serving both European territories as well as other countries such as Russia. So the expectations to increase/add activities in the Disadvantaged Regions can continue by exploiting already existing experiences. About e-commerce it is useful to remind that some services collateral to strictly defined logistics services, such as call centers supporting customer service, have been already located in Eastern European countries. This may facilitate the development of new ICT enabling services and other value added services supporting logistics to be located in Eastern European countries. Embryonic examples of that may be already recognized and some universities appear to be “incubators” of such new capabilities. These kind of services would in particular support the development of value added operation to be performed in freight villages.

The European or multicounty functions for e-commerce is often combined with local functions serving traditional distribution channels. In fact this kind of synergies may be significant both for inventory and for operations.

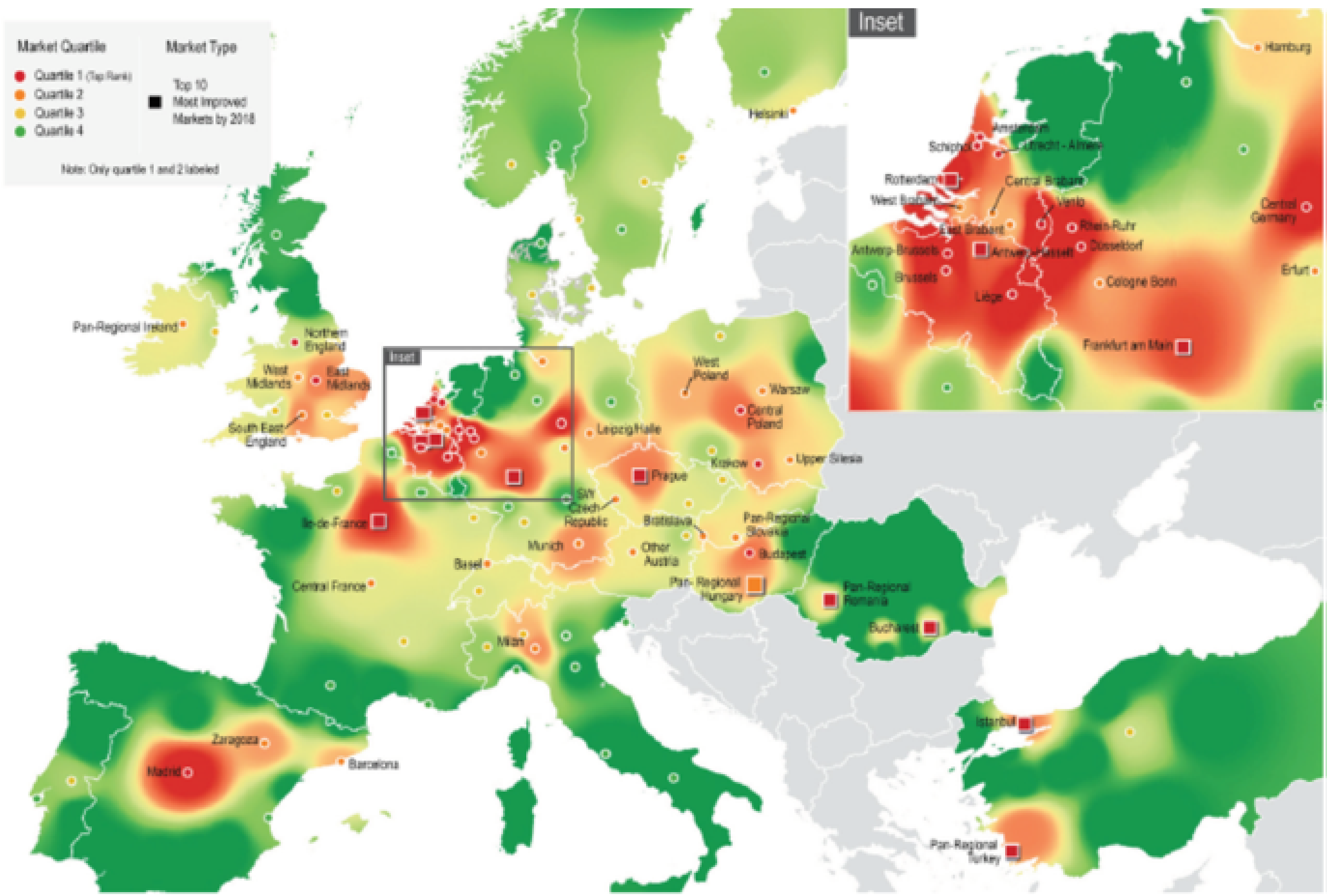


Fig x : European most desirable logistics locations – source Logistics facilities user survey eyefortransport/ Prologis 2013

c. Rail lines development needs

In EGNT perspective, the electrification of rail track is a major point of attention.

However all “modernization” items are important and the compliance with the TEN-T Core network looks still on its way to be completed.

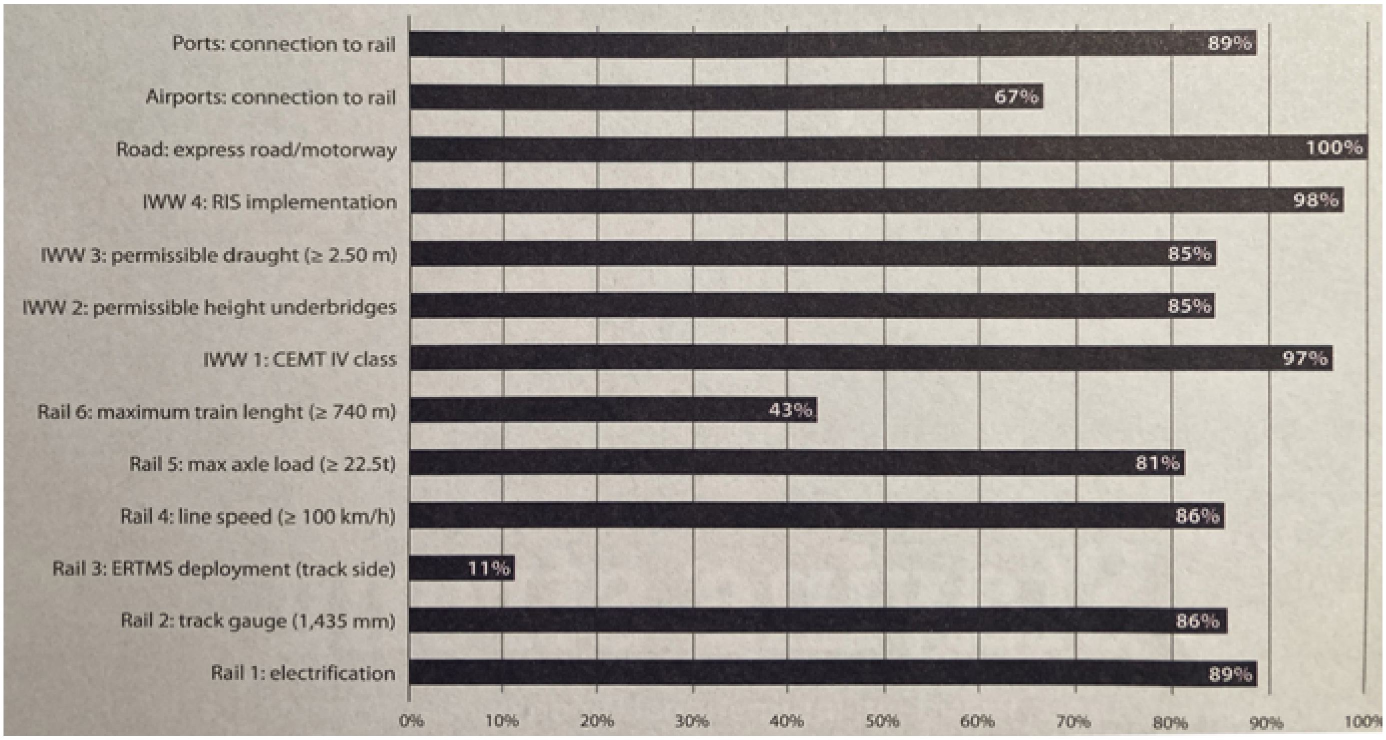


Fig x – Compliance in % for the TEN-T Core network – source "A patchwork of excellence, failure, and everything in between" – Baltic transport Journal June 2020

The quality of EU rail lines in the countries of entry into the European Union, seems to be an issue such as in Poland even if progressive improvements are taking place. In fact, in addition to slow entry operations, the average commercial speed on the rail lines appear still unsatisfactory and below the average in upstream rail segments (https://www.ferrovie.info/index.php/it/archivio/archivio-news-2018/13-treni-reali/5060-ferrovie-la-russia-aggira-l-ostacolo-della-polonia-sulla-via-della-seta).

While completing the Core Network Plan and moving on the Extended Network Design, a point of attention is the following. The Corridor concept is a "linear" principle connection while most of the countries and their major economic center have a "radial" connectivity design.

Here below is reproduced the Czech Republic example. This shows that the lines developments need to consider this particular requirement in order to enable the maximum co-modal shift efficiency and effectiveness.

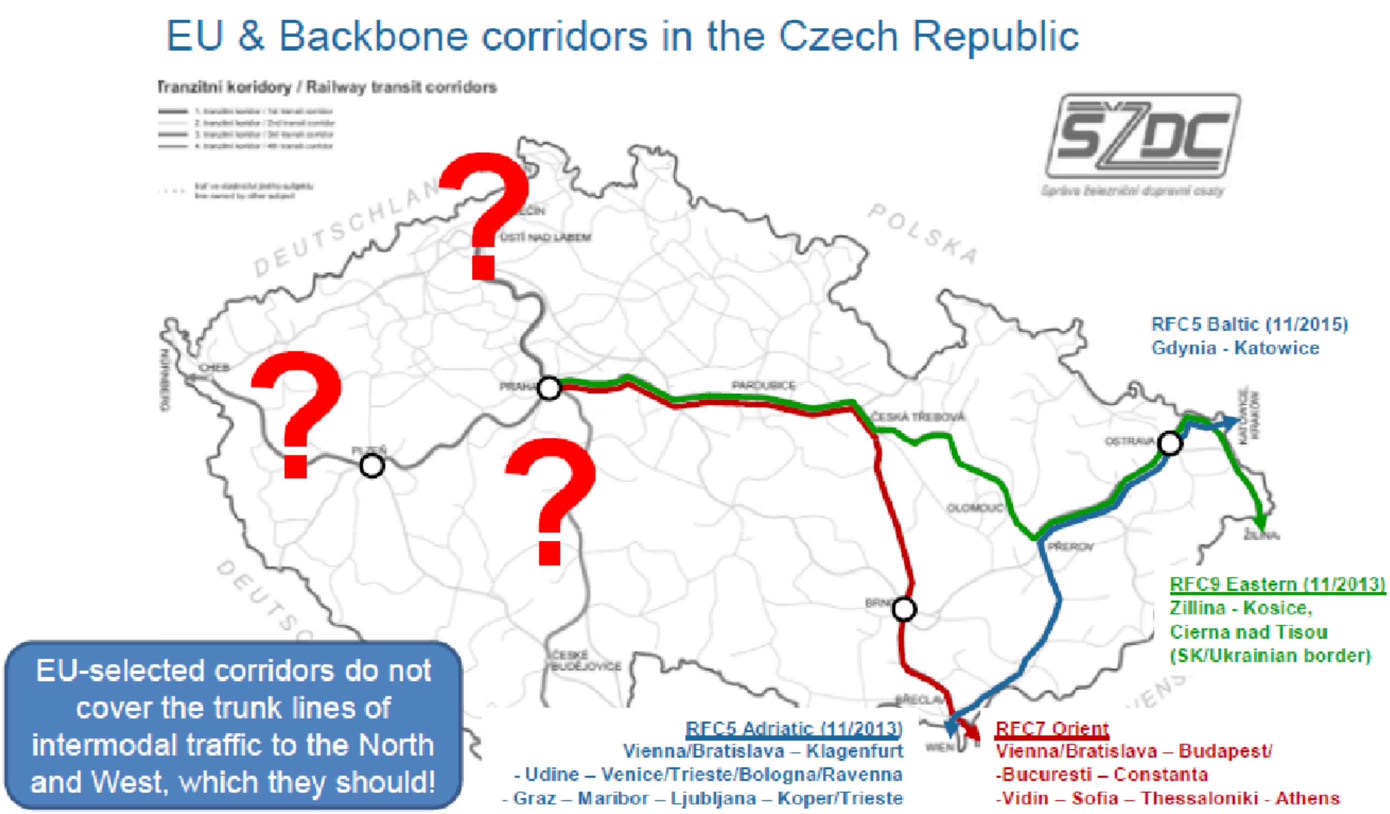


Fig x Track line needs in Czech Republic - source Uwe Sondermann, KombiConsult GmbH - Intermodal Round Table and Road Map for the Czech Republic – COSMOS project www.intermodal-cosmos.eu 2013-14

Regarding the large gauge lines penetrating EU, a number of different considerations can be done.

Even if unification of standards and interoperability principle require minimizing investments in technologies, the existence of long leg of track with large gauge, represents assets to be taken into account.

8. Exemplary hypothesis of actions and case studies

a. Hypothesis of actions

Multiple actions may be part of an evolutionary plan depending from specific geographies and from the contribution of individual new routes generating opportunities and synergies. Some hypothesis may be considered even without the impact of new routes, but additional reasons for improvements may be the reshaping of actions for unveiling additional value.

The following considerations are related to Disadvantaged Regions in Eastern Europe having significant rail implications, with focus to the West-East route in an EGNT perspective.

I. Expand infrastructural capacity

Having in mind the significant rail traffic increase generated by these new Chinese routes, forecasted in recent times, the capacity plans need to be consequently adjusted.

The main infrastructural topics are:

- inland terminals
- rail lines.

The capacity topics are to be addressed simultaneously including the technology dimension both on the infrastructures and on their management as well as on the ICT for maximizing the capacity utilization.

Inland Terminals – Transshipment transit traffic

It is appropriate to start with terminals because of transshipments' needs. Transshipment from broad gauge to European one is only one of the several functions of an inland terminal but is a key role in Belt and Road Initiative as well as for any other traffic between Europe and the Eastern countries.

Fig x: example of Transshipment equipment for CTR

Other technologies as (automatic) gauge changer exists but, at least for containers, transshipment is still the cheapest solution.

The transshipment additional capacity is needed according to the expected traffic increase and to this effect, actions are already progressing in this direction.

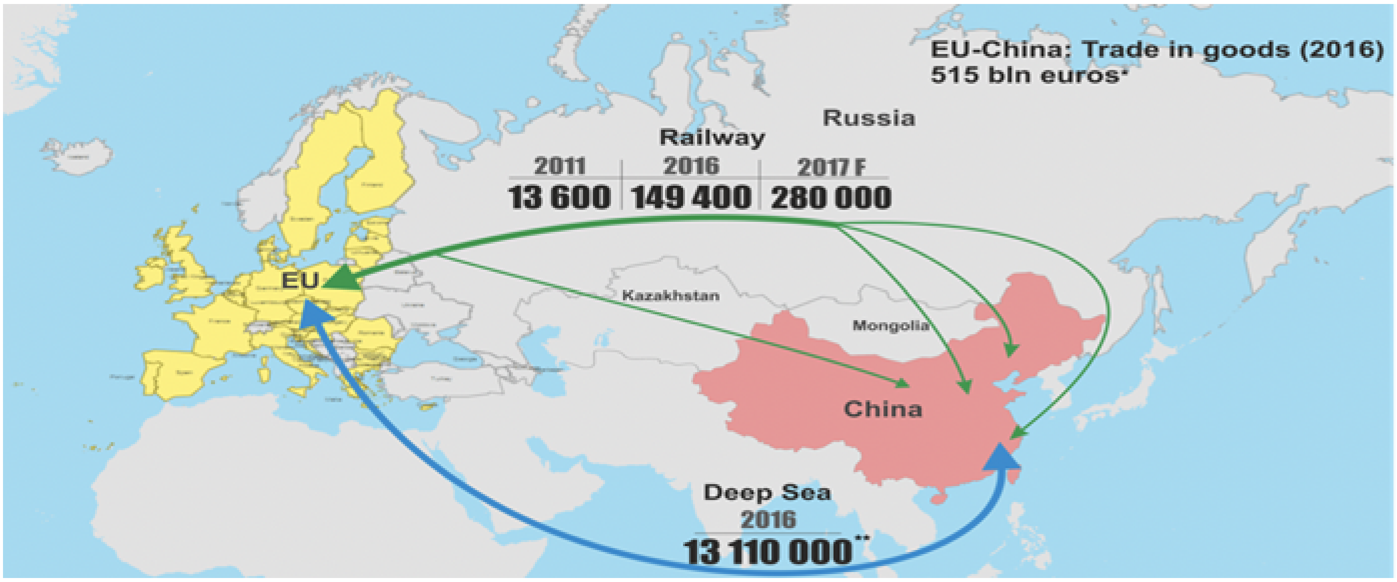


Fig x: EU-China trade in goods (rail-deep sea) in 2016 (in TEUs) - Source: FERRMED, November 2017, re-elaboration on Eurostat 2017 database

It is appropriate not to forget that capacity must not be concentrated in a single location, especially considering volume projections (636 kTEU at 2027, 810 at 2030 – source UIC and Roland Berger – with segmented data of shift from sea and air – at 2027 best scenario 742 kTEU, worst scenario 437 – 1000 kTEU at 2025, source UTCL-ERA).

In fact, the scale factors become more easily achievable in several locations with the overall traffic increase allowing to avoid unnecessary concentration. The risks include not only geopolitical but also industrial issues since any temporary traffic interruption would be extremely dangerous.

In such hypothesis, the possible candidate locations may be in Countries South of Poland, leveraging connections with existing Corridors in addition to North Sea – Baltic Corridor. Of course, such options should find mirroring actions in extra European Countries such as Ukraine with which Transport partnerships exist already. Unfortunately, the state of rail lines in the Ukraine is not very good.

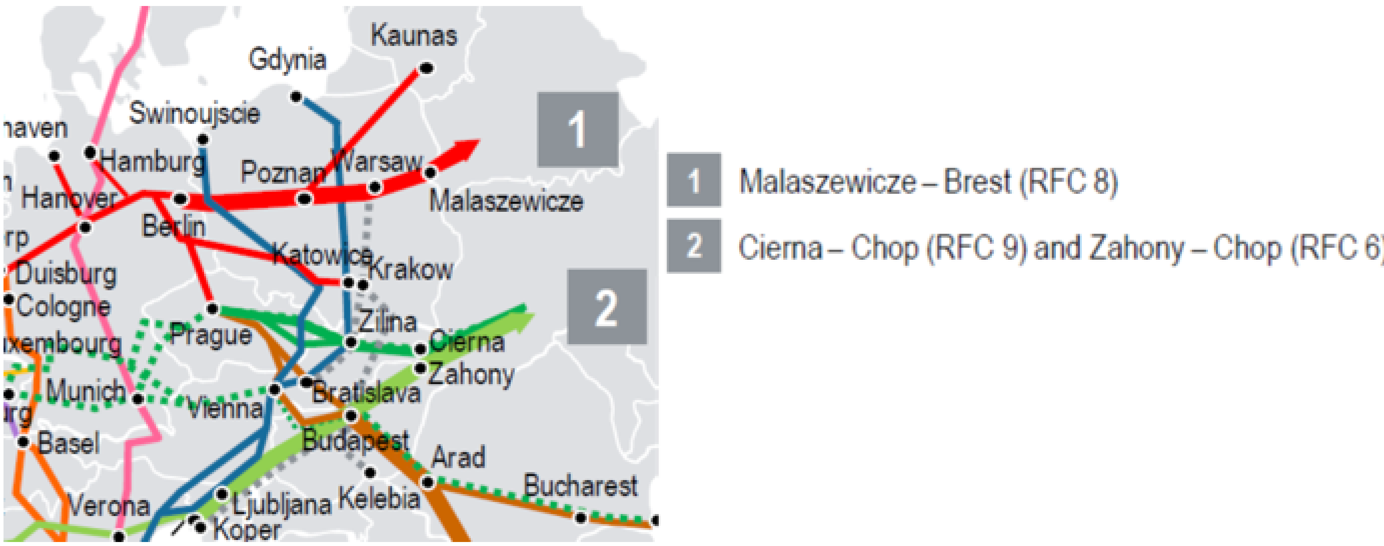


Fig x EU main entry points from Asian traffic – source UIC & Roland Berger - Eurasian Rail corridor 2017

Both "Northern" and "Southern" route alternatives require to fill relevant performance gaps managing a number of variables, not only deriving from infrastructural issues.

Parameter	Importance for rail link	Gap 2017	Changes since 2011 and comments for the Northern Routes
Transport time		↗	> Speed gains of approx. two days since 2011 > Gaps seen mostly inside Europe (slow transportation, delays)
Reliability		↗	> Rail now more reliable than sea > Especially shippers still see need for improvement and more information
Balanced quantities		→	> Continuously smaller eastwards transport volumes, changing only slowly > Alternatives like multi-leg returns make transport more complicated
Target goods		→	> Suitable goods are targeted and LCL offers were introduced > Still potential, e.g. in chemicals, temperature controlled goods and air freight
Price		↘	> No pure price competition but more competition through low sea freight rates > Potential for more cost efficiency and less dependence on subsidies
Frequency, flexibility		↗	> Frequency increased strongly in recent years > Many trains are still on request instead of regular trains
Target geographical coverage		→	> Network has increased in past years > Next step should be consolidation for more efficient geographical coverage
Availability		↗	> Imbalance of traffic complicates return of platforms/containers
Customs		↗	> Improvements in customs in recent years, partly seen as "problem solved" > More potential at Chinese border and through electronic documentation

Parameter	Importance for rail link	Gap 2017	Comments regarding Southern routes
Transport time	●	◕	> Speed slower than Northern routes (e.g. 17-20 days China-Turkey) > Long distance, more border crossings/customs or mode changes
Reliability	●	●	> No established regular services yet > Trial services TRACECA (DHL 2016) with delays of more than 4 days each
Balanced quantities	◕	◕	> Smaller eastwards transport volumes are expected > Need to examine possibilities for multi-leg transportation
Target goods	◕	◑	> Target goods in European O/Ds for Southern routes (East Europe) and in new O/Ds (Turkey, Iran) need to be specified and seasonality considered
Price	◕	◕	> Even greater competition from sea freight through shorter distance and good accessibility of Middle East and East European countries > High network costs in Iran and Turkey
Frequency, flexibility	◕	●	> Routes not established as regular services yet
Target geographical coverage	◑	●	> Routes not established as regular services yet
Availability	◑	●	> Routes not established as regular services yet
Customs	◑	◕	> Many transit countries are not part of a customs unit (Ukraine, Iran, Azerbaijan and Turkmenistan)

Fig: Evaluation of success factors for Northern and Southern routes for Asian traffic – source UIC & Roland Berger - Eurasian Rail corridor 2017

Nevertheless, the Poland entry points look to be the favorite one, at least in common forecast and projecting current situations – including geopolitical issues. Poland seems also managing momentum in a positive way (see following case Małaszewicze case study).

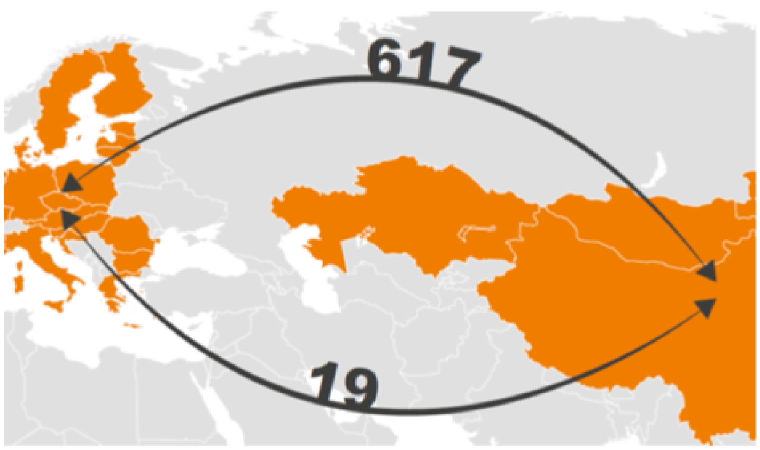


Fig: EU Trade volume distribution between "Northern" and "Southern" routes for Asian ground traffic at 2027 – source UIC & Roland Berger - Eurasian Rail corridor 2017

Inland Terminals – Service to traffic with local origin/destination

Assuming a positive impact on GDP due to intercontinental traffics shift and reduced transport cost gaps in servicing traffic with local origin/destination in the Disadvantaged Regions, the growth in Nodes density in these territories may be necessary. In fact rail terminal accessibility of significant territories may remain still limited, beyond the EGNT development objectives.

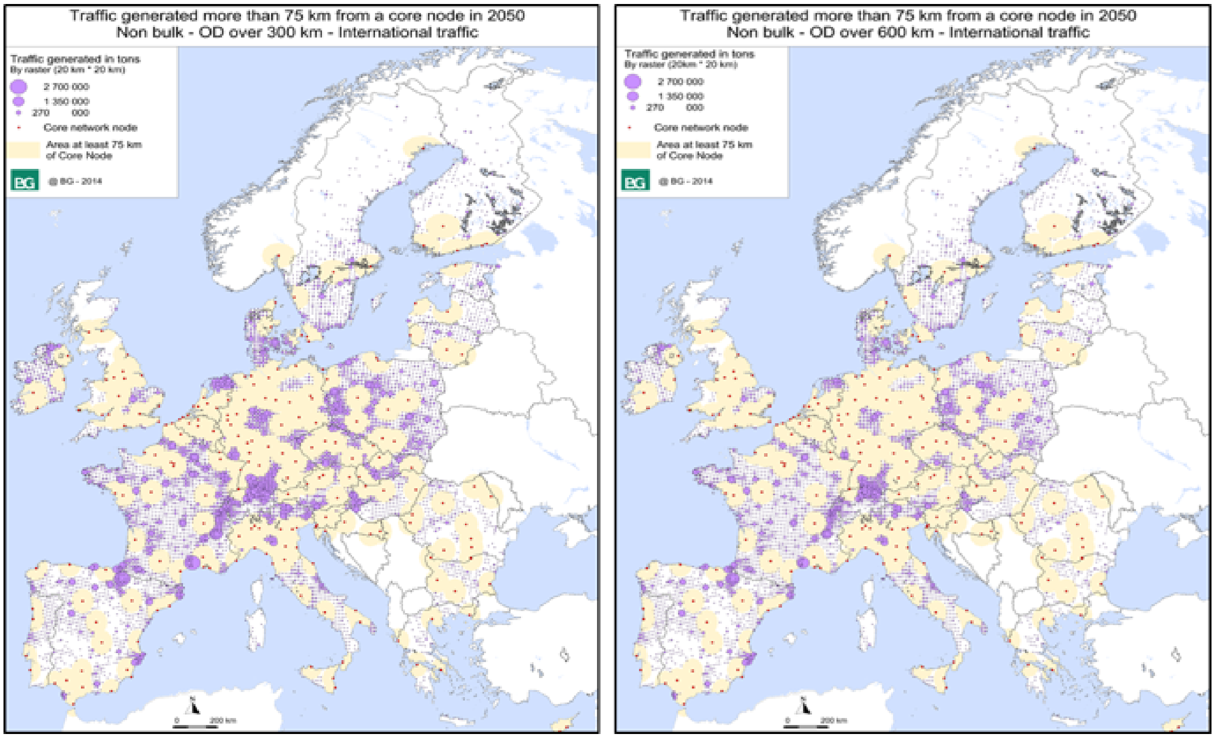
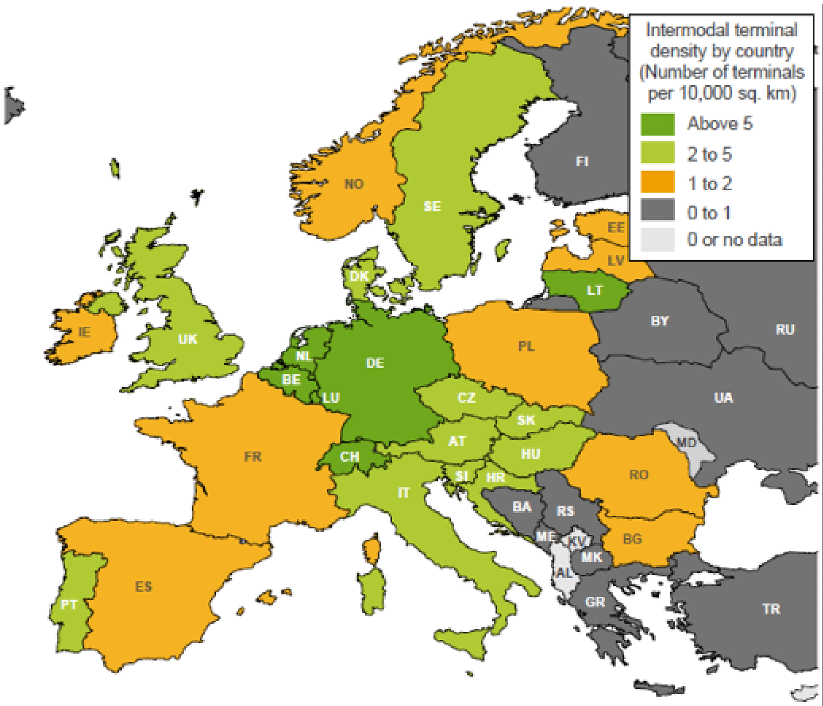


Fig: Traffic generated more than 75 km from a core node - Source; BG Group for NewOPERA 2014 - Road Map 2030-2050 - Towards the implementation of the comprehensive network: derived infrastructure development



Country	No of CT terminals
Austria	23
Belarus	20
Belgium	44
Bulgaria	13
Croatia	15
Czech Republic	22
Denmark	11
Estonia	7
Finland	19
France	101
Georgia	1
Germany	214
Greece	7
Hungary	23
Ireland	7
Italy	76
Kasachstan	1
Latvia	6
Lithuania	7
Luxembourg	2
Moldova	1
Montenegro	1
North Macedonia	2
Norway	34
Poland	44
Portugal	28
Romania	28
Russia	104
Serbia	7
Slovakia	18
Slovenia	5
Spain	51
Sweden	92
Switzerland	50
The Netherlands	30
Turkey	13
Ukraine	19
United Kingdom	58
TOTAL	1,204

Fig: Terminal density in European countries – source UIC freight department, 2020 report on combined transport in Europe, November 2020

The most involved countries such as Poland and Slovakia, show the need to increase rail terminal capacity.

In the picture below is reproduced the example of Poland. The Polish company in charge of infrastructure published an assessment of the need to increase capacity and the indication of candidate locations. Investments are accordingly in place both for lines and for terminals.

In the previous chapters the example of Slovakia plans has been also reported.

Some information about investments in terminals and close line bottlenecks, with reference to border transshipment facilities, can be found in the dedicated sections.

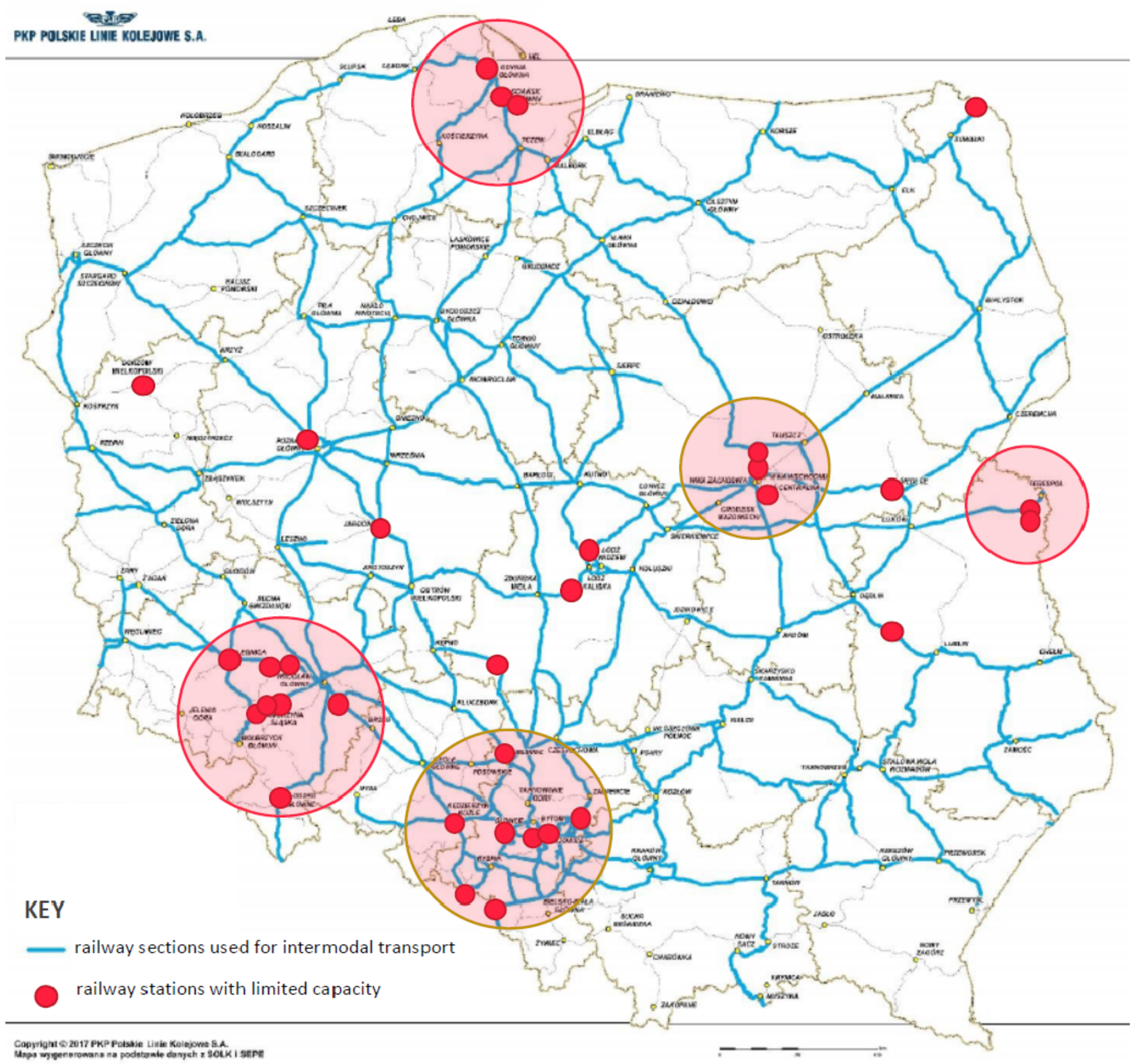


Fig: Poland - Railway lines used for intermodal transport in 2016 and current terminals bottlenecks – source European Commission, Analysis of the potential of the development of rail container transport market in Poland - 2019

Rail Lines – long distance

The Rail lines capacity and any congestion problem existing thereto may be drivers for preferring alternative routings, when line segments reach the European borders meeting the TEN T network. In fact the distance is not the only routing driver.

So the lines' capacity need to be adjusted according to traffic growth expectations and these actions need to be coordinated with the expansion of inland terminals.

As shown in exemplary TEN-T projects, the development of new lines or the restructuring of existing ones is the major focus of investments. Often the new investments develop new High Speed Rail that have limited potential for freight but free capacity in existing rail lines.

An important potential for increasing capacity for freight is related to the limits for train length. At present the regulatory (TSI - Technical Specifications for Interoperability) objective is to harmonize national limits and to allow train length of 740 m in the entire Core network.

Developments are in progress, even if not in line with expectations.

CER is monitoring progresses and related issues (http://www.cer.be/publications/latest-publications/longer-trains-facts-experiences-europe-0).

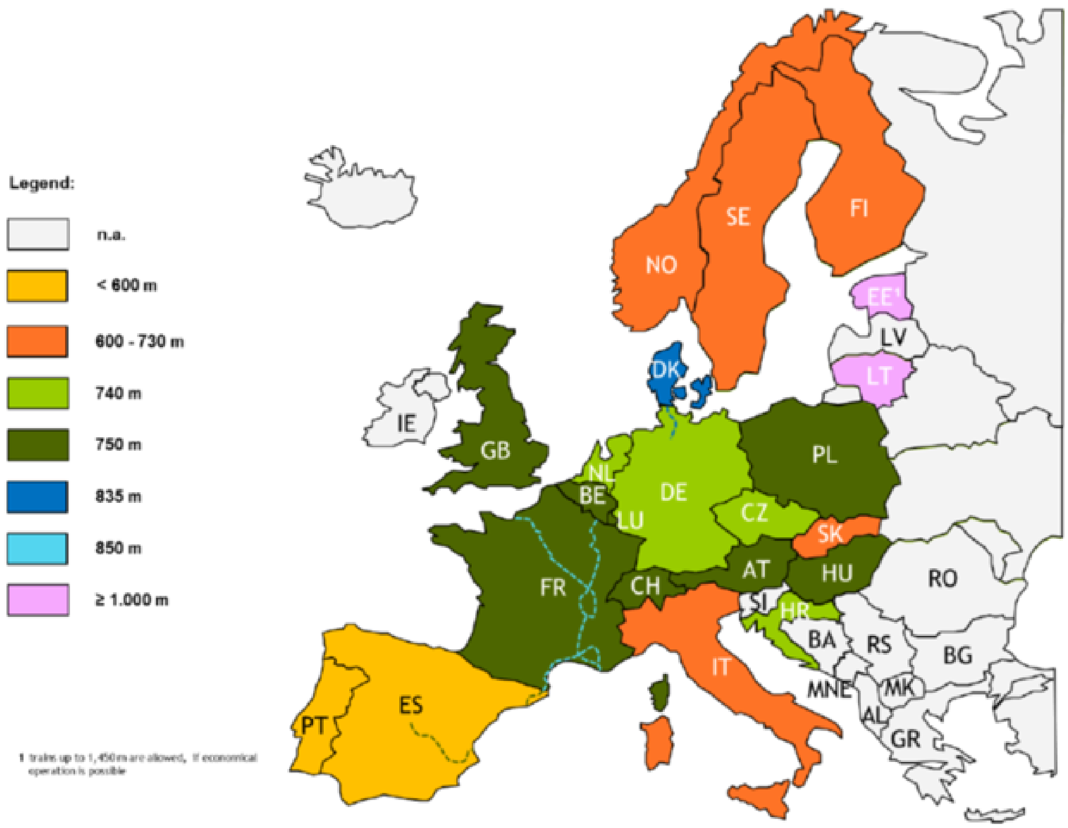


Fig: Max. train length per country – source: CER Longer trains - Facts & Experiences in Europe - Results of the CER working group on longer and heavier trains - 2018, 4th edition

Nevertheless the 740 m length cannot be the objective especially in the corridor segments with highest traffic where capacity may become not sufficient and expanding capacity with traditional solutions may be highly expensive and requiring long time.

The Marathon train (see afterward the case study) demonstrated the feasibility of doubling the train length so increasing the capacity with relatively small investment (http://www.cer.be/publications/latest-publications/longer-trains-facts-experiences-europe-0).

In fact the adjustments to the rail infrastructures are necessary although in rail terms of relatively modest nature. They include lengthening the overtaking rail sidings on the corridors, modification of rail tracks length at the departing and arrival terminals and for assembly and disassembly maneuvers.

Specific attention should be dedicated to lines connecting Eastern neighborhood countries where train length is commonly longer. In fact in Byelorussia train length is 910 m (in Russia 994 m) while in Poland it is currently 600 m. (https://www.ferrovie.info/index.php/it/archivio/archivio-news-2018/13-treni-reali/5060-ferrovie-la-russia-aggira-l-ostacolo-della-polonia-sulla-via-della-seta). **(Ukraine? Moldavia?)**

Terminals at border are already organizing themselves to cater for tracks above 1000 m in order to move containers quickly from train to train without additional maneuvering.

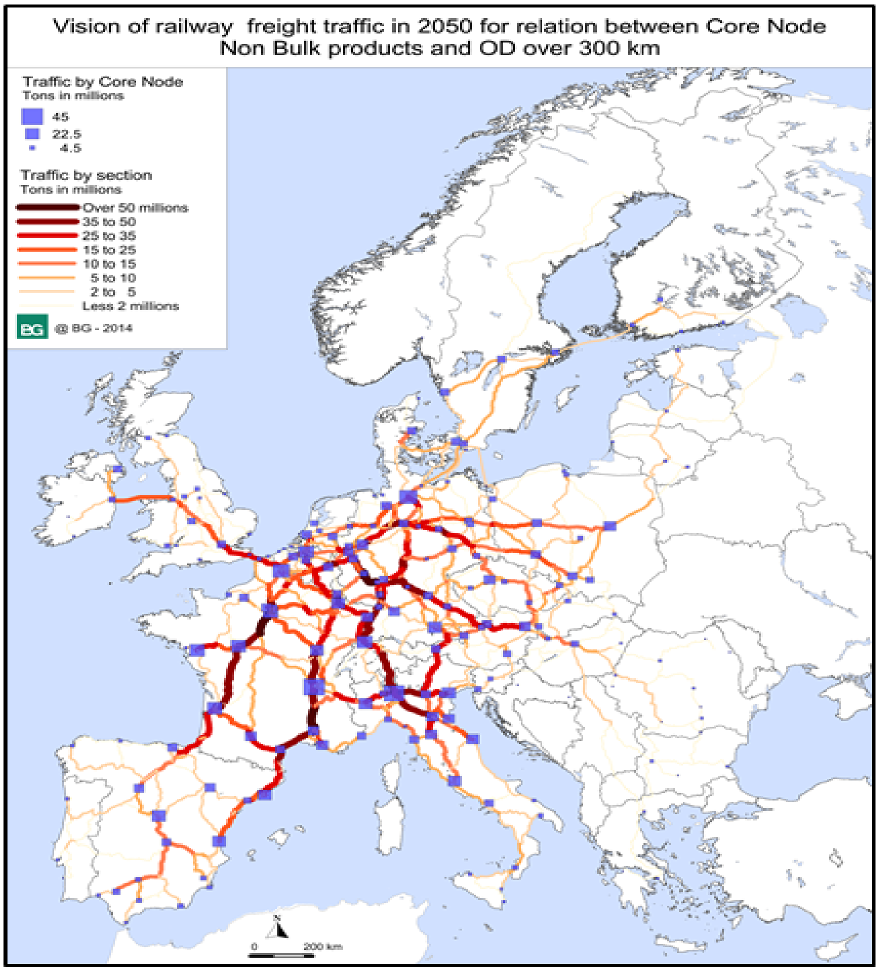


Fig: Railway traffic relation between Core Nodes - Source; BG Group for NewOPERA 2014 - Road Map 2030-2050 - Towards the implementation of the comprehensive network: derived infrastructure development

II. Increase logistics capabilities

The Logistics capabilities of inland terminals may increase according to the exemplary models above described (Dry port, Gateway/Hub, Freight Village) developing the particular aspects best suited for specific geographies, local markets and territory/industrial ecosystems.

The logistics capabilities develop with the establishment of new regular train services connecting directly and/or via gateway a given location or community or industrial district as applicable.

In any case the benefits from general and/or specific synergies may accelerate and facilitate the positive evolution in an overall EGNT perspective.

b. Case studies

I. Exemplary terminal facilities at Malasczewicze - Poland

The Małaszewicze terminal is located on the main transit route from the European Union to Russia serving the Belt and Road Initiative.

Situated in Eastern Poland, it is 5 km from the Belarusian border and 120 km from the Ukrainian border.

The facility covers a large area including

- railway connection - European and Russian standard tracks with capacity to load from train to train, from train to truck, from truck to train
- compound area and free Customs Zone.

Fig x : Car Terminal in Małaszewicze, source https://www.adampolsa.com.pl/en/terminals/#:~:text=Ma%C5%82aszewicze%20terminal%20The%20Ma%C5%82aszewicze%20terminal%20is%20located%20on,connect%20Western%20Europe%20with%20Eastern%20Europe%20and%20Asia

There is a number of projects ongoing in order to develop capacity and offerings.

A major comprehensive project is dedicated to the modernization of tracks and related infrastructures as well as the higher capacity of the intermodal terminal. The works will start at the end of 2021 and will last until the end of 2028. The handling capacity (also thanks to new 1050 m tracks an axle load of 25 ton per axis), will growth from the existing 14 pairs of trains per day to 55 pairs of trains per day (these figures include only the capacity of the broad gauge tracks).

“When the works are completed, the Małaszewicze Reloading Region will have an area of 30 square kilometres. The project also includes some other improvements in rail infrastructure of the transshipment region such as the higher speed of freight trains and higher axle load. More details will be unveiled after finalizing the feasibility study” (https://www.railfreight.com/intermodal/2020/08/07/pkp-cargo-to-increase-capacity-of-malaszewicze-terminal/?gdpr=accept&gdpr=accept).

Another important project includes a new bridge via the Bug River to be completed by 2023 in order to increase the capacity of the railway border junction. A new bridge with a double track will be added to the two existing single-track bridges. Besides the new bridge, other infrastructure projects are related to modernizing the stations of Terespol, Małaszewicze, Biała Podlaska and Kobylany.

Recent investments included an additional broad gauge track installed on the Terespol – Kobylany section in 2017. Some other tracks as well the modernization of the signaling equipment allowed to increase train speed from 40 to 60 kilometers per hour.

To be mentioned there is also the "increased track capacity on the Polish-German border. In 2016 a new bridge across the Lusatian Neisse river was opened. It enabled increased train speed from 50 to 120 kilometres per hour on the Węgliniec–Roßlau cross-border railway" (https://www.railfreight.com/policy/2019/01/24/poland-to-add-new-tracks-near-malaszewicze-terminal/).

In parallel the operational capacity is growing with the storage capacity in Małaszewicze to be increased from 2.5 million TEUs to more than 15 million TEUs in 2026. Investments in new locomotives and flatcars will allow to provide additional and better intermodal services.

Fig: Railway near Małaszewicze, source: PKP PLK - https://www.railfreight.com/specials/2019/05/21/poland-improves-rail-infrastructure-near-malaszewicze/

II. "The Marathon train" of 1500 m

This paragraph shows as exemplary case study of "longer and heavier trains" - the Marathon train. This case study has been selected for representing a major rail freight transport opportunity and technological innovation with the fundamental contribution of the EU Commission having co-financed the Marathon project.

The Marathon train concept is based on coupling two trains of 750 m each, with the second locomotive radio commanded by the front one. Each of the two locomotives contributes to the traction, and to the electric and pneumatic braking specifically in accelerating the braking and releasing of the pneumatic braking.

The Marathon project executed two trials with Kombiverkehr, not theoretical but effective trains, originating from Germany and destined to Spain.

On the 18th January 2014 Marathon performed the first demonstration phase of the project with the operation of a 1.5km long Marathon freight train across France. The test was conducted by Marathon partners with 2 electric locomotives BB37000, from Alstom. It took place between Lyon and Nimes and was very successful in demonstrating the practical developments stemming from the project. The braking system responded like intended and the communication system between the master and the slave locomotive worked without flaws. To add to the accomplishments, the train travelled at 100 km/h for long stretches, which is the same speed as that of standard freight trains.

The second pilot was carried out on April 12th. What set the difference from the first pilot was the use of two diesel locomotives, whereas the first pilot included two electric locomotives. Two Euro 4000 locomotives from Vossloh with the requested Marathon modifications were used to haul a train of 1,524m length, with 72 wagons and 4,020 tons. The results were equally satisfactory.

Vossloh Euro 4000-12th April 2014 : 1524m – 72 wagons – 4026 tons

Fig x Marathon Train 1500 m – source Handbook for Marathon – 2014 www.marathon-project.eu

The Marathon project in particular investigated impact on infrastructure Hallsberg-Malmö in Sweden which is part of the rail freight corridor 3 (Stockholm-Naples). Accordingly the corridor infrastructure is basically "ready" for such trains.

Relatively "minor" actions are in progress even if with the close objective to align to 740 m all the EU infrastructure, as pointed out and monitored by CER committees (http://www.cer.be/publications/latest-publications/longer-trains-facts-experiences-europe-0).

9. Summary of main points of attention

While targeting developments, the systemic approach is key and the SWOT, or other similar planning methodologies, can support such coordination.

	STRENGTHS	WEAKNESSES
INTERNAL	• **Sustainability, energy efficiency and easier energy transition, safety differential also in future projections** • **Cost advantages in scale economies, long distances, high co-modality potential** • **Growing industrialization benefits from exponential technologies (ICT, DSS & AI, digitalization, materials, automation & mechatronics, maintenance, ...), interoperability, modularization** • **TEN-T corridors drive towards EU Rail area** • **Application of Regulation European Rail Network for competitive freight** • Limited de-bottlenecks to be overcome for satisfying demand and service growth • Leveraging HSR investments as capacity increase and express freight services	• **Long lead time for implementing new services, investments, design/plan/build/ on new infrastructures/technologies** • **High capital intensity** • **Service performances not always competitive, inadequate mobility service integration in co-modal mind-set** • Slow EU harmonization (liberalization & regulations, infrastructure charges, etc...) • Multiple actors with inadequate collaborative Rail ecosystem approach • Many stakeholders • Traditional market segmentations and inadequate logistics engineering approach in market propositions • Concentration on Core Network may dismantled traffic and capacity • Aging staff with unclear replacement plans
	OPPORTUNITIES	**THREATS**
EXTERNAL	• **Fiscal policies favouring more sustainable modes and Rail centrality in co-modal perspective** • **Cost dynamics versus Road (Drivers shortage and other expected cost increase)** • **China policies about Rail drive traffic developments especially in Eastern regions** • Growing demand patterns in future projections fitting Rail (scale economies, intercontinental exchanges, urbanization, ...) • Developments of light assets collaborative/ virtual integrated new business models and public/private partnership • Growing logistics outsourcing in segments with professionalism and qualified actors • Co-modal integration through long term more efficient time/space planning • Faster acceleration towards responsible mobility after COVID 19 crisis	• Rail is a high capital intensive business, public resources are limited • The EU Commission efforts for creating a uniform Rail space area are sometimes finding obstacles due to local interests of limited vision • Fragmentation of Road transport industry and social protection to SME as barrier to increased Rail role in co-modal approach • Dramatic evolution in manufacturing foot print and distribution channels • Faster reaction of other modes to adopt ICT and exponential technologies and other dynamics

Figure x - SWOT Freight – Source: New Opera (November 2020) - TER4RAIL project

The individual points of attention regarding both disadvantaged regions and more in general synergies with overland intercontinental flows, may be several and their clustering depends upon alternative/complementary perspectives:

A **thematic** perspective may include:

- Territory planning at local and central level within Cohesion policy
    - Physical infrastructure - nodes
    - Physical infrastructure – lines
- ICT Technology and processes
    - Platforms
    - Services
- Logistics services offerings (not addressed in the present document)
    - Long distance/local (transport focus)
    - Specialist/integrated (logistics focus)

A **geographical** perspective may include:

- Sea port/dry port
    - Southern/Eastern (Greece, Poland Romania, Hungary)
    - East/West (Poland, Hungary)
- Gateway/Hub Crossing corridors
    - Batic-Adriatic Corridor 5 with North Sea- Baltic Corridor 8;
    - Orient/East Corridor 7 with Mediterranean Corridor 6;
    - Orient/East Corridor 7 with Czech Slovak/Rhine-Danube Corridor 9;
    - Etc…
- Freight villages
    - Metropolitan territory
    - Relevant local market distribution areas (Budapest, Bucharest, Prague, etc.…)
    - E-commerce (West Poland, etc...)
    - Free zone

A **governance** perspective may include:

- EU plans and supporting funds 2014-2020 and following time horizon
    - Cohesion Fund
    - Structural Funds (ERDF and ESF)
- Country plans and supporting funds
    - Poland
    - Slovakia
    - Hungary
    - Etc...
- Steering
    - Corridor
    - Network (both Core & Extended)
- Industry structure
    - Vertical integration (big groups development and M&A, Chinese funds, etc…)
    - Virtual integration (partnerships & business agreements, collaboration, etc...)
- Risk management

- Geopolitical
- Industrial

While developing hypothesis of actions and evaluating them, all significant elements have to be brought into the picture for facilitating their feasibility/sustainability while managing constraints.

The following graph may represent a useful scheme to classify exemplary topics to be included in a mind map for such exercises.

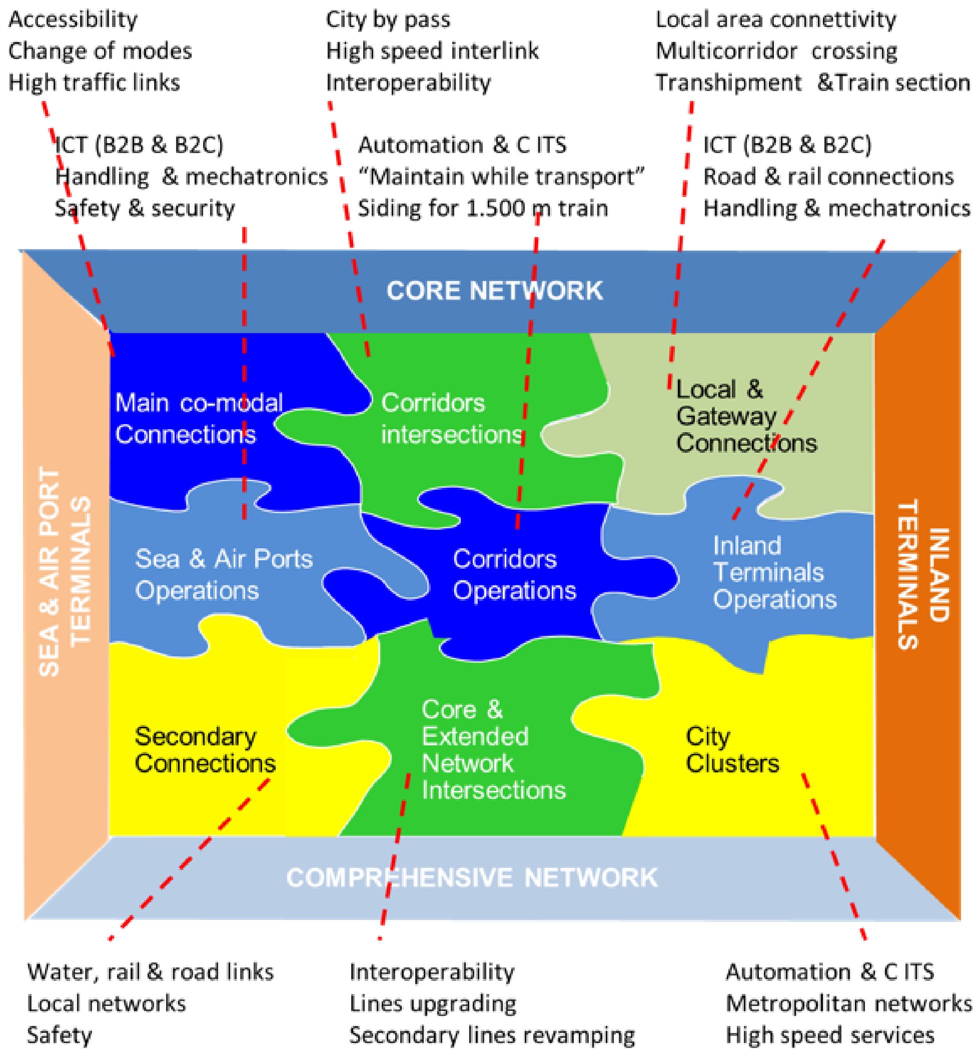


Fig: comprehensive guidelines applicable to EGNT development - Source SMILE Project proposal (MG-4-8-2020) NewOPERA 2020

3 References – Documents and Projects

Documents

ACCENTURE – Orchestrating a mobility ecosystem - 2019

ACCENTURE – Enterprise Security Strategies, Securing Rail and Mass Transit in the tra of converging threats – 2019

ALICE (Alliance for Logistics Innovation through Collaboration in Europe) - A Framework and Process for the development of a Roadmap towards Zero Emissions Logistics 2050 DECEMBER 2019

ALICE (Alliance for Logistics Innovation through Collaboration in Europe) - Roadmap to the Physical Internet – September 2020

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Projects

Cosmos	E-FREIGHT	FOX
Foster Rail	FR8RAIL	Impact 1 & 2
Innowag	Iconet	Living rail
Marathon	M2O	Mobility4EU
Near 2050	REFINET Score	Sense
Setris	Spectrum	Spider Plus
TER4RAIL	Tiger & Tiger Demo	VEL-WAGON
ViWas		