INTERMODEL EU

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

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1 Executive Summary

The European Union is highly dependent on seaports for trade with the rest of the world and within its Internal Market. Approximately, 74% of goods imported and exported and 37% of exchanges within the Union transit through seaports in 2013. To manage this amount of cargo in ports, smooth operations are required. The performance of ports is currently evaluated by using different types of Key Performance Indicators (KPIs). How the indicators are described is dependent on the stakeholders and their organizational interest.

The ports, and the transport sector as a whole, is undergoing several changes. For example, the amount of cargo is increasing and becoming concentrated, the vessels are enlarging, environmental issues are becoming more important and there are new requirements for the security. At the same time, the ports are usually located in the middle of existing neighborhood, which limits possibilities to enlarge the area. Therefore, there is a need to invest in the port infrastructure, but expansion or renovation of a port is extremely difficult. The required investments are big and the planning horizon is long. Hence, if the designed structures turn out to be unsuitable due to changes in needs, it is rather expensive to make changes.

The planning tools have developed remarkably during the past 10 years. Different types of planning tools are used in seaport and terminal design to model the completeness. Modelling generates digital representations of physical and functional characteristics of a terminal area, buildings and other infrastructures. With the help of model-based approach and with suitable KPIs, it is easier to understand and evaluate the effects of certain design solutions for terminal operations in a larger context. By using modelling tools, it is also possible to compare different design options to outline how certain choices in terminal design influences on the completeness.

There is a need to define the objectives of good terminal in order to plan the terminal and its operations. A good terminal would satisfy the stakeholders' expectations in best possible ways in the given preconditions. The achievement of objectives can be evaluated by using suitable indicators. However, the indicators used to plan and model terminal operations may differ from indicators used to evaluate the performance of current ports and terminals. The purpose of this paper is to analyze the indicators required for terminal planning and compare them with existing KPIs used for measuring the performance of ports and terminals.

Keywords: Intermodality; Key Performance Indicators (KPI); Terminal; BIM (Building Information Management)

On behalf of the contributors,

Ville Hinkka, VTT

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3 Introduction

3.1 Scope

This deliverable includes "Terminal Planning: The Selection of Relevant KPIs to Evaluate Operations" a conference paper sent to TRA2018 conference in Vienna Austria on April 16-19. The work considers indicators in performance evaluation, serving as background for integrated planning environment to be discussed more in upcoming work. That work will consider more thoroughly BIM and simulation, components and interfaces related to the approach.

The conference is 7th Transport Research Arena (TRA) and is headlined as a digital era for transport. This paper is a complete draft version on 31.08.2017. However, there is two more weeks until the deadline for the paper delivery, and therefore, some changes may be done before paper submission. In addition, paper will go through peer review process. Based on the review comments, the final paper may have some improvements.

In addition to be published in conference proceedings, the authors aim to publish the paper also in *Transportation Research Procedia*. The Transportation Research Procedia is an open access journal by Elsevier focusing entirely on publishing full sets of conference proceedings.

3.2 Audience

The deliverable is targeted to people who have interest on developing terminals from planning, logistics and performance point of view. This means all actors working at the terminals.

3.3 Definitions

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

<u>Terminal</u>

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.

<u>Digital models</u>

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).

INTERMODEL project definitions

Integrated planning environment: A methodology under development in INTERMODEL EU project to technically combine BIM based coordination model, operational simulation and performance evaluation with indicators in multimodal freight terminals.

3.4 Structure

The deliverable is structured to 4 sections, briefly explained below.

- **Section 1:** Executive summary (Abstract)
- **Section 2:** Table of contents
- **Section 3:** Introduction
- **Section 4:** The conference paper

4 The conference paper

4.1 Introduction

The significance of ports for the European Union is irrefutably high: 75% of all international goods traffic is handled via ports. For inner-EU goods traffic, waterway transports amounts to 40% of all transports. In 2011, EU ports handled about 3.7 billion tons of goods whereof 70% were bulk, 18% container, 7% Ro-Ro (roll on roll off) and 5% break bulk traffic. (Veregge 2013). Compared with the year 2011, total goods volume is forecasted to rise by 50% until the year 2030 (European Commission 2013).

In addition to the increased cargo volumes, port and maritime sector are facing several other changes and new requirements. For example, due to enlarged vessels, the cargo volumes are concentrating. The other topical issues are related to environmental concerns and new requirements for the security. Need for investment in new capacity is obvious, but the problem is that there are limited amount of space for totally new ports, and the current ports are usually in the middle of existing neighborhood limiting possibilities to enlarge the area. Therefore, there is a need to invest in ports, but the planning of new infrastructure is difficult. The required investments are big and the planning horizon is long. So, if the designed structures turn out to be unsuitable due to changes in users' needs, it is expensive to make changes later.

There is a need to define the objectives of a good terminal in order to plan the terminal and its operations. Good terminal would satisfy the stakeholders' expectations in best possible ways in the given preconditions. The achievement of objectives can be evaluated by using suitable indicators. Currently, the performance of individual port is evaluated by using different types of key performance indicators (KPIs). Stakeholders and their organizational interest define the way of describing the indicators.

The planning tools have developed remarkably during the past 10 years. Different types of planning tools are used in seaport and terminal design to model the completeness. The purpose of modelling is to generate digital representations of physical and functional characteristics of terminal area, buildings and other infrastructures. With the help of model-based approach and with suitable KPIs, it is easier to understand and evaluate the effects of certain design solutions for terminal operations in a larger context. By using modelling tools, there are also possibilities to compare different design alternatives to outline how certain choices in terminal design influences on the completeness.

However, the indicators used to plan and model terminal operations may differ from those indicators used to evaluate the performance of current ports and terminals. Therefore, the purpose of this paper is to analyze the indicators required for terminal planning and compare them with existing KPIs used for measuring the performance of ports and terminals.

This paper is organized as follows: The Introduction section is followed by, the methodology. This is then followed by the results of literature search on currently used KPIs for terminals, current logistics trends and development of BIM (Building Information Modelling) and simulation tools. The empirical material based on the workshop and experts' opinion is presented. The paper concludes with an analysis of different KPIs.

4.2 Methodology

The methodology for this paper consists of the following three phases: 1) Literature search about current KPIs used for evaluating the performance of the ports and terminals and current trends in port industry and marine transport. 2) Workshop, where experts from different stakeholder groups presented their views on relevant KPIs related to the evaluation of port performance and then discussed these KPIs to decide upon a common list of applicable KPIs. 3) The created list of KPIs was evaluated by experts who are specialized to simulate the operations of ports, terminals and other logistics centres.

Literature search was conducted by using the most common academic journal databases. The search aimed to find which kind of KPIs have been used or have been suggested to be used for evaluating the performance of the ports and terminals. The purpose of the search to find current trends was to evaluate whether the existing KPIs are relevant enough also in the future or is there need for new KPIs.

After the literature search on reported KPIs, the workshop was organized to get practitioners' views on current KPIs and later compare differences between academics' views and practitioners' views. The following participants attended the workshop:

- Port authority
- Logistics service provider
- Port operator
- Railroad operator
- Research organization
- Planner and designer

Based on the workshop, a list of 40 relevant indicators was created. The list consisted of indicators which at least some of the participants considered important from their organization's perspective. After the analysis and discussions, 27 indicators were named as KPIs and other 13 as other performance indicators. The main reasons for naming certain indicators "only" as 'performance indicators' was that those indicators either belonged to the other indicators or they were indicators that in practice measured something similar as another indicator. All the indicators were then grouped to five different categories named as a) Operational, b) Financial, c) Quality, d) Environmental, and e) Safety indicators.

After defining the list of indicators, the list was evaluated by directors and developers of a Dutch software company. The company is specialized to program software models to simulate the operations of ports, terminals and other logistics centres under consideration, or which require major improvements simulations. The software company experts scrutinized all the indicators and divided them in three different categories based on strict justifications. The first category consists of indicators that are possible to consider in simulations and define its value in different parameters. Third category consists of indicators that are very difficult to consider in current simulation models even if the model would be improved significantly. The second category consists of indicators that are between the first and third categories: they are indicators that are not used in current simulation models but, which could be included as a part of the models if someone is ready to invest adequate amount of resources in additional calculation development. This classification was based on expertise of using simulation models in different ports, terminals, and other logistics centres. The first category is rather obvious, but the challenge was to classify the indicators as second or third category. However, by analysing the available input data and used calculation models, the experts has rather well consciousness what would be possible to calculate and what would be very difficult to calculate.

4.3 Background information

4.3.1 Currently used KPIs for evaluating the performance of the terminal

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), % of target group reached by the project (outcome indicator) and reduction of CO2 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.

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).

4.3.2 The effect of megatrends in logistics and port management on terminal requirements

Different port governance models have been under discussion decades, and 'public versus private' has been the biggest debate (Brooks et al., 2007). Even if the debates have ended up promoting private sector involvement in ports, only a few countries with limited number of ports have been privatized during the past decade (Brooks et al., 2017). Since 2007, European Union has recommended to use landlord model for port governance (Verhoeven, 2009), and this model has become the most common and dominant model during the early twenty-first century (Brooks et al., 2017). In a landlord model, a public port authority acts as both landlord and regulatory body, while private companies carry out port operations (e.g. Bischou and Gray, 2005). Due to the changing nature of port governance, the port authority no longer has an integrated and holistic role within port activities; instead, it has given the control of operations to separate organizations and at least the ownership of superstructure and equipment if it has retain the ownership of infrastructure assets (Brooks et al., 2017).

Private organizations' involvement in port governance have an effect on ports' competitive position and investments are required to develop competitiveness and cargo volumes. Earlier, the ports competed against each other, but due to the involvement of private organizations operating in several ports, cooperation between ports has increased. This tendency has both good and counterproductive effects on the development of individual port. The terminals may achieve higher productivity and get additional investments by international terminal operators (Parola et al., 2017), while sometimes the operators may share the competencies and customers between the ports in a way that an individual port may end up for serving dying cargo segment and therefore it loses the interest of private investors (Shinohara, 2017).

The increased size of container vessels has affected container terminals in several ways. First, big vessels require particular investments in terminals such as the need for bigger cranes, deeper sea routes, etc. Secondly, the operations of big vessels concentrate on certain terminals, as the operations require particular investments and the big vessels operate most economically in long-distance lines. Therefore, the ports that serve mega vessels strengthen their role as transshipment port while the other ports nearby become as feeder ports (Rodrique and Ashar, 2016). Third, due to the high volumes and operating costs of the big vessels, the big vessels visit the terminals for longer intervals but they require rapid loading and unloading operations. This requirement forces terminals to arrange the needed capacity for unloading and loading and for quayside operations whenever the vessels arrive, as the vessel may choose another terminal if the quay were not available and waiting time would be too long (Fransoo and Lee, 2013). (Notteboom, 2004).

Port work has been very labor intensive and dangerous work, but well paid. Therefore, there are many incentives to automate port operations to decrease the number of required workers. However, automation requires large investments, and in order to gain cost savings and increased efficiency, there should be information about the type and volumes of handled cargo when designing the proper automation system. (Hinkka et al., 2016).

4.3.3 The use of Building Information Modelling (BIM) for terminal design

The design phase aims the development of a solution that is possible to be constructed. Traditionally various Computer Aided Design (CAD) applications are used to plan different functional areas and related technical domains and disciplines. Building Information Modeling (BIM) is a methodology to manage construction projects in an intelligent and collaborative manner. Succar (2009) describes BIM as 'a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format through the building's lifecycle. It has been used already for some time in the building industry, and since the past decade the methodology has been increasingly utilized to also manage other industry sectors such as infrastructures (Chong et al., 2016). BIM continues to be used more and more in civil engineering and freight terminals and ports have a great potential to utilize BIM.

In a large terminal development project, there is a tremendous need for advanced tools that enable using information together to address problems from the engineering perspective. These kind of actions could potentially save money and time. The purpose of BIM depends on the need of the project phase. With an integrated approach, all operations and maintenance of terminals during the life cycle can be better examined. Moreover, model-based work practices help to manage construction process and supports documenting end result into 'as built model'.

The fact that the 4th (time) and 5th (cost) dimensions can be added to BIM has boosted efficiency and quality in infrastructure projects (Bradley et al., 2016). Capabilities such as checking of space conflicts (Moon, Dawood, & Kang, 2014), use of satellite images for monitoring construction (Han, 2013), and incorporation of cost and schedule model for evaluation (Kim, Orr, Shen, & Moon, 2014) is a great asset when utilizing BIM. Such models help detect collisions in advance (clash detection) in e.g. equipment space reservations or storage areas. Traditionally undetected clashes are very costly to repair later, because the change causes a chain reaction to design and construction work.

Communication stands as a critical element in all project teams. A shared information and knowledge resource enables informed decisions and their communication to everyone. In many cases, traditional paper work is partially or completely avoided since the necessary designs are completed with the help of BIM (The National BIM Standard-United States, 2016). The need for BIM can also be explained by the need for better integration, cooperation and coordination within construction teams (Cicmil & Marshall, 2005) and having an inter-organizational information sharing system avoids situations where information is 'fuzzy, unformatted or difficult to interpret" (Ajam, Alshawi, & Mezher, 2010). By adopting BIM, information can be shared across the supply chain. This also means one source of input will facilitate many outputs, discouraging silo working and encouraging data-driven management strategies to be created (Beaumont & Underwood, 2015).

Model-based working can be used for designing both schematic massing models and detailed construction-ready models. Rather than having to create and document designs for each new phase, all the necessary information is stored in a database, which can be regularly updated and easier to manage. Thus, BIM is not just about geometrical modelling and the input of information, but also a way to improve collaboration between stakeholders and time required for documenting the work (Bryde, Broquetas, & Volm, 2013). BIM allows project managers to reengineer the ways to involve all actors (Bryde et al., 2013). There are also opportunities to provide a more accurate visualization and track changes automatically. This is an added value to traditional 2D drawings or 3D renderings resulting in better designs (Bachman, 2009).

Simulation models are widely used in terminal design (Dragovic et al, 2017). Efficient logistic operations can only be achieved by a proper and robust terminal design, as it establishes the foundations for operational choices and limits possible alternatives. Design choices typically cannot be easily changed, without extensive financial repercussions, or significant impact on the terminals operational performance. If these are in any way hampering the operations, the capacity assumptions might not be met. Design volume (desired throughput capacity) is closely connected with space requirements, transport modes, and possible container handling equipment and cannot be considered in isolation. Improper design cannot only underestimate the needs, but also overestimate them, ending up in too high capital and/or operational costs. Any layout considerations not taking into account the needs for adequate operations are insufficient, and may cause serious negative functional implications. Nevertheless, a proper infrastructure design is only the first step in reaching efficient logistics. It needs to be followed by suitable planning of the functional areas (such as stack ground spot plan), supporting equipment (e.g. number of automated guided vehicles), operational procedures, appropriate planning of arrivals (especially vessel calls), suitable Terminal Operating System (TOS), good coordination, and others.

Currently design, operational simulation and performance indicators are separated from each other and there is no interfaces available to export and import information. However, this is a very interesting topic for a holistic terminal development and it will elevate the terminal development to a next level in the future.

4.4 Empirical material

As explained earlier, the workshop defined a list of 27 relevant KPIs and 13 performance indicators to evaluate the performance of terminal. Then these indicators were grouped to five different categories named as a) Operational, b) Financial, c) Quality, d) Environmental, and e) Safety indicators. The indicators can be found in Table 1. The table shows the results of evaluation of indicators in a simulation point of view. I.e. which indicators can be evaluated by using a simulation model, which can be evaluated if some additional calculation model is programmed, and which of the indicators are very difficult to obtain even if there would be a reasonable amount of resources to program additional calculation model.

Table 1. A list of indicators for evaluating terminal performance. The indicators written in normal text are KPIs while the indicators written in italic are performance indicators. The values for indicators coloured in green are rather easily possible to obtain from simulation models, indicators coloured in yellow are possible to get from simulation if additional calculation model is programmed, but indicators coloured in red are very difficult to obtain from simulation despite the additional improvements for the model.

Operational	Financial	Quality	Environmental	Safety
Intermodal terminal throughput (volume)	Return on investment (ROI)	Turnaround time	Energy consumption per handled unit	Number of road accidents
Equipment utilization	Terminal's profitability	Waiting time	Carbon footprint per unit	Number of railway accidents
Gate utilization	Operating efficiency	Easiness of entry and exit from highways	CO, NOX, SOC, PM emissions	
Labour utilization rate	Operating revenues per unit	Easiness of entry and exit from rail network	Population exposed to high level traffic noise	
Storage area utilization	Operating benefits per unit	Delays produced (reliability) - road		
Rail track utilization	Direct jobs sustained from terminal activities	Delays produced (reliability) - railway		
Berth utilization	Indirect jobs sustained from terminal activities			
	Road and rail track maintenance cost			
Manoeuvring time	*Capital expenditures (CAPEX)*	*Unproductive time*	*Use of alternative fuels from total consumption*	*Accidents related to hazard cargo*
Service time	*Operational expenditures (OPEX)*			
Berthing time	*Corrective maintenance cost (equipment)*			
Idle time (equipment)	*Preventive maintenance cost (equipment)*			
	Corrective concrete structures maintenance cost			
	Preventive concrete structures maintenance cost			

4.5 Analysis of KPIs

The purpose of KPIs is to evaluate the companies' success and performance. Even if the targets for KPI values can be set in advance, usually KPIs are used to monitor and evaluate the performance afterwards when the exact figures of monitored period are available. When KPIs are used in terminal planning phase, the figures are, of course, estimates. However, because of modern BIM tools, rather detailed models for alternative solutions are made already in the planning phase and simulation tools are used to evaluate the efficiencies of different alternatives, but also how certain details affect the performance of an entire terminal and port. Therefore, there is a need to define suitable KPIs for a port and terminal already in the planning phase.

Recent trends in maritime transport and port sector has changed the position of port in a global supply chain. The ports and terminals are currently important intermodal nodes, but the place of the node can change quickly similar to the supply chains and their continuously changing transport needs. Therefore, the ports need to be flexible in order to attract customers to include the port as a part of their transport chain. However, flexibility of the port is rather difficult to measure by using KPIs even if the port's ability to be flexible can be more important factor in supply chain design than single operational performance value. When looking at Table 1, it seems that flexibility factors have minor role when defining KPIs or there are not established ways to measure flexibility.

Table 1 also shows that operational and quality performance indicators are rather well considered in simulation models. It also seems that environmental performance indicators are possible to include to simulations, even if they are for some reason not yet considered important to be simulated. Even if many of the stakeholder workshop participants considered financial indicators the most important, these indicators are not yet used in simulations. It also seems that some of the most relevant financial KPIs are not even possible to include in simulations. Based on Table 1, it also seems that safety indicators are not possible to include in simulation models.

4.6 Conclusions

Currently, financial performance indicators were seen as the most relevant indicators when evaluating the performance of the terminal or port. However, when planning a new terminal a terminal owner aims to improve the terminal and financial indicators are not included as a part of the simulation. However, some of the financial indicators could be included as a part of the simulation, even if it seems to be very difficult to include the some of the most relevant indicators such as return on investment (ROI) as a part of the simulation.

Terminal simulation software seems to concentrate on operational and quality indicators. They are, of course, relevant, but show only one view of the terminal's competitiveness and performance. Based on the expert opinion, it would be possible to include environmental indicators to the simulation model. In addition, it is possible to include some financial indicators. Including those indicators as a part of the model would offer a more comprehensive view on terminal performance.

One problem is that terminal's flexibility is not well considered in current indicators both based on literature and conducted workshop. However, there is a need to consider the flexibility factors as the optimization of some operational indicators such as utilization rates may decrease the terminal's ability to be responsiveness to varying customer needs.

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4.8 References

Ajam, M., Alshawi, M. & Mezher, T., 2010. Augmented process model for e-tendering: Towards integrating object models with document management systems. Automation in Construction 19, 762-778.

Bachman, M., 2009. BIM's Effect on Design Culture. Available at: https://www.di.net/articles/bims_effect_on_design_culture/ (Accessed September 8th, 2017)

Beaumont, W., & Underwood, J., 2015. Chapter 6: Data management for integrated supply chains in construction. In Supply Chain Management and Logistics in Construction. Edited by Greger Lundesjö. Kogan page, London, 1st ed., pp. 91–119.

Bichou, K., Gray, R., 2005. A critical review of conventional terminology for classifying seaports, Transportation Research Part A: Policy and Practice 39, 75-92,

Bradley, A., Li, H., Lark, R., Dunn, S., 2016. BIM for infranstructure: An overall review and constructor perspective. Automation in Construction 71, 139-152.

Bryde, D., Broquetas, M. & Volm, J., 2013. The project benefits of Building Information Modeling (BIM), International Journal of Project Management 31, 971-980.

Brooks, M.R., Cullinane, K.P.B., 2007. Devolution, port performance and port governance (research in transport economics 17). Oxford; Elsevier.

Brooks, M.R., Cullinane, K.P.B., Pallis, A.A., 2017. Revisiting port governance and port reform: A multi-country examination. Research in Transportation Business & Management 22, 1-10.

Cheng, J.C.P., Lu, Q., Deng, Y., 2016. Analytical review and evaluation of civil information modeling. Automation in Construction 67, 31-47.

Chong, Y., Lopez, R., Wang, J., Wang, X. & Zhao, Z., 2016. Comparative Analysis on the Adoption and Use of BIM in Road Infrastructure Projects. Journal of Management in Engineering, 32 (6).

Cicmil, S. & Marshall, D., 2005. Insights into collaboration at project level: Colplexity, social interaction and procurement mechanisms. Building Research and Innovation 33, 523-535.

DEFRA, 2006. Environmental Key Performance Indicators. Reporting Guidelines for UK Business. Report PB 1132. 1 Department for Environment, Food and Rural Affairs, London, UK.

Dragovic, B., Tzannatos, E. and Park N.K., 2017. Simulation modelling in ports and container terminals: Literature overview and analysis by research field, application area and tool. Flexible Services and Manufacturing Journal 29, 4-34.
European Commission, 'Ports: an engine for growth', COM/2013/0295, 23.05.2013, Brussels.

Fransoo, J.C., Lee, C.-Y., 2013. The Critical Role of Ocean Container Transport in Global Supply Chain Performance. Production and Operations Management 22, 253-268.

Gibson, 1982. Working with the Performance Approach in Building. International Council for Research and Innovation in Building and Construction (CIB), CIB report, publication no. 64. Rotterdam, Netherlands.

Ha, M.-H., Yang, Z., Notteboom, T., Ng, A.K.Y., Heo, M.-W., 2017. Revisiting port performance measurement: A hybrid multi-stakeholder framework for the modelling of port performance indicators. Transportation Research Part E 103, 1-16.

Han, D., 2013. Construction Monitoring of Civil Structures Using High Resolution Remote Sensing Images. Proceedings of SGEM, Surveying Geology & Mining Ecology Management (SGEM).

Hinkka, V., Eckhardt, J., Permala, A., Mantsinen H., 2016. Changing Training Needs of Port Workers Due to Future Trends. Transportation Research Procedia 14C, 4085-4094.

ISO (International Standardization Organization), 2010. ISO 21929:2010 Building Construction – Sustainability in Building Construction – Sustainability Indicators. Part 1 - Framework for the development of indicators for buildings and core indicators.

ISO (International Standardization Organization), 2014. ISO 37120:2014 Sustainable development of communities – Indicators for city services and quality of life.

Kim, H., Orr, K., Shen, Z., & Moon, H., 2014. Highway Alignment Construction Comparison Using Object-Oriented 3D Visualization Modeling. Journal of Construction Engineering and Management, 140 (10).

Mayer, A.L., 2008. Strengths and weaknesses of common sustainability indices for multidimensional systems. Environment International 34, 277-291.

Moon, H., Dawood, N., & Kang, L., 2014. Development of workspace conflict visualization system using 4D object of work schedule. Advanced Engineering Informatics, 28, 50–65.

Morales-Fusco, P., Saurí, S., Lekka, A.M., Karousos, I., 2016. Assessing customs performance in the Mediterranean ports. KPI selection and Best practices identification as part of the MEDNET project. Transportation Research Procedia 18, 374-383.

Notteboom, T.E., 2004. Container Shipping And Ports: An Overview. Review of Network Economics 3, 86-106.

Parola, F., Ferrari, C., Tei, A., Satta, G., and Musso, E., 2017. Dealing with multi-scalar embeddedness and institutional divergence: Evidence from the renovation of Italian port governance. Research in Transportation Business & Management 22, 89-99.

Pärn, E.A., Edwards, D.J., Sing, M.C.P., 2017. The building information modelling trajectory in facilities management: A review. Automation in Construction 75, 45-55.

Rodrique, J.-P., Ashar, A., 2016. Transhipment hubs in the New Panamax Era: The role of the Caribbean. Journal of Transportation Geography 51, 270-279.

Segnestam, L., 2002. Indicators of Environment and Sustainable Development. Theories and Practical Experience. The World Bank Environment Department. Environmental Economics Series. Paper No. 89. December 2002. Washington, USA.

Shinohara, M., 2017. Characteristics of Japanese port policy: Strategic ports and policy dilemma. Research in Transportation Business & Management 22, 100-107.

Succar, B., 2009. Building information modelling framework: A research and delivery foundation for industry stakeholders. Automation in Construction, 18, 357–375.

Tanguay, G.A., Rajaonson, J., Lefebvre, J.-F. and Lanoie, P., 2010. Measuring the sustainability of cities: An analysis of the use of local indicators. Ecological Indicators 10, 407-418.

The National BIM Standard United States, 2015. Guideline document, NBIMS-US version 3.

Veregge, A 2013, 'EU-Hafenpaket: gemischtes Echo', ITJ International Transport Journal, no. 23/26, p. 19.

Verhoeven, P. 2009. European ports policy: meeting contemporary governance challenges. Maritime Policy & Management 36, 79-101.

Winch, G., 1989. The construction firm and the construction project: A transaction cost approach. Construction Management and Economics, 7, 331–345.