INTERMODEL EU

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

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D2.1 – REQUIREMENTS FOR TERMINAL USE CASES

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1 Executive Summary

The main objective of the INTERMODEL project is to develop an integrated decision support platform to assess different pilot cases of multimodal, multiproduct and multipurpose freight rail terminals in terms of a wide range of Key Performance Indicators (KPIs) and Performance Indicators (PIs). By integrating simulation modules of the terminal operation and its relationship to the hinterland into a BIM design, both the quickness and the quality of the decision-making will be improved.

The main objective of WP2 is to be the binder for the rest of work packages, since the environment planning considers modelling and simulation to be tested efficiently throughout the other work packages. Solutions will be developed collaboratively with input from other required work packages. The task utilises software development experience from VIAN and builds on the modelling use case experience of VTT and IDP. Demonstration for logistical operations and mobility simulations to add into modelled information are provided by MAC and CENIT. The environment development requires consideration of interoperability and data exchange standards between potential software from different fields of planning. An approach will be proposed, allowing partners to remotely access the on-going virtual plans of railway terminals.

This document shows the results from the first task Integrated Planning Environment in WP2 completed during the late 2016 and early 2017 period (M1-M9). The aim of WP2 is to develop a holistic integrated planning environment that enables technical management of modelled terminal projects and supports decision making on assets throughout the life cycle. The purpose of this document is to report the findings of T2.1, aiming to analyse upcoming information and requirements for terminal use cases. According to the description of work, this task will be performed by collecting knowledge, use key performance and risk indicators from WP3 on freight terminals, and analysing and converting results into model-based information requirements to enhance performance, economy and reduce risk over the life cycle.

This deliverable explains the use cases for using strategic indicators, planning the terminal with models and coordinating designs, and terminal operational simulation. First, we explain how the terminal area with support operations and adjacent areas is divided into purposes of use. For the planning of these functional areas, BIM modelling technologies are used according to guidelines agreed on a project basis. Then, we explain how a 40 Key Performance and Performance Indicators framework has been initiated for intermodal freight terminals. The use of indicators is a requirement for the use cases, that are explained more in detail at the last chapter. We describe three use cases for terminal life cycle with a template explaining actors, pre- and post conditions, and utilisation. This is a final version of publishing time, and it will be updated if necessary during the project.

On behalf of the contributors,

Janne Porkka, VTT

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3 Introduction

3.1 Scope

The aim of work package 2 (WP2) is to develop a holistic integrated planning environment that enables technical management of modelled terminal projects and supports decision making on assets throughout the life cycle. The environment will extend to the utilisation of modelling concerning building and infrastructures (BIM and infraBIM) from planning, design and construction to the operational, economic and environmental performance analyses of freight terminals. The aim is an increased interaction between participants and enhanced decision making process. This particular work is necessary for the whole project and is closely connected with indicators to be developed in work package 3 (WP3), pilot modelling in work package 4 (WP4), and operational simulation in work package 5 (WP5). Specific objectives for the work package are as follows:

- Task 2.1: Information and requirements for terminal use cases
- Task 2.2: Integrated Planning Environment architecture and interface specifications
- Task 2.3: Implementation of integrating ICT environment
- Task 2.4: Model coordination
- Task 2.5: Decision support in integrated planning environment

The aim is to collect knowledge, use key performance and risk indicators from WP3 on freight terminals, and analyse and convert results into model-based information requirements for use cases to enhance performance, economy and reduce risk over the life cycle.

3.2 Audience

Development of terminals has an effect on multiple stakeholders; therefore, all the major development efforts should be done in cooperation with these stakeholders. A terminal is an entity of multiple actors. The actors act at different stages of the supply chain and could also be in competition against one another. However, as terminals compete against one another, improvement in a terminal's performance will provide the actors with long-term benefits. Therefore, this deliverable has been written to all stakeholders who are involved in development of terminals in one way or another. The deliverable is also addressed to actors working at the terminals.

3.3 Definitions

Main definitions with glossary and abbreviations used in this document are:

Terminal

Terminal: In transport and logistics, terminal means a place where passengers or cargo is gathered before moving to transport. In seafaring context, terminal has a particular function in a port area, such as container handling, coal, oil, or passenger terminal. In a case of a small and specialized port, terminal could refer to an entire port.

Port: This is usually understood as a synonym of seaport. Seaport is a coastal location with a harbour where ships dock and transfer goods to/from land. Port locations are selected to optimize access to land and navigable water, meet commercial demand, and shelter from wind and waves. There are also inland ports, e.g. airports or dry ports (see Dry port).

Dry port: This can also be called inland port. In intermodal, the terminal is directly connected by road or rail to a seaport and operates as a transhipment base for other hinterland destinations.

Hinterland: In shipping, a port's hinterland is the area that it serves, both for imports and for exports. The size of a hinterland can depend on the geography or on the ease, speed, and cost of transportation between the port and the hinterland.

Waterway: In general, waterway is any navigable body of water. In this document, waterway is considered as a part of general shipping routes, which capacity or other attributes do not restrict the development of port.

Terminal functional areas

Terminal area (restricted access): Cargo handling terminals are closed areas where movement is restricted. Therefore, only specified workers are allowed to enter and work in terminal area. The other people need to follow strict rules when moving there (e.g. truck drivers picking up containers from port).

Support operations (restricted access): Support operations are cargo or cargo handling related functions that are not done in the terminal area, but very close to it. For example, warehousing, packaging, cargo handling equipment maintenance can be done in this area. Depending on the location, type and size of the port, these operations may be located close to the terminal area or further away. In some particular cases, e.g. in free ports, the access to this area can be through the terminal.

Adjacent areas (public access): Certain operations gain benefits if they are located close to port, but they do not need to be inside the terminal area. For example, port administration, stevedore operators or forwarder companies mainly do administrative work that could basically be done anywhere. However, their location close to the business and other involved organizations help in many practical issues.

Digital models

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

InfraBIM: This stands for Infrastructure Building Information Modelling. The information is focused on infrastructure information model and related structures and environment information, but it is without for e.g. buildings.

GIS: This stands for Geographic Information System. The system deals with information concerning location, relative to the Earth. GIS is a broad term, referring to a number of different technologies, processes, and methods.

Indicators

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

KPI: This stands for Key Performance Indicator. It tells the user what to do to increase performance dramatically. The KPIs 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.

PI: This stands for Performance Indicator. It is a way to understand operations better and how they can be developed.

Terminal simulation

Baseline scenario: This is also called Base Case. It is a scenario in which the analysis is done based on the current way of working in a place without having any changes. This scenario serves as a comparison and starting point to other scenarios.

Conceptual model: This is a repository of high-level conceptual constructs and knowledge specified in a variety of communicative forms intended to assist in the design of any type of large-scale complex system.

Dashboard: A set of KPIs joined together in a single overview screen. This way a user gets the whole overview of the performance aspect in one view.

DES: This stands for Discrete Event Simulation. It is a type of simulation, which models a system as a discrete sequence of events, and where state changes are not possible in between of events.

DEVS: This is called Discrete Event System Specification. A modular and hierarchical formalism often used for developing DES engines.

Experiment: This stands for a number of simulation runs in which a single scenario is studied.

Model: This stands for a representation of anything such as a real system, a proposed system, a futuristic system design, an entity, a phenomenon, or an idea.

Monte Carlo Simulation: This uses a model built based on statistical random sampling.

Scenario: A situation that the user wants to study in the simulation tool. An experiment is the cross section of volume, control, equipment and infrastructure.

3.4 Structure

The deliverable is structured to 6 sections, briefly explained below.

- **Section 1:** Executive summary
- **Section 2:** Table of contents
- **Section 3:** Introduction
- **Section 4:** Terminal functional areas
- **Section 5:** Assessing terminal performance with indicators
- **Section 6:** Use cases

4 Terminal functional areas

A terminal is divided into sections referred to as functional areas, which have various purposes of use. These functional areas are explained briefly in this chapter. The development projects in terminals need to consider thoroughly information related to these functional areas.

4.1 Terminal area (restricted access)

In the terminal area, only specified workers are allowed to enter and work. The other persons need to follow strict rules (e.g. truck drivers picking up containers from port). Figure 1 presents an overview of how a container terminal operates. The basic idea of unloading the vessel is that the tall quay cranes move the containers one or more at a time to internal transporters that are more and more autonomous. These vehicles move the containers to stacking area where the containers are piled up and arranged. Depending on the terminal and e.g. the number of handled containers, either the containers are loaded onto trains or trucks directly from the piles or the containers are moved to a particular truck or train loading area. When the vessels are loaded, the operations are done in reverse. If the port has transhipment handling, the unloaded containers end up in the stacking area from where they are moved and loaded to other vessels.

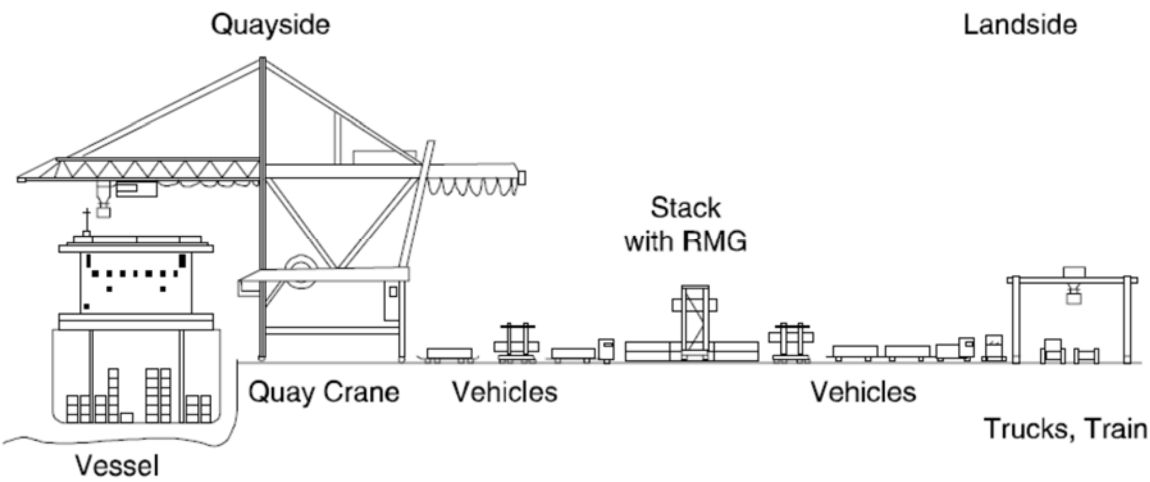

Figure 1. Overview of container terminal system. (Steenken et al., 2004)

1. **Waterside area**
   If the port is not a dry port, there is navigable water for vessels to enter port. In this document, the area where the vessels are moving and operations related to loading and unloading of vessels are performed in the waterside area.
   a. Quays
      i. Berths
      ii. Crane operation area
   b. Navigation area

2. **Quayside transport** (transport between vessel and stack area)
   There is a need to transport full containers from cranes to stacking area. The area reserved for this transport is called apron. In many terminals, unmanned vehicles are operating in this area.

3. **Stacking area**
   Stacking area is an area where containers are stored before proceeding further on another means of transport. On vessels, the containers are placed based on their external features (e.g. size, weight) to enable safe shipping. Therefore, the containers need to be arranged before loading. As the unloading time should be minimized, the containers are rearranged in stacking area to enable smooth loading to truck or train. In stacking area, the operations are done for full containers.
   a. Stack blocks of containers
   b. Container handling equipment (CHE)
      Fixed or removable to sort containers and load or unload containers to/from vehicles or trucks

4. **Vehicle loading/unloading area**
   Full containers are loaded to vehicles or unloaded from vehicles. This area is usually close to stacking area and sometimes, same equipment that are used for container arrangement in stacking area are used for loading and unloading. Especially, when loading and unloading is done by unmanned equipment, vehicle driver walks to the shelter in order to avoid possible accident caused by falling container.

   Vehicle loading/unloading areas are not common for larger terminals, as they require additional space and a possible extra container move. Instead, truck handling is done in a stack.

5. **Rail yard**
   Full containers are loaded to trains or unloaded from trains. This area is usually close to the stacking area.

6. **Internal transport area** (connects different parts of the terminal)
   There is a need for roads and railroads that connect different parts of terminal area.
   a. Railways
   b. Roads

7. **Other terminal facilities**
   In the terminal area, there might be some facilities that are needed for working.
   a. Restrooms for stevedore workers
   b. Storages for stevedoring equipment

4.2 Support operations (restricted access)

This area is usually very close to the port. There are sensitive operations such as gate, through which valuable cargo goes through. Part of support operations can be situated between the port and outside area, and there is a full access from both directions. Sometimes the only access to this area is through the port (e.g. if the logistics area is part of the Free economic zone of the port, or in the case of port equipment maintenance as the port equipment are not allowed to move in public roads. However, e.g. the workers of the area can go directly to this area without going through the port (of course depending of the layout of the port area).

1. **Gate area**
   Inland traffic between terminal area and hinterland goes through the gate area. It is also practical to place those functions that all incoming or outgoing cargo or vehicle need to go through, e.g. weighting of cargo, customs, etc.
   a. Truck gates
   b. Railway gates
   c. Customs
   d. Weighting of the containers
   e. Scanners to detect e.g. radiating material or contraband

2. **Logistics area**
   In logistics area, some of the containers of the port are unloaded and loaded. There are storage facilities both indoor and outdoor. In addition, there may be some small-scale assembly and product modification operations.
   a. storage facilities (outside and inside)
   b. container loading / unloading

3. **Container depot area**
   Container depot companies operate in container depot area. Container depot companies repair, maintain, wash and store empty containers. Due to large variety of the container types and owners, the amount of empty containers in depot area can be relatively big.

4. **Facilities for port equipment maintenance**
   Usually movable port equipment is specialized for port work (e.g. straddle carriers, container lift trucks, reach stackers) and it is not possible to drive with these in public roads. Therefore, the maintenance of this equipment is practical to arrange close to terminal.

4.3 Adjacent areas (public area)

This area is outside the fences of the port. Basically, there is public access for this area. However, this area has multiple sensitive operations (e.g. customs), and valuable cargo is going through this area, therefore, the visitors of this area are usually under surveillance.

1. **Connections to hinterland**

Roads and railroads which connect port to public road and railroad network:

a. Roads that connects port to hinterland road network
b. Railroad(s) that connects port to hinterland road network
c. Truck / rail waiting areas

2. **Connections to waterways**

There are navigable routes that connect port to waterways or open sea.

a. Waterways that connect port to open sea
b. Inland waterway system for hinterland transport

3. **Office area**

For practical reasons, different actors of the port such as port administration, stevedore operators, and forwarder companies have their offices outside the terminal area, but close to it. They are outside, because otherwise the visitors would need permission to enter the office. Proximity to terminal helps in practical work (e.g. supervisors need to work both in office and in terminal area, and there is a lot of communication between port actors).

a. Port administration
b. Company offices in the port (e.g. stevedore operators, forwarder companies, etc.)
c. Parking space

5 Assessing terminal performance with indicators

The INTERMODEL project aims at establishing a methodology to design an alternative appraisal of multimodal freight terminals making the most of the model-based integrated tools. Multi-dimensional models are combined with different simulations models resulting in an aggregated decision-making to be used during the project-planning phase and thorough its life cycle. Key Performance Indicators (KPI) and Performance Indicators (PIs) for intermodal freight terminals have been provided in WP3 and explained in more detail in Deliverable 3.1 (D3.1). This chapter gives an overview of indicators that are considered as requirements for use cases.

5.1 The benefits of using indicators in projects

Indicators are figures or other measures that enable information on a complex phenomenon, such as environmental impact, to be simplified into a form that is relatively easy to use and understand. The three main functions of indicators are quantification, simplification and communication (ISO, 2010). They can also support decision making by helping to set targets and track and monitor progress on performance (ISO, 2014). As Tanguay et al. (2010) presents, it is essential to clarify the difference between data, a variable and an indicator. Data or variable becomes an indicator only when its role in the evaluation of a phenomenon has been established, meaning that the changes of the data or variable have been defined as negative or positive.

Indicators are used in many sectors and for various purposes. The origin of Key Performance Indicators (KPIs) is in business administration. KPIs provide businesses with a tool for measurement (DEFRA, 2006). KPIs are known for example as measures of organizations', companies' or programs' success. On the other hand, many other sectors, such as buildings or transport, use them to assess the performance of their specific products or processes. Since indicators enable to compare the current state and communicate the evolution of performance in time (when assessed regularly), they are typically used for e.g. target setting, monitoring, benchmarking, ranking purposes - and ultimately, and most importantly, decision making.

Different types of indicators are used for different purposes and have been categorized in several ways. Performance indicators measure the required end performance instead of prescribing the technical solutions to achieve that performance (Gibson, 1982). The latter can be called prescriptive indicators. Another more detailed categorization is to group indicators based on whether they measure inputs, outputs, outcomes or impacts (Segnestam, 2002). Examples of those could be amount of expenditures spent or staff used (input indicators), no of sensors installed (output indicator), extent to which the activities planned in a project took place (process indicator), percentage of target group reached by the project (outcome indicator) and reduction of CO_2 emissions (impact indicator).

Hundreds of indicator systems or classifications have been developed for different purposes. They structure indicators under a hierarchy of main categories and sub-categories. In sustainability assessment frameworks for example, the main categories are often impacts on people, planet and prosperity (i.e. environmental, social and economic) and the sub-categories can focus for example on sectors such as energy, transport, ICT. Often target values are developed for indicators. If they exist on a uniform scale, e.g. from 1-5, that allows the comparison and scoring of indicators and construction of an overall performance index.

An index is an aggregate of many indicators. Still, it aims to provide a coherent and multidimensional, though simplified, view of a system. Usually indices provide a snapshot of the current situation and are used to compare e.g. cities, but they can also be calculated regularly and provide in one figure, an indication if the system is moving in a certain direction (Mayer, 2008).

Sometimes weighting factors are also used to indicate the relative importance of the indicators from e.g. the viewpoint of different stakeholders. Different stakeholders naturally view the relevance and importance of indicators from their viewpoint reflecting their needs and targets and therefore the needed indicators often differ between actors, even if the assessed process is the same.

Since one of the main purposes of indicators is communication of information, the visualisation of the assessment results has a central role. There are multiple different visualisation methods available, varying from trend or spider diagrams to 3D models. Such possibilities in INTERMODEL will be discussed later.

Different ports use different kinds of indicators to assess their own performance. Morales-Fusco et al. (2016) analysed 61 Mediterranean ports and found that those ports use altogether 77 different KPIs. By analysing found KPIs in more detail, they were able to reduce the numbers of KPIs to 27 and classify the indicators into six different categories: traffic, financial, operational, customs procedures, sustainability and security, and human resources. (Morales-Fusco et al., 2016).

Ha et al. (2017) reviewed 259 relevant papers from 1970 to 2016 on Web of Science to find different performance indices used in ports. Based on the review, they concluded that port stakeholders used 16 principal port performance indices, and 60 other indices. These indices could be divided in six different dimensions: core activities, supporting activities, financial strength, user satisfaction, terminal supply chain integration, and sustainable growth. (Ha et al., 2017).

Performance indicators help to get information about the port performance. An extensive analysis of port performance helps managers to make better decisions on port operations. Consciousness of port performance indicators can raise transparency on port performance with respect to various dimensions and hence managers in port can raise their port attractiveness by considering important corners from a certain key stakeholder. This offers diagnostic instruments to port managers, aiming to meet the different needs of port stakeholders. Additionally, information related to port performance indicators enables port managers to better understand and value the opinions of various stakeholders and offers diagnostic instruments to manage stakeholder relations. (Ha et al., 2017).

5.2 INTERMODEL indicator framework

A set of 40 indicators has been established for the assessment of intermodal freight terminals. The use of indicators allows an industry or an organization to evaluate their success at reaching business objectives. High level indicators, also distinguished as Key Performance Indicators (KPIs), focus on the overall performance goals, whereas performance indicators (PIs) consider relevant issues for daily processes shown in Figure 2. The selected indicators will be integrated within the developed BIM framework to create a holistic view of terminals.

INTERMODEL framework is built upon five dimensions named as:

Operational indicators
This performance dimension includes indicators that describe 1) effectiveness as a measure of the capability of producing the intended result and 2) efficiency as a measure of producing results by taking into account used resources.

Financial indicators
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 converted into revenues and benefits.

Quality indicators
The quality performance dimension links the service quality performance with customer service quality needs.

Environmental indicators
The environmental performance is focused on the environmental impact of intermodal freight terminal activities on the surrounding area.

Safety indicators
The safety performance dimension is usually included in the quality service dimension. It 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.

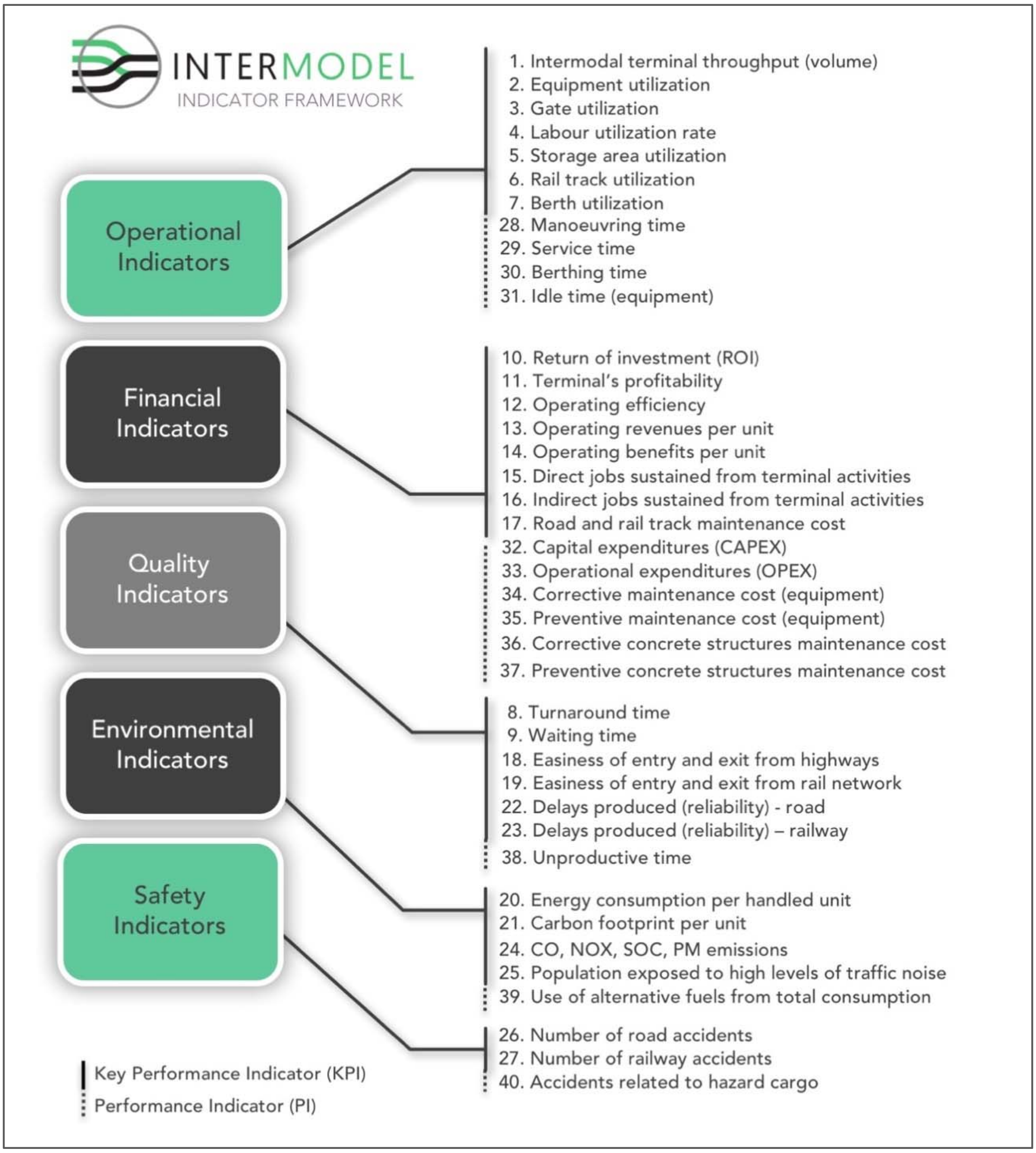

Figure 2. Updated indicator framework (based on deliverable D3.1).

5.3 Indicator descriptions

Descriptions for individual indicators in INTERMODEL indicator framework are introduced in following 3 pages (Table 1). Each one of the 40 indicators are explained with a short description, the unit used, stakeholders responsible and a collection frequency.

Table 1. Updated indicator framework table (based on deliverable D3.1).

Framework	ID	Name	Short description	Unit	Stakeholder	Frequency
Operational	**1**	**Intermodal terminal throughput (volume)**	*Cargo handling in terminal for imports, exports and transhipment.*	TEU, ITU or tons	Investor/ Operator	Daily/monthly/ annually
Operational	**2**	**Equipment utilization**	*Effective equipment use deployed over a specified period.*	Percentage (%)	Operator	Annually
Operational	**3**	**Gate utilization**	*Effective gate use deployed over a specified period.*	Percentage (%)	Operator	Annually
Operational	**4**	**Labour Utilization**	*Effective use of labour over a specified period.*	Percentage (%)	Operator	Annually
Operational	**5**	**Storage area utilization**	*Storage yard occupation calculated by storage capacity in piles and slots.*	Percentage (%)	Operator	Annually
Operational	**6**	**Rail track utilization**	*Rail track occupation for the total time.*	Percentage (%)	Operator	Annually
Operational	**7**	**Berth utilization**	*Amount of time berth occupied out of the total time.*	Percentage (%)	Operator	Annually
Quality	**8**	**Turnaround time**	*Elapsed time between arrival and departure for trucks, trains and vessels.*	Time (minutes, hours)	Operator	Daily/monthly/ annually
Quality	**9**	**Waiting Time**	*Unproductive time per visit such as waiting for service, gates and buffer areas.*	Time (minutes, hours)	Operator	Daily/monthly/ annually
Financial	**10**	**Return on Investment**	*Return on an investment relative to the investment's cost.*	Percentage (%)	Investor/ Operator	Monthly/annually
Financial	**11**	**Terminal's profitability**	*Terminal's profit through revenue minus total expenses in relation to business size.*	Percentage (%)	Investor/ Operator	Monthly/annually
Financial	**12**	**Operating efficiency**	*Share of terminal's revenue left after paying operational costs.*	Percentage (%)	Operator	Monthly/annually
Financial	**13**	**Operating revenues**	*Revenue generated per handled unit.*	Unitary revenues (€/TEU,ITU or ton)	Operator	Monthly/annually
Financial	**14**	**Operating benefits per unit**	*Benefits obtained per handled unit.*	Unitary benefits (€/TEU,ITU or ton)	Operator	Monthly/annually
Financial	**15**	**Direct jobs sustained from terminal activities**	*Direct employment from terminal activities.*	Number of full time employees (FTEs)	Operator/ Public Body	Annually, momentarily (e.g. specific projects)

Framework	ID	Name	Short description	Unit	Stakeholder	Frequency
Financial	**16**	**Indirect jobs sustained from terminal activities**	*Indirect employment from terminal activities within a specified area.*	Number of full time employees (FTEs)	Operator/ Public Body	Annually, momentarily (e.g. specific projects)
Financial	**17**	**Road and rail track maintenance cost**	*Public maintenance expenditures to keep road and rail infrastructures operational.*	Cost per road and track kilometer (€/km)	Operator/ Public Body	Annually, momentarily (e.g. specific projects)
Quality	**18**	**Easiness of entry and exit from highways**	*Average travel time to enter and exit terminal from highways and main roads.*	Time (minutes)	Operator	Annually
Quality	**19**	**Easiness of entry and exit from rail network**	*Average travel time to enter and exit terminal from railway network.*	Time (minutes)	Operator	Prior construction, momentarily (e.g. specific projects)
Environmental	**20**	**Energy consumption per handled unit**	*Energy and fuel consumption per handled unit calculated for different types (TEUs, ITUs, tons).*	kJ/kW and fuel per handled unit type	Operator	Monthly/Annually
Environmental	**21**	**Carbon footprint per unit**	*Carbon footprint per handled unit types to measure environmental impact of actions.*	CO_2/TEU,UTI,ton Kg CO_2/ tkm kg CO_2	Operator/ Public Body	Monthly/Annually
Quality	**22**	**Delays produced (reliability) - road**	*Delays of trucks due to congestion leading to longer waiting times in terminal.*	Time (minutes, hours)	Operator/ Public Body	Monthly/Annually
Quality	**23**	**Delays produced (reliability) - railway**	*Delays of freight trains leading to longer waiting times in terminal.*	Time (minutes, hours)	Operator/ Public Body	Annually
Environmental	**24**	**CO, NOX, SOC, PM emissions**	*Emissions per type of equipment and activities obtained from statistical data.*	Kg CO,NOX,SOC and PM/ handled unit, tkm	Operator/ Public Body	Annually
Environmental	**25**	**Population exposed to high levels of traffic noise**	*Amount of people exposed to noise from traffic and operations.*	Number of persons exposed to >55 dB noise	Operator/ Public Body	Annually
Safety	**26**	**Number of road accidents**	*Number of road accidents related to terminal and its hinterland at region.*	Number of accidents per year	Operator/ Public Body	Annually
Safety	**27**	**Number of railway accidents**	*Number of railway accidents related to terminal and its hinterland at region.*	Number of accidents per year	Operator/ Public Body	Annually

Framework	ID	Name	Short description	Unit	Stakeholder	Frequency
Operational	**28**	**Manoeuvring time**	*Time required per type of transport between terminal arrival and departure.*	Time (minutes, hours)	Operator	Daily/monthly/ annually
Operational	**29**	**Service time**	*Time elapsed per type of transport for terminal cargo operations and services.*	Time (minutes, hours)	Operator	Daily/monthly/ annually
Operational	**30**	**Berthing time**	*Time taken from vessel arrival to its departure from terminal.*	Time (minutes, hours)	Operator	Daily/monthly/ annually
Operational	**31**	**Idle time (equipment)**	*Non-productive time when equipment is ready for use but is not being used.*	Time (minutes, hours)	Operator	Daily/monthly/ annually
Financial	**32**	**Capital expenditures (CAPEX)**	*Sum of expenses in physical assets such as properties, buildings and equipment.*	€ and €/ton, €/TEU, €/UTI)	Investor	Monthly/Annually
Financial	**33**	**Operational expenditures (OPEX)**	*Sum of normal terminal operating expenses including business, facility and personnel running costs.*	€ and €/ton, €/TEU, €/UTI)	Operator	Monthly/Annually
Financial	**34**	**Corrective maintenance cost (equipment)**	*Annual downtime for corrective maintenance and breakdown repairs.*	Hours (each equipment)	Operator	Annually
Financial	**35**	**Preventive maintenance cost (equipment)**	*Annual downtime for preventive maintenance and breakdown repairs.*	Hours (each equipment)	Operator	Annually
Financial	**36**	**Corrective concrete structures maintenance cost**	*Adequate corrective maintenance according to plan to ensure the service life of concrete structures.*	Cost per kilometer of structure (€/km)	Investor/ Operator / Public body	Annually
Financial	**37**	**Preventive concrete structures maintenance cost**	*Adequate preventive maintenance according to plan to ensure the service life of concrete structures.*	Cost per kilometer of structure (€/km)	Investor/ Operator / Public body	Annually
Quality	**38**	**Unproductive time**	*Share of truck, train and vessel turnaround time spent for unproductive matters, such queuing or waiting for service.*	Percentage (%)	Operator	Daily/monthly/ annually
Environmental	**39**	**Use of alternative fuels from total consumption**	*Percentage of alternative fuel consumption from total energy consumed.*	Percentage (%)	Operator	Annually
Safety	**40**	**Accidents related to hazard cargo**	*Number of accidents and close incidents for personnel taking place at terminal loading, unloading and transit activities.*	Number of accidents per year	Operator/ Public Body	Annually

5.4 Sources of indicator data

The data needed to addressing INTERMODEL indicator framework is coming from various sources. The respondent need to use the raw data from terminal employees and operating system, together with layout, maintenance, management and financial information. Below is a list for the most relevant information sources for setting up the values for the indicators.

Raw data for indicators

- User input from terminal employee and management interviews
- Terminal operating system database
- Planning/layout related information
- GIS systems related information
- Financial systems related information
- Statistical information

Processed information for indicators

- Digital terminal plans (BIM, InfraBIM)
- Terminal simulation model
- Traffic simulation
- Validated assumption or evaluation from terminal employee or management (for data that is not directly available)

6 Use cases

The use cases considered in the INTERMODEL project are described in the following pages. These three use cases cover the entire lifecycle of a terminal, and particularly focus on improving planning and design through an integrated approach that brings a BIM based intelligent planning together with an operational simulation.

The fact that many ports are operating close to their full capacity, and the amounts of cargo are constantly increasing puts an enormous pressure on seaport terminals to improve their management and find better ways of conducting daily operations. Old-fashioned solutions, such as land expansion, are not realistic in many areas due to the scarcity of the land close to the seaports. Therefore, the suitable layout of terminal plays an important role.

The INTERMODEL use cases are positioned in the form of lifecycle of a terminal in Figure 3. The lifecycle highlights the nature of a repetitive and rapid development of the terminal. First, the terminal area is determined. Then, the logistical operations with supporting functions, facilities and structures are designed. The materials selected for the construction work have an important role for the maintenance of the terminal. Since the life span of the terminal is long, corrective and preventive maintenance operations are performed regularly.

However, terminal operations require reconsiderations from time to time. There may be changes in customers or at least the cargo, new logistics solutions coming to markets, and new and more efficient technologies becoming available. This leads to reconsiderations, because solutions that had been suitable earlier are becoming outdated. That is why logistical developments need to be performed infrequently. Later on, a situation could arise when the limitation of the current layout also becomes outdated and the performance of the terminal will require a more thorough evaluation. In that case, there is a need to consider possibilities to make larger logistical changes to improve the volume of the terminal and performance of functional areas. This leads to new development efforts to be planned and the bigger development process cycle starts again. The terminal life cycle has an iterative nature - phases follow each other therefore, in Figure 3 they are placed into a cycle to highlight the repetitive and iterative nature. Moreover, changes are also incremental. Hardly ever a terminal can stop operations and rebuild a new or to develop, typically they are constrained to smaller scale and incremental changes that are not optimal but allow for operations to continue. The investment costs for these incremental updates are often millions of Euros.

The first use case is about developing strategic needs into indicators to outline the lifecycle of the terminal (*UC1: Strategic indicators*). Select correct indicators for particular project and its phase, set those and later validate that targets were met when implemented. The approach utilises the INTERMODEL indicator framework with Key Performance Indicators (KPIs) and Performance Indicators (PIs).

In the second use case, model based working is taken into the project work and BIM based practices are taken into daily practices (*UC2: Design coordination*). A particular focus is stated to the collection of initial data and transforming that partially into models shared between the planning team to provide a foundation to logistical development of the port or dry port. Generated models are prepared according to agreed principles and data is combined into an integrated model for coordination purposes. Large terminals include various disciplines and contexts to be taken into account.

The final use case continues to enhance the integrative approach and operational simulation is merged into the integrated model (*UC3: Integrated simulation*). At high level, the terminal layout is brought together with an operational simulation. A simulation model depicts causal relationships among logistical objects over a time, which is valuable for determining the behaviour systems and their interrelations among highly complex entities. The approach is tested in pilot projects to show results for end users in decision making situation.

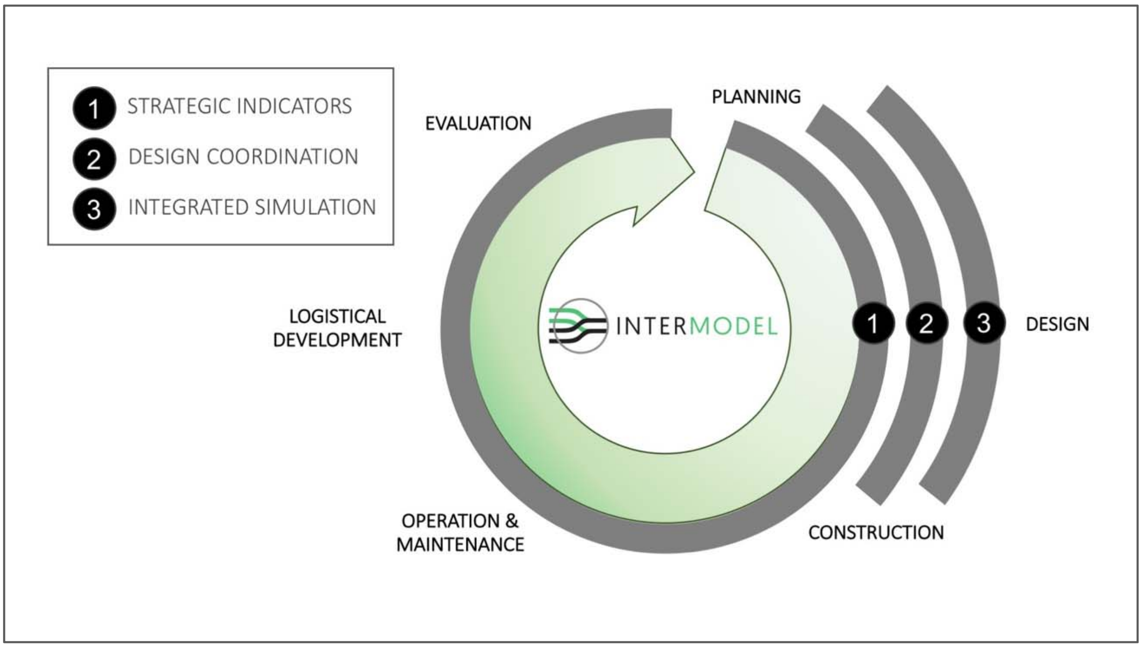

Figure 3. Overview to INTERMODEL use cases.

The three above mentioned use cases are described in Table 2. Each use case is given a name, a short description, a list of potential actors involved and the final target to be accomplished. For each use case, investor is a beneficiary for the work performed.

- UC: *Use case and number*
- NAME: *A short name for the use case*
- DESCRIPTION: *A general description to explain what is contributed*
- ACTORS: *A list of potential stakeholders involved*
- TARGET: *A brief explanation what the actors want to accomplish*

Table 2. List of INTERMODEL use cases.

UC	Name	Description	Actors	Target
UC1	Strategic indicators	Develop strategic needs into indicators to cover terminal life cycle	Operator, Port authority, Public body	Select correct indicators for the project. Set necessary INTERMODEL indicator framework indicators for project, and validate targets.
UC2	Design coordination	Use integrated model for design coordination for planning a better terminal	Planner/Designer, Operator, Logistic service provider, Port authority, Public body	Collect available initial data and transform content into BIM models. Refine that models are generated according to agreed principles, and transform data into an integrated model. The integrated model is used for design coordination between various disciplines and context.
UC3	Integrated simulation	Use BIM-based design practice together with an operational simulation to enhance logistical solution and decision support	Planner/Designer, Operator, Logistic service provider, Software provider, Port authority, Public body	Consider a terminal plan together with an operational simulation through an integrated approach. The approach is tested in pilot projects to see results with end users.

Each INTERMODEL use case is presented in a similar template in the following three sections. The template clarifies each use case and the characteristics are explained for each actor involved, tools used, the pre- and post-conditions for the work, and the target to be accomplished.

- UC: *A number of use case*
- NAME: *A short name for use case*
- ACTORS: *A list of stakeholders involved according to role*
- TOOLS: *What tools are used to carry out work to provide result*
- PRE CONDITION: *Status and activities that are required so that the work can be performed*
- POST CONDITION: *When the work is completed, what it the final end result*
- UTILIZATION: *How we can utilize/use the result later*

Moreover, we consider the connection these use cases have to the INTERMODEL Indicator framework. Thus, potential indicators may be selected from the framework based on the project needs.

6.1 Strategic indicators use case (UC1)

Different terminals use different kinds of indicators to assess their performance. There have been numerous indicator systems and frameworks targeted to classifying indicators to different categories. There are also at least 16 principal port performance indices and 60 other indices. Performance indicators help to get information about how well the whole system and its functional areas are performing and based on the analysis managers are able to make better decisions in managing the port and its operations. When the same indicator framework is used in different terminals, the managers also have a great diagnostic instrument.

The first use case is about utilising the INTERMODEL indicator framework with Key Performance Indicators (KPIs) and Performance Indicators (PIs). The strategic needs are developed into indicators to outline the lifecycle of the terminal (*UC1: Strategic indicators*). The general objectives are described by selecting relevant indicators from the INTERMODEL framework and calculate or evaluate their values for the project. The purpose is also to consider how it is possible to reach the targets when implemented. For the use case execution, the process model is made and all the relevant actors are named. The focal actor is a consultant or another expert who holds discussions about issues with different stakeholders. For the calculation of precise indicator values its often necessary to perform a operational simulation experiment to validate indicators, and this means information about many input variables such as arrivals, volumes, departures, available equipment, equipment. These values represent a specific situation.

Strategic indicators use case consists from two sub processes. First, *targets are set for the indicators*, and later *assessment is performed and results validated in relation to targets*.

Steps for the process in *UC1 Strategic indicators: target setting* are:

1. Collect source data from various systems (Operator, Port authority, Investor)
2. Propose relevant indicators (Consultant/expert)
3. Propose target values for indicators (Consultant/expert)
4. Review indicators (Operator, Port authority)

Table 3. INTERMODEL use case 1 – Strategic indicators: Target setting for indicators.

UC1: Strategic indicators **Target setting for indicators**				
Actors	Tools	Pre condition	Post condition	Utilization
Operator	Terminal operating system database, Financial systems		Operator source data in platform	Clarify needs for consultant/expert (in steps 2, 3)
Port authority	Planning/layout data, statistical data		Port authority source data in platform	Clarify conditions for consultant/expert (in steps 2, 3)
Investor	Financial calculations		Investor source data in platform	Clarify requirements for consultant/expert (in steps 2, 3)
Public body	Municipal systems		Societal impacts	Clarify impacts for consultant/expert (in steps 2, 3)
Consultant/ expert	Requirements management tool	Source data in platform	Target values for relevant indicators	Indicator review (in step 4)
Operator, Port authority, Investor, Consultant/ expert	Requirements management tool	Target values for relevant indicators	Target values for indicators agreed	Initial data for planning and design
				Assessment and validation of indicators (in steps 5-7)

Steps for the process in *UC1 Strategic indicators: assessment and validation* are:

5. Calculate indicator values based on plans and operational simulation (Operator, Port authority, Investor)
6. Check indicator values (Consultant/expert)
7. Validate indicator values (Consultant/expert, Operator, Port authority, Investor, Public body)

Table 4. INTERMODEL use case 1 – Strategic indicators: Assessment and validation of indicators.

UC1: Strategic indicators Assessment and validation of indicators				
Actors	Tools	Pre condition	Post condition	Utilization
Planner/ designer	Digital models (BIM, InfraBIM)	Planning/design performed	Calculated indicator values	Check indicator values (in steps 6, 7)
Terminal simulation provider	Operational simulation platform	Operational simulation performed	Operational indicator values	Check indicator values (in steps 6, 7)
Traffic simulation provider	Traffic simulation platform	Traffic simulation performed	Traffic indicator values	Check indicator values (in steps 6, 7)
Consultant/ expert	Requirements management tool	Indicator data in platform	Indicator profile analysis	Validate indicators (in step 7)
Consultant/ expert, Operator, Port authority, Investor, Public body	Requirements management tool	Indicator profile analysis	Indicators validated and action plan	Actions selected based on results, such as continue, revise change needs or make changes to plans.

6.2 Design coordination use case (UC2)

Building information modelling (BIM) is now used extensively across the world for example, in United States, United Kingdom (UK), France, Germany, Finland, Sweden, Denmark, Australia, Malaysia and Singapore. While creating a model is one aspect of BIM, many stakeholders now consider BIM as more of a process change than a new technology (Messner et al., 2013). It has been gaining popularity in architecture, engineering, and construction (AEC) and also amongst the owners and operators of building projects (Kubba, 2017).

Although BIM was first developed to strengthen the design phases of buildings, it has quickly gained popularity amongst infrastructures (InfraBIM or BIM for Infrastructures). Infrastructure projects and BIM concepts have quite many similarities such as design review, collaboration culture, and coordination of the tasks, which takes the same approach as the building sector BIM (Bradley et al., 2016). When planning infrastructures, there has been a strong focus in BIM development and its integration with GIS (Bradley et al, 2016).

Many benefits have been reported from using BIM in projects. It offers the power to attain intelligence and interoperability (Lee et al., 2006; Miettinen and Paavola, 2014). Design data and specifications can easily be transferred between different software applications, irrespective of whether it is within the organization or in a multidisciplinary team (Lee et al., 2006; Son et al., 2015). Amongst the many advantages, there is also the fact that it captures a comprehensive set of data, not just individual components, with locations and required details (Ghaffarianhoseini et al., 2017). The most outstanding benefits BIM provides include gaining faster client approvals, improved project quality, reduction in the number of changes needed to be done in a project, improved understanding of the overall project design, and reduced number of conflicts during construction (McGraw-Hill Construction, 2010).

With the help of modelling, all details are effortlessly updated and managed throughout the lifecycle (Lee et al., 2006; Son et al., 2015). Collaboration is increasingly going through various "neutral and open specifications" now controlled by a single vendor or group of vendors called open formats. These open formats are considered to improve interoperability across countries and include formats for geographic elements (LandInfraGML, CityGML), buildings (IFC), and infrastructure data (LandXML, RailML).

Collaboration between various design disciplines usually results in better designs and end results. Large terminals include various disciplines and contexts that need to be taken into account. The project benefits from having a combined model that includes a subset from various design disciplines and is able to combine content for a design review in one platform. BIM offers an opportunity to coordinate designs because of its detailed characteristics, which is necessary for efficient collaboration. There are also potential for visual capabilities to provide a more accurate visualization with 2D or 3D representations.

The second use case takes into account model based working and BIM based daily practices to provide a better plan (UC2: Design coordination). A particular focus is needed for the collection of initial data and transforming it partially into models to be shared between the planning team. This provides a foundation for an efficient logistical development in the port or dry port. Generated models are prepared according to the agreed BIM guidelines and design principles. Finally, the individual models for design disciplines and contexts are combined into an integrated model for coordination purposes. The design coordination, when merged together for design review, helps to find inconsistencies within the plans and save costs that can incur further down the road. The life cycle of the terminal is long and planning and design are iterative over that period leading to incremental changes. The changes to the terminal are usually not done in the most rigorous manner. The operation of the terminal creates cash flow that is required even during the improvements. The situation after the changes is not often the most optimal, but enables the terminal to operate during the development. The development of the terminal is planned together with operations. The planning concerns necessary functional areas in the terminal area, support operations, and adjacent areas.

Design coordination use case is made up from two sub processes. First, the baseline and sharing formats for initial data are agreed in the project and BIM based initial state models are developed for all needed design disciplines. Each planner or designer makes quality checks for their models, before those are shared. Second, the individual plans (design models) from all disciplines are combined by a BIM coordinator and results are evaluated in a collaborative design review meeting. The combined plans reduce the amount of design flaws originating from the lack of communication between the project stakeholders.

Steps for the process in *UC2 Design coordination: initial data and discipline models* are:

1. Collect initial data from various systems (Operator, Logistics system provider, Port authority, Planner/designer,)
2. Develop plans to discipline initial state BIM models (Planner/designer, Special design & system provider)
3. Check in discipline initial state BIM models (Planner/designer)
4. Initial state review for design disciplines (Operator, Port authority, Public body, Planner/designer, Special design & system provider)

Table 5. INTERMODEL use case 2 - Design coordination: Initial data and design disciplines.

UC2: Design coordination **Initial data and design in multiple disciplines**				
Actors	Tools	Pre conditions	Post condition	Utilization
Operator	Terminal operating system, layout and		Initial data for operation in platform	Convert initial data to BIM models (in step 2
Logistics system provider	Terminal simulation model		Initial data for logistics in platform	Convert initial data to BIM models (in step 2
Port authority	Planning/layout data		Initial data for functions in platform	Convert initial data to BIM models (in step 2
Planner/ Designer, Special design & system provider	Cadastral data, GIS, Land survey, BIM authoring tools	Targets for plan (see UC1 Strategic indicators)	Initial data collected	Convert initial data to BIM models (in step 2)
		Initial data collected	Discipline BIM models developed	Validate discipline initial state BIM models (in step 3)
Planner/ Designer	BIM checking tools	Discipline BIM models developed	Discipline initial state BIM models checked in	Initial state review for design disciplines (in step 4)
Operator, Port authority, Public body, Planner/ designer, Special design & system provider	BIM authoring tools	Discipline initial state BIM models checked in	Discipline initial state BIM models reviewed and validated	Drafts for discipline designs (note: individual design activities out of scope of INTERMODEL use cases)
				Combine and review designs (in steps 5-9)

Steps for the process in _UC2 Design coordination: combine and review designs_ are:

5. Combine individual design discipline plans (BIM coordinator)
6. Develop plan in collaborative design review (Operator, Port authority, Public body, Planner/designer, Special design & system provider)
7. Select suitable equipment and durable materials, and improve logistics (Planner/designer, Special design & system provider, Material suppliers, Logistics system provider)
8. Iterative plan development (Planner/designer, Special design & system provider, Logistics system provider)
9. Approve plan in collaborative design review (Operator, Port authority, Public body, Planner/designer, Special design & system provider)

Table 6. INTERMODEL use case 2 - Design coordination: Combined plans.

UC2: Design coordination **Combine and review designs**				
Actors	Tools	Pre condition	Post condition	Utilization
BIM coordinator	Design coordination platform	Design review for design disciplines	Combined BIM from design disciplines published	Develop plan in collaborative design review (in step 6)
Operator, Port authority, Public body, Planner/ designer, Special design & system provider	Design coordination platform	Combined BIM from design disciplines	Development needs collected from collaborative design review	Select suitable equipment and durable materials (in step 7)
Planner/designer, Special design & system provider, Material suppliers, Logistics system provider	Design coordination platform	Development needs considered from collaborative design review	BIM updated with systems and materials	Iterative plan development (in step 8)
BIM coordinator, Planner/designer, Special design & system provider, Logistics system provider	Design coordination platform	Development needs, systems and materials	Improved and combined BIM plan	Approve plan in collaborative design review (in step 9)
Operator, Port authority, Public body, Planner/designer, Special design & system provider	Design coordination platform	Improved and combined BIM plan	Plan approved in collaborative design review	Combined BIM model applicable for integrated simulation (see UC3 Integrated simulation)
				Combined BIM available for assessment and validation of indicators (see UC1 Strategic indicators)

6.3 Integrated simulation use case (UC3)

European Union is highly dependent on seaports for trade with the rest of the world and within its internal market. In 2013, 74% of the goods imported and exported and 37% of exchanges within the Union made a transit through seaports. In addition, by 2030 traffic is predicted to rise by 50% (European Commission, 2014). To obtain an efficient terminal, three decision levels shall be considered: strategic, tactical and operational. At the strategic level, for instance, the terminal layout and the choice of the material handling system in the yard shall be considered. At the tactical level, problems such as the placement of containers and the paths towards them are the main issues to be addressed. Finally, at the operational level, all detailed daily problems should be solved. (Liu et al., 2004).

The final and third use case continues to enhance the integrative approach to be developed in INTERMODEL. The approach merges operational simulation into the BIM model (UC3: Integrated simulation). A simulation model depicts causal relationships among logistical objects over a time, which is valuable for determining the behaviour systems and their interrelations among highly complex entities. It has a clear scope and a set of assumptions made during the design process.

The developed simulation platform uses a Discrete Event Simulation (DES) model based on the Discrete Event System Specification (DEVS) formalism and Monte Carlo method. It takes a set of defined input variables, also stochastic ones, stored in a database and obtains the outcome values of specific indicators. It comprises of infrastructure, equipment, control as well as volume and logistic layers. The planning and design data in BIM model is partially attached to the simulation as input and source data concerning e.g. functional areas of the terminal.

The integrative approach means in practice that an operational simulation is reflected on a terminal layout. Currently, the simulation model has a 2D animation possibility, but BIM models extend this opportunity towards 3D. The developed approach is based on the integrated platform and tested as pilot projects to show results for end users during the decision situation. When possible, indicators are presented visually. The approach for platform development is targeted to integrating two fronts, modelling and simulation, for a collaborative decision making situation. Due to characteristics of operational simulation, it is merely expected to show the simplified simulation perhaps without animations and experts are expected to make better terminal plans and verify before a decision meeting that planned infrastructures and logistical systems operate as planned.

The integrated simulation use case embodies two sub processes. First, the combined BIM and operational simulations are prepared for the terminal area. Second, the integrated simulation is executed and results are send to BIM environment for further plan development and the assessment of Key Performance Indicators. The integrated simulation use case relies on two platforms, design coordination and operational simulation, integrated through API (Application Programming Interface).

Steps for the process in *UC3 Integrated simulation: Prepare combined BIM and operational simulation* are:

1. Verify combined BIM model from terminal (BIM coordinator, Terminal simulation provider)
2. Collect initial data for operational simulation model from terminal (Terminal simulation provider)
3. Develop and validate operational simulation model and sync with combined BIM model (Terminal simulation provider, BIM coordinator)

Table 7. INTERMODEL use case 3 - Integrated simulation: Prepare combined BIM and operational simulation.

UC3: Integrated simulation				
Prepare combined BIM and operational simulation				
Actors	Tools	Pre condition	Post condition	Utilization
BIM coordinator, Terminal simulation provider	Design coordination platform	Combined and improved BIM plan approved in collaborative design review (see UC 2: Design coordination)	BIM model verified for simulation	Develop operational simulation model and sync with combined BIM model (in step 3)
Terminal simulation provider	Operational simulation platform	Targets for simulation	Initial operational simulation model	Develop and validate operational simulation model and sync with combined BIM model (in step 3)
Terminal simulation provider, BIM coordinator	Integrated planning and simulation platform	Verified BIM model and Initial operational simulation model	Terminal operational simulation model	Integrated planning and simulation execution (in steps 4-8)

Steps for the process in *UC3 Integrated simulation: Execute combined BIM and operational simulation*:

4. Set up terminal operational simulation experimentations (Terminal simulation provider)
5. Run terminal operational simulations (Terminal simulation provider)
6. Evaluate and improve terminal operational simulation experiments (Terminal simulation provider, BIM coordinator)
7. Generate feedback reports from terminal operational simulations (Terminal simulation provider, BIM coordinator)
8. Collaborative terminal operational simulation review (Terminal simulation provider, BIM coordinator, Planner/designer, Logistics system provider, Operator, Port authority)

Table 8. INTERMODEL use case 3 - Integrated simulation: Execute combined BIM and operational simulation.

UC3: Integrated simulation				
Execute combined BIM and operational simulation				
Actors	Tools	Pre condition	Post condition	Utilization
Terminal simulation provider	Integrated planning and simulation platform	Terminal operational simulation model	Terminal operational simulation experimentations ready for run	Run terminal operational simulations (in step 5)
Terminal simulation provider	Integrated planning and simulation platform	Terminal operational simulation experimentations set up	Terminal operational simulations executed	Evaluate and improve terminal operational simulation experiments (in step 6)
Terminal simulation provider, BIM coordinator	Integrated planning and simulation platform	Terminal simulations execution	Terminal operational simulation experiments evaluated and improved	Generate feedback reports from terminal operational simulations (in step 7)
Terminal simulation provider, BIM coordinator	Integrated planning and simulation platform	Terminal operational simulation experiments evaluated and improved	Feedback reports from terminal operational simulation experimentation generated	Collaborative terminal operational simulation experimentation review (in step 8)
Terminal simulation provider, BIM coordinator, Planner/designer, Logistics system provider, Operator, Port authority	Integrated planning and simulation platform	Integrated planning and simulation platform experimented in meeting	Collaborative terminal operational simulation review meeting held	Further development of Integrated planning and simulation platform into a market

6.4 Discussion for use cases

The operational simulations (Work Package 5 in INTERMODEL) represented in this report are focused at tactical and operational levels in the terminal area. These simulations are extensive and therefore those are not performed in real time. The calculation for simulation takes usually some time, and therefore, computational time for running simulations is expected. The scope in simulations is not only about the terminal area, there are subsystems considering interconnection simulation between the two terminals that are connected to each other (Work package 7: External Railway Affectations in INTERMODEL), and external mobility effects (Work package 6: External Mobility Affectations in INTERMODEL). Besides, the functional, economic and environmental analysis are also carried out (Work package 8: Functional, economic and environmental analysis in INTERMODEL).

This deliverable explains the use case for terminal operational simulation only. The other simulation and analysis use cases are following the same logic, but their technical characteristics are less integrated to BIM platform and thus more straightforward. This is a final version of publishing time, and it will be updated if necessary during the project. The implementation of other use cases will be decided later.

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