INTERMODEL EU

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

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D8.5 – Summary of results of work packages 2-7 and implications. Recommendations for new and to be renewed intermodal terminals (functional, economic, and environmental perspective)

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Executive Summary

This document intends to offer to the audience a set of recommendations to be considered when designing an intermodal terminal. These recommendations given by the Consortium are the result of the acquired experience during the last three years working in the project.

First, and with the aim to offer an initial context for a better understanding of the final part, the document takes a tour through the work packages that have generated either a tangible result (e.g. piece of software or document) or knowledge of added value during the whole life of the project.

In order to focus on what is important, the first part of the document includes a summarized narrative of WP2 to WP7, describing the main results achieved.

Secondly, the reader can find a collection of recommendations and best practices that the partners that compose the Consortium consider a must while the design phase of a new or renewed terminal. These indications are mainly oriented to the use of the platform that has been developed in the project.

Finally, there is a brief description of which actions can be performed in the future in order to improve the software by implementing new features.

Table of contents

List of Figures

1 Introduction

1.1 Scope

The document covers in a summarized way all the work packages that have generated either a tangible result or knowledge of added value during the whole life of the project together with a set of final recommendations.

As mentioned above, since the Section 2 of the document describes work packages in a brief format, it is highly recommended to consult specific deliverables for further details.

1.2 Audience

The document is public, of special interest to anyone with a view on logistics but more especially to those with an interest in planning and designing greenfield and brownfield container intermodal terminals.

1.3 Definitions / Glossary

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

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).

BIM Execution Plan - Plan prepared by the suppliers to explain how the information modelling aspects of a project will be carried out. It Include for example plans for the structure, management and exchange of information with applications used within the project.

BIM 7th dimension – Facility Management Applications. Where a model is created by the designer and updated throughout the construction phase, it will have the capacity to become an as-built model, which also can be turned over to the owner. The model will be able to contain all of the specifications, operation and maintenance (O&M) manuals and warranty information, useful for future maintenance.

Calibration - In the context of simulation models, the process of checking that obtained outputs are consistent respect to given inputs.

CMP – This stands for Corridor Management Platform. It is a network of business interoperating platforms where shippers and other logistic actors can control their operations throughout the formalized supply chain. The CMP aims at overcoming specific bottlenecks with a focus on paperless logistics / e-customs processes with priority for the integration of inland / seaport terminals and rail.

Decision support platform: A concept and prototype integrating BIM model, operational simulation and performance evaluation tool to test an integrated planning environment in freight terminal case studies in INTERMODEL EU project.

Digital Twin: A digital twin is a digital representation of a real-world entity or system. The implementation of a digital twin is an encapsulated software object or model that mirrors a unique physical object. Data from multiple digital twins can be aggregated for a composite view across several real-world entities such as a power plant or a city. The notion of a digital representation of real-world entities or systems is not new. Its heritage goes back to computer-aided design representations of physical assets or profiles of individual customers.

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 transshipment base for other hinterland destinations.

Environmental impact - Change to the environment, whether adverse or beneficial, wholly or partially resulting from environmental aspects.

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

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.

IFC: Industry Foundation Classes. An international, open specification for data exchange and sharing for architecture, engineering and construction of buildings and bridges. Two alternative exchange formats are provided for IFC, ISO 10303-21 standard (IFC Part-21 format), and XML (ifcXML). IFC is maintained and developed by buildingSMART.

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.

LandXML - A non-proprietary XML-based format containing civil engineering and survey measurement data commonly used in the land development and transportation industries. Since autumn 2012, the maintenance and development have been shared by OGC and *buildingSMART*.

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

Multi-criteria decision making - This term is concerned with structuring and solving decision and planning problems involving multiple criteria. The main goal is to organize the given alternatives (from the most to the least preferred one) giving a support tool for decision makers.

Open format: A neutral and open specification that is not controlled by a single vendor or group of vendors. Large building and infrastructure owners usually demand the use of open formats.

PI - Defined as the physical value used to measure, compare and manage the overall organizational performance.

Pilot: This report considers the integrated platform as an integrated planning environment and decision support proof-of-concept pilot. Referred as pilot in this deliverable. Pilot enables the user to see 3D game-like animation of the terminal operations with additional information important for the decision making.

Port: This is usually understood as a synonym of seaport. Seaport is a coastal location with a harbor 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).

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.

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.

TEU - The twenty-foot equivalent unit is a standard measure for a container for transporting goods, used to calculate how many containers a ship can carry, or a port can deal with.

Validation - Confirmation, through the provision of objective evidence that the requirements for a specific intended use or application have been fulfilled.

1.4 Abbreviations

BEP: BIM Execution Plan
BIM: Building Information Modelling
BREEAM: Building Research Establishment Environmental Assessment Methodology
DGNB: Deutsche Gesellschaft für Nachhaltiges Bauen (German Society for the Sustainable Building)
EPD: Enviromental Product Document
GIS: Geographical Information System
HQE: Haute Qualité Environnementale
ICT: Information and Communication Technology
IFC: Industry Foundation Classes
KPI: Key Performance Indicator
LEED: Leadership in Energy and Environmental Design (USA)
QGIS: Quantum GIS
ROI: Return of Investment
TEU: Twenty-foot Equivalent Unit
LIDAR: Light Detection and Ranging o Laser Imaging Detection and Ranging

1.5 Structure

- **Section 1:** contains an overview of this document, providing its Scope, Audience, various definitions and abbreviations and Structure.
- **Section 2**: includes a summarized narrative of the main results achieved in WP2 to WP7.
- **Section 3**: contains recommendations to be considered during the terminal design phase.

2 Project summary

2.1 WP2: Integrated planning environment and decision support

The main objective of WP2 was to be the binder for the rest of the work packages, by integrating model-based plans, simulations and KPIs from all of them. It was composed of 6 deliverables:

- Requirements for terminal projects
- Integrated planning environment architecture
- Interoperability and data exchange specification
- Documentation of implemented integrating ICT environment prototype
- Interactive decision making with an integrated planning environment
- Gaming technology in interactive operational visualization

The work started with requirements for terminal projects explained the use cases for using strategic indicators, planning the terminal with models and coordinating designs, and terminal operational simulation. The approach described first how terminals are developing and what kind of challenges exist and what trends are also affecting to the material flow and the operation of ports and inland terminals.

Model based tools have been used in design and construction, providing better opportunity to coordinate plans. Then, a software architecture for Decision Support System that brings together BIM based design, operative simulation of the terminal and performance evaluation with indicators was introduced. The utilisation of the platform has been tested in the INTERMODEL pilots at La Spezia port and Melzo inland multi-modal terminal.

The approach enabled the consideration of solutions with integrated planning where individual segment and discipline models were combined. It specified a software architecture and principles to the efficient utilisation of models through custom and standard interfaces connecting various technologies. Open formats have been used to improve interoperability.

The ICT environment prototype presented the concept and methodology for the integrated approach for the development of intermodal seaport and inland terminals. It also described data exchange models that enhance processes and synchronize the three information types together: models, simulation and indicators. As a result, the integration platform provides high-quality container logistics visualization in 3D animation together, providing also an opportunity to see operational information from e.g. containers and other equipment.

Also, this WP explained how decision processes are assisted with ‘integrated planning technology’, combining the integration platform to other technical approaches developed in INTERMODEL project: layout planning, simulation of operations and performance KPIs in a terminal. This way, the approach provides users with the simulation of the terminal in a 3D game-like visualization which adds value to decision making in a managerial meeting or in assisting discussions in an operational workshop where terminal operations are considered from multiple perspectives.

Finally, the document described implementation of the real-time visualization solution for inspecting terminal operation simulations. The outcome of the pilot implementation clearly demonstrated the benefits achieved by making the leap from pre-rendered visualization to real-time visualization and hopefully encouraged further work to develop this kind of solution towards being a production ready re-usable platform.

2.2 WP3: Data & Indicators definitions

The main objective of this WP has been to establish a set of Key Performance Indicators (KPIs) and Performance indicators (PIs) for the effective assessment of the layout design, building materials choice, operative planning, handling equipment selection and allocation of intermodal multimodal terminals through an ICT environment.

In addition, tasks focused on defining pilot cases (in terms of different attributes) and test scenarios representing different casuistry were also carried out. A total of four pilot cases have been modelled and analysed, two of them studied in real terminals and the other two implemented into virtual ones.

This work package was composed of 3 deliverables:

- Study of the state of the art and description of KPI and KRI of terminals, hinterland mobility and rail network.
- Pilot innovations and improvements.
- Input data analysis and scenarios.

In particular, a framework of 27 KPI and 11 PI had been defined, achieving a balanced role of the three main involved actors (investor, operator and public body) while covering the three main physical areas approached by this project: terminal, hinterland and railway network.

The real terminals, La Spezia container seaport terminals and Milan ‐ Melzo container dry port, have enabled to calibrate and verify the BIM model and the operation simulation with raw data made available by the terminal operators. The analysis included the study of the potential relationship between the operational functions of the Corridor Management Platform (CMP), which was developed by the WiderMos project between La Spezia and Melzo, with the planning functions covered by the BIM in the INTERMODEL EU project in order to have a full cycled covered.

The work started with the analysis of the future demand of real terminals and with a benchmarking of European terminals to obtain a representative capacity to set the dimensions and layout of the virtual terminals. Simultaneously, an analysis of elements having an impact in multimodal terminals was conducted based on the current situation of logistics and the evolution of global and regional economy, and also with the experience of partners involved.

With data analysed and information gathered, test scenarios are defined for the four case studies included in the project: La Spezia container seaport terminal, Milan ‐ Melzo container dry port, virtual bulk - container seaport terminal and virtual bulk - container inland terminal. In addition, input data required for defining these pilot cases has been listed according to models used for terminal operation simulation and considering other attributes such as innovations and improvements, climate conditions which will determine which materials are more appropriate for a better performance, and other data needed to obtain the Key Performance Indicators provided by the decision - making tool.

2.3 WP4: BIM intermodal Terminal

The aim of this work package was to develop a holistic integrated planning environment that enables technical management of modelled terminal projects and supports making decisions on assets throughout the life cycle. The environment extended utilisation of various building and infrastructure models (BIM and infraBIM) from planning, design and construction towards the operational, economic and environmental performance analysis in freight terminals.

This work package was composed of 5 deliverables:

- BIM Execution Plan Guideline
- BIM model Demonstration of both real locations
- 7th D BIM model of the Virtual Pilot Cases
- Pilot Cases alternatives including Pilot Innovations and Improvements
- 7th D BIM model of the Virtual Pilot Cases, including a multipurpose modular terminal for the seaport virtual terminal

First, a BIM Execution Plan was created in the early stages of the proposed pilot cases, including an identification of BIM methods and implementation strategies. Furthermore, BIM models of the two real pilot cases in Melzo and La Spezia were developed with the creation of specific libraries included in an Intermodel *plug-in* that would be available when building virtual cases.

The Intermodel *plug-in* was specifically developed in order to automatically model terminals and have a link to the database for obtaining information related to 4D (Scheduling), 5D (Cost Estimation), 6D (Sustainability) and 7D (Facility management) dimensions.

The starting point for designing the virtual case studies for multimodal terminals (inland railway and seaport railway) was the benchmark included in WP3. Initial parameters such as the typology of the terminal, the estimated area and the annual volume throughput were used to create a first sketch of the terminal layout and equipment requirements. With these sketches and using the developed set of libraries, both BIM models were generated.

After testing these virtual cases, the team concluded that the Intermodel *plug-in* tools allow the user to make changes in the layout and automatically obtain data related to the abovementioned dimensions updated according to changes. This facilitates the decision making and the comparison of different alternatives.

In a later stage, alternative cases for the two real terminals in Melzo and La Spezia were modelled. Initially, both real terminals were built from a 2D layout and all elements modelled had been parameterized so that information related to the different dimensions of a 7D BIM model could be provided. For the Melzo terminal, new terminal enhancements were studied:

- New terminal access gate
- New rail yard and staking area

For La Spezia, the alternative case study scenario was a reconfiguration of the rail and seaport terminal.

For this task, the set of libraries was extended, adding some new features for expansion works and project phasing for demolition works.

With the alternative cases in place, changes, improvements and innovations could be tested and part of the KPIs could be already obtained in order to determine its impact or positive effects in comparison to the KPIs of the existing real terminals.

One major achievement was the creation of a tool that allows exportation and importation of the data from BIM to the simulation platforms and vice versa. This improvement in the interaction from BIM to simulation is further explained on WP5.

Finally, the virtual model of the seaport terminal was further developed by including a modular multipurpose terminal for containerized bulk product allowing the operators to use the same logistics chain. For that, the Intermodel *plug-in* set was further extended implementing the equipment needed for the Bulk Unloading Station. During the project, the team was assessed that the use of railways and containers for shipping bulk solids could give to a multipurpose terminal many advantages in terms of social and environmental issues as well as in term of logistics, when high value commodities with relatively small volume are handled.

2.4 WP5: Terminals Operational Simulations

The main objective of WP5 was to build a simulation-based decision support environment supporting the optimization of the design process and the operational performance of intermodal freight terminals.

This work package was composed of 5 deliverables:

- Data model
- Ontology and conceptual modelling
- Operational simulation. Simulation model of the first real-life case.
- Operational simulation. Simulation model of the second real-life case.
- Operational simulation model of improvement to the first and second real-life cases

To reach this objective a data model was developed, which describes all relevant data used in the simulation component library. Furthermore, an ontology and conceptual model were developed, describing the inner working of the library of simulation components, their hierarchy and interrelationships.

The data model describes how data will be used in the operation simulation models and other requirements, i.e. describing also the necessary information on port and terminal layout, its operations and used equipment. Yet, uncertain or false information might skew the results, resulting in wrong conclusions. That is why data and process validation was of high importance. Also, defined data model represents connections varying objects have among each other and it was divided into functional groups, and analyzed separately, concentrating especially on infrastructure, network elements, resources and relations among them. Data model supports two types of terminals: container and dry bulk, yet additional terminals can be added if need arose.

Ontology and conceptual modelling aimed to outline a design of a terminal simulation model, bounding physical objects with their intended behavior. The ontology encapsulates taxonomy connected to the container terminal case studies, La Spezia and Melzo, as part of the WP5 and WP7. During this phase, a conceptual modelling framework of the simulation components was developed. The goal was to create an ontology and conceptual architecture that covers the scope for all types of terminals in the proposed scenarios.

Then, the design and development of a terminal simulation model, based on a library of simulation components, and coupling it to the integrated tool, was successfully carried out. These tasks included the verification, validation, calibration and testing based on the case studies of Melzo and La Spezia, obtaining results that have been consistent with expectations and the historical data provided by the terminal operator.

Finally, simulation of several chosen extensions for both case studies were performed, giving comparative results and data from the simulation of real cases and simulation of improved real cases.

2.5 WP6: External Mobility Effects

As it is well-known, INTERMODEL offers an integrated DSS tool combining different simulation models. The main purpose of this WP was the development of a traffic simulation model aiming to analyse the impact on the surrounding mobility because of the activity of the terminal, including not only trucks entering and leaving the premises but their interaction with private vehicles.

This work package was composed of 3 deliverables:

- D6.1 presenting the modelling framework to correctly simulate the impacts of the generated and attracted mobility of the terminal on the performance of the surrounding road network.
- In D6.2, both La Spezia and Melzo terminals are used to validate and calibrate the simulation framework.
- D6.3 aims at assessing the external mobility affectations of the pilot cases by the calculation of specific KPIs in terms of environment (such as emission or pollutants) and traffic (congestion or LOS)

The first task included in the WP was a benchmarking of traffic simulation environments in order to find the best one fitting with the objectives of the project. Once selected, an input data structure allowing the modelling of road networks along with interfaces between both BIM and TOS modules were defined, allowing a dynamic load of a road network from the BIM model and the truck demand of the model from the TOS component of the platform.

It is important to remark that a methodology to estimate arrivals of trucks into the road network based on their estimated arrival time to the terminal and simulated travel time was developed by means of an iterative process implementing a convergence criteria, giving as a result a more realistic and consistent traffic simulation.

During the calibration and validation stage, some minor improvements and fine-tuning of both dynamic load processing and specific algorithms was performed in order to have a more flexible traffic simulation component allowing more scenarios than the ones initially planned.

Finally, KPIs integration was developed by means of formatting one output XML file compatible with the visual component. This way, results of the traffic simulation can be shown in a specific dashboard of the 3D module.

2.6 WP7: Interconnection Simulations

The main objective of WP7 was to build a simulation-based decision support environment that helps investigation into rail interconnection between two intermodal freight terminals and its effect on the operational performance as well as to assess network resilience. This work package was composed of 4 deliverables:

- Rail interconnection simulator
- Assessment of the rail interconnection pilot cases
- Assessment of rail interconnection resilience
- Periodic inspections and maintenance methodology

This WP contains information on the design decisions made for simulation model components and their combination for the case study demonstrator, especially concentrating on the input data and control choices, as well as validation efforts for the model. Also, contains information on the data used for the assessment and how experimentation was performed, followed by results with KPIs and their discussion.

It starts with a description of the model inputs, considering in more detail the layout, terminal characteristics, and the rolling stock. In particular, the interconnection with known trains visiting the terminals, based on the historical data has been tested. Moreover, a try to estimate the amount of other traffic, i.e. trains that do not visit either of the two investigated terminals, whether they are passenger or freight trains has been tested. Finally, results were presented, displaying the KPIs.

Also, the WP describes the activities necessary for the assessment of the rail interconnection simulator resilience for the pilot cased. The model described there was used with real terminal data, coming mostly from WP5 models (both inputs and results).

First a description of how resilience is understood and how it's testing might be useful in such systems was presented. Then investigated cases was described and discussed. Since we were testing resilience, all the scenarios include some sort of disruption in the system, sometimes a few of them combined. Then, the results are presented, displaying the KPIs. A comparison is made across the investigated cases. Finally, conclusions are drawn based on the results and the added value of the interconnection model resilience testing is discussed.

Finally, the WP explain the smart railway maintenance methodology that has been developed to provide an estimation of the degradation of the track infrastructure. Here, the novel methodology was introduced and provided maintenance decision-making support allowing creating preventive maintenance plans. The methodology was based on LIDAR-mapping concept, segmentation and identification of railway geometry and elements for detecting variations over the time based on the evolution of the point-clouds in successive inspections.

3 Recommendations for new and to be renewed intermodal terminals

The previous section of this report has explained the results in different work packages in INTERMODEL project. Overall, INTERMODEL gives terminal owners and operators, who have plans to develop their terminals, an option to improve the decision-making process with integrated approach to establish holistic consideration of multimodal terminals. It offers a detailed vision to improve terminals in three perspectives: operational, economic and environmental effects.

The added value of the Integration Platform is the ability to gather the knowledge of different expertise areas in a common environment. Currently each of these areas of expertise works independently, being less efficient in the search of similar results. Consequently, the investment in time and cost is higher.

Figure 1: The concept of INTERMODEL Integration platform.

Life-cycle assessment is an essential part of terminal development. For this reason, the definition of a KPI framework is very important.

After consultation to several stakeholders from different countries and profiles, the INTERMODEL indicator framework has been set and provides a complete vision of the terminal performance.

These 40 KPI’s are also available for further industrial use, for example to be used in a benchmark of different sea and inland ports analyzing their performance. The indicators are embedded to the integration platform providing an accurate life-cycle assessment.

Terminals are long-term designed, and their throughput and performance depend strongly on selected logistical models.
Concerning terminal development and regardless the perspective to be empowered, it is necessary to clearly identify key aspects and to define alternatives around them.

These alternatives will represent different logistical options and scenarios to be compared using the integration platform. Data collection must not be undermined as it is a key factor in the definition of different alternatives and scenarios.

In order to take the most out of the integration platform, a set of recommendations has been considered by the consortium. These are presented below from different perspectives.

Planning of new and to be renewed terminals is currently performed in 3D, but operational data and simulations are usually performed separately. This means that terminal development workshops need often few weeks of time in-between that the team is able to provide simulations for new logistical scenarios. At this situation, the team benefits from INTERMODEL integration environment and plan update and performing related simulation experiments becomes faster and easier, thus, less time is needed between the terminal development workshops.

The INTERMODEL Project presents a decision-making tool which evaluates the different alternatives for the design and expansion of a terminal. In order to do so, several scenarios representing the different alternatives must be determined as inputs. However, selection and definition of these scenarios is not an easy task and requires a strong knowledge of the concepts and data needed as well.
Several operational aspects must be taken into consideration to create a well-rounded scenario to be simulated by the platform:

- **Connectivity of the terminal**: since all terminals (both sea and dry) are created for the exchange of containers, connectivity to rail, road and waterways, is very important when determining their design. Moreover, whenever possible, including traffic simulation would be very interesting since it would give more realistic results about the effects from the environmental point of view that are usually mispriced since they occur outside the terminal premises.
- **Layout, equipment and material**: alternative layouts considering any change of the rail tracks (length, number of tracks and switches and distribution into the terminal), internal logistics (road distribution, access gates, storage and parking areas), logistics equipment (number of cranes, ship-loaders, reach stackers, trucks) as well as material alternatives (e.g. rail tracks type, different types of concrete for foundations and internal roads…) to optimize throughput and equipment lifecycle.
- **Peak times**: it is important to create operational simulations of terminals processing during peak times to identify potential risks and bottlenecks (e.g. gates, loading, unloading, shunting, storage areas, traffic jams on the access network). For 24/7 oriented terminals, assessment of alternative setups covering wider time frames than just peak hours must also be considered.
- **Safety**: operational simulations of safety related setup changes should be considered as well. For example, analyzing the potential effects it might have on the throughput

One of the most important recommendations to be considered from a functional perspective is to have a well-formed team to provide well-defined scenarios, covering as much as possible and most important alternatives as well as clearly targeting which problems need to be solved and how the resoluteness will be addressed.

The platform developed (see figure below) represents a digital tool where identified questions are jointly (among the problem owner and experts) discussed and improved, and then quantitative predictions are given based on the developed holistic and integrative approach. Stakeholders with different backgrounds can understand various perspectives with a realistic ‘game-type’ visualization of operations. For the decision makers, it provides an opportunity to consider desired functional areas and it is possible to consider e.g. additional data, costs and outside terminal options on different scenarios.

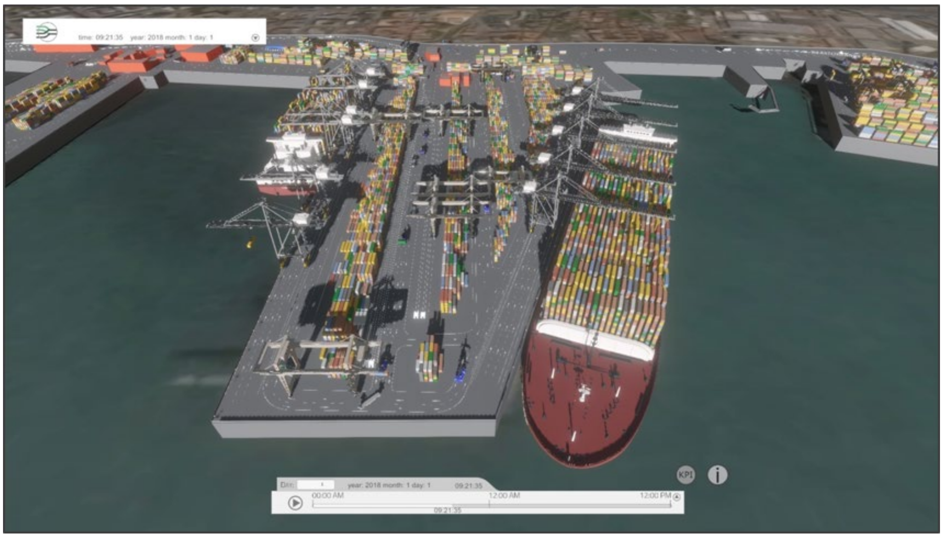

Figure 2: Screenshot from la Spezia Port pilot .

The data aspect – its completeness and quality are vital to a success, while it is often coming from many sources and might not be available or obtainable. Creating own models (BIM and simulation) to the largest extent possible crates flexibility to make reasonable assumptions to move forward, if the data is lacking. Parametrisation, sensitivity analysis, cross-referencing with other dependent variables allow to overcome certain deficiencies in data, which is not possible for other techniques.

The port industry is highly capital-intensive. The baselines of logistical solutions made now mean that the operations of the terminal will be based on these selections for decades.

INTERMODEL project provides also a good base for cost consideration thanks to the (5D) feature integrated in BIM.

Results from the interviews and discussions made with terminal experts and operators show that the costs are the most important consideration. For example, savings in operational costs have large cumulative effect during the operation period.

These features shown below, can help during the cost and benefit analysis by an easy comparison of associated costs for different scenarios, improving efficiency and return of investments.

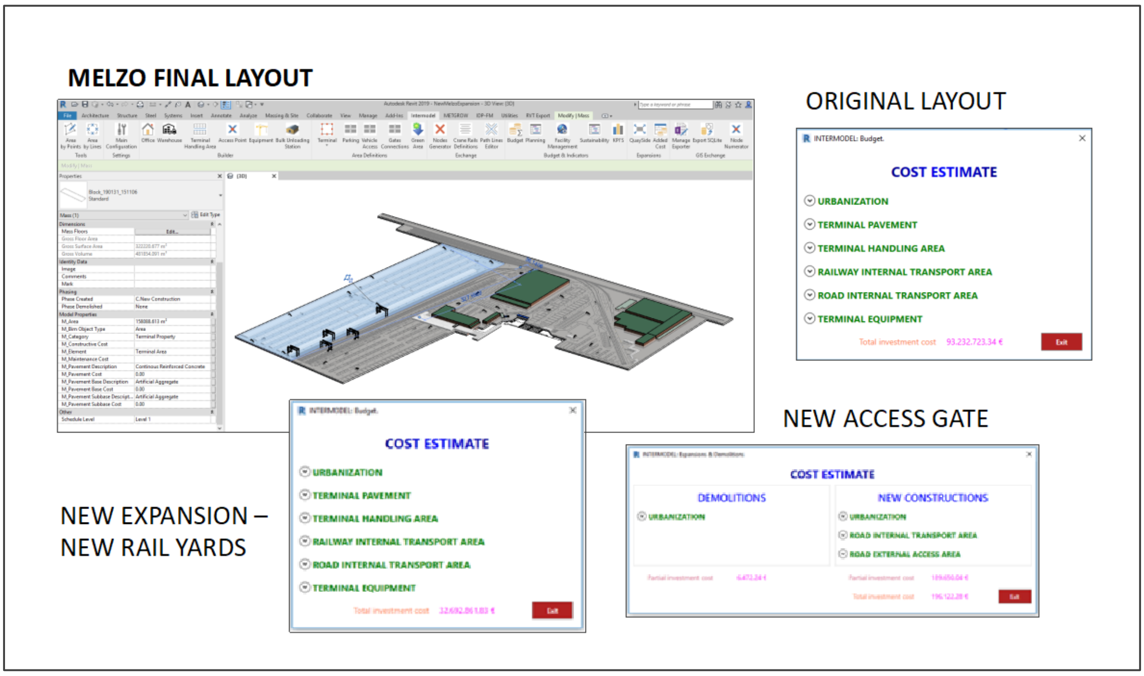

Figure 3: Pilot from Melzo Terminal developed in BIM with a financial calculation sheet opened for 2 scenarios.

The integration platform has also a function for simple financial calculations (see Figure below). The calculation is performed based on input values on:

- revenue in TEU
- costs (per running hour, total operating)
- terminal throughput
- Annual operating hours and carbon footprint.

The user is then able to get output including revenue, OPEX, operational profit and margin and carbon footprint for total and relative per TEU. The function helps to adjust operational numbers at the very high level, when there are e.g. discussions on reducing running costs per hour of the terminal.

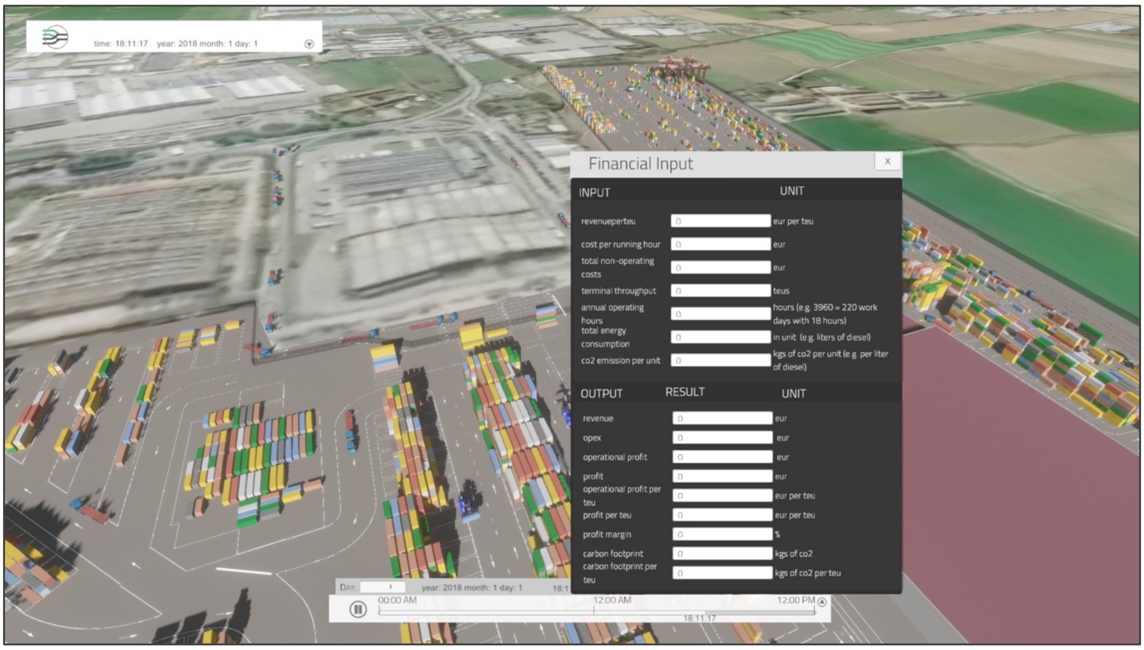

Figure 4: Pilot from Melzo Terminal with financial calculation sheet opened in the Integration Platform.

After analysing the Project performance made with the available data and based on the Consortium partners experience, can be concluded that a reduction in time for project definition and study of new terminal proposals could represent savings at around 30% in time and up to 80% in costs from the study perspective.

Savings could be maximized if following these recommendations:

- Having a higher volume of data
- Having an even better data quality
- Having a better data organisation structure
- Having a total implication of different extern agents involved in the Project

The terminals are nowadays often found in the middle of urban areas. Even if municipalities and other local public bodies consider benefits of ports e.g. due to their positive influence on local economy and employment, proximity of population centres involves also other types of concerns for e.g. port operations cause water and air pollution, noise and traffic. Therefore, the surroundings have different types of interest groups, which have different views on port operations and expansion plans.

Citizens are nowadays increasingly interested in environmental issues regarding their neighborhood. Therefore, part of the KPIs in the INTERMODEL indicator framework consider environmental information (see Figure below).

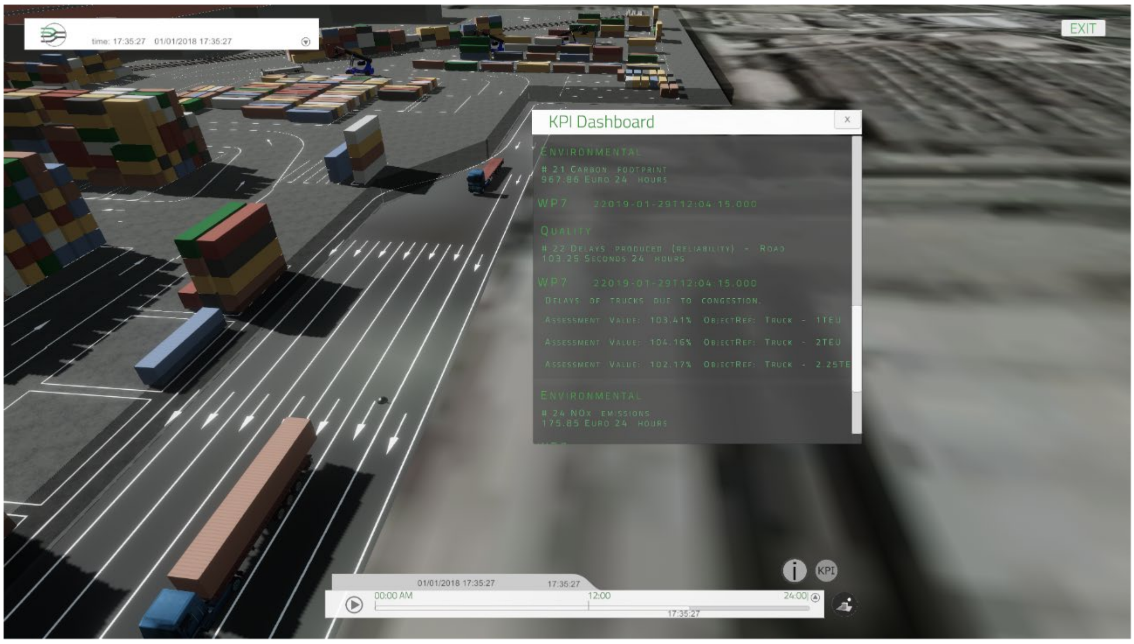

Figure 5: KPI Dashboard opened to view Indicator data.

Intermodel Project studies the impact that different type of concrete represents for the Sustainability allowing the user the possibility to evaluate how different materials can improve the indicators related.

Based on the obtained results, the use of new construction procedures and materials is highly recommended. e.g. concrete pavements reinforced with synthetic fibers instead of steel bars reducing the carbon footprint for the production and associated maintenance.

Truck typology of the incoming traffic to the terminal could be of a large interest in order to improve the results provided by the presented tool. On the one hand, it would provide exact values for the emissions given at the terminal and on the nearby premises, having a more accurate perspective of the carbon footprint, air pollution and noise pollution generated because of the activity of the terminal. Moreover, knowing the type of trucks that access the terminal would help not to overpass the defined environmental thresholds that institutions such as country government and EU legislation might set on the nearby future, making it essential for terminals of new creation. For example, heavy-duty vehicles produce around a quarter of CO_2 emissions from road transport in the EU and for some 6% of total EU emissions (as stated in the policies of the European Commission, section Energy, Climate Change and Environment / Climate Action / Transport Emissions / Road Transport). Having access to the appropriate information would simplify the process of determining whether these thresholds set by the

European Union would be exceeded. As a conclusion, typology of trucks entering and leaving terminals should be tracked in order to have enough information to be used as input of the simulation models, otherwise the results related to environmental aspects won't be accurate and therefore, unusable for the decision process.

Furthermore, knowing the origin or destination (e.g. by tracking mobile phone activity) set for all the incoming and outgoing trucks at the terminal will also improve the usefulness of the tool. By having this information, it is possible to identify the gate these trucks will use when accessing the terminal, and therefore, how the nearby roads will be affected, identifying any possible bottlenecks or congestion problems that might occur.

4 What's next?

This section aims at briefly defining which actions could be considered in order to take advantage of all the results of INTERMODEL not only because of identified weaknesses but with the objective of improving the platform itself based on the opinion of the Consortium after the last three years.

4.1 Consulting services

The Intermodel EU project delivered an integrated approach for modeling and simulation-based optimization of terminals. At the current stage, the prototype requires expert support of the project partners and individual adjustments. One of the logical next steps for further enhancement and product development would be to develop the accompanying consulting services for very specific requirements that go beyond the prototype (e.g. big data analysis of simulation results).

4.2 Basic version for self-service activities

As stated in the previous item, the platform may require certain customization of the underlying models in order to have reliable design of a terminal, representing a drawback for potential users that don't want to use the tool for a new terminal but for optimizing an existing one. These optimizations can depend on modifying a set of basic and well-identified parameters that can be simulated using the platform. Future versions of the platform can offer automation of the optimization of the parameters that are most commonly changed by terminal operators.

4.3 Specific feature extension

In addition to the different dimensions of a 7D BIM model, the software architecture of the platform can be easily extended in order to include components or connection to external tools that implement new features.

An External Manager Concrete Tool has been identified in the final stretch of the project that could be easily connected to the platform in the near future in order to:

- Provide assessment related to the environmental footprint of concrete used for building, based on the European standard EN 15804:2012+A1:2013, “Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products”. This standard is complementary to ISO 14025, which provides rules on how to operate a programme for type III environmental declarations.
- Allow a quick calculation of environmental indicators and cost impact for real concrete mix-designs.
- Allow a direct comparison of different scenarios and varying production, installation and disposal situations.
- Deliver a comprehensive report as a basis for concrete EPDs, and input for green building rating schemes (BREEAM, LEED, DGNB, HQE).
- Support concrete uses in improving process efficiency, energy and resource saving.

Not only connection to external applications but sharing data coming from other tools could feed the INTERMODEL platform. For example, data from the Corridor Management Platform La Spezia-Melzo, which is an end-to-end management system that validates transport procedures (bookings, invoicing, port calls and notifications, cargo declarations, customs procedures, etc.) from a business point of view, may be used as additional information for simulations or post-processing. Indeed, the data from the CMP can be collected in real time, if necessary. Other significant synergies and opportunities that have been identified are:

- Better calculation of ROI calculation for new investments.
- Analysis and optimization of existing infrastructures that are underused.
- Combination of two platforms may lead to build up a complete Digital Twin of a port terminal.

References

No external documents referenced