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

# D1.1 EGTN Foundational Position Papers and Simulation Scenarios

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1 According to PLANET's Quality Assurance Process

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## Glossary of terms and abbreviations used

| Abbreviation / Term | Description |
|---|---|
| BRI | Belt and Road Initiative |
| CCI | Corridor Connectivity Index |
| DR | Disadvantaged Regions |
| EGTN | Integrated Green EU-Global T&L Network |
| GA | Grand Agreement |
| ICT | Information and communications technology |
| IGOs | Intergovernmental Organizations |
| INSTC | North-South Trade Corridor |
| IoT | Internet of Things |
| IWT | Inland Waterway Transport |
| KPI | Key Performance Index |
| LL | Living Labs |
| MNCs | Multinationals Companies |
| NSR | Northern Sea Route |
| PP | Position Paper |
| SC | Supply Chain |
| SCM | Supply Chain Management |
| SOEs | State Owned Enterprises |
| TEN-T | Trans-European Transportation Network |
| TEU | Twenty-foot Equivalent Unit |
| UIC | International union of railways |

# 1 Executive Summary

This document contains the description of the main aspects of the four foundational Position Papers of the Planet project and the design of scenarios intended to assess their potential impact. The primary objective is to analyse, understand and assimilate the global, geopolitical, commercial, and economic imperatives of the main European trade routes.

Purpose of those 4 foundational Position Papers generated by the PLANET project is to provide a compendium of the research and study results related to the main aspects of the development of the EGTN and thus provide an initial view of it. These aspects namely include the geo-economic dimension which drives the emergence of new trade routes to EU, the impact of these routes on the existing EU transportation network (TEN-T), the existing land interconnection issues of the TEN-T to networks outside EU concerning rail infrastructure and finally, the emerging of the Physical Internet concept which has the potential to guide the shaping of the EGTN and the role of the PI enabling innovative technologies as tools for the enhancement of transport operations.

These, foundational Position Papers since the beginning of the project consolidated the contextual framework of PLANET, building upon concepts introduced as part of the proposal submission process, incorporating prior research work, and providing a common understanding of key issues. The areas covered, included: (1) geo-economic analysis of the dynamics and potential impact of new trade routes for EU covering both macro and microeconomic perspectives, (2) impact analysis of New Trade Routes on TEN-T: A preliminary impact analysis on the TEN-T corridors and multimodal transfer nodes (termed Principal Entry Nodes) are performed from economic and environmental perspectives, (3) focused analysis on railway transport-corridors to/from the EU: Interconnection problems relating to economic, information, scientific, technical, and ecological aspects will be studied, and (4) analysis of the transition towards the Physical Internet paradigm: Current thinking models and use cases are consolidated in our position paper.

A multi-step scenario definition methodology has been proposed. This mainly analyses the external forces that are expected to affect transport in the coming years along with the main uncertainties that may have an impact. It defines a scenario logic that allows the creation of narratives of the evolution of possible scenarios. Based on the definition of the individual scenarios, a consolidating exercise has been conducted to establish the integrated scenarios to be considered in the following tasks of the project.

This document also contains the definition of important indicators. Central is the role of the Corridor Connectivity Index (CCI) as introduced by PLANET proposes for each EGTN transport node. The Corridor Connectivity Index considers a transport node's level of integration in the global transport network, as manifested by its position in port capacity, efficiency and ease of processes, service frequency, service quality, and digital connectivity. This indicator together with other indicators such as transport costs, reliability, and emissions will be used to analyse the different proposed scenarios.

# 2 Introduction

This report is fully aligned with the central project objectives, namely: i) to understand and analyse global, geopolitical, trade and economic imperatives (ii) assess implications of new trade routes and how best to maximise the EU's economic prospects through steering best practices that align with EC regulatory and environmental policies iii) support the EU's strategic cooperation with China and the USA and explore international cooperation, including peripheral regions and landlocked developing countries and iv) model multimodal transfer zones and global trade zones under the concept of EU's Principal Entry Nodes.

The position papers and the scenarios definitions will provide a deeper understanding of: (i) trade development along global corridors under different geopolitical scenarios; (ii) impact of emerging PI-facilitating technologies on the operation of global trade corridors; (iii) impact of warehousing automation on corridor/last-mile delivery efficiency and sustainability. This will be achieved with the modelling simulation and analysis of the links between geopolitics, trade, and technological developments, building on the PLANET LLs (technology-trade link) and the PLANET Contextual framework.

## 2.1 Mapping PLANET Outputs

*The 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 1: Adherence to PLANET's GA Deliverable & Tasks Descriptions

| PLANET GA Component Title | PLANET GA Component Outline | Respective Document Chapter(s) | Justification |
|---|---|---|---|
| **DELIVERABLE** | | | |
| D1.1 EGTN Foundational Position Papers and Simulation Scenarios | Four position papers consolidating an initial view of EGTN and a set of associated simulation scenarios and target improvement KPIs. Final Version enhanced based on LL feedback M26. | Chapter 3 | Chapter 3 has a summary of the four position papers. |
| **SUBTASKS** | | | |
| **ST1.1.1**<br>**EGTN Foundational Position Papers** | This subtask will provide a compendium of research and study results (position papers) on month 2, consolidating an initial view of EGTN, focusing on the following issues (1) Geo-economics impact of new trade routes for Europe; (2) New trade routes' impact on TEN-T Corridors and nodes; (3) Interconnection issues of railway transport-corridors to/from Europe; (4) Transition towards the | Chapter 3 | Chapter 3 has a summary of the four position papers. |

| | | | |
|---|---|---|---|
| | Physical Internet paradigm. The intention is to publish this compendium in month 2, update it in month 12, and publish it as a book towards the end of the project in month 30 with all additional related project results included. | | |
| **ST1.1.2 Simulation scenarios** | This subtask will be responsible for Scenario Building to be used in Tasks 1.2 (physical flows simulation), and 1.4 (new technologies simulation). The scenarios will be based on the LL requirements and the results obtained through the Foundational Position Papers. | Chapter 4 | Chapter 4 defines scenarios from Position Paper. |
| | Scenario analysis will use long-term demand forecasting.<br>analysis and selection of technological alternatives; assessment of new transport infrastructure requirements; strategic, non-monetary factors, plus robustness and feasibility for each scenario. | Chapter 4.5 | Chapter 4.5 identifies the key variables and levels for the scenarios. |
| | The scenarios will incorporate the targeted KPI improvements for transport cost, reliability, and emissions. | Chapter 4.6 | Chapter 4.6 describes the main indicators. |

## 2.2 Deliverable Overview and Report Structure

The content of this document is structured in 5 chapters. Chapter 1 contains the executive summary of the document. Chapter 2 contains the introduction of the document and indicates the relation of the document to the project results. Chapter 3 contains a description of the main aspects of the position papers. At the end, there is a section (3.5) containing a consolidated view of the four papers. Chapter 4 contains the description of the scenarios considered. Section 4.5 contains the consolidated definition of the scenarios and section 4.6 the consolidated indicators. Chapter 5 contains the conclusions and the definition of the next steps and Chapter 6 the bibliographic references. The full document for each of the position papers can be found in Annex 1 of this document:

- PP1: Geo-economics impact on new trade routes for Europe.
- PP2: New trade routes' impact on TEN-T Corridors and nodes.
- PP3: Interconnection issues of railway transport-corridors to/from Europe.
- PP4: Transition towards the Physical Internet paradigm.

# 3 Foundational Position Papers

The vision of PLANET is to advance the European Commission's strategy for Smart, Green and Integrated Transport and Logistics by efficiently interconnecting infrastructure (TEN-T, Rail-Freight Corridors) with geopolitical developments, as well as to optimise the use of current & emerging transport modes and technological solutions, while ensuring equitable inclusivity of all participants, increasing the prosperity of nations, preserving the environment, and enhancing Citizens quality of life. The realization of this vision is what PLANET calls the Integrated Green EU-Global T&L Network (EGTN). One major objective that PLANET approaches is to assess the impact of emerging trade corridors on the TEN-T network and ensure effective connectivity and sustainability of the European Global Network. Crucial for this is to be aware of geo-economic developments that drive these emerging trade flows. To analyse all these objectives, the following research questions are proposed.

**Research questions:**

1. *"What is the relation between geo-economics and new trade routes, what are the dynamics of these trade routes and how can we measure and monitor the impact on existing TEN-T corridors?"*
2. *"What is the impact of new and emerging trade routes? What are the underlying trends? How can the EU anticipate managing these routes?"*
3. *"What should future rail developments look like in order to improve the interconnectivity of the European transport network?"*
4. *"What is the impact of PLANET logistics and transport concepts and technologies, such as Synchromodality, AI, IoT, Blockchain as contributing to the PI roadmap, on corridor development?"*

To respond to these questions, four key Position Papers (PP) have been developed that analyse the project's objectives from different points of view. The key position papers can be found in Annex 1 of this document.

***Geo-economic developments impacting global corridors for trade (PP1)***

To incorporate the geo-economic perspective, this foundational position paper applies the following structure to finally end up at the CCI. First, we describe the concepts of geopolitics and geo-economics that lie based on this paper. We introduce shifting trade patterns that are elaborated on further later. Third, we create a literature review that serves as a framework that shows what is already known about corridor connectivity related. The report elaborates on transport networks, the selection of ports and modalities by shippers, corridor connectivity as a new differentiator, and lastly the three most significant changing trade flows at the moment (BRI, Arctic Route, increase in transhipment hubs in Mediterranean & Middle East, and International North-South Trade Corridor (INSTC)). Further to this, we introduce the modelling practices that will take place to generate the CCI. Besides looking into the past, we apply a scenario methodology for the development of TEN-T networks, considering the most important factors that will shape the future of the TEN-T – those with the highest impact and uncertainty. Overview of the emerging trade routes

***New trade routes' impact on TEN-T Corridors and nodes (PP2)***

The emerging new routes are expected to change freight flows within the TEN-T network which will result in several impacts such as the pressure on current infrastructure and the creation of bottlenecks, the changing of the importance of nodes/links, etc. PLANET believes that the severity of these impacts and the capability of steering these flows to the desired corridors/links/nodes within the European network is dependent on the available infrastructure and the implementation of innovative technological tools which can enhance the operation of the network. The paper describes the boom of global freight transportation, the geo-economics trends, and the new trade routes. It also gives indications on how to adapt to the new circumstances.

***Interconnection issues of railway transport-corridors to/from Europe (PP3)***

In this foundational position paper, the analysis focuses on the various possible interconnections of the European Railway Network with its neighbouring countries and continents such as Asia and Africa. The basis of this paper is (1) the consolidation of the corridor descriptions of all TEN-T railway lines and Rail Freight Corridors relevant as key 'nodes' for intercontinental transport with a focus on the Eurasian corridors, (2) the collection of basic infrastructure parameters (such as track gauges, total admissible train weight/length, axle load and transported volumes) and (3) an inventory of the major stakeholders and institutions involved in intercontinental transport.

***Transition towards the Physical Internet paradigm (PP4)***

It is expected that the increase in efficiency and productivity of freight transport and logistics will bring the savings and value needed to enable companies to pay for the required asset transition (i.e., towards the greening of all transport assets). Yet, logistics networks are still highly fragmented, mainly dedicated to a company or a specific market, as promoted by the supply chain concept and vertical coordination. The Physical Internet (PI) is considered to be the visionary paradigm supplying an integrated approach to address logistics integration and collaboration issues and to pave the road forward to deploying efficient supply chains. The PI is a game-changing vision that caused agitation in the logistics industry. Advanced pilot implementations of the Physical Internet concept are expected to be operational and common in industry practice by 2030, contributing to a 30% reduction in congestion, emissions, and energy consumption from the transport sector.

*The following sections 3.1 to 3.4 summarize the main results and conclusions of the Position Papers produced in the project, available in Annex 1 of this document.*

## 3.1 Geo-economic developments impacting global corridors for trade (PP1)

Whereas the collapse of the Iron Curtain in 1989 and the reunification of the two Germanies in 1990 are marked as the most significant moments of the second half of the 20th century, the entry of China into the World Trade Organization sets the scene for the 21st century. World trade is the outcome of the friendly relations between state governments who exert their powers through international institutions such as the United Nation Security Council, World Bank, International Monetary Fund, World Trade Organization, and many other intergovernmental organizations (IGOs). The geographical dimension of power which is concerned with international relations and in particular the geostrategic concerns of major powers is what we refer to as geopolitics. The influence of these world powers has come to surface in many ways over the past decades: wars, regime changes, rivalry over resources, oil crises. In the post-cold war era, geopolitics have become more diplomatic and economically operationalized. Geostrategic concerns relate to dominance over scarce resources (oil and gas, precious metals), land for agriculture, technology, and access to markets. World trade and access to trade blocks and rivalry for infrastructure – both transport as well as information technology infrastructure - is still dominated by these post-WWII IGOs, with the United States of America, China, Russian Federation, France and the United Kingdom as the strongest powers.

Nowadays, multinational companies as well as State Owned Enterprises (SOEs) use the unequal level playing field to their advantage. Consequentially, multinationals (MNCs) set up manufacturing facilities in low-wage countries, sought tax havens, and avoided regulations where possible. Vice versa, these MNCs and SOEs are also used by governments to exercise power either to protect or provide much-needed resources. It is the interplay of international economics, geopolitics, and company strategy what explains how trading relationships are shaped.

### 3.1.1 Trade patterns are shifting

On a global scale, trade patterns are shifting. These trade patterns are driven by governments pursuing alternative shipping routes, either via large-scale infrastructure projects abroad or via the opening of natural sea routes which are becoming opportune due to the warming climate and the subsequent melting of the arctic waters in summer. For Europe, it is important to comprehend the emerging trade routes: the Arctic Sea routes, China's Belt and Road Initiative, and the rise of Mediterranean ports, (mainly because of transhipment activities), and the (slow) emergence of the International North-South Transport Corridor.

- The year 2013 marked a year of significant change with the announced revival of the ancient Silk Road, which has become known as the Belt and Road Initiative (BRI), connecting China to Europe by land and sea via better-connected ports and inland infrastructure. Chinese active promotion of overseas' infrastructure development goes hand in hand with the westward shift from China to industrial production, with the aim to develop the less developed western part of China and connect to international trading networks, mainly over land by rail.
- The rise of Mediterranean ports indicates another shift in trade patterns. Ports on the East coast of North America are already witnessing more frequent calls of ships from Mediterranean hub ports such as Algeciras and Tangiers, thereby connecting Canada to the Middle East, India, Pakistan, Africa, and the Far East.
- The third shift in trade patterns may come from global warming. As the ice cover in the arctic is significantly reduced both governments, as well as companies, turn the threat into an opportunity. The passage(s) via the North, could save up to 40% of the distance travelled between Japan and Rotterdam, compared to the traditional route via the Suez Canal. It remains yet to be seen whether an open sea route will come as a viable alternative considering that Russia might want to impose charges for a safe and open passage. Also, the duration of the 'ice- free' season is something cargo owners would want to consider when choosing to place bookings on the scheduled northern connections.
- The Fourth shift in trade patterns, though highly uncertain, comes from the ambition of Russia and India to connect via the North-South Transport Corridor, a multimodal network that crosses land and water and bypasses the Suez Canal.

### 3.1.2 Belt and Road Initiative

Regional integration by means of economic connectivity and political cooperation is what constitutes the geopolitical view on the Belt and Road Initiative. Forming relations through economic connections has intended and unintended geopolitical consequences. China is enacting a geopolitical code through twin economic and political strategies of which the BRI is the centrepiece. The fusion of economic agency that forms the BRI with the geopolitical goals of China rests on the practice and vision of regional integration (Flint and Zhu 2019).

The Belt and Road Initiative aims to achieve greater economic integration and development through better connectivity. The BRI concept promotes connectivity as the main enabler of trade growth and trade-driven prosperity. This connectivity consists of five coherent dimensions (Jacobs, 2019):

- Infrastructural connectivity: improve the region's infrastructure and put in place a secure and efficient network of land, sea, and air passages, lifting their connectivity to a higher level; further enhance trade and investment facilitation, establishing a network of free trade areas that meet high standards.

- Trade connectivity: trade can be enhanced both upstream as well as downstream in the value chain.
- Financial connectivity: trade surplus of China with the world results in an abundance of US dollars on the balance account of China. Investing in infrastructure and real estate particularly in sectors support China's position in the world.
- Political connectivity: active diplomacy is being applied to foster cooperation and sign bilateral agreements with countries.
- Cultural connectivity through promotion of knowledge transfers and cultural exchange via people-to-people connections, e.g., student exchange programs.

The BRI is also linked to China's "Made in China 2025" strategy wherein China outlined to supersede the United States and Japan as industrial high-tech manufacturer by 2025.

The exact route should not be taken literally. The visions and actions framework document suggest that five general routes (three over land, two by sea) are currently being considered (Aris 2016). BRI takes advantage of international transport routes as well as core cities to further strengthen collaboration. There are six international corridors identified: New Eurasian Land Bridge, China-Mongolia-Russia Economic corridor, China- Pakistan Economic Corridor, China-Central and Western Asia Economic Corridor, China-Indochina Peninsula Economic Corridor, and Bangladesh-China-India-Myanmar Economic Corridor (Wenwen, Ran, and Sicong 2019).

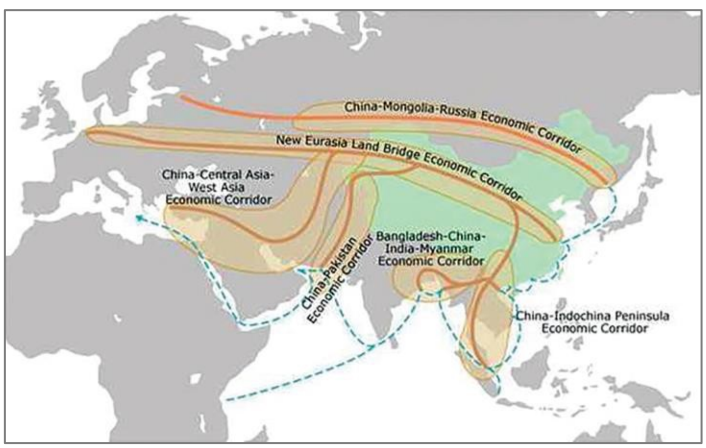



Figure 1: Six economic corridors. Source: www.china-trade-research.hktdc.com

The seven connections along the Eurasian Land Bridge are the following:

Table 2: Details of BRI railway connections

| Line | Year | Distance (KM) | Transit Time rail | Transhipment | Stakeholders |
|---|---|---|---|---|---|
| Chongqing-Duisburg | 2011 | 11,179 | 16 days | Dostyk (KZ) and Brest (BY) | JV Yuxinou-TEL (DB Schenker) |
| Chengdu-Lodz Line | 2012 | 9,965 | 12-14 days | Dostyk and Brest (BY) | DHL Global Forwarding |

| | | | | | |
|---|---|---|---|---|---|
| Chengdu-Tilburg | 2016 | 11,000 | 16 days | Dostyk (KZ) and Brest (BY) | Electronics: Samsung, Dell, LG, |
| Zhengzhou | 2013 | 10,214 | 11-14 days | - | DB Schenker |
| Suzhou-Warsaw | 2014 | 11,200 | 14 days | Malasczewicze-Brest Zabaikalsk-Manzhouli | Nokia, Bosch |
| Yiwu-Madrid | 2014 | 13,000 | 21 days | - | Wholesale |
| Xian – Hamburg | 2019 | 9,400 | 10 – 12 days | Mamonovo (RU)-Braniewo (PL) | DHL Global Forwarding |

### 3.1.2.1 Chinese investments in European transport infrastructure

Since the start of the 21st century, COSCO Shipping Ports and China Merchants Port holdings have acquired stakes in: Port Said – Egypt, Casablanca and Tangiers – Morocco, Marsaxlokk – Malta, Venice – Italy, Istanbul – Turkey, Piraeus, and Thessaloniki – Greece, Bilbao, and Valencia – Spain, Marseille, Nantes, Le Havre, and Dunkirk – France, Antwerp, and Zeebrugge – Belgium, and Rotterdam – The Netherlands. Chinese investments in ports on the arteries of major trade routes indicate that transport volumes are shifting, as well can already witness the revival of ports, such as Piraeus and Zeebrugge. Weekly port calls are added, volumes are on the rise and delivered by ever-larger ships.

Table 3: Chinese investments in European ports (China Global Investment Tracker, 2020)

| Year | Chinese entity | Transaction value in million USD | Share size (best estimate) | Transaction party | Sub-sector | Country of investment & port (if located in seaport) |
|---|---|---|---|---|---|---|
| 2007 | China Ocean Shipping (COSCO) | $140 | 80% | Burg Industries/ transport equipment | Shipping | The Netherlands, Port region Rotterdam |
| 2008 | China Ocean Shipping (COSCO) | $5.790 | 51% | Piraeus Port | Shipping | Greece, Port of Piraeus |
| 2010 | China Electronics Technology | $170 | - | China Belarus Industrial | Rail | Belarus |
| 2012 | Shandong Heavy | $460 | 75% | Ferretti / luxury yacht maker | Shipping | Italy, Marina di Pescara |
| 2013 | China Merchants | $530 | 49% | CMA CGM / Terminal Link | Shipping | France, Port of Dunkirk, HAROPA, port of Marseille, Port of Casablanca, Port of Tangiers, Port of Marsaxlokk |
| 2013 | Dalian Wanda | $500 | 92% | Sunseeker / yachts building | Shipping | Britain, Port of Southampton |
| 2014 | China Communications Construction | $950 | | Railway link Eilat - Mediterranean | Shipping | Israel, Eilat Harbour |
| 2015 | China Railway Engineering | $400 | | Solel Boneh | Rail | Israel |
| 2015 | CSR Corporation | $190 | 100% | Specialist Machine Developments | Shipping | Britain |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2016 | China Communications Construction | $110 | | Riga Commercial Port | Shipping | Latvia, Port of Riga |
| 2016 | China Ocean Shipping | $420 | 67% | Piraeus Port | Shipping | Greece, Port of Piraeus |
| 2016 | China Ocean Shipping (COSCO) Qingdao Port Group | $150 | 40% | APMT sells off Vado (Genoa) port | Shipping | Italy, Port of Genoa |
| 2016 | China Ocean Shipping (COSCO) Qingdao Port Group | $143 | 35% | Euromax Terminal, ECT | Shipping | The Netherlands, Port of Rotterdam |
| 2017 | Shenzhen Metro, China Railway Construction | $170 | | BOM Metro light rail Tel Aviv | Rail | Israel |
| 2017 | China Railway Engineering | $350 | | Belgrade-Stara-Pazova section | Rail | Serbia |
| 2017 | China Ocean Shipping | $230 | 51% | Noatum Ports | Shipping | Spain |
| 2018 | China Railway Engineering | $710 | | | Rail | Israel |
| 2018 | China Railway Engineering, China Communications Construction | $1.090 | | Novisad-Subotica section (Belgrade-Budapest) | Rail | Serbia |
| 2018 | CMG | - | 11% | CNG terminal | Shipping | Greece, Port of Thessaloniki |
| 2019 | China Railway Engineering | | 50% | Opus Global / link Belgrade-Budapest | Rail | Hungary |
| 2019 | Sinomach | $130 | | Logistics Centre Varna | Shipping | Bulgaria, Port of Varna |
| 2019 | China Ocean Shipping (COSCO) | $670 | 32% | Piraeus Port | Shipping | Greece, Port of Piraeus |

***Ports***

The ports in the North Adriatic Sea are of interest because of the shorter distance from the Far East into Central and Eastern Europe. The route from Shanghai to North Adriatic is 2000 miles shorter than the route to Hamburg (Koboevic, Kurtela, & Vujicic, 2018). There are several ports that are in a good position to fulfil the role of the node in the Chinese trade network, considering the position on the south side of the Alps. The North Adriatic ports connect well with the Baltic-Adriatic corridor which runs from Gdansk, Gdynia, Szczecin, and Świnoujście in the north to the Adriatic ports of Koper, Trieste, Venice, and Ravenna in the south. Along the corridor, there are major industrial regions in southern Poland, Katowice-Krakow, Ostrava/Zilina, Bratislava, Vienna, Klagenfurt, and Udine. The whole system of Adriatic ports could emerge into a multi-port gateway, conditional to further integration between five main ports in the region are enhanced. The Mediterranean Corridor is the other important transport connection with the North Adriatic Ports. This corridor crosses six EU countries: Spain, France, Italy, Slovenia, Croatia, and Hungary. It connects logistics and urban hubs such as Almeria - Valencia, Valencia/Madrid, Zaragoza/Barcelona – Marseille – Lyon - Turin – Milan – Verona - Padua/Venice - Trieste/Koper – Ljubljana – Budapest -Záhony.

***Terminals***

With the transaction in 2013 with CMA CGM, China Merchants Holding acquired 49% equity stake in Terminal Link, which owned 15 container terminals in 8 countries. In 2017 CMA CGM reinforced the cooperation with China with the Memorandum of Understanding between CMA Terminals Holding, the CMA CGM port subsidiary with COSCO Shipping Ports. Earlier in 2017, COSCO Shipping Ports received financial support of USD 26 billion over the next five years from the China Development Bank.

***Chinese actors involved in Europe's transport infrastructure***
The main actors involved in relation to Europe's transport infrastructure are the following companies:

- COSCO Shipping Ports Limited, container terminal operator has chosen Piraeus as the main hub in the Mediterranean but also has a significant stake in Rotterdam via a 35% stake in ECT Euromax terminal and Rotterdam World Gateway.
- China Merchant's Port, a terminal operator with strong links to CMA CGM. Both companies have increasingly tighter cooperation thereby combining liner shipping networks with container terminal positions in strategically chosen European seaports.
- Rail operator China Railway Container Transport Corp. has chosen Duisport, the largest inland terminal in Europe in Duisburg as their main hub and European headquarters.
- Construction companies that are supporting the development of infrastructure along the route. Think of terminal development, draught increases, and corridor infrastructure works.

### 3.1.3 Geopolitical interest in the Arctic

According to current estimations, Arctic Summers in mid-21st century will probably be hot enough to melt most of the ice that forms in the winter season. This makes the route navigable without the need for extra equipment during the summer months. Currently, extra equipment like icebreakers and tugboats are required (Maritime Executive, 2019). Transport volumes are reported since the early 1930s, a time in which cargo volumes were very limited, or just not reported. Cargo volumes peaked at 6.6 million tons in 1987, a few years before the official ending of the Soviet era in 1991. Volumes were mainly driven by the industrialisation of Siberia but declined sharply afterwards. After 1991 the first Non-Russian flagged ships were allowed to deploy the NSR. Since 2010 transport volumes are increasing again until a level of 10.5 million tons in 2017 (see Figure 2). In September 2018, the Venta Maersk (3,596 TEU) was the first containership to sail from St. Petersburg to Vladivostok via the NSR instead of taking the Suez-Canal. This was meant as a trial to gain experience with sailing through the Arctic.

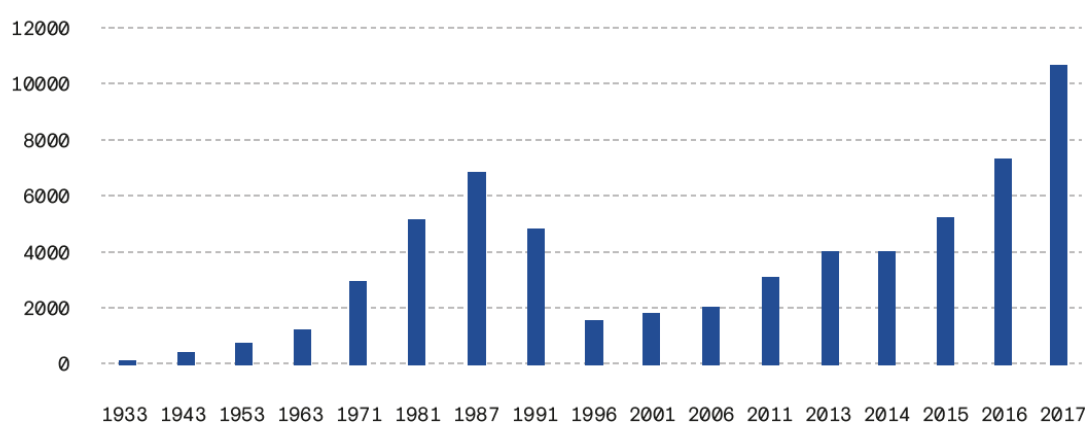



Figure 2: Annual cargo volume x1000 tons on the Northern Sea Route (Source: Northern Sea Route Administration)

Currently, the usage of the Arctic route is limited. Cargo throughput volumes are around 10.5 million tons and traffic is mainly intra-arctic and related to oil extraction in the region. Transit volumes increased strongly from 0,11 million tons in 2010 to 1,35 million tons in 2013. After 2013 volumes dropped steeply due to several reasons: economic downturn, geopolitical tensions, sanctions against Russia, and a lack of icebreaker capacity for transit journeys due to the assignment of these icebreakers for oil and gas-related projects. Due to these factors, the cost difference between the route via the Suez-Canal and the route via the Northern Sea route diminishes and becomes again in favour of the Suez Canal. In 2017 the transit volumes were at a level of 0,19 million tons which equals 1,8% of the total cargo volumes transported over the route.

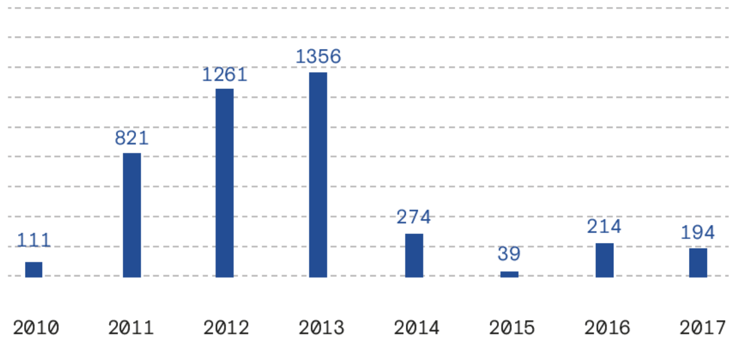



Figure 3: Transit cargo volumes x1000 tons through the Northern Sea Route

Another perspective is the division of multiple ship types over the voyages that take place. In Figure 4 an overview of this is shown over the year 2017. The top 5 vessel types undertaking voyages on the NSR are tankers (34%), general cargo vessels (30%), icebreakers (5,5%), tugs (5,5%) and container vessels (5,4%). The number of voyages made in 2017 was 1908, spread over 283 vessels.

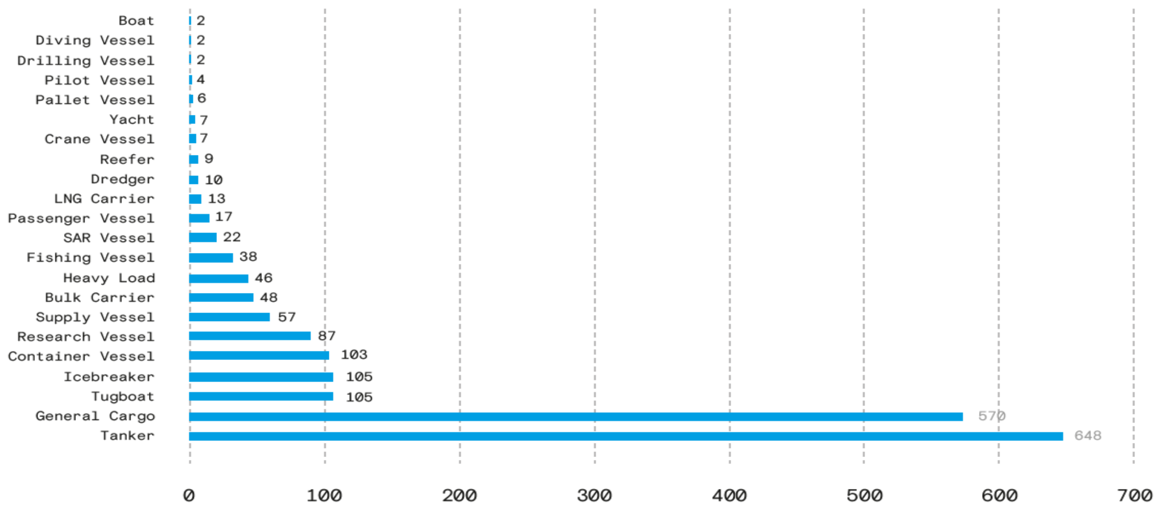



Figure 4: Number of voyages per ship type in 2017

The Russian government has high ambitions and aims for throughput volumes of 80 million tons in 2025 according to the Arctic Masterplan (Laruelle, 2020). For the PLANET project, it is mainly interesting to see how intercontinental container transport might change when the NSR increases in popularity. The Russian government is definitely not the only driver behind the increase or decrease of container traffic passing through the NSR. The table below summarises research that has already been carried out about the outlook of the usage of the NSR as a (container) shipping route. It shows that there is still large uncertainty about the viability of the route and about the time period in which we will see significant trade flows shifting from existing routes towards the NSR.

The viability of the Arctic waters as an emerging trading route is not only dependent on geopolitical interests but also depends on the perceived attractiveness among cargo owners. Since the beneficiary cargo owners are responsible for making the transport decisions, monitoring the attitude of shippers towards the NSR is important. The following table shows an overview of factors that determine the commercial usage of the NSR.

| Category | Factor |
|---|---|
| *Economy* | Additional fees (e.g., tugs) |
| | Availability and training of sailing personnel |
| | Traveling distance |
| | Fuel costs (different fuels) |
| | Legal status of NSR |
| | Costs of ice-class vessels |
| | Risk of oil spills |
| | Sailing speed |
| | Insurance rates can be higher (between 50-200%) |
| *Infrastructure* | Availability of port services |
| | Availability of infrastructure |
| | Level of safety for navigation |
| | Bathymetry (draft) |
| *Weather* | Stability of weather conditions |
| | Length of navigability window |
| | Seasonal availability of the corridor(s) |
| *Geopolitics* | Attitude and rulings between countries |
| *Ethics* | Attitude of shippers, shipping lines and other stakeholders |

Table 4: factors determining the commercial usage of the NSR (own elaboration)

Altogether, there are clear signs that trade patterns are shifting, both by geo-economical actions and commercial strategies. In PP1, we bring forward the concept of connectivity and how this relates to the nodes and corridors of the TEN-T network. We look at how global shifting trade patterns can influence the connectivity of TEN-T corridors with the outside borders of Europe and how to monitor this.

### 3.1.4 Transhipment hubs in the Mediterranean ports & Middle East

Here we will elaborate on the emergence of transhipment ports, such as Algeciras (Maersk, early 2000s) and Tangiers (Morocco), which recently expanded APMT container facilities. Same with Marsaxlokk (Malta), Gioia Tauro (Italy), Port Said (Egypt). These ports serve as transhipment hubs and are strategically located on the East-West trade routes. Algeciras and Tangiers have another advantage which is the location on both East-West and North-South trade routes. Terminals are often owned by carriers that use these facilities as turntables and these hubs are selected to serve continents instead of regions, to function as a crossing point between trade lanes. These transhipment hubs have a footloose nature, and they react on the dynamics in world trade (Rodrigue, 2020).

Something that should be considered is to what extent environmental regulations in the European territorial waters will set limitations to ships in such a way that shipping lines will divert the transhipment function of Northern European ports to ports in the Mediterranean. These limitations have already been in place under the sulphur cap regulations (also known as IMO2020) but can have more impact on shipping routes when emission pricing would be implemented by the European Commission or EU member countries. Introducing a price for carbon emissions in the shipping industry has the intention to influence the decision-making of shipowners or operators towards higher energy-efficiency and lower carbon footprint of their fleets (Streng, 2020). The implementation of such measures is likely the case as European Commission has announced the Green Deal, which also sets forward a policy to place the shipping industry under a regime of emission pricing, whether it will be a tax, a levy, or a trading scheme. Some researchers believe that transhipment hubs move even further away and will end up in the Middle East ports such as Dubai.

Another port that is expanding in transhipment volume is the Mediterranean port of Piraeus, serving as a hub for trade between China and Europe. The port has a couple of strengths for transhipment: it is on the crossroads of Asia, Africa, and Europe, due to its natural depths it can handle the biggest container ships and due to the multiple billion euros investments by COSCO Shipping it has the necessary infrastructure to handle these big ships. In 2019, the port was the busiest Mediterranean container handling port and the fourth busiest in Europe behind Rotterdam, Antwerp, and Hamburg.

### 3.1.5 International North-South Transport Corridor

The International North-South Transport Corridor (INSTC) is a 7,200 km long transport route that starts in India and crosses Iran, Afghanistan, Armenia, Azerbaijan, Russia, Central Asia, and Europe. The route from Mumbai and Saint-Petersburg can be shortened by 10 days by the INSTC, compared to the route that uses the Suez Canal. Like the BRI, the INSTC consists of a bundle of corridors, both on land and at sea. The biggest difference is the way in which it is being developed. The BRI is a purely China-sponsored activity, whereas the INSTC can be considered a multi-stakeholder activity. Connectivity is again a keyword in the development of this route and the aim is to increase trade connectivity between important cities such as Mumbai, Moscow, Baku, Astrakhan, Tehran, Bandar Abbas, and Bandar Anzali (On the Mos Way, 2020).


Figure 5: Mapping of the International North-South Transport Corridor

Between 2014 and 2017 a number of 'dry runs' have been performed over the route between Mumbai and Saint-Petersburg. The result of these runs showed a possible cost saving of 2.500 USD per 15 tons of cargo and a simultaneous drop-in transit time from 40-60 days to only 25-30 days (Reconnecting Asia, 2020). Even though the route has a high potential in terms of increasing transport efficiency, bottlenecks remain both in terms of infrastructural/engineering in Iran, as well as from a finance perspective. Currently, the INSTC already exists in a fragmented base of infrastructure with a total capacity of around 5 million MT. In the long term, a maximum capacity of 20 million MT is expected to be transported annually over the route.

### 3.1.6 Impact of emerging routes development to the TEN

#### *3.1.6.1 Dynamics and complexity: consequences on corridor level*

The international competitive position of ports and industries along TEN-T corridors is influenced by developments in international trade. In our assessment of the impact of shifting trade patterns, the methodology follows both an outside-in as well as an inside-out perspective on the dynamics and complexity of transport networks. The outside-in perspective looks at trade flows from a macroscopic level, which includes location-independent changes such as the effects of global warming on the Arctic Sea routes, geopolitical tensions between superpowers, but also technological advancements. At the same time, we are building awareness of geo-economic dynamics, whereby we regard company strategies, investments, and changes in the set-up of global value chains of multinationals. From the inside-out, we are witnessing pro-active strategies by inland nodes to develop new routes, supported with innovative technologies, to better connect with seaports.

Dynamics are broken down into operational dynamics, market dynamics, technology dynamics and counterproductive dynamics. Dynamics in the operational sphere relate for instance to new sailing routes, changing hub-and-spoke configurations (e.g., transhipment hubs in the Mediterranean). Market dynamics relate to fiercer competition between companies, market consolidation, the emergence of e-forwarders, the attractiveness of alternative transport modes, implementation of government instruments to stimulate low carbon transport fuels and the requirement by shippers for sustainable transport.

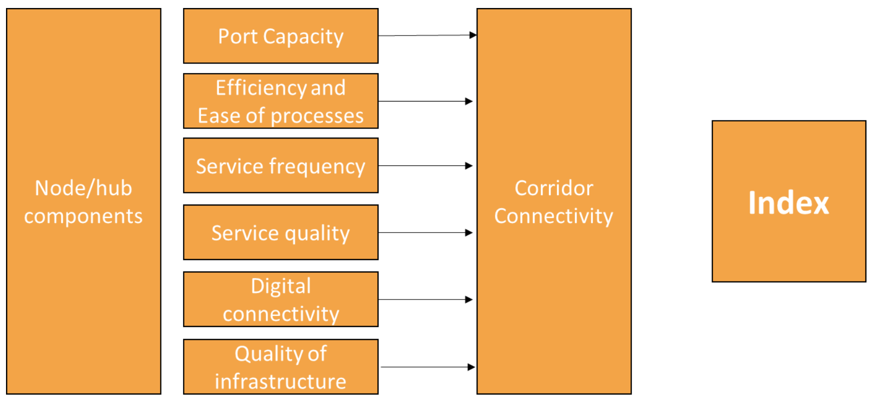
Furthermore, there are dynamics which are driven by technological advancements, such as the development of blockchain, the internet of things, online booking platforms, big data analytics, 5G networks, etc. Lastly, the corridor connectivity also depends on mitigating counterproductive developments, such as cyber threats, criminal activities at corridor hotspots, necessity to make informal payments. A questionnaire has been developed for living lab participants to collect feedback on these dynamics.

### 3.1.7 The Corridor Connectivity Index (CCI)

The strategic location of transport nodes in the international transport network is a key enabler for trade. Therefore ‘hubs’ or ‘main-ports’ or ‘principal entry nodes’ are vital nodes and connections over land, air and sea. The network dimension complements the economic dimension which offers important location factors for clusters of industries. Governments of countries with a keen interest in trade and logistics, such as The Netherlands but also Singapore and China, have considered ‘connectivity’ in their policy plans and aim to strengthen their competitive position in the world (Ministry of Economic Affairs of The Netherlands, 2009). Connectivity relates to the presence, quality, and utilization of the infrastructure. This determines the number of (inter-)national connections, the frequency of these connections and the service speed and reliability (Ministry of Economic Affairs of The Netherlands, 2009). De Langen and Sharypova (2013) distinguish two broad classes of measures to describe transport networks: the connectivity of a network and the accessibility of the node. They consider connectivity as an attribute of a network that indicates whether it is possible to reach all or certain nodes from a specific node. Important are the quality and costs to reach destinations via the nodes. Recent studies show advanced insights into the connectivity of maritime transport networks.

Several methods already exist to measure the connectivity of logistics locations and express this with an index. An example is the World Port Index which compares characteristics, position, facilities, and services of thousands of ports around the world. Another example is the Liner Shipping Connectivity Index (LSCI) which measures the integration of countries within global liner shipping networks (UNCTAD, 2019a). However, these indices are focusing on the foreland and port side, whereas this paper focuses on the connectivity of corridors/hinterland with (emerging) trade routes. The CCI is a combination of objective and subjective components where port capacity, digital connectivity and service frequency are objective and where efficiency and ease of processes, service quality and quality of port infrastructure are subjective.

Figure 6: Diagnostic model of the Corridor Connectivity Index




Changes of the CCI from one year to the other identify that the node is changing its capabilities/scale/accessibility. The CCI can be applied as a barometer of changing trade flows. A higher CCI means that it becomes more attractive to transport goods via this Principal entry node or Inland node.

## 3.2 Impact of the new trade routes to the TEN-T network (PP2)

The emerging new routes are expected to change freight flows within the TEN-T network, which will result in several impacts such as the pressure on current infrastructure and the creation of bottlenecks, the changing of the importance of nodes/links etc. PLANET believes that the severity of these impacts and the capability of steering these flows to the desired corridors/links/nodes within the European network is largely dependent on the available infrastructure and the implementation of innovative technological tools which can enhance the operation of the network. For this reason, the identified technologies will be tested through several scenarios in 3 Living Labs which will provide feedback on the actual impact these technologies can have in the future scenarios of EGTN.

The intentions are to assess the impacts of new global trade routes on the TEN-T network in Europe. It adopts a strategic angle, considering what trends underlie the emergence of these new trade routes and what recommendations can be formulated so that the EU might effectively anticipate the opportunities and challenges that these new trade routes pose. After briefly tracking the emergence and decline of major historic trade routes the focus shifts to the 21st century, highlighting key details of three major trade connections: China-EU rail, the international N-S route, and the Arctic.

### 3.2.1 The boom of global freight transportation

The position paper PP2 assesses the impact and amplifiers of the global freight boom of the last seventy years. It argues that containerization has marked a significant turning point in global trade and freight transport, and specifically that the introduction of the current globally adopted container standard has put trade processes of integration and efficiency into a higher gear as the standard allows intermodality[2]. The conditions for the current global spread of production of supply chains of MNCs were created and two factors resulted in the global integration of the (freight) economy. First, the general process of containerization meant that transport costs for most types of cargo were greatly reduced in terms of capital and time. Second, the intermodal container implied that virtually all sorts of cargo could change modes easily. Additionally, there are two other ways in which containerization has influenced the world economy and transport. First, as the increase in containerized transport resulted in a strong increase in overall seaborne transport, the structure of seaports and their hinterland infrastructure were forced to standardize, become denser, and increase their quality to be able to handle far larger volumes and specific dimensions of freight containers. Second, containerization increased the environmental impact of global trade as the speed and volumes with which freight is transported greatly increased. As these increased trade volumes are exerting pressure on hinterland infrastructures, motorways get congested (despite efforts to distribute transport more evenly across inland waterways and rail), and container ships are pressuring the environment through their emissions (despite a recent transition to 'slow steaming').

### 3.2.2 Geo- economic trends affecting global freight transportation

The role of geo-economic trends in shaping current global freight transportation. At its core, this section argues that the globalization of supply chains and production could take a turn towards a more regionalized base. The partial levelling of labour costs can be seen as the initiator of this trend, while demands for higher standards of production and products and the current COVID-19 crisis can be seen as factors that amplify this trend to unknown extents. Regionalization of production is expected for high-end (capital intensive) consumer goods, but not so much for their cheap (and less capital intensive) counterparts. Other factors that are likely to contribute to regionalization among the transportation and production patterns of consumer goods are strategic interests, labour costs, and higher standards for entering European markets. However, for mid-range products, the picture might be different because of the higher standards for products and production that Western markets are increasingly implementing in efforts to address environmental and labour-related concerns. A stronger and gradual decline of global freight flows of these goods is to be expected, not least because import and export flow into and from Western markets are calling for fast, reliable, and flexible services rather than the relatively slow ocean freight. Another aspect is the significance of the fact that the EU increasingly classifies products as 'strategically important' or 'strategically less important,' especially in the context of high-end and semi-finished products. This tendency has been sparked by growing concerns for Europe's security interests if Europe would become too dependent for the supply and/or production of 'strategically important'[3] goods on countries regarded as potential security risks. Conversely, goods seen as 'strategically less important' may see an equalization of trade flows, with high-tech production facilities belonging to the same supply chains spread over different continents[4]. In similar regard, there might occur a slight modal shift away from the ocean as states prefer to be resilient to supply-chain shocks[5].

[2] Shipping the same freight container onto different modes of transport.

[3] Such as defense or security technologies.

[4] A greatly simplified example would be a European car manufacturer who acquires car parts in Asia, ships these to Europe for assembly, and then ships its finished cars back to Asia.

[5] The April 2021 blocking of the Suez-canal Ocean route by a freight vessel illustrated the vulnerability of the ocean.

### 3.2.3 New trade routes affecting TEN-T

In addition to global corridors described in PP1, this chapter explains the effect of major new trade routes on TEN-T, devoting special attention to the Chinese Belt and Road Initiative (BRI), the potential Arctic Sea route, and the International North-South Transport Corridor. The drive behind the BRI is described as fostering economic and trade growth by strengthening transport and logistics ties between China and the larger Eurasian hemisphere, and the initiative is broken down into the 'Maritime Silk Road' and the 'Silk Road Economic Belt.' The incubation of new rail freight connections is vital for generating a domestic and foreign support base for the initiative, as it has the potential of creating a considerable increase in freight transportation and related revenues. Through this transport flow the connectivity between major cities in Western China and Europe (including western Russia), and between these cities and their hinterland is greatly increased. Currently, the most important intercontinental railway corridor connects the EU and China through Poland, Belarus, Russia, and Kazakhstan (planned and organized by Chinese operators acting by order of their authorities), and the Caspian East-West corridor and the North-South corridor might gain traction. The former eliminates twenty days of the lead time when compared to ocean and has brake of rail track gauge and customs procedures at the Polish-Belarusian and Kazakh-Chinese borders. Apart from more covert motivations, the fact that rail is cheaper than air and faster than ocean motivates additional BRI rail expansion, and factors such as occasional capacity shortages in ocean and air freight are strengthening rail's appeal. Nevertheless, important challenges such as infrastructure shortfalls and delays and congestion at EU arrival terminals remain, and EU shippers see additional obstacles such as import sanctions between the EU and Russia.

As for the Arctic route, optimism has been growing that it might form a supplement to the much more time-demanding Suez-canal route, depending on ice conditions and seasonal accessibility. Realism is warranted, however, since commercial viability of the route is hampered by increasing environmental regulations, passage levies from adjacent states, and little possibilities to make profitable interim cargo exchanges due to the absence of intermediate ports. Also, the extreme naval conditions of the route demand additional investment in specialized crew, vessels, and cargo protection. The arctic region itself is expected to see significant economic attention in the forms of natural resource exploitation (oil and gas, but also minerals such as nickel and coal), and is already experiencing exploitation by Russia and Europe. As such, despite rising environmental concerns an increase off transport flows to and from the Arctic (that exist relatively independent from major East-West transit services) is likely, manifesting as diverse marine traffic but also as land infrastructure. The EU, Scandinavian states, Russia, and other arctic states are either considering or planning an expansion of their land transportation networks to the area.

Last, the International North-South Transport Corridor (INSTC) between the Arabian Basin and Northern Europe (aimed at more connectedness between major Eurasian cities) may be another site of international rail expansion. The INSTC is a 7,200-km-long multi-modal network of ship, rail, and road route for moving freight between India, Iran, Afghanistan, Armenia, Azerbaijan, Russia, Central Asia and Europe, expected to gain traction in future.

### 3.2.4 Dynamics and complexity: consequences on corridor level

This chapter outlines the consequences of the elements for corridors in general and TEN-T in particular. It starts by making the core claim that a regionalization of production will gradually lead to a lower global volume of maritime container flows. However, regional transportation systems such as TEN-T will likely display a different trajectory, as they will be able to adapt to altered circumstances: location of production, and upcoming trade routes and their modes of transport (both augmented and facilitated by digital innovations in logistics). However, networks such as TEN-T will have to make the conscious shift from developing their *inland* to their *hinterland* infrastructure networks since current flows between entry points could shift to flows within countries or regions. To achieve this, the allocation of sufficient investment for the development of rail infrastructure is necessary (combining intra and intercontinental movements, similarly rooted in digital solutions). In the Arctic new entry points will emerge (aside from existing seaports), just as new or busier entry points in Europe.

### 3.2.5 Looking beyond TEN-T: how to adapt the network to changing circumstances?

Recommendations regarding the question of how TEN-T should respond to the changing circumstances outlined above. In essence, the section argues that the new challenges and opportunities will require a concerted effort from all case-related stakeholders. Responses in the form of revised policy and legal frameworks, governance, planning and monitoring of network development, and the technical specifications of all aspects of the infrastructure will be required. Then a specification of challenges (e.g., creating transparency in the selection of projects to support and invest in, especially in neighbouring countries, and reducing the dominance of, or reliance on single countries to restrain political-economic power) is provided. It is also recommended that future revision rounds of TEN-T include infrastructure that facilitates trade that has become substantial (e.g., routes to and from the Arctic). Governance procedures (and correlating legislation) need re-establishment via consensus and partnership with principal actors of the new trade routes, and a shift and adjustment of working procedures currently used are necessary. Similarly, updating and reporting procedures need updating, especially to include external EU countries to submit national implementation plans and reporting of KPI compliance. KPIs that monitor transport-specific concerns (e.g., lead time) should be added to the TENtec KPI system.

In a different vein, transport network bottleneck analyses would also need to be extended (though cautiously) to network sections outside the current TEN-T scope. Also, methods to prioritize projects, which are also inherently political, will need to be rethought so that the TEN-T network can develop in a fair and balanced manner. Last, TEN-T will need to become resilient and flexible enough to withstand future realities and catastrophic disruptions (e.g., pandemics or natural/man-made disasters in or outside the EU). Other challenges that upscaling the TEN-T could generate are the generation of new funding to upgrade infrastructure in new gateway countries, the inception of reliable transport flow forecast and information to upgrade impending bottlenecks (keeping into account progressing technological innovations such as 5G telecommunication), and the consideration of the creation of Synergy projects and green energy networks. Further research should also be carried out to understand impending challenges that may currently lie outside the scope of the forecast.

### 3.2.6 Principal conclusions

1. A gradual intellectual and logistical shift from *hinterland* transportation to *inland* transportation holds that the TEN-T system will be more intricate than ever before, necessitating far-reaching digital innovations (especially for the sustainable transport of single wagon/container and less-than-container loads, and integrating emerging trade routes into continental flows).
2. Also, emerging trade routes as well as changing intraregional transport patterns may increase the importance of infrastructure stretches from national to European relevance (especially: Principal Entry Points and infrastructure connecting growing sites of production). However, member state governments and the EU are also able to influence the location of newly regionalized industries through infrastructure investment. The addition of new transport corridors as vital extensions to the TEN-T network will require updates to the legislation and to updating and reporting procedures (as outlined in Article 49), especially to include external EU countries to submit national implementation plans and reporting of KPI compliance.

3. Finally, as emerging trade routes, often entering the EU's territory via third countries, exert a profound influence on intra-TEN-T development, the EU is increasingly compelled to take stock in extraterritorial infrastructure development too[6].

## 3.3 Interconnection issues of railway transport-corridors to/from Europe (PP3)

### 3.3.1 Problem background

The European Rail Freight Corridors (RFC) and the Tran-European Transport Networks (TEN-T) are the collection of those railway lines of the European Union rail infrastructure network, which are used by freight trains for their cross-border journeys. RFCs and TEN-T are linked to the external border-crossing links that connect the European Union's rail infrastructure to Asia. As a full railway network interoperability on all these Eurasian connections is not yet a reality on the different sections linking Europe with Asia, an inventory of current cross-border railway parameters should be elaborated. The international collaborative organisations and involved stakeholders that support the freight traffic that runs along these interfaces have been described in a separate section. A possible input for the modelling and scenario building for railway transportation is also described in a specific chapter.

### 3.3.2 Catalogue of railway interconnections

All railway interconnections have been collected according to their geographic directions:

- Eastbound: towards the Russian broad rail gauge network.
- Southeast: towards the Turkish UIC gauge network.
- Southwest: in the direction of Africa through a proposed railway tunnel under the Gibraltar strait (yet to be built).

A summary description per relation has been provided in a detailed table supported by additional notes on the various infrastructure parameters. It must be noted that several border crossing lines are presently not used for freight traffic. A 'rank' indicator has been developed whereby we categorised the connections in according to:

- **A**: high volume freight traffic.
- **B**: some freight traffic exists.
- **C**: not known if freight traffic is conducted.

Cargo types carried have been categorised as follows:

- **Int**: intermodal (ISO containers, non-ISO containers, (craneable) semi-trailers and swap bodies).
- **Bulk**: bulk cargo such as timber, crude oil and refined oil products, ores, etc.

The following consolidated table summarizes the findings on the three identified railway connections (Eastbound, Southeast and Southwest). It contains the basic key railway infrastructure parameters affecting the most the interoperability of the trains circulating between Europe and Asia. All these elements should be integrated into the simulation model and in the development of specific scenarios.

Table 5: Main parameter in railway corridor

[6] The items mentioned above will therefore be of particular importance for the PLANET project's conclusions and recommendations for future TEN-T development.

| **Railway corridor** | **Countries involved** | **Key parameters** | | | |
|---|---|---|---|---|---|
| | | **Broad gauge** | **Electrification** | **Train length and weight** | **Axle load** |
| Eastbound (Russia) | Finland, Estonia, Latvia, Lithuania, Poland, Slovakia, Hungary, Romanies | 1 520 mm (even 1 524 mm in Finland) | YES | 600m, 700 m or 1,100m | 22.5 t |
| Southeast (Turkey) | Bulgaria, Greece | UIC gauge | Partially | | |
| Southwest (Morocco) | Spain, Morocco, Algeria | New project (tunnel) – not relevant for PLANET | | | |

### 3.3.3 Stakeholders involved and international organisations

This chapter introduces the operational stakeholders (a person or legal entity, e.g., company) and institutions involved in the management of intermodal transport. For example, a freight forwarder or intermodal transport operator is the immediate partner of the consignor. Railway infrastructure operators, on the other hand, provide routes - this indirect service is a prerequisite for the organization of intermodal transport. An overview of the interaction of the individual actors in the context of the flow of information and loading units is given in the following figure.

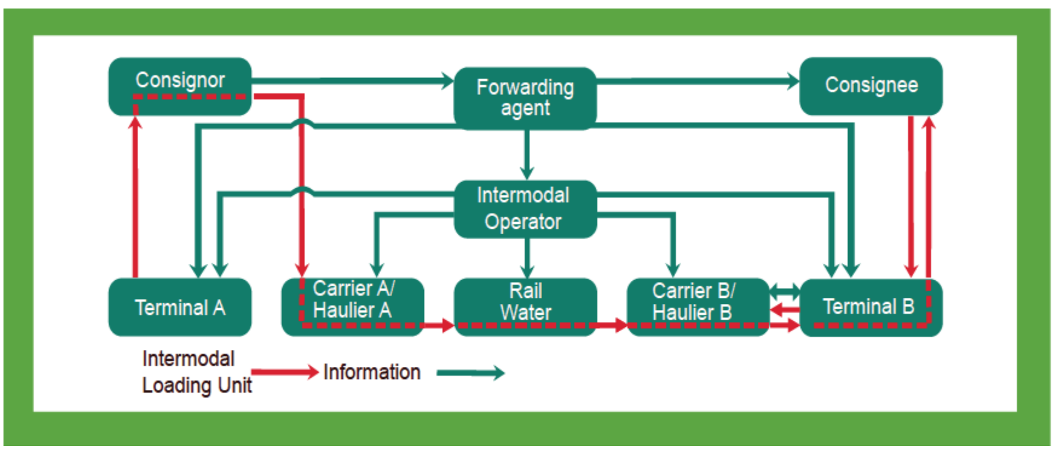



Figure 7: Stakeholders involved

Door-to-door intercontinental transport involves much more operational parties and official institutions compared to a more conventional European intermodal transport: trains departing from a European node to a Chinese destination will go through much more countries and will thus be submitted to a larger range of different procedures and rules (even in the country train operations might be addressed to local authorities like in China for example). The role(s) and the task(s) of each stakeholder remain, however (nearly) the same in both transport segments. The next subchapters will point out various stakeholders' initiatives to promote railway transportation to China.

#### *3.3.3.1 The EU-China Connectivity Platform*

The European Union (EU) and the People's Republic of China (China) are committed to maintaining and developing strong and fruitful relations in the area of transport. In an effort to improve transport connectivity, the European Commission (DG MOVE) and the National Development and Reform Commission of China (NDRC) established a Connectivity Platform in 2015.

The main objective of the Platform – as agreed by both sides – is to explore opportunities for further cooperation in the area of transport with a view to enhance synergies between the EU's approach to connectivity, including the Trans-European Transport Network (TEN-T), and China's Belt and Road Initiative (BRI). The platform is also used to work towards greater transparency, reciprocity in market access and a level playing field for businesses in the area of transport infrastructure development.

More specifically, this cooperation includes actions to:

- Share information, promote seamless traffic flows and transport facilitation, and develop synergies between their relevant initiatives and projects.
- Identify co-operation opportunities between their respective policies, including the Trans-European Transport Networks and The Belt and Road Initiative.
- Explore business and investment opportunities open to both China and the European side.
- Create a favourable environment for sustainable and inter-operable cross-border infrastructure networks in countries and regions between the EU and China.

#### *3.3.3.2 GETO*

GETO - Group of European Trans Eurasia Operators and Forwarders - was founded in Basel in 1978. Its foundation aimed to safeguard the interests of European Trans-Siberian operators and to support the increase of traffic on the Eurasian railway corridor. In the past, this primarily referred to Trans Sib, which was the original name of GETO "Community of European Trans-Siberian Operators and Forwarders".

GETO is the Western European pillar of the international network for the promotion of Trans-Siberian transport. It is one of the initiators and founders of the International Coordinating Council on Trans-Eurasian Transportation (CCTT) in Moscow. It supports the activities of this council in a constructive and committed manner. The joint efforts of CCTT and GETO to promote international transport on the Eurasian land bridge with a variety of initiatives have made a significant contribution to the development of these transports.

#### *3.3.3.3 CCTT*

The International Coordinating Council on Trans-Eurasian Transportation (CCTT) is a non-commercial transport association with an open-ended duration, registered in the Main Register of the canton of Bern (Switzerland).

The CCTT was founded by:

- The Ministry of Railway Communication of the Russian Federation (after the restructuring of 2003 – OJSC RZD (Russian Railways).
- Deutsche Bahn (DB AG).
- Group of European Trans-Eurasian Forwarders and Operators (GETO).
- Korean International Freight Forwarders Association (KIFFA).

Presently the CCTT has more than 91 member societies from 21 countries, including railways of Europe, Asia and the CIS states, leading shipping companies, operators and forwarders, ports and stevedoring companies, state organizations, administrations and municipalities, telecom and marketing companies, security services, and mass media. For more than 20 years history the CCTT has achieved a high international standing and has become an efficient international forum for networking and real cooperation between all parties involved in Trans-Siberian freight transportation.

The major goals of the International Coordinating Council on Trans-Eurasian Transportation (CCTT) are: (1) attraction of transit and foreign trade cargo on Trans-Eurasian routes passing through the territory of Russia, including on the ITC East-West, North-South; and (2) coordination of activities of participants in the carriage of goods by land and sea sections of Trans-Eurasian routes and international traffic to ensure the quality of delivery and development of economic relations between countries of Pacific region, Central Asia, CIS, Baltic States, and Europe using the infrastructure of Russian Railways.

##### *3.3.3.4 OSJD*

The Organisation for Co-operation of Railways in Eastern Europe and Asia (OSJD) is a governmentally influenced non-governmental organisation of Eastern European and Asian railway undertakings founded in 1956 and based in Warsaw. The OSJD has currently 25 members plus some western European railway undertakings having observer status. The strategic objectives of the OSJD are the formation of transport systems and the structural reform of transport aimed at better competition between transport enterprises, in particular the reduction of delivery times and acceleration of goods transport.

### 3.3.4 Research Gaps

Further research activities should focus on the following categories:

- Category I – Statistical: more details and accurate data on the current transport volumes (O/D matrix), the types of services and goods transported, average transit time, price indication, delays.
- Category II – Infrastructure: gap and impact analysis (TEN-T versus Asian corridors), investments needed in railway lines and nodes (entry points), full electrification.
- Category III – Economics: evolution of the tariffs of the different transport modes (rail, maritime, road), subsidies, European and Asian subsidy schemes, main reasons for unbalanced traffic flows, collaboration platforms, cost analysis.
- Category IV – Operations: better understanding of the current key business hurdles, improved collaboration models, interoperability of nodes.
- Category V – Innovation in technology and asset: technical interoperability of wagons and ILUs, specifications, IoT, data interoperability and digitalisation needs.

### 3.3.5 Model description & scenarios

The diagnostic model to be developed within the PLANET project should be used as an instrument to better comprehend the complex ecosystem of railway transport with intermodal loading units between Europe and Russia/China. The diagnostic model should be structured on a three-layer dimension:

- Infrastructure layer with detailed route descriptions (including a map visualisation): similar to the Rail Freight Corridors Document and Customer Information Platform (CIP) developed by RNE, the model should propose a visualisation of the selected routing with all lines, terminals, track gauges, railway profiles…
- Operational layer with detailed operational procedures at different key handover points (nodes, cross-border points). This level should differentiate the rules of the TEN-T corridors from the transcontinental relations (the connections between Europe and Russia and all selected routes linking Europe with China. This layer should include the exchange of customs and commercial documents as well (timing needed for the clearance for example).
- Legal & policy layer that might impact the two above mentioned layers and would lead to (1) significant changes in terms of infrastructure capacity/availability and (2) important modifications on the operational processes of (intermodal) freight trains.

For each layer of the model, clear quantifiable KPIs should be developed and integrated into the model. These KPIs should serve as a basis to identify and assess the potential of the emergent routes that will be defined in the various LLs, in particular in LL2 dealing with railway transportation. The impacts on the rail transport volumes should be first calculated per KPI and per layer and then mixing all KPIs with all layers in more complex scenarios.

The model should be validated mainly by the project partners active in the living lab 2 (all use cases). The LL2 partners shall take care of the following main tasks:

- Identify and select the most important emergent routes.
- List all potential parameters to be integrated into the model and this for all three layers (see chapter 4.2 for details).
- Select and prioritise the relevant parameters and criteria impacting the most the rail traffic growth on the selected emerging routes.
- Identify the types of goods that have the most promising growth rates on the various emergent routes.
- Define for each selected parameter the right KPIs (easy to quantify and calculate).
- Validate all outputs by external stakeholders (focused expert group or expert webinar).
- Consolidate all results and provide feedback to WP1 task leader responsible for the simulation model).

The main aim of the model should be to assess the impact of the selected parameters on the current transport volumes of the identified emerging routes. The credibility of the model should be continuously monitored and assessed by LL2 partners and their subcontractors. In addition, whenever necessary, the results might be discussed and addressed in specific LL2 webinars and/or workshops.

The methodology used to define the right scenarios for LL2 is based on the contributions of Foundation PP1 in which an eight-step process has been detailed. Transposed to the LL2 environment, the following main elements have been extracted:

- Focal issue: "How will the use of railway transport evolved in the next ten to 15 years in door-to-door supply chains between Europe and Russia/China?" "What are the main bottlenecks on the TEN-T and transcontinental corridors?" The shippers, LSPs, entry nodes, CT operators are the stakeholders from which we view the focal issue.
- Key factors: types of goods and loading units, volume throughput, efficiency of processes, transit time, railway infrastructure, digitalization of documents.
- External forces: economic (traction prices, new entrants), political (TEN-T governance, subsidy schemes in China, commercial trade agreements between Europe and China), environmental (Green Deal transposition, Chinese position on global warming), technological (wagons, emergence of platform providers, integration of PI and IoT mechanisms).
- Critical uncertainties and constraints: an assessment of each external force should be undertaken in order to integrate these risks into the model. The assessment criteria should be ranged between 1 (very low) to 5 (very high). These constraints have been categorized into 4 main groups:
    - GOODS (transport of Dangerous Goods): the restrictions on the transportation of dangerous goods through China have been a major challenge for the chemical sector. This is a booming market, and this market is eager to see the restrictions lifted.
    - INTEROPERABILITY (infrastructure): the need for door-to-door train interoperable parameters between Europe and Asia is a prerequisite for market growth as the non-interoperable infrastructure components cause numerous operational disruptions and increases the number of handlings and transit time.
    - HARMONISATION (document) – door-to-door customs and commercial document: the EU customs regulations lay down the rules for the European Customs area. This is not yet a reality at all for the Asian section of an intercontinental railway transport.
    - FUNDING (subsidies)- door-to-door subsidy scheme on the emergent routes: the current Chinese funding schemes are known even if they address mainly the Chinese exporters but are not stable in terms of time.

### 3.3.6 Conclusions

The paper accurately identifies the connections between the European (UIC) gauge network and the 1520mm Russian (broad) gauge railway network, which are largely inherited from the Soviet period. One exception is the East-West Gate Terminal in Northeast Hungary, which if completed in 2022, will match in capacity the Malaszevicze-Brest transhipment districts while offering state-of-the-art efficiency. The Southeast connections between Bulgaria and Turkey provide a UIC gauge connection for railways between Europe and Asia. The third Bosphorus bridge opened in August 2016, and the Argus Railport that will support its functioning premises to add substantial new capacities from 2022-23. Lastly, the paper identifies the mechanisms for international collaboration to organise the administrative trail, the customs procedures, as well as the rail safety, interoperability and communication links between the EU infrastructure and operators and those in the Russian, as well as the Turkish direction all the way to China.

The research gaps have been identified with the definition of 5 clusters (Statistical, Infrastructure: gap, economics, operations, and innovation) that should be further investigated in the living labs, in particular the living lab on railway transportation.

A diagnostic model is to be developed to better comprehend the complex ecosystem of the railway transport with intermodal loading units between Europe and Russia/China. This model should be structured on a three-layer dimension (infrastructure, operational and legal & policy) and recommendations to the LL2 partners have been elaborated to validate it. The authors of the current foundation paper propose to use the outputs for the WP1 (modelling/simulation) and WP3 (LL2 on railway transportation on Eurasian routes) activities. For WP1, the diagnostic model and the related scenarios should be considered in the simulation environment and for WP3 the analysis of the routes and the different scenarios should be further investigated and validated by the LL2 partners and external parties.

## 3.4 Transition towards the Physical Internet paradigm (PP4)

The PI concepts are embedded in the PLANET approach to investigate PI hub characteristics providing the interface between global and hinterland operation from both shipping and rail centred routes. It is within the objectives of PLANET project to assess how the transition to PI paradigm can be accelerated. PLANET will speed up the process and transition towards the PI paradigm, by: (i) providing evidence of the impact of PI's introduction in real-world business cases; (ii) assessing the applicability of the PI's synchromodality concepts; (iii) defining business and governance models for operating under a PI-Global trade web; (iv) providing transition guidelines & tools towards employing the PI paradigm in capability-rich and capability-poor SC (Supply Chain) environments; (v) enhancing stakeholder capacity in effectively and collaboratively governing a PI-Global trade web. Accelerating the PI will be achieved through simulation of PI hubs and corridors, with demonstration and assessment of PI-facilitating technologies in three global trade route Living Labs.

### 3.4.1 Physical Internet background

In response to the Paris Agreement, more and more governments, associations, and businesses are setting bold climate targets. **The ambition is for Europe to be the first climate-neutral continent in the world by 2050.** This will be achieved with a two-step approach, **designed to reduce CO2 emissions by 50%, if not 55%, by no later than 2030 [1]**. The Paris Agreement underlines the importance of meeting the 2030 targets for the EU, but, just as importantly, it identifies an overall ambition of limiting global warming to well below 2°C, and to pursue efforts to limit it to 1.5°C above pre-industrial levels [2]. This implies that EU programmes should include a focus on, firstly, coherence of all investments with the required **long-term decarbonisation trajectory**, and, secondly, on measures likely to facilitate or unlock more ambitious decarbonisation potential, and on the development of a new market for low carbon goods and services.

*It is expected that the increase in efficiency and productivity of freight transport and logistics will bring the savings and value needed to enable companies to pay for the required asset transition (i.e., towards the greening of all transport assets).*

Yet, logistics networks are still highly fragmented, mainly dedicated to a company or a specific market, as promoted by the supply chain concept and vertical coordination. The Physical Internet (PI) is considered to be the visionary paradigm supplying an integrated approach to address logistics integration and collaboration issues and to pave the road forward to deploying efficient supply chains. The PI is a game-changing vision that caused agitation in the logistics industry. Indeed, in a scenario in which all Physical Internet potential efficiencies are achieved the forecasted 300% increase in transport demand could be achieved with only 50% increase in assets [3]. The Alice platform has published a document with a comprehensive roadmap towards the Physical Internet. The roadmap sketches a path from now to 2040 showing important milestones, required technologies and first implementation opportunities for the PI. Advanced pilot implementations of the Physical Internet concept are expected to be operational and common in industry practice by 2030, contributing to a 30% reduction in congestion, emissions, and energy consumption from the transport sector.

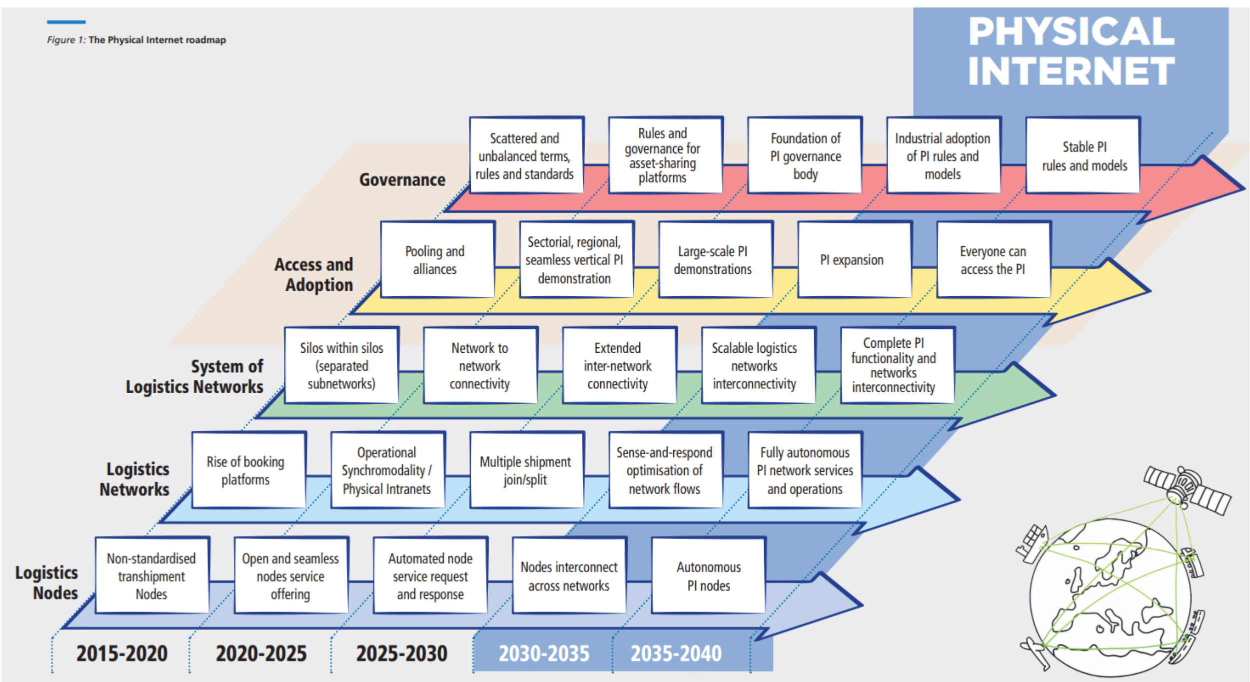



Figure 8: Physical Internet roadmap (SENSE project [4])

Inspired by the metaphor of Digital Internet, the Physical Internet (PI) aims to integrate logistics networks into an open and interconnected global system through standard containers and routing protocols (Ballot and Montreuil, 2014) [5]. The Physical Internet is a global logistics system in which products are transported in standardized, modular containers as efficiently and effortlessly between continents as in the case of Digital Internet transferring information between servers.

Physical Internet is an open framework also from the point of view of the use of the resources. The use of open warehouses and transport networks looks for a systemic load consolidation and optimization in which the capacity in the logistics sites and transport networks could be more available for the use of stakeholders in a more optimized way: reducing energy consumption, environmental emissions, and economic cost.

There are different concepts under PI that can improve the product flows addressed in PLANET. For example, one of the concepts that PI brings to the improvement of transport efficiency is the standardization and modularity of transport packaging, focusing on the redesign of product packaging, transport boxes and containers for optimal fit to product and for modularity, to allow efficient handling, consolidation, and pooling. This can be combined with re-usable containers (RCs), in anticipation of the implementation of the full Physical Internet concept.

### 3.4.2 Research questions

The following are the main research questions to be evaluated in this research work:

- RQ1: To what extent is the development of the physical and digital infrastructures toward EGTN inspired by and in support of progressive maturity levels of PI? In other words, what can PLANET learn from the PI Roadmap and how can the experiences in the PLANET project inform about the viability of the PI Roadmap?
    - Example: the development of Blockchain technology in conjunction with IoT and smart contracts could support standardized/predictable service responses to requests.
- RQ2: How could the various aspects of the Physical Internet contribute to improving the operational performance of intercontinental corridors that include the TEN-T corridors, gateway ports and intercontinental trade lanes?
    - Example: automated transport operations and better utilization of trucks constitute a potential answer to the deficit of drivers, PI increases container destination visibility that helps improve port operations.
- RQ3: To what extent do geo-economic aspects impact the adoption of PI?
- RQ4: What is the impact of PLANET logistics and transport concepts and technologies, such as Syncromodality, AI (Artificial Intelligence), IoT, Blockchain as contributing to the PI roadmap, on corridor development? Here we may dive into specific questions such as:
    - (i) Which are the benefits (and drawbacks) of having open/shared resources (warehouses, transport capacity…) as PI services in the intercontinental corridors?
    - (ii) What are the benefits and drawbacks of introducing flexible deployment and routing of transport means along corridors based on prognostics?

### 3.4.3 PI Literature review

The PI literature is constantly growing. The very first publication on the PI dates from 2006 while the concept of actual PI was initially introduced in 2010 by Montreuil et al. in [5], who laid its foundations and received the attention of academics and practitioners.

The main objective of Physical Internet is to make freight transport more efficient and sustainable [6]. PI creates a collaborative transport network by developing standardised, modular containers, common protocols and tools, and shared transport and technological assets [7]. The PI aims to organize the transportation of physical goods in a manner similar to the way in which data packages are moved on the digital Internet. By sharing resources, such as vehicles and data, and designing transit centres, which enable seamless interoperability, the transportation of goods will be optimized regarding cost, speed, efficiency, and sustainability. To achieve this optimization, the PI sets common and universally agreed-upon standards, and protocols to facilitate horizontal and vertical cooperation between organizations. (“The physical internet as a new supply chain paradigm: a ...”)

According to the PI setting, goods are firstly encapsulated in standard, modular containers, named PI-containers, which can be of varied sizes [8] and be intelligent [9]. One or several carriers then transport these containers from hub to hub to the destination. The hubs in PI, or PI-hubs [10], are open to shippers or carriers, which means that shippers or carriers may freely join or leave any hubs.

The European Commission, following the transport policy included in the White Paper of 2011 [11], aims at near 'zero-emission urban logistics' by 2030. The objective is to implement and demonstrate the cross-European implementation of the Network of networks, in which:

- bookings by shippers will be consolidated in terminals and distribution centres.
- planning will be real-time, adapted to the current availability of cargo, services, and resources.

Matusiewicz in [12] there is a description of the chances that the Physical Internet brings to the logistics efficiency from an EU perspective. The article describes the formal EU preparation for the PI concept as well as the selected first projects, ventures, and tools that already function as prototypes of the PI concept. The author's now-concluded survey shows stakeholders' reluctance toward sharing information and connecting to the common platform. No one has ever designed a coherent global transport system. Current solutions rely on a combination of national, regional, and local networks with no common structure resulting in a chaotic and ineffective transport model.

According to Alice 2016 [13] in the vision for a transport system supporting sustainable and efficient logistics towards the Physical Internet, indicates that the key Enabling factors for PI are:

- Reaching consensus and support from all transport and logistics stakeholders, including European Commission and Member States on the need to achieve the truly integrated transport system for sustainable and efficient logistics and on the overall vision on the system.
- Current development on robotics for logistics and autonomous operations.
- Autonomous transport.
- Internet of Things.
- Big Data.
- Crowdsourcing and sharing economy.
- Fast evolution of interoperability towards easier connectivity of independent ICT systems.
- Leadership and entrepreneurship.

In recent years, several European research projects have been developed to analyse different aspects of the Physical Internet. Some of them are Modulushca [14] (an acronym for Modular Logistics Units in Shared Co-Modal Networks) focused on fast-moving consumer goods (FMCG) logistics. SETRIS [15] (Strengthening European Transport Research and Innovation Strategies) whose objective was to deliver a cohesive and coordinated approach to research and innovation strategies for all transport modes in Europe. CLUSTERS 2.0 [16] (Open network of hyper-connected logistics clusters towards Physical Internet). It relied on an Open Network of Logistics Clusters operating in the frame of Ten-T and supporting local, regional, and European development while keeping neutral the local impacts such as congestion, noise, land use and local pollution levels. ICONET PROJECT; its goal is to establish a "cloud-based PI framework and platform" [17], which builds upon these latter leading-edge technologies, in a pathway that integrates PI-driven capabilities, by means of an incremental and verifiable approach that exploits progress in digital and physical interconnectivity through open and public Application Programming Interfaces (APIs). The SENSE project goal [18] is to accelerate the path towards the Physical Internet (PI). SENSE aims to increase the level of understanding of PI concept and the opportunities that bring to transport and logistics. By building stronger and wider support of industry, public bodies, and research worlds towards the PI we may reach consensus and enable coordinated strategic public and private investments in research and innovation embracing Physical Internet that could lead us to a new much more efficient and sustainable paradigm. One of the main outcomes of SENSE project is the development of a comprehensive and detailed roadmap towards the PI realization [19].

**Maritime container models as an initial PI reference model**

The global system of container logistics is a preliminary version of the envisioned PI. We can learn from the current maritime container system and it will help us to position Synchromodal transport as a preliminary concept for PI.

Following the ALICE Roadmap toward PI, we observe that: (1) container terminals are preliminary versions of PI Nodes as they handle containers in a standardized way and usually are shared among any number of shippers. Among other things, nodes have been automated and standardized response to service requests is underway; (2) container transport networks are already basically open to multiple shippers and allow for consolidation in intermodal transport networks; (3) container transport already deploys a system of various networks across modes and to some extent LSP's in horizontal and vertical collaboration; (4) the industry has adopted the use of standardized loading units and has started to accept digital standards as well; (5) same holds true for governance rules and standards.

However, there is room for further development in the container system: (1) container terminals are not yet synchronizing their operations with inbound and outbound transportation activities to the full extent possible; (2) intermodal transport networks need to develop more flexible deployment of assets, capabilities and resources by moving toward synchromodal services; (3) carriers and LSP's can move forward in progressively share their assets, capabilities and resources; (4) the adoption of a universal set of digital standards is underway but certainly not achieved; (5) same holds true for governance rules and standards.

In a way, establishing the PI roadmap at the level of maritime containers could be a great exercise to progress the PI for door-to-door logistics chains. Admittedly, the scope of the container network is limited. The development of digital booking platforms and synchromodal services for container logistics indicate that the roadmap is being improved.

### 3.4.4 Research gap

The literature on the Physical Internet is extensive. The following section highlights some of the gaps identified in the literature for the development of Physical Internet:

- In Matusiewicz [20] the authors include a survey that shows stakeholders' reluctance towards sharing information and connecting to the common platform. No one has ever designed a coherent global transport system.
- In order for the Physical Internet to work, we need new infrastructure and new entities. Montreuil in [21] recommends a hyper-connected logistics infrastructure containing:
    - certified open logistics service providers.
    - open logistics decisional and transactional platforms global logistics monitoring system.
    - certified open logistics facilities and ways.
    - standard logistics protocols.
    - containerized logistics equipment and technology.
    - Unified set of standard modular logistics.
- According to Alice 2016 [22] on top of the enablers and triggers, current barriers are impeding the truly integrated transport system for sustainable and efficient logistics:
    - Market dynamics. Logistics has traditionally been a sector with low innovation investments due to smaller margins and high fragmentation.
    - Lack of well-recognized industry business and operational models implementing horizontal collaboration.
    - Lack of modular load units facilitating inland and air transport.
    - Too many regulations that hinder innovation.

    - Lack of appropriate transhipment technology.
    - Lack of ICT to rapidly connect to, and disconnect from, supply networks at two levels: the business level, and the technical ICT level.
    - Lack of trust in sharing information services and systems.
    - Lack of appropriate standards for data collection, data collection systems for reporting commercially and socially valuable information as well as data quality monitoring.
- According to Matusiewicz in [23] there are still some horizons to be explored, like methods of network connection between carriers and shippers, new business models, and network security.
- According to Professor Eric Ballot in 2016 [24] there is truly little research on dynamic pricing in LTL (Less than Truckload) transport in the literature, there are other sectors concerned by the dynamic pricing problem, such as air cargo, liner shipping, railway freight, and FTL transport.

In general, it is noted that there are still gaps for research according to different authors. Some of the themes are repeated in their discussions: Standardisation of packaging and information to facilitate interoperability, reluctance towards sharing information and connecting to the common platform, lack of ICT platform to rapidly connect to, and disconnect from (plug and play), and need to assess the economic and social impact of the implementation of PI.

### 3.4.5 Relevance to the living labs

Physical internet is a standard of transport, collaborative and open. Within the LL, it is possible to evaluate the benefits of the progressive adoption of PI in terms of improved process efficiency, increased freight transport capacity and reduced environmental impacts. One of the main advantages of PI is the collaboration between different actors in the supply chain along the corridor. Throughout this collaboration, different decisions must be made that will impact on the processes of these agents. The modelling and simulation of the processes will make it possible to evaluate the impact of these decisions on the various aspects of transport: resource capacity, arrival times, congestion, etc.

The LL1 workflow can be used as an example to explain the relevance for living labs.

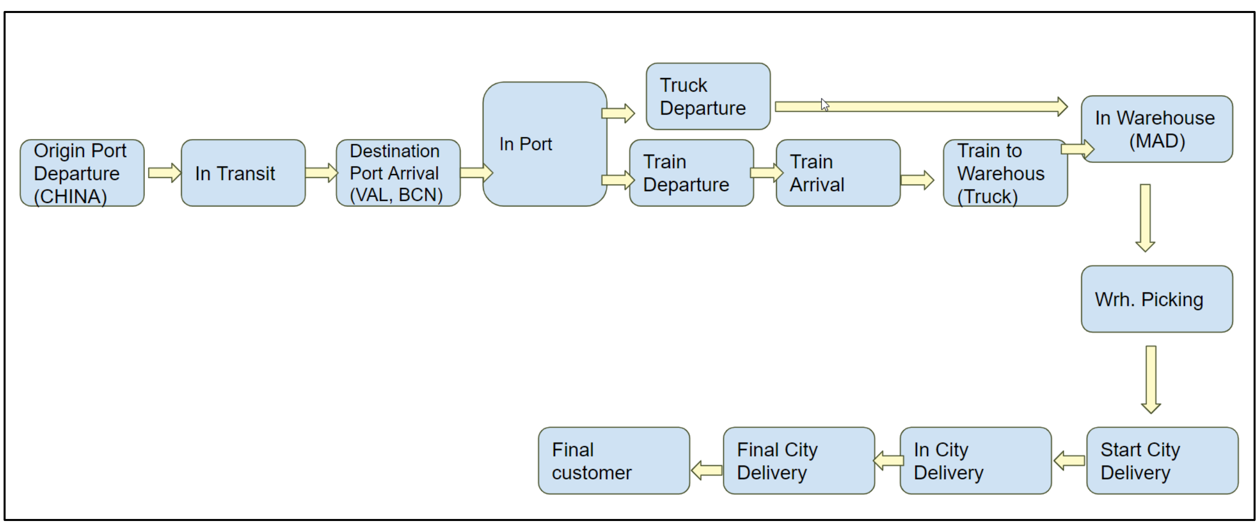



Figure 9: Main process representation in end-to-end corridor transport process

In these images (Figure 9) based on the LL1 description the representation of the main processes that take place in the context of freight transportation can be seen, during the journey from the point of origin (i.e., a production centre in China) to the final destination (i.e., a customer in the city of Madrid).

It can be observed that there are a lot of events and decisions that have to be taken by the agents of the chain. The coordination has to be excellent so that the goods arrive without delay to the final destination. The selection of alternatives is wide and a great amount of information and variables must be considered, in order to select the appropriate resources at each moment.

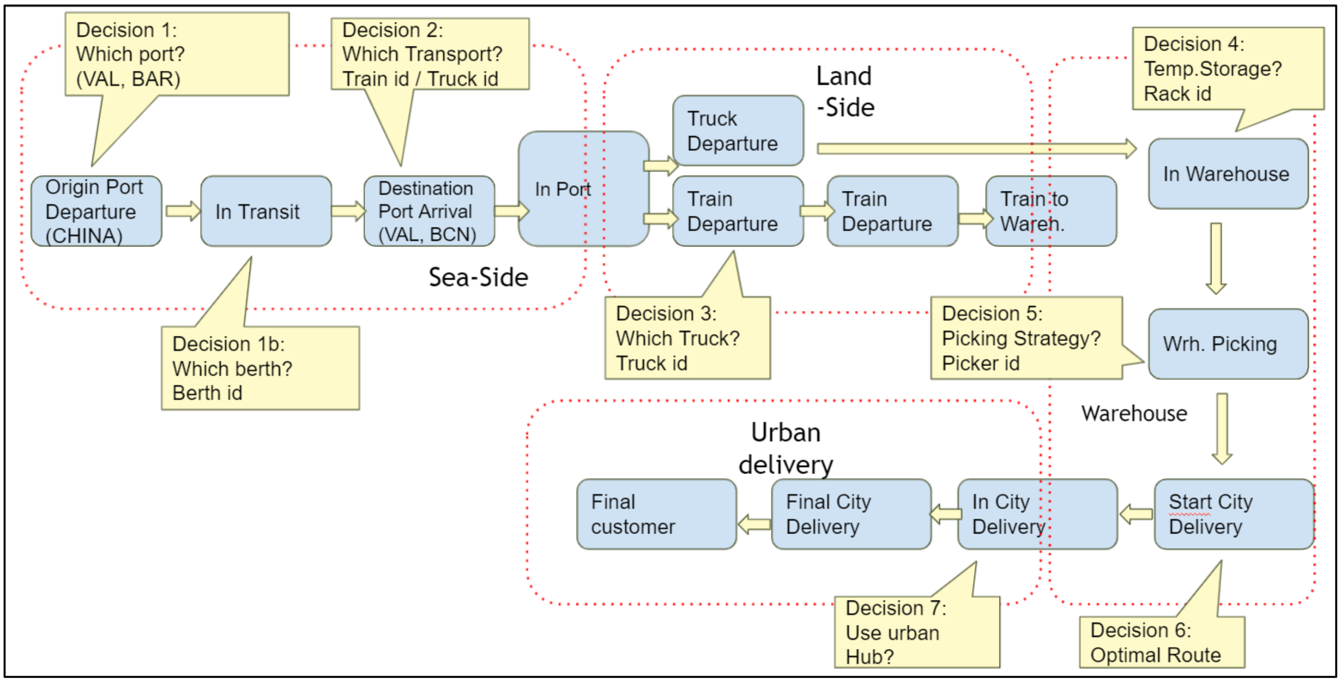



Figure 10: Main decisions in end-to-end corridor transport process

To carry out a "physical" collaboration, at the present time, sharing resources such as transport or storage areas, it is necessary to carry out a "digital" collaboration with the companies beforehand in order to be able to plan to deploy and to manage all their collaborating processes. Collaboration must be carried out in two-time areas, from the point of view of planning operations and from the point of view of executing operations.

Activities related to the planning horizon:

- Reserve space inside a container.
- Reserve berth in a port.
- Book train wagon.

Activities related to implementation horizon:

- Modify a route due to congestion at a specific point.
- Change of transport due to problem detected in the load (via IoT sensor).
- Changing the mode of transport due to a delay in a process.

All these planning and execution activities require coordination and exchange of information between different actors in the corridors. The technologies of IoT, AI and Blockchain can help to obtain information from the execution of the processes, share the information in a secure and unchangeable way and make the most appropriate decisions according to the information available and the rules of behaviour of the processes.

### 3.4.6 Towards the Physical Internet

The Physical Internet is an open collaborative framework, which can help improve the use of the resources that circulate along the intercontinental corridors. To be able to carry out "physical" collaboration, sharing resources such as transport or storage areas, it is necessary to carry out "digital" collaboration between companies in order to properly setup and orchestrate the collaborative processes.

Successful collaboration must be carried out on two levels, (a) from the point of view of planning operations and (b) from that of executing operations.

The Physical Internet literature survey concludes that the development of PI would have many benefits, especially from the point of view of taking advantage of available resources and reducing emissions to the planet. The use of standard maritime containers could be considered as a starting point in the PI framework.

The same bibliographic review has also identified different barriers like stakeholders' reluctance towards sharing information and connecting to the common platform, lack of certified open logistics service providers or lack of appropriate standards for data collection.

Therefore, a collaboration between agents may be necessary for the deployment of Physical internet and it should be based on trust; this implying that there are issues to be tackled to the Access and Adoption and the Governance levels, as it has been identified by the "Roadmap to Physical Internet Executive" issued by ALICE (12/2020).

To this end, security, provenance, and reliability enhancing technologies as IoT, AI and Blockchain, may work positively to help build trust between collaborating actors. In PLANET we will explore how the application of these technologies can help to foster collaboration between agents applying Physical internet concepts.

## 3.5 Position Papers Consolidated View

Purpose of the 4 foundational Position Papers of the PLANET project is to provide a compendium of the research and study results related to the main aspects of the development of the EGTN and thus provide an initial view of it. These aspects namely include the geo-economic dimension which drives the emergence of new global trade routes, the impact of these routes on the existing EU transportation network (TEN-T), the existing land interconnection issues of the TEN-T with networks outside EU regarding rail transportation and finally, the emerging of the PI concept and the corresponding PI enabling innovative and disrupting technologies which have the potential to guide the shaping of the EGTN towards a green and transport efficient future. The main conclusions from the foundational papers are presented in this chapter.

**1.- New trade patterns**

Starting from the content analysis of the first and second position papers, it becomes obvious that trade patterns to/from and through Europe are expected to change significantly over the next years. The reasons for this development include several geo-economic changes which induce the development of new trade routes connecting Europe to Asia with an emphasis on the connection with China. Among these changes, the trend for change in the current model of globalized production towards the regionalization of production, especially for middle-high end/strategic products but also environmental parameters related to the climate change (melting of Arctic ice, longer periods of drought) are expected to play a significant role in the emergence of three new trade routes.

As regards with these routes, China's desire to improve the connection with the European continent and the intention to move production towards the east and less developed part of the country has led to the One Belt One Road initiative which consists of six economic corridors and includes both a maritime and a land connection to Europe.

Furthermore, the quest for lower transport costs and faster transport in relation to the traditional but congested and time-consuming maritime route through the Suez Canal, together with the ambitions of Russia regarding the exploitation of the Arctic region has led to the consideration for a maritime route through the Arctic region. This consideration is further enhanced by models predicting larger ice-free periods in the region but also by the need for supply chain resilience. The need for this resilience is well depicted in the Suez Canal incidence in March 2021 when the canal was closed for 6 days because of an accident causing a significant disruption to the supply chains worth of millions of dollars.

Finally, the intention of Russia and India to connect has led to the intention to develop the International North-South corridor passing through central Asia which also bypasses the Suez Canal and has significant potential in terms of transport efficiency.

**2.-Impact on TEN-T & monitoring changes**

The three new emerging global trade routes connecting the EU and Asia (China) have the potential to change the main entry points of trade and the flows along the TEN-T corridors thus altering the capability of the current network to serve these flows. The current structure of the TEN-T is set up towards serving the flows reaching Europe from established routes, focusing mainly on the hinterland connection of maritime nodes. The bottlenecks that will emerge and possible capacity shortages will affect the service levels and the reliability of the corridors, requiring actions to adapt to the new circumstances.

At the same time, the trend towards globalization of production has the potential to reduce maritime flows while also altering the patterns of flows within the TEN-T, moving the focus for infrastructure development from hinterland connections of the main entry (maritime) points to inland connections between different regions of production and consumption. This will place further pressure on the TEN-T which will require sustained efforts to accommodate the new flows.

However, the changes are not expected to happen at the same pace. There is a significant difference in the maturity level and the uncertainties related to the development of the three emerging routes, with One Belt One Road initiative appearing to be the more developed among the routes under consideration.

The other two routes, the Arctic route and the International North-South corridors, despite both having significant advantages such as the bypassing of the Suez Canal thus providing resilience to the supply chains and also the shortening of the distance to Europe which is translated to significant time and cost savings, there are for both important parameters which increase the uncertainty of their future and more specifically the time horizon of their realization.

In short, the uncertainty related to the rate of global warming which will increase the navigable periods in the Arctic along with the environmental considerations related to the exploitation of the Arctic region and the geopolitical relations are some of the main uncertainties related to the development of this route. In the case of the International North-South corridor, infrastructural deficiencies, and the financial perspective as a multi-stakeholder activity among the transit countries are the main issues affecting its development. However, despite the important uncertainties that will affect the level and time of development of these two routes, when operational, they will add significant flows to Northern European ports (Arctic route) and to the rail corridors of East Europe (INSR).

Concluding from the above, the development of the new trade routes and the corresponding impact on the TEN-T will be a dynamic process in the following years. This will require an equally dynamic method for monitoring these changes at a node and region level to provide insight to the competent authorities for the planning of the development of the EGTN. This can be achieved through the development and implementation of indices that will capture a transport node's level of integration in the TEN-T/global network as well as in the global maritime transport network since accessibility and connectivity are indicators for the effectiveness of the transport network as an enabler for trade. Furthermore, the operational efficiency of nodes and corridors as well as their reliability of performance needs also to be captured and monitored over time.

Several methods already exist that measure the connectivity of logistics locations and express this with an index such as the World Port Index and the Liner Shipping Connectivity Index (LSCI). However, these indices are only focusing on the foreland and port side, whereas the current need is on the connectivity of corridors/hinterland with (emerging) trade routes. To respond to this need, the Corridor Connectivity Index (CCI) will be developed in the context of the PLANET project, capturing the connectivity of a node as manifested by its position regarding port capacity, efficiency and ease of processes, service frequency, service quality and digital connectivity. The changes of the CCI captured over the years will allow to identify the changes of nodes and even regions regarding their capabilities/scale/accessibility and thus be applied as a barometer of changing trade flows.

**3.- Main trends for influencing the development of EGTN**

Regarding the OBOR land and maritime corridors to Europe, the latter appears to be the one that has already been developed to an important degree, connecting Asia & Africa to Europe but also to the east coast of North America through maritime transhipment hubs. This is evident from the significant investments by China in infrastructure in Europe which mainly include ports and terminals but also other assets aiming to enhance port-hinterland connections. Regarding transhipment operations, the Mediterranean ports appear to have significant development in this field, attracting flows from the Northern European seaports as shown by the increase in the number of calls received by ports of the North America region from ships coming from the Mediterranean.

On the other hand, the Eurasian rail land corridor which is the land part of the OBOR initiative is appearing to be the route with the most significant perspective to develop and affect the future of TEN-T for a series of reasons related mainly to geo-economics.

The tendency observed towards moving production to the West and less developed part of China along with the emerging economies of Asia expected to induce demand for transportation of middle to high-end products through a fast and reliable way (considering also the trend for regionalization of production) is expected to increase significantly the land (rail) flows to the eastern borders of the EU. This in turn will possibly reduce the volumes transported through the maritime silk route, a possibility also enhanced by the environmental restrictions imposed by the EU and may move transhipment initially from Northern Europe to the Mediterranean and then away from European ports.

Currently, the majority of rail freight traffic between the EU and Asia is served through the wide-gauge (1520mm) railway network of the former Soviet Union, entering/exiting the EU from the border crossings in Latvia, Lithuania, Hungary and Poland. The latter includes the main eastbound railway connections and also the most important link between the EU and the wide-gauge network in the Małaszewicze transhipment area where trains arrive from Minsk/Brest. It can handle more than 20 trains per day (450 thousand TEUs/year) and its capacity is expected to quadruple by 2022.

Furthermore, the connection of the European rail network to the Turkish UIC gauge network appears to have the potential to support increased freight flows, due to major infrastructural investments realised by Turkey and when a new intermodal terminal will become operational in 2022.

However, the interconnection of the European rail transport corridors to the global network is not without problems. There is great uncertainty regarding aspects that have the potential to affect significantly the development of the intercontinental rail corridors and their ability to attract flows.

The poor interoperability of rail infrastructure causes operational problems and an increase in handling and transit time thus reducing the competitiveness of rail. This is also the result of the low digitalization levels today in terms of the management of customs and commercial documents together with the lack of data harmonization along the entire global corridors.

Finally, political issues with most prominent the granting of subsidies to Chinese companies for transferring containers through rail and thus creating conditions of unequal competition with European companies, the existing restrictions to the transportation of dangerous goods through the Chinese network and the complicated customs procedures pose additional obstacles to the development of the Eurasian land corridors.

Solving the rain interconnectivity issues is a complicated task requiring concentrated efforts in multiple levels including the development of hard infrastructure and the implementation of operational solutions which need to be supported by legal and policy initiatives and also international agreements.

**4.- The role of the technology**

As noted in the second Position Paper, the sustained efforts to accommodate the altered flows on the TEN-T network, part of which will be combining intra and intercontinental movements, which will also heavily rely on technological and digital solutions besides the infrastructure development. This is the case for all modes of transport with particular emphasis on rail, the development of which is expected to be one of the main trends in the future of TEN-T.

The implementation of the Physical Internet concept and of the enabling innovative, disrupting technologies is the PLANET approach towards reaching the Green and operational excellence aspects of the EGTN.

The increase in productivity and efficiency of freight transport which the PI has the potential to bring will utterly change the supply chain operations along the transport corridors, provide a solution to several identified current and future issues and thus facilitate the process of designing the EGTN towards the goals of greener transportation and operational excellence.

However, the specific research questions posed in the fourth position paper regarding the impact of PLANET logistics and transport concepts and technologies as contributors to the PI roadmap, the ways in which the various aspects of the Physical Internet can contribute to improving the operational performance of intercontinental corridors and finally the extent to which the geo-economic aspects may impact the adoption of PI cannot be yet answered. These will be examined in the context of the project in order to provide the answers and also to have a quantitative estimation of the impact of these technologies on the development of the EGTN.

**5.- Scenario building for the future**

Concluding from the above, the analysis of the contents of the Position Papers makes clear that the flows in the TEN-T are expected to change significantly over the next years due to a significant number of different parameters the majority of which have an increased degree of uncertainty. This is ever more pronounced in the case of parameters such as the geopolitical and environmental ones which are not under the direct control of the EU.

The scenarios building exercise which was performed in all four Position Papers has managed to capture the majority of these uncertainties and their variations, each PP in its field of interest and assessed them leading to the drawing of a set of plausible future narratives. In PP1 these narratives were then matched with the important early indicators and the corresponding implications to the European transportation network.

However, to be able to obtain a complete picture of the future, these different scenarios need to be combined and form several consolidated possible future scenarios that will consider all the critical individual uncertainties of the four position papers and thus include the geo-economic, the infrastructural and the technological aspects allowing for a better approach of the future.

The outcome of these scenarios will provide the insight needed to take control of the upcoming changes and shape the EGTN as the future of the TEN-T through applying changes which will affect policy and legal frameworks, governance, planning and monitoring of network development, and the technical specifications of all aspects of the infrastructure.

# 4 Simulation scenarios

In the forthcoming steps within the living labs, we propose to work out the following framework for geo-economic scenarios. This methodology is developed by Stratfor [25], a geopolitical intelligence platform and is targeted at companies that want to build a strategic plan without having certainty about the future. In the living labs we will use this methodology, but then from the perspective of the TEN-T network instead of viewing from a company perspective.

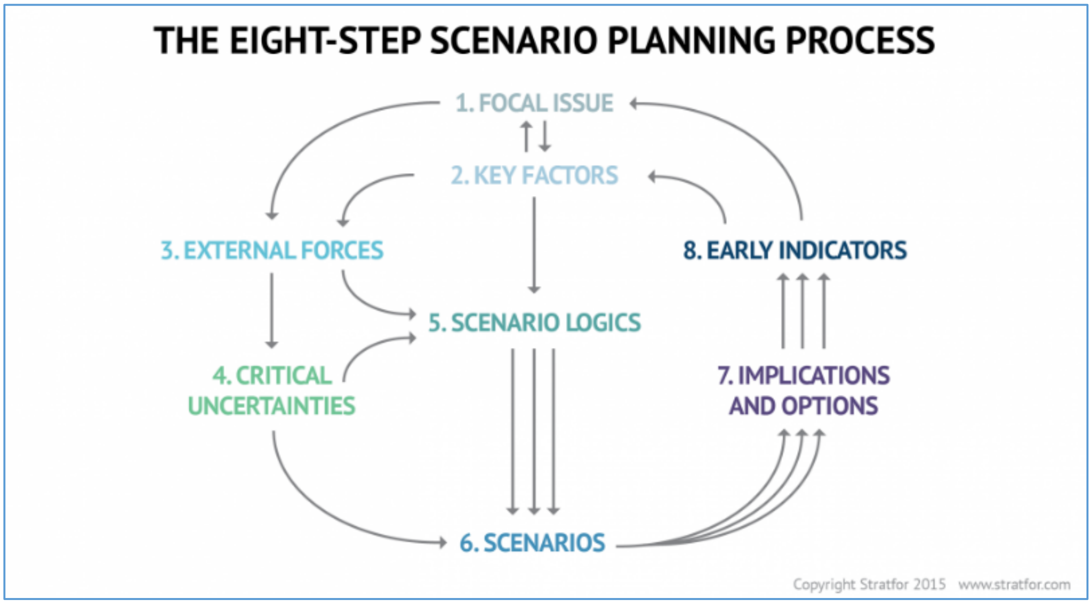



Figure 11: Steps for scenario planning process

According to Stratfor, the description of the eight-step process that helps to set up the scenarios is as follows:

1. Focal issue: which stakeholder perspective to choose? What is the strategic question that you want to develop your scenario around? What is the time horizon of the scenario?

2. Key factors: What are the key factors of the stakeholders that are impacted by trends and forces?

3. External forces: Determine external SEEPT factors (Social, Economic, Environmental, Political, Technology) that impact the key factors and focal issue in steps 1 and 2.

4. Critical uncertainties: how much impact does each external force has on the focal issue? How (un)certain is that impact?

5. Scenario logics: Narrow down from the virtually infinite number of possible futures to settle on just two to five that will lead to strategic insights.

6. Scenarios: Discuss and write down the stories that explain how driving forces interact and what effects they have on the operation or strategic direction.

7. Implications: Focus on the strategic implications and options. Define the consequences of the various scenarios to the TEN-T network and stakeholders within the network.

8. Early indicators: look around for early indicators that tell in which direction/scenario reality the future is moving.

## 4.1 (PP1) Scenario methodology and application to the new trade routes for Europe Simulation Scenario

To better describe the implementation of this methodology, the application to the case of analysis of the new trade routes for Europe is used. The aim of this exercise is to identify multiple pathways for the development of node connectivity on the TEN-T network, depending on developments in the geopolitical and geo-economic playing field. We will work out the scenario logic linked to the main question of this foundational position paper:

> *"What is the relation between geo-economics and new trade routes, what are the dynamics of these trade routes and how can we measure and monitor the impact on existing TEN-T corridors?"*

1. **Identify the focal issue:** In this step the topic on which the scenario analysis is to be developed is chosen. Writing the name of the actor who must manage the dynamics and evolution of the market.

   The focal issue can be formulated as following: 'how will geo-economic developments and new trade routes impact principal entry nodes and inland nodes on the TEN-T network?' This can be worked out for the three main trade flow developments: Belt and Road, Arctic Route (NSR) transhipment in the Mediterranean and the International North-South Transport Corridor, and it leads to four focal issues:

   - Belt and Road: how will the Belt and Road initiative evolve and how will it impact principal entry nodes and inland nodes on the TEN-T network?
   - Arctic: how will the development of the NSR impact principal entry nodes and inland nodes along the TEN-T network?
   - How will the expansion of transhipment hubs in the Mediterranean impact principal entry nodes and inland nodes on the TEN-T network?
   - International North-South Trade Corridor: How will the INSTC initiative evolve and how will it impact principal entry nodes and inland nodes on the TEN-T network?

2. **Identify key factors:** what are internal key factors that have an impact on the position of principal entry nodes and inland nodes on the TEN-T network?

   These can be described as the internal performance indicators of such nodes within the network. Examples can be found in the model as described in 3.5.1 (port capacity, efficiency of processes, service frequency, service quality, digital connectivity, cybersecurity).

3. **Identify external driving forces:** The goal of the scenarios is to anticipate possible and plausible futures and identify strategic options for the stakeholder. Crucial here is an understanding of how the environment among the logistics network is changing and to consider forces and trends that are often not considered in the business plan. Strategic plans that disregard such geopolitical, economic, social, and technological (SEEPT) forces are often left out often fail.

   Key external driving forces are among other investments of the Chinese government in the BRI, the d i s a p p e a r a n c e of Arctic ice, critical attitude towards Arctic sailings, the development of disruptive technologies, economic growth, nearshoring/re-shoring and (environmental) legislation. Some of these driving forces might be counterproductive towards the development of certain trade routes.

4. **Identify critical uncertainties:** after having followed this structured step-by-step process it is time to identify the key uncertainties. That is, ranking the key uncertainties on potential impact (low-high) and uncertainty (low-high) and plotting it in a graph. The Goal is to find the two most important uncertainties, which will have the largest potential impact on the node and the highest level of uncertainty.

Critical uncertainties will be determined within the living labs, in close collaboration with the partners (principal entry nodes and inland nodes)

5. **Scenario logics:** In step five the question is how to narrow down from the virtually infinite number of possible futures to settle on just two to five that will lead to strategic insights. The two critical uncertainties identified in step 4 serve as the axes of a 2-by-2 matrix. Obviously, 2 factors can impossibly explain the full picture of the future. However, by using the factors with the highest level of uncertainty and impact we force ourselves to think of 4 completely different worlds. Factors that have been filtered out, but not included on the axis, should be used to feed each of the four future states.

Below follows an example of a scenario structure outline, using the focal issue about the Northern Sea Route:

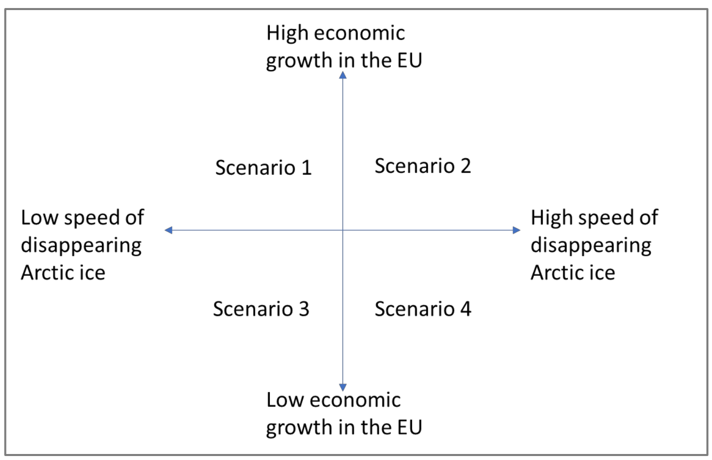



Figure 12: Scenario structure outline example

**Scenario logics:**

The following figure shows the different scenarios that result from applying the different uncertainty factors:

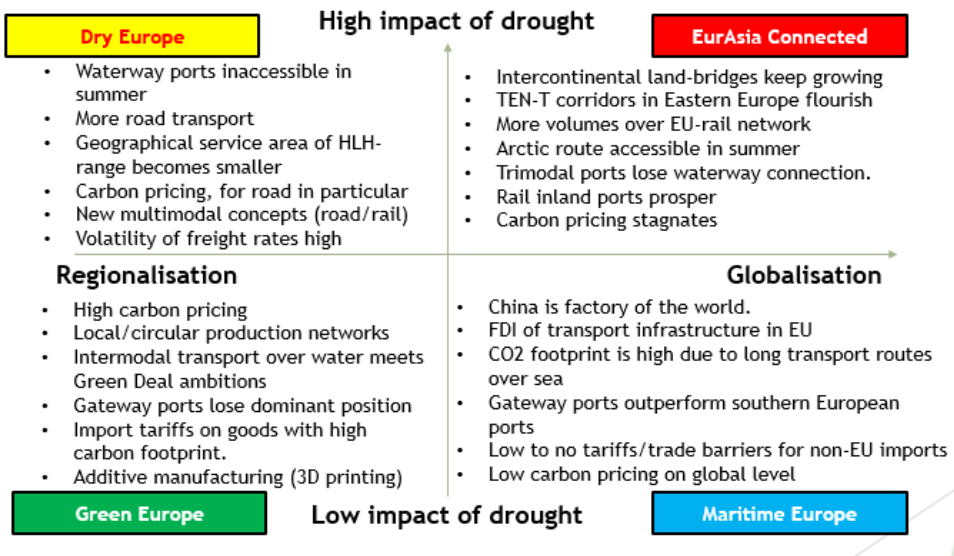



Figure 13: Scenario logics

Each scenario is described below, identifying how it is likely to evolve towards 2035:

## Dry Europe

Europe suffers from drought – related to climate change and worldwide failure of reducing $CO_2$ emissions – which negatively affects water levels of rivers and thereby makes Inland Waterway Transport (IWT) unreliable, thereby road and rail transport increase even further in modal split. Europe is regionalising its economy by increasing local production and strengthening the circular economy. On the one hand driven by the increase of trade blocks, on the other hand driven by increased carbon pricing and the resulting decrease in the attractiveness of global supply chains. The arctic route starts becoming ice-free for longer periods and becomes a reliable alternative for the Suez-canal route between Asia and the EU. Shippers start considering using the route for container liner shipping more and more.

## EurAsia Connected

Europe suffers from drought which makes IWT unreliable, thereby road and rail transport increase even further in modal split. The EU-Asia connection over land increases significantly due to the Belt and Road ambitions of China and the shifting economic point of gravity towards Eastern Europe. This goes hand in hand with investments of China into logistics infrastructure and assets. The import-export balance becomes more equal on the rail-route and the geopolitical relation between the EU and China is stable.

**Green Europe**

Europe has succeeded in its climate ambitions for 2030 and is on the way to reach its 2050 ambitions. Also, outside Europe countries are doing well in drastically reducing CO2 emissions. Carbon pricing is done at a large scale, both inside and outside Europe. Thereby global warming is flattening, and the impact of drought is limited, and river systems are reliable enough to accommodate growth. Economies become more regionalised and circularity becomes the norm. This results in more regional and less intercontinental transport flows. Global transport chains are no longer the standard and gateway ports in the HLH-range lose throughput volume in containers.

**Maritime Europe**

Europe still receives many intercontinental flows and China is still the factory of the world. Regionalisation has not gained any traction and transport movements around the world are strongly increasing year by year. This is the result of the worldwide lack of carbon pricing and thereby the lack of incentives to change to more renewable ways of production and transportation. This scenario could be considered as the status quo scenario where citizens, politics and companies are not willing to change their behaviour.

Implications of the scenarios should be determined by the modelling team. For example:

- How does the modal split in Europe change in each scenario?
- What will be the relative growth change of Southern European ports compared to NW-European ports?
- Which inland transport nodes gain traction under each scenario?
- How will transport tariffs per MT/TKM change when inland waterways cannot be used anymore?

## 4.2 (PP2) TEN-T Corridors & Nodes as impacted by New Trade Routes Simulation Scenario

Scenarios offer insight into possible future developments. Scenarios can be used to gain insight into the most likely direction the future will take, but you can also use scenarios to gain insight into what the future will look like when certain choices are made.

| |
|---|
| What is the impact of new and emerging trade routes? What are the underlying trends? How can the EU anticipate managing these routes? |

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 about 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 during this study the number of scenarios will be expanded. Each scenario will be simulated for 2030 and 2050.

Table 6 Overview of the preliminary scenarios used in task 1.2.

| Year | Scenario type | Reference scenario | Specific Scenario's | | |
|---|---|---|---|---|---|
| | | | **Exogenous developments** | **Rail scenario** | **Disadvantaged Regions (DR)** |
| **2030** | **High** | *Business-as-usual* | *High growth* | *High investment* | *Progress in DR* |
| | **Low** | | *Low growth* | *Low investment* | *Decline in DR* |
| **2050** | **High** | *Business-as-usual* | *High growth* | *High investment* | *Progress in DR* |
| | **Low** | | *Low growth* | *Low investment* | *Decline in DR* |

**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.

**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.

In addition to a scenario in which railways are used more intensively for freight transport, we are also looking at a situation in which this does not happen. In this situation, the majority of freight transport between Europe and Asia will go by sea. This provides insight into the consequences of the underdevelopment of rail freight transport.

***Disadvantaged regions***

Eastern Europe is the gateway for rail transport to and from Asia. In this scenario, we look at what happens if the disadvantaged regions develop strongly. This involves infrastructural development on the one hand, and socio-economic development on the other. We also look at what happens if this region lags behind.

**Model parameters**

The table below provides an overview of the parameters in the model that can be adjusted per scenario. Similar parameters are available to model the inter-Europe trade flows, i.e., the trade flows from the principal entry nodes and the European hinterland destinations:

Table 7: Model parameters for Europe-China trade flows

| **Parameter** | **Parameter adjustments** |
|---|---|
| Trade data | Increase/decrease trade between countries |
| Rail terminals | Add or remove terminals |
| Rail routes | Add/remove routes |
| Rail services | Add/remove services |
| Rail costs | Increase/decrease rail costs |
| Terminal costs | Increase/decrease attractiveness of terminals |
| Sea ports | n.a. – all sea ports are included |
| Sea services | n.a. –all sea services are included |
| Sea costs | Increase/decrease costs |

## 4.3 (PP3) Railway transport-corridors to/from Europe Simulation Scenario

In this project the aim is to provide simulation capabilities for the assessment of the expected impact of emerging trade routes, national strategies and technological concepts on the TEN-T corridors and Principal Entry

Nodes/inland nodes interfacing TEN-T to global trade and will define the Reference Specifications of Integrated EU-Global Networks (EGTN).

The methodology used to define the right scenarios for LL2 is based on the contributions of Foundation PP1 in which an eight-step process has been detailed (see figure 3.1). Transposed to the LL2 environment, the following main elements can be extracted:

- Focal issue: "How will the use of railway transport evolved in the next ten to 15 years in door-to-door supply chains between Europe and Russia/China?" "What are the main bottlenecks on the TEN-T and transcontinental corridors?" The shippers, LSPs, entry nodes, CT operators are the stakeholders from which we view the focal issue.
- Key factors: types of goods and loading units, volume throughput, efficiency of processes, transit time, railway infrastructure, digitalization of documents
- External forces: economic (traction prices, new entrants), political (TEN-T governance, subsidy schemes in China, commercial trade agreements between Europe and China), environmental (Green Deal transposition, Chinese position on global warming), technological (wagons, emergence of platform providers, integration of PI and IoT mechanisms).
- Critical uncertainties: an assessment of each external force should be undertaken in order to integrate these risks into the model. The assessment criteria should be ranged between 1 (very low) to 5 (very high). For example, the risk that the Chinese government won't pursue the subsidy program for railway transportation on some routes is very high.
- Scenarios: four different scenarios could be envisaged for the railway transport on intercontinental corridors and should be further investigated by the LL2 partners:
    - GOODS (transport of Dangerous Goods): the restrictions on the transportation of dangerous goods through China have been a major challenge for various industries. With the growing demand for electric cars, there is a growing demand for batteries, not only for electric cars but also for electric bicycles, laptops or households. This is a booming market, and this market is eager to see the restrictions lifted.
    - INTEROPERABILITY (infrastructure) - door-to-door train parameters: the current railway essential infrastructure parameters are not the same between Europe and Asia. This causes numerous operational disruptions and increases the number of handlings and transit time. The impacts of the acceptance of longer and heavier trains on the entire transcontinental TEN-T network should be assessed and determined.
    - HARMONISATION (document) – door-to-door customs and commercial document: the EU customs regulations lay down the rules for the European Customs area. This is not yet a reality at all for the Asian section of intercontinental railway transport. The impacts of such a harmonization on a door-to-door supply chain should be carefully analysed and could be also demonstrated in the LL2.
    - FUNDING (subsidies)- door-to-door subsidy scheme on the emergent routes: the current Chinese funding schemes are known even if they address mainly the Chinese exporters but are not stable in terms of time (what will happen if those subsidies are adapted or event stopped in the near future).
- Implications:
    - GOODS: routing and tracing of dangerous goods on the TEN-T corridors, policy changes in Russia and China (on the identified emergent routes).
    - INTEROPERABILITY: alignment of TEN-T basic parameters with Asia.
    - HARMONISATION: alignment of operations rules on the TEN-T corridors connected with Asia and analysis of relevant Asian procedures.
    - FUNDING: special CEF funding calls for intercontinental transport (investment in terminals for example) – open Chinese subsidy schemes for European-based companies.
- Early indicators:

- GOODS: share of dangerous goods, transit time, number of containers with dangerous goods.
- INTEROPERABILITY: number of trains per day, handling time.
- HARMONISATION: number of documents processed, digitalization level.
- FUNDING: € per tkm, € per container, number of handled containers.

Based on the above-described elements the following scenarios could be modelled in the framework of PLANET by mixing the different identified constraints. These scenarios should first be evaluated individually and can be afterwards combined in a more complex simulations ecosystem.

**Scenario I**
**RAILWAY INTEROPERABILITY**

- The railway corridors are not yet fully interoperable and thus limiting a smooth transfer of trains/wagons/intermodal loading units between Europa and Asia.
- Three levels:
  - Poor interoperability: AS-IS situation.
  - Medium interoperability: AS-SITUATION + partial interoperability (train length, axle load…) on some routes.
  - Full interoperability: all routes are fully interoperable.
- Initial key indicators: number of trains/day/route, transit times and cost per unit.

**Scenario II**
**POLITICAL FRAMEWORK**

- The political context both in Europe and in especially in China, significantly affects the railway transport on the Eurasian routes.
- Three levels:
  - Degraded mode: the subsidies will only be allocated to Chinese companies, the dangerous goods are not accepted at all on the Chinese railway network – customs procedures are reinforced.
  - Status mode: AS-IS situation
  - Upgraded mode: open subsidy schemes for all companies transporting goods from/to China – dangerous goods are accepted – simplified customs' procedures.
- Initial key indicators are: number of trains/day/route, transit times and cost per unit., number of loading units with dangerous goods, subsidies received per loading unit and number of produced documents.

**Scenario III**
**DIGITALISATION**

- The European railway sector is submitted to regulations regarding data exchanges and digital platforms (for example TAF TSI). This scenario should evaluate the impacts of digitalization on the management of documents (customs and commercial) on the Eurasian routes
- Three levels:
  - Low: current situation
  - Medium: partial digital document management
  - High: full digital document management
- Initial key indicators are: number of paper documents versus digital documents and number of community platforms (business & authorities).

Figure 14: Scenario options

## 4.4 (PP4) Physical Internet Paradigm Simulation Scenario

To define scenarios related to the potential adoption of PI, the following main research question has been considered:

| |
|---|
| How could the various aspects of the Physical Internet contribute to improving the operational performance of intercontinental corridors in PLANET? |

To construct a scenario where the influence of the different parameters can be analysed, the methodology previously described has been followed in steps. First, the principal point of focus is identified. In this case on how the different PI aspects can help to improve the performance of intercontinental corridors. Secondly, identifying the main factors that influence the definition of scenarios. We refer to factors such as collaboration, standardisation, or trust in the exchange of information. Then, external forces that may have an influence from a social, economic, environmental, political, or technological point of view are identified. The main uncertainties are then identified and ranked according to the potential impact they may have, using 3 grades: high, medium, or low. Finally, the logic of the scenario is defined, where the main axes that group the dimensions of analysis are identified. In this case, the level of adoption of PI by companies and the government policies that can support the deployment of PI are distinguished. An example of all these steps is shown in the chart below:

Table 8: Steps definition for PI Scenario

| Step | Explanation |
|---|---|
| 1. Focal issue | How could the various aspects of the Physical Internet contribute to the improvement of the operational performance of intercontinental corridors in PLANET? |
| 2. Key factors | Collaboration, Standard containers, Trust sharing information, Open Logistics Services (Supporting Policy). |
| 3. External forces<br>• **S**ocial<br>• **E**conomic<br>• **E**nvironment<br>• **P**olitical<br>• **T**echnological | **S:** Trust in PI system; Open Collaboration between companies.<br>**E:** Dynamic pricing; win-win for all players.<br>**E:** CO2 pricing in shipping; increase of the fill rate.<br>**P:** Incentives for Open collaboration; Supporting Policy (PI regulations).<br>**T:** Digital visibility; Automated distribution systems. |
| 4. Critical uncertainties | Stakeholders' reluctance toward sharing information. **(high impact)**<br>Certified open logistics service providers. **(low impact)**<br>Standard logistics protocols. **(medium impact)**<br>Containerized logistics equipment and technology. **(high impact)**<br>Physical interoperability between different load units. **(low impact)**<br>Too many regulations that hinder innovation. **(low impact)**<br>Lack of trust on sharing information services and systems. **(medium impact)**<br>Lack of appropriate standards for data collection. **(medium impact)**<br>Development of reference IT architecture. **(medium impact)** |
| 5. Scenario logics | High / Low PI Adoption<br>Weak / Strong supporting policy |

The scenarios are defined based on the main dimensions of the scenario logic along two defined axes. The first axis deals with the level of adoption of PI (High/Low) and the second axis with the supporting policy (Weak/Strong). The combination of these four levels identifies four possible scenarios.

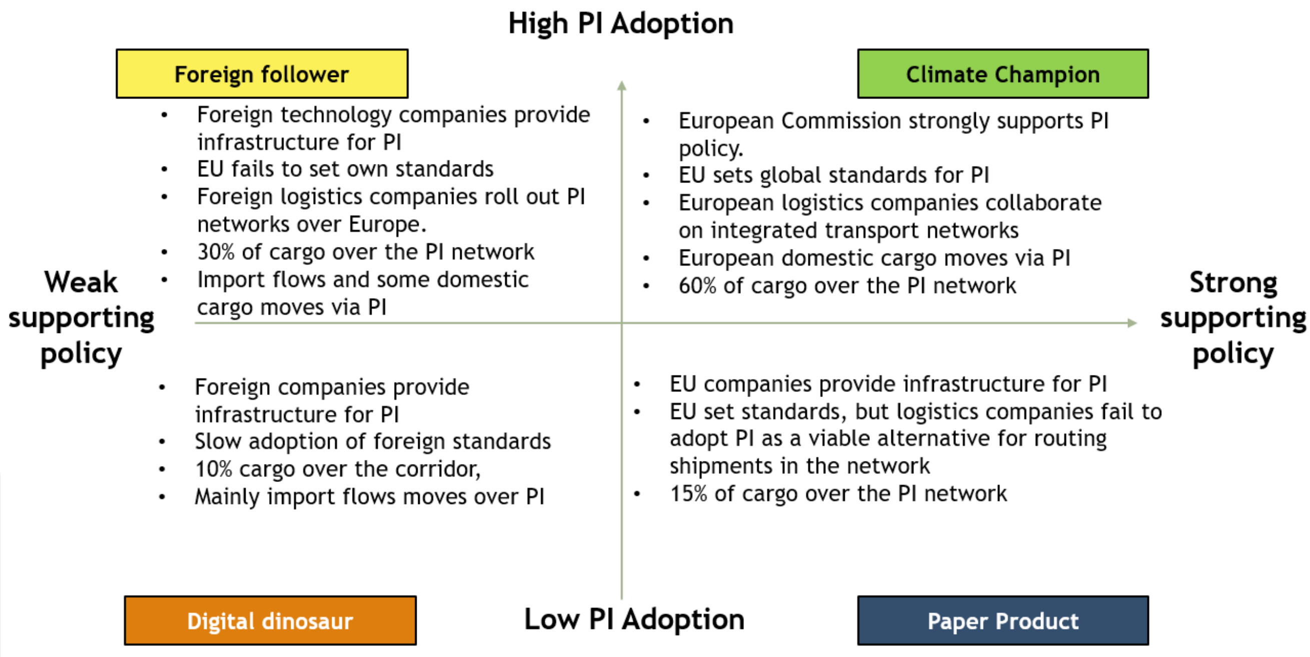



Figure 15: Scenario logics for PI

The first scenario "Foreign follower" (High PI Adoption: Weak supporting policy) describes a situation where companies are committed to using PI and there is limited government support. The second scenario "Climate Champion" (High PI Adoption: Strong supporting policy) illustrates a situation with a strong uptake of both business and institutional support. The third scenario "Digital dinosaur" (Low PI Adoption: Weak supporting policy) represents a more pessimistic situation where neither companies nor governments are making a firm commitment to the development of PI. The last scenario "Paper Product" (Low PI Adoption: Strong supporting policy) illustrates a scenario where the main support for PI comes from governments and companies do NOT make a firm commitment to adoption.

## 4.5 Consolidated scenarios

In each of the four Position Papers presented above, the main parameters related to the corresponding subjects examined were assessed regarding their expected impact on the future of freight flows towards Europe and within the TEN-T. This process led to the drawing of a set of plausible scenarios in each PP following the methodology presented in the first Position Paper. Because of the different nature of the examined subjects in the four PPs (geo-economics, infrastructure, technology), the methodology was adapted accordingly to serve the needs of each Paper. The scenarios formulated are based on the combination of the variations of the parameters that are expected to have the highest impact on the development of EGTN but also the highest uncertainty.

Following this process, to capture together all aspects of the future which are detailed in the four PPs and thus obtain a more realistic forecast for the future, two consolidated scenarios are formulated based on the combination of selected PP scenarios variations and their corresponding parameters. These two scenarios will be assessed in comparison to a third one which is referring to the base year (2019).

More specifically, the consolidated scenarios are based on the PP1 and PP4 scenarios concerning the geo-economic and technological aspects respectively, enriched by the parameters and uncertainties provided by the second and third Position paper, regarding the demand for transportation, the development of rail infrastructure and services and the development of disadvantaged regions.

The structure which was used for drawing the consolidated EGTN scenarios includes the combination of variations of the main parameters that are expected to affect the future demand and supply for transportation, building on the work performed in the PPs, leading to the definition of the narrative of each scenario. The assessment of the results from the simulation of the two scenarios will be made through the implementation of proper Key Performance Indicators which are described in the next chapter of this document.

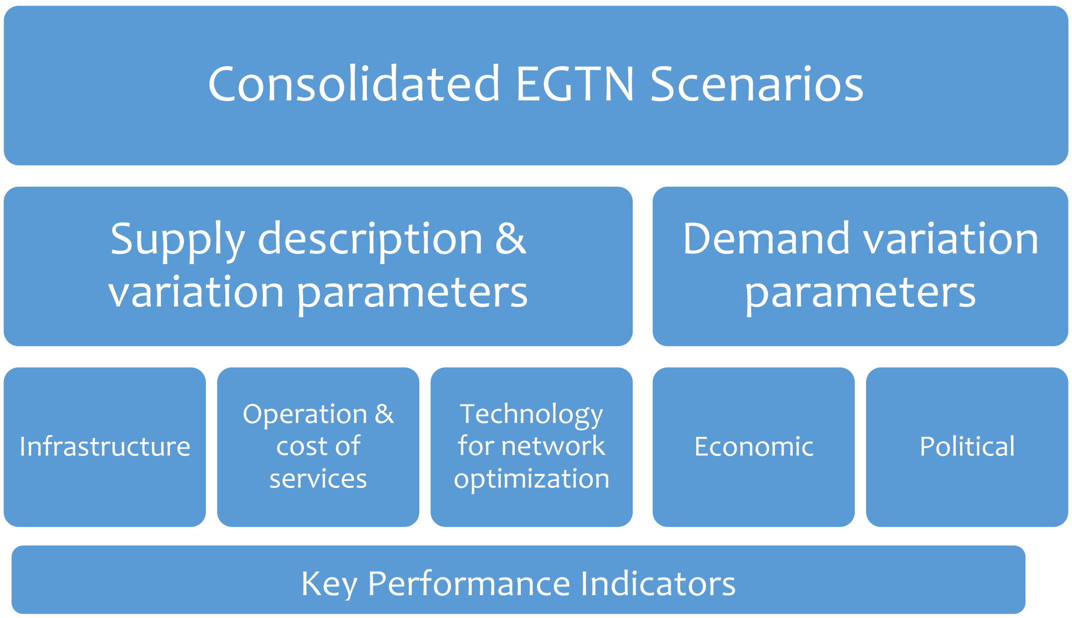



Figure 16: Consolidated scenarios structure

**1. Definition of demand:**

The demand for freight transportation is expected to be mainly affected by parameters related to economic and political development. According to the uncertainties used in the PP scenarios these parameters include:

- Economic parameters:
  - Economic and population growth (EU, China, World).
  - Location of production (Regionalization vs Globalization).
- Political parameters:
  - Funding schemes (subsidies) from China supporting rail transportation.
  - Tariff regimes.
  - Restriction on the rail transportation of dangerous goods from China.
  - Commercial agreements with China.

**2. Definition of Supply:**

The supply regarding freight transportation includes the available hard infrastructure, the services and the technological infrastructure for serving the flows but also the environmental parameters affecting capacity and decisions made regarding the use of the available infrastructure. According to the uncertainties used in the PP scenarios these parameters include:

- Investments in transport and logistics infrastructure (concerning all modes of transport with special focus on investments in rail infrastructure to increase efficiency and attractiveness of rail corridors).
- Interoperability of rail infrastructure along the Eurasian corridor.

- Development of new nodes.
- Level of PI adoption and implementation of the enabling innovative, disruptive technologies.
- Harmonization of documents (commercial & customs) along the rail corridors.
- Impact of global warming (on IWW in Europe & on the Arctic route).

Another parameter also considered in drafting the consolidated scenarios, which affects both the supply and demand dimensions of such scenarios, is related to policy and legislation initiatives of the EU towards the development of the EGTN in terms of hard and soft infrastructure. These initiatives mainly include the provisions of DTLF, which will affect interoperability and also the harmonization of documents & procedures along the supply chains, the support by EU policy regarding the development of the PI and also the EU policy on the disadvantaged regions.

## 3. Scenario narratives & implications for the transport system

The combinations of variations of the main uncertainties of the scenarios of four Position papers selected for drafting the consolidated scenarios are presented in the following table. The selection was made based on a realistic approach of the possible future combinations of these parameters.

Table 9: *Critical uncertainties*

| Position Paper | All main critical uncertainties | Variation | Consolidated Scenario 1 | Consolidated Scenario 2 |
|---|---|---|---|---|
| PP1 | Impact of drought (climate change) | High | ✓ | |
| | | Low | | ✓ |
| | World economy | Regionalization | | ✓ |
| | | Globalization | ✓ | |
| PP2 | Economy & Population Growth | High | ✓ | |
| | | Moderate | | ✓ |
| | Development of rail infrastructure | High | ✓ | ✓ |
| | | Low | | |
| | Development disadvantaged regions | High | | ✓ |
| | | Low | ✓ | |
| PP3 | Railway Infrastructure interoperability | High | ✓ | ✓ |
| | | Low | | |
| | | Medium | | |
| | Level of Chinese subsidies, restriction on transport of dangerous goods & complexity of customs procedures. | Subsidies for all companies, restrictions lifted & simplified customs procedures. | ✓ | |
| | | Remaining as is today. | | ✓ |
| | | Subsidies only for Chinese companies, | | |

| | | | | |
|---|---|---|---|---|
| | | restrictions remain & complex customs procedures. | | |
| | Digitalization of the management of documents (customs and commercial) on the Eurasian routes. | High | | ✓ |
| | | Medium | ✓ | |
| | | Low | | |
| **PP4** | EU PI supporting Policy | Weak | ✓ | |
| | | Strong | | ✓ |
| | PI adoption | High | | ✓ |
| | | Low | ✓ | |

The detailed analysis of the two sets of combinations of uncertainties regarding the structure of the consolidated scenarios, namely the demand forecasting, the supply infrastructure development and the technology development is presented in the following tables:

**DEMAND VARIATIONS**

Table 10: *Scenario demand variations*

| **Parameters** | **Demand Forecasting Variation 1 (DEM 1)** | **Demand Forecasting Variation 2 (DEM 2)** | **Source** |
|---|---|---|---|
| **Economic growth - GDP** | High | Moderate | PP2 |
| **Population Growth** | High | Moderate | PP2 |
| **Shift to regionalization of production** | Low<br>(Moderate decrease of international flows due to low regionalisation of production for high-tech/strategic products). | High<br>(Major decrease of high-tech/strategic products on specific corridors due to regionalization & Increase of EU macro regional flows). | PP2 |
| **Other Economic parameters** | Rail subsidies schemes for all companies transporting goods to/from in China. | Rail subsidies schemes in China remaining same as today. | PP3 |
| **Political Parameters** | • Tariff regimes as per today.<br>• Restrictions to rail transport of dangerous goods from China lifted.<br>• Geopolitical relation between EU and China is stable. | • Decrease of tariffs.<br>• New entrant & emergence of government owned enterprises impacting applied tariffs.<br>• Restrictions to rail transport of dangerous goods from China remain as today. | PP3 |

| | | | |
|---|---|---|---|
| **Other** | • Low development of disadvantaged regions.<br>• The shifting of economic point of gravity towards Eastern Europe. | • The import-export balance becomes more equal on the rail-route to Eastern Europe.<br>• Strong development of disadvantaged regions. | PP1 &PP2 |

**SUPPLY VARIATIONS**

Table 11: *Scenario supply variations*

| Parameters | Supply Infrastructure development Variation 1 (INFRA 1) | Supply Infrastructure development Variation 2 (INFRA 2) | Source |
|---|---|---|---|
| **Impact from climate change** | High | Low | PP1 |
| **Modal Infrastructure limitations /capacity** | Inland Waterway Transport (IWT) unreliable & capacity reduction on all IWT services. The Arctic route becomes a reliable alternative for the Suez Canal. | Minor capacity reduction in IWT or no reduction. Navigability periods of the Arctic route remain relatively small. | PP1 |
| **Railway infrastructure development** | **(CONNECTED EURASIA scenario)**<br>• The EU-Asia connection over land increases significantly the rail corridors operation. Significant investments from China into logistics infrastructure and assets.<br>• Increase of all operational parameters in corridors connecting European to the broad-gauge network towards Russia.<br>• Increased interoperability through infrastructure investments. | **(GREEN EUROPE scenario)**<br>• Significant investments in rail toward succeeding the targets of the Green Deal.<br>• Shift2Rail policy successful and all rail TEN-T corridors are implemented with increased operational characteristics & capacity.<br>• Increased interoperability through infrastructure investments. | PP1 & PP3 |
| **Maritime development** | • Decreased modal split for maritime transport. Ports in Northern Europe have lost their part of their connectivity in favour of Southern ports in Europe. | • Low increase/Decrease of Northern and Southern ports maritime connections and traffic<br>• Green ports infrastructure development.<br>• Maritime-rail intermodality | PP1 |
| **Road Transport Infrastructure development** | • Road infrastructure connecting ports and Dry terminal development. | • Policy against emissions leads to reduction of road development | PP1 |

| | | | |
|---|---|---|---|
| | • Development of Syncromodality in Europe. | and reduced modal split for road. | |
| **Other Economic parameters** | | TEN T governance on collaboration and balanced development. | |

**TECHNOLOGY VARIATIONS**

Table 12: *Scenario Technology variations*

| Parameters | Technology development Variation (TECH 1) | Technology development Variation 2 (TECH 2) | |
|---|---|---|---|
| **Interoperability** | Low adoption of DTLF (federated platforms). | High adoption of DTLF (federated platforms). | |
| **PI infrastructure development** | **(FOREIGN FOLLOWER scenario)**<br>• The EU fails to set its own standards for PI.<br>• Foreign technology companies provide infrastructure for PI and foreign logistics companies roll out PI networks over Europe.<br>• The 30% of cargo is transported over the PI network including import flows and some domestic cargo moves. | **(CLIMATE CHAMPION scenario)**<br>• European Commission strongly supports PI policy.<br>• EU sets global standards for PI.<br>• European logistics companies collaborate on integrated transport networks and European domestic cargo moves via PI.<br>• Overall, 60% of cargo is transported over the PI network. | PP4 |
| **PI enabling services & technologies availability** | • PI Services available & used in some advanced cases. | • PI enabling services and technologies (AI, IoT, blockchain...) largely adopted by industry.<br>• Business Collaboration advanced and operation of Intelligent Hubs and Corridors. | PP4 |
| **Harmonization of documents & procedures** | • Single Documents and procedures harmonization within EU (moderate DTLF adoption - eFTI). | • Customs and Business Document harmonisation also outside EU (high DTLF adoption - eFTI). | |

➢ **<u>Consolidated Scenario 1 (based on the CONNECTED EURASIA & FOREIGN FOLLOWER scenarios)</u>**

**Situation**

In this scenario, a high economic growth is achieved followed by a significant population growth. However, this growth is paired with worldwide failure in the reduction of $CO_2$ emissions resulting in an increase of global warming and periods of high drought. At the same time, these high levels of growth do not allow the trend of regionalization to become dominant and globalization continues, keeping the majority of production in Asia (China) and thus the international freight flows remain high. The geopolitical relations between the EU and China remain stable allowing, from more investments from China to logistics infrastructure and assets in Europe.

**Translation towards the transport system**

Regarding the impacts on the transportation network, drought negatively affects the capacity of inland waterways by lowering water levels of rivers for long periods and thereby making inland waterway transport unreliable. In contrast, the melting of ice allows the Arctic route to have significantly larger navigability periods, making this route more attractive. However, the expected increase in traffic to Northern ports because of the potential development of the Arctic route is restrained by the impacts of drought causing problems in their connectivity through IWT. These results in road transports keeping their role in the system but as part of synchromodal solutions together with rail. The latter increased its share considerably. Furthermore, the connectivity issues of Northern ports send traffic to the congested north route, a fact which further causes the development of synchromodal solutions for the hinterland transportation from the Mediterranean ports.

The belt and road ambitions of China supported by the stable relations with the EU and the aforementioned Chinese investments in logistics infrastructure and assets, strongly enhance the use of rail for intercontinental transportations and also induces the shift of economy towards Eastern Europe. However, these investments are focused on the improvement of specific corridors (related mainly to interoperability issues and capacity shortages) and thus do not contribute significantly to the development of disadvantaged regions, especially in Eastern Europe.

The tariff regimes remain the same but in order to further enhance the intercontinental rail freight transport, China expands the subsidy schemes which provided an unfair advantage to Chinese firms over all companies transporting goods from/to China, while the restrictions in the rail transportation of dangerous goods are also lifted.

**Innovation and technology implementation**

Regarding the technological dimension of this scenario, the development of the Physical internet fails to follow the strong growth of the economy and to support the increased intercontinental and domestic flows. The EU does not support strongly the PI implementation, leaving room for foreign technology companies to set their own standards for the PI while foreign logistics companies establish PI networks to the EU. Furthermore, the policy initiatives of the EU through the Digital Transport & Logistics Forum (DTLF) do not have the expected rate of adoption and do not contribute significantly to the wide implementation of the PI. More specifically, the federated platforms have a low adoption and thus are not supporting interoperability while the electronic Freight Transport Information (e-FTI) has a moderate adoption achieving single document and procedures harmonization only within the EU.

As a result, the PI services are not widely available and are used only in certain advanced cases/networks thus keeping the percentage of cargo transported through the PI network relatively low, <30%, including mainly import flows and a small percentage of the domestic cargo moves. This has a negative impact on the environment, as the PI has the potential to increase efficiency and reduce significantly the environmental impact of transportation.

- **<u>Consolidated Scenario 2 (based on the GREEN EUROPE & CLIMATE CHAMPION scenarios)</u>**

**Situation**

In this scenario, a moderate growth of the economy and the population is followed by a successful implementation of the EU and worldwide policies against climate change and thus there is not a significant rise in temperature/drought. At the same time, such growth pushes EU economies to become more regionalized and circularity becomes the norm. This, in turn, causes the reduction of international freight flows especially of high tech/strategic products while at the same time the EU macro regional flows increase.

**Translation towards the transport system**

Regarding the impacts on the transportation network, the successful control of climate change leaves the capacity of IWW unaffected, which allows Northern European ports to retain their good connectivity through IWWs. The navigability periods of the Arctic route remain relatively limited while additionally, the environmental concerns reduce further the potential use of the Arctic route in the near future.

Despite the good connectivity of northern ports, the implementation of emission pricing by the European Commission or EU member countries affects shipping lines which initially divert transhipment from Northern Europe to the Mediterranean and then to countries outside the EU. This results in the decrease of the maritime connections and the traffic to both Northern and Southern ports, a trend further enhanced by the regionalization of production which reduces international maritime flows. As a response to the new conditions, European ports move towards the green infrastructure development and invest in the maritime-rail intermodality.

The regionalization of production causes an increase in the share of rail for regional flows within the EU. This fact, together with the ambitions of the EU regarding the Green deal, leads to significant investments in rail infrastructure with the purpose of increasing operational characteristics and efficiency of rail corridors which results also in the attraction of significant intercontinental freight flows. Furthermore, the EU investments in Eastern Europe are made considering the development of the disadvantaged regions, leading to their infrastructural and socio-economic development.

In order to further enhance rail flows EU works towards the decrease of tariffs. However, the restrictions to rail transport of dangerous goods continue to exist the same as today, while also Chinese subsidies to the rail transport of containers remain to maintain the inequity in the competition between EU & Chinese companies.

Finally, the more stringent market-based measures on carbon emissions make road transport less competitive in terms of cost compared to rail and barges and reduces significantly their modal split.

**Innovation and technology implementation**

Regarding the technological dimension of this scenario, the EU strongly supports the policy for the PI development and leads this effort by setting the standards for the PI. The European logistics companies are also participating in this effort by collaborating on integrated transport networks and widely adopting the available PI enabling services and technologies (AI, IoT, Blockchain, etc.). Furthermore, the EU policy in the form of DTLF provisions is widely adopted, regarding both the federated platforms and the electronic Freight Transport information, leading to high levels of interoperability and harmonization of documents and procedures, not only within the EU but along the entire global supply chains.

As a result, 60% of total cargo (imported and domestic) is transported over the PI network, leading to significant benefits in terms of the environmental impact of transport and the greening of the supply chains.

## 4. Translating consolidated scenarios implications for transport modelling

The implications of the two consolidated scenarios described in the narratives above, need to be translated to specific input parameters to be able to be inserted into the NEAC model. The following input parameters of NEAC will be used to quantify the foreseen implications of the future scenarios:

- Average speeds of transport modes.
- Generalized transport cost of transport modes, including all types of costs (labour, capital, fuel costs, tariffs etc.), transport time etc.
- The “Attractiveness” cost of nodes.

In the following table the implications of the two consolidated scenarios are linked to variations in the values of the aforementioned parameters related to the base year:

Table 13: *Scenario parameters*

| Parameter | Implications & relevant NEAC parameters | |
|---|---|---|
| | **Consolidated Scenario 1** | **Consolidated Scenario 2** |
| **Infrastructure** | • Lower average speeds to IWW (because of reduced capacity).<br>• Lower average speeds to road network (because of road congestion).<br>• The average speed of rail increases (because of investments to infrastructure and increased interoperability). | • The average speed of rail increases (because of investments to infrastructure and increased interoperability).<br>• The average speed of IWW and road does not change. |
| **Barge Tariffs** | Structural increase factor (because of reduced capacity). | No structural factor applied, remains equal. |
| **Road tariffs** | Structural increase factor because of increase of demand for road transportation (due to lost capacity of IWW). | Structural factor >1 per t.km (because of carbon pricing). |
| **Rail tariffs** | Structural increase factor because of increase of demand for road transportation (due to lost capacity of IWW). | Structural factor <1 per t.km (in order to make rail more competitive). |
| **Modal split** | • Decrease of generalized transport cost of rail (increased share).<br>• Increase of generalised transport cost of barges (significantly decreased share).<br>• Small increase of generalised transport cost of road (small increase of share). | • Significant increase of generalised transport cost of road (significant decrease of share).<br>• Significant decrease of generalized transport cost of rail and barges because of high efficiency due to high PI & DTLF adoption (increased share) |
| **Continental divide ratio** | • Increase of attractiveness cost of Northern seaports because of IWW connectivity problems (reduction/small increase in the throughput of Northern seaports).<br>• Small decrease of attractiveness cost of Southern seaports (Globalisation of production remains predominant).<br>• Decrease of attractiveness cost of Eurasian land bridge (increased intercontinental rail transportation). | • Decrease of attractiveness cost of nodes of the Eurasian land bridge (due to regionalisation of production). |

| | | |
|---|---|---|
| **Transport Efficiency** | • Reduction of transport time for all modes to certain corridors with PI implementation, referring to up to 30% of freight flows. | • Reduction of transport time for all modes to corridors referring to 60% of freight flows (due to extended PI implementation). |
| **Transport Cost** | • Reduction of generalised transport costs for all modes in the corridors with PI implementation (referring to up to 30% of flows) due to the reduction in the use of assets & transport time. | • Reduction of generalised transport costs for all modes in the corridors with PI implementation (referring to 60% of flows) due to the reduction in the use of assets & transport time. |

## 4.6 Consolidated KPI's

The expected outcome of the PLANET analytics is to allow stakeholders within the EGTN networks to optimise planning and re-planning based on pre-defined goals and constraints e.g., Low-Carbon routes, fastest routes, lowest cost routes etc. As transport companies will increasingly have to account for their carbon emissions, a trade-off between reliability, cost, and carbon footprint will have to be achieved in the geo-economic and connectivity models.

A single performance indicator (KPI) is inadequate for the purpose. Multiple KPI's are needed, as no single KPI can do justice to the complexity of the supply chain and the distinct roles and parts involved.

One of the indicators highlighted in the position papers is the **CCI (Corridor Connectivity Index).** The definition of Corridor Connectivity Index is: a transport node's level of integration in the global transport network, as manifested by its position in port capacity, efficiency and ease of processes, service frequency, service quality and digital connectivity. Connectivity in our definition is a relative measure, in the sense that we do not use costs and transit time. The index has been designed to help port authorities – both seaport as well as inland port authorities – to identify and improve their position in the network, and thereby improve the network.

In addition to the CCI, for the analysis of the economic and environmental impact in each scenario, defined three additional categories of KPI's are defined that allow measuring and comparing results from the scenarios in terms of transport costs, reliability, and emissions. This can be obtained with models evaluating trip by trip to a high-level reporting of the emissions reduction over a year.

Target indicators should be quantifiable and aligned with economic and environmental improvements. The use of these indicators should be simple but useful for analysis for all parties, analysing supply chain in total and form analysing specific parts, helping in comparing and benchmarking. The indicators need to be calculated for different congestion levels and considering different origins-destination loads.

The following table shows the list of KPIs grouped into main categories:

Table 14: *Consolidated KPI's*

| CATEGORY | INDICATOR | UNITS | DESCRIPTION |
|---|---|---|---|
| **Corridor Connectivity Index** | Port capacity | Terminal area in m2 | Port capacity in terms of TEU and volume capacity is applicable for both seaports and inland hubs. |
| | Efficiency and ease of process | Moves per hour | Efficiency depends on customs and border clearance quality, the competence of logistics services (skills, knowhow) and reliability. |
| | Service frequency | # services per week | The higher the frequency per week the more flexibility is gives shippers for planning the transport of their goods. |
| | Service quality | # direct connections to seaport | The more direct connections to principal entry nodes and nodes, the better. |
| | Digital connectivity | # digital services | Explains the stage of digital development on a 4-scale grid, which explains digital ability:<br>1) Ability to track and trace.<br>2) Create and book route online.<br>3) Find shipping information online.<br>4) Measure carbon footprint. |
| | Quality of infrastructure | Accessibility | Having high-quality infrastructure improves the level of safety along the route and lowers the risk of congestion. Measured by accessibility of multiple transport modes: by road, rail, waterways, pipeline. 1 credit for each modality. |
| **Transport cost** | Absolute cost | €/ton | Total transport cost from origin (loading) to final destination (unloading). |
| | Relative cost | €/ton-km | Total transport cost from origin (loading) to final destination (unloading) divided by the total distance of the journey. |
| | Fill rate (used capacity / total capacity) | % | Determines the occupied transport capacity in relation to its total capacity in volume (m3) or weight (Ton). |
| **Reliability** | Transport time | Hrs | Time taken to travel the distance from the loading point to the unloading point. |

| | | | |
|---|---|---|---|
| | On-time deliveries | % | Relationship between actual and expected transport time. |
| | Bottlenecks | Graded scale | Evaluation of the status of different types of bottlenecks. |
| **Emission** | CO2 emissions | g/ton·km | Total CO2 emissions due to transportation. |
| | NOx emissions | g/1000·ton·km | Total NOx emissions due to transportation. |

The scope of these categories is briefly explained in the following paragraphs.

### 4.6.1 Corridor Connectivity Index

The main purpose of this indicator is to measure the level of connectivity of the current TEN-T network with emerging trade corridors, this chapter presents a methodology to measure corridor connectivity. Several methods already exist to estimate the connectivity of logistics locations and express this with an index. An example is the World Port Index which compares characteristics, position, facilities, and services of thousands of ports around the world. Another example is the Liner Shipping Connectivity Index (LSCI) which measures the integration of countries within global liner shipping networks (UNCTAD, 2019a). However, these indices are focusing on the foreland and port side, whereas this paper focuses on the connectivity of corridors/hinterland with (emerging) trade routes. An extensive definition of this indicator and its dimensions can be found in Position Paper 1.

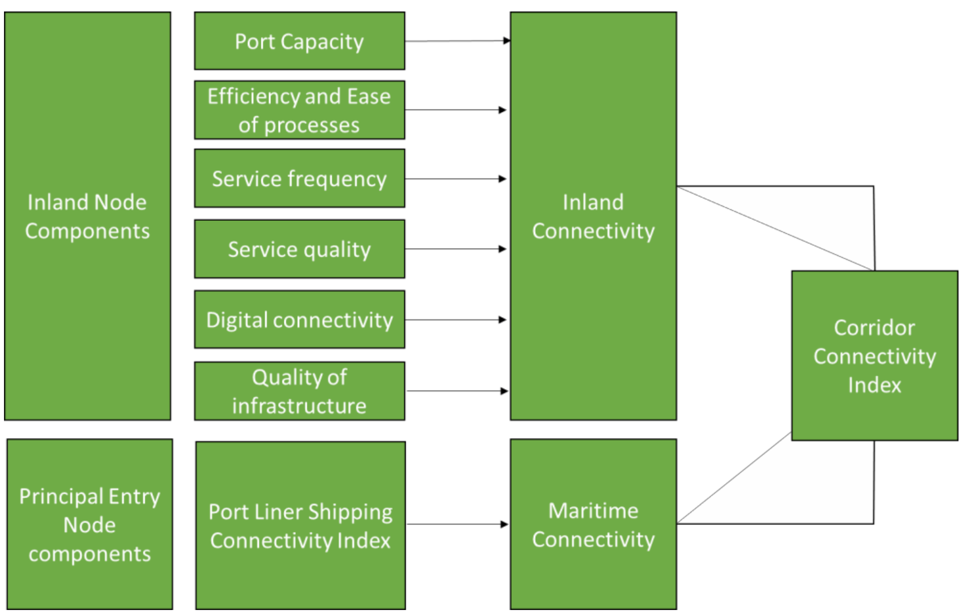



Figure 17: Main dimensions of the CCI indicator

### 4.6.2 Transport costs

These KPIs are related to the economic costs of transport operations and facilitate the analysis of the logistical impact of the transport flow at each stage of the supply chain. KPIs are employed in terms expressed in €/ton-km relative to the total volume of goods transported from the origin to the destination. Allows comparison of the different alternatives of transport modes in a particular corridor or with other corridors:

- Freight cost for container, Ton. This is critical to understand the overall freight spend. Determined by dividing the total costs for freight shipping by the number of container or Ton or km shipped for a given time:
    - Absolute cost: €/ ton.
    - Relative cost: €/ ton ·km.
- Fill rate: determines the occupied transport capacity in relation to its total capacity in volume (m3) or weight (Ton).
    - Actual capacity utilized / Total capacity.

### 4.6.3 Reliability

Reliability requires a good understanding of the five dimensions of connectivity: infrastructure, trade, political, financial, and cultural. It is important to address issues, risks, and bottlenecks, which need to be mitigated for reliable transport on the corridor.

Reliability is an important function of transport systems, is an essential component of traffic efficiency, which expresses the ease of mobility and thus should also be measured. Reliability measures should reflect the ease or difficulty of goods to perform their trips. Since reliability is concerned with travel time variability, speed, system usage and system capacity, many reliability measures will come from the perspective of the suppliers of the modes and the infrastructure.

The reliability KPIs deals with the ease of mobility and with congestion occurrence and duration on the transport network. Congestion may be defined as an increase in travel time (or reduction of speed) above a threshold. So, congestion-related attributes and traffic efficiency are typically estimated based on the information on travel time for origin-destination pairs, speeds, delays etc. The same measure may be calculated for separate times of the day and distinct levels of congestion (relating to reliability).

Within this category are grouped indicators such as speed of transport, reliability, which expresses the percentage of on-time deliveries, or the frequency of service, or the frequency of service.

Reliability measurements:

- Congestion level: to evaluate situations that generate bottlenecks and therefore impair traffic flow, waiting times and delays. This KPI includes:
    - Number of areas along the corridor that generate queues.
    - Average retention (waiting) time per bottleneck.
- On-time deliveries: reveal the agility of transport as a percentage:
    - No. of on-time deliveries / Total No. of deliveries made x 100.
    - %Containers arriving on date or less than one day late.
    - %Containers arriving more than one week late.
- Transport time or speed: it refers to the travel time in hours by the distance travelled in km between significant nodes. It usually indicates the average transport speed from the loading node to the unloading node.
    - Total distance (km) / Total transport time (h).

### 4.6.4 Emission

This group of indicators reflects the emissions in g/ton-km of the main pollutants and greenhouse gases that describe the impact on the climate due to logistics operations.

Environmental impacts include emissions from vehicles and other emissions from any operations and waste produced. Environmental indicators measure emissions of harmful gases such as $CO_2$ or NOx and check compliance with continental or global emissions reduction targets.

In general, the focus of the environmental impacts of SCM (Supply Chain Management) has been on transport chains, which are key functions in logistics. Therefore, many of the relevant measures to evaluate the energy efficiency of supply chains are related to transport chains.

The KPI selected in the environmental sustainability group is $CO_2$ equivalent greenhouse gases, as it includes not only carbon dioxide, but all greenhouse gases, that produce such effect. This indicator is directly related to the carbon footprint, which in this case, is an estimate of the total impact that an activity has on climate change. Carbon dioxide equivalent is a universal measure used to indicate the global warming potential of each greenhouse gas. It is used to assess the impacts of the emission (or avoidance of emission) of different greenhouse gases.

Emission measures (environmental impact):

- Emissions (per Tons, km): Quantity of harmful gases released into the environment ($CO_2$, NOx...). Transport emissions are calculated based on an emission rate expressed in g/ton-km. This KPI will therefore need to be inferred based on flows, lengths, and transport mode, according to the distance travelled or to the amount and type of fuel used or to the type of transport or fuel used:
    - Emissions $CO_2$-e = total $CO_2$-e emissions [g] / (Total goods [ton] x Distance [km]).
    - Emissions NOx g/1000·ton·km.

**Consolidated KPIs next steps**

However, it should be noted that the initial list of KPIs presented below as these emerged from the analysis of the Position Papers is not exhaustive at this stage of the project. It will be reassessed during the project execution and will be further enriched to also include indicators that will emerge from the outcome of the model used for the scenario's simulation, the assessment of the various scenarios' narratives developed and the provisions of the proposal document.

These will include indicators related to the monitoring and governance of EGTN, the connectivity of entire regions and the different aspects of reliability and operational efficiency.

Regarding the type of indicators that will be used, the combination of both objective and subjective types is expected to serve better the purposes of the project. Further information and details about the KPIs will be provided also to D1.10.

# 5 Conclusions & Way Forward

The international competitive position of Ports and Industries is enabled through the strategic cooperation with logistics hubs in the hinterland, other ports in the EU and across the world. PLANET proposes a new connectivity index for each EGTN transport node. An extension to the model is the integration of landside and shipping connectivity. The latter extension is particularly interesting for seaports as trade patterns may shift from a maritime to a land-based corridor. With this document, an attempt to build a comprehensive understanding of the geo-economic developments and how they influence existing and emerging principal entry nodes and inland nodes in the TEN-T corridors has been performed.

From the point of view of new transport routes (PP2), it is expected to have a gradual intellectual and logistical shift from hinterland transportation to inland transportation and that the TEN-T system will be more intricate than ever before, necessitating far-reaching digital innovations. Also, emerging trade routes as well as changing intra-regional transport patterns may increase the importance of particular infrastructure stretches from national to European relevance (especially: Principal Entry Points and infrastructure connecting growing sites of production). As emerging trade routes, often entering the EU's territory via third countries, exert a profound influence on intra-TEN-T development, the EU is increasingly compelled to take stock in extraterritorial infrastructure development too.

Regarding the intermodal rail connections on the Eastern flanks of the European Union, tPP3 accurately identifies the connections between the European (UIC) gauge network and the 1520mm Russian (broad) gauge railway network. The Southeast connections between Bulgaria and Turkey provide a UIC gauge connection for railways between Europe and Asia. The third Bosphorus bridge opened in August 2016, and the Argus Railport that will support its functioning promises to add substantial new capacities from 2022-23. There is a plan to connect Europe to Africa through the Gibraltar Railway Tunnel, a project that could create a direct rail freight link to Morocco and Algeria. The planning for this tunnel started several decades ago. The construction of the Gibraltar tunnel is likely not to be decided soon. Lastly, PP3 identifies the mechanisms for international collaboration to organise the administrative trail, the customs procedures, as well as the rail safety, interoperability and communication links between the EU infrastructure and operators and those in the Russian, as well as the Turkish direction to China.

The Physical Internet is an open collaborative framework, which can help improve the use of the resources that circulate along the intercontinental corridors. To be able to carry out "physical" collaboration, sharing resources such as transport or storage areas, it is necessary to carry out "digital" collaboration between companies to properly set up and orchestrate the collaborative processes. Successful collaboration must be carried out on two levels, (a) from the point of view of planning operations and (b) from that of executing operations.

The Corridor Connectivity Index (CCI) shows the connectivity performance of locations along the corridor over time and enables us to observe change in the TEN-T network (partly) caused by changes in the geo-economic playing field. The index has been designed to help port authorities to identify and improve their position in the network, and thereby improve the network. The CCI will be used for assessing the impact of changes due to emerging trade routes, and for further forecasting and predictions of the T&L networks of the future.

In the next steps, we answer these questions by looking both at macro and micro levels. At the macro level, the focus will be on how changes in trade policies, trade flows, and investments are expected to influence trade/routes to and from the EU and EU businesses. At the micro level, we will look at models that guide EGTN design. We do this by measuring and monitoring the connectivity performance of principal entry nodes and inland nodes within the TEN-T network. Besides looking into the past, we apply a scenario methodology for the development of TEN-T networks, considering the most important factors that shape the future – those with the highest impact and uncertainty.

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# Annex 1: Position Papers

- A1.1. PP1: Geo-economics impact of new trade routes for Europe.
- A1.2. PP2: New trade routes’ impact on TEN-T Corridors and nodes.
- A1.3. PP3: Interconnection issues of railway transport-corridors to/from Europe.
- A1.4. PP4: Transition towards the Physical Internet paradigm.