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

D4.1 Recommendations for TEN-T interfacing to Global Trade Routes

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1 According to PLANET's Quality Assurance Process

Table of Contents

List of Figures

List of Tables

Glossary of terms and abbreviations used

Abbreviation / Term	Description
CEF	Connecting Europe Facility
HE	Horizon Europe
DEP	Digital Europe Programme
LL	Living Labs
EGTN	Integrated Green EU-Global T&L Network
UC	Use Case
IoT	Internet of Things
Pi	Physical Internet
AI	Artificial Intelligence
ML	Machine Learning
DSS	Decision Making Systems
MAMCA	Multi- Agent Multi Criteria Analysis
BRI	One Belt One Road Initiative
PEP	Principle Entry Points
RNE	Rail Net Europe
IM	Infrastructure Managers
PCS P	Port Community Systems

1 Executive Summary

Work Package 4 provides guidance and builds capacity on geo-economic and technological awareness. This awareness is critical in the development of the EGTN. Geo-economical awareness learns us about the geo-economical context of the EU network, and technological awareness will learn us how technological innovations can be deployed to support the strengthening of the EGTN network. This documents 4.1 has come up with recommendations on funding research and infrastructure development by the Commission in an effort to facilitate the transition from TEN-Ts to EGTN. These recommendations will feed future CEF and Horizon calls. This deliverable has built upon the findings from Task 1.2 (PLANET simulation models) and Task 3.6 (on the development and pilots of the living labs).

This deliverable consists of three topics that were separately examined: intra-European transport patterns, global connectivity trends and disruptive technologies. The effect of the Eurasian freight on the EU transport infrastructure is assessed using the results of the PLANET simulation model. The model identifies which corridors, PEPs and nodes needs to be strengthened in order to be able to accommodate the additional demand by 2030. Global connectivity issues were considered when designing the scenarios included in the simulation model and in the evaluation framework developed for assessing the impacted of disruptive technologies. Within this framework literature review, modelled impacts from D 1.2, and an evaluation workshop during the PLANET GA were input for assessing future impact of the technologies as wells as the governance needs in the transition of TEN-Ts to EGTNs. After examining future infrastructure and technological developments potential obstacles were identified. The identified issues were coupled to appropriate research and funding that will help to overcome these obstacles.

The deliverable proposes guidelines on which future CEF and HE calls should be developed for EU funding. The transition to EGTN networks and PI facilitating nodes that should focus on investments in both physical and digital solutions, since both solutions are interwoven. It also gives some brief recommendations for the next DEP calls.

The transition to PI networks requires the development not only of digital infrastructures as counterpart to physical infrastructures, but even more explicitly the involvement of stakeholders of freight and person mobility. Governance issues and future needs of these stakeholders are explicitly addressed within both CEF and HE next calls.

CEF funding targets at strengthening, improving and facilitating the integration of TEN-Ts, the improvement of nodes to strengthen these corridors as well as technological infrastructure supporting PI operations, the development of PI enabled nodes and strengthening the stakeholder ecosystem. On the contrary our recommendation for HE calls focuses on the further research and development (R&D) of various technological innovations (e.g. Blockchain, Smart Contracts, ML and AI models), the increase in the TRL level of already developed innovation in the context of the PLAET LLs and the support of stakeholder training, raising awareness and trust actions.

2 Introduction

The PLANET project has tested the effect of technological innovation as well as infrastructural development stemming for changes in the intra-European network and in geopolitical solutions. These tests were conducted either via simulation models or via pilot applications in the LLs.

The aim of Deliverable D4.1 is to identify which funding mechanisms (HE and CE) can be applied to further develop the disruptive technologies or to fund the necessary infrastructural developments. It also synthesizes the funding and proposes new CEF and HE call topics that can serve as guidelines for the 2030 review of the programs. These topics will contribute to the transition of TEN-Ts the next generation of PI enabling EGTNs.

Specifically Task 4.1 consists of the following subtasks:

- Subtask 4.1.1. Examines the implications for TEN-T stemming from expected changes in intra-European transport patterns as a result from global geo-economic trends and develop future CEF and related Horizon Europe call topics for TEN-T hinterland connections and intermodal nodes.
- Subtask 4.1.2. Examines the implications for TEN-T's connections with global networks as a result from global trends and develops future CEF and related Horizon Europe call topics for interconnectivity between TEN-T and other (global) networks.
- Subtask 4.1.3 Examine the implications for TEN-T stemming from disruptive technologies examined in the Living Labs in WP3 and other technologies and develop future CEF and related Horizon Europe call topics for TEN-T infrastructure and global connectivity.
- Subtask 4.1.4 Synthesizes the post-2023 CEF and Horizon Europe call topics to serve as guidelines for the 2023 review of these programmes.

This deliverable builds on the existing PLANET results by identifying the technological, governance and infrastructural developments which will contribute to the evolution of the TEN-Ts to EGTN's. In order to properly evaluate the results of PLANET interventions we developed an evaluation framework which we verified in a workshop with the project stakeholders.

Once we evaluated the necessary interventions we identified which are the needs for further development in order to ensure their proper uptake. Finally, after reviewing the CEF and HE legislations we synthesized the results and we proposed recommendations for the 2023 review of these programs. Although it is not mentioned in the PLANET GA we include a small mention on what could be additionally funded by DEP.

2.1 Mapping PLANET Outputs

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

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

PLANET GA Component Title	PLANET GA Component Outline	Respective Document Chapter(s)	Justification
TASKS			
T4.1 Recommendations for TEN-T Interfacing to	Task 4.1 will provide analysis and recommendations to feed future Connecting Europe Facility (CEF) and related Horizon Europe call	Chapter 3-6	Task 4.1 builds upon the technological innovations simulated or applied in the PLANET LLs. It evaluates them and prioritizes the next calls for funding should be focused.

Global trade routes	topics, thus allowing for the integration of the PLANET project's results in the forthcoming Programme revisions (CEF 2023 review) and calls. This Task will partially build upon the results from Tasks 1.2 and 3.6. In doing so, three distinct topics will be analysed: (1) future implications for TEN-T stemming from expected changes in intra-European transport flow patterns as a result from global geo-economics trends; (2) future implications for TENT's connections with global networks as a result of those trends; and (3) future implications for TEN-T stemming from disruptive technologies.		It also applies the results of the simulation models developed in Task 1.2 to identify the needs for infrastructural investments. In addition to infrastructural developments and technological solutions we look into governance needs.
ST4.1.1	Future implications for TEN-T stemming from expected changes in intra-European transport patterns as a result from global geo-economic trends	Subsection 4.1	Building upon the investigative reports of the three alternative routes Modelled in WP1, a picture will emerge focusing on changing patterns in freight transport within the TEN-T network. Based on this, focal points for future CEF and related H2020 call topics will be identified for TEN-T hinterland connections and intermodal nodes.
ST4.1.2	Future implications for TEN-T's connections with global networks as a result from global trends	Subsection 4.1	The work will focus on TEN-T connectivity with global networks. Expected focal points include seaports, border crossings and transhipment facilities between the EU and third countries and customs procedures. Thus, particular points of attention are identified for post-2023 CEF and H2020 calls concerning interconnectivity between TEN-T and other (global) networks.

ST4.1.3	Future implications for TEN-T stemming from disruptive technologies	Sub sections 4.1 and 4.4	Building upon the methodology applies in Section 3 and the results from the Living Labs referring to disruptive technologies, a survey is made of disruptive technologies both existing and expected that may deserve particular attention in forming post-2023 CEF and Horizon Europe call topics. This subtask will address both intra-European patterns as well as those pertaining to TEN-T connectivity to global networks.
ST4.1.4	Synthesis and recommendations for post-2023 call topics	Chapter 5	Results of subtasks 1, 2 and 3 will be consolidated set of recommendations that may serve as guidelines in the 2023 review of these programmes and could potentially be shared with a group of stakeholders from Member States and Agencies involved in CEF procedures for further improvement on the basis of their contributions. A short mention to post 2023 DEP calls in included.

2.2 Deliverable Overview and Report Structure

The aim of this deliverable is to provide guidelines for the 2023 revision of the CEF and HE programs using the PLANET results. This deliverable consists of four chapters that present the following:

- Chapter 3. Develops a methodological framework which evaluates which technological innovations investigated in PLANET need to be funded. It also evaluates the importance of the various infrastructural innovations.
- Chapter 4. Identifies and evaluates the most important infrastructural and nodal points that will make the TEN-Ts more responsive to change in patterns and geopolitical trends. WP 1 and specifically Task 1.2 served as an input to this chapter.
- Chapter 5. Evaluates the effect of the disruptive technologies on the TEN-Ts and also looks into the governance aspect.
- Chapter 6. Synthesizes the results of Chapter 5 and 6 and proposes guidelines for the next HE and CEF revision in 2023.

3 Methodological Framework

The PLANET vision is to advance the European Commission's strategy for Smart, Green and Integrated Transport and Logistics making the existing infrastructure (TEN-Ts, rail networks) responsive to geopolitical trends. In addition via the realization of the EGTN PLANET aims to optimize the use of current & emerging transport modes and technological solutions. Specifically, PLANET is developed around three key R&D pillars:

1. Understanding and Assimilating Global, Geopolitical, Trade and Economic Imperatives,
2. Leveraging Technological Advancements and New Logistics Concepts,
3. Deal with the development of a governance layer the permits the collaboration between the engaged stakeholders.

The EGTN vision is summarized in Figure 1.

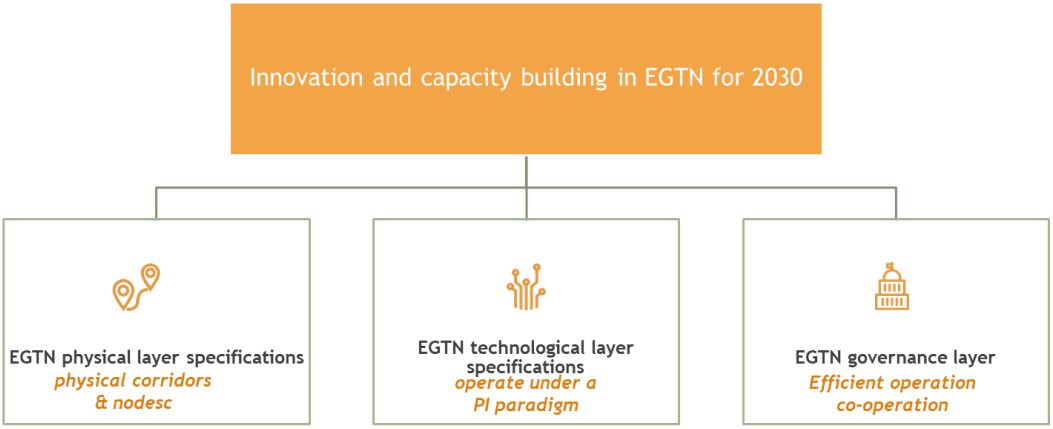

Figure 1 EGTN innovation layers for 2030

Therefore it is crucial to evaluate which of the **technological innovations and infrastructural priorities** are expected to influence the transition of the TEN-Ts to EGTNs. An important softer layer we also take into account are the **governance needs** that facilitate the transition to the PI paradigm. Once we have identified the solutions we propose possible funding mechanisms to ensure that these innovations and priorities will be promoted.

In order to make the most accurate and efficient recommendations on which will be the next actions to be funded by the EU funding instruments, namely CEF and HE we follow the process presented in Figure 2.

Figure 2 Approach followed for the development of the recommendations

Specifically, we first develop an evaluation methodology on which innovations from the ones presented (researched/developed) in PLANET should be included in the next HE and CEF funding program. We divide the interventions into two different categories. For the **infrastructural priorities** we use the results of the **PLANET simulations** as they are presented in D1.2, D1.3 and D1.5. The model simulation showed the effect of the various geopolitical developments on the EU TEN-T and global networks and we use them to evaluate and validate the interventions. For the evaluation of the **technological developments** since we do not have simulations results, we develop a framework that takes into account the EGTN vision, the impacts of interventions as identified in WP1 and WP3, the EGTN specific case studies and the evaluation methodology as developed in the European toolbox for better regulation (European Comission, 2021). The same framework is applied also and for the

governance needs. Via the application of the framework we qualitatively specify which intervention has the biggest effect on TEN-T networks. Once we prepared the evaluation for all the interventions we conducted a workshop where we engaged all the PLANET stakeholders to validate the results of the evaluation of the PLANET interventions. They also identify which type of funding will be necessary for the more efficient application of the interventions. From extensive research on previous HE and CEF calls of proposal we were able to identify which type of interventions can be funded by which program. In the final stage we developed the recommendations for the next programs.

In the next section we will identify the methodology for evaluation.

3.1 Evaluation Methodology

As it is crucial to identify which interventions will assist achieving the EGTN goals we develop an evaluation methodology that consists (Figure 3):

1. **STEP 1:** In Step 1 we developed an **evaluation matrix** which was applied to assess the impact of the **technological innovations and governance needs**. These interventions were researched in PLANET either by the LLs or by the developed models. To develop the matrix we conducted an extensive research on the **PLANET goals and deliverables, on EU guidelines for evaluation and on existing literature research**. Therefore, we set the evaluation criteria which take under consideration the goals set by the EGTN vision, the impacts as they were measured in the LLs, the PLANET GA and the criteria presented in EU toolbox for better regulations. We synthesized them and developed a unique matrix around certain criteria categories that helped us to qualitative identify the effect of interventions on the TEN-Ts. For the **infrastructural developments** we applied the **results of the PLANET simulations**.
2. **STEP 2:** In the second step we identified which t**echnological innovations, infrastructural developments and governance needs** proposed by the PLANET project should be evaluated. We reviewed the project deliverables and identified which will be the most important innovations/solutions that need to be funded in order to better support the development of the EGTN. We also identified the geopolitical scenarios under which we have evaluated the PLANET interventions.
3. **STEP 3:** In this step we conducted **the actual evaluation** of the PLANET innovations/solutions. In doing so, three distinct topics were analysed: (1) infrastructural interventions in terms of the network and the intermodal connections in the intra-European TEN-T networks and in their connections with the global networks especially for the eastern freight traffic; (2) disruptive technologies as they were tested in the PLANET LLs or simulated in WP2; and (3) governance needs for the adoptions of the disruptive technologies and the transition towards synchromodal and PI networks.
4. **STEP 4:** In order to ensure that the evaluation matrix was applied properly we **validated** them with the rest of the consortium during a **workshop o**n the PLANET GA.
5. **STEP 5:** Synthesized the findings of the previous steps and proposed **recommendations** for future CEF and HE calls in 2030. We also included a short mention to the DEP calls.

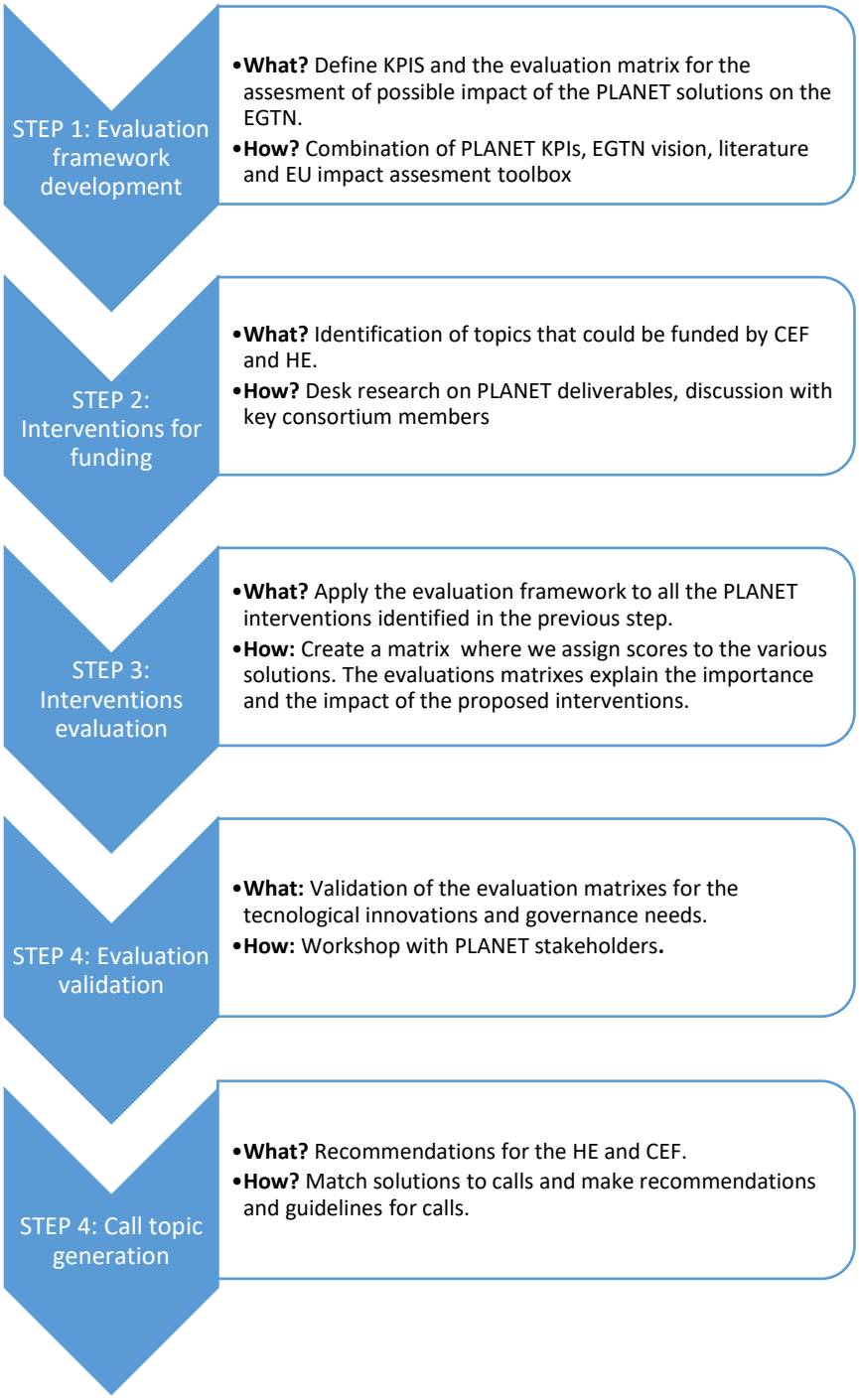

Figure 3 Methodology of Task 4

3.1.1 Evaluation Matrix Criteria selection

To develop the evaluation framework we have defined a set of **evaluation criteria under** which each PLANET intervention has been evaluated. We first looked into existing literature and in the PLANET deliverables to identify the most relevant criteria which we could incorporate in the evaluation matrix.

PLANET aims to help the TEN-Ts transit to EGTNs therefore we first look into the definition and the goals of the EGTNs as they are presented in Deliverable D2.1 (PLANET, 2021). As EGTN is considered the next generation of

TEN-Ts funding opportunities should aim to facilitate this transformation always in line with the EU-TEN-T regulations.

The EGTNs therefore need to have the following characteristics:

1. **Geo-economics aware:** A European T&L network that is aware of the geo-economics aspects driving the development of new trade routes and flows to/from Europe and their impact on the TEN-T;
2. **Innovation:** A European T&L network that takes advantage of the potential of innovative logistics concepts (e.g. synchromodality and PI) and enabling technological innovations (Smart sensors, blockchain, IoT, etc.) in its operation;
3. **Impact:** A T&L network that is more economically, environmentally and socially sustainable than the existing TEN-T ;
4. **Integrated:** An EU T&L network integrated with the global network both in terms of hard & soft infrastructure ;
5. **Inclusive:** Accessible to disadvantaged regions, supporting the development of workforce skills & knowledge.

Ex ante evaluation EU Toolbox

In parallel as we aimed to look into guidelines for future EU funding we consulted the toolbox for EU regulations. The review of the EU Better Regulation Toolbox (European Comission, 2021) was able to provide us with a series of criteria already used by the European commission to evaluate and/ or assess the impact of possible interventions of the EU policy.

Based on the criteria used by evaluating a set of policies (or a set of funding alternatives in our case) we needed to identify which of these policies will deliver the necessary outcomes. A series of evaluation was included in the toolbox that assisted in the identification of the most effective and efficient solution:

- The ***relevance*** of the solution, i.e. the extent to which the objectives are pertinent to the needs, problems and issues to be addressed.
- The ***effectiveness*** of the solution, i.e. the level to which they effectively contribute to the achievement of the set objectives
- The ***efficiency*** of the chosen solution, i.e. the extent to which desired effects are achieved at a reasonable cost.
- The ***coherence*** of the solution, i.e., the degree of (in) consistency and (in)compatibility between the solution and other relevant regulatory instruments.
- The ***European Added Value*** of the solution, i.e. the value resulting from the two Regulations which is additional to the value that would have been otherwise created by Member State action alone.

Criteria from the various LLs.

From the 3 PLANET LLs we identified the KPIs used for the evaluation of the use cases of each of the LLs. The table below summarizes the KPIs applied for each LL.

Table 2 Summary of LL KPIs

LL1	LL2	LL3
• Orders fulfilled • Orders shifted to rail • Delivery lead time • Improved forecasting, planning and routing • Reduced operating costs, paper used, process costs, time for document preparation • Reduced distance travelled • Reduced waiting times, delivery times, operational time • Increase average speed • Reduced transport cost	• Documentation Accuracy • Shipping documentation generation time • Indirect cost related to the production • Delivery performance to customer commit date • Ship product cycle time • Order delivery costs • Delivery performance to customer commit date • Receive and verify product by customer cycle time • Increase in modal shift (towards rail) • Lower lead times • Lower costs	• Reduced compliance costs • Improved end-to-end visibility • Improved customer experience • Increased volumes • Reduced operational costs • Reduced disruptions of the supply chain • Reduction in CO_2 emissions

3.1.2 Final version of the evaluation matrix

We combined the criteria we identified in the previous chapter and we divided them in subcategories based on the characteristics on the EGTN vision. In Table 3 we present the final version of the evaluation matrix.

Table 3 Final version of the Evaluaton Matrix

EGTN vision	Criteria	Scenario 1	Scenario 2
Ge-economic aware	*Resilient*		
	Adaptive		
Innovative	*Maturity*		
	Feasible implementation / Efficacy		
Impact	*Social impacts*		

EGTN vision	Criteria	Scenario 1	Scenario 2
	Environmental impacts		
	Economic impacts		
	Time saving impacts		
Integrated	*Support intra- EU network integration*		
	Support exo- EU network integration		
Inclusive	*Disadvantaged region inclusion*		
	EU land cohesion		
	Stakeholder inclusion		
Resources to be committed	*Cost related*		
	Stakeholders/ Governance related		

The first set of criteria deals with how the TEN-Ts can become more geo-economically aware:

1. The first most important attribute of the geo-economic aware EGTNs is to ensure their resilience when confronted with unexpected events and disruptions. For example the COVID-19 pandemic was an event that challenged the resilience of the EU TEN-T networks. Another example can be their response in a disruption (i.e. an accident or extreme weather conditions) that can hinder the application in a specific part of the network.
2. The second criterion deals with the adaptiveness of the TEN-T networks to more long term changes. For examples changes that result from climate change or from geopolitical or general economic conditions. Changes the EGTN will need to adjust to in the future information and communication technologies.

The second set criteria is related to the innovation potential of each proposed solution/intervention. Specifically, we have evaluated each intervention in terms of the level of innovation:

1) The first criterion describes the level of maturity of each innovation. Can this interventions be implemented directly or does it need further research and development.
2) The second criterion deals with the efficacy of the intervention. Is the implementation feasible or there is need for extensive governance changes for the implementation of the intervention.

The third category describes the impacts of each intervention and is related to the LL case studies. At first we estimated the impact of the developments of EGTN on social indicators (e.g. employment). Second, we assessed the environmental impacts, i.e. what is the impact of ECGTN on the climate and bio-diversity? The impact on the

welfare economy was analysed as well, will public investment have higher welfare gains as a result of EGTN? At last, does the intervention results in increased time-efficiency as a result of EGTN developments?

The fourth category is the integration criteria. Will the proposed technological, infrastructural or governance intervention promote the integration of the various parts of the European network? Will the chosen intervention contribute to the better integration of the TEN- networks to the global logistics networks and supply chains?

The fifth category is inclusion. Here we evaluated the ability of the intervention to promote the inclusion of all EU lands, even the disadvantaged ones and to provide access to the TEN-T networks and connect all European regions to the global economy. The last criterion of this category deals with the inclusiveness of all stakeholders in the decision making process but also in the exploitation of the networks.

The sixth category does not deal with the evaluation but identifies the amount of resources (monetary and human resources) that should be engaged for the promotion of this interventions. In the terms of costs we tried to make an estimation based on costs for similar projects.

The evaluation is qualitative so we evaluated whether each intervention is expected to present a medium, high or low impact or effect on the future development of the TEN-T networks. Finally, we compared between two possible PLANET scenarios as they were presented in the position paper for the future modification of the TEN-Ts.

3.1.3 Scenarios taken under consideration

Within the context of the PLANET project, the main future uncertainties have been identified which are expected to affect future freight flows and the TEN-T network development. These critical uncertainties cover all aspects, i.e., social, economic, environmental, political, technological and were used to draw plausible alternative future scenarios for the time horizon of 2030 which were then simulated through the strategic modelling capability of the project.

More specifically, according to the analysis performed, Europe's transport & logistics Network needs to face risks/uncertainties of the following main areas of interest:

- Climate change;
- Disruptive events;
- EU economic development;
- Digital transformation / innovative Transport & Logistics concepts & technologies;
- Geo-political parameters;
- Global development;
- Development of disadvantaged regions.

Considering these uncertainties, PLANET formulated two main scenarios for the 2030 development of TEN- T, a short description of which is as follows:

- In the first 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 for more investments from China in logistics infrastructure and assets in Europe.

- In the second 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.

The variations of the uncertainties used in each scenario are presented in the following table.

Table 4 Scenarios taken under consideration in PLANET D4.1

Critical uncertainties	Variation	Scen.1	Scen.2
Impact of drought (climate change)	High	✓	
	Low		✓
World economy	Regionalization		✓
	Globalization	✓	
Economy & Population Growth	High	✓	
	Moderate		✓
Development of rail infrastructure	High	✓	✓
	Low		
Development disadvantaged regions	High		✓
	Low	✓	
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		
EU PI supporting Policy	Weak	✓	
	Strong		✓
PI adoption	High		✓
	Low	✓	

3.1.4 Validation workshop

Once we have completed the evaluation matrixes of the technological and governance interventions we conducted a workshop with the PLANET stakeholders. The workshop took place on during the PLANET General Assembly on the 5th of October in Poznan Poland. The number of participants in the workshop was **27**[2] and we collected **19 completed questionnaires**.

In total we included the following 8 technological interventions:

1. Further application of **digital documents** and **paperless procedures**.
2. Application of **smart contracts**.
3. Application of **Blockchain** technologies to shift to the PI paradigm.
4. Further improvement and application of **sensors** and **IoT** technologies.
5. Further development and application of **Predictive Models** (using either machine learning of Artificial Intelligence). For example, the models could include: 1) Prediction of vessel ETA in terminals, 2) Predictive logistics for Tasks and Resources – daily demand- in warehouses, 3) Demand for city logistics, etc.
6. Further development and application of **Optimization Models** (using either machine learning of Artificial Intelligence). For example, the models could include: 1) Routing algorithms within terminals, 2) Optimization of scheduling in warehouses, 3) Routing algorithms for last-mile, 4) Better planning of deliveries etc.
7. Further development and application of **collaborative platforms** such as the EGTN Planet Platform for the development of intelligent PI-enabled synchromodal nodes (interconnected regional logistics hubs & ecosystem approach) & PI corridors.
8. Further development and application of real-time **Decision Support Systems** that could support real-time network and corridor visualizations, calculation of network and hub performance, calculation of what if scenarios for investments.

And the following 4 governance needs:

1. Increased **training of stakeholders** in order to be able to:
    i. Apply new technologies
    ii. Adopt and improve collaborative platforms
2. Development of **monitoring services**:
    i. Ensure the implementation of legislation
    ii. Adjust and improve network operations in order to identify weak points and improve efficiency
3. Development of **trust** between the stakeholders to exchange data with the platform **and increase awareness** on the existence of these platforms.
4. Development of **business models** to further exploit the interventions/innovations proposed within PLANET.

We divided the participants into 2 groups. To each group we gave half of the evaluations matrixes already completed (4 technological interventions and 3 governance interventions) (please refer to the APPENDIX A for the completed matrixes) and asked them to indicate if they agreed with them. They were also asked to change the scores provided in every intervention with which they disagree. In addition we asked them 2 additional questions: 1) to provide us with maximum three parameters that would hinder the implementation/application of the intervention, 2) to identify the most adequate funding mechanism for the interventions and for the improvement of the parameters. The next subsection summarizes the results of the workshop and discusses

[2] The technological and governance interventions together with the resulted evaluation matrixes will be presented more in detail in sections 4.2.1, 4.2.2, 4.3.1 and 4.3.3.

briefly the replies to the questions. The final validation results are incorporated in the evaluation of the interventions (Sections 4.2.1 and 4.3.1) and in the funding opportunities (Sections 4.2.2 and 4.3.2).

Summary results of validation workshop

In this subsection we present the summary results of the workshop. Table 5 summarizes the results of the matrix evaluation. The majority of the respondents verified the initial completed matrixes and made no changes. For the technological innovations 3 respondents made minor changes in the digital documents and the predictive model matrixes. In the case of IoT sensors and optimization models two respondents made minor changes. Major changes were made by two respondents in the case of the smart contracts, Blockchain and IoT sensors. All respondents agreed with the DSS matrix. For the governance interventions matrixes the majority agreed with the initial version while only one respondents made major changes in the training stakeholders' matrix. All the responses were taken under consideration to reach the final version of the matrixes presented in sections 4.2.1 and 4.3.1.

Table 5 Summary results of the validation of the evaluation matrixes.

Technological	Nr of respondents who totally agreed - no changes	Nr of respondents who made minor changes (1-6 changes)	Number of respondents who made major changes (more than 6 changes)
Digital documents and paperless procedures	5	3	1
Smart contracts	7	1	2
Blockchain	7	1	2
Sensors and IoT technologies	6	2	2
Predictive Models	5	3	1
Optimization Models	6	2	1
Collaborative platforms	8	1	1
Decision Support Systems	9	0	0
Governance			
Training of stakeholders	8	1	1
Monitoring services	9	1	0
Trust and increase awareness	9	0	0
Business models	8	1	0

Regarding the replies in the second question that asked participants to identify the parameters that hinder the implementation of the interventions their replies can be summarized around the following pillars.

1. **Data availability.** The identified problems concern building trust among stakeholders to share data that that consider private and competitive interest. Processing and exchange the data in proper formats.
2. **Costs** for developing, implementing and maintaining the digital infrastructure and costs that smaller non technologically companies should bear.
3. **Stakeholder collaboration and integration** in EU level for data exchange, technology and knowledge exchange but also for sharing of services and infrastructure as dictated by the PI paradigm.
4. **Geo political situation.** PLANET looks into Eurasian corridors and current post-COVID-19 and Ukrainian war geopolitical situation raised concerns to many respondents.
5. **Regulations.** Currently an EU regulatory framework that ensures equal playing field to all T&L companies (SMEs and large companies) to access and benefit from the advantages of EGTNs is missing.

6. **Security.** Cybersecurity of the digital infrastructure of companies and the data exchange is missing and needs to be ensured.

One by one the replies that are grouped above were used to identify the opportunities for funding presented in sections 4.2.2 and 4.3.2.

The last question was regarding which funding mechanism the respondent's believed is adequate to cover the needs and improve implementation of the intervention[3]. The majority 63% of the interventions need to be addressed by a HE call, while approximately 47% of the interventions can be addressed by HE calls. The option of DE was also added to ensure that the digital/technical parameters are addressed and 20% could potentially be solved by this option.

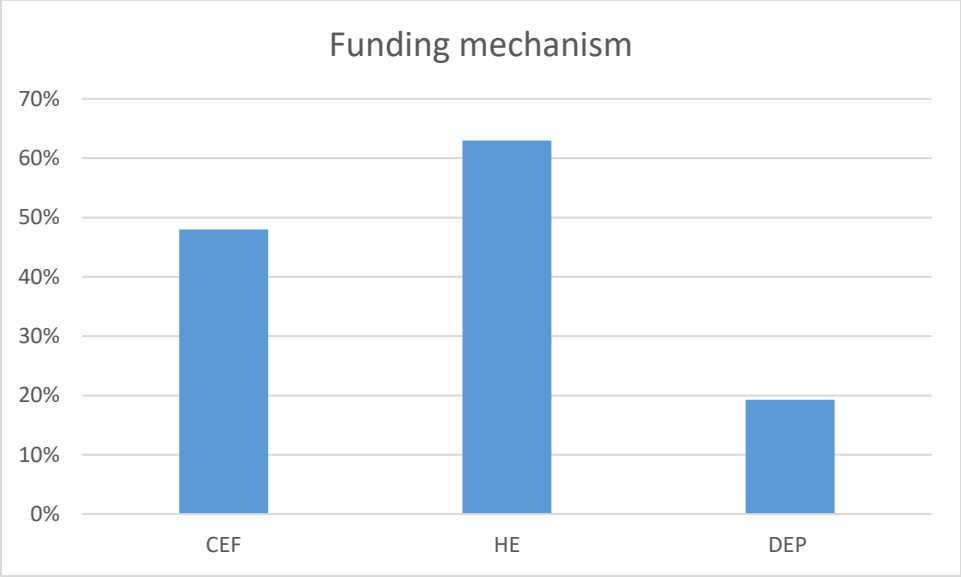

Figure 4 Selected funding mechanism

The results of this questions were considered when making the recommendations in Chapter 5.

[3] The respondents could select multiple options so the numbers do not add up to 100%.

4 Topics of Intervention for further EGTN development

This section presents and analyses the results of the PLANET interventions. To identify the needs for infrastructural interventions we use the results of PLANET simulations as they are developed in the position paper and we also include the preliminary findings of D1.4. For the governance and disruptive technologies interventions we apply an evaluation matrix. More specifically, for each selected intervention we present and explain the evaluation matrix and we identify which are the challenges, aspects or solutions that need to be further developed and funded. It should be noted that D4.1 is based on the initial basic simulations of T1.2. More points of intervention may emerge with the final simulations of the enhanced scenarios that will be performed and reported at the end of the project in the context of T1.5 and D1.11. which will include also other aspects such as the impact of policy & legislation and the technology implementation.

4.1 Identification of points for infrastructural intervention

4.1.1 Summary of new routes identified in PLANET

This chapter is based on the results of T1.2 and the effect of new trade routes as they were presented in PP2 via which cargo traffic will come from Asia to Europe and vice versa. Various routes were investigated with the most important being the BRI, the NSR and the INTSC. More specifically[4],

- The Chinese One Belt one Road Initiative (BRI). Through this initiative China is aiming to achieve greater economic development by integrating the transport network of China with the European transport network and the rest of the world. China is making investments in rail and maritime corridors in many European and Asian countries in an effort to influence the trade relationships with the rest of the world. From 2015 onwards, a substantial increase in rail container flows between the two continents has been observed. The most important intercontinental railway corridor, now and in the foreseeable future, connects the EU and China through Poland, Belarus, Russia and Kazakhstan (North route). Other routes that may gain traction in future include the Caspian East-West corridor (Middle route) and the North-South corridor connecting the Persian Gulf to the Baltic (North South route). The extra transshipment to cross the Caspian and the Black Sea increases lead time and costs making it less competitive compared to the North route (PLANET, 2021). The North South route will mostly focus on traffic between Europe and India which is much less compared to the expected traffic in the North route. Under normal circumstances, lead times from inland China to Western Europe stand at 15 to 16 days, which would allow for a time saving of up to 20 days compared to maritime transport. Brake of rail track gauge, and therefore transshipment handling, takes place on the Polish-Belarusian border (typically Malaszewicze/Brest) and on the Kazakh-Chinese border (typically Dostyk/Alashankou). Customs procedures also take place on these border crossings, with Russia, Belarus and Kazakhstan being members of the Eurasian Economic Union (EAEU) customs area. The organization and planning of rail freight transport between China and Europe is carried out by Chinese intermodal operators, who act by order of city or regional authorities. Although, during the corona pandemic the traffic in the BRI was flourishing, mainly due to the high sea rates, the Ukrainian war has caused a significant decrease of traffic in this route.
- The Northern Sea Route (NSR) through the arctic that is becoming more navigable due to climate change and the reduction of ice thickness/presence and can thereby shorten the sailing distance between Southeast Asia and Northwestern Europe up to 36% compared to the route through the Suez-Canal. Currently, sailings in the Artic are mainly intra-arctic and transit traffic that serveexperimental purposes. The expectation is that it will take several decades until this route is navigable and economically feasible as big investments in infrastructure and services are needed to make it a reliable and navigable route.

[4]For more information refer to PLANET:
D1.2 Simulation and Modelling Capability
PLANET Position Paper 2 New trade routes' impact on the TEN-T network

From an environmental perspective there is also much pressure to ban the NSR due to the risk of oil spills and other negative externalities that could damage the Arctic region. Currently there is also an ongoing discussion on which country will exploit which part of the Artic area with Russia playing a major role. However, as the ice melts and the climate is expect to shift from permafrost to forestry, more economic development and activity is expected to take place across this area. EU has already been looking into the possibility of making investments and expanding the TEN-T network to include the possibility of increased traffic via the Artic. However, with a plethora of environmental, geopolitical and economic issues to be solved we do not expect a substantial development in the Artic area before 2050. Finally, with many parts of this route being controlled by Russia and given the fact that after the Ukrainian war EU and Russian relationships are becoming more and more tense, the exploitation of this route is expected to be further hindered.

- The International North-South Transport Corridor (INSTC)is a 7,200 km long transport route for moving cargo between India, Iran, Azerbaijan, Russia, Central Asia and Europe.. Its successes depending on cross-country development of rail-infrastructure and currently, this route is not in use. In the event that this route does come into use by 2030, its impact on TEN-T is expected be limited, because the volumes of high-value goods from India to the countries in the Baltic Sea are too small to run shuttle trains on a regular basis. (PLANET, 2022)

The effect of the Ukrainian war

Russia plays an important role in the Eurasian rail network routes. In 2021, trains moved 766 000 TEU carrying goods between China and Europe. Over 80% of this rail cargo from China to Europe was transported via Russia and Belarus.

Before the war, Ukraine has tried to establish a stronger position on the New Silk Road. At that time, the transit through Ukraine accounted for just **2%** of the westbound container traffic volumes on the New Silk Road in 2021. In January 2022, Chinese president Xi Jinping underlined Ukraine's importance for China's BRI. In addition, Hungary recently made a large investment of around 35 million euros in the Záhony region (bordering Ukraine) and in September 2021, the Slovakian government pledged it wanted to support the development of the route through Ukraine and Slovakia via Dobra. However, in February 2022 Russia started a war in Ukraine and as of March 7 routes via Ukraine stopped, while other routes (including via Russia and Belarus) are still operating but with an increasing risk of future blockage.

Although various sanctions has been imposed to Russia Chinese rail traffic through Russia was excluded from EU sanctions. EU sanctions on Russia and Belarus only ban air traffic and road transport but not rail transport, except for trains carrying specific Russian-origin items like coal. However, security concerns, and payment hurdles from sanctions discourage customers from using the Russian rail lines and it is estimated that the rail traffic will decrease on a range between 50% to 80% percent year over year. In addition, the cost of gas, oil and coal has increased significantly due to disruptions in supply and will likely lead to various surcharges in the rail sector.

Congestion and delays on the New Silk Road dropped significantly, due to the decreased demand for services on the main route between China and Europe. The situation in the North route could lead to possible growth in other rail-corridors for example in the middle corridor through Azerbaijan and Georgia to Istanbul. However, we already saw that these routes are unlikely to be able to take on the full demand – the middle corridor's capacity is 3 – 5% of the total capacity of the Northern route.

Based on the simulation developed in PLANET by applying trade data and costs that have been adjusted for 2021 demand and costs, an effort was made to identify the effect of the Ukrainian war in the TEN-T network. The model results show the resilience of the network and which other routes can used as alternatives to Eurasian rail transport. Model results show that most cargo is expected to shift to sea and specifically to the following ports which can be taken as an alternative (see Figure 5). The situation in Ukraine could provide a potential to shift of cargo to the 'Middle corridor' through Azerbaijan and Georgia to Istanbul. This corridor however, has a limited capacity that accounts only for about 3-5 per cent of the total capacity of the northern routes. More specifically,

short-haul sea leg across the Caspian Sea is still a major bottleneck for the route, with only three vessels currently operating. Currently the BTK (Baku-Tbilisi-Kars) route between Azerbaijan, Georgia and Turkey, as well as the port in Constance are overloaded due to the pandemic and the war in Ukraine and in general the middle route is slower and less reliable that the northern route that is still in use.

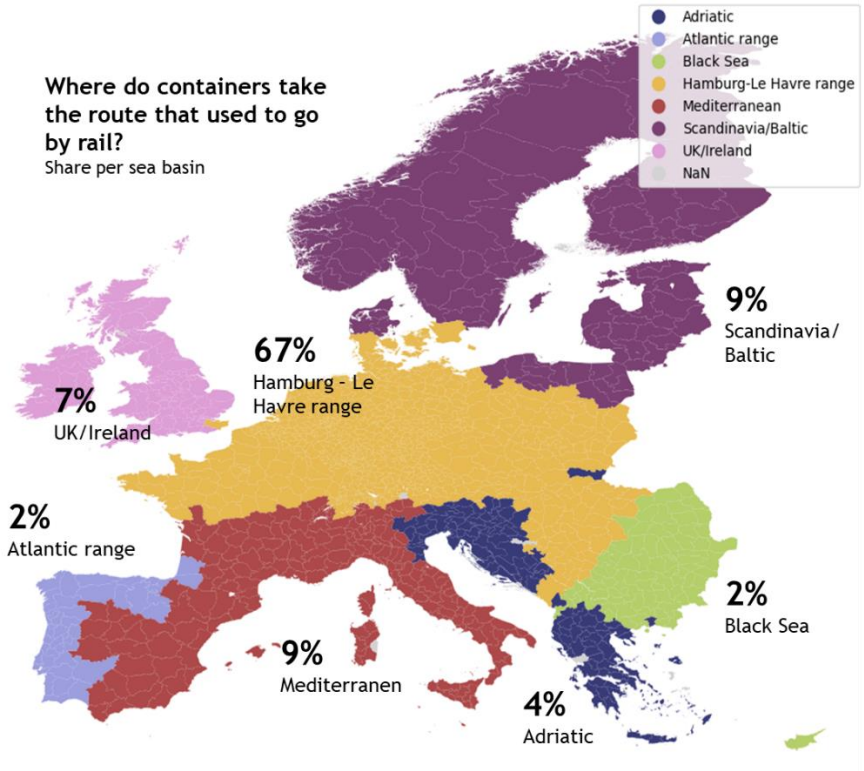

Figure 5 Results of the cargo shift due to the Ukrainian war

Final remarks of the Ukrainian war analysis.

Although there are still sanctions affecting the Russian economy they do not affect rail traffic and even though the rail traffic is currently decreased, as the situation stabilizes more freight will use rail again and the traffic of the northern corridor will bounce back. The Ukrainian war highlights the importance of making the EU TEN-T networks more resilient.

4.1.2 Geo-economic trends

When making the analysis of infrastructural needs we take into consideration geo-economic and geo-political trends as they were applied to make predictions for future transport demand (in 2030 and 2050) respectively . In summary we consider the following trends:

1. During the last years a shift to more to more regionalised production is being observerd. Although for cheap goods that are produced in bulk the globalized market is not expected to change for mid-range products the picture will probably be different. Western markets might put in place higher craftsmanship but also environmental standards that lead to a gradual decline of the global slow ocean freight transport and a shift to faster and more reliable services. Moreover, with the emergence of new high-income economies elsewhere, import and export flows into and from Western markets of mid-range products may become ever more balanced, in many cases calling for fast, flexible and reliable services rather than relatively slow ocean freight. Regarding “strategically important” high tech products for example defense and security technologies but also a plethora of ‘dual use goods’ such as computation/microchip

technologies, aircraft manufacturing, production of high-class materials, etc. , European countries are considering the relocation of these industries close to home. For strategically less-important high-end products, on the other hand, global East-West and West-East flows may become more even, with high-tech production facilities belonging to the same supply chains spread over different continents.

2. As proved in the previous point. Although global maritime transport will be far but diminished, lower volumes is expected to be transported by the sea. TEN-T networks will then be asked to adapt to altered circumstances with regard to where production will be located. Inland networks will be important not only by connecting marine terminals to the hinterlad but also by creating links between regional production centres and populous areas. Eurasian cargo will therefore be required to offer better quality services in order to be able to accommodate the increasing demand.
3. The tense relationships developed with Russia due to the Ukrainian reports, although they are not expected to reduce the rail transport in the short term could probably lead to the strenghtening of alternative corridors or other PEP.
4. Finally, tense relationships between China and United States might have an effect on the amount of Chinese subsidies and investments in Eurasian rail and transport infrastructure in Europe.

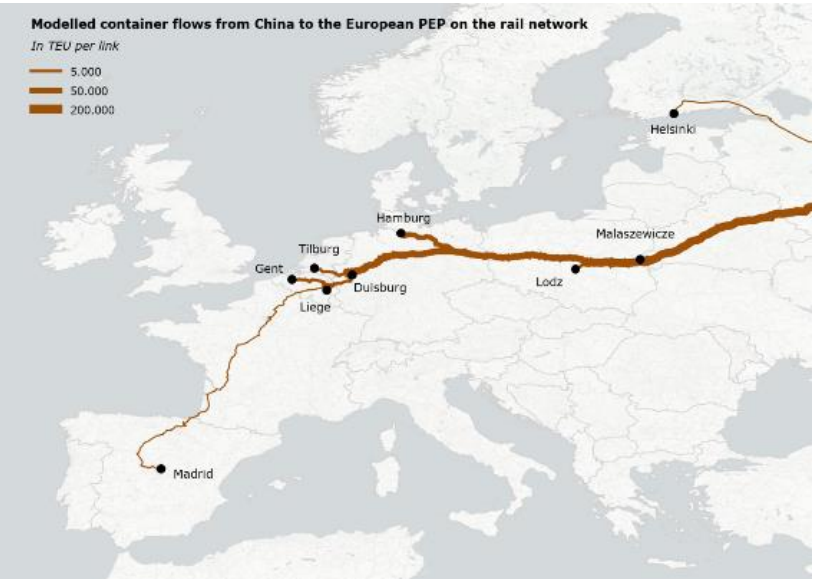

Figure 6 Modelled container flows from China to the European PEP on the rail network

Figure 6 presents an example of the modelled container flows within the PLANET model.

4.1.3 PEPs and terminals

The simulation model developed in Task 1.2 (PLANET, 2021) is based on existing PANTEIA models: NEAC10 and Terminal Model. These models use detailed multimodal networks and follow classic mode and route choices approaches based mostly on the cost functions. They model traffic flows as multimodal chains describing the transport of a commodity from its region of production, via transhipment locations to the region of consumption. Different scenarios are developed and the response of the transport system is simulated. Parameters that are modified in each scenario include new terminals & EU-CN rail services, reduction in border crossing times and varying levels of Chinese subsidies.

More specifically, **the baseline scenario** (2019) accounts for the pre-covid & pre-war situation and includes 9 rail PEP. The results of this scenario are presented in D1.4. Predictions are made for the years 2030 and 2050 and the following scenarios are considered:

- ***2030**:* increased trade between EU & CN, higher share of high value goods, 11 new rail PEP and intercontinental rail services, reduced cross-border time, no Chinese subsidies.
    - **Scenario 1- 2030 Rail investment scenario**: lower costs for rail container freight (Eurasian and hinterland).
    - **Scenario 2- 2030 impact on disadvantaged regions:** improved trade and connectivity between regions with below EU average GDP.
    - **Scenario 3- 2030 Technological & policy impact scenario**: uptake of technological solutions such as PI.
- ***2050**:* increased trade between EU & CN, higher share of high value goods.

At this point in PLANET project only the first scenario has been simulated as this is the most relevant for the identification of infrastructural developments. The results of the simulation were used together with information on capacity, bottlenecks and scheduled works in the network.

Simulation model results

Although approximately 200,000 TEUs were imported via rail from China during the baseline year 2019, this is expected to grow to 1.1 million TEUs by 2030 and 1.6 million TEUs by 2050. The scenario also assumes that maritime container transport prices are normalised again and are less volatile then now. The economy continues to be globalized and the vast majority of containers are transported through the sea. Figure 7 compares the cost difference between Eurasian rail and maritime transport between 2019 and 2030. It can be seen that, the geographical boundary at which Eurasian rail transport is competitive is expected to shift eastwards due to better connectivity and lower costs & towards the south due to new PEPs. Given the increase in Eurasian rail transport the area where investments in infrastructure are needed becomes larger therefore there it is need to prioritize investments in PEPs and networks.

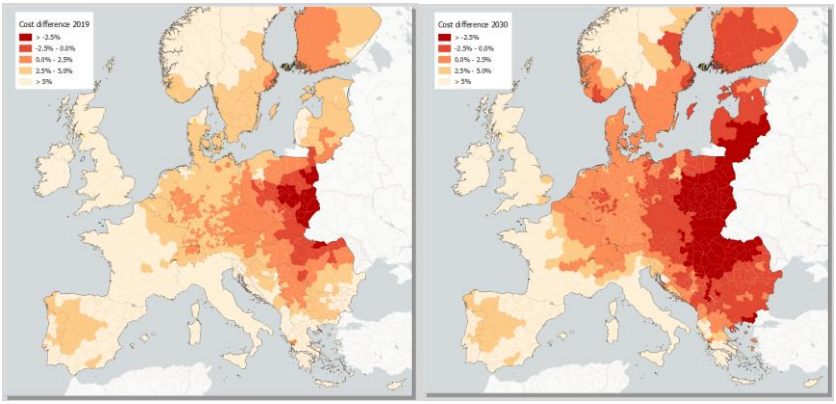

Figure 7 Cost difference Eurasian rail transport compared to maritime transport for high value (> 15 €/KG) goods (Left: 2019, Right: 2030)

Table 6 summarizes the results of PLANET simulation model for 2030 for the main corridors. The table shows the increase in the number of Eurasian freight trains that will pass through main parts of the TEN-T in 2030 together with some characteristics of the lines (Number of tracks, maximum axle load and whether they are part of the TEN-T core network). To prioritize the corridors that need intervention, the ones with an increase of more than 3 trains per day were considered (highlighted with green color in the table).

Table 6 Additional demand from Eurasian Freight in 2030 based on the PLANET simulation model

Area	Main Corridors	2019 [TEU]	2030 [TEU]	Increase in trains per day	Number of tracks	Max axle load	TEN-T status
Eastern Europe	Malaszewicze - Skierniewice	319.641	926.064	23,7	2	22,5	Core
Eastern Europe	Skierniewice - Berlin	266.261	564.323	11,7	2	22,5	Core
Eastern Europe	Lukow - Slavkov	6.989	261.498	10,0	2	22,5	No
Eastern Europe	Slawkow - Skalite - Zilina	14.420	211.328	7,7	2	22,5	Core
Germany	Berlin - Hannover	168.222	334.135	6,5	2	22,5	Core
Germany	Hannover - Duisburg	167.612	326.008	6,2	2	22,5	Core
Germany	Duisburg - Tilburg	54.261	172.199	4,6	2	22,5	Core
Germany	Berlin - Hamburg	100.345	190.322	3,5	2	22,5	Core
Eastern Europe	Ostrava - Vienna	6.989	89.890	3,2	2	22,5	Core
Germany	Hamburg - Fulda	59.439	125.351	2,6	2	22,5	Core
Eastern Europe	Zilina - Budapest	7.431	72.420	2,5	2	22.5 until HU, after which 20	Partly Core & Comprehensive
Eastern Europe	Skierniewice - Lodz	46.391	100.242	2,1	2	22,5	Core
Germany	Fulda - Frankfurt	31.940	84.707	2,1	2	22,5	Core
Western Europe	Geldermalsen - Gent	18.016	68.009	2,0	2	22,5	Core
Eastern Europe	Zilina - Kosice	-	49.017	1,9	2	22,5	Core
Germany	Frankfurt - Karlsruhe	27.425	75.671	1,9	2	22,5	Core
Baltic	BG border - Kaunas	-	40.571	1,6	2	22,5	Core
Germany	Fulda - Wurzburg	22.456	40.892	0,7	2	22,5	Core
Western Europe	Köln - Liege	12.474	26.177	0,5	2	22,5	Core
Baltic	RU border - Helsinki	5.971	9.334	0,1	2	22,5	Core
Germany	Duisburg - Frankfurt	37.680	38.299	0,0	2	22,5	Core

With respect to the terminals, Table 7 presents the most important findings from the PLANET model regarding the increase in demand (inland and PEP terminals). The table shows the increase in number of trains and in number of trucks that will need to be served by these terminals by 2030 per day. It also shows the number of TEUs that will use rail and will be originated from disadvantaged regions. To prioritize the terminals that need intervention the ones with an increase of more than 3 trains per day and more than 90 trucks per day were considered (highlighted with green color in the table).

Table 7 Additional demand in terminals from Eurasian Freight in 2030 based on the PLANET simulation model

Node name	TEU 2030 Trains/day	TEU 2030 Trucks/day	TEUs 2030 rail	TEUs Dis. Reg.	Total TEUs 2030
Tilburg RT	4,4	190	163.736	104.191	267.927
Liege RT	1,1	48	43.557	26.177	69.734
Madrid RT	0,6	25	33.137	13.459	46.596
Hamburg RT	8,0	348	296.757	187.233	483.990
Duisburg RT	5,2	223	199.680	120.947	320.626
					-
					-
Lodz RT	4,2	183	135.935	112.098	248.033
Gent RT	2,9	124	144.265	68.009	212.274
Malaszewicze RT	6,5	281	196.328	168.056	364.383
Helsinki RT	0,4	17	17.672	7.877	25.549
Slawkow RT	2,1	92	74.010	59.716	133.725
Kosice RT	2,1	90	58.752	54.412	113.164
Bratislava RT	0,5	23	18.857	15.059	33.916
Be6grad RT	0,0	0	5	2	6
Bucuresti RT	0,0	0	2	2	4
Constanza RT	0,7	32	32.221	20.780	53.001
Kaunas RT	1,7	74	57.828	49.148	106.976
Vienna RT	1,0	43	36.639	18.475	55.114
Milan RT	1,1	46	48.447	25.162	73.609
Budapest RT	3,1	132	104.642	87.622	192.265
Istanbul RT	0,8	33	31.792	21.507	53.298

4.1.4 Opportunities for funding

In the previous section we identified and prioritised which terminals and which parts of the TEN-T corridors will be prioritised for possible investments in the next CEF calls.

For the corridors we identify which bottlenecks (Table 8) are being observed at the moment and should be solved in order to be able to accommodate the future increase in traffic.

Table 8 Corridors for intervention and their bottlenecks

Area	Main Corridors	Number of tracks	Max axle load	TEN-T status	Bottlenecks
Eastern Europe	Malaszewicze - Skierniewice	2	22,5	Core	Until Lukow there is sufficient capacity[5] The part Lowicz – Skierniewice requires improvements (increase of speed and electrification, station modernization)[6]

[5] https://rfc-amber.eu/assets/downloads/other_public_documents/RFCAmber_bottleneck_study_final.pdf

[6] https://transport.ec.europa.eu/system/files/2017-06/north_sea-baltic_study_0.pdf

Area	Main Corridors	Number of tracks	Max axle load	TEN-T status	Bottlenecks
Eastern Europe	Skierniewice - Berlin	2	22,5	Core	High/speed line Warsaw – Łódź – Poznań is missing. [7]
Eastern Europe	Lukow - Slavkov	2	22,5	No	Serious capacity bottleneck[8]
Eastern Europe	Slawkow - Skalite - Zilina	2	22,5	Core	Szechowice Dziedzice - Zwardoń border PL and Slovakia; Border crossing Skalité -Zwardoń, Single track, max train length 330/360m (or route via CZ can be taken as well) + Žilina zr.st - Žilina (Speed restriction - 40 km/h)
Germany	Berlin - Hannover	2	22,5	Core	Electrified, no issues with capacity.
Germany	Hannover - Duisburg	2	22,5	Core	Electrified, no issues with capacity.
Germany	Duisburg - Tilburg	2	22,5	Core	No capacity bottleneck expected
Germany	Berlin - Hamburg	2	22,5	Core	Electrified, no issues with capacity.
Eastern Europe	Ostrava - Vienna	2	22,5	Core	Dětmarovice - Petrovice - Karviné state border. Limited capacity during section upgrade

Based on the analysis, most of the Eurasian cargo will pass through Poland (more than 10 trains per day). In this network there are parts that still need improvements (even electrification). For the line Malaszewicze - Skierniewice which will need to serve the highest increase in cargo volumes, capacity shortage is expected and the development of an additional track can be justified. The line from Lukow – Slavkov already faces serious capacity issues. Additional investments however depend on whether the broad gauge lines that have been developed in Ukraine can be used. Even if the war stops and the Ukrainian rail network takes over part of the traffic, it will be necessary to upgrade the Polish corridors to make them more resilient.

Before the war, Ukraine was investing heavily into improving its railway network and although the war is ongoing, efforts are being made to reinstate the rail traffic within the country. In general, the focus on upgrades and investments in the east European rain network and especially in Poland depends on how quickly the route through Ukraine can be brought back into service.

An additional point that needs to be noted is the differences between the countries in signaling and traction systems. Improving interoperability will ensure smoother operational handling and less waiting times in the borders. The introduction of ERTMS will play an important role in this matter (PLANET, 2020).

From the PLANET simulation model, the terminals presented in Table 9 were identified which are expected to face issues with their capacity due to the increase of demand.

[7] https://transport.ec.europa.eu/system/files/2017-06/north_sea-baltic_study_0.pdf

[8] https://rfc-amber.eu/assets/downloads/other_public_documents/RFCAmber_bottleneck_study_final.pdf

Table 9 Terminals for intervention and their bottlenecks

Node name	TEU 2030 Trains/day	TEU 2030 Trucks/day	Total TEUs 2030	TEN-T network	Bottlenecks
Tilburg RT	4,4	190	267.927	No	No information
Hamburg RT	8,0	348	483.990	No	Today functions in full capacity[9]
Duisburg RT	5,2	223	320.626 - -	Core	Programmed project development of the Iron Rhine that connects Flemish ports to Duisburg
Lodz RT	4,2	183	248.033	No	No information
Gent RT	2,9	124	212.274	Core	No capacity issues
Malaszewicze RT	6,5	281	364.383	Comprehensive	Already faces capacity issues
Slawkow RT	2,1	92	133.725	Core	No capacity issues[10]
Kosice RT	2,1	90	113.164	Core	No capacity issues[11]
Budapest RT	3,1	132	192.265	Core	No significant capacity issues; minor infrastructure interventions could further increase capacity

A major bottleneck at the moment is congestion at the border points of intercontinental transport. Expanding the capacity of the border points themselves is a solution to this, but of course this is not an option in the short term. As more train connections to the Far East are established, also on routes that do not exist at the moment, this allows for more cooperation between the terminals. However especially for the maritime terminals the increase in demand from the Eurasian Freight is not very high and is not expected to create issues with their capacity.

EGTN involves the emergence new nodes/hubs in areas that currently have limited connection to global trade routes as well as better cooperation between the nodes/hubs. With the rise of Eurasian rail transport, container traffic now enters TEN-T not only through seaports, but through entry points for intercontinental rail. From there, cargo is transported to every corner of Europe. EGTN is envisaged to be a resilient network and to achieve this it is introducing the concept of the Intelligent PI nodal point which expands the current definition of nodal points from single terminals to entire areas which may be several km around e.g. a port (node). The development of new type of nodes aims at achieving the attribute of network resilience (both in terms of capacity availability & handling unexpected operations disruptions) and also the enhanced economic, environmental & social efficiency of freight transport operations. These PI nodes/hubs include: 1) a sum of transport infrastructure assets (e.g., ports, intermodal stations, transportation links) covering a specific geographical area or located along a corridor, 2) the technological infrastructure for supporting PI operations and 3) the ecosystem of stakeholders who are active and operating in this area, sharing interests and collaborating towards the increase of the node efficiency and attractiveness.

As it has emerged from the analysis presented above, these intelligent PI nodal points should be developed in the PEP of the intercontinental rail connection to China (in Eastern Europe mainly) to facilitate the increasing

[9] https://www.bmvi.de/SharedDocs/EN/publications/rail-freight-masterplan.pdf?__blob=publicationFile

[10] https://www.netherlandsandyou.nl/binaries/netherlandsandyou/documenten/publications/2021/08/30/polish-railway-market-report-2021/Polish+Railway+Market+Report+2021_FINAL_web.pdf

[11] https://rfc-amber.eu/assets/downloads/other_public_documents/RFCAmber_bottleneck_study_final.pdf

flows. In addition, the analysis performed for the Ukraine war has shown where the flows will move if the intercontinental rail corridors close (resilience exercise) and thus has indicated the areas (mainly port areas) where these intelligent PI nodal points need to be developed also.

Softer measures

Especially in the case of terminals since the increase in capacity is quiet marginal instead of proposing large investments such as the increase in capacity or additional equipment policy and technology are crucial in further improving connectivity. Although they are less costly operational and administrative issues are usually very complex and include several individual actions. Some of the proposed measures are described in Figure 8.

Ref. no.*	Proposed measures	Issue impact	Total score	Priority category
1B	Enhance surveying and consideration of RU demand in PaP parameters and RC to offer competitive RFC capacity	high	18	proposed
2A	Actions to improve communication efficiency and transparency at national borders	high	18	proposed
2C	Interventions improving coordination in planning and sharing information on capacity restrictions, disturbances	high	16	proposed
3A	Harmonisation of processes and procedures at borders	high	16	proposed
3B	Interventions to ensure priority and increase punctuality of RFC trains	medium	16	proposed
3C	Develop efficient re-routing options, contingency for disturbances, restrictions	high	16	proposed
4A	Enhance cross-border interoperability by harmonisation of national rules, requirements and use of common IT platforms	high	16	proposed
2B	Improve functionality and reliability of RNE Tools for RFC Amber	medium	14	to be considered
1A	Ensure resources and increase role of a competent C-OSS for path allocation and capacity planning	medium	12	to be considered
2D	Improve language skills of staff and ease their communication by using standardized forms, messages with IT support	medium	12	to be considered
3D	Strengthen the role and capacity of RFC traffic management by preparing staff and exchange of experience	low	12	to be considered
4B	Simplify procedures in the multimodal transport chains and support freight forwarders in route planning, cost calculation and path reservation	medium	10	to be considered
1C	Improve applicability of the PCS and reliability of its data content	low	8	desired
4C	Harmonisation of rules/legislation to ease administrative burden (at EU border)	medium	6	desired

Figure 8 List of possible softer measures. Source: (Amber, 2020)

These actions include the harmonization of administrative burden, improvement of interoperability, harmonization of the processes and the documents that need to be exchanged in crossborder transport. The training of the employees to overcome language and different processes issues in the project. The development of common IT platform enriched with re-routing and predicting models are also additional soft measures.

4.2 Overview of disruptive technologies

The following 8 disruptive technologies researched or demonstrated within PLANET are expected to have an effect on the TEN-T development.

Technological interventions

1. Further application of **digital documents** and **paperless procedures**.
2. Application of **smart contracts**.
3. Application of **Blockchain** technologies to shift to the PI paradigm.
4. Further improvement and application of **sensors** and **IoT** technologies.
5. Further development and application of **Predictive Models** (using either machine learning of Artificial Intelligence). For example, the models could include: 1) Prediction of vessel ETA in terminals, 2) Predictive logistics for Tasks and Resources – daily demand- in warehouses, 3) Demand for city logistics, etc.
6. Further development and application of **Optimization Models** (using either machine learning of Artificial Intelligence). For example, the models could include: 1) Routing algorithms within terminals, 2) Optimization of scheduling in warehouses, 3) Routing algorithms for last-mile, 4) Better planning of deliveries etc.
7. Further development and application of **collaborative platforms** such as the EGTN Planet Platform for the development of intelligent PI-enabled synchromodal nodes (interconnected regional logistics hubs & ecosystem approach) & PI corridors.
8. Further development and application of real-time **Decision Support Systems** that could support real-time network and corridor visualizations, calculation of network and hub performance, calculation of what if scenarios for investments.

4.2.1 Matrix application

In this section we have described the application of the PLANET evaluation Matrix:

Digital documents

The introduction of paperless documentation is consideration crucial for the development of the EGTN platform and from the exchange of stakeholders. One of the main challenges regarding data exchange between the various logistics stakeholders is to enable transparency of logistics processes, traceability of cargo and more efficient supply chains. To deal with these challenges stakeholder employ Blockchain technologies. A prerequisite for the employment of these technologies is the application of paperless technologies as manifested in LL2. A use case of the LL focuses on the automated creation of an Entry In Declarant's Records (EIDR) document, that is needed for to import goods in the UK and the creation of an audit-trail on the blockchain based on the underlying assets allowing for digital proof-of-existence, proof-of-integrity and proof-of-origin of those assets (PLANET, 2021). The LL ensures the development of a platform that create virtual multimodal shipments in which clients are allowed and authorized to add, view and transfer the ownership of the documents required by the authorities and companies for these shipments. The LL deals with documents from China to the UK and digitalizes the following documents: 1) (Electronic) Road Transport Document ("e-RTD", or "e-CMR"), required for road freight transport within the European Union, 2) (Electronic) Bill of Lading ("e-BL"), required for international sea freight transport, 3) (Electronic) Rail Transport Document ("e-CIM"), required for international rail freight transport. Additionally, the platform enriches the digital information flow with trade documents, customs declarations and sanitary certificates from Dutch food authorities.

The development of paperless processes will guarantee the safety and security of paperless transactions, reduction of errors and operational time and the improvement of the level of service. It will also ensure the real-time information exchange between actors, will ensure trust, transparency and the collaboration between stakeholders. Paperless transactions will reduce the costs of logistics, increase the process automation (through

smart contracts) and ensure the cost reduction of operations. Digitalisation will reduce the human labor, but also enrich information with real-time add and help the transition towards PI concepts (Hasan, et al., 2021), (Dalmolen, et al., 2019).

Further application of **digital documents and paperless** procedures.

Table 10 Evaluation of digital documents.

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	Medium
	Adaptive	High	Medium
Innovative	*Maturity*	*Medium*	*High*
	Feasible implementation / Efficacy	Medium	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Medium	High
	Economic impacts	Medium	High
	Time saving impacts	Medium	High
Integrated	*Support intra- EU network integration*	High	High
	Support exo- EU network integration	High	Medium
Inclusive	*Disadvantaged region inclusion*	Medium	Low
	EU land cohesion	High	High
	Stakeholder inclusion	Medium	Medium
Resources to be committed	*Cost related*	Medium	Low
	Stakeholders/ Governance related	High	High

The transition to paperless documentation will help TEN-Ts become more resilient and adaptive in the first scenario but in the second, less globalized scenario the effect is expected to be medium. In the first less digitalized scenario paperless document technologies will be have a medium level of maturity and a level medium of

feasibility. On the in a more digitalized scenario the innovation of this type of technologies will be high and it will be easier to adopt this type of technologies. Regarding the expected impact of paperless transactions and documents they are expected to be medium in the first scenario and high (expect the social impacts) in the second scenario. One of the most important advantages of the paperless documents is their ability to support the integration of the EU networks. Paperless transaction can provide the first step towards the integration of the networks in PI. In the first scenario, they are expected to provide high intra-EU and exo-EU integration of the networks via the best communication and interaction with the stakeholders. The less globalized scenario will be highly benefited by this technology for the intra-EU network integration and medium benefited for the exo-EU network integration. In terms of inclusiveness it is expected to have a high effect in EU land cohesion for both scenarios and medium effect in stakeholder inclusion for both scenarios. The medium effect can be attributed to the fact that medium levels of technological maturity can hinder the digitalization of various stakeholder processes. Finally, regarding the inclusion of disadvantaged regions the effect is expected to be very limited in the non-globalized scenario compared to the medium effect in the globalized scenario.

Regarding the resources digital document require medium costs in the less digitalized scenarios and low costs in the scenario 2 (more digitalized scenario). Regarding the stakeholders a large number of stakeholders need to be commitment both for the promotion of digital and paperless documents.

Smart Contracts

Smart Contracts will have a high impact on resilience and adaptiveness of international trade, as deliverable 1.8 expects collaboration increases after the implementation of smart contracts, making it possible to handle quicker when unforeseen events occur within supply chains. In the Port of Valencia (LL1 UC2) Smart Contracts are used to improve the flow of transportation between the port to city hubs and other warehouses. Transactions in the current process are automatized by an automatic exchange of documents.

Smart Contracts in LL1 especially affect Warehouses. When new requirements in the supply chain occur (e.g. new pick-up time as a result of delays), these new requirements become automatically available through smart contracts. Such additional requirement and rules, for instance, are even more relevant for the application of smart contracts in which it is needed to determine rules involving thresholds and quantities of pallets or containers within specific time frames that are relevant to determine in a timely manner the need of future resources in warehouses or ports. Such resources can take the form of area layout configurations for storage, transportation, or personnel (or automated robots) to carry out the “pick-up” processes. Once the required information is determined the contracts could (or not) be digitally signed to allocate the resources required across port and warehouses when a significant number of pallets are about to arrive.

LL2 is centered on China-Europe trade relations smart contracts are also one of the IT tools that was analyzed. It was clear that a dynamic allocation and dynamic pricing of containers can be supported by smart contracts. Also the import documentation procedure can be simplified with the use of smart contracts

Having the above in mind we developed the evaluation of the **smart contracts** intervention.

Table 11 Evaluation of Smart Contracts

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	Medium
	Adaptive	High	Medium
Innovative	*Maturity*	Low	Medium

	Feasible implementation / Efficacy	High	Medium
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	High	Medium
	Economic impacts	High	Medium
	Time saving impacts	High	Low
Integrated	*Support intra- EU network integration*	Medium	Low
	Support exo- EU network integration	High	Low
Inclusive	*Disadvantaged region inclusion*	High	Low
	EU land cohesion	High	Low
	Stakeholder inclusion	High	Medium
Resources to be committed	*Cost related*	Low	High
	Stakeholders/ Governance related	Medium	Medium

Smart contracts have a high effect on making TEN-Ts more economic aware. This is especially the case in scenario one with high levels of globalization and economic trade. Smart contracts are making transport companies more flexible in times of droughts and simultaneous economic growth. In scenario 2 this impact is smaller since climate change will influence international trade less.

The more complex international trade relations, due to the globalization and the impact of draughts in scenario 1 it will be more complex to implement smart contracts. In scenario 2 the smart contracts will be more mature since it can create extra trust. In deliverable 2.15 becomes clear that in the PLANET living labs the use of smart contracts creates extra trust between partners. This extra trust also results in that in scenario 2 it is more feasible to implement a system of smart contracts.

The more efficient way of transportation as a result of smart contracts has various positive impacts. As modelled in Deliverable 1.8 decision reaction time will drastically fall, making it possible to have a 300% growth in in transport demand with only 50% extra assets. On top of this smart contracts will decrease the need of administrative overhead as is suggested in deliverable 2.18. This results in saved travel times, economic impacts and environmental impacts since there will be relatively less congestion. These impacts are most visible in flourishing economic times (scenario 1).

Smart contracts support integration of transportation systems of different countries. As mentioned in deliverable 2.15 Smart Contracts create better data security via encryption. This better data security will foster integration

between stakeholders. According *ALICE* (Alliance for Logistic companies in Europe) expects smart contracts being a catalyst for transportation companies to collaborate in an automated manner. In scenario 1 the integration as a result of automated collaboration will be mainly global integration, in scenario 2 regional integration. The EU support for PI in scenario 2 creates a larger uptake of Smart Contracts and EU land inclusion in general. Disadvantaged regions will mainly be included by smart contracts in scenario 2.

In scenario 2 is a larger resources required from governments and stakeholders for the uptake of innovation. Therefore the costs and stakeholder/government commitment are higher in scenario 2 than in scenario 1.

Blockchain

Blockchain will have a high impact on resilience and adaptiveness of international trade, as deliverable 1.8 expects collaboration increases after the implementation of Blockchain, making it possible to handle quicker when unforeseen events occur within supply chains. As mentioned in Deliverable 2.15 the true potential of Blockchain can be untapped in the face of an unforeseen event when certain actions need to take place.

Blockchain is the most widely tested new technologies in PLANET Living Labs. In LL1 Blockchain is seen as a technology opening up the door even more between the Mediterranean and China. In LL1 UC1 Blockchain has been developed at Valencia's port hinterland, managing multiple interactions and transactions during import procedure with a large number of different stakeholders, public and private, including port and maritime authorities, customs and other inspection bodies, transport companies, port terminals and rail terminals, freight forwarders, importers and exporters, etc. Special attention was given to the interoperability between PLANET's and DHL Blockchain technology. Also in LL1 UC2 Blockchain technology was tested to establish a more efficient flow between Valencia's port and warehouses in its hinterland.

The aim of the implementation of Blockchain technology in LL1 is to improve document exchange and reduce paper-based processes. Improving interaction and reducing documentary time and costs.

The first use case in LL2 focuses on synchromodality in a Blockchain enabled platform creating best multi-modal alternatives for logistic solutions on LL2-corridors. The second use case investigated expansion rail freight transport between China and Europe by using Blockchain innovation.

Having the above in mind we developed the evaluation of the Blockchain intervention.

Table 12 Evaluation of Blockchain

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	Medium
	Adaptive	High	Medium
Innovative	*Maturity*	Low	High
	Feasible implementation / Efficacy	Medium	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	High	Medium

EGTN vision	Criteria	Scenario 1	Scenario 2
	Economic impacts	High	Medium
	Time saving impacts	High	Low
Integrated	*Support intra- EU network integration*	Medium	Low
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	High	Low
	EU land cohesion	High	Low
	Stakeholder inclusion	High	Medium
Resources to be committed	*Cost related*	Low	High
	Stakeholders/ Governance related	Medium	Medium

The effect of Blockchain on making TEN-Ts as economic aware is expected to be substantial. This is especially the case in scenario one with high levels of globalization and economic trade. Blockchain is making transport companies more flexible in times of droughts and simultaneous economic growth. In scenario 2 this impact is smaller since climate change will influence international trade less.

The more complex international trade relations, due to the globalization and the impact of draughts in scenario 1 it will be more complex to implement Blockchain technology. In scenario 2 Blockchain will be more mature since it the public investments in PI will create feasible circumstances for the implementation of Blockchain.

The more efficient way of transportation as a result of Blockchain technology has various positive impacts. As modelled in Deliverable 1.8 decision reaction time will drastically fall, making it possible to have a 300% growth in in transport demand with only 50% extra assets. Blockchain technology will also enable, according to Deliverable 2.15, better tracking of data across networks. This will give stakeholders a more safe feeling of doing business as mentioned in deliverable 2.17. These advantages of Blockchain technologies result in saved travel times, more economic collaboration and environmental impacts since there will be relatively less congestion. These impacts are most visible in flourishing economic times (scenario 1).

Blockchain supports the integration of transportation systems of different countries. Blockchain technology has according to deliverable 2.15 the potential to enable stakeholders to cooperate seamlessly. In scenario 1 the integration between stakeholders will be mainly global integration, in scenario 2 regional integration. The EU support for PI in scenario 2 creates a larger uptake of Blockchain and EU land inclusion in general. Disadvantaged regions will mainly be included by Blockchain technology in scenario 2.

In scenario 2 the costs for governments and stakeholders are higher for the uptake of innovation. Public investments will be the main driver of the innovation of Blockchain technology and design.

Sensors and IoT technologies

The 4th intervention deals with the further implementation of **sensors and IoT technologies**. The IoT is described by a network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. In the PLANET LL1 UC3 smart sensors are implemented to containers enabling customers, service providers and carriers to Track& Trace their cargo. In addition, the sensors are equipped with next-generation wireless networks, connecting containers to central systems and assisting identify delays bottlenecks but also possible disruptions in parts of the network. Smart sensors can also be used in warehouses (LL1 a The data are exchanged via a cloud can be connected to platforms (for example EGTN specific infrastructure, (PLANET, 2020) and the data can be combined with AI or ML optimization and/ or predictive models for calculation of optimal routing decisions or better planning of the operations within a warehouse. In addition these services provide real time monitoring of the status of the container (temperature, humidity) making sure that there are no damages to the cargo. The sensors require the development of an architecture that not only simply sensors that locate and monitor containers or cargo, already used in the logistics world, but are capable to provide added values such as supporting the consolidation and the deconsolidation operations, or commercial devices for the goods characterization (e.g., scales and dimensional sensors) and monitoring (e.g., ethylene sensor device to monitor the fruit ripening).

For example, PLANET develop the Smart LU (PLANET, 2020) which provides added value services

1. **Asset and LU identification**. Identification of a (reusable) asset (i.e., pallet, basket, etc.).
2. **LU characterization**. It will be possible to characterise each LU in terms of items consolidated (i.e., amount and types, GS1 GTINs), weight and size.
3. **Specialised monitoring**, defining special rules for specifically monitor the goods consolidated on the LU.

From the application in the LL1 the specific technology was expected to:

- Assist in the development of intelligent nodes/logistics to help them take decisions and re-route taking into account the service level they provide to their clients, the time and the costs they can save.
- Better control the location of the cargo, improve the planning and ensure lower waiting times in terminals and warehouses
- Real-time connectivity to improve service quality, optimize asset utilization, and shorten response times for operations support
- Assist in the synchronization of the processes and networks and help the transition to synchromodal and PI examples. This is possible via assessing the impact of changing either maritime or inland transport routes.
- Provide an extra step towards for the paperless transaction and data exchange through Blockchain, inter-connected with existing Blockchains.
- Real time monitoring of speed, humidity and temperature an ensure the security of the cargo and the

Having the above in mind we developed the evaluation of the **sensors and IoT technologies** intervention.

Table 13 IoT technologies evaluation.

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	High
	Adaptive	High	Medium

Innovative	*Maturity*	High	High
	Feasible implementation / Efficacy	Medium	High
Impact	*Social impacts*	Low	Low
	Environmental Impacts	Medium	High
	Economic impacts	Medium	High
	Time saving impacts	Medium	High
Integrated	*Support intra- EU network integration*	Medium	Medium
	Support exo- EU network integration	High	Low
Inclusive	*Disadvantaged region inclusion*	Low	Medium
	EU land cohesion	Low	High
	Stakeholder inclusion	Low	High
Resources to be committed	*Cost related*	Low	Low
	Stakeholders/ Governance related	Medium	Medium

The real time information provided by the sensors, combined with the ability to provide data in algorithms that can identify disruptions and optimize routing and planning is expected to offer high level of resilience and adaptiveness to TEN-Ts in the first scenario of the continuing globalization and have medium effects in the second more regionalized scenario. In terms of the innovation level this technology is expected to be mature in both scenarios but will be easier to implement in the second scenario of the digitalization of the economy. Regarding the impacts sensors are expected to have low social impacts but by enabling data collection and hence better planning they are expected to have medium environmental, economic and time saving impacts for the globalized scenario where the networks are larger, more complex and in need for better synchronization. On the other hand, in the more regionalized scenario where digitalization is also higher the social, economic and environmental impacts of sensors are expected high. Applying sensors in the globalized scenario could have a medium impact on the intra-EU network integration in both scenarios while they can provide high support to the integration of the TEN-Ts with the global networks. In the globalized scenario with low level of digitalization implementing sensors is expected to have low impact on the inclusion of disadvantaged regions the EU land cohesion and the inclusion of all the stakeholders. On the other hand, the most globalized scenario has a medium benefit on the inclusion of the sensors for the inclusion of disadvantaged regions and high effect on the EU land and stakeholder inclusion.

If we consider now the resources that need to be committed for the implementation of these technologies once the technology is mature enough we expect low costs for their implementations and in both cases we expect a medium engagement of the stakeholders in terms of accepting to install the sensors and agreeing to exchange the data.

Predictive Models

Predictive Models will have a high impact on resilience and adaptiveness of international trade, as deliverable 1.8 expects collaboration increases after the implementation of predictive model, making it possible to handle quicker when unforeseen events occur within supply chains. This is especially the case in scenario one with high levels of globalization and economic trade. Predictive Models are making transport companies more flexible in times of droughts and simultaneous economic growth.

Living Lab 1 Use Case 2 of PLANET used predictive models to forecast the volume flows to and from the warehouses. Optimizing their logistic operations. The predictive models also allow warehouses to react to events in real time, something that is of great value for the tactical and strategic planning for logistical operations. There are several data sets made available within the PLANET project that were used to carry out preliminary test of predictive models for the forecasting of inflow of pallets and containers to warehouses and ports respectively. There are other datasets, some of them in the form of samples, which have been considered to build additional predictive models that could be relevant for services linked to transport models and last mile delivery route optimisation applications. Other data considered include data regarding train services that could be relevant in applications of synchromodality for transportation, and other related services to be considered within the living lab scenarios and carried out within the WP2.

Further development and application of Predictive Models (using either machine learning of Artificial Intelligence). For example, the models could include: 1) Prediction of vessel ETA in terminals, 2) Predictive logistics for Tasks and Resources – daily demand- in warehouses, 3) Demand for city logistics, etc.

Having the above in mind we developed the evaluation of the **Predictive Models** intervention.

Table 14 Predictive Models evaluation.

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	Medium
	Adaptive	High	Medium
Innovative	*Maturity*	Medium	High
	Feasible implementation / Efficacy	Medium	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Medium	Medium
	Economic impacts	High	Low
	Time saving impacts	Medium	Low

Integrated	*Support intra- EU network integration*	Medium	Low
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	Medium	Low
	EU land cohesion	Medium	Low
	Stakeholder inclusion	Medium	Medium
Resources to be committed	*Cost related*	Medium	High
	Stakeholders/ Governance related	Medium	Medium

In deliverable 2.15 it becomes clear that predictive models create a reliable prediction making transport companies better able to anticipate. In scenario 2 the impact of predictive models on adaptiveness and resilience is smaller since climate change will influence international trade less.

The maturity of Predictive Models is lower in scenario 1 since globalization and a political liberal climate lower the need for predictive models. Also the more complex international trade relations, due to the globalization and the impact of draughts in scenario 1 it will be more complex to implement predictive models. In scenario 2 the predictive models will be more mature since it can create extra trust. This extra trust also results in that in scenario 2 it is more feasible to implement a system of smart contracts.

The more efficient way of transportation as a result of predictive models has various positive impacts. As modelled in Deliverable 1.8 decision reaction time will drastically fall, making it possible to have a 300% growth in in transport demand with only 50% extra assets. As an example given in D 2.9 the forecasted information by predictive models enables warehouse operators to optimise resources regarding the allocation of trucks and personnel. These better insights results in saved travel times, economic impacts and environmental impacts since there will be relatively less congestion. As mentioned in deliverable 2.15 predictive models also create more efficient negotiations resulting in positive economic impacts. These impacts are most visible in flourishing economic times (scenario 1).

Predictive models support integration of transportation systems of different countries. In scenario 1 this will be mainly global integration, in scenario 2 regional integration. The EU support for PI in scenario 2 creates a larger uptake of Predictive Models and EU land inclusion in general. Disadvantaged regions will be better included (as a result of predictive models) in the global trade in scenario 2.

In scenario 2 is a larger resources required from governments and stakeholders for the uptake of innovation. Therefore the costs and stakeholder/government commitment are higher in scenario 2 than in scenario 1.

Optimization Models

Optimization models are becoming increasingly important tools for supply chain for freight transport as well as for supply chain management. Warehouse operators and supply chain managers are in need for supply chain management tools that help them improve their daily operations. Optimization model developed with the application of the new advanced techniques such as AI and ML can assist operators do things like allocate the optimal number of staff to certain tasks within the warehouses, plan the grouping of orders for trucks for more

efficient routing decisions and optimize the daily planning of human resources and equipment. In more long haul transport efficient optimization of services of the various models can assist to the development synchromodal network and in the final introduction of PI.

In the PLANET[12] project develops service route optimization model and supplier collaboration and warehousing optimization services.

The route optimization services require Big Data augmented by simulation models and information gathered from IoT sensors (PLANET, 2021). These optimization services are delivered in LL1 and LL3. Specifically:

- In LL1, COSCO develops re-routing shipping services and CityLogin develop efficient Last Mile Delivery (LMD) routing services
- In LL3 ILIM aims to review and specify how the China-EU End-to-End transport process via rail, road and sea could become more integrated and Polish Post will develop a LMD routing module.

An effective routing service is one of the best ways to provide value to the transport and logistics networks by adopting big data and analytics. This to be able to make an informed timely decision to adjust a pre-determined route, which might require different sources of data to form a more solid criterion. The data is not only used by the predictive models, but also required to better understand the dynamic evolution of the network flow.

In the case of COSCO re-routing service a dynamic routing algorithm identifies the re scheduling of cargo between the different inland and maritime transport modes. With this companies can deal with congestion and bottlenecks in ports and transport networks. ML models are applied to handle real-time data from continuous events and make sure that they can reroute the traffic to avoid possible incidents. The proposed services are the most relevant for time series forecasting in PI scenarios. The routing layer, in fact, is the layer responsible for identifying the suggested route for each PI- modules. In addition, the combination of the optimization models with a forecasting model Therefore, if a trained machine learning forecasting model is employed as part of the optimization service and the gathered insights are published, the routing service will calculate the route and can consider the most probable distribution of goods, resulting in an optimal outcome in terms of time and mover's utilization.

Supplier collaboration and warehousing models which can be applied within the smart contracts within the PLANET in:

1. LL 1 UC2 development of a supplier communication and collaboration channel between COSCO and CityLogin.
2. LL 2. The infrastructure analysis will aim to organize delivery processes within the different rail systems along the China Europe corridor. In addition a coordination system between the supply chain actors in the various geographic areas in the Blockchain T&L Solution UC is required to reach the synchromodality concept.

A first implementation instances for the proposed work in supplier collaboration warehouse application is the use of Blockchain to improve the traceability and visibility of the warehouse operations and how predictive analytics can contribute to the development of intelligent logistic nodes. Specifically, a service is proposed that can optimise the collaboration within the warehouses. A second solution investigated is PLANET is a warehouse-as-a-service applications where a space owner (individual or enterprise storage provider) can remove the need of a middleman (marketplace) to directly reach the consumers, while retaining some of the benefits of selling through conventional retail platforms. A Blockchain based warehouse "space-as-a-service" is proposed which addresses the inventory synchronization challenge and removes the need of marketplace and allows space providers to reach consumers directly (PLANET, 2021).

Further development and application of **Optimization Models** intervention.

[12]The PLANET project has taken the optimization models developed within the ICONET project as step further.

Table 15 Optimization Models evaluation.

EGTN vision	Criteria	Scenario 1	Scenario 2
Ge-economic aware	*Resilient*	High	Medium
	Adaptive	High	Medium
Innovative	*Maturity*	Medium	High
	Feasible implementation / Efficacy	Medium	High
Impact	*Social impacts*	NA	NA
	Environmental impacts	Medium	Low
	Economic impacts	Medium	Low
	Time saving impacts	Medium	Low
Integrated	*Support intra- EU network integration*	Medium	Low
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	Medium	Low
	EU land cohesion	Medium	Low
	Stakeholder inclusion	Medium	Medium
Resources to be committed	*Cost related*	Medium	High
	Stakeholders/ Governance related	Medium	Medium

The benefits provided by optimization models, are expected to have offer high level of resilience and adaptiveness to TEN-Ts in the first scenario of the continuing globalization and have medium effects in the second more regionalized scenario. In terms of the innovation level optimization models are expected to have a medium level of maturity and feasibility in the first less digitalized scenario while the innovation score is high in digitalized scenario where the models developed and more data is available. Regarding the expected impacts from the application of Optimization models social impacts are not expected. However the application of such models is

expected to have economic, environmental and time impacts in the globalized scenario while the effect of the models are expected to be low in more regionalized scenario. Applying optimization models in the globalized scenario could have a medium impact on the intra-EU network integration in both scenarios while they can provide high support to the integration of the TEN-Ts with the global networks. In the globalized scenario with low level of digitalization the development of optimization models is expected to have a medium impact on the inclusion of disadvantaged regions the EU land cohesion and the inclusion of all the stakeholders. On the other hand, the most globalized scenario has a low benefit from the development optimization models for the inclusion of disadvantaged regions and the EU land cohesion and a medium impact on the stakeholder inclusion.

Regarding the resources that need to be committed optimization models require medium cost investment in the less digitalized scenario while they will necessitate high investments in the less digitalized scenario. In both scenarios medium stakeholder resources are necessary especially when collaboration models are developed.

Collaborative Platforms

Physical Internet (PI) will have a high impact on resilience and adaptiveness of international trade, as deliverable 1.8 expects collaboration increases after the implementation of Physical Internet, making it possible to handle quicker when unforeseen events occur within supply chains. PLANET LL1 has evaluated how novel technologies and concepts such as Physical Internet can enhance the efficiency of the processes and operations performed along the door-to-door transport and logistics in the link between the Maritime Silk Road and EU internal corridors. PI concept have been implemented to create flexible and resilient door-to-door services, where logistics assets do not follow pre-defined transport routes, but these are dynamically calculated and identified at each logistics node, which has the intelligence to identified the optimal routing, considering historical and real-time data.

In UC2 of LL1 warehouses and terminals have opened their data infrastructure (becoming PI Nodes) for both optimizing their own operation as well as connecting their operations with operations of other logistic services. The idea behind this blockchain workflow is that information is shared in a transparent and trustful manner between all stakeholders involved. This is a rather important point, since a critical element of the Physical Internet (PI) is the sharing of information between multiple actors in an open and trustful manner.

Synchromodality and Physical Internet have received attention in the first use case of LL2; Synchromodal dynamic management of TEN-T & intercontinental flows promoting rail transport. In particular, the first use case will focus on Synchromodality on a Blockchain enabled Platform, utilizing advanced IoT, supporting individual firms including SMEs (PoR customers/ communities) to create the best multi-modal alternatives for logistics solutions within the LL2 corridors.

As studied in LL3 by avoiding dependencies in the cargo flow, a more flexible and efficient transport network towards the Physical Internet (PI) concept of digital internet inspired protocols on adaptive routing, at each node, for information networks, can be enabled.

Having the above in mind we developed the evaluation of the **collaborative platforms** intervention.

Table 16 Collaborative platforms evaluation

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	High
	Adaptive	High	High
Innovative	*Maturity*	Low	High

EGTN vision	Criteria	Scenario 1	Scenario 2
	Feasible implementation / Efficacy	Low	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Low	High
	Economic impacts	High	Low
	Time saving impacts	High	High
Integrated	*Support intra- EU network integration*	High	High
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	Medium	Low
	EU land cohesion	High	High
	Stakeholder inclusion	Medium	Medium
Resources to be committed	*Cost related*	High	High
	Stakeholders/ Governance related	High	High

This is especially the case in scenario two with high levels of investments in PI by governments and stakeholders. Physical Internet makes transport companies more flexible in times of regionalization and hindrance in international trade.

The maturity of Physical Internet is lower in scenario 1 since globalization and a political liberal climate lower the need for PI synchromodal nodes. Also the more complex international trade relations, due to the globalization and the impact of draughts in scenario 1 it will be more complex to implement the concept of Physical Internet. In scenario 2 the PI will be more mature since stakeholders need reliant structures to collaborate in a more fragmented world. This results also that in scenario 2 it is more feasible to implement a system of PI synchromodal nodes.

The more efficient way of transportation as a result of PI has various positive impacts. As modelled in Deliverable 1.8 decision reaction time will drastically fall, making it possible to have a 300% growth in in transport demand with only 50% extra assets. D2.13 states that PI enables smart decision making at nodes and networks increasing efficiency. This results in saved travel times, economic impacts and according to D2.13 environmental impacts since there will be relatively less congestion and a more optimal routing of last-mile deliveries. However, the impacts on the environment will be less positive in scenario 1 since PI will induce travel demand. In scenario 2

the regionalization will create shorter travel distances and lower environmental impact since the benefits of less congestion outweigh the effects of extra induced demand.

PI supports integration of transportation systems of different countries. As concluded in D2.13 PI nodes create vertical integration of global corridor services to port clusters and their hinterland. This integration is a result of a PI Hub choice model where an algorithm decides the optimal hub for synchromodality. In scenario 1 this vertical integration is mainly global integration, in scenario 2 regional integration. The EU support for PI in scenario 2 creates a larger uptake of PI and EU land inclusion in general. Disadvantaged regions will mainly be included by PI in scenario 2.

In scenario 2 is a larger resources required from governments and stakeholders for the uptake of innovation. Therefore the costs and stakeholder/government commitment are higher in scenario 2 than in scenario 1.

DSS

Decisions makers are in need for the development of DSS tools with predicting capability and KPIs dashboards that can drive efficient and effective decision making. DSS tools should be equipped with simulation models that can provide real time information on the effect of their decisions. . In addition DSS tools should be equipped with predictive tools and models which can provide stakeholders with projections on the effect of future scenarios (economic, geopolitical etc.). To develop DSS tools collaboration with stakeholders in order to be able to identify which KPIs are essential to them, to apply the weights determining the significance of each KPI for each stakeholder, to determine the performance of each possible scenario against each stakeholder interests. Stakeholders should be able to identify to choose between various factors and identify the most adequate scenario.

In the context of PLANET a DSS tool is included in the EGTN infrastructure. The tool implements a MACMA approach and focuses on PI development and integration with global trade corridors (PLANET, 2021). It identifies the most important criteria for the evaluation of each technological and investment alternative and their geographic implementation. To identify the KPIs for the assessment of each future scenarios, assessing geopolitical and geo-economic impacts, as well as the impacts of new trade routes key network performance KPIs are considered. Key factors considered include port capacity, container throughput, service frequency, service quality, digital connectivity, port infrastructure, efficiency of processes, emissions (Co2, NOx, PM), Logistics activities (employment/added value), Foreign Direct Investment (FDI). In addition social KPIs (pressure from society on sustainability, ageing population), economic (regionalization of trade blocks, shifting trade patterns (BRI, Arctic route, INSTC), Chinese investments), environmental (CO2 pricing in shipping and logistics, de-carbonization of transport system), political (geo-economic strategies etc.) and technological (transport equipment life cycle, (digital) transport platform providers, etc.). Behind the PLANET DSS both strategic and operational models are developed function that can calculate all the relevant KPIs.

Further development and application of **real-time Decision Support Systems** intervention.

Table 17 DSS evaluation

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	Medium
	Adaptive	High	Medium
Innovative	*Maturity*	Medium	High

	Feasible implementation / Efficacy	Medium	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Medium	Medium
	Economic impacts	High	High
	Time saving impacts	High	High
Integrated	*Support intra- EU network integration*	High	Medium
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	Medium	High
	EU land cohesion	Medium	High
	Stakeholder inclusion	Medium	High
Resources to be committed	*Cost related*	High	High
	Stakeholders/ Governance related	High	High

Application of DSS that gives the ability to stakeholder to have a more holistic view of the network, possible disruptions and to predict the effect that various scenarios will have on making the TEN-Ts more resilient and adaptive in the more globalized scenario and their expect will be medium in scenario 2. Regarding the evaluation of the innovative aspects of the DSS in the digitalized scenario both the technology will be already more mature and the feasibility of implementation will be higher. Regarding the expected impacts from the application of Optimization models social impacts are not expected. The inclusion of all types of stakeholders in a DSS can have medium impacts in both scenarios. Regarding the environmental, economic and time saving impacts it is assessed that they will have medium and high impacts in both scenarios. DSS systems can provide high support to the intra-EU application in scenario 1 while the effect will be medium in scenario 2. Regarding the exo-EU integration it is expected to be medium in the most globalized scenario because collaboration and more data from stakeholders outside the EU is necessary. For the same reason the effect in the non-globalized scenario is expected to be low. In the globalized scenario with low level of digitalization the development of DSS is expected to have a medium impact on the inclusion of disadvantaged regions, the EU land cohesion and the inclusion of all the stakeholders. On the other hand, the most globalized scenario will be benefited highly by DSSs in all the inclusiveness criteria.

Regarding the resources DSS require high costs (for the development of models, data exchange, visualization dashboards etc.) in both criteria. Regarding the stakeholders a large number of stakeholders need to be commitment both for the development and the implementation of DSS.

4.2.2 Opportunities for funding

This section presents the opportunities for funding as they emerge from the evaluation of the technologies and the replies provided by the stakeholders in the workshop.

Paperless documents

The digitalization of documents and the paperless transport documents exchange is a requirement for the development of blockchain technologies, smart contracts etc. and for the transition to PI scenarios. To be able to apply them still there is need for:

- Resolve legal issues that deal with the digital exchange of data (i.e. IGPR). Standardization of the information that need to include the documents, of the document exchange protocols and the data exchange processes could help resolve legal issues and improve the data exchange.
- Increased of government engagement to ensure the harmonization of documents and regulations.
- The issue of who will bear the initial costs for the transition of the paperless documents especially for companies with lower level of technological maturity is still not solved. Demonstrating the positive effects of these technologies to companies could help them increase their willingness to invest and could also increase their flexibility towards change.

Smart contracts

Before a full scale-up of Smart contracts can be achieved a number of issues need to be resolved. Requiring additional research and funding:

- Developing a transactional protocol that can be implemented throughout international logistic chains.
- Standardisation of digital documents. For a more efficient usage of smart contracts legal (custom) documents should be harmonized. When using the same (digital) format the roll out of smart contracts will be easier.
- Digitalisation of operations at warehouses and other logistic nodes. Logistic nodes should embrace the usage of algorithms and the digitalisation of their operation (digital administration, HR systems etc.)
- Investment of the sector in faster internet connection at logistic nodes. The logistic nodes should be digitally very accessible. This entails that logistic nodes in disadvantaged regions must be connected to fast internet. In this way, all logistic nodes can update contracts real-time.

Blockchain

In order to fully uncap the potential of Blockchain technology additional investments and research is required:

- Reduce the paper-based processes at borders and logistic nodes. By investing in the digitalisation of processes the uptake of Blockchain technologies can be accelerated.
- Improve the security of Blockchain technologies to provide safe data exchange. Additionally the safeness of the data exchange will create more trust in the technologies resulting in a higher uptake.
- Investment in data storages. Blockchain data needs to be saved. New data centres are mandatory for the roll out of Blockchain-based technologies.
- International regulation on Blockchain technology. A clear legal framework will create a stable outlook for investors in Blockchain technology.

Sensors and IoT technologies

During the PLANET research and application we identified the additional needs for the implementation of IoT sensors. Additional points of development are:

- Legal issues that deal with the tracking of the goods but also trucks

- It is important to promote or a first subsidy for their penetration in the market. When dealing with such sensors we have to look into what are and who will bear the additional costs. Increasing the awareness of the benefits for the users can promote their willingness to apply the technologies.
- The exchange of data in order to be able to take advantage of all the possibilities offered by the sensors requires the development and adoption of collaborating models between the stakeholders.
- On a technical level it is important to ensure the sstandardization of the sensors aiming to deal with interoperability issues among the systems. In addition it is important to improve the range of the batteries. Lack of 4 or 5G coverage in certain areas can lead to problems.

In parallel to the development of sensors it is important to ensure that there is supporting infrastructure for the further collection and analysis of the transmitted data. PLANET already proposes the development of an IoT cloud platform that provides a cooperative environment for the horizontal and vertical collaboration between the different stakeholders at every level of the data collection chain, exploiting interoperable standardized solutions.

Predictive Models

For the adoption and development of predictive models there still some prerequisites that need additional research and funding. Specifically:

- Increase the availability of transport data. Investing in safe and secure data exchange technologies will increase the availability of transport data among supply chains.
- Digitalization of transport operations. By digitalization of processes more data on those processes becomes available and can be used to analyze and predict future demand.
- Have a better tracking of goods. In order to use predictive models real-time, investments must be made in making transport data available in real-time.
- Set up data-standards. Create a data-standard that allows all predictive models to use the same data without the need of adjustments.

Optimization Models

In the context of the research conducted in PLANET and the application in the LLs we identified the additional needs for the implementation of the optimization models. Specifically the additional points are:

- Integration of the optimization models with predictive models which will assist the development of more accurate optimizations.
- Incorporate the optimization models to simulation models for a better representation of the optimized systems and real-time testing of scenarios and policies. Digital Twinning will provide users, planners and decision makers with representation of the systems and further assist real-time decisions and improvements in operation KPIS.
- To build feasible and implementable route optimization services, there is a strong requirement for relevant data and information on the current routing systems available for their validation. There is a need for historical data with enough time resolution regarding the journey origin and destination locations for delivery, available modes of transportation, transport capacity, availability of alternative routes are required. Furthermore, data regarding relevant external factors such as traffic, weather and news data need to be considered as requirements for developing more effective routing services or predictive models with the PLANET LLs scenarios.
- Strong collaboration with stakeholders to better understand the processes to be optimized, possible bottlenecks and overall opportunities for improvements.
- Research to improve the current state-of-the-art in optimization techniques such as improvement of AI and ML algorithms
- Improve the calculation abilities of computers to be able to provide results in the minimum time and data driven approaches such as machine learning based predictive models.

Collaborative platforms

Physical Internet (PI) has a pivotal role in PLANET. In order to unlock PI full potential investments and additional research is required on:

- Subsidies to compensate for the implementation costs. PI consists of a multitude of new technologies that all have implementation costs. Subsidies can compensate for these costs speeding up the implementation of PI.
- Standardisation of regulation, especially on borders. These standards make PI solutions more efficient and easier to implement.
- Create more trusts between actors on the entire supply-chain. So also among actors outside of the EU. This can be done by facilitating exchange programs, trade missions and conference where actors can become familiar with each other.
- Improve the decision making at PI nodes. Decision making protocols can be developed, so managers at PI nodes can make efficient and effective decisions. These decision protocols will also harmonize working processes among the corridors.

DSS

For the adoption and development of effective and efficient real time DSS there still some prerequisites that need additional research and funding. Specifically:

1. It is necessary to develop coordination mechanisms between the various stakeholders. Coordination is crucial to better understand their needs, processes and business models so that they are accurately represented in the developed models. It is also important to assist DSS development in identifying the best possible KPIs that could inform their decision making.
2. Large scale implementation of DSS in PI contexts require understanding of the needs of stakeholders but also their willingness to share know-how and their business data. DSS tools are data thirsty for micro-level and micro level data so data sharing is crucial for the optimal development of these systems.
3. International coordination from all the MS is important if we want to talk about a DSS that could cover the entire of Europe. Different levels of stakeholders but also different businesses can ensure that we deal with heterogeneity of actors in a satisfactory manner.
4. Harmonization of processes and data exchange protocols is important for the development of DSS.

4.3 Overview of governance needs

Based on the results of the stakeholders analysis report it is essential for the uptake of the PLANET interventions (PLANET, 2020). D5.1 has identified the relevant stakeholder groups, analysed their interests and their needs for the further exploitation of the PLANET interventions.

Among their needs and expectations is to build a strong consensus for sectorial changes and to promote the cooperation among players. Therefore it is essential to create strong governance among the plethora of stakeholders for the uptake of the interventions.

The most important governance needs are the ones below:

5. Increased **training of stakeholders** in order to be able to:
    i. Apply new technologies
    ii. Adopt and improve collaborative platforms
6. Development of **monitoring services**:
    i. Ensure the implementation of legislation
    ii. Adjust and improve network operations in order to identify weak points and improve efficiency
7. Development of **trust** between the stakeholders to exchange data with the platform **and increase awareness** on the existence of these platforms.

8. Development of **business models** to further exploit the interventions/innovations proposed within PLANET.

4.3.1 Matrix application

This section presents the implementation of the PLANET evaluation matrix

Training stakeholders

Stakeholder organisations have different levels of technological maturity hence they need to be trained to use the new technologies. In addition, training will put stakeholders in touch with the new technologies and assist them in understanding their benefits hence, accelerating their implementations. The training of stakeholders makes the international trade community more resilient and adaptive. More skilled workers and managers creates a more adaptive workplace able to bounce back better from external shocks.

Increased **training of stakeholders** in order to be able to:

1) Apply new technologies
2) Adopt and improve collaborative platforms

Table 18 Training stakeholders evaluation

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	High
	Adaptive	High	High
Innovative	*Maturity*	Low	High
	Feasible implementation / Efficacy	Medium	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Low	High
	Economic impacts	High	Low
	Time saving impacts	High	High
Integrated	*Support intra- EU network integration*	Medium	High
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	High	High

	EU land cohesion	High	High
	Stakeholder inclusion	High	High
Resources to be committed	*Cost related*	Medium	Medium
	Stakeholders/ Governance related	Medium	Medium

The training of stakeholders will not influence the maturity of technology itself, but it does support the feasibility of implementing the technology. Better trained stakeholders have a better understanding of handling the new technology making it easier to implement the technology in the working process. The circumstances for the uptake of new technology are better in scenario 2 than in scenario 1, since stakeholders invest more in new technology in scenario 2.The more efficient way of transportation as a result of a better understanding of PI has various positive impacts. As modelled in Deliverable 1.8 decision reaction time will drastically fall, making it possible to have a 300% growth in in transport demand with only 50% extra assets. This results in saved travel times, economic impacts and environmental impacts since there will be relatively less congestion. However, the impacts on the environment will be less positive in scenario 1 since PI will induce travel demand. In scenario 2 the regionalization will create shorter travel distances and lower environmental impact since the benefits of less congestion outweigh the effects of extra induced demand. The trainings indirectly contribute to these effects. A better uptake of PI by stakeholders supports integration of transportation systems of different countries. In scenario 1 this will be mainly global integration, in scenario 2 regional integration. In scenario 1 the training will mainly contribute to exo-EU integration. Scenario 2 makes training more supporting intra-EU integration. The EU support for PI in scenario 2 creates a larger uptake of PI and EU land inclusion in general. Disadvantaged regions will mainly be benefit from the trainings in scenario 2 since they are better included by PI in scenario 2.

In both scenarios stakeholders will have higher costs, since they have to finance the training of the workforce. These costs will be returned when innovative technologies can be used better, resulting in decreasing overall resources committed by stakeholders

Monitoring services

As presented in the EGTN definition the technological layer also includes technologies that monitor assets& processes along the EGTN infrastructure. Monitoring services can ensure in one hard that the stakeholders properly implement the legislation, to identify possible delays and bottlenecks and to better manage the physical and the digital infrastructure of the network.

Development of **monitoring services**:

1) Ensure the implementation of legislation
2) Adjust and improve network operations in order to identify weak points and improve efficiency

Table 19 Monitoring services evaluation

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	High

EGTN vision	Criteria	Scenario 1	Scenario 2
	Adaptive	High	High
Innovative	*Maturity*	Medium	High
	Feasible implementation / Efficacy	Low	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Medium	Medium
	Economic impacts	High	Medium
	Time saving impacts	High	High
Integrated	*Support intra- EU network integration*	High	High
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	Medium	Medium
	EU land cohesion	High	High
	Stakeholder inclusion	High	High
Resources to be committed	*Cost related*	Medium	Medium
	Stakeholders/ Governance related	High	High

The monitoring of border customs makes the international trade community more resilient and adaptive. Identifying irregularities in procedures creates a more adaptive workplace able to bounce back better from external shocks. Since disruptions will be resolved more quickly creating more efficient and adaptive trading routes. The monitoring of services will not influence the maturity of technology itself, but it does support the feasibility of implementing the technology. Better monitoring creates a better view on the challenges on implementing new technologies. This extra knowledge of current procedures will also raise the bar of the technology before it can be implemented. Especially in scenario 1 where trade volumes are high, and immature technology will costs the most money. The circumstances for the uptake of new technology are better in scenario 2 than in scenario 1, since stakeholders invest more in new technology in scenario 2. The more efficient way of transportation as a result of a better understanding of the performance of PI has various positive impacts. As modelled in Deliverable 1.8 decision reaction time will drastically fall, making it possible to have a 300% growth in in transport demand with only 50% extra assets. This results in saved travel times, economic impacts and

environmental impacts since there will be relatively less congestion. The monitoring of services indirectly contributes to these effects. The monitoring of services and the exchange of the insights gathering from the monitoring creates a better understanding between stakeholders. This results in more integration between stakeholders and the inclusion of other stakeholders (e.g. stakeholders in disadvantaged regions).

In both scenarios stakeholders will have higher costs, since they have to finance the monitoring of services. The resources have to be committed long-term, since the effects will only be achieved once the monitoring will be over longer time.

Trust and increase awareness

The implementation of all the necessary the technologies to pave the way to PI requires exchange of data and information between the various stakeholders in the supply chain. Some shorts of data however are considered as sensitive business information and companies are reluctant to share them with their competitors. Therefore, building trust among should be promoted along with the technological development of cooperative platforms. Getting stakeholders in touch with these technologies and letting them experience the advantages that they can offer to their operations is an essential step for the development of the platforms. The 3rd governance intervention proposed with PLANET is the development of **trust** between the stakeholders to exchange data with the platform **and increase awareness** on the existence of these platforms.

Table 20 Trust and increase awareness evaluation

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	Medium	Medium
	Adaptive	Medium	Medium
Innovative	*Maturity*	NA	NA
	Feasible implementation / Efficacy	NA	NA
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Low	Low
	Economic impacts	Low	Low
	Time saving impacts	High	High
Integrated	*Support intra- EU network integration*	High	High
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	High	High

EGTN vision	Criteria	Scenario 1	Scenario 2
	EU land cohesion	High	High
	Stakeholder inclusion	High	High
Resources to be committed	*Cost related*	Low	Low
	Stakeholders/ Governance related	High	High

Building trust between the stakeholders is expected to have a medium influence in the resilience and the adaptiveness of the TEN-Ts in both scenarios. In general these soft governance measures are not expected to have substantial difference between both scenarios. Developing trust between the stakeholders is not expected to have influence on the innovation level of the TEN-Ts. Improving the awareness of the stakeholders is expected to have medium level social impacts via the inclusion of all types of actors in both scenarios. Improving the trust of actors will facilitate data exchange which is essential for the optimization of company operations and the integration of networks leading to high saving impacts. From environmental and economic point the impacts are expected to low in both scenarios. Trust will have high impact in supporting intra-EU network integration in both scenarios. On the other hand the effect of making stakeholders trust will have a medium effect in supporting exo-EU network integration but will have a low effect in the second less globalized scenario. Improving trust between stakeholders will have high effect in both scenarios and in all the inclusiveness criteria.

In both scenarios low costs are necessary to develop trust between stakeholders. On the other hand, it is necessary to have a high a level of commitment and engagements for stakeholders in both scenarios.

Business models

The introduction of technological innovations introduced in PLANET will lead to changes in the way that various engaged companies operate. For example, new businesses are required to develop the platforms, develop models and algorithms and to orchestrate the physical and digital integration of the networks.

The 8th governance intervention is the development of **business models** to further exploit the interventions/innovations proposed within PLANET:

Table 21 Business models evaluation

EGTN vision	Criteria	Scenario 1	Scenario 2
Ge-economic aware	*Resilient*	High	High
	Adaptive	High	High
Innovative	*Maturity*	Low	Medium
	Feasible implementation / Efficacy	High	High
Impact	*Social impacts*	Medium	Medium

EGTN vision	Criteria	Scenario 1	Scenario 2
	Environmental impacts	Medium	Medium
	Economic impacts	High	High
	Time saving impacts	High	High
Integrated	*Support intra- EU network integration*	High	High
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	Medium	Medium
	EU land cohesion	High	High
	Stakeholder inclusion	High	High
Resources to be committed	*Cost related*	Low	Low
	Stakeholders/ Governance related	Medium	Medium

Researching the development of new business models stakeholders which will lead to PI is expected to have medium influence in making TEN-Ts geo-economic aware in both scenarios. In general these soft governance measures are not expected to have substantial difference between both scenarios. These innovative business models will have a low maturity in the first less digitalized scenario and medium maturity in the second scenario. In both scenarios it will be possible to develop the innovative business models. In terms of impacts medium social and environmental effects are expected especially due to the advantages for the TEN-Ts via the uptake of the businesses. The successful development for these models and the business will have high economic and time saving impacts. The business models will have high impact in supporting intra-EU network integration in both scenarios. On the other hand the effect of innovating the existing business models will have a medium effect in supporting exo-EU network integration but will have a low effect in the second less globalized scenario. Improving business models will have high effect in both scenarios on the EU land cohesion and stakeholder inclusion and will have a medium in the disadvantaged region inclusion.

In both scenarios low costs are necessary to research and develop the new business models. On the other hand, it is necessary to have a medium level of commitment and engagement of stakeholders in both scenarios.

4.3.2 Opportunities for funding

To further improve the governance aspect it is necessary to ensure further funding for the points below:

1) Development of a detailed governance framework for the governance of the innovative technologies and the physical and digital integrated networks. Efficient and effective governance should be made a priority in an aim to ensure cooperation, data sharing and the inclusion of all businesses and stakeholders

regardless their position in the market (not only big players) and their technological maturity. For all the big projects that lead to integration of physical or digital infrastructure governance framework should be developed and followed.

2) Train businesses and try to change their perception into valuing also the environmental benefits and not only the costs and potential benefits from some specific interventions. Fund and develop training programs for all actors to ensure that they efficiently share data abut they also protect the privacy of their customers data.
3) Looking for solutions to build trust among stakeholders. Building trust with cannot be achieved fast but it is a long process. Research on trust models and processes should be conducted to ensure the inclusion of all the types of stakeholders
    a. Proving to the engaged actors the advantages they can get from the implementation of these technologies and the share of their data.
    b. Improve the legal framework to ensure the confidentiality of data and protect businesses regardless of their size. Provide public support to ensure the confidence of all actors in the use to these technologies.
    c. Protect business from cybersecurity threats.

5 Synthesis and Recommendation

This section synthesizes the funding needs presented in Sections 4.1.5, 4.2.2 and 4.2.3 and turns them to recommendations for the next funding calls for HE and CEF.

The two calls for funding are focusing in different types of actions as it is presented in Table 10.

- **HE Transport**

HE Transport funds' investments in building new transport infrastructure or rehabilitating and upgrading the existing ones in the Core and Comprehensive TEN-T network and the Alternative Fuel Infrastructure Facility.

- **CEF Transport**

The Connecting Europe Facility (CEF) for Transport is the funding instrument to realize European transport infrastructure policy. It aims at supporting investments in building new transport infrastructure in Europe or rehabilitating and upgrading the existing one. Trans-European Networks for Transport (TEN-T) policy objectives foresee:

- Completion by 2030 of the Core Network, structured around nine multimodal Core Network Corridors.
- completion by 2050 of the Comprehensive Network in order to facilitate accessibility to all European regions

CEF Transport focuses on cross-border projects and projects aiming at removing bottlenecks or bridging missing links in various sections of the Core Network and on the Comprehensive Network (link), as well as for horizontal priorities such as traffic management systems. CEF Transport also supports innovation in the transport system in order to improve the use of infrastructure, reduce the environmental impact of transport, enhance energy efficiency and increase safety. The budget for CEF Transport is of **€25.81 billion** (including €11.29 billion for cohesion countries).

Table 22 Summary of CEFs and HE scope and objectives

	CEF	**Horizon Europe - Transport**
Objective	Fund investments in building new transport infrastructure or rehabilitating and upgrading the existing ones in the Core and Comprehensive TEN-T network and the Alternative Fuel Infrastructure Facility.	Fund research activities and infrastructures (including partnerships) to strengthen science and technology, to foster industrial competitiveness, and to implement the sustainable development goals in the EU.
Funding scope	Infrastructure – transport, digital Charging and hydrogen refuelling infrastructure	Research and innovation activities
Location specific	Core and comprehensive network Cohesion countries have reserved budget Cross-border projects	International partnerships are funded for some topics.

	CEF	**Horizon Europe - Transport**
Priorities	Each transport mode has specific priorities defined in the TEN-T regulations. Overall there are TEN-T policy goals. (Mobility, Accessibility, Optimal use of capacities, Safety, Intermodality and interoperability, Economic viability, Environment, Modal balance.)	

In addition we include considerations for the **DEP** which takes care of the Digitalization of European services and facilities and aims to provide safe, secure and fast computing to all MS states and stakeholders. Its funding scope are digitalization activities and it includes calls for internationally funded topics.

5.1 Recommendations for CEF

With respect to the logistics operations, the EGTN will be a network with an increased development of collaborative logistics as a backbone of the PI concept implementation. The PI concept builds on the availability of open and integrated networks that connect freight transport origins and destinations. To ensure this transition EU networks need to be assisted to make the transition to the next generation by CEF via the inclusion of the following points.

- **Increase capacity on the network and nodes.**

In Section 4.2.1 we identified the key corridors and nodes that will face capacity shortages due to the increase in the Eurasian freight by 2030. The following corridors are already facing problems and this situation is expected to identify:

1) Malaszewicze – Skierniewice
2) Skierniewice – Berlin
3) Lukow – Slavkov
4) Slawkow - Skalite – Zilina (Extended network)
5) Ostrava - Vienna

Especially the railway networks in Ukraine (1-4) will be the ones required to service the vast majority of the additional capacity. However, only in 1) Malaszewicze – Skierniewice which is expected to service more than 20 trains per day. In the rest of the networks ensure making high speed investments could ensure lower lead times. Ensuring the acceptance of longer and heavier trains on all these corridoes could potentially decrease the number of disruption and the number of handlings and transit time.

In all the above corridors which are parts partially reconstruction and improvements are proposed.

Integral part of the PLANET's EGTN vision is a new type of intelligent PI nodes/hubs which will replace the node concept as it is applied today (as individual terminal(s) in a specific geographic location, e.g., the port, the airport and the railway station in the TEN-T node of a city). The terminals identified in Section 4.1.5 could be turned into PI nodes by first of all ensuring that they have enough capacity and that they can handle unexpected operational disruptions.
The most important link between the European railway network and the broad-gauge Russian network is the Małaszewicze transhipment area where trains arrive from Minsk/Brest. Currently the border point can handle more than twenty trains per day, or 450 thousand TEUs per year. With the current volumes, it has more capacity than required and works are planned to increase the capacity four times. In addition, after the end of the war in Ukraine and given that geopolitical relationships are reinstated investments on the Ukrainian rail infrastructure could relieve the Polish railway network and improve the TEN-T resilience.

Regarding the marine terminals such as Hamburg most of them operate in full capacity but the increase in the demand expected by the Eurasian freight is a small percentage compared to the demand they service in the sea. Therefore softer measures should be applied to improve their capacity and efficiency.

- **Interoperability (ERTMS and electrification) :**

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. Interoperability requirements means the minimum infrastructure requirements along the corridors (primarily compliance with the TEN-T line parameters) (Amber, 2020). The requirements depend on the traffic characteristics of the line but the most important parameters for freight trains are in line with the TEN-T Guidelines:

• Traction mode: full electrification

• Train length: possibility to run 740m at least (along the lines incl. stations to handle trains and manage traffic)
• Axle load: at least 22,5t (i.e. in combination with 8,0 tons/m meter-load requirement: UIC Line Class D4)

• Line speed for freight trains: at least 100 km/h

• Signaling: full deployment of ERTMS

Since all the proposed networks for intervention are part of the TEN-T network it should be ensured that they fully interoperable. As CEF permits.

- **Softer measures**

As mentioned above the Eurasian freight is a fraction of the amount of the demand that the TEN-T networks are required to serve daily therefore it is proposed that softer measures could improve capacity and efficiency issues. The development of new type of nodes aims at achieving the attribute of network resilience (both in terms of capacity availability & handling unexpected operations disruptions) and also the enhanced economic, environmental & social efficiency of freight transport operations. Administrative and/or operational deficiencies, cause inadequate capacity supply or inefficient use of the infrastructure “affecting the continuity of long-distance or cross-border flows” are considered bottlenecks.

1. Improvement of capacity management.
    a. Improve the coordination between infrastructure managers in neighbouring countries. Train them to give priority rail units.
2. Improve the interfaces between the national infrastructure IT and the RNE.
    a. Currently the issues in interfaces lead to poor quality of communication and delayed exchange of messages.
3. Improve the procedures that cause ineffective traffic management in border crossings.
    a. Improve the technical condition of the wagon
    b. Increase the parking capacity to wait for inspection or for change of drive/locomotive especially in the wagons.
4. Train the staff in traffic management can also be included in CEF actions.
5. Improve the collaboration of stakeholders for the development of the PI intelligent nodes. Assist stakeholders to identify their common goals and to find common ground to establish trust-based relationships and reach consensus in investment policies, leading to in-depth collaboration and the implementation of resource sharing business models in alignment to the PI concept. Develop these ecosystems in a way that can easily expand to include all actors who are operating in the node.

- **Improvement of digital infrastructure**

The transition to EGTN and to the PI paradigm requires the existence of technological infrastructure that can support the PI operations especially in the nodes/hubs.

1. As a first step it should be the implementation of PCS in all terminals which will ensure the availability of data.
    a. Harmonization of the PCS with national IM's ITs.
    b. Improvement of the workflow within the existing PCS in order to be applied by all types of stakeholders.
    c. Reduce the number of uploads of documents.
2. Application of digital platforms that permit paperless transactions, connectivity between the stakeholder's digital systems, facilitate information exchange and offer predictive services for example the PLANET EGTN digital infrastructure.
   These digital infrastructures are still under development but they are integral part of network integration as envisaged by PI vision. They will contribute at achieving the attribute of network resilience (both in terms of capacity availability & handling unexpected operations disruptions) and also the enhanced economic, environmental & social efficiency of freight transport operations. CEF actions could improve at first stage the digital infrastructure of actors (companies, IMs, public authorities), and prepare them for the connection to these platforms at a later stage.
    a. Funding for the application of IoT sensors and ensuring full 5G coverage along the networks could assist seamless and real-time data exchange Ensure that all nodes and terminals and the environment of stakeholders around them are fully digitalized (from big inland terminals to smaller warehouses and logistics companies)
    b. Subsidies to compensate for the implementation costs. PI consists of a multitude of new technologies that all have implementation costs. Subsidies can compensate for these costs speeding up the implementation of PI.
    c. Ensuring the digital infrastructure that can enhance the development of the PI intelligent nodes.

5.2 Recommendations for HE

In the recommendation for HE we will include the R&D actions as well as actions that refer to better stakeholder engagement and improvement of stakeholder awareness. The actions referring to HE could be IA – Innovation Action aiming to achieve a TRL above 5, RIA- Research and Innovation Actions aiming to achieve a TRL less up to 5 and CSA- Communication and Stakeholder Engagement Actions.

- **Actions that refer to Big Data**:

Big data is a field that treats ways to analyze, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing application software. To ensure the transition to PI Big Data should be collected, analyzed and used to support new business models and innovative services according to the physical internet paradigm. They will also feed to digital twins, simulation, optimization and predictive models.

- Further development Big Data analysis and collection tools that refer only to T&L processes and business. **RIA**
- Investing in safe and secure data exchange technologies will increase the availability of transport data among supply chains. **IA**
- Further development and standardization of IoT technologies (sensors, etc.). **IA**
- Awareness of stakeholders on the importance of sharing data, build trust between stakeholders. **CSA**

- **Actions to promote Physical Internet:**

Further research on model, technologies and governance structure in order to create the PI open global logistics system founded on physical, digital, and operational interconnectivity, through encapsulation, interfaces and protocols.

- Research on the best information exchange protocols and further development of the data exchange protocol. **(IA ad RIA)**
- Research on the new business models developed under the PI paradigm. **IA**

- **Actions to improve governance and stakeholder engagement:**
  - Development of a detailed governance framework for the governance of the innovative technologies and the physical and digital integrated networks. Efficient and effective governance should be made a priority in an aim to ensure cooperation, data sharing and the inclusion of all businesses and stakeholders regardless their position in the market (not only big players) and their technological maturity. **(RIA and CSA)**
  - Train businesses and try to change their perception into valuing also the environmental benefits and not only the costs and potential benefits from some specific interventions. Fund and develop training programs for all actors to ensure that they efficiently share data abut they also protect the privacy of their customers data. **CSA**
  - Looking for solutions to build trust among stakeholders. Building trust with cannot be achieved fast but it is a long process. Research on trust models and processes should be conducted to ensure the inclusion of all the types of stakeholders **(RIA and CSA)**
- **Action towards Blockchain technologies and Smart Contracts:**
  - Developing transactional protocol that can be implemented throughout international logistic chains. **(RIA)**
  - Standardisation of digital documents. For a more efficient usage of smart contracts legal (custom) documents should be harmonized. When using the same (digital) format the roll out of smart contracts will be easier and research on how to deal with legal issues. Propose standardization of document exchange protocols**(RIA and IA)**
  - Improve the security of Blockchain technologies to provide safe data exchange through research in Blockchain related protocols. **(RIA and IA)**
  - International regulation on Blockchain technology. Propose and research a clear legal framework that will create a stable outlook for investors in Blockchain technology. **IA**
- **Actions towards the further development of AI and ML models.**

Within T&L processes, the application of intelligent algorithms (based on AI and ML) can be applied for predictive and optimisation purposes.

- Integration of the optimization models with predictive models which will assist the development of more accurate optimizations. **(RIA and IA)**
- Incorporate the optimization models to simulation models for a better representation of the optimized systems and real-time testing of scenarios and policies. Digital Twinning will provide users, planners and decision makers with representation of the systems and further assist real-time decisions and improvements in operation KPIS. **(RIA and IA)**
- Research to improve the current state-of-the-art in optimization and prediction techniques such as improvement of AI and ML algorithms. **RIA**
- Have a better tracking of goods. In order to use predictive models real-time, investments must be made in making transport data available in real-time. **RIA**
- Set up data-standards. Create a data-standard that allows all predictive models to use the same data without the need of adjustments. **IA**

- **Actions towards the uptake and further development of digital platforms.**
  - Research on the models, interoperability and data exchange issues that are related to these technologies. **RIA**
  - It is necessary to develop coordination mechanisms between the various stakeholders. Coordination is crucial to better understand their needs, processes and business models so that they are accurately represented in the developed models. Their assistance is crucial for the

identification of identifying the best possible KPIs that could inform their decision making**. (IA and CSA)**

- Large scale implementation of platforms in PI contexts require understanding of the needs of stakeholders but also their willingness to share know-how and their business data. DSS tools are data thirsty for micro-level and micro level data so data sharing is crucial for the optimal development of these systems. **RIA**
- International coordination from all the MS is important for platforms that could cover the entire EU that could cover the entire of Europe. Different levels of stakeholders but also different businesses can ensure that we deal with heterogeneity of actors in a satisfactory manner. Research and inclusion of SMES in order to improve their technological maturity is necessary. **RIA**
- Research on harmonization of processes and data exchange protocols is important for the development for the implementation of platforms especially on large scale. **(RIA and IA)**

5.3 Recommendations for DEP

The transition to the EGTN requires the existence of fast, robust and secure EU digital infrastructure on which T&L digital services can be developed. Specifically we point to the following three topics that can be included in the next DEP calls.

- **Actions for the improvement of Cloud Computing**: In transport, cloud computing enables the sharing on the local network and in real time of information relating to vehicle diagnostics, the load of goods being transported, the number of passengers, to improve the flow of information in the industry by enabling stakeholders to store more data on the fleet. It can also connect multiple partners along the supply chain and provide real-time visibility and monitoring of logistics processes and data. It is therefore necessary to provide the industry with fast, secure and robust Cloud Computing infrastructure.
- **Actions to improve cybersecurity**: It is crucial for all T&L related transport and systems to provide a secure interface for the exchange of data and the conduction of transaction between the various stakeholders. Platforms that connect company system must be secured from the threat of cyberattacks that could disturb the operations of companies and have serious negative impacts on the functioning of the global supply chains.
- **Improve the calculation abilities of computers.** Improving the processing time can lead to faster functioning optimization, predictive and simulation models. It can provide these models the ability to process more data in shorter time frames and effectively inform real-time logistics decisions.

6 Conclusions

The deliverable in hand synthesizes the digital technologies, infrastructural needs and governance interventions that had been investigated in WP1 and in the LLs. It evaluates their effect in the transition of TEN-Ts to EGTNs and develops a set of recommendation for the next funding calls in CEF and HE. We also provide short recommendations for the inclusion of T&L in the next DEP calls.

It builds upon the simulation models developed in WP1 and identifies which parts of the TEN-T network (mostly rail corridors, terminals and PEPs) which mostly be required to deal with the additional Eurasian traffic. Taking into account the various geopolitical scenarios developed within PLANET it prioritizes the infrastructural and digital needs that need to be addressed by the next CEF topics. An additional focus is given not only to hard infrastructural needs such as building an additional rail line or improving the equipment in specific terminals but it also proposes the adoption of softer measures (improvement of digitalisation, improvement of simulation and predictive models, collaboration and development of trusts between the stakeholders). Improvement of technological and governance structures for the transition of nodes to PI enabling nodes is in the center of PLANET EGTN vision and also of this deliverable.

In parallel it is evaluated the expected effect of disruptive technologies, applied an evaluation methodology to specify which technologies will have which effects and under which geopolitical scenarios and proposes guidelines for funding priorities in the next CEF and EU calls.

One specific part has been highlighted in almost all the deliverables and in the evaluation workshop is the importance proper governance. The infrastructural and digital integration of intra and exo- TEN-T networks and the transition towards a PI internet concept requires a great amount of information exchange between the various stakeholders. The PI is based on the physical and digital collaboration between different actors in the supply chain along the corridors, through sharing information and resources such as transport capacities or storage areas.Hence, development of the proper governance frameworks on which stakeholders will collaborate with which and which type of information will ensure the security of the exchanges data, should offer access to all type and stakeholders and is fundamental for building trust among the actors. The technological maturity for the development of PI is already here or can be assured but softer measures such as development of trust or the training of stakeholders are essential and require time and funds.

Recognition of design of digital infrastructures as counterpart to physical infrastructures requires even more explicitly the involvement of stakeholders of freight and person mobility. In addition, private and public investments in digital infrastructures are currently interwoven and require careful consideration of the public stake in developing and upholding digital connectivity.

During the project the offset of the war in Ukraine changed the diplomatic relationship between EU and Russia leading to an updated geopolitical situation different from the one in mind when the scenarios considered in PLANET were developed. In this deliverable we include a first analysis of the effect that the war had in Eurasian freight traffic especially the one that passes via Russia. We still make the assumption that by the end of the war the relationships between Russia, China and the EU will be reinstated. However, there is high uncertainty around the duration of the problems between the countries and it is possible that the relationships will worsen changing the geopolitical environment and the connection of the TEN-Ts with the rest of the world. In the meantime the increase in energy prices is accelerating the regionalisation of the economies and it is possible that part of production could be transferred to disadvantaged regions leading to the development of new production regions, new PEPs and even to the redesign of the TEN-T networks.

7 References

Dalmolen, S. et al., 2019. *Maintaining control over sensitive data in the Physical Internet: Towards an open, service oriented, network-model for infrastructural data sovereignty.* s.l., s.n.

European Comission, 2021. *Better Regulation Toolbox,* Brussels: European Comission.

Hasan, H. R. et al., 2021. Blockchain Architectures for Physical Internet: A Vision, Features, Requirements, and Applications. *IEEE Network,* Volume 35, pp. 174-181.

PLANET, 2020. *D2.4 EGTN IoT infrastructure final version ,* s.l.: PLANET .

PLANET, 2020. *D5.1 Stakeholder Analysis Report,* s.l.: PLANET.

PLANET, 2020. *Position Paper 2 - New Trade Routes,* s.l.: s.n.

PLANET, 2021 . *D2.1 Open EGTN Platform Architecture ,* s.l.: PLANET Consortium .

PLANET, 2021. *D 1.4 Simulation based impact of new trade routes v1,* s.l.: PLANET.

PLANET, 2021. *D2.9 Deliverable EGTN Support Services Based on Big Data and Analytic Models. ,* s.l.: PLANET.

PLANET, 2021. *Deliverable 1.4 Simulation based impact of new trade routes on TEN-Ts and disadvantaged regions,* s.l.: PLANET.

PLANET, 2021. *Deliverable 2.15 Integration and Interoperability of proprietary Blockchain Systems for Seamless Global Trade Workflows v1,* s.l.: PLANET.

PLANET, 2022. *PLANET contribution to TEN-T revision,* s.l.: PLANET.

Annex I: Validation workshop questionnaires

Task 4.1

Workshop 29/09/2022,

Name_____, Organisation:_____, E-mail:_____

Group A

Please state your level of agreement with the following evaluation of one of the interventions which are proposed by PLANET:

Technological interventions

1st intervention

Further improvement and application of Smart Contracts:

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	Medium
	Adaptive	High	Medium
Innovative	*Maturity*	Low	Medium
	Feasible implementation / Efficacy	High	Medium
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	High	Medium
	Economic impacts	High	Medium
	Time saving impacts	High	Low
Integrated	*Support intra- EU network integration*	Medium	Low
	Support exo- EU network integration	High	Low
Inclusive	*Disadvantaged region inclusion*	High	Low
	EU land cohesion	High	Low
	Stakeholder inclusion	High	Medium

Resources to be committed	*Cost related*	Low	High
	Stakeholders/ Governance related	Medium	Medium

1) Do you agree with the evaluation above? Yes/ No. (if you have comments you can also add them on the matrix)
    a. If **No** then please state why??_____
2) Which parameters do you think hinder the adoption of the above technology (please name maximum 3)
    a. _____
    b. _____
    c. _____
3) Which do funding mechanism do you think could be applied for the further implementation of the above technology? (You can also mention which hindering mechanisms can be funded by what?)
    a. **CEF**_____
    b. **HE**_____
    c. **DEP**_____

2nd intervention

Application of *Blockchain technologies and concepts* to shift towards the PI paradigm.

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	Medium
	Adaptive	High	Medium
Innovative	*Maturity*	Low	High
	Feasible implementation / Efficacy	Medium	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	High	Medium
	Economic impacts	High	Medium
	Time saving impacts	High	Low
Integrated	*Support intra- EU network integration*	Medium	Low

EGTN vision	Criteria	Scenario 1	Scenario 2
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	High	Low
	EU land cohesion	High	Low
	Stakeholder inclusion	High	Medium
Resources to be committed	*Cost related*	Low	High
	Stakeholders/ Governance related	Medium	Medium

1) Do you agree with the evaluation above? Yes/ No. (if you have comments you can also add them on the matrix)
    a. If **No** then please state why??_____
2) Which parameters do you think hinder the adoption of the above technology (please name maximum 3)
    a. _____
    b. _____
    c. _____
3) Which do funding mechanism do you think could be applied for the further implementation of the above technology? (You can also mention which hindering mechanisms can be funded by what?)
    a. **CEF**_____
    b. **HE**_____
    c. **DEP**_____

3rd intervention

Further development and application of Predictive Models (using either machine learning of Artificial Intelligence). For example, the models could include: 1) Prediction of vessel ETA in terminals, 2) Predictive logistics for Tasks and Resources – daily demand- in warehouses, 3) Demand for city logistics, etc.

EGTN vision	Criteria	Scenario 1	Scenario 2
Ge-economic aware	*Resilient*	High	Medium
	Adaptive	High	Medium
Innovative	*Maturity*	Medium	High

	Feasible implementation / Efficacy	Medium	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Medium	Medium
	Economic impacts	High	Low
	Time saving impacts	Medium	Low
Integrated	*Support intra- EU network integration*	Medium	Low
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	Medium	Low
	EU land cohesion	Medium	Low
	Stakeholder inclusion	Medium	Medium
Resources to be committed	*Cost related*	Medium	High
	Stakeholders/ Governance related	Medium	Medium

1) Do you agree with the evaluation above? Yes/ No. (if you have comments you can also add them on the matrix)
    a. If **No** then please state why??_____
2) Which parameters do you think hinder the adoption of the above technology (please name maximum 3)
    a. _____
    b. _____
    c. _____
3) Which do funding mechanism do you think could be applied for the further implementation of the above technology? (You can also mention which hindering mechanisms can be funded by what?)
    a. **CEF**_____
    b. **HE**_____
    c. **DEP**_____

4th Intervention

Further development and application of collaborative platforms such as the EGTN Planet Platform for the development of intelligent PI-enabled synchromodal nodes (interconnected regional logistics hubs & ecosystem approach) & PI corridors.

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	High
	Adaptive	High	High
Innovative	*Maturity*	Low	High
	Feasible implementation / Efficacy	Low	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Low	High
	Economic impacts	High	Low
	Time saving impacts	High	High
Integrated	*Support intra- EU network integration*	High	High
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	Medium	Low
	EU land cohesion	High	High
	Stakeholder inclusion	Medium	Medium
Resources to be committed	*Cost related*	High	High
	Stakeholders/ Governance related	High	High

1) Do you agree with the evaluation above? Yes/ No. (if you have comments you can also add them on the matrix)
    a. If **No** then please state why??_____

2) Which parameters do you think hinder the adoption of the above technology (please name maximum 3)
    a. _____
    b. _____
    c. _____
3) Which do funding mechanism do you think could be applied for the further implementation of the above technology? (You can also mention which hindering mechanisms can be funded by what?)
    a. **CEF**_____
    b. **HE**_____
    c. **DEP**_____

Governance Interventions

1st intervention

Increased **training of stakeholders** in order to be able to:

3) Apply new technologies
4) Adopt and improve collaborative platforms

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	High
	Adaptive	High	High
Innovative	*Maturity*	Low	High
	Feasible implementation / Efficacy	Low	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Low	High
	Economic impacts	High	Low
	Time saving impacts	High	High
Integrated	*Support intra- EU network integration*	High	High
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	High	High

	EU land cohesion	High	High
	Stakeholder inclusion	High	High
Resources to be committed	*Cost related*	Low	Low
	Stakeholders/ Governance related	High	High

1) Do you agree with the evaluation above? Yes/ No. (if you have comments you can also add them on the matrix)
    a. If **No** then please state why??_____
2) Which parameters do you think hinder the adoption of the above technology (please name maximum 3)
    a. _____
    b. _____
    c. _____
3) Which do funding mechanism do you think could be applied for the further implementation of the above technology? (You can also mention which hindering mechanisms can be funded by what?)
    a. **CEF**_____
    b. **HE**_____
    c. **DEP**_____

2nd Intervention

Development of **monitoring services**:

3) Ensure the implementation of legislation
4) Adjust and improve network operations in order to identify weak points and improve efficiency

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	High
	Adaptive	High	High
Innovative	*Maturity*	Medium	High
	Feasible implementation / Efficacy	Low	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Medium	Medium

	Economic impacts	High	Medium
	Time saving impacts	High	High
Integrated	*Support intra- EU network integration*	High	High
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	Medium	Medium
	EU land cohesion	High	High
	Stakeholder inclusion	High	High
Resources to be committed	*Cost related*	Medium	Medium
	Stakeholders/ Governance related	High	High

4) Do you agree with the evaluation above? Yes/ No. (if you have comments you can also add them on the matrix)
    a. If **No** then please state why??_____
5) Which parameters do you think hinder the adoption of the above technology (please name maximum 3)
    a. _____
    b. _____
    c. _____
6) Which do funding mechanism do you think could be applied for the further implementation of the above technology? (You can also mention which hindering mechanisms can be funded by what?)
    a. **CEF**_____
    b. **HE**_____
    c. **DEP**_____

Thank you for your participation!!!

Group B

Task 4.1

Workshop 29/09/2022,

Name_____, Organization: _____, E-mail:_____

Group B

Please state your level of agreement with the following evaluation of one of the interventions which are proposed by PLANET:

Technological interventions

1st intervention

Further improvement and application of **sensors** and IoT technologies :

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	Medium	High
	Adaptive	Low	Medium
Innovative	*Maturity*	High	Medium
	Feasible implementation / Efficacy	Medium	High
Impact	*Social impacts*	Low	High
	Environmental impacts	Low	High
	Economic impacts	High	Medium
	Time saving impacts	Medium	Low
Integrated	*Support intra- EU network integration*	Medium	High
	Support exo- EU network integration	High	Low
Inclusive	*Disadvantaged region inclusion*	Low	Medium
	EU land cohesion	Low	High

	Stakeholder inclusion	Low	Medium
Resources to be committed	*Cost related*	Low	Medium
	Stakeholders/ Governance related	Low	High

4) Do you agree with the evaluation above? Yes/ No. (if you have comments you can also add them on the matrix)
    a. If **No** then please state why??_____
5) Which parameters do you think hinder the adoption of the above technology (please name maximum 3)
    a. _____
    b. _____
    c. _____
6) Which do funding mechanism do you think could be applied for the further implementation of the above technology? (You can also mention which hindering mechanisms can be funded by what?)
    a. **CEF**_____
    b. **HE**_____
    c. **DEP**_____

2nd intervention

Further development and application of **Optimization Models** (using either machine learning of Artificial Intelligence). For example, the models could include: 1) Routing algorithms within terminals, 2) Optimization of scheduling in warehouses, 3) Routing algorithms for last-mile,4) Better planning of deliveries etc.

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	Medium
	Adaptive	High	Medium
Innovative	*Maturity*	Medium	High
	Feasible implementation / Efficacy	Medium	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Medium	Medium
	Economic impacts	High	Low
	Time saving impacts	Medium	Low

EGTN vision	Criteria	Scenario 1	Scenario 2
Integrated	*Support intra- EU network integration*	Medium	Low
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	Medium	Low
	EU land cohesion	Medium	Low
	Stakeholder inclusion	Medium	Medium
Resources to be committed	*Cost related*	Medium	High
	Stakeholders/ Governance related	Medium	Medium

4) Do you agree with the evaluation above? Yes/ No. (if you have comments you can also add them on the matrix)
    a. If **No** then please state why??_____
5) Which parameters do you think hinder the adoption of the above technology (please name maximum 3)
    a. _____
    b. _____
    c. _____
6) Which do funding mechanism do you think could be applied for the further implementation of the above technology? (You can also mention which hindering mechanisms can be funded by what?)
    a. **CEF**_____
    b. **HE**_____
    c. **DEP**_____

3rd intervention

Further development and application of **real-time Decision Support Systems** that could support real-time network and corridor visualizations, calculation of network and hub performance, calculation of what if scenarios for investments.

EGTN vision	Criteria	Scenario 1	Scenario 2
Ge-economic aware	*Resilient*	High	Medium
	Adaptive	High	Medium

Innovative	*Maturity*	Medium	High
	Feasible implementation / Efficacy	Medium	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Medium	Medium
	Economic impacts	High	High
	Time saving impacts	High	High
Integrated	*Support intra- EU network integration*	Medium	High
	Support exo- EU network integration	Low	High
Inclusive	*Disadvantaged region inclusion*	Medium	High
	EU land cohesion	Medium	High
	Stakeholder inclusion	Medium	High
Resources to be committed	*Cost related*	High	High
	Stakeholders/ Governance related	High	High

4) Do you agree with the evaluation above? Yes/ No. (if you have comments you can also add them on the matrix)
    a. If **No** then please state why??_____
5) Which parameters do you think hinder the adoption of the above technology (please name maximum 3)
    a. _____
    b. _____
    c. _____
6) Which do funding mechanism do you think could be applied for the further implementation of the above technology? (You can also mention which hindering mechanisms can be funded by what?)
    a. **CEF**_____
    b. **HE**_____
    c. **DEP**_____

4th Intervention

Further application of **digital documents and paperless** procedures:

EGTN vision	Criteria	Scenario 1	Scenario 2
Ge-economic aware	*Resilient*	High	Medium
	Adaptive	High	Medium
Innovative	*Maturity*	*Medium*	*High*
	Feasible implementation / Efficacy	Medium	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Medium	High
	Economic impacts	Medium	High
	Time saving impacts	Medium	High
Integrated	*Support intra- EU network integration*	High	High
	Support exo- EU network integration	High	Medium
Inclusive	*Disadvantaged region inclusion*	Medium	Low
	EU land cohesion	High	High
	Stakeholder inclusion	Medium	Medium
Resources to be committed	*Cost related*	High	Medium
	Stakeholders/ Governance related	High	High

4) Do you agree with the evaluation above? Yes/ No. (if you have comments you can also add them on the matrix)
    a. If **No** then please state why??_____

5) Which parameters do you think hinder the adoption of the above technology (please name maximum 3)
    a. _____
    b. _____
    c. _____
6) Which do funding mechanism do you think could be applied for the further implementation of the above technology? (You can also mention which hindering mechanisms can be funded by what?)
    a. **CEF**_____
    b. **HE**_____
    c. **DEP**_____

Governance Interventions

1st intervention

Development of **trust** between the stakeholders to exchange data with the platform **and increase awareness** on the existence of these platforms.

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	Medium	Medium
	Adaptive	Medium	Medium
Innovative	*Maturity*	Medium	Medium
	Feasible implementation / Efficacy	High	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Low	Low
	Economic impacts	Low	Low
	Time saving impacts	High	High
Integrated	*Support intra- EU network integration*	High	High
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	High	High
	EU land cohesion	High	High

	Stakeholder inclusion	High	High
Resources to be committed	*Cost related*	Low	Low
	Stakeholders/ Governance related	High	High

7) Do you agree with the evaluation above? Yes/ No. (if you have comments you can also add them on the matrix)
    a. If **No** then please state why??_____
8) Which parameters do you think hinder the adoption of the above technology (please name maximum 3)
    a. _____
    b. _____
    c. _____
9) Which do funding mechanism do you think could be applied for the further implementation of the above technology? (You can also mention which hindering mechanisms can be funded by what?)
    a. **CEF**_____
    b. **HE**_____
    c. **DEP**_____

2nd Intervention

Development of **business models** to further exploit the interventions/innovations proposed within PLANET:

EGTN vision	**Criteria**	**Scenario 1**	**Scenario 2**
Ge-economic aware	*Resilient*	High	High
	Adaptive	High	High
Innovative	*Maturity*	Low	Medium
	Feasible implementation / Efficacy	High	High
Impact	*Social impacts*	Medium	Medium
	Environmental impacts	Medium	Medium
	Economic impacts	High	High
	Time saving impacts	High	High

Integrated	*Support intra- EU network integration*	High	High
	Support exo- EU network integration	Medium	Low
Inclusive	*Disadvantaged region inclusion*	Medium	Medium
	EU land cohesion	High	High
	Stakeholder inclusion	High	High
Resources to be committed	*Cost related*	Low	Low
	Stakeholders/ Governance related	Medium	Medium

10) Do you agree with the evaluation above? Yes/ No. (if you have comments you can also add them on the matrix)
    a. If **No** then please state why??_____
11) Which parameters do you think hinder the adoption of the above technology (please name maximum 3)
    a. _____
    b. _____
    c. _____
12) Which do funding mechanism do you think could be applied for the further implementation of the above technology? (You can also mention which hindering mechanisms can be funded by what?)
    a. **CEF**_____
    b. **HE**_____
    c. **DEP**_____

Thank you for your participation!!!