INTERMODEL EU

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

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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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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).

STAKEHOLDERS PERFORMANCE DIMENSION	INVESTOR	OPERATOR	PUBLIC BODY
OPERATION	**Terminal throughput**	**Equipment utilization** **Gate utilization** **Labour utilization rate** **Storage area utilization** **Rail track utilization** **Berth utilization** **Turnaround time** • Manoeuvring time • Service time • Berthing time • Equipment idle time **Waiting time** **Terminal throughput**	
FINANCE	**Return On Investment (ROI)** **Terminal's profitability** • CAPEX	**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**
QUALITY		**Turnaround time** **Waiting time** • Waiting time / turnaround time **Easiness of entry and exit from highways** **Easiness of entry and exit from rail network**	**Delays produced (reliability) on road** **Delays produced (reliability) on railway**
ENVIRONMENT		**Energy consumption per handled unit** • Use of alternative fuels from total consumption	**Carbon footprint per unit** **CO, NOX, SOX and PM emissions per unit** **Population exposed to high-levels of traffic noise**
SAFETY			**Number of road accidents** **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 CO_2 (in kg) that reinforces the greenhouse effect to the same degree as the substance emitted. CO_2 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

SFA: Stochastic Frontier Analysis

TEU: Twenty Foot Equivalent Unit

UNCTAD: United Nations Conference on Trade and Development

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 COCKPIIT 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 CO_2 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 Paixao (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 Paixao (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

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

Category of performance indicator	Subcategory of performance indicator	Performance indicator	Main sources
Financial	Investment and funding	Infrastructure construction Equipment purchase Profitability Turnover Revenues/Expenditures	Ferreira and Sigut (1993) UNCTAD (1976) Chung (1993) Talley (2007)
	Costs and pricing	Labour costs Equipment costs Infrastructure costs Maintenance costs	Ferreira and Sigut (1993) Marlow and Paixao (2003) Talley (1996) UNCTAD (1976)

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 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

Category of performance indicator	Subcategory of performance indicator	Performance indicator	Main sources
Quality service	Safety and security Flexibility Reliability and service care Accessibility and connectivity	Time-related indicators % of lost or damaged cargo No delays, no wrong delivery Employees qualification Incidence of train/vessel delay in departure (%) Schedule reliability	Ballis (2004) Huynh and Awad-Núñez et al. (2015) Walton (2005) Dragović et al. (2005) Henesey et al. (2003) Notteboom (2006) Marsden et al. (2005) Agerschou (2004) Fourgeaud (2000)
Environmental /sustainable	Accidents Noise Air pollution Climate change Water pollution Habitat loss Hydrologic impacts Energy consumption Sprawl Congestion Resource efficiency	Number of transport accidents, fatalities, injured, polluting accidents, etc. Crash casualties and costs Air pollution emissions Embodied emissions Noise pollution exposure People exposed to traffic noise above 55 LAeq Impervious surface coverage Habitat preservation Community livability ratings Water pollution emissions	Litman (2007) Litman (2016) GPI (2008) Marsden, et al (2005) Hanaoka and Regmi, 2011

Category of performance indicator	Subcategory of performance indicator	Performance indicator	Main sources
		Use of renewal fuels Energy efficiency Vibrations Mode split	
Socio-economic impact	Economic impact Return on investment	Value added per ton Employment per unit of land Value added per invested euro by the public sector Port-related employment Port value added	ESPO (2010) De Langen et al. (2007)

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 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.

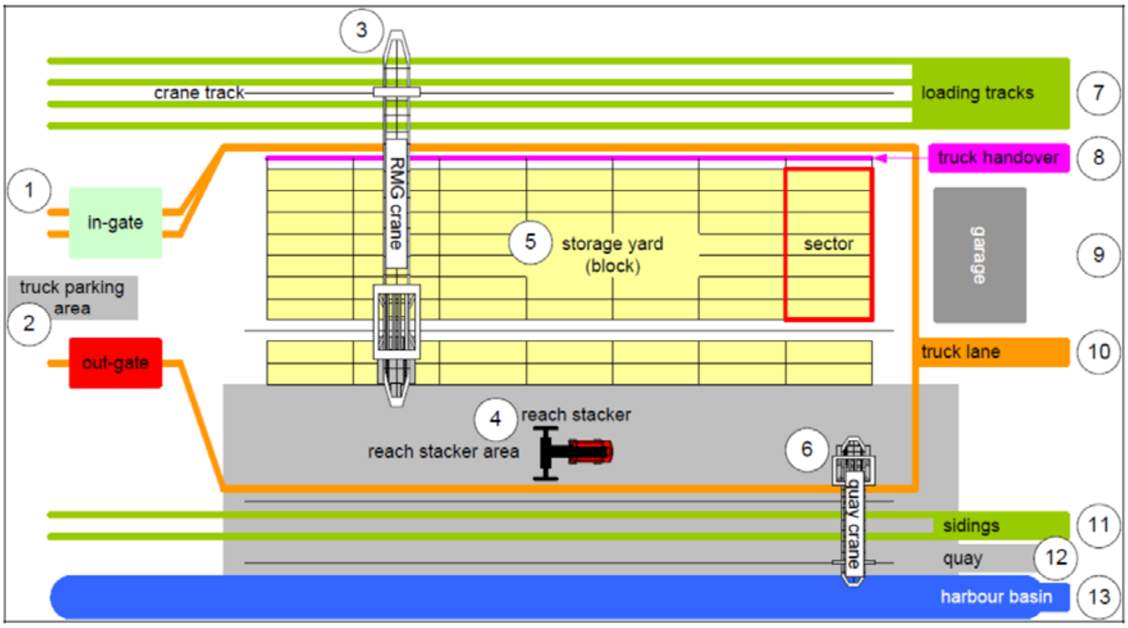
  The process of storing (or retrieving) a container or ITU includes the time for adjusting the RTG, picking up the container or ITU, moving toward the allocation place and downloading the container or ITU.

- **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



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 PIs 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.

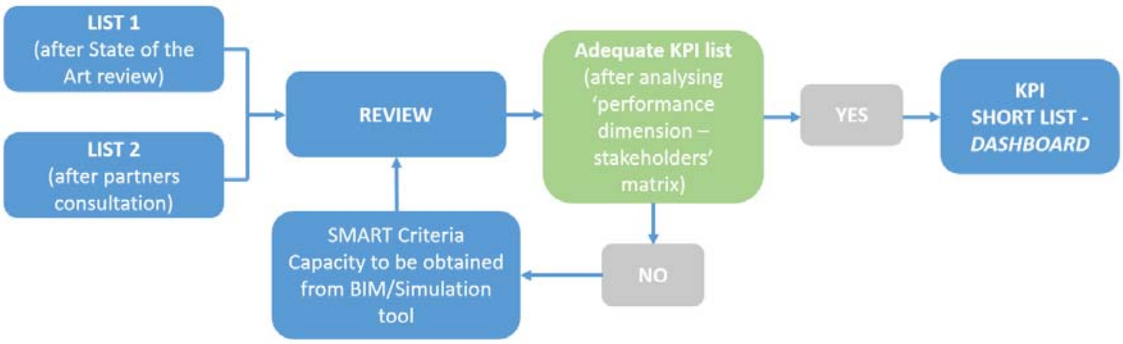
4. **Identification of particular strategic goals**

   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 PIs set**

   The selection of feasible KPIs and PIs 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.

Figure 2. KPI & PI list methodology



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.

  $$TPF(k) = Y(k)/X(k)$$

  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 Delphy 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 PIs 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 3. Relevant actors and functions in freight terminals

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

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

		Stakeholders		
		Investor	Operator	Public authority
Performance dimension	Operation			
	Finance			
	Quality			
	Environment			
	Safety			

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

		Stakeholders		
		Investor	Operator	Public authority
Performance dimension	Operation	Productivity	Efficiency Productivity Volume Congestion	
	Finance	ROI Costs Revenues	Unit cost Maintenance costs Revenues	Employment Maintenance costs Investment on modal shift
	Quality		Service quality – time Damages	Congestion (road and rail)
	Environment		Energy efficiency Alternative fuels	Carbon footprint
	Safety			Accidents costs

(1) 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 6. KPI list for intermodal freight terminals

Performance dimension	Stakeholder	Subgroup	Indicator	Scope	Goal
OPERATION	Investor	Productivity	Terminal throughput	Terminal	1
	Operator	Efficiency; Productivity – Utilization	Equipment	Terminal	2
			Gate	Terminal	2
			Labor utilization rate	Terminal	2
			Storage area	Terminal	2
			Rail track occupancy	Terminal Rail network	2/3
			Berth occupancy	Terminal	2
		Efficiency; Productivity – time related	Turnaround time	Terminal	2
			Waiting time	Terminal	2
			Manoeuvring time	Terminal	2
			Service time[1]	Terminal	2
			Berthing time	Terminal	2
			Idle time	Terminal	2
		Total traffic	Terminal throughput	Terminal	2
			ROI	Terminal	1

Performance dimension	Stakeholder	Subgroup	Indicator	Scope	Goal
FINANCE	Investor	Financial indicators	Profitability	Terminal	1
		Costs	CAPEX	Terminal	1
	Operator	Operating cost	Efficiency	Terminal	1
			OPEX	Terminal	1
		Maintenance cost - equipment	# hours on corrective maintenance per machine	Terminal	1
			# hours on preventive maintenance per machine	Terminal	1
		Revenues	Revenues per unit	Terminal	1
		Benefits	Benefits per unit	Terminal	1
		Maintenance cost - Infrastructure	Corrective concrete structures maintenance cost	Terminal	1
			Preventive concrete structures maintenance cost	Terminal	1
	Public authority	Employment	Direct jobs	Terminal	1/5(4)
			Jobs sustained in the region	Terminal	5
		Maintenance cost	Road and rail track maintenance	Hinterland Rail network	3
QUALITY	Operator	Service quality - time	Turnaround	Terminal	2
			Waiting time / turnaround	Terminal	2
		Accessibility	Easiness of entry and exit from highways	Hinterland	3
			Easiness of entry and exit from rail network	Rail network	3
	Public authority	Investment on modal shift	Investment in infrastructure improvement(2)	Hinterland Rail network	3/4
			Subsidies(2)	Hinterland	4
		Road congestion	Delays produced(5)	Hinterland	3

Performance dimension	Stakeholder	Subgroup	Indicator	Scope	Goal
		Rail network congestion	Delays produced[(5)]	Rail network	3
ENVIRONMENT	Operator	Energy efficiency	Total consumption per num. of handled units	Terminal	1/4
		Alternative fuels	Use of alternative fuels/total consumption	Terminal	1/4
	Public authority	Climate change	Carbon footprint	Hinterland	4
		Air pollution	CO, NOX, SOC, PM emissions	Hinterland	4
		Noise	Population exposed to high levels of traffic noise	Hinterland	4
		Health[(3)]		Hinterland	4
SAFETY	Public authority	Accidents	Num. of road accidents	Hinterland	2/4
			Num. of railway accidents	Rail connection	2/4
			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 7. Classification of performance indicators (KPIs and PIs)

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

Key Performance Indicators (KPIs)	Performance Indicators (PIs)
26-Number of road accidents 27-Number of railway accidents	

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

KPI name			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
[Operational, Financial, Quality, Environment, Safety]	[Investor, Terminal operator, public body]	[Terminal, Rail Network, Hinterland]	[Name]
Description and objective:		**Formula:**	**Unit:**
[Describe the KPI and its objective]			
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
[Describe which data is required and the exact location of the necessary raw data/raw information to calculate the metric of the KPI]		[Daily, monthly, annually, etc.]	[BIM, simulation tool, analytical]
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
[Number or graphical]	[Panel; Historical data]	[Operational, Tactical and strategic]	
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.

Figure 3. Proposed KPI (in bold) and PI list (bullet points). Dashboard for IFT integrated in BIM

STAKEHOLDERS PERFORMANCE DIMENSION	INVESTOR	OPERATOR	PUBLIC BODY
OPERATION	**Terminal throughput**	**Equipment utilization** **Gate utilization** **Labour utilization rate** **Storage area utilization** **Rail track utilization** **Berth utilization** **Turnaround time** • Manoeuvring time • Service time • Berthing time • Equipment idle time **Waiting time** **Terminal throughput**	
FINANCE	**Return On Investment (ROI)** **Terminal's profitability** • CAPEX	**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**
QUALITY		**Turnaround time** **Waiting time** • Waiting time / turnaround time **Easiness of entry and exit from highways** **Easiness of entry and exit from rail network**	**Delays produced (reliability) on road** **Delays produced (reliability) on railway**
ENVIRONMENT		**Energy consumption per handled unit** • Use of alternative fuels from total consumption	**Carbon footprint per unit** **CO, NOX, SOX and PM emissions per unit** **Population exposed to high-levels of traffic noise**
SAFETY			**Number of road accidents** **Number of railway accidents** • Accidents related to hazard cargo

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 PIs. 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.

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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.

Indicator	Short description	Priority	Acces to data	Effort	Clarity	Measurable	Transferable	Scope	Point of view		
									Investor	Terminal operator	Public Bodies
Financial performance											
Total Revenue	Total sales per period; indicates absolut performance against targets or previous periods	X	low	high	++	medium	yes	T	X	X	
OPEX (Operational Expenditure)	Main costs components (operations)	X	low	high	++	medium	yes	T	X	X	
Total Costs	Sum of all terminal costs of a period		low	high	++	medium	yes	T	X		
Cost of Sales	Especially 3party transportation costs		low	high	++	medium	yes	T	X		
Staff costs	In monetary terms		low	high	++	medium	yes	T	X	X	
Costs of electricity, fuel, etc.	Energy costs	X	low	high	++	medium	yes	T	X	X	
Depreciation	Buildings, equipment, etc.		low	high	++	medium	yes	T	X	X	
Revenue per unit	Revenue per handled or transported unit (e.g. per TEU)	X	low	high	++	good	yes	T		X	
Unit costs	Cost per handling unit (e.g. per TEU)	X	low	high	++	good	yes	T		X	
Staff costs / FTE	In EUR per full time employee		low	high	++	good	yes	T		X	
Staff costs / shipment	In EUR per shipment		low	high	++	good	yes	T		X	
Staff costs / ton	In EUR per ton		low	high	++	good	yes	T		X	
Staff costs / handling unit	In EUR per handling unit (e.g. per TEU)		low	high	++	good	yes	T		X	
Total costs / handling unit	In EUR per handling unit (e.g. per TEU)	X	low	high	++	good	yes	T		X	
Profitabilty per handling unit	e.g. Gross Profit per TEU or Handling Unit	X	low	high	++	good	yes	T	X		
Service center over/under coverage	Variance analysis on service center level		low	high	++	good	yes	T		X	
Net Working Capital	Management of trade receivables and trade payables, inventory if applicable		low	high	++	medium	yes	T	X		
CAPEX (Capital Expenditure)	Investments	X	low	high	++	medium	yes	T	X		
Return on Capital Employed (ROCE)	Value generated by invested capital	X	low	high	++	medium	yes	T	X		
Claims	Customer claims (financial risks)		low	low	+	low	yes	T		X	
Bad debt	Uncollectables	X	low	high	+	low	yes	T	X		
ROI	%	X	low	high	++	good	yes	T	X		

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.

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

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.

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

Access to data (good/medium/poor): Data can be obtained from statistics, studies or internet.
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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.

Indicator	Short description	Priority	Acces to data	Effort	Clarity	Measurable	Transferable	Scope	Point of view		
									Investor	Terminal operator	Public Bodies
Operational performance											
Equipment utilization	TEUs per year per crane/RS...		low	low	++	good	yes	T		X	
Equipment productivity	Moves per crane/RS per hour	X	low	low	++	good	yes	T		X	
Distance traveled by terminal tractors b/w train and designated terminal positions of unloaded containers	In meters, kilometers		low	low	++	good	yes	T		X	
Distance traveled by terminal tractors b/w terminal locations of the containers to be loaded and trains	In meters, kilometers		low	low	++	good	yes	T		X	
Service quality											
# damages	Quality KPIs	X	low	high	++	low	no	T/H		X	
# accidents	Quality KPIs	X	low	low	++	low	no	T/H		X	X
# departures in time	Quality KPIs		low	low	++	good	yes	T		X	
Average round trip	In minutes, hours	X	medium	high	++	good	yes	H		X	
Average time spent in terminal per container	In minutes, hours	X	medium	high	++	good	yes	T		X	
Waiting hours of trucks at terminal door	In minutes, hours	X	medium	high	++	medium	yes	T		X	
Average time spent by train at terminal	In minutes, hours	X	medium	high	++	good	yes	T		X	
Average time spent by truck at terminal	In minutes, hours	X	medium	high	++	good	yes	T		X	
# trains spending over 50% more than the av. time for trains	Related to waiting time/delays		low	high	+	good	yes	T		X	
# trucks spending over 50% more than the av. time for trucks	Related to waiting time/delays		low	high	+	good	yes	T		X	
Turnaround time of trains	In minutes, hours	X	medium	high	++	good	yes	R		X	

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.

Indicator	Short description	Priority	Acces to data	Effort	Clarity	Measurable	Transferable	Scope	Point of view		
									Investor	Terminal operator	Public Bodies
Environmental performance											
Total carbon emissions	Total carbon emitted through energy consumption of terminal	X	low	high	++	medium	yes	H			X
Carbon footprint per handling unit (e.g. container or ton)	Carbon footprint of a handled standard container (e.g. TEU)	X	low	high	++	good	yes	T			X
Dangerous goods KPIs	Specific KPIs in case of dangerous goods (depending on local regulations)	X	low	high	+	good	yes	T			X
"# of trucks in rush hour"; "number of containers handled in peak season"	Directly related with emissions		low	high	++	low	yes	H/R			X
Socio-economic											
# of jobs @terminal	Role as employer	X	low	high	+	good	no	T			X
Taxes	Contribution to area in terms of taxes		low	high	-	low	no	H			X
Traffic	Effects on local traffic, key routes due add. trucks, trains	X	low	medium	+	low	no	H/R			X
Market											
Trading balance	Trading balance of country, region		low	high	++	low	no	H		X	
Trade flows	Volumes of goods shipped from and to the region of the terminal		low	high	++	low	no	H		X	
Transport modes / logistics grid	Share of road, rail, air, ocean, ... transportation	X	good	low	++	good	no	H/R			X
Development of transportation modes	Develoment rail volume, road volume, etc. (absolute and in %)	X	low	low	++	low	no	H/R			X
Competitor volumes	Volume handled by main competitors		low	low	++	low	no	H		X	
Competitor revenue	Revenue and Revenue devlopment of main compeitiors		low	low	++	low	no	H		X	
Competitor profitability	Profitability and development of main competitors		low	low	++	low	no	H		X	

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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.

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

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.

Appendix II

This appendix includes the definition of each KPI and PI included in the proposed final list.

1. Intermodal terminal throughput (volume)			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Operational	Investor Operator	Terminal	Productivity Total traffic
Description and objective:		**Formula:**	**Unit:**
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.		Summation of TEU, ITU or tons of cargo handled by the terminal, either as imports, exports or transhipment	TEUs ITUs Tonnes Differentiating total, imports, exports and transhipment
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
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).		Daily/monthly/annually	Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Number and graphically	Throughput evolution per year	Strategic Tactical	Efficiency Financial indicators (unitary revenues, benefits and costs)
Notes and comments:			
Imports and exports are treated separately from transhipment to avoid double counting.			

2. *Equipment utilization*			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Operational	Operator	Terminal	Efficiency; Productivity-utilization
Description and objective:		**Formula:**	**Unit:**
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.		Eq-U (%)=$T_A/(T_R-T_D)$ • 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)	Percentage (%)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Time related data from the terminal simulation model.		Annually	Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Average results and for each equipment item	Utilization's evolution per year	Strategic Tactical	Productivity Waiting time Preventive/Corrective maintenance time
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			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Operational	Operator	Terminal	Efficiency; Productivity-utilization
Description and objective:		**Formula:**	**Unit:**
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.		Gate-U (%)=T_A/T_R • T_A: Total gate active time in a period of time • T_R: Total rostered time for a gate in a period of time	Percentage (%)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Time related data from the terminal simulation model.		Annually	Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Average results and for each gate	Utilization's evolution per year	Tactical Operational	Productivity Waiting time
Notes and comments:			
Gate utilization should be considered separately for entering/departing trucks.			

4. Labour utilization rate			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Operational	Operator	Terminal	Efficiency; Productivity-utilization
Description and objective:		**Formula:**	**Unit:**
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		Labour-U (%)=T_A/T_R • T_A: Total man active time in a period of time • T_R: Total rostered time for a man in a period of time	Percentage (%)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Time related data from the terminal simulation model.		Annually	Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Results per employee type and graphically	Utilization's evolution per year	Operational	Productivity
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*			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Operational	Operator	Terminal	Efficiency; Productivity-utilization
Description and objective:		**Formula:**	**Unit:**
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		Storage U (%)=Slots occupied/Total available slots	Percentage (%)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Storage yard occupation from the simulation model.		Annually	Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Visual chart with percentages	Utilization's evolution per year	Operational	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			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Operational	Operator	Terminal Rail network	Efficiency; Productivity-utilization
Description and objective:		**Formula:**	**Unit:**
This measure reflects the amount of time that the rail track was occupied out of the total time available.		Rail track-U (%)=Rail track time occupied/Total available time	Percentage (%)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Time related data from the terminal simulation model.		Annually	Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Chart	Utilization's evolution per year	Operational	Productivity
Notes and comments:			

7. *Berth utilization*			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Operational	Operator	Terminal	Efficiency; Productivity-utilization
Description and objective:		**Formula:**	**Unit:**
This measure reflects the amount of time that the berth was occupied out of the total time available.		Berth-U (%)=Berth time occupied/Total available time	Percentage (%)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Time related data from the terminal simulation model.		Annually	Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Visual chart with percentages	Utilization's evolution per year	Operational	Productivity
Notes and comments:			
It can be related to the berth length or to the number of berthing points.			

8. Turnaround time			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Operational Quality	Operator	Terminal	Efficiency; Productivity-time related Service quality - time
Description and objective:		**Formula:**	**Unit:**
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.		Terminal $TT=T_{Arr}+T_{unload}+T_{load}+T_{dep}$ <u>Trains</u>: • T_{Arr}: Train shunting time + Train entrance control time + Train waiting time before unloading • T_{unload}: Sum of unloading times from train to storage • T_{load}: Sum of loading times from storage to train • T_{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 <u>Trucks</u>: • T_{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	Time (minutes, hours)

<table>
<tr><th colspan="4">8. Turnaround time</th></tr>
<tr><td colspan="2"></td><td>

- 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

</td><td></td></tr>
<tr><td colspan="2">Input data and data source:</td><td>Frequency of measurement:</td><td>Calculation method:</td></tr>
<tr><td colspan="2">Time related data from the terminal simulation model.</td><td>For each vessel/truck/train arrival</td><td>Terminal simulation model</td></tr>
<tr><td>Presentation of results</td><td>Evolution of the indicator:</td><td>Decision level:</td><td>Relationship with other indicators:</td></tr>
<tr><td>Total and individual results represented in numbers and graphically</td><td>Average values per year and per type of customer (ship, truck, train)</td><td>Operational</td><td>Waiting time
Service time
Maneuvering time
Berthing time</td></tr>
<tr><td colspan="4">Notes and comments:</td></tr>
<tr><td colspan="4"></td></tr>
</table>

9. *Waiting time*			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Operational	Operator	Terminal	Efficiency; Productivity-time related
Description and objective:		**Formula:**	**Unit:**
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.	Time (minutes, hours)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Time related data from the terminal simulation model.		Daily/monthly/annually	Terminal simulation model

9. Waiting time			
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Waiting time per hour-day (chart)	Evolution per day/month/year	Operational	Turnaround time
Notes and comments:			
It is recommended to register each component of waiting time separately for better evaluation.			

10. Return On Investment (ROI)			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Financial	Investor	Terminal	Financial indicators
Description and objective:		**Formula:**	**Unit:**
This performance indicator measures the amount of return on an investment relative to the investment's cost.		ROI= (Gain from Investment - Cost of Investment)/Cost of Investment = Benefits/Investment cost	Percentage (%)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Capital expenses (CAPEX) Benefits from terminal's operation		Monthly/annually	BIM
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Graphically and percentage	Against previous year during concession period	Strategic	CAPEX Profitability
Notes and comments:			

<table>
<tr><th colspan="4">11. Terminal's Profitability</th></tr>
<tr><td>Performance dimension:</td><td>Stakeholder involved:</td><td>Scope:</td><td>Subgroup:</td></tr>
<tr><td>Financial</td><td>Investor</td><td>Terminal</td><td>Financial indicators</td></tr>
<tr><td colspan="2">Description and objective:</td><td>Formula:</td><td>Unit:</td></tr>
<tr><td colspan="2">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.</td><td>PI=Present Value of future cash flows /initial investment

EBITDA margin=EBITDA/Total revenue</td><td>Percentage (%)</td></tr>
<tr><td colspan="2">Input data and data source:</td><td>Frequency of measurement:</td><td>Calculation method:</td></tr>
<tr><td colspan="2">Revenues
Operating costs
Financial costs
Initial investment</td><td>Monthly/annually</td><td>BIM</td></tr>
<tr><td>Presentation of results</td><td>Evolution of the indicator:</td><td>Decision level:</td><td>Relationship with other indicators:</td></tr>
<tr><td>Percentage</td><td>Not required</td><td>Strategic</td><td>ROI</td></tr>
<tr><td colspan="4">Notes and comments:</td></tr>
<tr><td colspan="4">The profitability can also be evaluated with the EBITDA margin.
EBITDA is equal to earnings before interest, tax, depreciation and amortization.</td></tr>
</table>

<table>
<tr><th colspan="4">12. Operating efficiency (operating margin)</th></tr>
<tr><td>Performance dimension:</td><td>Stakeholder involved:</td><td>Scope:</td><td>Subgroup:</td></tr>
<tr><td>Financial</td><td>Operator</td><td>Terminal</td><td>Operating cost</td></tr>
<tr><td colspan="2">Description and objective:</td><td>Formula:</td><td>Unit:</td></tr>
<tr><td colspan="2">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.</td><td>OM=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.</td><td>Percentage (%)</td></tr>
<tr><td colspan="2">Input data and data source:</td><td>Frequency of measurement:</td><td>Calculation method:</td></tr>
<tr><td colspan="2">Operating expenditures

Operating revenues

Turnover (net sales)</td><td>Monthly/annually</td><td>BIM</td></tr>
<tr><td>Presentation of results</td><td>Evolution of the indicator:</td><td>Decision level:</td><td>Relationship with other indicators:</td></tr>
<tr><td>Graphically and percentage</td><td>Against previous year during concession period</td><td>Strategic

Tactical</td><td>OPEX

Profitability</td></tr>
<tr><td colspan="4">Notes and comments:</td></tr>
<tr><td colspan="4"></td></tr>
</table>

13. Operating revenues per unit			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Financial	Terminal operator	Terminal	Revenues
Description and objective:		**Formula:**	**Unit:**
It is a measure of the revenue generated per handled unit. It allows to analyse the revenue generation and growth at per unit level.		Total revenue in a month or per year/ Number of handled units	Unitary revenues (€/TEU; €/ITU; €/ton)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Total revenues over a period. Number of handled units: by type and size, by category (TEUs, ITUs, tonnes of cargo).		Monthly Annually	BIM
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Number and graphically	Evolution per month, per year	Strategic	Terminal throughput Revenues 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 revenue-generator.			

14. Operating benefits per unit			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Financial	Terminal operator	Terminal	Benefits
Description and objective:		**Formula:**	**Unit:**
It is a measure of the benefits obtained per handled unit. It allows to analyse the benefit generation and growth at per unit level.		Total benefits in a month or per year / Number of handled units	Unitary benefits (€/TEU; €/ITU; €/ton)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Total benefits over a period. Number of handled units: by type and size, by category (TEUs, ITUs, tonnes of cargo).		Monthly Annually	BIM
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Number and graphically	Against previous years	Strategic	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			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Financial	Public body	Terminal	Employment
Description and objective:		**Formula:**	**Unit:**
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.		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.	Number of employees hired (full time employee-FTE)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Number of workers necessary for each type of area in the terminal for its proper operation and statistical ratios.		Annually Ad-hoc (e.g. in function of specific projects)	BIM
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Number	Against previous years	Operational Strategic	
Notes and comments:			
Can be unbundled on a sector level (cargo handling, logistics, shipping, etc.)			

<table>
<tr><th colspan="4">16. Indirect jobs sustained by terminal activities</th></tr>
<tr><td>Performance dimension:</td><td>Stakeholder involved:</td><td>Scope:</td><td>Subgroup:</td></tr>
<tr><td>Financial</td><td>Public body</td><td>Hinterland</td><td>Employment</td></tr>
<tr><td colspan="2">Description and objective:</td><td>Formula:</td><td>Unit:</td></tr>
<tr><td colspan="2">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.</td><td>• 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.</td><td>Number of employees hired (full time employee-FTE)</td></tr>
<tr><td colspan="2">Input data and data source:</td><td>Frequency of measurement:</td><td>Calculation method:</td></tr>
<tr><td colspan="2">Multipliers obtained from surveys or studies (Economic Effect Analyses).</td><td>Annually

Ad-hoc (e.g. in function of specific projects)</td><td>BIM</td></tr>
<tr><td>Presentation of results</td><td>Evolution of the indicator:</td><td>Decision level:</td><td>Relationship with other indicators:</td></tr>
</table>

16. Indirect jobs sustained by terminal activities			
Number and graphically	Against previous years	Strategic	
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			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Financial	Public body	Rail Network Hinterland	Maintenance cost
Description and objective:		**Formula:**	**Unit:**
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.		<u>Road</u>: Total road maintenance cost in a year / road traffic flow in the hinterland <u>Rail track</u>: Total rail track maintenance cost in a year / track kilometer in the rail network	Monetary cost per road kilometer (€/veh-km) Monetary cost per track kilometer (€/km)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Total road/rail maintenance cost: Publications, annual accounts, statistics. Kilometers within the hinterland.		Annually Ad-hoc (e.g. in function of specific projects)	Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Number and graphically	Against previous years	Strategic	Public investment Reliability
Notes and comments:			
Indicator that can be calculated considering road and truck separately. It is a variable cost.			

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			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Quality	Terminal operator	Hinterland	Accessibility
Description and objective:		**Formula:**	**Unit:**
The easiness of entry and exit from highways is defined as the accessibility or connection to main roads.		Average driving time from terminal to main road network connections	Time (minutes)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Time related data from the simulation model. Number of network connections.		Annually	Traffic simulation tool
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Number and graphically	Against previous years	Strategic	Hinterland connection
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			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Quality	Terminal operator	Rail network	Accessibility
Description and objective:		**Formula:**	**Unit:**
The easiness of entry and exit from railway network is defined as the accessibility or connection to main rail track.		Average travel time between the terminal and the main railway connections	Time (minutes)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Distance between the terminal and the main rail track. Layout		Previously to the construction of the terminal Ad-hoc (e.g. in function of specific projects)	Traffic simulation tool
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Number and graphically.	Against previous years	Strategic	Hinterland connection
Notes and comments:			
Data needed is easy to research and the effort for collection is low.			

20. Energy consumption per handled unit			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Environment	Terminal operator	Terminal	Energy efficiency
Description and objective:		**Formula:**	**Unit:**
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.		Total energy consumed / Number of handled units	kJ/kW per load unit Volume of fuel per handled unit
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Total energy consumption in the terminal estimated with the traffic simulation tool. Total number of handled units.		Monthly Annually	Traffic simulation tool
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Number and graphically	Against previous year	Strategic	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			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Environment	Public body	Hinterland	Climate change
Description and objective:		**Formula:**	**Unit:**
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.		Total carbon emissions / Number of handled units Total carbon emissions= EF CO_2 *Fuel consumption	Carbon dioxide/TEU Carbon dioxide/UTI Carbon dioxide/ton Kg CO2/ tkm Annual inventory (kg CO2)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
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).		Monthly Annually	Traffic simulation tool
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Number and graphically	Against previous years	Tactical Strategic	Terminal throughput
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			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Quality	Public body	Hinterland	Road congestion
Description and objective:		**Formula:**	**Unit:**
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).		Average delays (extent)	Time (minutes, hours)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Time related data from the terminal simulation model. Traffic flows from traffic simulation.		Monthly Annually	Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Number and graphically	Against previous year	Operational	Waiting time Turnaround time Reliability
Notes and comments:			

23. Delays produced (reliability) - Railway			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Quality	Public body	Rail Network	Rail network congestion
Description and objective:		**Formula:**	**Unit:**
Expresses arrival and departures delays. It is an external factor (e.g. delays of freight trains lead to longer waiting times in the terminal).		Average delays (extent)	Time (minutes, hours)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Time related data from the terminal simulation model.		Annually	Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Number and graphically	Against previous years	Operational	
Notes and comments:			

24. CO, NOX, SOC, PM emissions			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Environment	Public body	Hinterland	Air pollution
Description and objective:		**Formula:**	**Unit:**
The aim is to analyse 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.		Total emissions / Number of handled units 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	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:		**Frequency of measurement:**	**Calculation method:**
Emissions factors per type of equipment and/or activity obtained from statistical data.		Annually	Traffic simulation tool
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Number and graphically	Against previous years	Strategic	
Notes and comments:			

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			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Environment	Public body	Hinterland	Noise
Description and objective:		**Formula:**	**Unit:**
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 ($L_{eq\text{-}55dB}$)=$\sum_n \iint d(n)\theta(L-L_{limit})\,dxdy\cdot$ • n represents a squared area within the hinterland region • d(n) is the population density at square n • $\theta(L-L_{limit})$: Step function for noise level	Number of persons exposed to a noise level over 55 dB
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Maximum outdoors noise level (dBA). Road traffic noise prediction.		Annually	Traffic simulation tool
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Number and graphically	Against previous years	Strategic	
Notes and comments:			
Often connected with additional costs.			

[1] 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			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Safety	Public body	Hinterland	Accidents
Description and objective:		**Formula:**	**Unit:**
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.		Number of accidents per vehicle-km according to National EU standards (average number of accidents and deaths)	Number of road accidents/year
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Statistics. National EU standards related to number of accidents and deaths. Traffic flow from the traffic simulation model.		Annually	Traffic simulation tool
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Number	Against previous years	Tactical	
Notes and comments:			
Statistical data may refer to the country where the terminal is located.			

27. Number of railway accidents			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Safety	Public body	Hinterland	Accidents
Description and objective:		**Formula:**	**Unit:**
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.		Number of accidents per train-km according to National EU standards (average number of accidents and deaths)	Number of railway accidents/year
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Statistics. National EU standards related to number of accidents and deaths. Traffic flow from the traffic simulation model.		Annually	Traffic simulation tool
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**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			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Operational	Operator	Terminal	Efficiency; Productivity-time related
Description and objective:		**Formula:**	**Unit:**
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.		<u>Trains</u>: Sum of train shunting time for entrance and departure <u>Trucks:</u> Truck driving time from waiting area to loading position and reverse processes <u>Ships:</u> Sum of ship port services time for entrance + ship port services time for departure	Time (minutes, hours)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Time related data from the terminal simulation model		Daily/monthly/annually	Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
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.			

<table>
<tr><th colspan="4">29. Service time</th></tr>
<tr><td>Performance dimension:</td><td>Stakeholder involved:</td><td>Scope:</td><td>Subgroup:</td></tr>
<tr><td>Operational</td><td>Operator</td><td>Terminal</td><td>Efficiency; Productivity-time related</td></tr>
<tr><td colspan="2">Description and objective:</td><td>Formula:</td><td>Unit:</td></tr>
<tr><td colspan="2">It is the time elapsed from the commence of cargo operations to their completion.</td><td><u>Trains</u>:
Sum of train loading and/or unloading time
<u>Trucks:</u>
Sum of truck loading and/or unloading time
<u>Ships:</u>
Sum of net berthing time (loading and/or unloading time)</td><td>Time (minutes, hours)</td></tr>
<tr><td colspan="2">Input data and data source:</td><td>Frequency of measurement:</td><td>Calculation method:</td></tr>
<tr><td colspan="2">Time related data from the terminal simulation model.</td><td>Daily/monthly/annually</td><td>Terminal simulation model</td></tr>
<tr><td>Presentation of results</td><td>Evolution of the indicator:</td><td>Decision level:</td><td>Relationship with other indicators:</td></tr>
<tr><td>Service time per truck/train/vessel</td><td>Evolution per day/month/year</td><td>Operational</td><td>Turnaround time
Berthing time</td></tr>
<tr><td colspan="4">Notes and comments:</td></tr>
<tr><td colspan="4">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.</td></tr>
</table>

30. Berthing time			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Operational	Operator	Terminal	Efficiency; Productivity-time related
Description and objective:		**Formula:**	**Unit:**
It is the gross time elapsed from the arrival of vessels to the terminal to its departure.		Sum of gross berthing time: loading and/or unloading time and waiting time to be served	Time (minutes, hours)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Time related data from the terminal simulation model.		Daily/monthly/annually	Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Service time per truck/train/vessel	Evolution per day/month/year	Operational	Turnaround time Service time
Notes and comments:			

31. Idle time (equipment)			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Operational	Operator	Terminal	Efficiency; Productivity-time related
Description and objective:		**Formula:**	**Unit:**
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.		Sum of non-productive time per equipment and employee	Time (minutes, hours)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Time related data from the terminal simulation model		Daily/monthly/annually	Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Idle time per equipment item and employee	Evolution per day/month/year	Operational	Equipment utilization
Notes and comments:			

32. Capital Expenditures (CAPEX)			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Financial	Investor	Terminal	Costs
Description and objective:		**Formula:**	**Unit:**
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.		CAPEX is the sum of all expenses (money spent) on buildings, equipment and infrastructure items by the terminal operator	Monetary units (€) Unitary costs (€/ton; €/TEU; €/UTI)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Expenditures associated to buildings, equipment and infrastructure items		Monthly/annually	BIM
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Graphically and amount of money	Yes (annually)	Strategic Operational	Profitability
Notes and comments:			

33. Operational Expenditures (OPEX)			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Financial	Operator	Terminal	Operating cost
Description and objective:		**Formula:**	**Unit:**
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.	Monetary units (€) Unitary costs (€/ton; €/TEU; €/UTI)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Cost modelling from Terminal simulation model or BIM cost module		Monthly/annually	BIM/Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Graphically and percentage	Yes, monthly/annually	Tactical Operational	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.			

34. Corrective maintenance cost (equipment)			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Financial	Operator	Terminal	Maintenance cost - equipment
Description and objective:		**Formula:**	**Unit:**
This indicator is related to the total downtime in a period scheduled for corrective maintenance and breakdown repairs.			Hours per year for each equipment item
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
		Annually	BIM
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Graphically and percentage	Yes, annually	Strategic Operational	Operating efficiency Profitability
Notes and comments:			

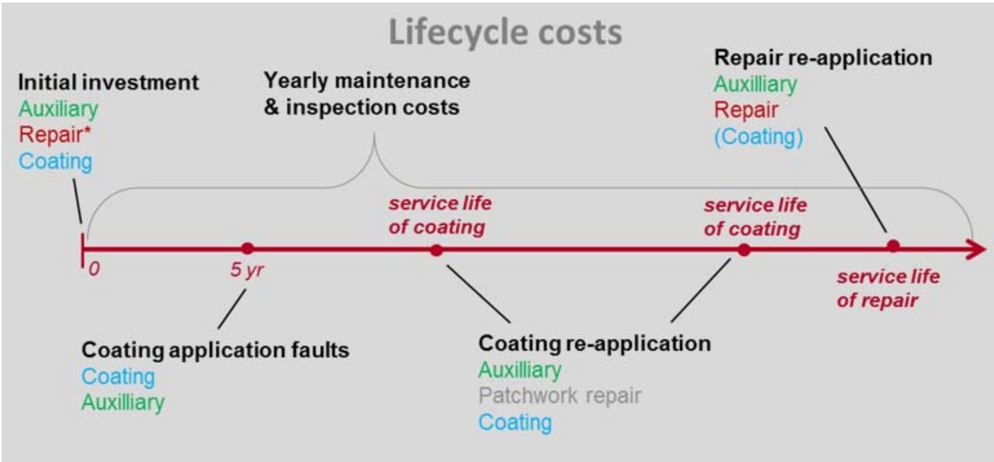
35. Preventive maintenance cost (equipment)			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Financial	Operator	Terminal	Maintenance cost - equipment
Description and objective:		**Formula:**	**Unit:**
This indicator is related to the total downtime in a period scheduled for preventive maintenance and breakdown repairs.			Hours per year for each equipment item
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
		Annually	BIM
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Graphically and percentage	Yes, annually	Strategic Operational	Operating efficiency Profitability
Notes and comments:			

36. Corrective concrete structures maintenance cost			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Financial	Investor Terminal operator Public body	Terminal	Infrastructure maintenance cost
Description and objective:		**Formula:**	**Unit:**
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).		Maintenance index	
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Crack opening Chloride content Carbonation Steel corrosion rate Exposure class Lifespan		3 years	BIM
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Graphically	Every 5 years	Strategic	Operating efficiency

36. Corrective concrete structures maintenance cost			
		Operational	Profitability

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).



<table>
<tr><th colspan="4">37. Preventive concrete structures maintenance cost</th></tr>
<tr><td>Performance dimension:</td><td>Stakeholder involved:</td><td>Scope:</td><td>Subgroup:</td></tr>
<tr><td>Financial</td><td>Investor
Terminal operator
Public body</td><td>Terminal</td><td>Infrastructure maintenance cost</td></tr>
<tr><td colspan="2">Description and objective:</td><td>Formula:</td><td>Unit:</td></tr>
<tr><td colspan="2">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.</td><td>Maintenance index</td><td></td></tr>
<tr><td colspan="2">Input data and data source:</td><td>Frequency of measurement:</td><td>Calculation method:</td></tr>
<tr><td colspan="2">Exposure class
Lifespan
Frost attack
Chemical attack</td><td>-</td><td>BIM</td></tr>
<tr><td>Presentation of results</td><td>Evolution of the indicator:</td><td>Decision level:</td><td>Relationship with other indicators:</td></tr>
<tr><td>Graphically</td><td>-</td><td>Strategic
Operational</td><td>Operating efficiency
Profitability</td></tr>
<tr><td colspan="4">Notes and comments:</td></tr>
<tr><td colspan="4">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</td></tr>
</table>

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).

38. Waiting time / Turnaround time			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Quality	Terminal operator	Terminal	Service quality - time
Description and objective:		**Formula:**	**Unit:**
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.		Train waiting time / Train turnaround time Truck waiting time / Truck turnaround time Ship waiting time / Ship turnaround time	Percentage (%)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Time related data from the terminal simulation model.		For each vessel/truck/train arrival	Terminal simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Graphically and percentage	Average values per year and per type of customer (ship, truck, train)	Operational Strategic	Waiting time Turnaround time
Notes and comments:			

39. Use of alternative fuels from total consumption			
Performance dimension:	**Stakeholder involved:**	**Scope:**	**Subgroup:**
Environment	Terminal operator	Terminal	Alternative fuels
Description and objective:		**Formula:**	**Unit:**
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.		Alternative fuels consumption / Total energy consumption	Percentage (%)
Input data and data source:		**Frequency of measurement:**	**Calculation method:**
Total energy consumption in the terminal. Types of terminal equipment and characteristics used in BIM. Alternative fuels consumption.		Annually	Traffic simulation model
Presentation of results	**Evolution of the indicator:**	**Decision level:**	**Relationship with other indicators:**
Graphically and percentage	Against previous years	Strategic	Energy consumption
Notes and comments:			

<table>
<tr><th colspan="4">40. Accidents related to Hazard cargo</th></tr>
<tr><td>Performance dimension:</td><td>Stakeholder involved:</td><td>Scope:</td><td>Subgroup:</td></tr>
<tr><td>Safety</td><td>Public body</td><td>Hinterland</td><td>Accidents</td></tr>
<tr><td colspan="2">Description and objective:</td><td>Formula:</td><td>Unit:</td></tr>
<tr><td colspan="2">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.</td><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>
<tr><td colspan="2">Input data and data source:</td><td>Frequency of measurement:</td><td>Calculation method:</td></tr>
<tr><td colspan="2">Statistical data</td><td>Annually</td><td>Traffic simulation tool</td></tr>
<tr><td>Presentation of results</td><td>Evolution of the indicator:</td><td>Decision level:</td><td>Relationship with other indicators:</td></tr>
</table>

40. Accidents related to Hazard cargo			
Number	Against previous year	Operational	Total number of accidents
Notes and comments:			
Statistical data may refer to the country where the terminal is located. Consider in case the terminal handles hazard cargo.			