

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

D3.10 EGTN impact assessment

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Glossary of terms and abbreviations used

Abbreviation / Term	Description
AHP	Analytic Hierarchy Process
BC	Blockchain
CO2	Carbon Dioxide
EGTN	European-Global Transport & Logistics Networks
GA	Grant Agreement
GUC	Generic Use Case
ICT	Information & Communication Technology
KPI	Key Performance Indicator
LL	Living Lab
LMD	Last Mile Deliveries
SC	Supply Chain
ST	Subtask
T	Task
TEN-T	Trans-European Transport Network
TEU	Twenty-foot Equivalent Unit
T&L	Transport & Logistics
WP	Work Package

1 Executive Summary

This deliverable presents the EGTN impact assessment considering Living Labs technical & operational, financial & business and environmental & social perspectives, as outlined in Task 3.4 of WP3. The methodological approach adopted includes defining the expected impact categories, identifying indicators and targets, collecting data and evaluating the impacts. The impact assessment approach is bottom-up, using a scoring system to assign numerical values to each indicator based on their performance in Baseline and TO-BE scenarios. The data collected includes measurements for 30 indicators, and indicator weights derived through a questionnaire addressed to relevant stakeholders. In total, 27 indicators had targets assigned to them, out of which 24 achieved them.

Stakeholders were asked to conduct pairwise comparisons on a scale of importance between 1 and 9 to determine the importance of impacts and indicator categories. The views of 27 stakeholders were taken into account to calculate the weights of the impact categories and indicators. The results show that stakeholders rated as the most important the 'Technical & Operational' impacts, the indicator of 'Operational Efficiency' within this impact category, the 'Total transport costs' in Financial & Business impacts and the 'CO2 emissions related to T&L operations' in the Environmental & Social impacts. The impact and indicator categories which were rated as least important by the same stakeholders are the 'Environmental & Social impacts', the 'Compliance costs' indicator in Financial & Business impacts, and 'Visibility of operations' as well as 'Interactions between SC stakeholders' in Technical & Operational impacts.

The performance of each indicator was measured as a percentage difference between the baseline and to-be scenarios. The overall performance of the indicators is observed to have increased on average by 44.4%, with the Environmental & Social impacts category contributing the most to the overall performance. With respect to specific indicator categories, the solutions implemented in the LLs had a significant impact on the potential increase of the share of rail, the visibility of operations as well as the customer satisfaction with the services provided. Overall, the technological solutions developed in the project had a positive impact on 29 out of 30 indicators, ranging from 11% to 107% percentage increase when comparing the Baseline and TO-BE measurements.

2 Introduction

The aim of this Deliverable is to develop an overall EGTN impact assessment considering the impacts of all 3 Living Labs (LLs) and the Generic Use Case (GUC), following the application of the solutions developed within PLANET. The various impacts fall in three major categories: technical & operational, financial & business and environmental & social perspectives and KPIs are categorized accordingly. In order to facilitate the assessment, the following key phases are identified:

1. Define the expected impacts of Living Labs across the three main categories (e.g. technical performance, cost efficiency, CO2 reduction).
2. Determine the KPIs that fall in each impact category across Living Labs and the Generic Use Case.
3. Perform EGTN scenario impact assessment validating the impact of the innovation of the technologies developed, based on the KPI measurements.
4. Assess the outcome and identify areas of improvements and next steps.

2.1 Mapping PLANET Outputs

The following Table 1 presents the Grant Agreement commitments, both within the formal Deliverable and Task description, against the project's respective outputs and work performed in the context of this Deliverable. The respective Chapters within this report are also presented together with a short description of their content.

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

PLANET GA Component Title	PLANET GA Component Outline	Respective Document Chapter(s)	Justification
DELIVERABLE			
D3.10 EGTN impact assessment	An overall EGTN impact assessment will be consolidated considering Living Labs technical & operational, financial & business and	Chapter 5	Chapter 5 presents the analysis of the results and the overall performance of the indicators measured across technical & operational, financial & business

	environmental & social perspectives.		and environmental & social impact categories.
TASKS			
T3.4 Generic Use Case and EGTN Impact Assessment / ST3.4.3 EGTN impact assessment	An overall EGTN impact assessment will be carried out and will include the following categories: (i) technical/operational impacts, focusing on issues of technical performance and user acceptance; (ii) financial & business impacts, focusing on issues of quality improvements and cost efficiencies achieved in day-to-day operations; organisational issues, and wider changes in the way the various LL stakeholders operate and cooperate; (iii) economic & social impacts, focusing on issues such as congestion, accidents, air & noise pollution and climate change.	Chapter 3, 4 and 5	Chapter 3 outlines the 6-step methodology (adapted from FENIX) for the evaluation of the LLs & GUC results which include KPIs measured for a Baseline and TO-BE scenarios covering the 3 categories of impacts (technical & operational, financial & business and environmental & social). Chapter 4 presents the data collected and the actual measurements of the KPIs and Chapter 5 elaborates on the findings of the impact assessment across the 3 impact categories.

2.2 Deliverable Overview and Report Structure

Table 2 below summarises the interrelations between different work packages (WP) and the EGTN impact assessment presented in this Deliverable. As shown at the last column of the Table, the output of various Deliverables within WP1 and WP3 was used for the KPI specification.

Table 2: Interrelations between WPs and the EGTN impact assessment

Work Package	Task/Subtask	Relevance to EGTN impact assessment	Deliverable
WP1	T1.1/ST1.1.2	Scenario analysis will use: long-term demand forecasting; analysis and selection of technological alternatives; assessment of new transport infrastructure requirements ; strategic, non-monetary factors, plus robustness and feasibility for each scenario. The scenarios will incorporate the targeted KPI improvements for transport cost, reliability and emissions .	Deliverable 1.3 Modelling & Simulation Capability final version
	T1.4/ST1.4.2	Impact assessment of T&L and ICT innovation technologies will apply the quantitative models to EGTN simulation scenarios to establish a comparative evaluation of potential benefits from innovations considered (autonomous vehicles, warehousing automation, advances in Sensors, IoT, Blockchain, 3D printing for some product types, hyperloop) and to define the factors affecting their selection in EGTN corridors.	Deliverable 1.8 Simulation-based analysis of T&L and ICT innovation technologies
WP3	T3.3/ST3.3.1	This subtask will provide among others '(vi) the related KPIs for evaluation; (vii) the expected results and (viii) specification of surveys from LL actors to ascertain impact KPIs as specified in section 2.1'	Deliverables 3.1, 3.3, 3.5 on LLs Specifications and Baseline measurements & Deliverable 3.7 EGTN Generic use case

The overall structure of this Deliverable is outlined as follows:

- **Chapter 1** presents the summary of the report including the purpose of the work carried out and the main conclusions;

- **Chapter 2** includes an introduction of the Deliverable summarising the objectives of the Deliverable, how are these relevant with the overall project, and what was the approach followed in order to achieve them.
- **Chapter 3** outlines the overall approach to the impact assessment, presenting the impact categories (technical & operational impacts, financial & business impacts, environmental & social impacts), the assessment process phases, data sources and implementation method. The KPIs as suggested in the relevant Deliverables are reviewed and the final list of KPIs is formulated for the Baseline and TO-BE scenarios together with the respective targets. The approach to collect indicator weights is presented which is based on the AHP method and pairwise comparisons through a questionnaire addressed to stakeholders.
- **Chapter 4** presents the progress of all KPIs with respect to their targets. Moreover, the responses to the questionnaire are discussed and the indicator weights are derived based on the stakeholder views that participated to the questionnaire.
- **Chapter 5** includes the analysis of the results of the KPI measurements for all 3 Living Labs. The overall performance per indicator as well per impact category is also discussed, with respect to the three category impacts.
- **Chapter 6** concludes the report and summarises the outputs. Next steps and potential future improvements are also discussed.
- **Chapter 7** includes all references used in the deliverable.

3 Impact assessment approach

The methodological approach adopted for the EGTN impact assessment unfolds over 6 steps as outlined in Figure 1 below. The process is adopted from the FENIX evaluation framework [1], adjusted to fit the scope of the PLANET solutions developed and the KPIs measured in LLs and the GUC. Steps 1-4 of the 6-step methodology refer to horizontal processes that gather information and data, Step 5 is applied collectively to determine the outcome of the implemented solutions, and Step 6 proves the impact of the solutions applied in all LLs and the GUC. The following subchapters 3.1-3.3 describe and present each one of the 6 steps in more detail.

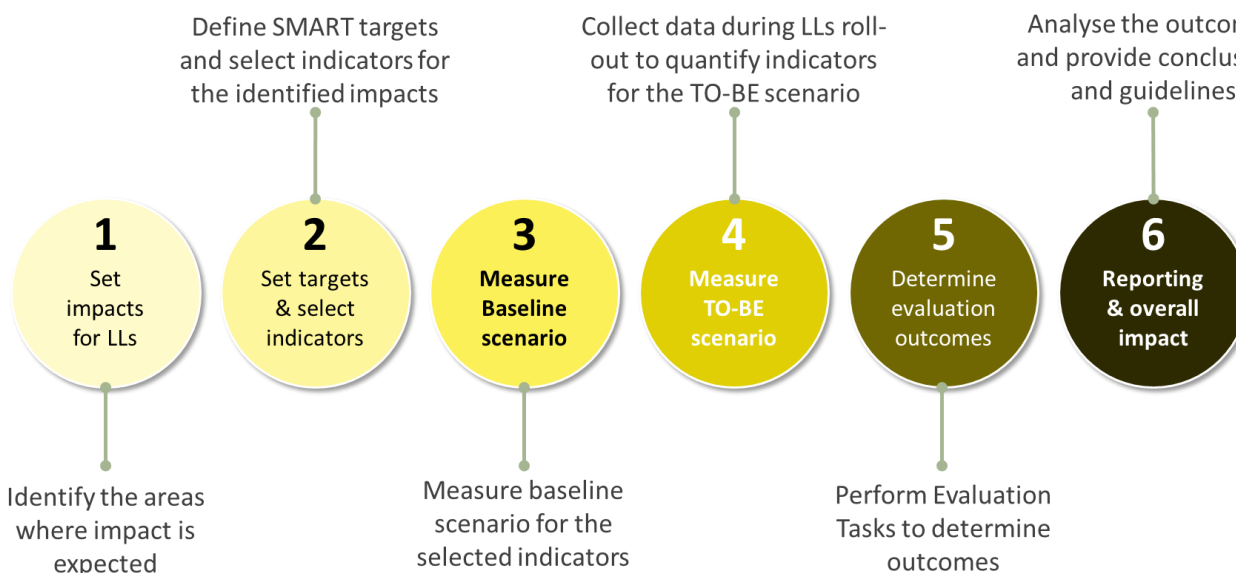


Figure 1: The 6-step impact assessment process, adapted from FENIX [1]

The impact assessment process defines “what” needs to be evaluated, “how” it is evaluated and “who” implements the evaluation. It outlines the evaluation objectives, and the required key performance indicators and measurements from LL data. In addition, it presents the impact categories that are used as a basis to categorise the relevant performance indicators and defines the structure for developing them, i.e. the logical order and responsibilities. Finally, the impact assessment process presents and analyses findings, and extracts useful conclusions.

3.1 Expected Impacts

In alignment with the description of Subtask 3.4.3, the EGTN impact assessment is carried out based on the three impact categories specified, adjusted to fit the concept and definition of the expected impacts and measured KPIs in all LLs and the GUC (**Step 1**). The expected impact categories, together with the specific impacts are presented in the following Table 3.

Table 3: Expected Impact Categories and Specific Impacts

#	Expected Impact Categories	Specific impacts on LLs and GUC
1	Technical & operational impacts, focusing on issues of technical and operational performance (Only for Living Labs)	Increase operational efficiency (time)
		Optimize end-to-end transport service improving transport service levels and volume of products
		Decrease disruption of the Supply Chain process
		Increase collaboration with other stakeholders and reduce redundant data transactions
		Improve forecasting, planning and rerouting maritime/inland/LMD transport decisions
		Increase visibility along the whole supply chain and of the spare capacity by having access to real time data
2	Financial & business impacts, focusing on issues of quality improvements and cost efficiencies achieved in day-to-day operations; organisational issues, and wider changes in the way the various LL stakeholders operate and cooperate	Reduce transport costs and costs of paper-based processes
		Reduce logistics costs by increasing orders fulfilled through blockchain
		Reduce operational costs
		Increase share of rail
		Reduce compliance costs associated with time spent at customs
3	Environmental & social impacts, focusing on issues such as user acceptance, air pollution and climate change	Reduce CO2 emissions
		Improve customer experiences by bringing trust, transparency and collaboration

The expected impact categories and specific impacts refer to the result anticipated following the implementation of the technological solutions in all 3 LLs and the GUC, apart from the first impact category regarding ‘Technical & operational impacts’ which is only relevant for the LLs.

3.2 Indicators and targets for all LLs and the GUC

For each one of the expected impact areas, one or more indicators are identified (**Step 2**); indicators that reflect and are able to quantify the respective impact. Furthermore, the targets to be met are specified for each indicator, which derive either from the project objectives as described in the Grant Agreement or the expected impacts of LLs and the GUC. The target-setting allows for data comparison and enables tracking of any progress towards meeting goals and achieving results. The targets were specified based on the SMART criteria [2]:

- **Specific** – targeted to a specific area for improvement
- **Measurable** – quantified indicators of progress
- **Achievable** – realistic and attainable
- **Relevant** – aligned with results that can realistically be achieved given available resources
- **Timebound** – related to specific dates when results can be achieved

The list of indicators, including targets and units of measurements, were determined for LL1, LL2, LL3 and the GUC in Deliverables 3.2, 3.4, 3.6 and 3.9 respectively. A collective overview of the indicators and the correspondence with the expected impact category for each one of them is presented in Table 4 below. Furthermore, similar indicators were grouped into the same indicator category as those presented in column 2.

Table 4: Indicators, units, targets for each impact category and test area

Impact Category	Indicator category	Description of indicator	Unit	Target	Simulation/Real Case / Not Tested	LL/GUC
Technical & operational impacts	Operational efficiency	Delivery time reduction	minutes	7% reduction	S	LL1
		Delivery lead time in inland transport	days	10% reduction	S	LL1
	Volume of products	Quantities of products, expressed in	deliveries per month	>8% increase	S	LL3

		pieces/packages/pallets, that can potentially be processed through logistics operations in the SC	deliveries per month		R	LL3	
	Disruptions of the Supply Chain	Availability of unloading slots	% available unloading slots	>15% increase	S	LL3	
		In the hiring process in the spot market for specific vehicle	minutes	7% reduction	S	LL1	
	Interactions between supply chain stakeholders	Time stakeholders interact with each other	days	20% reduction	S	LL1	
		Speed of collaboration decisions -automation in routing decisions	minutes	20% increase	S	LL1	
	Visibility of operations	End to end visibility	% of container route	>50% increase	R	LL3	
		Visibility of the spare capacity > speed of inventories	yes/no	Full visibility	S	LL1	
		Access to temperature, humidity, bump, gate opening and tracking information	yes/no	Real time access	R	LL1	
	Financial & business impacts	Transport orders fulfilled through BC	Orders fulfilled through BC	orders	5% use of BC	NT	LL1
		Rail increase	Number of transport orders shifted to rail	% orders	15% increase	S	LL1
Rail share			%	N/A	S	GUC	

	Total transport costs	Transport cost	euro	10% reduction	S	LL1	
		Transportation cost per container	euro	N/A	S	GUC	
	Compliance costs	Customs clearance costs	euro	>10%	R	LL2	
		Working time of the Customs Agency	minutes	>10% reduction	S	LL3	
		Working time of the Customs Office	minutes		S	LL3	
	Operational costs	Operational costs associated to the use of resources	workers	3% reduction	S	LL1	
		Total monthly working time	hours / month	10% reduction	S	LL3	
		Total monthly working time	hours / month		R	LL3	
		Cost of paper-based processes	euro	15% reduction	S	LL1	
		Operating costs in transport and logistics	euro	7% reduction	S	LL1	
	Environmental & social impacts	CO2 emissions related to transport and logistics operations	Total emissions	t/CO2eq	15 % reduction	S	LL1
			CO2 emissions per container	t/CO2	N/A	S	GUC
			CO2 emissions related to transport and logistics operations	Kg	15% reduction	S	LL1
			Transports planned in the most efficient way (No need for reshipment)	trips	20% increase	S	LL3

	Customer satisfaction / experience	Ratio of disputes	% disputes	10% reduction	R	LL1
		Customer experience	survey points	Qualitative increase	R	LL1
		Significant or optimal usefulness with current and potential services	% satisfied	>15% increase	R	LL3

For each indicator, the table provides a description of the indicator, its unit of measurement, a target value, whether it has been simulated (S), tested in a real case scenario (R) or not tested at all (NT), and which LL or GUC the indicator refers to. It is noted that the indicators presented in this table are considered Key Performance Indicators (KPIs) since they are key indicators or they have a significant effect on the expected impacts [3].

Out of 11 indicator categories as those presented in Table 4 below, 7 include indicators measured by two different LLs or one LL and the GUC. Only 3 indicator categories are represented by measurements taken by one LL, which are all in 'Technical & operational impacts'. This is reasonable and most likely to happen, since the GUC assessment is excluded by this impact category. Lastly, the 'CO2 emissions related to T&L operations' is the only indicator category that presents measurement from 3 different LLs/GUC.

The assessment process follows two phases, as the KPI values are measured in two time periods for all LLs and the GUC; before and after the implementation of the technological solutions (**Step 3 & Step 4**).

For the development of the KPIs included in each impact category, the following guidelines were considered:

- The 'Product Quality Model' and the 'Quality in Use Model' of ISO/IEC 25010 [4] for assessing the Technical & Operational impacts of the LLs; although these models refer to the evaluation of software products, some of the indicators suggested (e.g. performance efficiency, reliability) were deemed relevant for the current assessment.
- The results of DG MOVE's Handbook on External Costs of Transport [5] were used as an inspiration for assessing the environmental impacts of the LLs and the GUC, in particular for the formulation of the 'CO2 emissions related to T&L operations' indicator.

It is noted that the Guide to CBA of Investment Projects [6] for the assessment of the Financial & Business aspects of the LLs and the GUC, were used only for the purpose of identifying suitable KPIs. This methodology was not adopted for the overall EGTN impact assessment, since monetary values were not calculated, hence making this methodology non applicable.

3.3 Methodological approach

The impact assessment (**Step 5**) of the EGTN technological solutions developed and applied in LLs and the GUC follows a bottom-up approach, meaning that indicators were selected according to the specific needs and requirements of the LLs, having the targets already established. Given the context and goals of the evaluation, a scoring system is applied, assigning numerical values to each indicator based on their performance, which is measured as the difference between the Baseline (AS-IS) and TO-BE scenarios. An overall score can be then derived for each impact category, a specific LL or collectively for all indicators. This approach is suitable as numerical values are collected for all indicators, and a quantitative assessment of the performance is desired.

To incorporate both the AS-IS and TO-BE scenarios in the impact assessment, a comparative approach is adopted with 5 main steps as described below:

1. Each indicator value is normalised to a common scale, adjusting values measured on different scales to a common one, to allow for comparison of the performance of each indicator between the AS-IS and TO-BE scenarios and across the impact categories and/or LLs and the GUC;
2. The difference between the AS-IS and TO-BE measurements for each indicator is calculated, to understand the magnitude and direction of the change. The difference is calculated in absolute terms to account for the fact that some targets are aiming for a value increase while others for a decrease;
3. A weight to each indicator is assigned based on the views of stakeholders. This step is performed with an AHP based approach, and the implementation of a survey to collect weights following a pairwise comparison among all indicators and impact categories (more details are provided in section 3.3.1 below);
4. An overall weighted score is calculated for all indicators, as well as for each impact category using the normalised indicator measurements and weights;
5. Identify areas of improvement and best performances among indicators and impact categories based on the magnitude of the change and the stakeholder priorities.

It is noted that it is not within the scope of this impact assessment to compare the performance between LLs and the GUC, therefore separate scores per LL or the GUC are not calculated. In addition, this approach can be supplemented by others such as benchmarking, qualitative assessments or cost-benefit analysis, given that more data is collected.

3.3.1 Determination of indicator weights

The approach to calculate indicator weights is based on the Analytic Hierarchy Process (AHP), by following a pairwise comparison of the 3 impact categories and 12 indicators by stakeholder views on a scale from 1 to 9.

The scale is designed to capture the relative importance of one criterion or alternative compared to another (in this case indicators), with 1 representing equal importance and 9 representing absolute importance as shown at Table 5 below [7].

Table 5: Saaty's 1-9 scale for AHP

Scale of importance	Definition
1	Equally importance
2	Slightly more important
3	Moderately more important
4	Strongly more important
5	Very strongly more important
6	Extremely more important
7	Demonstrably more important
8	Decidedly more important
9	Absolutely more important

The AHP allows the calculation of indicator weights by determining the actual priority of each criterion through a pairwise comparison matrix, which represents the relative importance of each indicator based on judgments of stakeholders. The steps to calculate the indicator weights using pairwise comparisons are as follows [8] [9]:

1. A pairwise comparison matrix is constructed that shows the relative importance of each criterion compared to each other criterion. In this case, a matrix is constructed for the indicators of each impact category (5x5, 5x5, 2x2) as well as one that compares the impact categories (3x3), where each cell (i, j) represents the relative importance of indicator i compared to indicator j. The matrix is symmetrical, so that when indicator i is more important than indicator j, then the reciprocal cell (j, i) shows that indicator j is less important than indicator i.
2. Each matrix table represents the average of all stakeholder ratings for all indicators.
3. For each matrix table, the geometric mean of each row is calculated.

4. The next step is to normalise the resulting new column of the pairwise comparison matrix, by dividing each calculated geometric mean with the sum of the column.
5. The resulting final column which sums into 1, shows the normalised weights for each row, corresponding to each impact and indicator category.

The findings of the implementation of the approach described in this chapter are outlined in chapter 5 which presents an analysis of the results and the overall performance of the technological solutions developed with respect to the indicator and impact categories (**Step 6**).

4 Data collection

The impact assessment of the EGTN technological solutions consists of two main datasets; the measurements of the indicators for the AS-IS and TO-BE scenarios and the indicator weights which were derived through a questionnaire addressed to relevant stakeholders.

4.1 Indicator values for Baseline and TO_BE scenarios

The measurements for all indicators were collected for LL1, LL2, LL3 and the GUC as those presented in Deliverables 3.2, 3.4, 3.6 and 3.9 respectively. Annex I: Indicators, targets, values and progress includes a table with all indicator values together with the level of achievement for all the targets set.

For those indicators that were measured as 'yes' or 'no', a value of 1 and 0 was assigned respectively. Furthermore, the qualitative indicators related to customer satisfaction were measured by adding the responses with a positive element on the survey scale given to participants (e.g. significant or optimal, medium or high importance). The indicators that were not measured were excluded from the final list of indicators. It is noted that for all indicator categories, there was at least one indicator measured, which allows for an impact assessment across all impact and indicator categories.

A summary of the findings regarding the indicator values and their targets is provided in Figure 2 below. In total 27 indicators have targets assigned to them, since for the 3 indicators of the GUC no targets were set. As shown at Figure 2 above, 24 indicators achieved their target. Only for 3 out of the 27 indicators measured, the result following the implementation of the technological solutions was below their target.

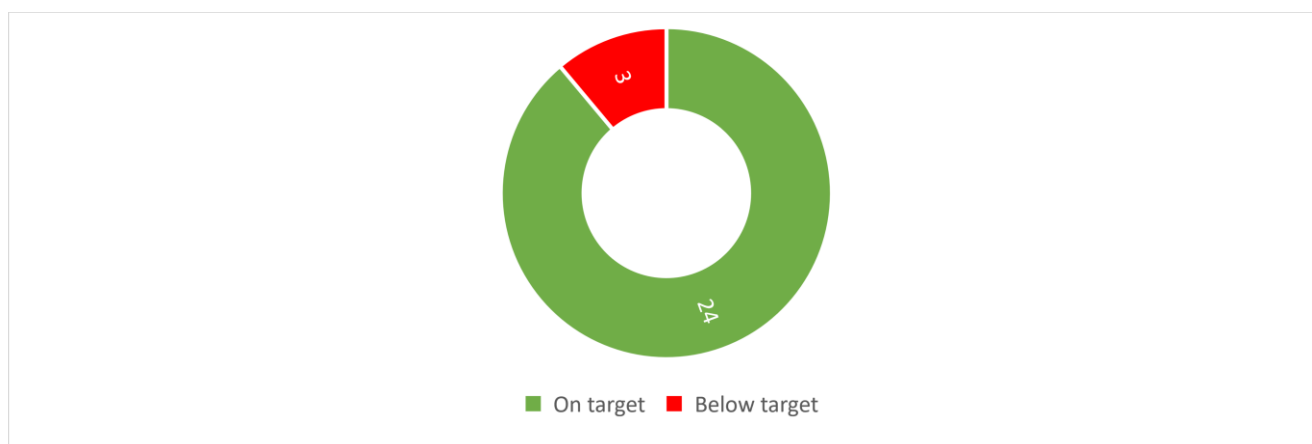


Figure 2: Overview of the achievement of indicator targets

Nevertheless, the progress of all those 3 indicators was in the right direction and in fact, in most of the cases, very close to the initial target set (Figure 3). A possible explanation of this result may be that the target was not realistic in some of the cases, or that further considerations should be taken into account to improve the performance of some of the indicators, in particular ‘Customer satisfaction’ in relation to the usefulness with current and potential services which presented more than 5% distance from the initial target set.

Most of the indicators exceeded by far their initial targets set, with 13 indicators surpassing their target by more than 5% compared to the initial value. Another 7 indicators exceeded their target by up to 5% and 4 indicators achieved their target on the exact percentage set. For the 3 indicators that didn’t achieve their target, as elaborated previously, their performance was still close (up to 5% difference) to their initial target.

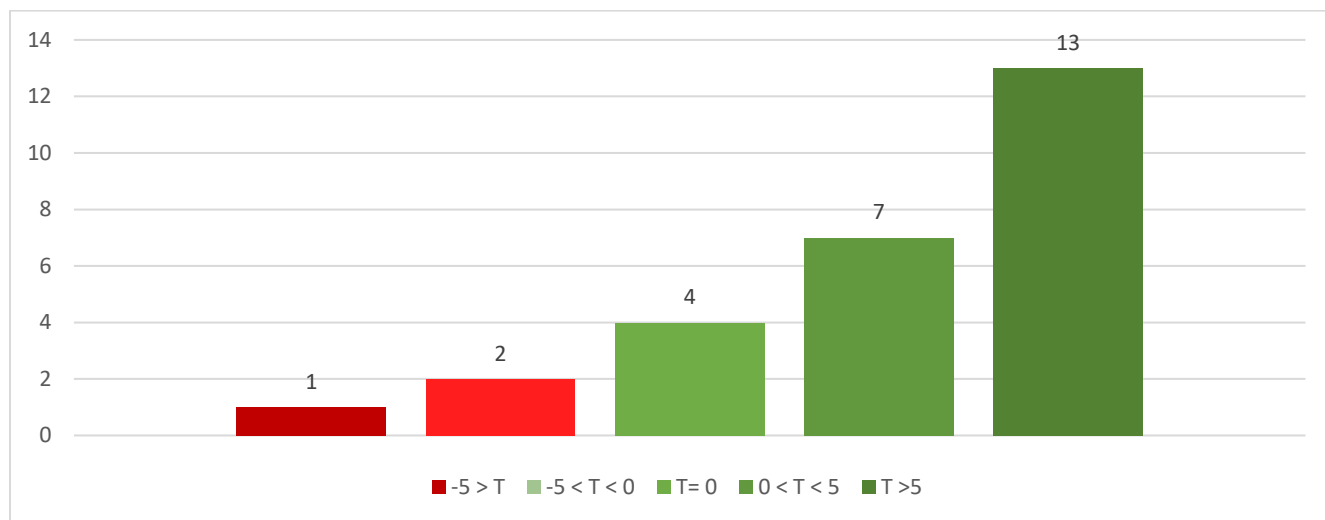


Figure 3: Percentage distance from targets (T)

4.2 Questionnaire for indicator weight calculation

To determine the importance of impacts and indicator categories, the views of stakeholders was sought through an online questionnaire.

Stakeholders' views are critical for determining the importance of indicators measuring the performance of technological solutions as they bring diverse perspectives, enhance decision-making, ensure user-centricity, promote accountability and transparency, and enable continuous improvement. By taking into account stakeholders' views, the technological solutions developed can be more effective and impactful. Each stakeholder involved in the project and the Living Labs, was willing to participate in this evaluation process, with effective communication and coordination of actions, achieving as a result the development of technological

solutions which had a great positive impact on the operation of EGTN, as presented later in chapter 5: Analysis of Results.

When stakeholders are involved in the evaluation process, they are more likely to have a sense of ownership and accountability for the outcomes [10]. This, in turn, enhances transparency, trust, and legitimacy of the evaluation process. Stakeholders' input can help identify areas for improvement, as well as strengths and weaknesses of the solutions tested in this context. This information can be used to improve organisational performance, increase efficiency, and reduce risks. The collection of data, knowledge exchange and high share in the participation to the questionnaire used for the development of EGTN impact assessment, were crucial for the success of its outcome.

Stakeholders were asked to conduct pairwise comparisons on a scale of importance between 1 and 9 (as presented in section 3.3.1) between the 3 impact categories and 12 indicator categories. The numerical values of the importance scale of indicators were not shown to stakeholders who provided their response. Not showing numerical values of importance scale can help avoid bias by promoting independent assessment and encourage a qualitative assessment based on stakeholders' expertise and understanding. In addition, respondents were asked to select the stakeholder category that represents them and specify the years of their experience. A copy of the questionnaire is provided in Annex II: Questionnaire.

The 24 pairwise comparisons were distributed in 3 sections, and participants provided a response by sliding a bar towards the most important indicator or impact category for each pair. It was deemed appropriate not to implement pairwise comparisons among all 30 indicators, since this would result in 435 iterations which would be inconvenient for respondents. Therefore, indicator categories were chosen instead, grouping similar indicators together. Indicator categories were only compared within the same impact category, since the number of pairwise comparisons necessary for this assessment would be 55, making the questionnaire too long, and risking the participation ratio.

The link to the questionnaire was shared via email only to stakeholders familiar or involved with the Transport and Logistics sector. The questionnaire was circulated to project partners and a number of selected colleagues, ensuring respondents are all qualified and knowledgeable of the questionnaire scope and content. In total, 31 responses were gathered out of which 24 were complete and valid. For the purpose of indicator weight calculations, 25 responses are taken into account, since one of the incomplete questionnaires was actually filled in apart from the last voluntary question which was open for comments. Another 2 responses were considered, so in total 27 responses, for the calculation of weights for the 3 impact categories only, since these questions were completed. Responses were gathered over a period of 3 days; 3-5 of May 2023.

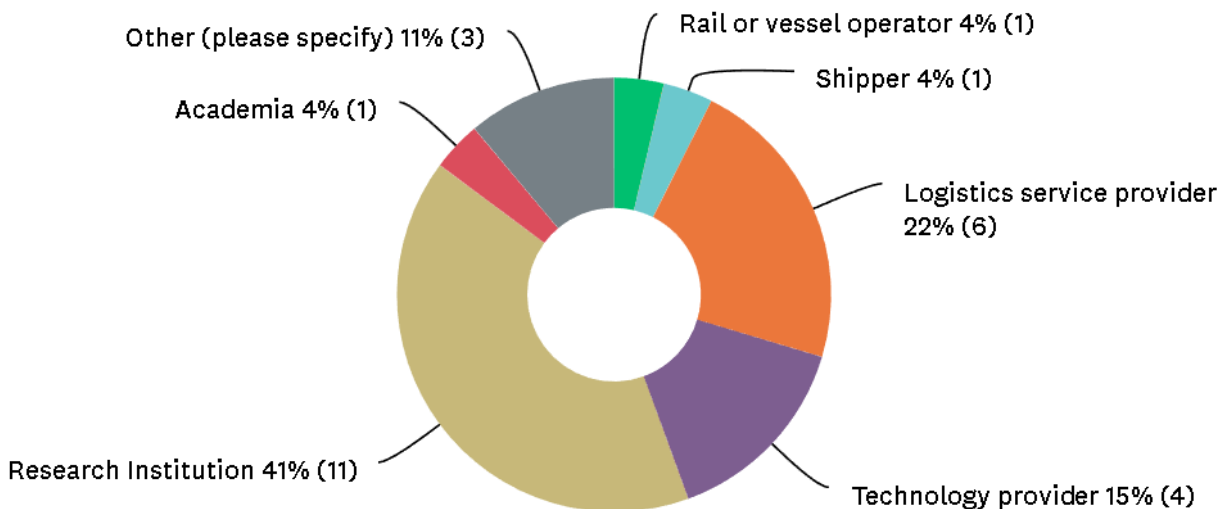


Figure 4: Participants of the questionnaire

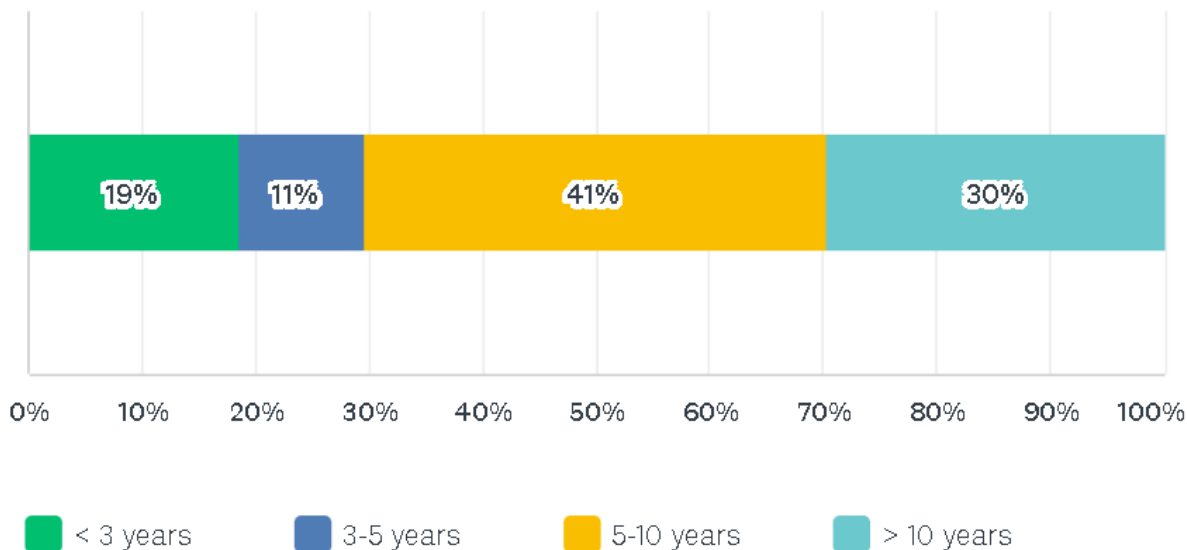


Figure 5: Participants' years of experience

Figure 4 and Figure 5 above, show the category of stakeholders and the years of experience in the sector they are working for. Most of the respondents work for a research institution (11), are logistics service providers (6) or technology providers (4). Furthermore, the majority of respondents have more than 5 years of experience, while 8 of the respondents have more than 10 years of experience in the sector they are now working for.

Following the review of the 24 pairwise comparisons conducted from the 27 stakeholders that completed the questionnaire, the weights of the impact categories and indicators are calculated as shown at the matrix Tables 6-9 below. The calculation of weights was implemented following the steps described in section 3.3.1, which was assisted by an online calculation tool [11]. The pairwise comparisons are all consistent since the consistency ratio as shown under each table (*C.I.) was less than 0.1 for all 4 matrix tables.

Table 6: Calculation of impact category weights

Impact categories	Technical & operational impacts	Financial & business impacts	Environmental & social impacts	Weights
Technical & operational impacts	1	2.20	1.99	0.50
Financial & business impacts	0.46	1	2.46	0.32
Environmental & social impacts	0.50	0.41	1	0.18

*C.I.=0.0560

Table 7: Calculation of 'Technical & operational impacts' indicators weights

Indicators in 'Technical & operational impacts' category	Operational efficiency	Volume of products	Disruptions of the SC	Interactions between SC stakeholders	Visibility of operations	Weights
Operational efficiency	1	3.38	2.12	3.08	2.44	0.39
Volume of products	0.30	1	1.61	2.16	1.55	0.20
Disruptions of the SC	0.47	0.62	1	2.85	1.77	0.19
Interactions between SC stakeholders	0.32	0.46	0.35	1	1.86	0.11
Visibility of operations	0.41	0.64	0.57	0.54	1	0.11

*C.I.=0.0679

Table 8: Calculation of 'Financial & business impacts' indicators weights

Indicators in 'Financial & business impacts' category excluding 'Transport orders fulfilled through BC'	Rail increase	Total transport costs	Compliance costs	Operational costs	Weights
Rail increase	1	1.49	2.07	1.32	0.33

Total transport costs	0.67	1	4.06	2.80	0.38
Compliance costs	0.48	0.25	1	0.88	0.13
Operational costs	0.76	0.36	1.13	1	0.17

*C.I.=0.0564

Table 9: Calculation of 'Environmental & social impacts' indicators weights

Indicators in 'Environmental & social impacts' category	CO2 emissions related to T&L operations	Customer satisfaction	Weights
CO2 emissions related to T&L operations	1	2.02	0.67
Customer satisfaction	0.49	1	0.33

*C.I.=0

A pairwise comparison matrix is constructed that shows the relative importance of each indicator compared to each other indicator (Tables 7-9); one 5x5 matrix table for the indicators in 'Technical & operational impacts' category, one 4x4 matrix table for the indicators in 'Financial & business impacts' category excluding 'Transport orders fulfilled through BC' which was not measured, and one 2x2 matrix table for those in 'Environmental & social impacts' category. Similarly, a 3x3 matrix table is constructed for the calculation of the relative importance of each impact category (Table 6).

Each matrix table represents the average of all stakeholder ratings for all indicator and impact categories. For each matrix table, the geometric mean of each row is calculated, and the new column is normalised by dividing each calculated geometric mean with the sum of the column. The resulting final column which sums into 1, shows the normalised weights for each row, corresponding to each impact and indicator category.

Figure 6 below illustrates all impact and indicator category weights, based on the views of stakeholders who answered the questionnaire (red text). For comparative purposes, equal weights were also assigned to the 3 impact categories and the 11 indicator categories included in each one of them, illustrated with gray text in the same figure. The application of equal weighting, assumes that each indicator category of the same impact category has equal importance. In the same manner, all three impact categories share equal weights assuming equal importance towards achieving EGTN impact assessment. In both cases, the weights within each impact category, as well as the weights of the three impact categories sum into 1.

The indicators that were not measured were excluded from the assessment and a weight of '0' was assigned to them, therefore not being accounted for in the final calculation of results. In particular, since the 'Transport orders fulfilled through BC' indicator was not measured, the weights were recalculated once it was removed from the overall assessment.

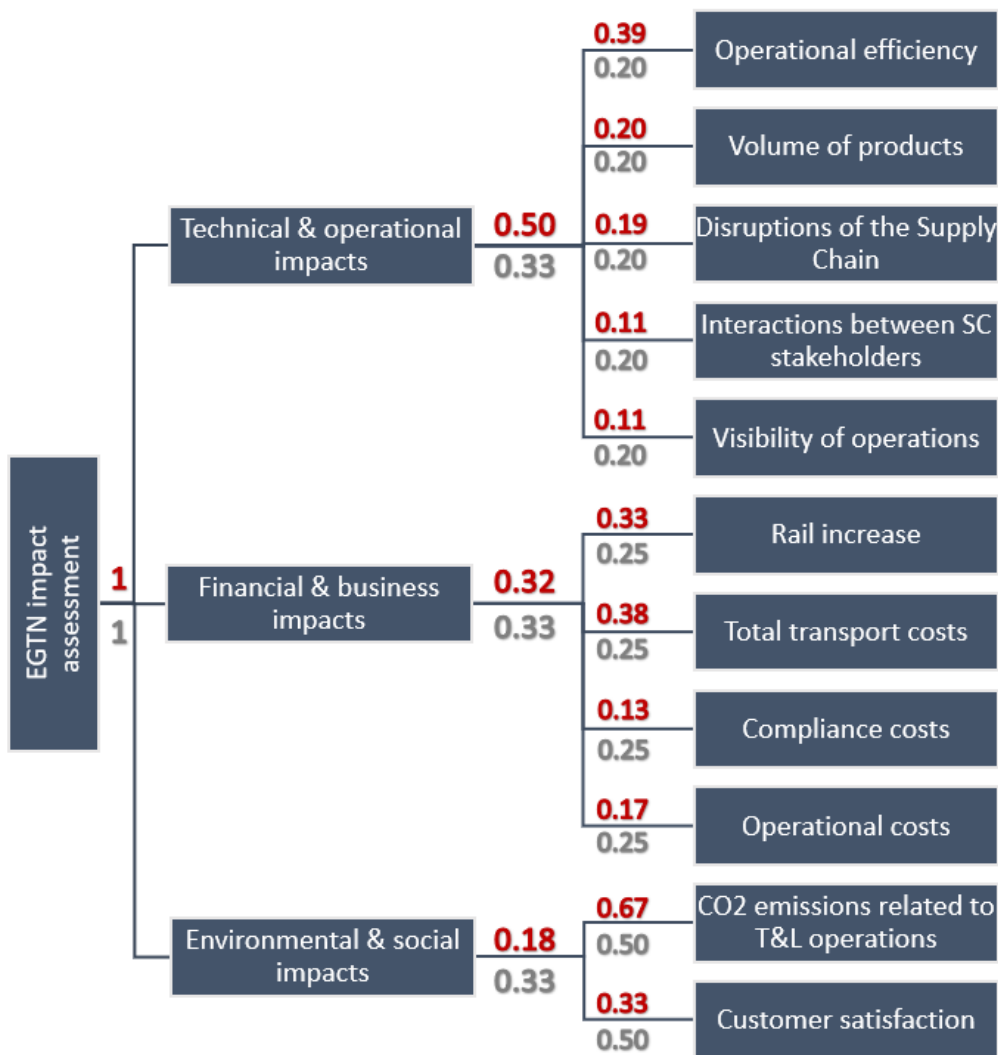


Figure 6: Calculated weights (red) & equal weights (gray) from 0-1 for all impact categories and indicators

Figure 7 and Figure 8 below illustrate collectively the comparison of equal vs stakeholder weights across impact categories and across indicator categories respectively. Regarding the impact categories, stakeholders perceive 'Technical & operational' impacts more important compared to 'Financial & Business' or 'Environmental & Social' impacts. The 'Financial & Business' impact category is the only one for which stakeholder weights coincide with equal weights.

Within ‘Technical & operational’ impact category, stakeholders perceived ‘Operational efficiency’ as the most important indicator compared to the rest of the same category. Furthermore, ‘Visibility of operations’ and ‘Interactions between SC stakeholders’ are perceived as the least important indicators in this impact category. Looking into the ‘Financial & Business’ impact category, it is observed that stakeholders rated ‘Total transport costs’ and ‘Rail increase’ more important compared to the other indicators. Perhaps the indicators ‘Compliance costs’ or ‘Operational costs’ were considered to be part of the ‘Total transport costs’, and thus rated lower. In the last category of ‘Environmental & Social’ impacts, the indicator of ‘CO2 emissions related to T&L operations’ was rated considerably more important than ‘Customer satisfaction’, when taking into account the average ratings of all 27 responses.

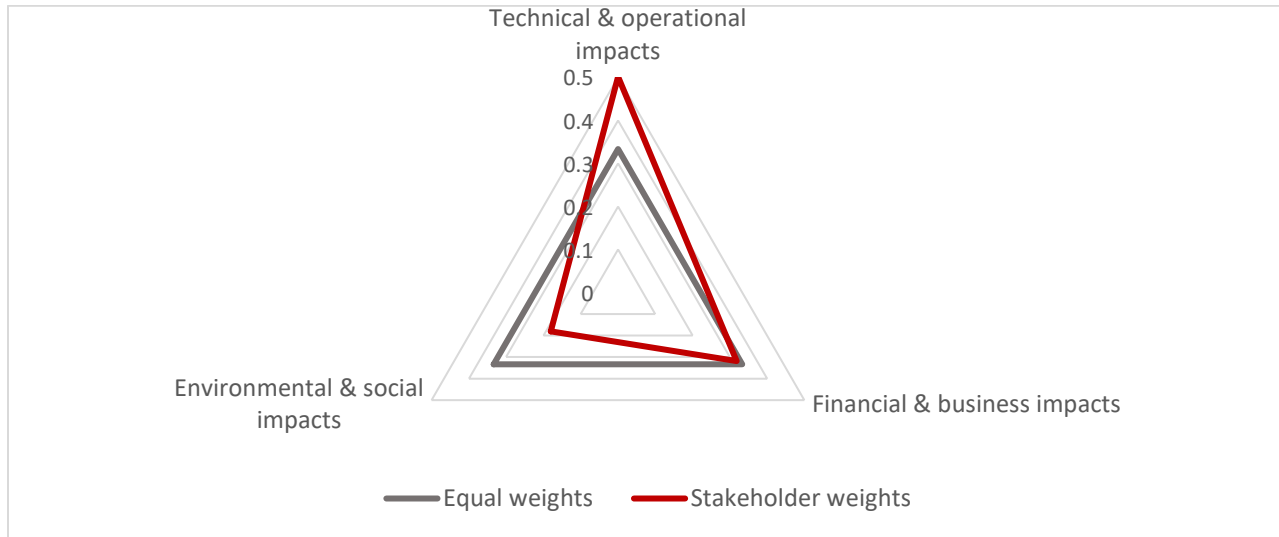


Figure 7: Equal vs stakeholder weights among impact categories

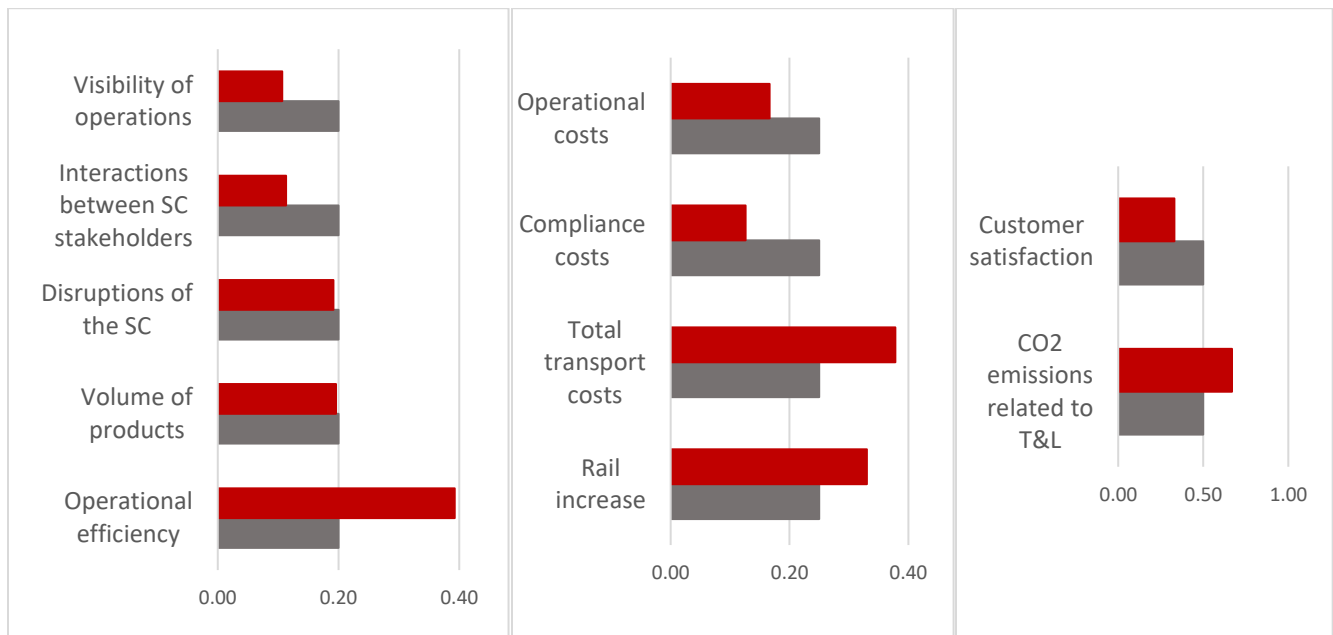


Figure 8: Equal vs stakeholder weights among indicator categories of ‘Technical & operational’ impacts (left), ‘Financial & Business’ (centre) and ‘Environmental & Social’ (right)

5 Analysis of Results

This chapter includes an analysis of all data collected as those presented in chapter 4, focusing on how the different indicator and impact categories contributed to the impacts of the EGTN technological solutions developed.

5.1 Overall performance

For this impact assessment, a total of 3 impact categories and 11 indicator categories are considered, since one of the indicators was not actually measured, thus it was excluded from the analysis and indicator weights were recalculated. For those 11 indicator categories, there is a total of 30 indicators measured by all LLs and the GUC.

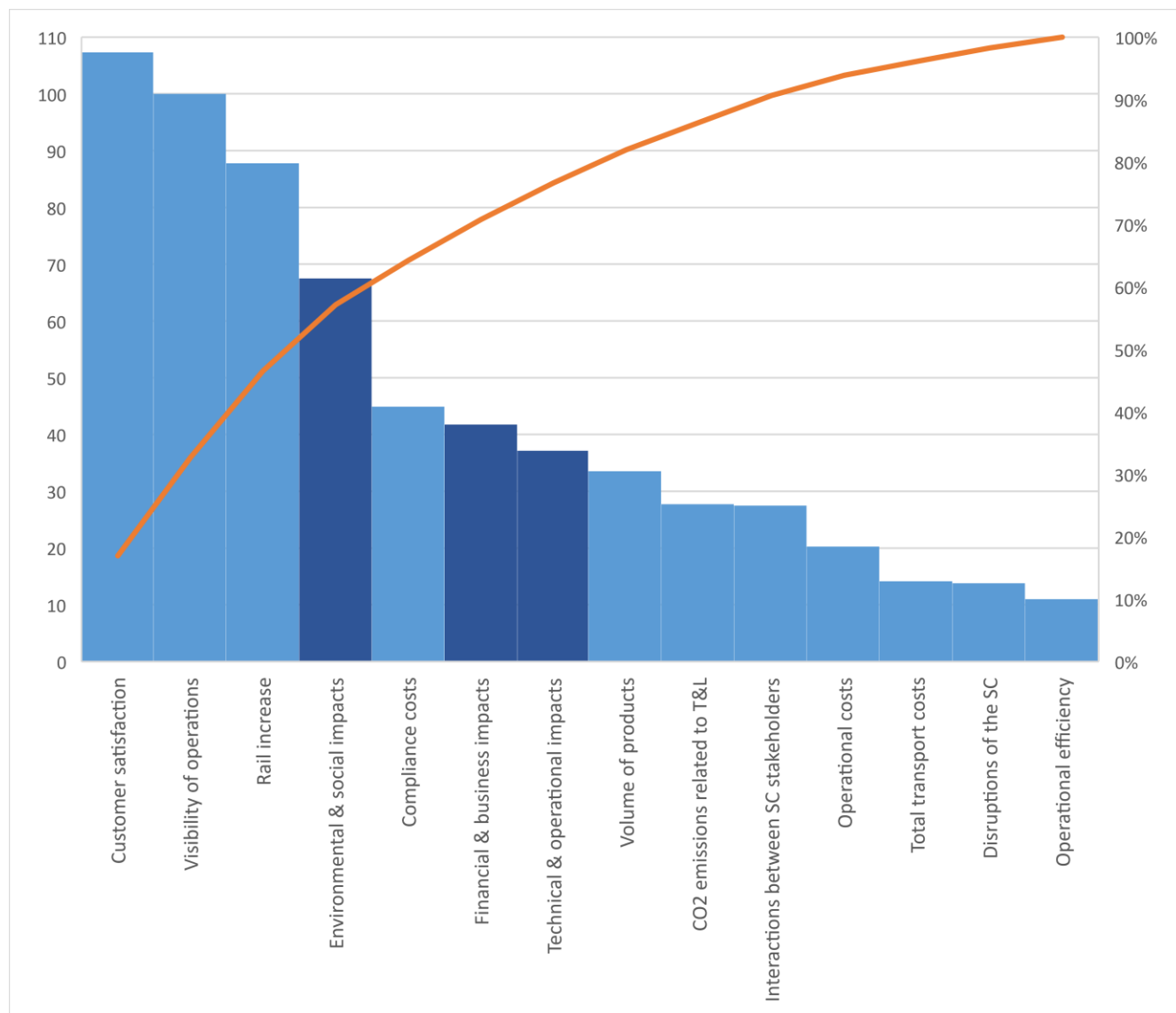


Figure 9: Pareto graph showing the overall performance of indicator and impact categories

The performance of each indicator category is measured as a percentage difference between the Baseline and TO-BE scenarios, a value reflecting their absolute progress in relation to the target. Before applying the indicator category weights, the performance of all indicators of the same category is averaged. For the only indicator that presented opposite performance to the desired one suggested by its target, (i.e. Improved customer experience – LL3), the percentage difference was subtracted before calculating the average performance for the indicator category.

Figure 9 above shows the progress of each impact category (darker blue) and indicator category, assessed based on the percentage difference of their performance when comparing the Baseline value to the TO-BE value, calculated before assigning weights. On average for all indicator categories, it is observed a 44.4% percentage increase. The pareto graph illustrates the impact and indicator categories in descending order, according to which categories contributes most to the overall performance. It is shown that the 'Customer satisfaction', 'Visibility of operations' and 'Rail increase' contributed the most to the positive impact on the performance of EGTN, while 'Operational efficiency', 'Disruptions of the SC' and 'Total transport costs' contributed the least, while having still a positive impact.

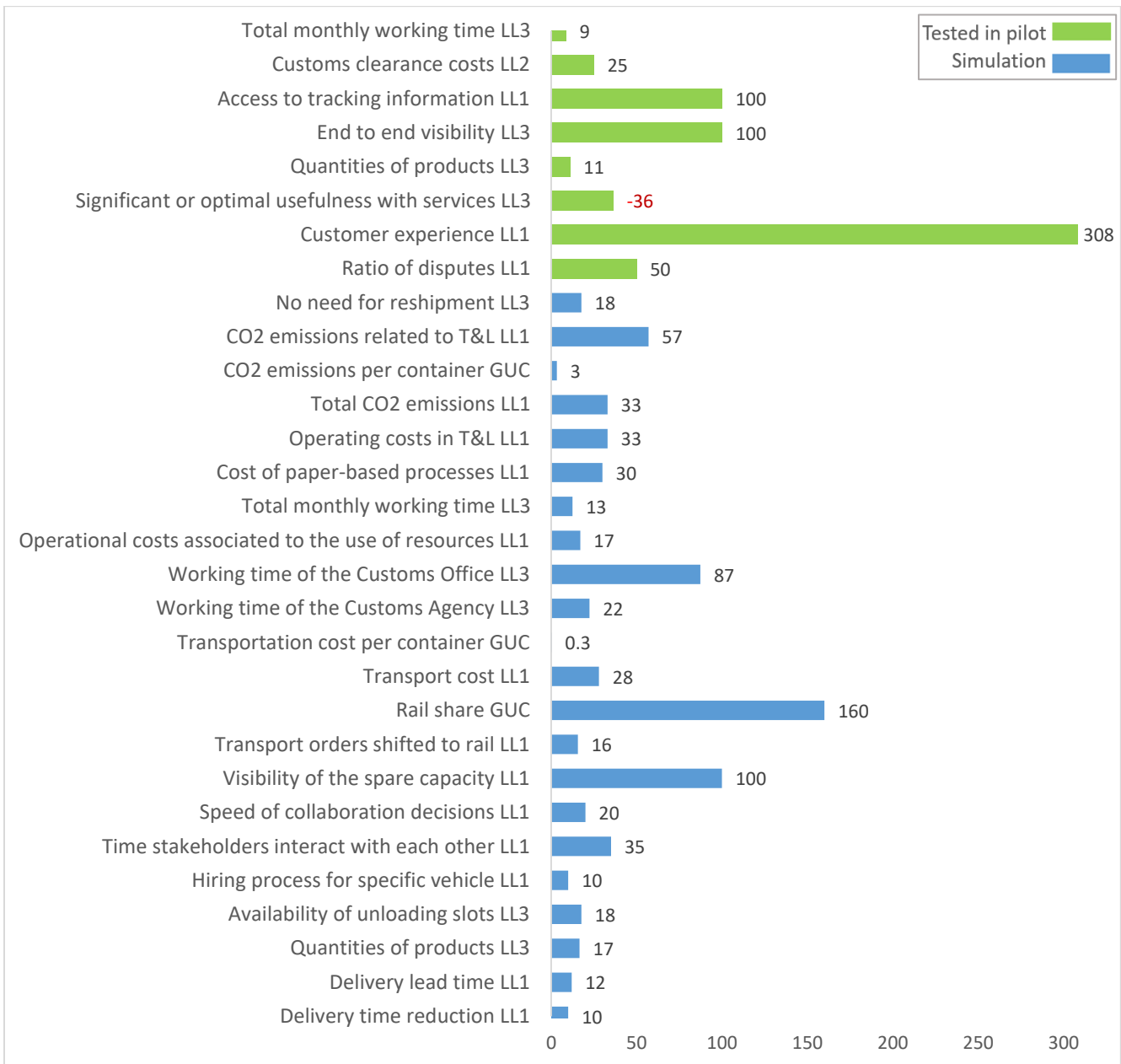


Figure 10: Performance of indicators simulated or tested in LLs and the GUC

Looking into all 30 indicators measured across LLs and the GUC, it is shown that 8 of them were tested in a real case scenario and 22 were calculated based on simulations (Figure 10). The average absolute progress for the indicators that were simulated is 33.6% while for those tested in a real case scenario is 70.9%. Excluding the ‘Customer experience’ indicators tested in LL1, the average absolute progress of the indicators tested in pilots is still slightly higher compared to those simulated (36.9%), demonstrating the credibility of the simulation results. Overall, the absolute progress in relation to the indicator targets, is positive for all but one indicator related the customer satisfaction tested with surveys in LL3.

The next step is to apply impact and indicator category weights (as shown in Figure 6 of the previous chapter), for each category. For comparative purposes, impact and indicator weights are also applied assuming equal importance across the 3 impact categories (0.33 each) and the indicator categories within each one; 0.20 for all indicators in Technical & operational impacts, 0.25 for those in Financial & business impacts, and 0.50 for the two indicators in Environmental & social impacts. The resulting scores are presented in the following Table 10.

The red highlighted cells in the table present the indicator category values with the poorest performance within the respective impact category, while the green highlighted cells show the corresponding best performance. It is demonstrated, that the results are slightly different between equal and stakeholder weights. Stakeholders rated the importance of 'Operational efficiency' higher compared to the 'Disruptions of the SC', and although the performance of 'Operational efficiency' was a bit lower compared to 'Disruptions of the SC', the latter ranked lower within 'Technical & operational impacts' category. Both weighting approaches, derive the same best performance indicator categories (2nd column) across all impact categories (1st column). The grey highlighted cells show the three indicators that didn't achieve their target.

Table 10: Scores for all impact and indicator categories with equal and stakeholder weights

Impact categories	Indicator	Description of indicator	Absolute progress (in relation to the target)	Average score	Score with equal weights	Score with stakeholder weights
Technical & operational impacts	Operational efficiency	Delivery time reduction	10.0	11.0	0.7	2.2
		Delivery lead time in inland transport	12.0			
	Volume of products	Quantities of products, expressed in pieces/packages/pallets, that can potentially be processed through logistics operations in the SC	16.7	33.6	2.2	3.3
			11.1			
	Availability of unloading slots	17.6	13.8	0.9	1.3	

	Disruptions of the Supply Chain	In the hiring process in the spot market for specific vehicle	10.0				
	Interactions between supply chain stakeholders	Time stakeholders interact with each other	35.0	27.5	1.8	1.6	
		Speed of collaboration decisions -automation in routing decisions	20.0				
	Visibility of operations	End to end visibility	100.0	100.0	6.7	5.4	
		Visibility of the spare capacity - speed of inventories	100.0				
		Access to temperature, humidity, bump, gate opening and tracking information of shipping containers and pallets	100.0				
	Financial & business impacts	Rail increase	Number of transport orders shifted to rail	15.6	87.8	5.9	9.2
			Rail share	160.0			
		Total transport costs	Transport cost	28.0	14.2	0.9	1.7
Transportation cost per container			0.3				
Compliance costs		Customs clearance costs	25.0	44.9	3.0	1.8	
		Working time of the Customs Agency	22.4				

		Working time of the Customs Office	87.3			
	Operational costs	Operational costs associated to the use of resources	17.0	20.3	1.4	1.1
		Total monthly working time	12.5			
		Total monthly working time	8.8			
		Cost of paper-based processes	30.0			
		Operating costs in transport and logistics	33.0			
Environmental & social impacts	CO2 emissions related to transport and logistics operations	Total emissions	33.0	27.7	4.6	3.3
		CO2 emissions per container	3.3			
		CO2 emissions related to transport and logistics operations	57.0			
		Transports planned in the most efficient way (no need for reshipment)	17.6			
	Customer satisfaction / experience	Ratio of disputes	50.0	107.3	17.9	6.4
		Customer experience	308.3			
		Significant or optimal usefulness with current and potential services	-36.4			

5.2 Performance per impact category

Figure 11 below illustrates the performance across the three impact categories, when applying equal and stakeholder weights. In the case of equal weights, the Environmental & social impacts are performing best while in the case of applying stakeholder weights, this impact category has the poorest performance. The business interest of stakeholders is reflected in the findings, since the Financial & business impacts are perceived as more important, raising the overall performance of the indicators included in this impact category.

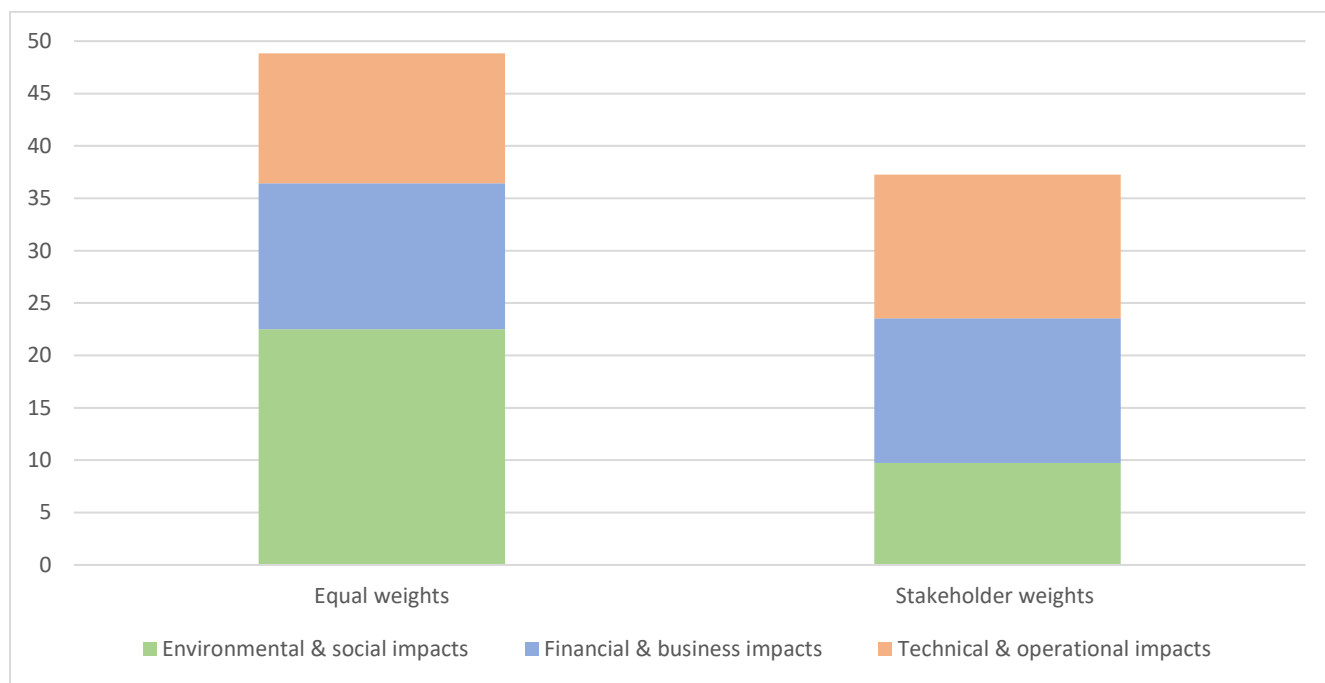


Figure 11: Performance of impact categories with equal & stakeholders’ weights

In summary, it is shown that the implementation of EGTN technological solutions had a positive impact on all but one indicator. It is noted that the indicator performance is not compared between weighting methods, neither among LLs and the GUC. The result of the overall performance remains the same, regardless of the application of equal or stakeholders’ weights on impacts and indicators, demonstrating a robustness in the outcome of the assessment.

5.3 Performance per indicator category

The result of the performance of all indicator categories following the application of stakeholders’ weights and in comparison with the application of equal weights, is shown in Figure 12 below. For illustration purposes, the percentage differences were converted into a logarithmic scale. Taking into account the views of stakeholders with an interest in the technological solutions developed, ratings compared to assigning equal weights are lower

for 'CO2 emissions related to T&L operations', 'Customer satisfaction', 'Visibility of operations', 'Compliance costs' and 'Operational costs'. Operational and compliance costs were rated relatively low perhaps in comparison to the 'Total transport costs' which were rated high.

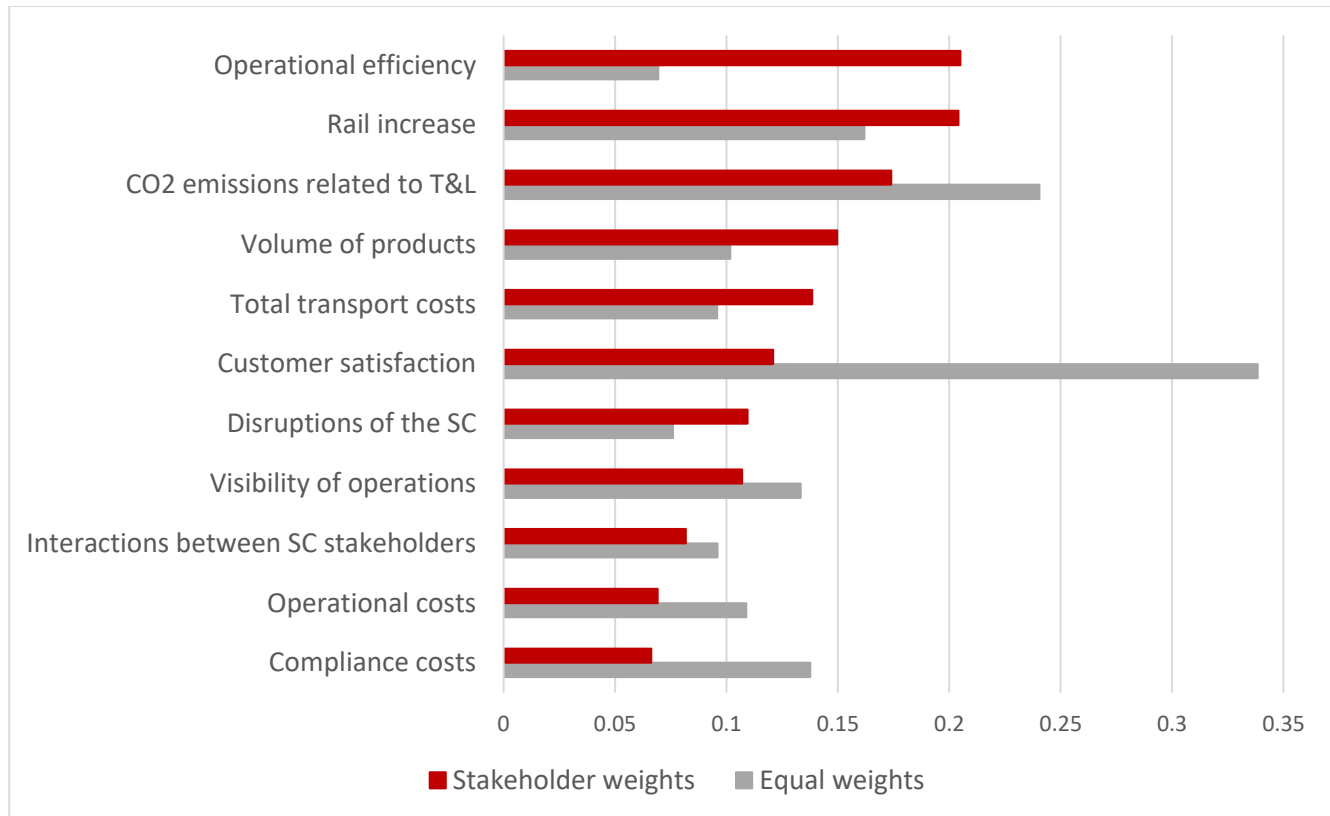


Figure 12: Performance of all indicators with equal and stakeholder weights (logarithmic scale)

On the other hand, 'Operational efficiency', 'Rail increase', 'Volume of products', 'Total transport costs' and 'Disruptions of the SC' indicators were rated higher by stakeholders. The major difference between equal and stakeholder weights, is observed for 'CO₂ emissions related to T&L operations', 'Customer satisfaction' and 'Compliance costs'.

The different weighting method of the indicators, has resulted in a slightly different overall performance, due to the fact that the importance of indicators changes the final value of their absolute progress. Similarly, if no weights were assigned on any of the indicator and impact categories, a different interpretation of the results would be derived. Since stakeholders that took part in the questionnaire are involved in the EGTN operation and processes, their perspective is deemed highly valuable for the assessment of the technological solutions developed.

Figure 13 above illustrates the indicator category scores on a spider graph for all impact categories taking into account stakeholder weights. The logarithmic scale is chosen for illustration purposes, to ease the interpretation of the findings.

In a spider graph, each dimension (indicator) gets its own spoke, and the spokes are evenly distributed around the wheel. The relative importance of each indicator is based on the distance of its data point from the centre of the graph. Indicators with data points closer to the centre have lower values, while those further from the centre have higher values.

The interpretation of the scorings cannot be performed across impact categories, since stakeholders rated the importance of indicators only within the same impact category. Nevertheless, it is shown that the indicators that outperformed are 'Operational efficiency', 'Rail increase' and 'CO2 emissions related to T&L' in 'Technical & operational', 'Financial & business' and 'Environmental & social' impact categories respectively.

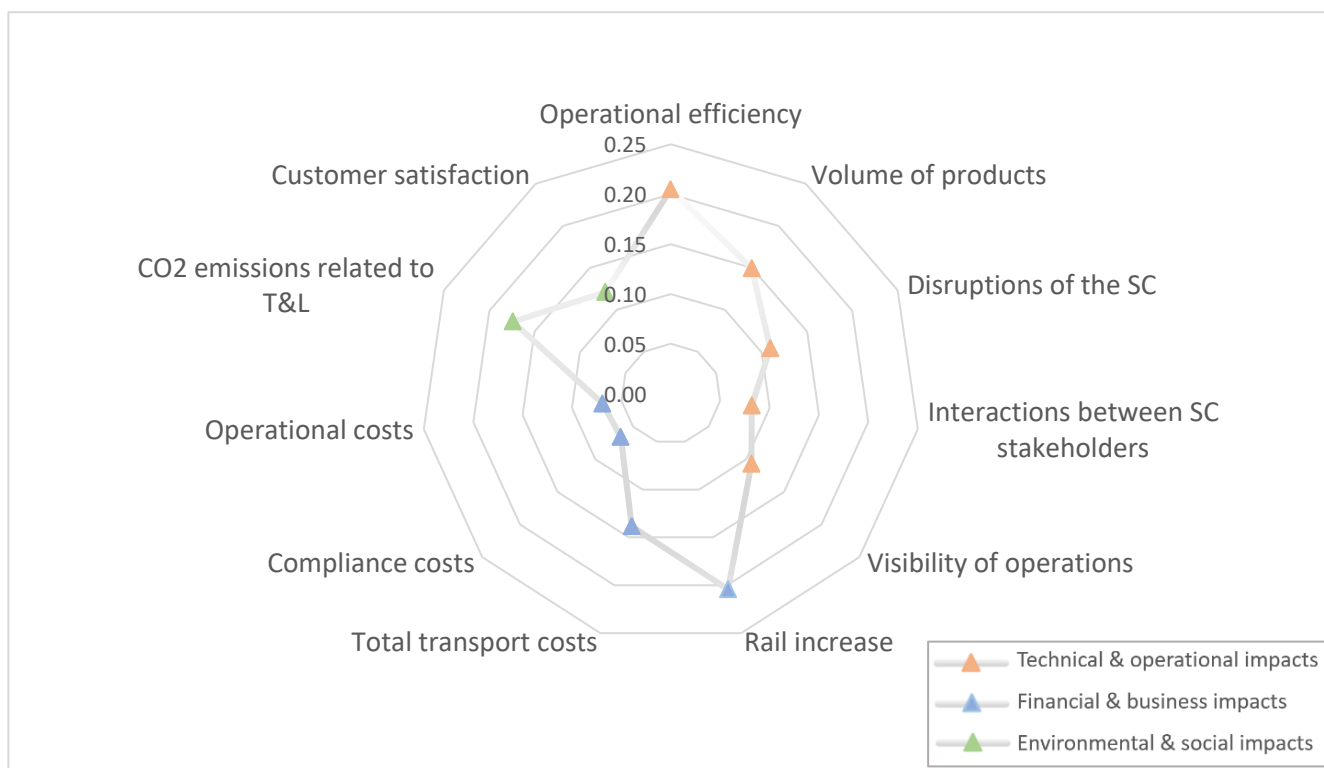


Figure 13: Score of indicators with stakeholder weights (logarithmic scale)

Observing the inner circles of the spider graph, it is shown that 'Operational costs', 'Compliance costs' and 'Interactions between SC stakeholders' had the poorest performance. The remaining five indicator categories present an average performance which is close to the total average absolute score of 44.4% for all indicator categories.

6 Conclusions

This section outlines the findings and conclusions of the EGTN impact assessment that was carried out in this report, based on three thematic areas:

Impact assessment approach

- The evaluation method for assessing the impact of the implemented technological solutions on the EGTN, was adapted from the 6-step impact assessment process of the FENIX framework and follows a bottom-up approach, with the indicators and targets already defined by LLs and the GUC. The scoring system used, was appropriate for assessing the numerical values measured for all indicators, in order to derive their overall performance.
- This approach could be supplemented by others such as benchmarking, by comparing the performance with similar indicators or projects. However, given the limited number of common indicators measured across LLs and the GUC, such an approach couldn't be adopted, therefore separate scores per LL or the GUC were not calculated, as it was also not within the scope of this impact assessment.
- The indicators were assessed towards reaching their targets. Since no threshold values were defined for indicators, the comparison of the indicators is possible only within the context of this project. Comparability with other projects that examine similar technological solutions or indicators, could be achieved by setting minimum and maximum threshold values for each indicator.

Stakeholder views and weighting

- The most important impact and indicator categories with respect to assessing the performance EGTN based on the views of stakeholders involved in the T&L sector who participated in the questionnaire are the 'Technical & Operational' impacts, the indicator of 'Operational Efficiency' within this impact category, the 'Total transport costs' in Financial & Business impacts and the 'CO2 emissions related to T&L operations' in the Environmental & Social impacts.
- The impact and indicator categories which were rated as least important by the same stakeholders are the 'Environmental & Social impacts', the 'Compliance costs' indicator in Financial & Business impacts, and 'Visibility of operations' in Technical & Operational impacts.
- The EGTN impact assessment became feasible following a thorough gathering of data and active involvement of stakeholders who demonstrated a willingness to engage in this evaluation process, exchanging knowledge and information. Through effective communication and coordinated efforts, the outcome was the successful development of technological solutions that significantly enhanced EGTN's operations, resulting in a notable positive impact.

Overall performance

- Out of 27 indicators which had a target assigned to them, 24 achieved their target, presenting a great improvement in their performance. Only one of the remaining 3 indicators, regarding 'Customer satisfaction' as one of the 3 indicators in this category, presented a decrease in its performance. To achieve an improvement of this indicator, a repetition of the survey is recommended, examining the questions for which respondents provided a low score.
- Before the application of stakeholder weights, it is observed that 'Customer satisfaction', 'Visibility of operations' and 'Rail increase' contributed the most to the positive impact on the performance of EGTN, while 'Operational efficiency', 'Disruptions of the SC' and 'Total transport costs' contributed the least, while having still a positive impact.
- The implemented solutions had a positive impact on several more indicators such as the 'Compliance costs' and 'Volume of products' while some of the indicators improved but at a lower extent. These indicators are the 'Operational efficiency', 'Disruptions of the SC' and 'Transport costs'. This demonstrates that it is more challenging to improve the performance of these indicators, however an improvement was still observed.
- The average absolute progress for the indicators that were simulated is 33.6% while for those tested in a real case scenario is 70.9% demonstrating accountability of the simulation results.
- Considering the views of stakeholders, the EGTN performance following the application of the technological solutions developed in PLANET, was mostly impacted by the indicators regarding the 'Operational efficiency', 'Increase in the share of rail' and 'CO2 emissions related to T&L operations'. Although the stakeholder weights assigned to these indicators were not as high as others, their performance stood out from the rest of the indicators. This fact proves that the solutions implemented in the LLs had a significant impact on the potential increase of the share of rail, operational efficiency and reduction of CO2 emissions.
- On the other hand, 'Compliance costs', 'Operational costs' and 'Interactions between SC stakeholders' improved but at a lower extent, taking into account stakeholder views.
- Considering impact categories and in the case of equal weights, the Environmental & social impacts are performing best while in the case of applying stakeholder weights, this impact category has the poorest performance. The business interest of stakeholders is reflected in the findings, since the Financial & business impacts are perceived as more important, raising the overall performance of the indicators included in this impact category.
- Comparing the application of equal vs stakeholder weights, the differences are only observed in the final values of indicator categories that improved the least; 'Operational efficiency' was highlighted as the

least improved indicator when applying equal weights compared to 'Disruptions of the SC' when applying stakeholder weights, and 'Total transport costs' as opposed to 'Operational costs' were highlighted as the least improved indicators similarly. Nevertheless, their values are still in similar levels.

- Considering that the stakeholders who participated in the questionnaire have an interest in the solutions developed in this project, the indicator weights derived from their perspective should be accounted for. The result of the overall performance remains the same, regardless of the application of equal or stakeholders' weights on impacts and indicators, demonstrating a robustness in the outcome of the assessment.
- It is apparent that the solutions implemented in LLs and the GUC, had a positive impact on 29 out of 30 indicators. Taking into account the average performance of the indicators within each category, a positive impact was observed for all of them, ranging from 11% to 107% percentage increase when comparing the Baseline and TO-BE measurements.

7 References

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Annex I: Indicators, targets, values and progress

Impact categories	Indicator	Description of indicator	Target	AS-IS	TO-BE	Actual progress %
Technical & operational impacts	Operational efficiency	Delivery time reduction	7% reduction	90.0	81.0	-10.0
		Delivery lead time in inland transport	10% reduction	4.0	3.5	-12.0
	Volume of products	Quantities of products, expressed in pieces/packages/pallets, that can potentially be processed through logistics operations in the SC	>8% increase	18.0	21.0	16.7
				18.0	20.0	11.1
	Disruptions of the Supply Chain	Availability of unloading slots	>15% increase	85.0	100.0	17.6
		In the hiring process in the spot market for specific vehicle	7% reduction	30.0	27.0	-10.0
	Interactions between SC stakeholders	Time stakeholders interact with each other	20% reduction	2.0	1.3	-35.0
		Speed of collaboration decisions -automation in routing decisions	20% increase	30.0	24.0	-20.0
	Visibility of operations	End to end visibility	>50% increase	0.0	100.0	100
		Visibility of the spare capacity > speed of inventories	Full visibility	0.0	1.0	100
		Access to temperature, humidity, bump, gate opening and tracking information of shipping containers and pallets	Real time access	0.0	1.0	100
	Financial & business impacts	Transport orders fulfilled through BC	Transport orders fulfilled through Blockchain	5% use of BC	0.0	0.0
Rail increase		Number of transport orders shifted to rail	15% increase	0.0	15.6	15.6
		Rail share	N/A	2.5	6.5	160
Total transport costs		Transport cost	10% reduction	600.0	432.0	-28.0
		Transportation cost per container	N/A	1234.0	1230.0	-0.3
	Customs clearance costs	>10%	N/A	N/A	25	

	Compliance costs	Working time of the Customs Agency	>10% reduction	91.2	70.8	-22.4
		Working time of the Customs Office		68.9	8.7	-87.3
	Operational costs	Operational costs associated to the use of resources	3% reduction	70.0	58.1	-17.0
		Total monthly working time	10% reduction	62.4	54.6	-12.5
		Total monthly working time		62.4	56.9	-8.8
		Cost of paper-based processes	15% reduction	150.0	105.0	-30.0
		Operating costs in transport and logistics	7% reduction	800.0	536.0	-33.0
Environmental & social impacts	CO2 emissions related to transport and logistics operations	Total emissions	15% reduction	0.5	0.3	-33.0
		CO2 emissions per container	N/A	1.8	1.8	-3.3
		CO2 emissions related to transport and logistics operations	15% reduction	7.1	3.0	-57.0
		Transports planned in the most efficient way (No need for reshipment)	20% increase	17.0	20.0	17.6
	Customer satisfaction / experience	Ratio of disputes	10% reduction	18.0	9.0	-50.0
		Customer experience	Qualitative increase	24.0	98.0	308.3
		Significant or optimal usefulness with current and potential services	>15% increase	39.1	24.8	-36.4

Annex II: Questionnaire



Questionnaire on the importance of EGTN impact categories and indicators

The purpose of this questionnaire is to assess the relative importance among the impact categories and the respective indicators which measure the performance of the EGTN solutions tested in PLANET Living Labs and the Generic Use Case. The assessment will be performed through a set of pair-wise comparisons on a scale of importance from 1-9, where 1 corresponds to equal importance and 9 to extreme importance. The result of this exercise will be a prioritisation of the impact categories and final relative scores of all indicators which will be used in the context of Deliverable 3.10 regarding the EGTN impact assessment.

The completion of this questionnaire takes approximately 5 minutes.

In case you have any questions related to this questionnaire, please contact us at cgeorgouli@certh.gr

Thank you for your participation!

PLANET project is funded from the European Union's Horizon 2020 research and innovation programme under grant agreement No 860274.

* Please select which stakeholder category represents you.

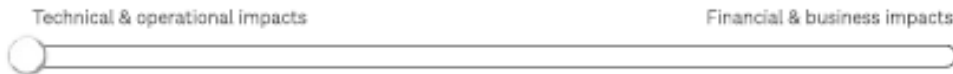
- Rail or vessel operator
- Terminal operator
- Hinterland transport operator
- Shipper
- Logistics service provider
- Technology provider
- Government body
- Research Institution
- Academia
- Other (please specify)

Please specify the years of experience in the sector you are now working for.

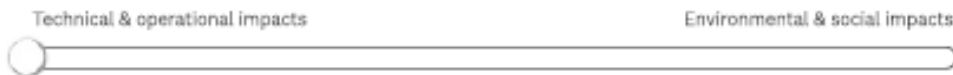
- < 3 years
- 3-5 years
- 5-10 years
- > 10 years

Impact categories

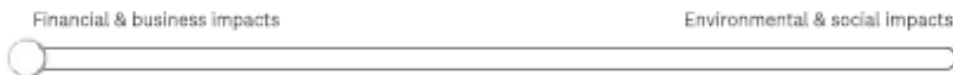
* Please specify the relative importance for each of the impact category pairs below by moving the slider. The closer the slider is at the impact category the more important you consider that category compared to the other.



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Indicators (1/2)

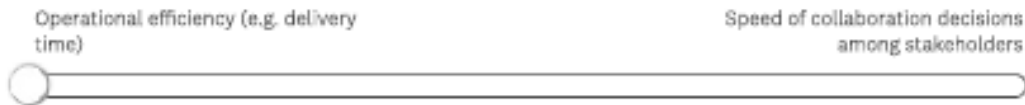
* Please specify the relative importance for each of the indicator pairs below by moving the slider. The closer the slider is at the indicator the more important you consider that indicator compared to the other.



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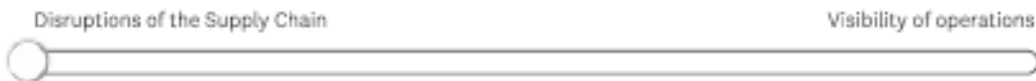
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Indicators (2/2)

* Please specify the relative importance for each of the indicator pairs below by moving the slider. The closer the slider is at the indicator the more important you consider that indicator compared to the other.



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Please let us know in case you have any comments.

Thank you for your time in completing this survey!