INTERMODEL EU

Simulation using Building Information Modelling Methodology of Multimodal, Multipurpose and Multiproduct Freight Railway Terminal Infrastructures

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Executive Summary

The INTERMODEL project aims at establishing a methodology to design and alternative appraisal of multimodal freight terminals taking the most of the BIM tool and their capacity for providing multi-dimensional models. The dimensional models are to be combined with different simulations models resulting in an aggregated decision-making tool to be used during the project-planning phase and thorough its life cycle.

In such context, some performance measures and metrics are required, in order to identify the key factors accountable in the design and location decision process, while considering the future evolution of the terminals. Thus, the goal of WP3 during the first three months of the project (M1-M3) was to establish a set of Key Performance Indicators (KPIs) for the assessment of intermodal freight terminals through in an ICT environment. The work done and final findings being provided in this deliverable (D3.1).

The study started with a state of the art review of current performance measures used in transport, logistics and the supply chain. The findings were completed with a consultation on the project partners, in which experienced consultants in logistics, building management and design, railway operators, terminal operators and public bodies identified additional KPIs according to their particular objectives.

The combined work from the state of the art and the consultation process derived in a long list of KPIs covering the different assessable aspects from any intermodal freight terminal. The resulting list was examined during a working meeting held in Melzo and La Spezia (Italy), and a deeper discussion took place regarding what indicators were the most relevant to the different stakeholders. As a result, a methodology to identify the final selection of KPIs to be used was proposed. First, a framework to organize the KPIs from the expanded list was constructed where the main strategic goals, stakeholders, performance dimensions and scope to be considered were identified and allowing to first classify the KPIs according to the framework and afterwards shortlist the most representative ones, to cover all fields in the classification.

The proposed methodology for selecting feasible performance measures (based on relevant inputs from the literature review) is briefly introduced as follows:

1. Identification of the strategy and mission of the organization
2. Identification of stakeholders involved
3. Identification of the different perspectives that should be considered in the performance system
4. Identification of particular strategic goals
5. Selection of effectiveness criteria and feasible KPIs and PIs set
6. Scoring process and determination of overall KPI score (aggregation method)

As mentioned before, the previous work derived in a dashboard for intermodal freight terminals (Figure below) that will be integrated in the investment decision making tool (BIM and simulation models result from INTERMODEL EU project). This dashboard (matrix scheme) includes the selected KPIs (in bold) and PIs (in bullet points) which are also defined in detail in this manuscript (Appendix II).

<table>
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<th>STAKEHOLDERS PERFORMANCE DIMENSION</th>
<th>INVESTOR</th>
<th>OPERATOR</th>
<th>PUBLIC BODY</th>
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| OPERATION                         | Terminal throughput | Equipment utilization  
Gate utilization  
Labour utilization rate  
Storage area utilization  
Rail yard utilization  
Bench utilization  
Turnaround time  
- Maneuvering time  
- Service time  
- Berthing time  
- Equipment idle time  
Waiting time  
Terminal throughput | Operating efficiency  
- OPEX  
- Corrective maintenance cost  
- Preventive maintenance cost  
Operating revenues per unit  
Operating benefits per unit | Direct jobs sustained in the region  
Indirect jobs sustained in the region  
Road and rail maintenance cost |
| FINANCE                           | Return On Investment (ROI)  
Terminal’s profitability  
- CAPEX | Turnaround time  
Waiting time  
- Waiting time / turnaround time  
Excess of entry and exit from highways  
Excess of entry and exit from rail network | Delays produced (reliability) on road  
Delays produced (reliability) on railway | |
| QUALITY                           | Turnaround time  
Waiting time  
- Waiting time / turnaround time  
Excess of entry and exit from highways  
Excess of entry and exit from rail network | Carbon footprint per unit  
CO, NOX, SOX and PM emissions per unit  
Population exposed to high levels of traffic noise | Number of road accident  
Number of railway accidents  
- Accidents related to hazard cargo |
Finally, it should be highlighted that this tool will be really useful for both public institutions and private companies since it will support decisions as regards to layout design, building materials choice, operative planning, handling equipment selection and allocation of intermodal freight terminals, simultaneously in the same framework.
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1. Introduction

1.1. Scope

The INTERMODEL project aims at establishing a methodology for multimodal freight terminals which allows taking the most of the BIM tool and its capacity for providing multi-dimensional models. These dimensional models are likely to be an input of different simulations models in order to optimize the decision-making process during the project phase, based on financial, economic and environmental impact and throughout the project life cycle, considering both the investment period and the operation.

By combining and integrating abovementioned models (BIM and simulation tools) a decision-making tool would be developed. The target of this tool is to help decision-makers to determine which actions and proposals will contribute to reach a better terminal performance, through the selection of the best location regarding both operational and environmental aspects, an improved layout and optimized processes, among others.

In such context, bearing in mind that this tool will show how future scenarios are working, some performance measures and metrics are required to focus on key factors and to make proper decisions. Thus, the aim of this deliverable is to establish a set of Key Performance Indicators (KPIs) for the assessment of intermodal freight terminals through an ICT environment. In particular, selected performance measures regarding financial, operational, security, environmental and quality service issues would be integrated within the developed BIM framework methodology resulting in a potential contribution to the research community since no previous works have been found in that sense.

To sum up, this deliverable will provide a set of KPIs (high-level indicators) and PIs (secondary level indicators) that will be included in a scoreboard integrated in the BIM decision-making tool. This comparative scoreboard that includes the selected KPIs related to financial, operational, quality service, sustainable and safety issues and from three points of view (investor/management, operator and public body) will help to compare alternatives, assess potential measures and solutions and provide support to decision-makers taking into account both project definition and exploitation phases.
1.2. Audience

The intended audience of this document is any actor involved in activities related to intermodal freight terminals, both seaport and inland, such as public administrations, private terminal operators, logistics companies, shippers and rail operators.

The integrated tool developed within the project will allow a fast way to make decisions in the planning and operation, taking into account the relevant KPIs defined in this document.

1.3. Definitions / Glossary

In the current section a short description of main terms used in the manuscript are described, that is:

**BIM** - Building Information Model. Shared digital representation of physical and functional characteristics of any built object, including buildings, bridges and traffic networks. The acronym is also used to define management and Building Information Modelling in general, referring to using model-based applications. (ISO 12911)

**BIM 6th dimension** - Energy efficiency and environmental impact. BIM is used to model and evaluate energy efficiency and environmental impact, monitor a building/infrastructure’s cycle costs and optimise cost efficiency.

**BIM 8th dimension** - Operational simulation. Simulation of the operational running of the infrastructure (e.g. the movement of cargo, the design’s adequacy to an efficient logistics supply chain, detection of bottlenecks). BIM model will result in an integral control platform.

**Cargo** - Freight that is loaded into a container or on a trailer.

**Dashboard** - A set of KPIs joined together in one overview screen. This way the user gets an overall overview of the performance in one view.

**Environment** - Surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans and their interrelations.

**Environmental impact** - Change to the environment, whether adverse or beneficial, wholly or partially resulting from environmental aspects.
Environmental aspect - Aspect of construction works, part of works, processes or services related to their life cycle that can cause change to the environment.

Environmental performance - Performance related to environmental impacts and environmental aspects.

Equipment - Crane, vehicles, reach stacker and others machines used in the terminal.

Functional performance - Performance related to the functionality of the construction works or an assembled system (part of works), which is required by the client and/or by users and/or by regulations.

Gate - A point at an intermodal terminal where a clerk checks in and out all containers and trailer. All reservations and paperwork are checked at the gatehouse.

Greenhouse effect - Environmental issue related to pollution. The greenhouse effect is defined as the amount of CO₂ (in kg) that reinforces the greenhouse effect to the same degree as the substance emitted. CO₂ emissions as a result of fuel combustion and CH₄ emissions are mainly responsible for the greenhouse effect.

Idle time – Non-productive time.

Indicator - Quantifiable value related to performance or environmental impacts/aspects.

Key Performance Indicator - Indicator that tells you what to do to increase performance dramatically. They represent a set of measures focusing on those aspects of organizational performance that are the most critical for the current and future success of the organization. The KPI will be calculated on the results of the simulation model.

Life Cycle - Consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to the final disposal.

Maintenance - Combination of all technical and associated administrative actions during the service life to retain a building or an assembled system (part of works) in a state in which it can perform its required functions.

Output (operational) - The simulation tool will provide two types of output: animation and KPI.
Performance - Expression relating the magnitude of a particular aspect of the object of consideration relative to specified requirements, objectives and/or targets.

Social aspects - Aspect of construction works, part of works, processes or services related to their life cycle that can cause change to society or quality of life.

Social impact - Any change to society or quality of life, whether adverse or beneficial, wholly or partially resulting from social aspects.

Terminal simulation model - A detailed simulation model of the intermodal operational terminal processes. The network is either not simulated or at a higher level of abstraction.

1.4. Abbreviations

The following list contains the most common abbreviations used in this deliverable:

3PL: Third Part Logistics
AI: Aggregated Indicators
ASC: Automated Stacking Cranes
BIM: Building Information Model
CAPEX: Capital Expenditure
DEA: Data Envelopment Analysis
ITU: Intermodal Transport Unit
KPI: Key Performance Indicator
OPEX: Operational Expenditure
PI: Performance Indicator
PMS: Performance Measurement System
ROI: Return On Investment
RMG: Rail-Mounted Gantry cranes
RTG: Rubber-Tired Gantry cranes
RoRo: Roll-on Roll-off
1.5. Structure

The present document is organized as follows:

- **Introduction**: contains an overview of this document, providing its scope, audience and structure.
- **State of the art and description of KPI and KRI**: literature review carried out for this research project focuses on potential areas and factors to be used for defining performance and risk indicators for intermodal freight terminals. In addition, the main contributions to the research community are described in the last part of this section. And as a result of the assessment the use of KRIs is disregarded and integrated within the PI used.
- **Methodology for KPI definition**: contains the methodological approach followed for the definition of the most appropriate performance indicators.
- **Definition of KPI and PI**: presents and describes the KPIs and PIs developed for the performance measurement of the intermodal freight terminals through a new decision making tool.
- **Evaluation methods**: proposes two different existing methods for aggregating a set of KPIs in a single indicator.
- **Conclusions**: gathers the main study findings and the final KPI and PI list proposed to be included in the dashboard for the assessment of intermodal freight terminals through the decision-making tool, which will show the supposed upgrade in performance in both design and operation phases.

In addition, Appendix I includes the list of KPI and PI obtained from the partners’ consultation, and in Appendix II, the definitions of the KPI and PI finally proposed are set out.
2. State of the art

2.1. Introduction and objectives

The literature review carried out for this research project focuses on potential areas and factors to be used for defining performance indicators for intermodal freight terminals. Firstly, this section reviews the trends of organizations in regard to performance measures and includes different definitions and approaches used in the literature. Secondly, a categorization of the performance indicators in the field of logistics, supply chain and freight transport from the literature is provided. Finally, examples of integration of performance measures and indicators within BIM framework methodologies has also been included in the analysis, but few cases were found—and even not directly related to the scope of this project.

The purpose of this section is being a first step for selecting the relevant KPIs that the model framework will use to make the right decisions that would contribute to an improved layout, operational processes and location of intermodal terminals.

2.2. General overview of measuring performance

2.2.1. Purpose and definition

Within the last years, measuring the performance of organizations has become more significant with the globalization and increasing level of competition. Thus, performance management systems are being used to ensure that companies and processes are going in the right direction, achieving targets in terms of organizational goals and objectives (Ghalayini and Noble, 1997).

Measuring or monitoring performance could be used by several purposes, that is:

- Evaluating one or more aspects of the business or part of it and comparing it with the best in its specific sector (Haponava and Jibouri, 2009);
- Revealing the gap between planning and execution, helping companies to identify potential problems and areas for improvement and making decisions based on facts and;
- Identifying success if improvements planned actually happened, identifying whether customer needs are met, where problems and bottlenecks exist and where improvements are required (Parker, 2000; Gunasekaran and Kobu, 2007).
According to the above purposes, different definitions of performance can be found in the literature. For instance, Mentzer and Konrad (1991) defined performance as an investigation of effectiveness and efficiency in the accomplishment of a given activity and where the assessment is carried out in relation to how well the objectives have been met. Neely et al. (1995) also considered that a performance measure is a set of metrics used to quantify the efficiency and/or effectiveness of an action. In such case, the term metric refers to the definition of the measure, how it will be calculated, who will be carrying out the calculation, and from where the data will be obtained.

Gosselin (2005) stated that a performance indicator could be defined as the physical value used to measure, compare and manage the overall organizational performance. Similarly, Parmenter (2009) defined it as an indicator used by management to measure, report, and improve performance. The approach given by Parmenter (2009) was aimed at providing the missing link between the balanced scorecard work of Kaplan and Norton (1996) which is a framework for integrating measures derived from the organization’s strategy in which the drivers, encompassing customers, internal-business processes and learning and growth perspectives were derived into tangible objectives and measures. This approach was extremely useful for a myriad of purposes: to communicate strategy, to link strategic objectives to long-term targets, to identify and align strategic initiatives or even to perform periodic and systematic strategic reviews and obtain feedback to learn from.

However, it should be mentioned that performance indicators used for measuring, managing and comparing the performance of organizations, vary depending on the nature of the organization, its strategy and the industry considered. Thus, different authors (Leong et al. 1990; Mapes and Szwejckewski, 1997) stated that each organization has to determine performance indicators and, subsequently, performance measures and figures that are strategically relevant to its respective situation.

Therefore, we can find several perspectives or typologies of overall business performance in the literature, but it is largely accepted that KPIs should be specific, measurable, attainable, realistic and time-sensitive (Shahnin and Mahbod, 2004). In fact, they considered their so-called smart criteria for defining and selecting appropriate performance indicators and proposed an analytical hierarchy process to prioritize
indicators. Thus, the rest of the section will be focused on logistics and transportation indicators.

Beyond the considerations from Shanin and Mahbod (2004), Castillo and Pitfield (2010) presented a framework for identifying and selecting a small subset of sustainable transport indicators and suggested five methodological and analytical attributes that are desirable for transport indicators, that is: measurability, ease of availability, speed of availability, interpretability and transport’s impact isolatable. Complementarily to both previous criteria, the research project COCKPIT suggested that indicators should have direct relevance to objectives, an appropriate spatial and temporal scale, high quality and reliability, clear identification of causal links and their collection should be realistic and limited.

### 2.2.2. Classification of indicators

On the first hand, we could find the classification of indicators according to Parmenter (2009), that is:

- **Key result indicators (KRI)** informs how something has been done in a perspective;
- **Performance indicator (PI)** indicate what to do in order to improve the performance;
- **Key performance indicator (KPI)** indicate what is the best to do to improve the performance. Usually, these indicators are focused on those most critical for the current and future success of an organization aspects of organizational performance.

Secondly, and regarding the performance indicators (both PI and KPI), it was found that many authors have suggested many categories for different approaches of performance measurement but there are **two main groups that are widely used**, that is: financial or cost based (measuring rate of return on investment, cash flow and profit margins) and non-financial or non-cost based measures of performance (De Toni and Tonchia, 2001; Bhatti et al., 2014, for instance). However, as stated in Gunasekaran and Kobu (2007) other authors such as Beamon (1999) considered time, resource utilization, output and flexibility or (Bagchi, 1996) classified indicators as function-based and value-based, like performance measurements in logistics.
White (1996), De Toni and Tonchia (2001), Neely et al. (2005) and Parmenter (2009) also consider non-cost measures as quality, time, learning and growth, delivery reliability and flexibility indicators for measuring the organizational performance. They also concluded that the four main categories are namely costs, time, flexibility and quality. Out of these, Sinclair and Zairi (1995) also consider the customer satisfaction, employee factors, safety and environmental/social performance as the indicators of business performance used by many organizations.

On the other hand, indicators can be classified according to the process and stage measured and the scope of their effect (Marsden and Bonsall, 2005). Thus we can differentiate by input, output, outcome and impact indicators; quantitative and qualitative indicators, short term, intermediate and long term/final indicators, and finally, as regards to the relation to decision-making levels, in strategic, tactical and operational (Gunasekaran et al., 2001).

Moreover, the classification proposed by De Rus et al. (2003) for transport activities should be mentioned as well. They proposed two main groups: technical and economic indicators. And for each group, the indicators were classified according to the relationship between inputs and outputs. As an example, the productivity is an output/input indicator, technical efficiency is an input/input indicator and utilization measures could be output/output indicators. Then, we could have costs and revenues in relation to input/outputs as the average cost and revenue per ton of cargo.

To sum up, performance measures and metrics could be classified according to the main following sets:

- Financial-cost based /Non-financial
- Qualitative/Quantitative
- Short/Medium/Long term
- Strategic/tactical/operational level
- Function-based/Value-based
- Input/output/outcome indicators
- Time/Quality/Flexibility/reliability
- Safety and security
- Environmental and sustainable indicators
2.2.3. Measuring Risk, KRI feasibility

Regarding the development of Key Risk Indicators (or KRI) (please not mistake with Key Result Indicators, previously cited), are mainly used to assess the potential effect of events that could determine a variation on the company (in this case terminal) initial objectives (COSO, 2004). The potential loss resulting from each event can be quantified in terms of probability and severity or impact (Sheffi and Rice, 2005; Einarsson and Rausand, 1998).

Some efforts have been done to integrate both Performance and Risk Indicators in a common framework, since the former measure performance and the later potential losses measured in probability and impact. However, giving their different nature, they are usually assessed separately (Arena and Arnaboldi, 2014).

The most common technique for KRI production is to assess all activities taking place, identify their exposure to failure (risks), the cause behind such exposure and the probability of its occurrence and its severity (Scandizzo, 2005).

The literature provides two different approaches to identify the risks a terminal can face: in-depth interviews with experts to identify risks and the relationships between causes and consequences or by means of taxonomies of risks with associated sources and manifestations (Cagliano et al, 2012). Once this point was reached, however, it would become extremely difficult to produce meaningful KRIs to assess the vulnerability of the system (terminal) at a planning stage. In fact, KRIs are dependent on environmental factors and even operational (managerial) decisions that would provide frequency and severity of the risks. In fact, KRIs are hard to be produced at a planning stage and virtually impossible in virtual scenarios with no real placement.

Therefore, and given the previous considerations, it does not seem appropriate to calculate Risk Indicators at this stage of the research, although initially considered.

The next section focuses on both performance indicators in logistics and supply chain and in transport and infrastructure. The combination of them shapes a comprehensive basis for the current research project.
2.3. Measuring the performance of logistics, supply chain management and freight transport

The logistics and transport industry also measures its performance through the use of indicators and metrics which are essential for effectively managing logistics and transport operations, particularly in a competitive global economy.

2.3.1. Logistics and supply chain performance

A comprehensive review of recent literature (1995-2004) regarding performance measures and metrics in logistics and supply chain management can be found in Gunasekaran and Kobu (2007) who tried to determine performance of a supply chain system by using a minimum number of KPIs and providing reasonable accuracy with minimum cost. The selected literature identified several important performance indicators in the evaluation of logistics efficiency and effectiveness differentiating those researchers focused on the field of logistics from those focused on the broader supply chain, such as Garcia et al. (2012), Schönsleben (2012) and Lohman et al. (2004).

The results of the literature survey indicated that clear and specific objectives and consistency in measuring are the key factors to success. In parallel, they provided 27 measurements called KPI for supply chain performance. They also stated the most widely used performance measurement was financial performance, usually related to strategic level of decisions such as rate of return on investment, sales, profit, etc. The non-financial most common measures were labor efficiency, capacity utilization, forecasting accuracy, cycle times, production flexibility, value added, service variety and perceived quality.

Following the above approach, Krauth et al. (2005) presented a literature survey on the concept of performance indicators in logistics and a framework capturing the dynamics of performance indicators for logistical service providers including an extensive list of KPIs. In particular, they proposed the following type of indicators: (1) from the management point of view (effectiveness, efficiency, satisfaction, IT and innovation); (2) from the employee’s point of view (working conditions, salaries and benefits or km per trip); (3) customer’s point of view (transportation price, goods safety, response time, timeliness of goods delivery, etc.) and; (4) from the society’s point of view (level of CO₂ emissions, disaster risk, road maintenance costs, number of available work places, use
of innovation technologies, etc.). However, their contribution was that they present a first-step towards a long term aim to use indicators ex-ante rather than post-ante.

Other authors as Rafele (2004), Rushton et al. (2010) and Domingues et al. (2015) organized the logistics indicators according to three dimensions: activities (transport, warehousing and customer service), actors (carriers, 3PL and warehouses) and decision level dimension (operational, tactical and strategic).

Domingues et al. (2015) also proposed a performance measure framework focused on the transportation activity of a 3PL firm, offering a clear guide to compute and organize the 27 selected indicators with a user-friendly interface. They introduced a record sheet for each KPI where a more detailed description and usage recommendations were presented, including the formula, frequency of measurement, the drivers involved and units of measure. Among the selected indicators, it is worthy to highlight the following indicators: capacity, distance travelled per day, turnover per km, delivery frequency, profit per delivery, on-time delivery performance, product changeover time, claims due to quality fails, order to delivery cycle time, distribution of transportation costs and the traditional productivity.

Finally, some useful and relevant indicators regarding the performance of maritime logistics chains can be found through the literature. In such context, Gunasekaran et al. (2001) suggested the following indicators: lead time, the percentage of goods in transit, the number of faultless notes invoiced, the flexibility of delivery systems or the total distribution cost.

Despite the logistics and supply chain approach is not directly related to the scope of the current project, there are several performance measures that can be adapted for the performance of intermodal freight terminals. In fact, the approach given by Krauth et al. (2005) satisfies the overall target of the INTERMODEL EU project and will be taken into account for the final KPIs definition.

2.3.2. Intermodal transport and freight terminals performance

According to the major trend found in the literature review, it has been considered appropriate to analyze indicators in this section distinguishing between operational and financial performance measures and, on the other hand, indicators related to quality service, environmental and sustainable measures.
Operational and financial performance indicators

In the maritime and seaport terminals field, many indicators have been defined to compare performance. Thomas and Monie (2000) stated the measurement of port or terminal efficiency is of particular importance because they are vital to the economy of the region and to the success and welfare of its industries and citizens.

Traditionally such measurements have been focused on cargo-handling productivity indicators at berth (UNCTAD, 1976; Bendall and Stent, 1987; Ashar, 1997), by measuring a single factor productivity (De Monie, 1987) or by comparing actual with optimum throughput over a specific time period (Talley, 1998).

Since then, the number of port performance studies has increased roughly and can be organized in three groups according to its approach (González and Trujillo, 2009): (1) studies that use partial indicators of productivity but do not analyze the joint contribution of all inputs to production nor give an acceptable treatment to multi-output processes; (2) studies that deploy simulation tools and queueing theory to analyze operations and processes from an engineering view; and (3) a new generation of studies based on formal efficiency measures stemming from the work developed by Chang (1978). In this view, two approaches namely Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) have been utilized to analyze port performance in terms of technical efficiency (González and Trujillo, 2009; Tongzon, 2011; Cullinane et al., 2005; etc.).

Nevertheless, this kind of approaches falls beyond the scope of this research project, since the target is developing a decision-making tool for decision-makers in intermodal transport and not to compare intra-port performance of on-going intermodal freight terminals, although some concepts and approaches could be adapted. In addition, these techniques require large amounts of data and makes their calculation quite difficult and complex due to its stochastic character.

Regarding the use of performance indicators in ports and container terminals, it should be firstly mentioned the original performance indicators that were proposed by UNCTAD (1976) and classified in two groups: financial and operational indicators.

Then, Owino et al. (2006) were able to identify up to 30 different performance indicators in 18 different papers. As an example, Le-Griffin and Murphy (2006) proposed various
productivity indicators as well as utilization rates at crane, berth, yard, gate, and gang levels. Due to the vast number of indicators, Trujillo and Nombela (1999) and Bichou and Gray (2004) stated that all performance indicators can be roughly grouped in three categories: physical, productivity and economical and financial related; whereas Thomas and Monie (2000) suggested that measures can be divided into four categories also: production (throughput measures), productivity, utilization and service measures.

Other researchers such as Chung (1993), Talley (2007), Longo et al. (2013), Ducruet et al. (2004) and Hakam (2015) consider an additional category of operational performance measures namely, time-related indicators. These kind of indicators could largely illustrate the capability of ports and terminals in terms of operational and service quality performance showing how efficiently ports serve the customers. The most common used indicators in that sense are the average turnaround time and the dwell time which is the number of days a unit of cargo remain at the terminal. In that context, Cariou (2012) and Suarez-Aleman et al. (2013) disaggregated turnaround time (port time) in the combination of several components such as port access, waiting, maneuvering, berthing, productive (service) and idle time, which can be applied for the main actors of an intermodal terminal (trucks, trains and vessels). Indeed, the time between ship arrival and departure, for many years has been described as one of the major indicators measuring time efficiency of ports, although it is not reported by ports regularly (De Langen, Nijdam, Horst, 2007). Finally, the time for customs and other administrative procedures could also be considered.

As regards to financial performance, the port’s performance can be evaluated over time from a single-port approach or relative to the performance of other ports (multi-port approach) which generally relay upon frontier statistical models (DEA and SFA).

Traditional indicators were firstly introduced by UNCTAD (1976) such as the cargo handling revenue, contribution per ton or the capital equipment expenditure per ton of cargo, etc. but usual financial statements (income, profit and loss account, balance sheet) related to the tonnage of cargo handled at the port/terminal.

However, regarding the objective of the INTERMODEL project and following Talley (2007), a port/terminal should be evaluated from the standpoint of technical efficiency, cost efficiency and effectiveness by comparing its actual throughput with its economic technically efficient optimum throughput, cost efficient optimum throughput and
effectiveness optimum through-put, respectively. In that sense, deriving from a previous work of Talley (1996), 17 performance indicators with respect to the cost/technical efficiency and effectiveness were proposed. From this research work, it is worthy to highlight those indicators that try to perform the maximization of annual throughput subject to a profit constraint, bearing in mind operating, financing and maintenance costs.

Marlow and Paixo (2003) also included financial indicators within a basis framework for measuring the multimodal process effectiveness relative to the objective of minimizing door-to-door cost in order to provide a better customer satisfaction and improved performance. These indicators were the overall transport cost, ship costs by unit of cargo carried and port costs by unit of cargo handled. In addition, and beyond operational port performance measures, Marlow and Paixo (2003) highlighted the importance of measuring port effectiveness in the context of the need for leanness and agility in port operations, and suggested a set of new indicators to reflect increased visibility within the port environment and along the entire logistics transport chain.

Alternatively, to classic financial measures, De Langen et al. (2007) focused on the regional economic impact of the ports and on the attractiveness of the port as a location for port-related industries. Therefore, port-related employment and value added were also used as port performance indicators, concept that could be extended to intermodal freight terminals as well.

Regarding performance measures of intermodal freight terminals, Ferreira and Sigut (1993) considered that the major determinants on terminal performance were lifting equipment and labor productivity, pick-up/delivery cycle times, track and physical layout, train reliability, management information systems and work practices. According to them, the most useful performance indicators are related to the lifting equipment performance (equipment availability, reliability and operational productivity) and the financial performance distinguishing between the ones used to monitor performance of the terminal on an ongoing basis, and those which address the long term financial viability of terminal operations. In particular, the terminal operating cost and the overall terminal cost (including capital provision) per container handled are the indicators required to manage a terminal.
To sum up, Table 1 shows the most common indicators as regards to operational and financial performance used for measuring namely port performance, seaport terminals and intermodal freight terminals.

Table 1. Most common operational and financial indicators found in the literature review

<table>
<thead>
<tr>
<th>Category of performance indicator</th>
<th>Subcategory of performance indicator</th>
<th>Performance indicator</th>
<th>Main sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Productivity/utilization</td>
<td>Quay productivity/utilization</td>
<td>UNCTAD (1976)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Terminal area productivity/utilization</td>
<td>Ferreira and Sigut (1993)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Storage area utilization</td>
<td>Le-Griffin and Murphy (2006)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gate utilization</td>
<td>Hakam (2015)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Berth occupancy</td>
<td>Thomas and Monie (2000)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Labor productivity/utilization</td>
<td>Talley (1996)</td>
</tr>
<tr>
<td>Time-related</td>
<td>Turnaround time</td>
<td></td>
<td>Le-Griffin and Murphy (2006)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waiting time</td>
<td>Cariou (2012)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Service time</td>
<td>Chung (1993)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maneuvering time</td>
<td>De Langen, Nijdam and Horst (2007)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Berthing time</td>
<td>Ducruet et al. (2004)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Idle time</td>
<td>Marlow and Paixao (2003)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cut-off time</td>
<td>Nam et al. (2002)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dwell time</td>
<td>Suarez-Aleman et al. (2013)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total time delays</td>
<td>UNCTAD (1976)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time for administrative procedures</td>
<td>Pachakis and Kiremidjian (2004)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tahar and Hussain (2000)</td>
</tr>
</tbody>
</table>
### Quality service and environmental performance indicators

Beyond financial and operational performance measurements, the literature review shows how organizations, ports and terminal operators also focus on indicators related to product quality, flexibility and reliability, product variety and innovation.

Regarding port terminals and, for extension any kind of freight terminal, **quality indicators** are waiting time over service time, berth occupancy rate and total turnaround time - and its two components, service time and waiting time-, among others. In all cases considering both, average values and their probability distribution function (Huynh and Walton 2005, Dragović et al. 2005 or Henesey et al. 2003). Actually, authors like Ballis (2004) or Henesey (2006) consider waiting time as one of the most important indicators when evaluating the quality/performance of a terminal and Notteboom (2006) related the influence of time factor and delays due to port congestion on liner shipping schedule reliability.

Waiting time over service time ratio is a performance indicator found in a broad range of papers, from Bassan (2007) to UNCTAD (2006) or Fourgeaud (2000). It expresses the idea that ships with less cargo to discharge cannot afford waiting as long as ships which may have several times more cargo. However, this indicator can be misleading since its

<table>
<thead>
<tr>
<th>Category of performance indicator</th>
<th>Subcategory of performance indicator</th>
<th>Performance indicator</th>
<th>Main sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Investment and funding</td>
<td>Infrastructure construction</td>
<td>Ferreira and Sigut (1993)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equipment purchase</td>
<td>UNCTAD (1976)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Profitability</td>
<td>Chung (1993)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turnover</td>
<td>Talley (2007)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Revenues/Expenditures</td>
<td></td>
</tr>
<tr>
<td>Costs and pricing</td>
<td>Labour costs</td>
<td>Ferreira and Sigut (1993)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Equipment costs</td>
<td>Marlow and Paixao (2003)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Infrastructure costs</td>
<td>Talley (1996)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maintenance costs</td>
<td>UNCTAD (1976)</td>
<td></td>
</tr>
</tbody>
</table>
value increases as the turnaround time for a ship in port decreases, due to, for instance, a better performance of the terminal operative.

Berth occupancy rate, in turn, is commonly used as a means to express the degree of congestion a specific terminal is facing. Usually, a maximum waiting probability is given, from which the maximum berth occupancy can be obtained by means of either simulation or simplified queuing problems (see Bassan (2007), for instance). However, those numbers depend as well on the terminal typology whether bulk, container (the most studied kind) or RoRo, the arrivals traffic pattern, the number of berthing points and the service time as well as the maximum waiting time allowed (Agerschou, 2004; Fourgeaud, 2000) and, therefore, cannot define quality without help of any other indicators.

Later on, the quality of service issue was also considered a key role in the design and operation of intermodal freight terminals (Ballis, 2004). This was introduced through the Level of Service concept that was developed to provide a measure of the comfort and convenience experienced by system users. In that sense, Ballis (2004), following the conclusions drawn by the project IQ by the European Commission (Mathonnet, 2000), proposed quality standards and were quantified through a limited number of indicators that are classified according to an A-F scale.

Service (quality) is tightly linked with time measurements to complete the processes affecting the customer (Morales-Fusco et al., 2010). In that sense, the indicators that are directly affecting time-related performance identified in the literature are: waiting time of the user in the system, reliability (no delays, no wrong delivery), flexibility (if a system can easily respond to changes in requirements), qualification (terminal’s capability), terminal accessibility during the day which can be both identified as the opening and closing time of the terminal and in regard to physical access. Additionally, safety and security (% of lost or damaged cargo) should be considered as quality related indicators.

On the other hand, energy efficiency and emissions have gained importance in recent years since minimizing the environmental impact of transport has become a cornerstone of transportation policies at an EU level and in general, while accident-free transport is in the interest of all parties involved. For example, the PPRISM project (ESPO, 2010) developed a port performance dashboard of indicators at European level in which socio-
economic impact and environmental performance indicators were included together with other kind of categories (market, logistic chain, operational and governance); and the Delft University developed a model that determines transport cost and emissions related to intermodal transport chains (Rigo et al., 2007). The environmental indicators (Litmann, 2007) range from air emissions to noise hindrance, erosion of river banks, habitat loss and disturbance of animal habitats. The energy consumption and the use of renewable fuels together with transport accidents were also recommended.

As regards to green performance measurements, environmental impact is considered besides time, cost, quality, volume, flexibility (Andersen and Fagerhaug, 1999). Air pollution, energy recovery and recycling were used to measure the environmental performance in the green supply chain management and performance measurement system (Hervani, 2005). In Rothenberg (2005), they discuss the performance indicators used to do environmental benchmarking in the automobile industry. The metrics they use include regulatory, gross emission efficiency and life cycle.

The Halifax Regional Municipality (GPI, 2008) also intended to provide sustainable transportation indicators. The energy consumption, greenhouse gas emissions, space taken by transport facilities, access to public transportation are some examples used to evaluate transportation system performance in Halifax region.

As regards to the performance assessment for intermodal chains, Rigo et al. (2007) introduce a sustainable transport performance indicator which is a global score obtained by analyzing environmental, economic, logistic and safety performance in an integrated way. In particular, they focused on air emissions (CO2, CO, NOX, SOX and PM) measured in grams per ton of cargo.

The potential of environmental indicators has been found when analyzing intermodal transport and the location of dry ports. Many studies (Lv and Li, 2009; Wei et al., 2010; Hanaoka and Regmi, 2011) consider the environmental protection, the reduction of air emissions and port congestion or even the promotion of intermodal transport through the modal shift as potential decision-indicators.

With regards to the socio-economic impacts, the PPRISM project distinguished indicators in two categories: expressed in absolute figures and expressed in relative terms. In relation to the first category, we could find the gross value added, the
employment measured in full-time equivalent, fiscal revenues which provides an insight into how port activities contribute to the flow-back to the treasury of a country/region, the investment and trade values that provide an insight of the importance of the port for international trade. Based on the analysis of indicators expressed in absolute terms, a number of indicators could also be useful for a variety of purposes: value added per ton, employment per unit of land and/or value added per invested euro by the public sector.

Similar to previous section, Table 2 resume the most common measures and indicators regarding quality service, environmental, sustainable and socio-economic issues.

Table 2. Most common quality service, environmental and economic impact indicators found in the literature review

<table>
<thead>
<tr>
<th>Category of performance indicator</th>
<th>Subcategory of performance indicator</th>
<th>Performance indicator</th>
<th>Main sources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flexibility</td>
<td>No delays, no wrong delivery</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reliability and service care</td>
<td>Employees qualification</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accessibility and connectivity</td>
<td>Incidence of train/vessel delay in departure (%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Schedule reliability</td>
<td></td>
</tr>
<tr>
<td>Environmental/sustainable</td>
<td>Accidents</td>
<td>Number of transport accidents, fatalities, injured, polluting accidents, etc.</td>
<td>Litman (2007)</td>
</tr>
<tr>
<td></td>
<td>Noise</td>
<td>Crash casualties and costs</td>
<td>Litman (2016)</td>
</tr>
<tr>
<td></td>
<td>Air pollution</td>
<td>Air pollution emissions</td>
<td>GPI (2008)</td>
</tr>
<tr>
<td></td>
<td>Climate change</td>
<td>Embodied emissions</td>
<td>Marsden, et al (2005)</td>
</tr>
<tr>
<td></td>
<td>Water pollution</td>
<td>Noise pollution exposure</td>
<td>Hanaoka and Regmi, 2011</td>
</tr>
<tr>
<td></td>
<td>Habitat loss</td>
<td>People exposed to traffic noise above 55 LAeq</td>
<td></td>
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<tr>
<td></td>
<td>Hydrologic impacts</td>
<td>Impervious surface coverage</td>
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<tr>
<td></td>
<td>Energy consumption</td>
<td>Habitat preservation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sprawl</td>
<td>Community livability ratings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Congestion</td>
<td>Water pollution emissions</td>
<td></td>
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</tbody>
</table>
The use of performance indicators in the port industry has increased in recent years. For instance, the Port of Rotterdam uses 32 KPIs to grade port operations and assess the current quality of the services. Similarly, the Port of Hamburg, in the framework of project StratMoS (Doderer, 2011), developed three sets of indicators -depending on the point of view of the stakeholder being involved- to assess port performance, qualitatively, and depending on the user considered. The system is usually automated and can be checked dynamically, for instance, the Port of Venice developed the LogiS system to follow up how several KPIs perform.

Finally, we would like to highlight, the project COCKPIIT (Posset et al., 2010) that presented and analyzed the different areas of application for intermodal performance indicators. This concept intended to provide a new approach in the domain of intermodal performance indicators from a door-to-door perspective in which transshipment nodes (terminals) are part of it. The core element of this innovative approach was the so-called transport pyramid that includes all components of intermodal transport. Actually, they considered three different dimensions:

- System dimension: chain, entity, process and resource perspective;
- Performance dimension: operational, service quality, financial and environmental;
- Transport mode view: rail, road and inland navigation.

Then, by combining the three different dimensions several indicators were proposed. For example, under the operational performance we could find the total lead time, utilization, productivity and throughput. The service quality dimension is related to

<table>
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<tr>
<th>Category of performance indicator</th>
<th>Subcategory of performance indicator</th>
<th>Performance indicator</th>
<th>Main sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of renewal fuels</td>
<td>Energy efficiency</td>
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</tr>
<tr>
<td></td>
<td>Vibrations</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mode split</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Socio-economic impact</td>
<td>Economic impact</td>
<td>Value added per ton</td>
<td>ESPO (2010)</td>
</tr>
<tr>
<td></td>
<td>Return on investment</td>
<td>Employment per unit of land</td>
<td>De Langen et al. (2007)</td>
</tr>
<tr>
<td></td>
<td>Port-related employment</td>
<td>Value added per invested euro by the public sector</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Port value added</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
three main subcategories (flexibility, reliability and service care and safety and security). The financial performance includes resulting costs for operation, maintenance and final prices for the customers. Finally, environmental performance was focused on emissions, noise pollution, energy consumption land take and conservation.

2.4. **Adoption of performance indicators to the BIM concept**

In such context, the literature regarding the use of performance measures is mainly focused on the benefits due to the use of BIM methodologies in construction projects (Fazli et al., 2014; Sarkar et al., 2015; McAuley et al., 2013). In particular, this kind of indicators try to measure the effectiveness of BIM as a tool in project management. They measure whether a project is considered successful in relation to budget, project schedule, satisfaction of the client, or according to technical specifications. That is, they compare the cost and time reduction or control with traditional Design-Bid-Build approach or even the improvements in communication between main stakeholders involved.

The only KPI that could be currently integrated in BIM tools might be the cost estimation at any point in the design phase which can be used as input data to evaluate financial indicators.

Therefore, the literature showed a need for integrating and developing a tool in BIM in which performance measures related to the operating phases (post-building) of transport infrastructure should be included. This will help decision-makers to deliver a project successfully, not only in the coordination, communication and construction planning but also in financial, operating, environmental, safety and quality terms once on duty. It should be highlighted that the three last issues are related to the 6th, 7th and 8th BIM dimensions which are currently being developed.

To conclude the literature review, the **potential contributions** of this research project as regards to the use of performance measures is threefold:

1. A selected group of performance indicators organized in five categories are proposed in order to measure and monitor the performance of intermodal freight terminals (road/rail and road/rail/sea facilities) in a holistic approach. These indicators will evaluate (1) the performance of terminal operations from both technical and economical point of view; (2) the external effects as regards
to sustainable, safety and environmental terms; and (3) the financial requirements from the investor/management point of view.

2. The literature review showed that operational and financial performance indicators are vastly employed for seaport and intermodal terminals but quality service, sustainable and environmental measures are particularly required for evaluating freight terminals (transhipment nodes within supply chains) and its impact on its neighbourhood. Individual contributions were found from a sustainable and environmental point of view but an integrated approach is required for intermodal freight terminals.

3. The integration of selected performance indicators in BIM tools for assessing the performance of intermodal freight terminals in both construction and operating phases will constitute a great contribute since just construction cost indicators are currently integrated in BIM.
3. Processes at intermodal terminals

In order to evaluate the performance of intermodal freight terminals and its interaction with the hinterland and railway network as a whole, it is necessary to first understand the operations and processes of intermodal terminals, how they interact with each other and how cargo is transhipped between modes of transport.

Intermodal freight terminals are interfaces within intermodal transport chains where transhipment of loading units between different modes of transport (ship, truck and train) take place, and they depend widely on the trunk haul operation forms and the hinterland transport.

Terminal processes can be organized according to the following subsystems:

- **Delivery and receipt operations**: It refers to those terminal operations required to deliver or receive cargo from a truck or train. This kind of operations includes gate operations in which trucks and trains are identified and registered at land gates and then, loading and unloading operations. Depending on the terminal layout, the container or ITU will be picked-up or delivered by internal transportation equipment or by yard cranes in corresponding transfer points.

- **Storage operations**: The storage yard serves as a buffer for loading, unloading and transhipping cargo. According to the type of cargo, two ways of storing can be distinguished: storing on chassis or directly with the truck/trailer and, stacking on the ground in which cargo is piled up. Usually, the container yard is served by several yard cranes such as rubber-tired or rail-mounted gantry cranes (RTG/RMG), straddle carriers or automated stacking cranes (ASC) in the case of an automated terminal.

  The process of storing (or retrieving) a container or ITU includes the time for adjusting the RTG, picking up the container or ITU, moving toward the allocation place and downloading the container or ITU.

- **Transfer operations**: It refers to transport operations within the intermodal terminal. It includes those moves from the storage yard to the gate, from the shore to the yard and, when needed, to relocate cargo within the storage area. This horizontal transportation moves are performed by internal trucks, straddle carriers or even reach stackers.
- **Ship/Train-to-shore operations**: It refers to quayside operations at seaport terminals or rail track operations at intermodal freight terminals in which loading and unloading of ships and/or trains is carried out by quay cranes and lifting equipment (gantry cranes), respectively.

The Figure 1 below shows a typical layout of an intermodal freight terminal including relevant infrastructure and terminal equipment according to the subsystems abovementioned.

![Figure 1. Inland terminal layout](image-url)

Source: COCKPIIT Final Report (Posset et al., 2000)

Other common logistical functions at intermodal freight terminals are: packing/groupage, cargo consolidation, warehouse services, trucking service, maintenance and repair of vehicles/equipment/means of transport, provision of equipment/TEUs/ITUs, etc.
4. Methodology for KPI definition

This section outlines the methodology adopted on this task to establish a suitable short list of recommended KPIs for adoption in the ‘investment decision making tool’. This tool will be useful for both public institutions and private organizations and based on the application of the BIM modelling technology to the logistic processes and the terminal operations management combined with simulation tool models.

As shown in the literature review (Section 2), deriving KPIs is not a simple accounting task, as it must include a deep understanding of the business and/or operations to be successful. As such, different Performance Measurement Systems (PMS) were proposed to determine and monitor KPIs. The most well-known approach is the Balance Scorecard developed by Kaplan and Norton (1996) which links the vision and strategy of an organization between four perspectives (customer, financial, internal business processes and learning and growth). Then for each strategic organization’s objective a performance measure and target values are defined. Later, different measures and solutions are proposed to achieve it.

Other PMS include the performance measurement matrix implemented by Keegan, Eiler and Jones (1989) and the Performance Prism (Neely, Adams and Kennerley, 2002) which was used in the project COCKPIIT (Posset et al., 2010) in order to provide a new approach in the domain of intermodal performance indicators from a door-to-door perspective in which transshipment nodes (terminals) are part of it.

However, above techniques require the user to consider potentially dozens of relationships at one time. Thus, there is a demand for simple KPI selection processes such as the approach suggested by Horst and Weiss (2015) which focuses on manufacturing processes and excludes much of the complexity found in other PMS.

In such context, taking inputs from the previous approaches, the method of KPI and PI selection proposed for the INTERMODEL EU project is introduced as follows:
1. **Identification of the strategy and mission of the organization**

   The first step for selecting feasible KPIs and PI is identifying the strategies that an organization would like to achieve. That is, the selection of those performance indicators must be aligned with the strategies in order to assess and monitor major decisions and measures related to each strategy.

2. **Identification of stakeholders involved**

   In order to make appropriate decisions it is really important to identify all those stakeholders involved and affected by those decisions. Thus, selected performance measures should take into account the different points of view.

3. **Identification of the different perspectives that should be considered in the performance system**

   The objective of identifying the different perspectives involved in the performance system is minimizing information overload by limiting the number of measures used. Actually, if forces managers and decision-makers to just focus on handful measures that are most critical for an organization.

4. **Identification of particular strategic goals**

   The target of this stage is identifying those objectives that an organization’s strategy is trying to achieve. For instance, under the strategy of increasing the operational efficiency a strategic goal could be the improvement of equipment productivity.

5. **Selection of effectiveness criteria and feasible KPIs and PI set**

   The selection of feasible KPIs and PI will result in a comparative scoreboard which will be used to assess different terminal layouts, operational processes, allocation, type of equipment and materials, etc. Due to the importance of this stage, the authors have followed the sequential phase depicted in Figure 2.
First of all, a revision of the literature and main research projects regarding the use of performance measures within supply chain, freight terminals, multimodal transport and logistics has been undertaken. In parallel, main partners involved in the industry of intermodal transportation (terminal operators, public administration, road freight providers, railway operators and experts in transport and logistics) were consulted in order to provide their inputs and experiences regarding the use of performance measures in their daily decisions. The KPI list generated by the partners’ consultation is included in Appendix I of this deliverable.

As a result of this initial phase, a list of KPIs was obtained. Then, these indicators are assessed qualitatively against the following criteria:

- Data access, referring to the easiness in researching the information needed to calculate the performance indicator;
- Effort, in case data has to be collected by the operator, then it is referred to the amount of effort that it takes;
- Clarity, defined as the ability to easily understand the performance indicator;
- Measurability, on basis of comparable data;
- Transferability, referring to the possibility of using the same data source in terminals modelled from different regions or Member States.
- SMART criteria: It is the acronym standing for Specific, Measurable, Attainable, Relevant and Time-bound.
6. **Scoring process and determination of overall KPI score (aggregation method)**

Following the objective of developing a decision-making tool, it has been considered the possibility of combining the values of different KPIs in a single and/or reduced number of values. This section outlines two possible methods to calculate the aggregated indicator(s). However, the choice of the final methodology should be done after further analysis is done and some KPI and PI values are obtained to be used as benchmarking. That is, at completion of WP2, WP4 and WP8.

Ideally, the aggregated indicator(s) (AIs) should cover all stakeholders, performance dimensions and scopes of INTERMODEL project, either by providing a value for each field considered or by considering them equitably in its final form.

In any case, the analysis proposed has to be multivariate considering the multiple sources (KPI and PI values) available to evaluate. Despite the quantity of data available, the ability to obtain a clear picture of what is going on and make proper decisions is a challenge.

Possible methodologies for the multivariate analysis:

- **Total factor productivity (OECD, 2002):** Total factor productivity (TFP) derives directly from differentiating ‘cost/input’ from ‘profit/output’ indicators. That is, assessing, how much it can be achieved (outputs) considering the investment (inputs) made. The formulation of this AI is rather simple to obtain since is calculated directly by dividing all outputs contribution by all inputs.

\[ TPF(k) = \frac{Y(k)}{X(k)} \]

With:

\[ Y(k) = \sum_{i} v_i y_i(k), \quad \sum_{i} v_i = 1 \]

\[ X(k) = \sum_{i} w_i x_i(k), \quad \sum_{i} w_i = 1 \]

To construct such AI it will be necessary to first identify which KPIs are outputs and which are inputs. Some of them will come straightforwardly (total throughput or Work places would be desirable outputs whereas CAPEX
and OPEX would be inputs) but some others might be more difficult to classify (equipment utilization, to say one).

Another difficulty would be weighting the relative importance of each input and output on the final score. In that sense, different weighting methodologies, like the ones defined below, could be applied to each set of variables.

- **Delphi method (Loo 2002):** The Delphi method is a methodology to weight variables in a multi-criteria analysis using the opinions of panels of experts in a structured manner. The technique is designed as a succession of communication processes which aims to achieve a convergence of opinion on specific issue, in this case, the weight assigned to each indicator.

  The method needs of a board panel of experts covering all stakeholders affected by the evaluated alternatives, experts on the topic and policy makers. The members of the panel will be consulted in multiple (3-4) rounds by the coordination of the consultation process. Each time a structured questionnaire will have to be answered anonymously by all panel members. The results will be then assessed quantitatively and qualitatively and redistributed to the panelists together with further and more precise questionnaires focusing on the areas where consensus has not been found.

  The main issues with the Delphi method, besides untying irreconcilable mixed opinions is the possible lack of representativeness of the panel of experts. This problematic can be partially addressed triangulating the results (for instance with independent samples).

- **ELECTRE methods:** ELECTRE (ELimination and Choice Expressing REality) method is a family of multi-criteria decision analysis dating back to the mid 1960s and first proposed by Bernard Roy (1968) and updated thorough the years and applied to multiple fields related where choices or rankings between multiple alternatives have to be done.

  The main idea behind the method is to compare each pair of alternatives comprehensively (using all KPIs) and assess the outranking relationships
between them, allowing to disregard some alternatives and the KPIs that do not add value in the decision-making process.

In this case, the application of the method will result in a shortlist of KPIs (and alternatives). The shortlisted alternatives can then be assessed by any other method or, using again the ELECTRE approach, successively until the final weights and winning alternative are obtained. As a result, the final set of KPIs and their relative importance would vary each time.
5. Selection and definition of KPI

In this section, the methodology previously proposed is applied for the scope of the INTERMODEL EU project in order to get a selection of KPIs and PIIs that will be integrated in the resulting BIM methodology.

5.1. Identification of strategies and goals

The first steps before defining the list of KPIs that will drive terminal performance involve identifying the strategic actions and its goals. For the particular case of intermodal freight terminals, future and current working intermodal facilities should focus on:

1. **Optimising the economic performance** of the terminal, considering both the investment in construction phase and the reduction of the costs during its operation (including the cost related to maintenance) and maximising revenues. Main party involved in this optimization is the investor, who promotes the terminal.

2. **Ensuring the service quality** within the terminal: Maximize efficiency and reduce congestion in the seaport/inland terminal by aligning loading, discharge and gate operations; Minimize turnaround time of trucks, trains and/or vessels by ensuring containers are placed strategically for loading, and that there will be areas available for unloading; Maintain haulier truck service levels so that they can be served in a timely manner;

3. **Minimizing the effects of the hub on the immediate surroundings**, identifying the impact on the access road network and on the railway network. It is essentially important to identify possible periods of congestion in both networks, in order to make the most appropriate decisions to avoid these periods during the project. The key stakeholders are the connection infrastructure operators.

4. **Reducing the environmental impact and external costs** during construction and operation phases. In this case, it is especially relevant to reduce greenhouse gas emissions to the atmosphere in order to minimize the climate change effects. All the actors involved (public administrations, investors, terminal operators, railway operators) must be interested in this reduction;
5. **Increasing the benefits** obtained within the region because of the activities associated to the terminal operation (social impacts).

5.2. **Identification of actors involved**

Different actors are involved in a seaport/inland terminal, each having its own strategy depending on its business. The most relevant stakeholders are indicated in Table 3.

<table>
<thead>
<tr>
<th>Actors</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hinterland / Rail network</strong></td>
<td></td>
</tr>
<tr>
<td>Public authorities</td>
<td></td>
</tr>
<tr>
<td>Planning agency</td>
<td>Modal shift</td>
</tr>
<tr>
<td></td>
<td>Economic development of the metropolitan area</td>
</tr>
<tr>
<td>Port authority</td>
<td>Modal shift</td>
</tr>
<tr>
<td></td>
<td>Port throughput</td>
</tr>
<tr>
<td><strong>Operators</strong></td>
<td></td>
</tr>
<tr>
<td>Rail operators</td>
<td>Volumes</td>
</tr>
<tr>
<td>Haulage companies</td>
<td>Door-to-door transport</td>
</tr>
<tr>
<td>Shipping lines</td>
<td>Haulage</td>
</tr>
<tr>
<td></td>
<td>Container logistics</td>
</tr>
<tr>
<td>Terminal operators (port, rail)</td>
<td>Management</td>
</tr>
<tr>
<td></td>
<td>Intermodal</td>
</tr>
<tr>
<td></td>
<td>Storage</td>
</tr>
<tr>
<td>Freight forwarders</td>
<td>Haulage</td>
</tr>
<tr>
<td></td>
<td>Consolidation</td>
</tr>
<tr>
<td></td>
<td>Deconsolidation</td>
</tr>
<tr>
<td></td>
<td>Buffer</td>
</tr>
<tr>
<td>Investor</td>
<td></td>
</tr>
<tr>
<td>Private companies</td>
<td>Success in terms of financial result</td>
</tr>
<tr>
<td>Investment organizations</td>
<td>Operating profitability</td>
</tr>
</tbody>
</table>

In further analysis, when evaluating outputs from BIM and simulation models, it will be necessary to take into account the conflicts of interest that can appear according to the different key stakeholders involved.
5.3. Identification of the different perspectives for performance system

The perspectives proposed for the performance system have been chosen taking into account the strategies and stakeholders involved, and on the other hand, according to data gathered in Section 2.3.2 and after a consultation to main involved partners.

The resulting performance dimensions are as follows:

1. Operational performance

   This performance dimension includes indicators that describe effectiveness, as a measure of the capability of producing and intended result, and efficiency, as a measure for producing results taking into account used resources.

   These indicators are grouped according to the following subcategories:

   - Productivity and throughput
   - Efficiency (productivity – utilization)
   - Efficiency (productivity – time related)
   - Total traffic

2. Financial performance

   The financial performance dimension is focused on evaluating how efficiently and effectively terminal resources are used to generate services and increase shareholder value or how investments are traduced into revenues and benefits.

   In particular, the following financial factors should be covered:

   - Financial indicators
   - Costs
   - Revenues
   - Benefits
   - Employment
   - Maintenance costs
   - Investment on modal shift
3. **Quality performance**

The quality performance dimension links the service quality performance with customer service quality needs. The indicators should cover the following quality factors:
- Service quality (time-related indicators)
- Accessibility
- Damages

4. **Environmental performance**

The environmental performance is focused on the environmental impact of intermodal freight terminal activities on the surrounding area. In that sense, the indicators cover the following sustainable/environmental issues:
- Energy efficiency
- Alternative fuels
- Climate change
- Road and rail network congestion
- Air pollution
- Noise pollution
- Health

5. **Safety performance**

The safety performance dimensions that usually is included in the quality service dimensions is focused on analysing whether safety-related actions are achieving the pursued results and whether such actions are leading to less adverse impact on human health, environment or property from an accident. These indicators should cover the following dimension:
- Accidents/Collisions

It should be mentioned that the environmental and safety performance dimensions are related to the 6th and 8th dimensions of BIM methodologies. Therefore, it has been
considered appropriate to be treated separately in order to give more emphasis within the decision-making process.

Later, once the main stakeholders and performance dimensions for the decision-making process are identified and analysed, the following step is to create the **basic framework for the KPIs and PIs selection**. This is represented through the matrix introduced in Table 4.

### Table 4. Performance dimensions - Stakeholders matrix

<table>
<thead>
<tr>
<th>Performance dimension</th>
<th>Stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Investor</td>
</tr>
<tr>
<td>Operation</td>
<td></td>
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<tr>
<td>Finance</td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td></td>
</tr>
</tbody>
</table>

5.4. **Selection of effectiveness criteria and feasible KPIs and PIs set**

According to the methodological procedure from Figure 2 and taking into account the previous strategic goals, performance dimensions and stakeholders, the Table 5 includes the proposed key indicators’ categories.

### Table 5. Indicator’s categories proposed for the KPIs and PIs set

<table>
<thead>
<tr>
<th>Performance dimension</th>
<th>Stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Investor</td>
</tr>
<tr>
<td>Operation</td>
<td>Productivity</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Finance</td>
<td>ROI</td>
</tr>
<tr>
<td></td>
<td>Costs</td>
</tr>
<tr>
<td></td>
<td>Revenues</td>
</tr>
<tr>
<td>Quality</td>
<td>Service quality – time</td>
</tr>
<tr>
<td></td>
<td>Damages</td>
</tr>
<tr>
<td>Environment</td>
<td>Energy efficiency</td>
</tr>
<tr>
<td></td>
<td>Alternative fuels</td>
</tr>
<tr>
<td>Safety</td>
<td>Accidents costs</td>
</tr>
</tbody>
</table>
This short-list was obtained as a result of the discussions held during the working meeting in La Spezia and Melzo (Italy) between partners, including terminal operators, logistics companies and a port authority.

Secondly, once the main categories are identified (items introduced in matrix cells), the particular performance indicators are proposed (Table 6) for each category by considering, on one hand, intermodal terminal operations and, on the other hand, the three different scopes that the INTERMODEL project takes into account:

- **Intermodal terminal**: in order to measure characteristics of its work, including efficiency, effectiveness, reliability, safety and sustainability;

- **Hinterland**: in order to measure the environmental and social impact on the surrounding area and the capacity and accessibility to local transport infrastructure, mainly roads;

- **Railway network**: in order to assess the performance of the rail infrastructure connecting logistic nodes in terms of capacity, reliability, environmental impact and operation and maintenance costs.

<table>
<thead>
<tr>
<th>Table 6. KPI list for intermodal freight terminals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Performance dimension</strong></td>
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<tr>
<td>---------------------------</td>
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<tr>
<td><strong>OPERATION</strong></td>
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<td></td>
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<tr>
<td>Performance dimension</td>
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<tr>
<td>-----------------------</td>
</tr>
<tr>
<td>FINANCE</td>
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<tr>
<td>QUALITY</td>
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<tr>
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<td></td>
</tr>
</tbody>
</table>
### Performance dimension | Stakeholder | Subgroup | Indicator | Scope | Goal |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVIRONMENT</td>
<td>Operator</td>
<td>Rail network congestion</td>
<td>Delays produced(^{(5)})</td>
<td>Rail network</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Public authority</td>
<td>Energy efficiency</td>
<td>Total consumption per num. of handled units</td>
<td>Terminal</td>
<td>1/4</td>
</tr>
<tr>
<td></td>
<td>Public authority</td>
<td>Alternative fuels</td>
<td>Use of alternative fuels/total consumption</td>
<td>Terminal</td>
<td>1/4</td>
</tr>
<tr>
<td></td>
<td>Public authority</td>
<td>Climate change</td>
<td>Carbon footprint</td>
<td>Hinterland</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Public authority</td>
<td>Air pollution</td>
<td>CO, NOX, SOC, PM emissions</td>
<td>Hinterland</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Public authority</td>
<td>Noise</td>
<td>Population exposed to high levels of traffic noise</td>
<td>Hinterland</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Public authority</td>
<td>Health(^{(3)})</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| SAFETY               | Public authority | Accidents | Num. of road accidents | Hinterland | 2/4 |
|                     | Public authority | Accidents | Num. of railway accidents | Rail connection | 2/4 |
|                     | Public authority | Accidents | Percentage of accidents related to hazard cargo | Hinterland | 2/4 |

\(^{(1)}\) Related to congestion  
\(^{(2)}\) Difficult to obtain  
\(^{(3)}\) Difficult to measure  
\(^{(4)}\) Conflict of interests  
\(^{(5)}\) When it affects both terminal and public road users

In the previous table, it can be observed that each proposed performance indicator is related to a performance dimension, stakeholder, category, scope and strategic goal (the number indicated correspond to the index defined in section 5.1).

Finally, since some performance indicators are dependent of others, it has been considered convenient to classify the proposed indicators in two levels:

1. **High-level performance indicators (KPIs)**, which are focused on big picture performance goals;
2. **Secondary level performance indicators (PIs)**, focused more on the daily processes in each area of an organization – in intermodal freight terminals e.g. different sections: cargo handling, container handling, shunting, shipping, etc.

As an example, the indicator turnaround time provides generic information regarding the quality of service or the productivity of an intermodal terminal while service time or berthing time just inform about the efficiency of loading/unloading operations without taking into account waiting times. Thus, the former indicators are categorized as performance indicators (secondary level) and the turnaround time as a KPI (high-level).

According to the above categorization, Table 7 shows the resulting classification.

<table>
<thead>
<tr>
<th>Key Performance Indicators (KPIs)</th>
<th>Performance Indicators (PIs)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operational</strong></td>
<td></td>
</tr>
<tr>
<td>1-Intermodal terminal throughput (volume)</td>
<td>28-Maneuvering time</td>
</tr>
<tr>
<td>2-Equipment utilization</td>
<td>29-Service time</td>
</tr>
<tr>
<td>3-Gate utilization</td>
<td>30-Berthing time</td>
</tr>
<tr>
<td>4-Labour utilization rate</td>
<td>31-Idle time (equipment)</td>
</tr>
<tr>
<td>5-Storage area utilization</td>
<td></td>
</tr>
<tr>
<td>6-Rail track utilization</td>
<td></td>
</tr>
<tr>
<td>7-Berth utilization</td>
<td></td>
</tr>
<tr>
<td>8-Turnaround time</td>
<td></td>
</tr>
<tr>
<td>9-Waiting time</td>
<td></td>
</tr>
<tr>
<td><strong>Financial</strong></td>
<td></td>
</tr>
<tr>
<td>10-Return On Investment (ROI)</td>
<td>32-Capital Expenditure (CAPEX)</td>
</tr>
<tr>
<td>11-Terminal’s profitability</td>
<td>33-Operational Expenditure (OPEX)</td>
</tr>
<tr>
<td>12-Operating efficiency (operating margin)</td>
<td>34-Corrective maintenance cost - equipment</td>
</tr>
<tr>
<td>13-Operating revenues per unit</td>
<td>35-Preventive maintenance cost - equipment</td>
</tr>
<tr>
<td>14-Operating benefits per unit</td>
<td>36-Corrective concrete structures maintenance cost</td>
</tr>
<tr>
<td>15-Direct jobs sustained by terminal activities</td>
<td>37-Preventive concrete structures maintenance cost</td>
</tr>
<tr>
<td>16-Indirect jobs sustained by terminal activities</td>
<td>38-Waiting time / turnaround time</td>
</tr>
<tr>
<td>17-Road and rail track maintenance cost</td>
<td>39-Use of alternative fuels from total consumption</td>
</tr>
<tr>
<td><strong>Quality, environmental and safety</strong></td>
<td>40-Accidents related to hazard cargo</td>
</tr>
<tr>
<td>18-Easiness of entry and exit from highways</td>
<td></td>
</tr>
<tr>
<td>19-Easiness of entry and exit from rail network</td>
<td></td>
</tr>
<tr>
<td>20-Energy consumption per handled unit</td>
<td></td>
</tr>
<tr>
<td>21-Carbon footprint per unit</td>
<td></td>
</tr>
<tr>
<td>22-Delays produced (reliability) – road</td>
<td></td>
</tr>
<tr>
<td>23-Delays produced (reliability) – railway</td>
<td></td>
</tr>
<tr>
<td>24-CO, NOX, SOC, PM emissions</td>
<td></td>
</tr>
</tbody>
</table>
| 25-Population exposed to high levels of traffic noise | }
### Key Performance Indicators (KPIs)

<table>
<thead>
<tr>
<th>Key Performance Indicators (KPIs)</th>
<th>Performance Indicators (PIs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>26-Number of road accidents</td>
<td></td>
</tr>
<tr>
<td>27-Number of railway accidents</td>
<td></td>
</tr>
</tbody>
</table>
6. Definition of KPIs and PIs

This section outlines the proposed list of KPIs and PIs which have emerged from the previous analysis. For each indicator a record sheet has been developed whose template is introduced in Table 8. In addition, the range of answers and information is included in the corresponding cells.

Table 8. Template for KPI & PI definition

<table>
<thead>
<tr>
<th>KPI name</th>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Operational, Financial, Quality, Environment, Safety]</td>
<td>[Investor, Terminal operator, public body]</td>
<td>[Terminal, Rail Network, Hinterland]</td>
<td>[Name]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description and objective:</th>
<th>Formula:</th>
<th>Unit:</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Describe the KPI and its objective]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input data and data source:</th>
<th>Frequency of measurement:</th>
<th>Calculation method:</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Describe which data is required and the exact location of the necessary raw data/raw information to calculate the metric of the KPI]</td>
<td>[Daily, monthly, annually, etc.]</td>
<td>[BIM, simulation tool, analytical]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Presentation of results</th>
<th>Evolution of the indicator:</th>
<th>Decision level:</th>
<th>Relationship with other indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Number or graphical]</td>
<td>[Panel; Historical data]</td>
<td>[Operational, Tactical and strategic]</td>
<td></td>
</tr>
</tbody>
</table>

Notes and comments:

Particular issues related to the KPIs that should be taken into account

Finally, each of the proposed and selected KPIs and PIs indicated in Table 7 are described in Appendix II.
7. Conclusions

The objective of this deliverable was to establish a set of Key Performance Indicators (KPIs) and Performance indicators (PIs) for the assessment of the layout design, building materials choice, operative planning, handling equipment selection and allocation of intermodal freight terminals through an ICT environment. In particular, a selection of feasible performance measures integrated in a dashboard would be integrated within the developed BIM framework methodology (BIM and simulation tools) resulting in a potential investment decision making tool that will be useful for both public institutions and private organizations and an important contribution to the research community since no previous works have been found in that sense.

In order to achieve the objective, a method composed by sequential stages was proposed to select feasible KPIs and PIs. The work was preceded with an extended literature review aimed at identifying the key performance indicators used by researchers and terminal managers and the most common KPI selection methodologies used to evaluate organizational performances.

The resulting proposed methodology focuses on handling and transport processes and excludes much of the complexity found in other PMS. At a glance, it involves the following steps:

1. Identification of the strategy and mission of the organization
2. Identification of stakeholders involved
3. Identification of the different perspectives that should be considered in the performance system
4. Identification of particular strategic goals
5. Selection of effectiveness criteria and feasible KPIs and PIs set
6. Scoring process and determination of overall KPI score (aggregation method)

As a result of its application to our study case (intermodal freight terminals), the dashboard for Intermodal Freight Terminals depicted in Figure 3 has been defined and proposed.
As it can be observed, five performance dimensions (operation, finance, quality, environment and safety) and three points of view (investor, operator and public body) have been considered for defining and selecting the feasible KPIs and Pls. In particular, 27 KPI and 11 PI have been defined, achieving a balanced role of the three main involved actors while covering the three main physical areas approached by this project: terminal, hinterland and railway network.

Finally, the main contributions of this study regarding the performance of intermodal freight terminals and its integration in the BIM methodology are:

1. A selected group of performance indicators organized in five categories are proposed in order to measure and monitor the performance of intermodal freight terminals (road/rail and road/rail/sea facilities) in a holistic approach. The
selected indicators evaluate (1) the performance of terminal operations from both a technical and economical point of view; (2) the external effects in terms of sustainability, safety and environment; and (3) the financial requirements to the investor/management.

2. The literature review showed that operational and financial performance indicators are vastly employed for seaport and intermodal terminals. In turn, quality service, sustainability and environmental measurements are particularly required for evaluating freight terminals (transhipment nodes within supply chains) and their impact on their neighbourhood. Finally, individual contributions were found assessing specific aspects on sustainability and environmental impact but an integrated approach is required for intermodal freight terminals.

3. The integration of the selected performance indicators to the BIM tools in both, construction and operating phases, of intermodal freight terminals will constitute a great contribution of this project. Currently, only construction cost indicators are included in BIM.
References


McAuley, B., Hore, A.V., West, R. (2013). Establishing Key Performance Indicators to Measure the Benefit of Introducing the Facilities Manager at an early Stage in the
D3.1 Study of the state of the art and description of KPI and KRI of terminals, hinterland mobility and rail network


D3.1 Study of the state of the art and description of KPI and KRI of terminals, hinterland mobility and rail network


Appendix I

This appendix includes the KPI and PI list proposed by the partners during the consultation carried out during the development of Task 2.1.
### D3.1 Study of the state of the art and description of KPI and KRI of terminals, hinterland mobility and rail network

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Short description</th>
<th>Priority</th>
<th>Access to data</th>
<th>Effort</th>
<th>Clarity</th>
<th>Measurable</th>
<th>Transferable</th>
<th>Scope</th>
<th>Point of view</th>
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<tbody>
<tr>
<td><strong>Financial performance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total Revenue</td>
<td>Total sales per period; indicates absolute performance against targets or previous periods</td>
<td>X</td>
<td>low</td>
<td>high</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
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<tr>
<td>OPEX (Operational Expenditure)</td>
<td>Main costs components (operations)</td>
<td>X</td>
<td>low</td>
<td>high</td>
<td>++</td>
<td>medium</td>
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<td>X</td>
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<tr>
<td>Total Costs</td>
<td>Sum of all terminal costs of a period</td>
<td>low/high</td>
<td>++ medium</td>
<td>yes</td>
<td>T X</td>
<td>X low</td>
<td>high</td>
<td></td>
<td></td>
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<tr>
<td>Cost of Sales</td>
<td>Especially 3party transportation costs</td>
<td>low/high</td>
<td>++ medium</td>
<td>yes</td>
<td>T X</td>
<td>X low</td>
<td>high</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff costs</td>
<td>In monetary terms</td>
<td>low/high</td>
<td>++ medium</td>
<td>yes</td>
<td>T X</td>
<td>X low</td>
<td>medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Costs of electricity, fuel, etc.</td>
<td>Energy costs</td>
<td>X low</td>
<td>high</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T X</td>
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<tr>
<td>Depreciation</td>
<td>Buildings, equipment, etc.</td>
<td>X low</td>
<td>high</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Revenue per unit</td>
<td>Revenue per handled or transported unit (e.g. per TEU)</td>
<td>X low</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T X</td>
<td></td>
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<tr>
<td>Unit costs</td>
<td>Cost per handling unit (e.g. per TEU)</td>
<td>X low</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff costs / FTE</td>
<td>In EUR per full time employee</td>
<td>low/high</td>
<td>++ medium</td>
<td>yes</td>
<td>T X</td>
<td>X low</td>
<td>high</td>
<td></td>
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<tr>
<td>Staff costs / shipment</td>
<td>In EUR per shipment</td>
<td>low/high</td>
<td>++ medium</td>
<td>yes</td>
<td>T X</td>
<td>X low</td>
<td>medium</td>
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<td>Staff costs / ton</td>
<td>In EUR per ton</td>
<td>low/high</td>
<td>++ medium</td>
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<td>T X</td>
<td>X low</td>
<td>medium</td>
<td></td>
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<tr>
<td>Total costs / handling unit</td>
<td>In EUR per handling unit (e.g. per TEU)</td>
<td>X low</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T X</td>
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<tr>
<td>Profitability per handling unit</td>
<td>e.g. Gross Profit per TEU or Handling Unit</td>
<td>X low</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T X</td>
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<tr>
<td>Service center over/under coverage</td>
<td>Variance analysis on service center level</td>
<td>low/high</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
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<tr>
<td>Net Working Capital</td>
<td>Management of trade receivables and trade payables, inventory if applicable</td>
<td>low/high</td>
<td>++ medium</td>
<td>yes</td>
<td>T X</td>
<td>X low</td>
<td>medium</td>
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<tr>
<td>CAPEX (Capital Expenditure)</td>
<td>Investments</td>
<td>X low</td>
<td>high</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
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<td>Return on Capital Employed (ROCE)</td>
<td>Value generated by invested capital</td>
<td>X low</td>
<td>high</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
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<td>Claims</td>
<td>Customer claims (financial risks)</td>
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<td>low</td>
<td>+</td>
<td>low</td>
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<td>Bad debt</td>
<td>Uncollectables</td>
<td>X low</td>
<td>high</td>
<td>+</td>
<td>low</td>
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<td>ROI</td>
<td>%</td>
<td>X low</td>
<td>high</td>
<td>++</td>
<td>good</td>
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Access to data (good/medium/poor): Data can be obtained from statistics, studies or internet.
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Clarity (++/+/−): Ability to understand the KPI (++: good; +: medium; −: low).
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Scope: T - terminal; H - hinterland; R - rail network.
D3.1 Study of the state of the art and description of KPI and KRI of terminals, hinterland mobility and rail network

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<th>Short description</th>
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<th>Effort</th>
<th>Clarity</th>
<th>Measurable</th>
<th>Transferable</th>
<th>Scope</th>
<th>Point of view</th>
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<td></td>
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<tr>
<td>Volumes (e.g. # of TEUs, tons of bulk good, etc.)</td>
<td>Sum of handled or transported units (further splits by product or type of goods possible)</td>
<td>X</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
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<tr>
<td>Weight in terminal (in tons)</td>
<td>Weight of handled goods (further splits by products or type of goods possible)</td>
<td></td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
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<tr>
<td># of trucks</td>
<td>Total number of trucks</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
<td>X</td>
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<tr>
<td># of trains</td>
<td>Total number of trains</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
<td>X</td>
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<tr>
<td># of shipments</td>
<td>Number of shipments handled by the terminal</td>
<td>X</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
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<tr>
<td># of standard containers (e.g. TEUs)</td>
<td>Number of standard containers handled by the terminal</td>
<td>X</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
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<tr>
<td># of handling units (e.g. TEUs)</td>
<td>Number of handling units e.g. containers handled by the terminal</td>
<td>X</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
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<tr>
<td># of FTEs at month end</td>
<td>Workforce in terms of number of Full Time Employees at month end</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
<td>X</td>
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<tr>
<td># of FTEs on average</td>
<td>Workforce in terms of number of Full Time Employees (monthly average)</td>
<td>X</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
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<tr>
<td>Headcount</td>
<td>Workforce in terms of number of people employed</td>
<td>X</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
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<tr>
<td>Overtime FTEs on monthly average</td>
<td>Average extra hours per month</td>
<td>low</td>
<td>medium</td>
<td>-</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Unpaid overtime FTEs on monthly average</td>
<td>Unpaid extra hours per month</td>
<td>low</td>
<td>medium</td>
<td>-</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
<td>X</td>
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<tr>
<td>FTE Arrival Gateway</td>
<td>Number of employees at arrival gateway</td>
<td>good</td>
<td>low</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>FTE Departure Gateway</td>
<td>Number of employees at departure gateway</td>
<td>good</td>
<td>low</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td># of not own FTE (white collar)</td>
<td>Number of subcontracted white collar workers</td>
<td>good</td>
<td>low</td>
<td>+</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
<td>X</td>
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### Operational performance

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<th>Clarity</th>
<th>Measurable</th>
<th>Transferable</th>
<th>Scope</th>
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<tr>
<td># of not own FTE (blue collar)</td>
<td>Number of subcontracted blue collar workers</td>
<td>X</td>
<td>good</td>
<td>low</td>
<td>+</td>
<td>medium</td>
<td>yes</td>
<td>T X</td>
</tr>
<tr>
<td>Total FTE capacity terminal</td>
<td>Total employees</td>
<td>X</td>
<td>good</td>
<td>low</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T X</td>
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<tr>
<td>Productivity (machinery and blue collar)</td>
<td>Handled units (e.g. TEUs) per hour, per day, per FTE, per...</td>
<td>X</td>
<td>good</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T X</td>
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<tr>
<td>Productivity (white collar)</td>
<td>Shipments per FTE (white collar)</td>
<td>X</td>
<td>good</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T XX</td>
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<tr>
<td>Productivity (blue collar)</td>
<td>Handling units per FTE</td>
<td>X</td>
<td>good</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T X</td>
</tr>
<tr>
<td>Shipments / FTE in Terminal</td>
<td>Number of shipments per Full Time Employees</td>
<td>X</td>
<td>good</td>
<td>high</td>
<td>+</td>
<td>good</td>
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<td>T X</td>
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<tr>
<td>Tonnage / FTE</td>
<td>Total tons per Full Time Employees</td>
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<td>good</td>
<td>high</td>
<td>+</td>
<td>good</td>
<td>yes</td>
<td>T X</td>
</tr>
<tr>
<td>Handling units / FTE</td>
<td>Number of handling units per Full Time Employees</td>
<td>X</td>
<td>good</td>
<td>high</td>
<td>+</td>
<td>good</td>
<td>yes</td>
<td>T X</td>
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<tr>
<td>Productivity per machine related to the effective working hours</td>
<td>Number of handled units per machine considering only effective working hours</td>
<td>X</td>
<td>low</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T X</td>
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<tr>
<td>Hours of machinery working per year</td>
<td>Working hours per year</td>
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<td>high</td>
<td>++</td>
<td>good</td>
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<td>T X</td>
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<td>Hours of machinery inactive per year</td>
<td>Inactive hours per year</td>
<td>X</td>
<td>low</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T X</td>
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<tr>
<td>Availability of machinery</td>
<td>% RMG, % RTG, % RS, % trucks...</td>
<td>X</td>
<td>low</td>
<td>high</td>
<td>+</td>
<td>medium</td>
<td>yes</td>
<td>T X</td>
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<tr>
<td>Volume related to space (storage productivity)</td>
<td>TEUs per square meter, tons per square meter...</td>
<td>X</td>
<td>good</td>
<td>low</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T X</td>
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<td>% use of terminal warehouse space</td>
<td>%</td>
<td>X</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>good</td>
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<td>T X</td>
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<td>Gate utilization</td>
<td>%</td>
<td>X</td>
<td>good</td>
<td>low</td>
<td>++</td>
<td>good</td>
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<td>T X</td>
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<td>Berth utilization</td>
<td>%</td>
<td>X</td>
<td>good</td>
<td>low</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T X</td>
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<tr>
<td>Rail utilization</td>
<td>Train per year per rail</td>
<td>X</td>
<td>good</td>
<td>low</td>
<td>++</td>
<td>good</td>
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<td>T X</td>
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<td>Land utilization</td>
<td>TEUs per year per gross square meter</td>
<td>X</td>
<td>low</td>
<td>low</td>
<td>+</td>
<td>good</td>
<td>yes</td>
<td>T X</td>
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</table>

**Clarity**
- ++: good; +: medium; -: low
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D3.1 Study of the state of the art and description of KPI and KRI of terminals, hinterland mobility and rail network

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<tr>
<td><strong>Operational performance</strong></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Equipment utilization</td>
<td>TEUs per year per crane/RS...</td>
<td>X</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>X</td>
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<tr>
<td>Equipment productivity</td>
<td>Moves per crane/RS per hour</td>
<td>X</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>X</td>
</tr>
<tr>
<td>Distance traveled by terminal tractors b/w train and designated terminal positions of unloaded containers</td>
<td>In meters, kilometers</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>X</td>
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<tr>
<td>Distance traveled by terminal tractors b/w terminal locations of the containers to be loaded and trains</td>
<td>In meters, kilometers</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>X</td>
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<td><strong>Service quality</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># damages</td>
<td>Quality KPIs</td>
<td>X</td>
<td>low</td>
<td>high</td>
<td>++</td>
<td>low</td>
<td>no</td>
<td>T/H</td>
<td>X</td>
</tr>
<tr>
<td># accidents</td>
<td>Quality KPIs</td>
<td>X</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>low</td>
<td>no</td>
<td>T/H</td>
<td>X</td>
</tr>
<tr>
<td># departures in time</td>
<td>Quality KPIs</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Average round trip</td>
<td>In minutes, hours</td>
<td>X</td>
<td>medium</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>H</td>
<td>X</td>
</tr>
<tr>
<td>Average time spent in terminal per container</td>
<td>In minutes, hours</td>
<td>X</td>
<td>medium</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>X</td>
</tr>
<tr>
<td>Waiting hours of trucks at terminal door</td>
<td>In minutes, hours</td>
<td>X</td>
<td>medium</td>
<td>high</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>T</td>
<td>X</td>
</tr>
<tr>
<td>Average time spent by train at terminal</td>
<td>In minutes, hours</td>
<td>X</td>
<td>medium</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>X</td>
</tr>
<tr>
<td>Average time spent by truck at terminal</td>
<td>In minutes, hours</td>
<td>X</td>
<td>medium</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>X</td>
</tr>
<tr>
<td># trains spending over 50% more than the av. time for trains</td>
<td>Related to waiting time/delays</td>
<td>low</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td># trucks spending over 50% more than the av. time for trucks</td>
<td>Related to waiting time/delays</td>
<td>low</td>
<td>high</td>
<td>+</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Turnaround time of trains</td>
<td>In hours</td>
<td>X</td>
<td>medium</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>R</td>
<td>X</td>
</tr>
</tbody>
</table>

Access to data (good/medium/poor): Data can be obtained from statistics, studies or internet. Effort (high/medium/low): data collection requires high/medium/low effort from operator’s side. Clarity (+/+/‐): ability to understand the KPI (+: good; +: medium; ‐: low). Measurable (good/medium/low): measurability on basis of comparable data. Transferable (yes/no): data varies significantly from a country to another. Scope: T - terminal; H - hinterland; R - rail network.
### Environmental performance

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Short description</th>
<th>Priority</th>
<th>Access to data</th>
<th>Effort</th>
<th>Clarity</th>
<th>Measurable</th>
<th>Transferable</th>
<th>Scope</th>
<th>Point of view</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total carbon emissions</td>
<td>Total carbon emitted through energy consumption of terminal</td>
<td>X</td>
<td>low</td>
<td>high</td>
<td>++</td>
<td>medium</td>
<td>yes</td>
<td>H</td>
<td>Investor</td>
</tr>
<tr>
<td>Carbon footprint per handling unit [e.g. container or ton]</td>
<td>Carbon footprint of a handled standard container [e.g. TEU]</td>
<td>X</td>
<td>low</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>Terminal operator</td>
</tr>
<tr>
<td>Dangerous goods KPIs</td>
<td>Specific KPIs in case of dangerous goods [depending on local regulations]</td>
<td>X</td>
<td>low</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>Public Bodies</td>
</tr>
<tr>
<td>&quot;# of trucks in rush hour&quot;; &quot;number of containers handled in peak season&quot;</td>
<td>Directly related with emissions</td>
<td></td>
<td>low</td>
<td>high</td>
<td>++</td>
<td>low</td>
<td>yes</td>
<td>H/R</td>
<td></td>
</tr>
</tbody>
</table>

### Socio-economic

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Short description</th>
<th>Priority</th>
<th>Access to data</th>
<th>Effort</th>
<th>Clarity</th>
<th>Measurable</th>
<th>Transferable</th>
<th>Scope</th>
<th>Point of view</th>
</tr>
</thead>
<tbody>
<tr>
<td># of jobs @terminal</td>
<td>Role as employer</td>
<td>X</td>
<td>low</td>
<td>high</td>
<td>+</td>
<td>good</td>
<td>no</td>
<td>T</td>
<td>Investor</td>
</tr>
<tr>
<td>Taxes</td>
<td>Contribution to area in terms of taxes</td>
<td></td>
<td>low</td>
<td>high</td>
<td>-</td>
<td>low</td>
<td>no</td>
<td>H</td>
<td>Terminal operator</td>
</tr>
<tr>
<td>Traffic</td>
<td>Effects on local traffic, key routes due add. trucks, trains</td>
<td>X</td>
<td>low</td>
<td>medium</td>
<td>+</td>
<td>low</td>
<td>no</td>
<td>H/R</td>
<td>Public Bodies</td>
</tr>
</tbody>
</table>

### Market

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Short description</th>
<th>Priority</th>
<th>Access to data</th>
<th>Effort</th>
<th>Clarity</th>
<th>Measurable</th>
<th>Transferable</th>
<th>Scope</th>
<th>Point of view</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trading balance</td>
<td>Trading balance of country, region</td>
<td></td>
<td>low</td>
<td>high</td>
<td>++</td>
<td>low</td>
<td>no</td>
<td>H</td>
<td>Investor</td>
</tr>
<tr>
<td>Trade flows</td>
<td>Volumes of goods shipped from and to the region of the terminal</td>
<td></td>
<td>low</td>
<td>high</td>
<td>++</td>
<td>low</td>
<td>no</td>
<td>H</td>
<td>Terminal operator</td>
</tr>
<tr>
<td>Transport modes / logistics grid</td>
<td>Share of road, rail, air, ocean, ... transportation</td>
<td>X</td>
<td>good</td>
<td>low</td>
<td>++</td>
<td>good</td>
<td>no</td>
<td>H/R</td>
<td>Public Bodies</td>
</tr>
<tr>
<td>Development of transportation modes</td>
<td>Development rail volume, road volume, etc. (absolute and in %)</td>
<td>X</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>low</td>
<td>no</td>
<td>H/R</td>
<td></td>
</tr>
<tr>
<td>Competitor volumes</td>
<td>Volume handled by main competitors</td>
<td></td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>low</td>
<td>no</td>
<td>H</td>
<td>Investor</td>
</tr>
<tr>
<td>Competitor revenue</td>
<td>Revenue and Revenue development of main competitors</td>
<td></td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>low</td>
<td>no</td>
<td>H</td>
<td>Terminal operator</td>
</tr>
<tr>
<td>Competitor profitability</td>
<td>Profitability and development of main competitors</td>
<td></td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>low</td>
<td>no</td>
<td>H</td>
<td>Public Bodies</td>
</tr>
</tbody>
</table>

---

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<table>
<thead>
<tr>
<th>Indicator</th>
<th>Short description</th>
<th>Priority</th>
<th>Access to data</th>
<th>Effort</th>
<th>Clarity</th>
<th>Measurable</th>
<th>Transferable</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maintenance (railway tracks)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failures in total</td>
<td>Number of failures</td>
<td>low</td>
<td>++</td>
<td>low</td>
<td>yes</td>
<td>T/H</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Faults in infrastructure with unknown cause</td>
<td>Unknown cause failures</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>low</td>
<td>yes</td>
<td>H</td>
<td>X</td>
</tr>
<tr>
<td>Faults in infrastructure with known cause</td>
<td>Known cause failures</td>
<td>low</td>
<td>low</td>
<td>++</td>
<td>low</td>
<td>yes</td>
<td>H</td>
<td>X</td>
</tr>
<tr>
<td>Faults interfering with traffic</td>
<td>Faults affecting operation</td>
<td>medium</td>
<td>low</td>
<td>++</td>
<td>low</td>
<td>yes</td>
<td>H/R</td>
<td>X</td>
</tr>
<tr>
<td>Meantime between failures and repair (MTBF and MTTR)</td>
<td>Average time between failures and mean time to repair</td>
<td>medium</td>
<td>low</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>H/R</td>
<td>X</td>
</tr>
<tr>
<td>Overall equipment effectiveness (OEE)</td>
<td>(Availability) * (Performance) * (Quality)</td>
<td>low</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>H/R</td>
<td>X</td>
</tr>
<tr>
<td>Capacity utilization</td>
<td>%</td>
<td>medium</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T/R</td>
<td>X</td>
</tr>
<tr>
<td>Hours of freight train delays due to infrastructure</td>
<td>In minutes, hours</td>
<td>X</td>
<td>medium</td>
<td>high</td>
<td>++</td>
<td>low</td>
<td>yes</td>
<td>T/R</td>
</tr>
<tr>
<td>Maintenance cost per track-kilometer</td>
<td>Monetary cost per track kilometer</td>
<td>medium</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>no</td>
<td>R</td>
<td>X</td>
</tr>
<tr>
<td><strong>Maintenance (equipment)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># hours on corrective maintenance per machine</td>
<td>Hours per year per each equipment item</td>
<td>X</td>
<td>medium</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T/R</td>
</tr>
<tr>
<td># hours on preventive maintenance per machine</td>
<td>Hours per year per each equipment item</td>
<td>X</td>
<td>medium</td>
<td>high</td>
<td>++</td>
<td>good</td>
<td>yes</td>
<td>T/R</td>
</tr>
<tr>
<td><strong>Maintenance (infrastructure)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crack opening</td>
<td>For concrete elements</td>
<td>low</td>
<td>high</td>
<td>+</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>X</td>
</tr>
<tr>
<td>Chloride content</td>
<td>For concrete elements</td>
<td>low</td>
<td>high</td>
<td>+</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>X</td>
</tr>
<tr>
<td>Carbonation</td>
<td>For concrete elements</td>
<td>low</td>
<td>high</td>
<td>+</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>X</td>
</tr>
<tr>
<td>Steel corrosion rate</td>
<td>For steel elements</td>
<td>low</td>
<td>high</td>
<td>+</td>
<td>good</td>
<td>yes</td>
<td>T</td>
<td>X</td>
</tr>
<tr>
<td>Exposure class</td>
<td>Related with concrete and steel</td>
<td>good</td>
<td>high</td>
<td>+</td>
<td>low</td>
<td>yes</td>
<td>T</td>
<td>X</td>
</tr>
</tbody>
</table>

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Appendix II

This appendix includes the definition of each KPI and PI included in the proposed final list.
### 1. Intermodal terminal throughput (volume)

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Investor</td>
<td>Terminal</td>
<td>Productivity</td>
</tr>
<tr>
<td></td>
<td>Operator</td>
<td></td>
<td>Total traffic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description and objective:</th>
<th>Formula:</th>
<th>Unit:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The terminal throughput is a measure of the activity related to the delivery of outbound cargo, reception of inbound cargo and loading/unloading transhipment cargo. The goal of new intermodal terminals should be to maximize equipment and labor productivity while achieving as much throughput as possible.</td>
<td>Summation of TEU, ITU or tons of cargo handled by the terminal, either as imports, exports or transhipment</td>
<td>TEUs, ITUs, Tonnes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input data and data source:</th>
<th>Frequency of measurement:</th>
<th>Calculation method:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of handled containers / ITUs / tonnes of cargo per quay crane / rail lifting piece of equipment. Number of trucks and trains arriving / leaving the terminal and their average cargo (TEU / ITU / tonnes).</td>
<td>Daily/monthly/annually</td>
<td>Terminal simulation model</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Presentation of results</th>
<th>Evolution of the indicator:</th>
<th>Decision level:</th>
<th>Relationship with other indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number and graphically</td>
<td>Throughput evolution per year</td>
<td>Strategic</td>
<td>Efficiency Financial indicators (unitary revenues, benefits and costs)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tactical</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Notes and comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imports and exports are treated separately from transhipment to avoid double counting.</td>
</tr>
</tbody>
</table>
## 2. Equipment utilization

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Operator</td>
<td>Terminal</td>
<td>Efficiency; Productivity-utilization</td>
</tr>
</tbody>
</table>

### Description and objective:

The utilization of any item or type of equipment is defined as the proportion of time that it was effectively deployed over a specified period.

The goal is to measure the equipment performance (availability, reliability and operational productivity) in order to estimate the terminal’s investment in cargo-handling.

This is calculated per type of equipment and individually for each working unit.

### Formula:

$$\text{Eq-U (\%)} = \frac{T_A}{T_R - T_D}$$

- $T_A$: Total equipment active time over a time period
- $T_R$: Total rostered time for a piece of equipment over a time period
- $T_D$: Total downtime in a period of time (scheduled maintenance and breakdown repairs)

### Unit:

Percentage (%)

### Input data and data source:

Time related data from the terminal simulation model.

### Frequency of measurement:

Annually

### Calculation method:

Terminal simulation model

### Notes and comments:

The time for maintenance and breakdown repairs depends on type of equipment and hypothesis on their calculation (regarding working time / total time or units processed).

As many KPIs values as types of terminal equipment.
### 3. Gate utilization

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Operator</td>
<td>Terminal</td>
<td>Efficiency; Productivity-utilization</td>
</tr>
</tbody>
</table>

**Description and objective:**

The utilization of terminal gates is defined as the proportion of time that they were effectively deployed over a specified period.

Gate utilization is a valuable measure for terminal operators related to the gate efficiency.

**Formula:**

\[
\text{Gate-U} (\%) = \frac{T_A}{T_R}
\]

**Unit:** Percentage (%)

- \( T_A \): Total gate active time in a period of time
- \( T_R \): Total rostered time for a gate in a period of time

**Input data and data source:**

Time related data from the terminal simulation model.

**Frequency of measurement:** Annually

**Calculation method:** Terminal simulation model

**Presentation of results**

Average results and for each gate

**Evolution of the indicator:** Utilization’s evolution per year

**Decision level:** Tactical

**Relationship with other indicators:** Productivity

**Waiting time**

**Notes and comments:**

Gate utilization should be considered separately for entering/departing trucks.
### Labour utilization rate

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Operator</td>
<td>Terminal</td>
<td>Efficiency; Productivity-utilization</td>
</tr>
</tbody>
</table>

**Description and objective:**
The utilization of labour is defined as the proportion of time that it was effectively deployed over a specified period. It is important to monitor labour well and know what the productivity per man-hour is over a measured period.

**Formula:**
\[ \text{Labour-U (\%)} = \frac{T_a}{T_r} \]

- **TA:** Total man active time in a period of time
- **TR:** Total rostered time for a man in a period of time

**Unit:** Percentage (%)

**Input data and data source:**
Time related data from the terminal simulation model.

**Frequency of measurement:** Annually

**Calculation method:** Terminal simulation model

**Presentation of results**

<table>
<thead>
<tr>
<th>Evolution of the indicator:</th>
<th>Decision level:</th>
<th>Relationship with other indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utilization’s evolution per year</td>
<td>Operational</td>
<td>Productivity</td>
</tr>
</tbody>
</table>

**Notes and comments:**
- It considers blue collar employees working at gates, storage yard, berth, railway yard, etc.
- Assumed productivity per employee can vary.
- Utilization of labour is difficult to measure.
### 5. Storage area utilization

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Operator</td>
<td>Terminal</td>
<td>Efficiency; Productivity-utilization</td>
</tr>
</tbody>
</table>

**Description and objective:**
The storage area utilization is calculated by comparing the number of storage slots (considering the possibility to pile up the UTIs/TEUs as well) occupied with the total number of available slots according to the storage yard’s design capacity.

**Formula:**

\[
\text{Storage Utilization (U)} = \frac{\text{Slots occupied}}{\text{Total available slots}} \times 100\%
\]

**Input data and data source:**
Storage yard occupation from the simulation model.

**Frequency of measurement:**
Annually

**Calculation method:**
Terminal simulation model

**Presentation of results**
Visual chart with percentages

**Evolution of the indicator:**
Utilization’s evolution per year

**Decision level:**
Operational

**Relationship with other indicators:**
Productivity

**Notes and comments:**
It could be applied for railway delivery/reception area, storage area, marshalling areas, buffer areas, etc.

Slots are considered as “spaces where a TEU/ITU can be stored”, not only footprint slots but also possibility of piling up units being considered.
## 6. Rail track utilization

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Operator</td>
<td>Terminal</td>
<td>Efficiency; Productivity-utilization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rail network</td>
<td></td>
</tr>
</tbody>
</table>

### Description and objective:
This measure reflects the amount of time that the rail track was occupied out of the total time available.

### Formula:
Rail track-U (%) = \( \frac{\text{Rail track time occupied}}{\text{Total available time}} \)

### Unit:
Percentage (%)

### Input data and data source:
Time related data from the terminal simulation model.

### Frequency of measurement:
Annually

### Calculation method:
Terminal simulation model

### Presentation of results
Chart

### Evolution of the indicator:
Utilization’s evolution per year

### Decision level:
Operational

### Relationship with other indicators:
Productivity

### Notes and comments:
### 7. Berth utilization

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Operator</td>
<td>Terminal</td>
<td>Efficiency; Productivity-utilization</td>
</tr>
</tbody>
</table>

#### Description and objective:
This measure reflects the amount of time that the berth was occupied out of the total time available.

#### Formula:
Berth-U (%) = Berth time occupied / Total available time

#### Unit:
Percentage (%)

#### Input data and data source:
Time related data from the terminal simulation model.

#### Frequency of measurement:
Annually

#### Calculation method:
Terminal simulation model

#### Presentation of results
Visual chart with percentages

#### Evolution of the indicator:
Utilization’s evolution per year

#### Decision level:
Operational

#### Relationship with other indicators:
Productivity

#### Notes and comments:
It can be related to the berth length or to the number of berthing points.
### 8. Turnaround time

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Quality</td>
<td>Operator</td>
<td>Terminal</td>
<td>Efficiency; Productivity-time related Service quality - time</td>
</tr>
</tbody>
</table>

#### Description and objective:

The elapsed time between a truck/train/vessel’s arrival at a terminal and its departure.

It is frequently used as a measure of terminal efficiency.

#### Formula:

\[ TT = T_{\text{Arr}} + T_{\text{unload}} + T_{\text{load}} + T_{\text{dep}} \]

**Trains:**
- \( T_{\text{Arr}} \): Train shunting time + Train entrance control time + Train waiting time before unloading
- \( T_{\text{unload}} \): Sum of unloading times from train to storage
- \( T_{\text{load}} \): Sum of loading times from storage to train
- \( T_{\text{dep}} \): Train waiting time for departure processing + train operations monitoring time + train safety inspection time + train shunting time + train waiting time from shunting to departure

**Trucks:**
- \( T_{\text{Arr}} \): Truck waiting / queueing time at-gates + Truck time for-gate processing + In-gate checking time + Truck waiting time at buffer area + Truck driving time from waiting area to loading position

#### Unit:

Time (minutes, hours)
8. **Turnaround time**

- **$T_{unload}$**: Sum of unloading times from truck to storage
- **$T_{load}$**: Sum of loading times from storage to truck
- **$T_{dep}$**: Truck driving time from loading position to out-gate + Truck time for out-gate processing

**Ships:**

- **$T_{Arr}$**: Ship port services time + Ship waiting time before unloading
- **$T_{unload}$**: Sum of unloading times from ship to storage
- **$T_{load}$**: Sum of loading times from storage to ship
- **$T_{dep}$**: Ship waiting time for departure processing + ship port services time

<table>
<thead>
<tr>
<th>Input data and data source:</th>
<th>Frequency of measurement:</th>
<th>Calculation method:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time related data from the terminal simulation model.</td>
<td>For each vessel/truck/arrival ship</td>
<td>Terminal simulation model</td>
</tr>
</tbody>
</table>

**Presentation of results**

- **Evolution of the indicator:** Average values per year and per type of customer (ship, truck, train)
- **Decision level:** Operational
- **Relationship with other indicators:**
  - Waiting time
  - Service time
  - Maneuvering time
  - Berthing time

**Notes and comments:**
### 9. Waiting time

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Operator</td>
<td>Terminal</td>
<td>Efficiency; Productivity-time related</td>
</tr>
</tbody>
</table>

**Description and objective:**

**Unproductive time** spent waiting (queueing) for labour/equipment service. Waiting at the gates, buffer areas or to be loaded/unloaded. It reflects the terminal congestion level.

The objective of all terminals is to reduce the truck/train/ship's waiting time. The time spent in waiting to enter the terminal/to be served is a consequence for the terminal performance.

#### Trains:

Sum of train waiting time before unloading, train waiting time for departure processing and train waiting time from shunting to departure.

#### Trucks:

Sum of truck waiting time before in-gate (in-gate), truck waiting time at buffer area + truck waiting time for out-gate processing (out-gate).

#### Ships:

Sum of ship waiting time before unloading and ship waiting time for departure processing.

**Input data and data source:**

Time related data from the terminal simulation model.

**Frequency of measurement:**

Daily/monthly/annually

**Calculation method:**

Terminal simulation model
9. **Waiting time**

<table>
<thead>
<tr>
<th>Presentation of results</th>
<th>Evolution of the indicator:</th>
<th>Decision level:</th>
<th>Relationship with other indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waiting time per hour-day (chart)</td>
<td>Evolution per day/month/year</td>
<td>Operational</td>
<td>Turnaround time</td>
</tr>
</tbody>
</table>

**Notes and comments:**

It is recommended to register each component of waiting time separately for better evaluation.
### 10. Return On Investment (ROI)

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Investor</td>
<td>Terminal</td>
<td>Financial indicators</td>
</tr>
</tbody>
</table>

**Description and objective:**
This performance indicator measures the amount of return on an investment relative to the investment's cost.

**Formula:**
\[
\text{ROI} = \frac{(\text{Gain from Investment} - \text{Cost of Investment})}{\text{Cost of Investment}} = \frac{\text{Benefits}}{\text{Investment cost}}
\]

**Unit:** Percentage (%)

**Input data and data source:**
Capital expenses (CAPEX)
Benefits from terminal’s operation

**Frequency of measurement:** Monthly/annually

**Calculation method:** BIM

**Presentation of results**
Graphically and percentage
Against previous year during concession period

**Evolution of the indicator:**

**Decision level:** Strategic

**Relationship with other indicators:**
CAPEX
Profitability

**Notes and comments:**
### 11. Terminal’s Profitability

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Investor</td>
<td>Terminal</td>
<td>Financial indicators</td>
</tr>
</tbody>
</table>

**Description and objective:**
The profitability is a measure of efficiency (utilizing its resources and its initial investment) and is used to determine the scope of a terminal’s profit (revenue minus total expenses) in relation to the size of the business.

The objective is to evaluate the ability of the terminal’s business to produce a return on an investment based on its resources.

**Formula:**
- PI = Present Value of future cash flows / initial investment
- EBITDA margin = EBITDA / Total revenue

**Input data and data source:**
- Revenues
- Operating costs
- Financial costs
- Initial investment

**Frequency of measurement:**
- Monthly/annually

**Calculation method:**
- BIM

**Presentation of results**
- Percentage

**Evolution of the indicator:**
- Not required

**Decision level:**
- Strategic

**Relationship with other indicators:**
- ROI

**Notes and comments:**
The profitability can also be evaluated with the EBITDA margin.

EBITDA is equal to earnings before interest, tax, depreciation and amortization.

EBITDA is equal to earnings before interest, tax, depreciation and amortization.
12. **Operating efficiency (operating margin)**

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Operator</td>
<td>Terminal</td>
<td>Operating cost</td>
</tr>
</tbody>
</table>

**Description and objective:**
This indicator is used to measure a terminal’s pricing strategy and operating efficiency. That is, it shows the ability to gauge how efficiently a terminal is operating, or how profitable it is.

It is a measurement of what proportion of a terminal’s revenue is left over after paying the variable cost of production/operation. It also shows the terminal’s potential to generate operating cash flow.

**Formula:**

\[
OM = \frac{Operating \ profit}{Net \ sales}
\]

- **Operating profit**
  - Operating revenue
  - Operating expenses – depreciation - amortization
- **Net sales:** Amount of sales generated by a terminal after the deduction of returns, allowances and any discounts allowed.

**Unit:** Percentage (%)

**Input data and data source:**

<table>
<thead>
<tr>
<th>Operating expenditures</th>
<th>Frequency of measurement:</th>
<th>Calculation method:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating revenues</td>
<td>Monthly/annually</td>
<td>BIM</td>
<td></td>
</tr>
<tr>
<td>Turnover (net sales)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Presentation of results**

<table>
<thead>
<tr>
<th>Graphically and percentage</th>
<th>Evolution of the indicator:</th>
<th>Decision level:</th>
<th>Relationship with other indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Against previous year during concession period</td>
<td>Strategic</td>
<td>OPEX</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tactical</td>
<td>Profitability</td>
</tr>
</tbody>
</table>

**Notes and comments:**

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<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Terminal operator</td>
<td>Terminal</td>
<td>Revenues</td>
</tr>
</tbody>
</table>

**Description and objective:**
- It is a measure of the revenue generated per handled unit.
- It allows to analyse the revenue generation and growth at per unit level.

**Formula:**
Total revenue in a month or per year / Number of handled units

**Unit:**
Unitary revenues (€/TEU; €/ITU; €/ton)

**Input data and data source:**
- Total revenues over a period.
- Number of handled units: by type and size, by category (TEUs, ITUs, tonnes of cargo).

**Frequency of measurement:**
- Monthly
- Annually

**Calculation method:**
BIM

**Presentation of results**
- Number and graphically
- Evolution per month, per year

**Evolution of the indicator:**
- Strategic

**Decision level:**
- Terminal throughput
- Revenues
- Profitability

**Relationship with other indicators:**

**Notes and comments:**
Indicator that can be calculated considering different types of handled units: by type and size or by category. It will allow to identify which handled unit is high/low revenue-generator.
### 14. Operating benefits per unit

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Terminal operator</td>
<td>Terminal</td>
<td>Benefits</td>
</tr>
</tbody>
</table>

**Description and objective:**
- It is a measure of the benefits obtained per handled unit.
- It allows to analyse the benefit generation and growth at per unit level.

**Formula:**
Total benefits in a month or per year / Number of handled units

**Unit:** Unitary benefits (€/TEU; €/ITU; €/ton)

**Input data and data source:**
- Total benefits over a period.
- Number of handled units: by type and size, by category (TEUs, ITUs, tonnes of cargo).

**Frequency of measurement:**
- Monthly
- Annually

**Calculation method:** BIM

**Presentation of results**
- Number and graphically

**Evolution of the indicator:**
- Against previous years

**Decision level:** Strategic

**Relationship with other indicators:**
- Volume
- Benefits
- Profitability

**Notes and comments:**
Indicator that can be calculated considering different types of handled units: by type and size or by category. It will allow to identify which handled unit is high/low benefit-generator.
### 15. Direct jobs sustained by terminal activities

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Public body</td>
<td>Terminal</td>
<td>Employment</td>
</tr>
</tbody>
</table>

**Description and objective:**

Amount of employment directly sustained and/or created by terminal activities at a given moment or over a given period. Jobs is a measure of the number of jobs required to produce a given volume of production.

Describes the direct contribution of terminal activities to the creation of employment.

**Formula:**

Sum of the employment generated in each company working in the terminal

Calculated based on different areas assigned in the terminal and the ratio of workers per area unit, and according to number of equipments, gates, etc.

**Unit:**

Number of employees hired (full time employee-FTE)

**Input data and data source:**

Number of workers necessary for each type of area in the terminal for its proper operation and statistical ratios.

**Frequency of measurement:**

Annually

Ad-hoc (e.g. in function of specific projects)

**Calculation method:**

BIM

**Presentation of results**

<table>
<thead>
<tr>
<th>Evolution of the indicator:</th>
<th>Decision level:</th>
<th>Relationship with other indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Against previous years</td>
<td>Operational Strategic</td>
</tr>
</tbody>
</table>

**Notes and comments:**

Can be unbundled on a sector level (cargo handling, logistics, shipping, etc.)
16. Indirect jobs sustained by terminal activities

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Public body</td>
<td>Hinterland</td>
<td>Employment</td>
</tr>
</tbody>
</table>

**Description and objective:**

Amount of employment indirectly sustained and/or created by terminal activities at a given period, within a given geographical area. Describes the indirect contribution of terminal activities to the creation of employment within a certain region.

Several applications exist:

- Upstream economic activities (sectors supplying terminal activities);
- Downstream economic activities, mostly referred to as induced employment;
- Strategic or catalytic effects: linked to the attraction of specific activities due to the presence of the terminal.

Work places is a measure of the number of jobs required to produce a given volume of production.

**Formula:**

- For indirect impacts: A multiplier is defined which quantifies the relationship between direct and indirect employment.
- For induced impacts: In most cases a multiplier is defined which quantifies the relationship between direct and induced employment.
- For strategic and catalytic impacts, a multiplier is defined which quantifies the relationship between direct and strategic/catalytic employment.

**Input data and data source:**

Multipliers obtained from surveys or studies (Economic Effect Analyses).

**Frequency of measurement:**

- Annually
- Ad-hoc (e.g. in function of specific projects)

**Calculation method:**

BIM

**Presentation of results**

**Evolution of the indicator:**

**Decision level:**

**Relationship with other indicators:**
<table>
<thead>
<tr>
<th>Number and graphically</th>
<th>Against previous years</th>
<th>Strategic</th>
</tr>
</thead>
</table>

**Notes and comments:**

- Can be unbundled on a sector level.
- Data can vary from a country to another.
### 17. Road and rail track maintenance cost

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Public body</td>
<td>Rail Network Hinterland</td>
<td>Maintenance cost</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description and objective:</th>
<th>Formula:</th>
<th>Unit:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance expenditure on road/truck infrastructure is the expenditure for keeping infrastructure in working order. It refers to public spending and do not include expenditure financed by the private sector. Expresses the Public body interest in increasing safety and improving mobility, and in reducing the environmental impact of road transport, congestion and CO2 emissions.</td>
<td><strong>Road:</strong>&lt;br&gt;Total road maintenance cost in a year / road traffic flow in the hinterland</td>
<td>Monetary cost per road kilometer (€/veh‐km)</td>
</tr>
<tr>
<td></td>
<td><strong>Rail track:</strong>&lt;br&gt;Total rail track maintenance cost in a year / track kilometer in the rail network</td>
<td>Monetary cost per track kilometer (€/km)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input data and data source:</th>
<th>Frequency of measurement:</th>
<th>Calculation method:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total road/rail maintenance cost: Publications, annual accounts, statistics. Kilometers within the hinterland.</td>
<td>Annually&lt;br&gt;Ad-hoc (e.g. in function of specific projects)</td>
<td>Terminal simulation model</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Presentation of results</th>
<th>Evolution of the indicator:</th>
<th>Decision level:</th>
<th>Relationship with other indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number and graphically</td>
<td>Against previous years</td>
<td>Strategic</td>
<td>Public investment&lt;br&gt;Reliability</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Notes and comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator that can be calculated considering road and truck separately. It is a variable cost.</td>
</tr>
</tbody>
</table>
17. Road and rail track maintenance cost

Data coverage varies significantly from a country to another, mainly due to the lack of more detailed common definitions and the difficulty for countries to change their data collection system.
### 18. Easiness of entry and exit from highways

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>Terminal operator</td>
<td>Hinterland</td>
<td>Accessibility</td>
</tr>
</tbody>
</table>

#### Description and objective:
The easiness of entry and exit from highways is defined as the accessibility or connection to main roads.

#### Formula:
Average driving time from terminal to main road network connections

#### Unit:
Time (minutes)

#### Input data and data source:
Time related data from the simulation model.
Number of network connections.

#### Frequency of measurement:
Annually

#### Calculation method:
Traffic simulation tool

#### Presentation of results

<table>
<thead>
<tr>
<th>Evolution of the indicator:</th>
<th>Decision level:</th>
<th>Relationship with other indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number and graphically</td>
<td>Against previous years</td>
<td>Strategic</td>
</tr>
</tbody>
</table>

#### Notes and comments:
Data needed is easy to research and the effort for collection is low.
### 19. Easiness of entry and exit from rail network

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>Terminal operator</td>
<td>Rail network</td>
<td>Accessibility</td>
</tr>
</tbody>
</table>

**Description and objective:**
The easiness of entry and exit from railway network is defined as the accessibility or connection to main rail track.

**Formula:**
Average travel time between the terminal and the main railway connections

**Unit:**
Time (minutes)

**Input data and data source:**
Distance between the terminal and the main rail track.
Layout

**Frequency of measurement:**
Previously to the construction of the terminal
Ad-hoc (e.g. in function of specific projects)

**Calculation method:**
Traffic simulation tool

**Presentation of results**
Number and graphically.

**Evolution of the indicator:**
Against previous years

**Decision level:**
Strategic

**Relationship with other indicators:**
Hinterland connection

**Notes and comments:**
Data needed is easy to research and the effort for collection is low.
### 20. Energy consumption per handled unit

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Terminal operator</td>
<td>Terminal</td>
<td>Energy efficiency</td>
</tr>
</tbody>
</table>

**Description and objective:** Measures the energy consumed by handled unit. The aim is to measure the environmental improvement according to changes in modal split, use of efficient vehicles or alternative fuels, and a better management.

**Formula:**

\[
\text{Total energy consumed} \div \text{Number of handled units}
\]

**Unit:**

- kJ/kW per load unit
- Volume of fuel per handled unit

**Input data and data source:**

- Total energy consumption in the terminal estimated with the traffic simulation tool.
- Total number of handled units.

**Frequency of measurement:**

- Monthly
- Annually

**Calculation method:** Traffic simulation tool

**Presentation of results**

- Number and graphically
- Against previous year

**Decision level:** Strategic

**Relationship with other indicators:**

- Energy consumption
- Terminal throughput

**Notes and comments:**

Indicator that can be calculated considering different types of handled units: by type and size or by category (TEUs, ITUs, tons)
## 21. Carbon footprint per unit

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Public body</td>
<td>Hinterland</td>
<td>Climate change</td>
</tr>
</tbody>
</table>

### Description and objective:
Carbon footprint of a handled unit (e.g. TEU, UTI, ton).
The aim is to measure the impact that terminal activities have on the environment of the region.

### Formula:
Total carbon emissions / Number of handled units
Total carbon emissions = EF CO₂ * Fuel consumption

### Unit:
Carbon dioxide/TEU
Carbon dioxide/UTI
Carbon dioxide/ton
Kg CO₂/ tkm
Annual inventory (kg CO₂)

### Input data and data source:
Emission factors (EF) are published by different agencies.
Total carbon emissions can be measured by estimating the amount of CO₂ emitted using activity data (such as the amount of fuel used) and conversion factors (e.g. emission factors).
Number of handled units (volume).

### Frequency of measurement:
Monthly
Annually

### Calculation method:
Traffic simulation tool

### Decision level:
Tactical
Strategic

### Relationship with other indicators:
Terminal throughput

### Presentation of results

Number and graphically
Against previous years

### Notes and comments:
21. **Carbon footprint per unit**

Indicator that can be calculated considering different types of handled units: by type and size or by category (TEUs, ITUs, tons).
### 22. Delays produced (reliability) - Road

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>Public body</td>
<td>Hinterland</td>
<td>Road congestion</td>
</tr>
</tbody>
</table>

**Description and objective:**
Expresses arrival and departures delays. It is an external factor (e.g. delays of trucks due to congestion lead to longer waiting times in the terminal).

**Formula:**
Average delays (extent)

**Unit:**
Time (minutes, hours)

**Input data and data source:**
- Time related data from the terminal simulation model.
- Traffic flows from traffic simulation.

**Frequency of measurement:**
- Monthly
- Annually

**Calculation method:**
Terminal simulation model

**Presentation of results**
- Number and graphically

**Evolution of the indicator:**
- Against previous year

**Decision level:**
Operational

**Relationship with other indicators:**
- Waiting time
- Turnaround time
- Reliability

**Notes and comments:**
### 23. Delays produced (reliability) - Railway

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>Public body</td>
<td>Rail Network</td>
<td>Rail network congestion</td>
</tr>
</tbody>
</table>

**Description and objective:**

Expresses arrival and departures delays. It is an external factor (e.g. delays of freight trains lead to longer waiting times in the terminal).

**Formula:** Average delays (extent)

**Unit:** Time (minutes, hours)

**Input data and data source:**

Time related data from the terminal simulation model.

**Frequency of measurement:** Annually

**Calculation method:** Terminal simulation model

**Presentation of results**

Number and graphically

**Evolution of the indicator:** Against previous years

**Decision level:** Operational

**Relationship with other indicators:**

**Notes and comments:**
### 24. CO, NOX, SOC, PM emissions

<table>
<thead>
<tr>
<th>Performance dimension</th>
<th>Stakeholder involved</th>
<th>Scope</th>
<th>Subgroup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Public body</td>
<td>Hinterland</td>
<td>Air pollution</td>
</tr>
</tbody>
</table>

**Description and objective:**
The aim is to analyse and quantify the adverse effects that acid rain and smog precursors can have on biodiversity.

Acid rain and smog precursors (CO, NOX and SOC) are emissions to air which, with dispersion, can be transported in the atmosphere over distances of hundreds to thousands of miles, and eventually deposited through precipitation or by direct ‘dry’ processes.

**Formula:**

- Total CO emissions = EF \( CO \) *Fuel consumption
- Total NOx emissions = EF \( NOx \) *Fuel consumption
- Total SOC emissions = EF \( SOC \) *Fuel consumption
- Total PM emissions = EF \( PM \) *Fuel consumption

**Unit:**
- Kg CO, NOX, SOC and PM per handled unit
- Kg CO, NOX, SOC and PM / tkm
- Annual inventory of CO, NOX, SOC and PM (kg, tons)

**Input data and data source:**
Emissions factors per type of equipment and/or activity obtained from statistical data.

**Frequency of measurement:**
Annually

**Calculation method:**
Traffic simulation tool

**Presentation of results** and **Evolution of the indicator:**
Number and graphically Against previous years Strategic

**Decision level:**
Strategic

**Relationship with other indicators:**
Against previous years Strategic
### 24. CO, NOX, SOC, PM emissions

Indicator that can be calculated considering different types of handled units: by type and size or by category (TEUs, ITUs, tons).
### 25. Population exposed to high levels of traffic noise

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Public body</td>
<td>Hinterland</td>
<td>Noise</td>
</tr>
</tbody>
</table>

#### Description and objective:

Expresses the amount of people exposed to levels of traffic noise above the maximum outdoors noise level permitted.

Shows the awareness for environmental concerns as measures for a better protection of the environment.

It is calculated according to the **sound power level from the traffic flow (vehicles-km) by using simulation model for propagation distance** (Örgen and Barregard, 2016)\(^1\)

\[
M (L_{eq, 55\text{dBA}})= \sum_n \int d(n) \theta(L - L_{\text{limit}}) \, dx \, dy.
\]

- \(n\) represents a squared area within the hinterland region
- \(d(n)\) is the population density at square \(n\)
- \(\theta(L - L_{\text{limit}})\): Step function for noise level

#### Input data and data source:

<table>
<thead>
<tr>
<th>Frequency of measurement:</th>
<th>Calculation method:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum outdoors noise level (dBA).</td>
<td>Traffic simulation tool</td>
</tr>
<tr>
<td>Road traffic noise prediction.</td>
<td>Anually</td>
</tr>
</tbody>
</table>

#### Presentation of results

<table>
<thead>
<tr>
<th>Evolution of the indicator:</th>
<th>Decision level:</th>
<th>Relationship with other indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number and graphically</td>
<td>Strategic</td>
<td>Against previous years</td>
</tr>
</tbody>
</table>

#### Notes and comments:

Often connected with additional costs.

---

\(^1\) [https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4865157/#pone.0155328.ref008](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4865157/#pone.0155328.ref008)
### 25. Population exposed to high levels of traffic noise

Noise emission models are not native implemented within the traffic simulation tool. Thus, it should be developed ad-hoc.

Poor data access.
### 26. Number of road accidents

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Public body</td>
<td>Hinterland</td>
<td>Accidents</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description and objective:</th>
<th>Formula:</th>
<th>Unit:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of road accidents related to terminal activities in terminal and its hinterland at a given period, within a given geographical area. Describes the safety and security of terminal activities within a certain region.</td>
<td>Number of accidents per vehicle-km according to National EU standards (average number of accidents and deaths)</td>
<td>Number of road accidents/year</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input data and data source:</th>
<th>Frequency of measurement:</th>
<th>Calculation method:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistics. National EU standards related to number of accidents and deaths. Traffic flow from the traffic simulation model.</td>
<td>Annually</td>
<td>Traffic simulation tool</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Presentation of results of indicator:</th>
<th>Evolution of the indicator:</th>
<th>Decision level:</th>
<th>Relationship with other indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Against previous years</td>
<td>Tactical</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Notes and comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical data may refer to the country where the terminal is located.</td>
</tr>
<tr>
<td>Performance dimension:</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Safety</td>
</tr>
</tbody>
</table>

**Description and objective:**

Total number of railway accidents related to terminal activities in terminal and its hinterland at a given period, within a given geographical area. Describes the safety and security of terminal activities within a certain region.

**Formula:**

Number of accidents per train-km according to National EU standards (average number of accidents and deaths)

**Unit:**

Number of railway accidents/year

**Input data and data source:**

Statistics.

National EU standards related to number of accidents and deaths.

Traffic flow from the traffic simulation model.

**Frequency of measurement:**

Annually

**Calculation method:**

Traffic simulation tool

**Presentation of results:**

Number

**Evolution of the indicator:**

Against previous year

**Decision level:**

Operational

**Relationship with other indicators:**

Number Against previous year Operational

**Notes and comments:**

Statistical data may refer to the country where the terminal is located.
### 28. Manoeuvring time

<table>
<thead>
<tr>
<th>Performance dimension</th>
<th>Stakeholder involved</th>
<th>Scope</th>
<th>Subgroup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Operator</td>
<td>Terminal</td>
<td>Efficiency; Productivity-time related</td>
</tr>
</tbody>
</table>

**Description and objective:**

It is the time required for port services/shunting operations/driving operations to arrive/depart to/from the terminal.

It reflects layout effectiveness and the effects of internal congestion on circulation.

**Formula:**

- **Trains:**
  - Sum of train shunting time for entrance and departure

- **Trucks:**
  - Truck driving time from waiting area to loading position and reverse processes

- **Ships:**
  - Sum of ship port services time for entrance + ship port services time for departure

**Unit:**

- Time (minutes, hours)

**Input data and data source:**

- Time related data from the terminal simulation model
- Daily/monthly/annually
- Terminal simulation model

**Presentation of results**

- Waiting time per hour-day (chart)
- Evolution per day/month/year
- Operational
- Turnaround time

**Notes and comments:**

This partial time is included in arrival and departure time in Turnaround Time indicator.
### 29. Service time

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Operator</td>
<td>Terminal</td>
<td>Efficiency; Productivity-time related</td>
</tr>
</tbody>
</table>

## Description and objective:

It is the time elapsed from the commence of cargo operations to their completion.

### Formula:

- **Trains:**
  - Sum of train loading and/or unloading time
- **Trucks:**
  - Sum of truck loading and/or unloading time
- **Ships:**
  - Sum of net berthing time (loading and/or unloading time)

### Unit:

Time (minutes, hours)

### Input data and data source:

Time related data from the terminal simulation model.

### Frequency of measurement:

Daily/monthly/annually

### Calculation method:

Terminal simulation model

## Presentation of results

<table>
<thead>
<tr>
<th>Service time per truck/train/vessel</th>
<th>Evolution of the indicator:</th>
<th>Decision level:</th>
<th>Relationship with other indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Evolution per day/month/year</td>
<td>Operational</td>
<td>Turnaround time Berthing time</td>
</tr>
</tbody>
</table>

### Notes and comments:

This time is included in loading/unloading time within turnaround time indicator.

In case of simultaneous loading/unloading processes, we should consider total operational time and not the sum of both components.
## 30. Berthing time

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Operator</td>
<td>Terminal</td>
<td>Efficiency; Productivity-time related</td>
</tr>
</tbody>
</table>

### Description and objective:
It is the gross time elapsed from the arrival of vessels to the terminal to its departure.

### Formula:
Sum of gross berthing time: loading and/or unloading time and waiting time to be served

### Unit:
Time (minutes, hours)

### Input data and data source:
Time related data from the terminal simulation model.

### Frequency of measurement:
Daily/monthly/annually

### Calculation method:
Terminal simulation model

### Presentation of results:

### Evolution of the indicator:
Service time per truck/train/vessel

### Decision level:
Operational

### Relationship with other indicators:
Turnaround time

### Notes and comments:
### 31. Idle time (equipment)

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Operator</td>
<td>Terminal</td>
<td>Efficiency; Productivity-time related</td>
</tr>
</tbody>
</table>

**Description and objective:**
It is the non-productive time in which an employee or equipment item remain on site ready for use but is placed in a standby basis.

**Formula:**
Sum of non-productive time per equipment and employee

**Unit:**
Time (minutes, hours)

**Input data and data source:**
Time related data from the terminal simulation model

**Frequency of measurement:**
Daily/monthly/annually

**Calculation method:**
Terminal simulation model

**Presentation of results:**
Idle time per equipment item and employee

**Evolution of the indicator:**
Evolution per day/month/year

**Decision level:**
Operational

**Relationship with other indicators:**
Equipment utilization

**Notes and comments:**

---

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### 32. Capital Expenditures (CAPEX)

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Investor</td>
<td>Terminal</td>
<td>Costs</td>
</tr>
</tbody>
</table>

**Description and objective:**
The capital expense are funds used by a company/terminal operator to acquire or upgrade physical assets such as property, buildings or equipment.

These costs are spread over the useful life of the asset and need to be capitalized.

**Formula:** CAPEX is the sum of all expenses (money spent) on buildings, equipment and infrastructure items by the terminal operator.

**Unit:** Monetary units (€)

**Unitary costs (€/ton; €/TEU; €/UTI)**

**Input data and data source:**
- Expenditures associated to buildings, equipment and infrastructure items

**Frequency of measurement:** Monthly/annually

**Calculation method:** BIM

**Presentation of results**
- Graphically and amount of money

**Evolution of the indicator:** Yes (annually)

**Decision level:** Strategic

**Operational**

**Relationship with other indicators:** Profitability

**Notes and comments:**

---

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### 33. Operational Expenditures (OPEX)

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Operator</td>
<td>Terminal</td>
<td>Operating cost</td>
</tr>
</tbody>
</table>

**Description and objective:**
An operating expense is an ongoing cost a business/terminal operator incurs through its normal business operations. Those include accounting expenses, license fees, maintenance and repairs, office expenses, supplies, utilities, insurance, property management, taxes, labour, energy, etc.

OPEX is the sum of all expenses (money spent) on accounting expenses, concession fees, maintenance and repairs, equipment operating costs, office expenses, supplies, utilities, insurance, taxes, labour, energy, etc.

**Formula:**

**Unit:**
Monetary units (€)
Unitary costs (€/ton; €/TEU; €/UTI)

**Input data and data source:**
Cost modelling from Terminal simulation model or BIM cost module

**Frequency of measurement:**
Monthly/annually

**Calculation method:**
BIM/Terminal simulation model

**Presentation of results**
Graphically and percentage

**Evolution of the indicator:**
Yes, monthly/annually

**Decision level:**
Tactical
Operational

**Relationship with other indicators:**
Operating efficiency

**Notes and comments:**
Operating expenses are often considered to be either fixed or variable.
It may be quite difficult to calculate OPEX in detail. Therefore, it is suggested to estimate them as flat rates per item/unit.
<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Operator</td>
<td>Terminal</td>
<td>Maintenance cost - equipment</td>
</tr>
</tbody>
</table>

**Description and objective:**
This indicator is related to the total downtime in a period scheduled for corrective maintenance and breakdown repairs.

**Input data and data source:**

**Formula:**

**Unit:** Hours per year for each equipment item

**Presentation of results**
Graphically and percentage

**Evolution of the indicator:** Yes, annually

**Decision level:** Strategic, Operational

**Relationship with other indicators:** Operating efficiency, Profitability

**Notes and comments:**
### 35. Preventive maintenance cost (equipment)

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Operator</td>
<td>Terminal</td>
<td>Maintenance cost - equipment</td>
</tr>
</tbody>
</table>

**Description and objective:**
This indicator is related to the total downtime in a period scheduled for preventive maintenance and breakdown repairs.

**Input data and data source:**

**Frequency of measurement:**

**Calculation method:**

Annually BIM

**Presentation of results**

**Evolution of the indicator:**
Yes, annually

**Decision level:**

**Relationship with other indicators:**
Graphically and percentage

**Decision level:**

Operating efficiency

**Notes and comments:**
### 36. Corrective concrete structures maintenance cost

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Investor</td>
<td>Terminal</td>
<td>Infrastructure maintenance cost</td>
</tr>
<tr>
<td></td>
<td>Terminal operator</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Public body</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description and objective:</th>
<th>Formula:</th>
<th>Unit:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A concrete structure shall retain the required levels of its performance for the intended service life with adequate reliability by providing necessary maintenance activities. For accomplishing it, an adequate maintenance plan, in which the performance of the concrete structure shall be clearly specified on the basis of a service life scenario incorporating maintenance strategy, should be preliminarily made. The appropriate maintenance plan for existing structures should be formulated under the basis of appropriated indicators (see input data).</td>
<td>Maintenance index</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input data and data source:</th>
<th>Frequency of measurement:</th>
<th>Calculation method:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crack opening</td>
<td>3 years</td>
<td>BIM</td>
</tr>
<tr>
<td>Chloride content</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbonation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel corrosion rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposure class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifespan</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Presentation of results of indicator:</th>
<th>Evolution of the indicator:</th>
<th>Decision level:</th>
<th>Relationship with other indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphically</td>
<td>Every 5 years</td>
<td>Strategic</td>
<td>Operating efficiency</td>
</tr>
</tbody>
</table>
36. Corrective concrete structures maintenance cost

<table>
<thead>
<tr>
<th></th>
<th>Operational</th>
<th>Profitability</th>
</tr>
</thead>
</table>

Notes and comments:

For fulfilling the rational and reliable maintenance activities in order to keep the performance of structure always above its required level, it is necessary to evaluate the time-dependent degradation process of the performance of structure during the life, with adequate reliability (deterioration evaluate model). The maintenance strategy comprehensively encompasses inspections, estimation of deterioration levels and rates, evaluation of performance of structure, remedial actions, and recording. The combination of these steps differs to the different maintenance category, considering the importance of the structure (lifespan), and environmental conditions (exposure classes).
## 37. Preventive concrete structures maintenance cost

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Investor</td>
<td>Terminal</td>
<td>Infrastructure maintenance cost</td>
</tr>
<tr>
<td></td>
<td>Terminal operator</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Public body</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Description and objective:
For achieving proper maintenance of newly constructed structures, the maintenance plan should be formulated at the design stage, with the proper selection of the materials to be used in the construction, which assure easy and less maintenance tasks during the structure design service life.

### Input data and data source:

<table>
<thead>
<tr>
<th>Exposure class</th>
<th>Frequency of measurement</th>
<th>Calculation method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifespan</td>
<td></td>
<td>BIM</td>
</tr>
<tr>
<td>Frost attack</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical attack</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Presentation of results

<table>
<thead>
<tr>
<th>Evolution of the indicator:</th>
<th>Decision level:</th>
<th>Relationship with other indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphically</td>
<td>Strategic</td>
<td>Operating efficiency</td>
</tr>
<tr>
<td></td>
<td>Operational</td>
<td>Profitability</td>
</tr>
</tbody>
</table>

### Notes and comments:
For fulfilling the rational and reliable maintenance activities in order to keep the performance of structure always above its required level, it is necessary to evaluate the time-dependent degradation process of the performance of structure during the life, with adequate reliability (deterioration evaluate model). The maintenance strategy comprehensively encompasses inspections, estimation of...
37. Preventive concrete structures maintenance cost

deterioration levels and rates, evaluation of performance of structure, remedial actions, and recording.
The combination of these steps differs to the different maintenance category, considering the importance of the structure (lifespan), and environmental conditions (exposure classes).
<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>Terminal operator</td>
<td>Terminal</td>
<td>Service quality - time</td>
</tr>
</tbody>
</table>

**Description and objective:**

It is the unproductive time spent waiting (queueing) for labour/equipment service, waiting at the gates, buffer areas or to be loaded/unloaded over the total time (turnaround).

Expresses the terminal operator’s ability to run reliable and punctual operations.

<table>
<thead>
<tr>
<th>Input data and data source:</th>
<th>Frequency of measurement:</th>
<th>Calculation method:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time related data from the terminal simulation model.</td>
<td>For each vessel/truck/train arrival</td>
<td>Terminal simulation model</td>
</tr>
</tbody>
</table>

**Presentation of results**

Graphically and percentage

**Evolution of the indicator:**

Average values per year and per type of customer (ship, truck, train)

<table>
<thead>
<tr>
<th>Decision level:</th>
<th>Relationship with other indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Waiting time</td>
</tr>
<tr>
<td>Strategic</td>
<td>Turnaround time</td>
</tr>
</tbody>
</table>

**Formula:**

- Train waiting time / Train turnaround time
- Truck waiting time / Truck turnaround time
- Ship waiting time / Ship turnaround time

**Unit:** Percentage (%)

**Notes and comments:**
### 39. Use of alternative fuels from total consumption

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Terminal operator</td>
<td>Terminal</td>
<td>Alternative fuels</td>
</tr>
</tbody>
</table>

**Description and objective:**

- It is the ratio between the energy consumed from alternative fuels/sources and the total energy consumed.
- The aim is to measure the environmental improvement according to use of alternative fuels.

**Formula:** 

\[
\frac{\text{Alternative fuels consumption}}{\text{Total energy consumption}}
\]

**Unit:** Percentage (%)

**Input data and data source:**

- Total energy consumption in the terminal.
- Types of terminal equipment and characteristics used in BIM.
- Alternative fuels consumption.

**Frequency of measurement:** Annually

**Calculation method:** Traffic simulation model

**Presentation of results**

- Graphically and percentage

**Evolution of the indicator:** Against previous years

**Decision level:** Strategic

**Relationship with other indicators:** Energy consumption

**Notes and comments:**
### 40. Accidents related to Hazard cargo

<table>
<thead>
<tr>
<th>Performance dimension:</th>
<th>Stakeholder involved:</th>
<th>Scope:</th>
<th>Subgroup:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Public body</td>
<td>Hinterland</td>
<td>Accidents</td>
</tr>
</tbody>
</table>

**Description and objective:**

Measures accidents/incidents that occur at the loading and unloading points or ‘in-transit’ related to terminal activities.

**Accident:** any occurrence involving a commercial motor vehicle on highway, national or local roads resulting in a fatality, injury to a person requiring immediate treatment away from the scene of the accident, disabling damage to a vehicle requiring it to be towed from the scene, loss of product or involvement of authorities.

**Transport:** The "in-transit" transport of chemicals by motor vehicles between the site of a supplying company and that of the final destination, excluding transport activities at loading and unloading premises of the supplying chemical company and the final destination.

**Injury:** where the injury requires intensive medical treatment, or requires a stay in hospital of at least one day, or results in the inability to work for at least three consecutive days irrespective of whether or not the chemical product contributed to the injury.

The aim is to be able to identify weak points and improve them.

<table>
<thead>
<tr>
<th>Formula:</th>
<th>Unit:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of accidents per road-km related to hazard cargo according to National EU standards (average number of accidents and deaths)</td>
<td>Percentage (%)</td>
</tr>
</tbody>
</table>

**Input data and data source:**

- Statutory data

**Frequency of measurement:**

- Annually

**Calculation method:**

- Traffic simulation tool

**Presentation of results of the indicator:**

**Evolution of the indicator:**

**Decision level:**

**Relationship with other indicators:**
### 40. Accidents related to Hazard cargo

<table>
<thead>
<tr>
<th>Number</th>
<th>Against previous year</th>
<th>Operational</th>
<th>Total number of accidents</th>
</tr>
</thead>
</table>

**Notes and comments:**

Statistical data may refer to the country where the terminal is located.

Consider in case the terminal handles hazard cargo.