Expansion Planning at Container Terminals

Marvin Kastner(✉), Ann-Kathrin Lange, and Carlos Jahn

University of Technology Hamburg, Am Schwarzenberg-Campus 4 (D), 21073 Hamburg, Germany
marvin.kastner@tuhh.de

Abstract. Container terminals are highly complex systems where various processes need to interoperate smoothly in order to offer the required level of service at competitive prices. Hence, with changing logistics network structures, higher expected service standards, and increasing transportation demands, container terminals continuously need modification. When resources at a terminal get scarce, an expansion provides additional space, e.g. to improve superstructure and/or to increase the yard size. The presented literature review examines the process of expansion: With which methods and tools are the expansion plans developed and which requirements are inherent to expansion projects? Here, the perspective of both industry and academia on this planning problem is of interest. The examined literature suggests that throughout the project many factors influence the final result. The first draft often changes several times before a project is completed. This is reflected in the tools which are used to create valuable input at intermediate steps during the planning phase, such as layout design tools, ship handling simulators, and logistics simulation. Logistics simulation is the only reported quantitative method to estimate future operation characteristics. The link between the different software solutions remains weak – for each a representation of the container terminal needs to be kept up to date. Hence, in future the coupling of simulation with other software tools seems promising.

Keywords: Container terminal · Inland terminal · Expansion planning · Simulation · Literature analysis

1 Introduction

Seaport container terminals are the backbone for world-wide logistic networks – over 80% of the world-wide traded volume is handled in ports and over 17% of the seaborne trade is containerized (United Nations Conference on Trade and Development 2019). While containers for international trade are standardized (cf. ISO 2013), the way they are handled in ports are not. Seaport container terminals show large individual differences: They differ in their layout (e.g. the stack layout is perpendicular or parallel to the quay side), in the container handling equipment (e.g. they use container stacking cranes or straddle carriers), in the strategies for task assignment (e.g. first-come-first-served, pick spatially closest task, or more sophisticated assignment strategies), and in the strategies for storing containers in the yard (e.g. chaotic, sort by destination, or order stack by predicted pickup). Plenty of decisions need to be made for each subsystem of

M. Freitag et al. (Eds.): LDIC 2020, LNLO, pp. 114–123, 2020.
https://doi.org/10.1007/978-3-030-44783-0_11

the terminal. Each of them needs to mesh with the others like cogwheels in a clockwork. In academic research, subsystems have been identified and examined for decades (see e.g. Steenken et al. 2004; Stahlbock and Voß 2007; Gharehgozli et al. 2014; Gharehgozli et al. 2016; Expósito-Izquierdo et al. 2019). These literature reviews shed light on how complex the operation processes at seaport container terminals are. This gives cause to the question: If seaport container terminals are so different from each other and the optimization of subsystems is that complex, how can this be accounted for in strategic planning tasks such as expansion planning?

Expansion projects for container terminals are difficult endeavors. When hinterland access needs to be expanded, this often creates dependencies on external infrastructure projects. During the planning and realization, political pressure might arise or environmental requirements can be imposed. And even if a project is realized as initially wished, this might not meet the requirements at the time of completion. In the beginning, assumptions (such as the expected vessel growth or future transportation demands) are made. It is known that these are subject to change over years and therefore some buffer for later adjustments is needed. At the same time, expensive over-dimensioning needs to be avoided. In the end of the project, the container terminal needs to operate smoothly while amortizing its investment costs for the expansion.

Seaport container terminals usually offer up to three interfaces to the hinterland: road, rail, and inland waterways. To reduce transportation costs, emissions and alleviate road traffic in seaports, trucks can be surrogated by either trains or inland vessels. By those means of transport, goods can be moved to proxies in the hinterland. There they provide the interface for trucks. For such a proxy Witte et al. (2019) use, inter alia, the term "inland terminal". It is tempting to group inland terminals together with seaport container terminals because the interfaces might be the same and by definition mainly containers are transported. This conclusion is as such premature and not justified. In literature, the role of inland terminals in their respective political and economic environments are largely overlooked (Witte et al. 2019). Rozic et al. (2016) note that in scientific literature the processes at inland terminals are insufficiently explored. Nevertheless, in the scope of this literature review expert interviews suggest that inland terminals, just like seaport container terminals, are complex systems that are subject to modification and expansion over time. Therefore, inland terminal expansion planning needs to consider individual factors as well.

In the scope of the presented literature review, both seaport container terminals and inland terminals are conjunctly explored. The key question of this article is "Which methods and tools are currently used to develop expansion plans at container terminals?" This question is relevant when it comes to (a) detecting research gaps and (b) gaps between academia and practice.

In the scope of this paper, the working definition of a container terminal expansion is that new adjacent space is added to a container terminal, potentially by re-dedicating land that has previously served a different purpose or by reclaiming land by earthwork operations. Furthermore, conversions to container terminals are added to consideration.

At this point we take a methodological perspective. The method needs to ensure that the planned expansion will meet the actual requirements once the plans are implemented. Such a method is most likely transferrable between different types of container terminals. Furthermore, success criteria are expected to be transferable, too.

This research excludes the aspect of how exactly the container terminal is constructed, like whether and which new construction techniques or materials are used. Instead, the way decisions regarding the terminal layout, the operating system (the combination of container handling equipment types), and the fleet sizes (the amount of equipment of each type) are focused on.

2 Methodology

Literature reviews are a common tool to set different publications into relation with each other. Grant and Booth (2009) describe a mapping review as a kind of literature review that maps out the existing literature, introduces categories, and identifies research gaps. This is applied in the presented article to indicate common approaches in expansion planning and to highlight how the process can be supported better in future.

For this literature search, the search terms need be chosen with care. For each of the terms of interest, a set of synonyms are identified. Alternative names for “seaport container terminals” are “maritime container terminals” (cf. Expósito-Izquierdo et al. 2019) or “marine container terminals” (cf. Nooramin et al. 2011). Because except inland terminals no other types of container terminals exist, here the search term can be relaxed to “container terminal”. The distinction between seaport container terminals and inland terminals is re-introduced in the evaluation.

As further names for inland terminals in academia, Witte et al. (2019) identify a set of synonyms and related concepts. All their reported terms are added to the search terms, namely “dry port”, “inland terminal”, “inland port”, “inland transport hub”, “inland logistics hub”, “freight village”, “intermodal terminal”, “intermodal logistics platform”, and “thruport”. In industry, facilities which fulfill the definition of an inland terminal sometimes also call themselves container terminals (e.g. TriCon Container-Terminal Nürnberg GmbH 2019). As this search term has already been added for seaport container terminals, this can be neglected at this stage.

Synonyms and related words for expansion are taken from the online thesaurus Merriam Webster and checked with the search engine google for reasonability. To the term “expansion”, this procedure adds the terms “extension” and “enhancement”. Other terms proved to be either completely unsuitable (“upturn”, “accumulation”, etc.) or were too broad (“development”, “evolution”, etc.). Each expansion of a container terminal can make new use of areas that previously served a different purpose. This is referred to as “conversion” (cf. The Port of Los Angeles 2019). This expression is added to the search terms.

Each article must cover the topic of expansion. All its different synonyms are connected with an “or”. All aforementioned synonyms for inland and seaport container terminals are connected with an “or”, as well. The literature search is limited to the last twenty years, i.e. 1998–2018. The exclusion of the year 2019 (the year of writing the article) allows the repeatability of the search at a later point. Publications published after 1997 are of interest because with the starting 21st century, China influenced the international commodity flow drastically. New ports gained importance and grew in capacity. Only publications published in English are considered so that a greater audience can thoroughly understand the referenced literature. Publications are restricted to conference articles and academic journal articles.

The two scientific databases Scopus and Web of Science are used to query. Scopus is described as the largest database of peer-reviewed literature (Elsevier 2019). Web of Science on the other hand is attributed to be “the world’s largest publisher-neutral citation index and research intelligence platform” (Clarivate Analytics 2019).

The guiding question “Which methods and tools are used for developing expansion plans at container terminals?” Explicitly focuses on how the designers arrive at the plan. Literature is excluded if it focuses on the construction process, on operational planning problems, or if the focus is not on a single container terminal, e.g. the whole supply chain or a container terminal network. Furthermore, it needs to be ensured that the article actually covers the topic of container terminal expansion as it has been previously defined. First, the literature is filtered by its abstract. If the abstract has not provided any reason for exclusion, then the full text of the article is analyzed. If the article fulfills the aforementioned criteria, it is included.

The article is then assigned one category: (a) publications reporting practical expansion projects, (b) scientific case studies, and (c) methodological contributions. The first category is assigned if all authors indicated to be employed in industry or by public authorities. Here, deep insights in the daily business are gained. For scientific case studies, a reference to one concrete container terminal was made and at least one of the authors had an affiliation to a university. In this category, academic novel principles in the context of a project are reported. The last category, methodological contributions, does not focus to a specific container terminal and emphasize how expansion projects can be improved. The comparison between these three categories allows to identify gaps between theory and application as well as research gaps.

3 Results and Discussion

The designed search query resulted in 231 hits in Scopus and 81 hits in Web of Science. After having filtered the abstracts as defined above, only 26 publications remained. These results are displayed in Table 1, the literature is listed in the appendix.

Each of the publications is examined according to the employed methods to plan the terminal expansion. Here, it is of interest how experts check for the viability and suitability of the current plan. One way to ensure that the spatial expansion will result in an overall better performance, is to learn from the insights of the operational staff. In *workshops or discussions,* they can share their experience from daily work and help to avoid pitfalls. When communicating different drafts to project members or other shareholders, proper tools for iterative *layout design* are essential. A tick is left if the tooling is explicitly presented. By using a *ship handling simulator*, the quayside characteristics of the expanded container terminal are explored.

Table 1. Container terminal expansion in conference and scientific journal articles. For the scope, "B" encodes berth, "RI" rail interface, "TI" truck interface and "Y" yard. The ampersand (&) reflects a combination of subsystems in one model, commas indicate separate models. The literature is listed in the appendix.

	Author(s)	Workshop/Discussion	Layout design	Ship handling simulator	Logistics simulation			Other Methods/Tools
					Used	Type	Scope	
Industry	Armour et al. (1998)	✓						[a]
	Bardi and Ingram (2010)	✓						
	Bichich et al. (2010)							
	Brown et al. (2013)	[b]						
	Butler and Denton-Brown (2007)	✓			✓	DES*	B	
	Di Meglio and Sisson (2013)	✓						[c]
	Dickson (2012)				✓	DES	RI	
	Fant McDowell (2016)				✓	DES*	RI & Y	
	Johnson (2007)				✓	DES*	TI & Y & B	[d]
	Jones et al. (2016)	[b]						
	McNeal et al. (2001)							[e]
	Nye et al. (2004)							
	Padron et al. (2007)			✓	✓	DES*	B, Y	
	Priestley (2005)	✓						[f]
	Watson et al. (1998)							
	Westerman and Nye (2007)				✓	DES*	RI & Y & B	
Case study	Ambrosino and Tanfani (2009)				✓	DES	Y & B	
	Baird (1999)							
	Horvat (2010)				✓			
	Kotachi (2016)				✓	DES	TI & Y & B	
	Perkovic et al. (2013)			✓				
	Wibowo et al. (2015)				✓	ABS	Unknown	
Method	Guo et al. (2015)				✓	DES	TI & Y & B	
	Saanen (2011)				✓	N/A	Discussion	
	Sun et al. (2013)		✓		✓	ABS	Y & B	
	Twrdy and Beskovnik (2008)	✓			✓	N/A	Discussion	

[a]A phasing study to ensure continuous operation during the construction period
[b]Workshops with people living close-by about a park that serves as a buffer from noise
[c]Comparison with similar container terminals, detailed assessment
[d]Decision Support Matrix to create a single score from several objective and subjective ratings
[e]Rough estimates for future performance are the foundation for uncertain plans
[f]Several studies regarding effects of the planned container terminal on its environment
*Due to a lack of direct information this item has been guessed.

Logistics simulation is a tool to examine future operation and to detect bottlenecks. This provides means to weigh different options before making decisions. During expansion projects, some location-specific requirements can demand for additional examination. The used methods and tools are listed in a separate column with footnotes. By adding a publication in Table 1, it is solely stated whether the method has been explicitly mentioned in the text or not - no further claims about the project are made.

3.1 Industry: Project Reflections

The first category of literature are industrial contributions about real expansion projects. Here, the author(s) who had been involved in an expansion project reproduce the course of events, possibly in an anecdotal way. Such a report possibly holds information that could have hardly been obtained as an external (e.g. competitor, journalist, or scientist). A project reflection allows deep insights into the difficulties of expansion projects. The most commonly named method is logistics simulation, followed by workshops/discussions. One study uses a ship handling simulator to assess the consequences of larger vessels for the berthing area of a container terminal. While most of the publications contained a layout, the way the layout has been obtained (which tool or which tool chain) has been neglected. Throughout the project reflections, various concerns and obstacles a project can face have been addressed. The expansion plans are a product of a larger team. During the development historic data is analyzed, the current (operational) situation is assessed and several design alternatives are evaluated according to the anticipated future operation of the container terminal. The expertise of the operation staff and use of simulation paired with prudent and cautious planning contribute to a successful implementation of an expansion plan. As a quantitative method to predict future operation performance, only logistics simulation has been reported. All except one of the project reflections are about seaport container terminals, therefore insights about inland terminals could hardly be gained.

3.2 Case Study: Specific Scientific Examples

A case study refers to a specific container terminal expansion. In that scope, the authors discuss the consequences of choices or how a depicted method can support the decision-making process in that specific case. Here, it is not obvious from the publication whether and how the research results have been incorporated into the expansion project. Studies that focus on how to optimize a single subsystem of a container terminal according to one specific metric are excluded. In three cases logistics simulation is used to discuss expansion project related topics. One publication uses a ship handling simulator and one discusses the historical development of a port, including several past expansions. Neither workshops or discussions nor the terminal layout process is covered. Compared with project reflections, just a few case studies are published. This might be due to less cooperation between universities and container terminal operators. Operational data is seen as highly valuable, especially in the hands of competitors. This leads to a cautious behavior when it comes to sharing such data with third parties.

3.3 Method: General Discussions

A method paper discusses a specific method, a framework, or introduces a new tool. This might be inspired by some real-world problem and it can be applied to one as a proof-of-concept. All method papers use simulation. One discusses the importance of workshops and discussions to gain valuable insights that can be incorporated into a simulation model. Another one links simulation and layout design by a geographic information system. This makes it easier to create a simulation models that fits to a terminal layout and suits to the spatial characteristics. No reference is made to a ship handling simulator. Logistics simulation prevails as the quantitative method to describe the dynamic processes at a container terminal. None of the publications have employed mathematical optimization such as integer programming models - even though those approaches are frequently used at container terminals in other contexts (see inter alia Steenken et al. 2004; Stahlbock and Voß 2007; Gharehgozli et al. 2014; Gharehgozli et al. 2016; Expósito-Izquierdo et al. 2019).

4 Conclusions and Future Research Directions

When it comes to estimating the performance of a container terminal after expansion, both industry and academia are in favor of logistics simulation. Both in theory and in practice, a simulation model serves as a valuable project artifact. First, it is used to estimate the consequences of different decisions. Second, during the process of modelling many real-world processes need to be thoroughly understood by all while creating a shared simulation model. Therefore, the process of model creation offers a common ground for discussion. In academia, several ideas exist in how simulation and other tools can be combined. On the one hand, a link of a simulation model with optimization seems desirable. On the other hand, an integration with visual planning tools make it easier to keep the construction plan and the simulation model aligned.

Potentially, valuable literature has been omitted. There is no guarantee that all synonyms which are currently in use in literature have been covered. The literature selection process was quite rigorous because of the strict working definition of expansion and the focus on a single container terminal. Furthermore, several publications picked up the topic of expansion to state what the authors tried to avoid. Instead, they voted for optimizing operational processes (e.g. Boer and Saanen 2008). Other authors noted that non-adjacent areas need to be included into the transportation concept because terminal expansion was impossible (e.g. Bogusz and Artur 2016). Since these did not answer the question of our paper, such publications have been excluded.

Especially the examined industrial contributions suffer from a publication bias. Only if an expansion project is supposed to be of sufficient interest for the community, project members might feel the urge to share their experiences. This means that the presented data might overestimate the usage of sophisticated methods in practice.

The presented literature has shown that many factors affect expansion projects. This requires a lot of flexibility throughout the planning and construction period. Since logistics simulation has proved to be an important decision-support tool, a tight coupling of simulation with other (software) tools will increase the efficiency and quality of the planning process. The conceptual publications regarding how logistics simulation can be coupled with other planning activities are all rather recent. Here, further methodological research and more case studies will shed new lights on when and how these approaches can create the largest benefit in industry for expansion planning.

Appendix: Reviewed Literature

1. Ambrosino, D & Tanfani, E 2009, 'A Discrete Event Simulation Model For The Analysis Of Critical Factors In The Expansion Plan Of A Marine Container Terminal'. *Proceedings 23rd European Conference on Modelling and Simulation,* eds J Otamendi, A Bargiela, JL Montes & LM Doncel Pedrera, ECMS, pp. 288–294.
2. Armour, WM, England, G & Bonifacio, N 1998, 'Up and Running: Final Design and Startup of the Terminal 5 Expansion at the Port of Seattle'. *Ports '98. Conference proceedings,* ed MA Kraman, American Society of Civil Engineers, Reston, Va., pp. 182–191.
3. Baird, A 1999, 'Analysis of private seaport development: the port of Felixstowe', Transport Policy, vol. 6, no. 2, pp. 109–122.
4. Bardi, J & Ingram, D 2010, 'Manzanillo Container Terminal Redevelopment: Maximizing Throughput in a Limited Space'. *Ports 2010,* eds T Ward & BI Ostbo, American Society of Civil Engineers, Reston, VA, pp. 1173–1182.
5. Bichich, S, Davidson, F & Bennett, R 2010, 'Blair-Hylebos Peninsula Terminal Redevelopment: Road/Rail/Infrastructure Improvements'. *Ports 2010,* eds T Ward & BI Ostbo, American Society of Civil Engineers, Reston, VA, pp. 1108–1117.
6. Brown, C, Aryan-Zahlan, D & Hamwey, S 2013, 'The Port/Community Edge: A Successful Case Study'. *Ports 2013. Success through diversification,* eds BI Ostbo & D Oates, Amer Society of Civil Engineers, Reston, VA, pp. 1552–1561.
7. Butler, S & Denton-Brown, J 2007, 'Master Planning for a New Seaport in Doha, Qatar'. *Ports 2007. 30 years of sharing ideas, 1977–2007: March 25-28, 2007, San Diego, California,* ed W Watson, ASCE, American Society of Civil Engineers, Reston, VA, pp. 1–11.
8. Di Meglio, LJ & Sisson, M 2013, 'Planning for the TraPac Automated Container Terminal'. Ports 2013. Success through diversification, eds BI Ostbo & D Oates, Amer Society of Civil Engineers, Reston, VA, pp. 1882–1890.
9. Dickson, C 2012, 'Simulate, update, repeat : for the Port of Long Beach, modeling has been a key part of successful expansion', *Marine Technology and SNAME News*, JULY, pp. 36–41.
10. Fant, AL & McDowell, JG 2016, 'Port of New Orleans: Mississippi River Intermodal Terminal'. Ports 2016. Port Planning and Develop-ment, eds D Oates, E Burkhart & J Grob, American Society of Civil Engineers, Reston, pp. 323–332.
11. Guo, Z, Yu, X, Tang, G & Wang, W 2015, 'A simulation model for determining throughput capacity of container terminals'. The 17th International Conference on Harbor, Maritime and Multimodal Logistics Modelling and Simulation. HMS 2015; Bergeggi, Italy, September 21–23, 2015, ed AG Bruzzone, DIME Università di Genova, pp. 23–27.
12. Horvat, U 2010, 'Possibility of Increasing Container Traffic in the Port of Koper Due to Introducing the Sea Motorway', PROMET - Traffic&Transportation, vol. 22, no. 5, pp. 333–339.
13. Johnson, D 2007, 'Re-setting the Productivity Bar: Conceptual Planning of Jebel Ali New Container Terminal, Dubai'. *Ports 2007. 30 years of sharing ideas, 1977–2007: March 25-28, 2007, San Diego, California,* ed W Watson, ASCE, American Society of Civil Engineers, Reston, VA, pp. 1–8.

14. Jones, Bryan; Friedman, Jerry; Hargens, Andrew; McWeeney, Kevin (2016): Conley Terminal Freight Corridor and Buffer Open Space. In: *Ports 2016: Port Planning and Development*, S. 932–941.
15. Kotachi, Mariam (2016): A Modeling and Simulation Platform for Evaluating Optimization Methods in Container Terminals. In: T. M. Roeder, P. I. Frazier, R. Szechtman und E. Zhou (Hg.): Proceedings of the 2016 Winter Simulation Conference. Simulating complex service systems. Piscataway, NJ: IEEE, S. 3658–3659.
16. McNeal, P, Headland, J, Ellis, W, Genn, A & Dromsky-Reed, J 2001, 'New York/New Jersey Harbor Navigation Project: Marine Terminal Planning Aspects'. Ports '01, ed TJ Collins, American Society of Civil Engineers, Reston, VA, pp. 1–10.
17. Nye, L. W.; Johnson, R. K.; McCollough, T. J.; Davidson, F.; Erickson, B. P. (2004): Terminal transformation. In: Civil Engineering 74 (10), S. 52–57.
18. Padron, DV, Itriago, J & Al Abbar, A 2007, 'Master Plan for Expansion of Jebel Ali Port'. *Ports 2007. 30 years of sharing ideas, 1977–2007: March 25-28, 2007, San Diego, California,* ed W Watson, ASCE, American Society of Civil Engineers, Reston, VA, pp. 1–10.
19. Perkovic, M, Twrdy, E, Batista, M & Gucma, L 2013, 'Container transport capacity at the port of Koper, including a brief description of studies necessary prior to expansion' in *Marine navigation and safety of sea transportation. Maritime transport & shipping,* eds A Weintrit & T Neumann, CRC Press Taylor & Francis Group, Boca Raton, pp. 207–213.
20. Priestley, S 2005, 'Design aspects of the Fergusson Container Terminal expansion, Auckland, New Zealand'. 17th Australasian Coastal and Ocean Engineering Conference 2005 and the 10th Australasian Port and Harbour Conference 2005 (COASTS and PORTS 2005), ed M Townsend, Curran, Red Hook, NY, pp. 101–106.
21. Saanen, YA 2011, 'Modeling Techniques in Planning of Terminals: The Quantitative Approach' in *Handbook of Terminal Planning,* ed JW Böse, Springer New York, New York, NY, pp. 83–102.
22. Sun, Z, Tan, KC, Lee, LH & Chew, EP 2013, 'Design and evaluation of mega container terminal configurations: An integrated simulation framework', SIMULATION, vol. 89, no. 6, pp. 684–692.
23. Twrdy, E & Beskovnik, B 2008, 'Planning and Decision-Making to Increase Productivity on a Maritime Container Terminal', PROMET - Traffic&Transportation, vol. 20, no. 5, pp. 335–341.
24. Watson, W, Steinberg, A, Leue, M & Davis, R 1998, 'Development of the Proposed Pier T Container Terminal at the Port of Long Beach, California'. Ports '98. Conference proceedings, ed MA Kraman, American Society of Civil Engineers, Reston, Va., pp. 108–117.
25. Westerman, H & Nye, L 2007, 'Planning the Prince Rupert Container Terminal'. Ports 2007. 30 years of sharing ideas, 1977–2007: March 25-28, 2007, San Diego, California, ed W Watson, ASCE, American Society of Civil Engineers, Reston, VA, pp. 1–10.
26. Wibowo, RA, Hidayatno, A, Komarudin, K & Moeis, AO 2015, 'Simulating Port Expansion Plans using Agent based Modelling', International Journal of Technology, vol. 6, no. 5, p. 864.

References

Boer, C.A., Saanen, Y.: Controls: emulation to improve the performance of container terminals. In: Mason, S.J. (ed.) 2008 Winter Simulation Conference, pp. 2639–2647. IEEE, Piscataway (2008)

Bogusz, W., Artur, K.: Conditions for developing a port city transport infrastructure illustrated with the example of szczecin agglomeration. Transp. Res. Proc. **16**, 566–575 (2016)

Clarivate Analytics: Web of Science Group appoints Anand Desai as Research Office Policy and Assessment Advisor for the Institute for Scientific Information (2019). https://clarivate.com/news/web-of-science-group-appoints-anand-desai-as-research-office-policy-and-assessment-advisor-for-the-institute-for-scientific-information/. Accessed 18 Aug 2019

Elsevier: The largest database of peer-reviewed literature. About Scopus (2019). https://www.elsevier.com/solutions/scopus. Accessed 18 Aug 2019

Expósito-Izquierdo, C., Lalla-Ruiz, E., de Armas, J., Melián-Batista, B., Moreno-Vega, J.M.: Maritime container terminal problems' in handbook of heuristics. In: Rafael, M., Panos, P., Resende, M.G.C., Springer International Publishing; Imprint, pp. 1–27. Springer, Cham (2019)

Gharehgozli, A.H., Roy, D., DeKoster, R.: Sea container terminals: new technologies, OR models, and emerging research areas. SSRN Electron. J. 1–48 (2014). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2469175, https://repub.eur.nl/pub/51656

Gharehgozli, A.H., Roy, D., DeKoster, R.: Sea container terminals: new technologies and OR models. Marit. Econ. Logistics **18**(2), 103–140 (2016)

Grant, M.J., Booth, A.: A typology of reviews: an analysis of 14 review types and associated methodologies. Health Inf. Libr. J. **26**(2), 91–108 (2009)

ISO: Series 1 freight containers – classification, dimensions and ratings, Geneva, Switzerland, vol. 55.180.10, ISO 668 (2013)

Rozic, T., Rogic, K., Bajor, I.: Research trends of inland terminals: a literature review. PROMET – Traffic Transp. **28**(5), 539–548 (2016)

Saeed Nooramin, A., Reza Ahouei, V., Sayareh, J.: A six sigma framework for marine container terminals. Int. J. Lean Six Sigma **2**(3), 241–253 (2011)

Stahlbock, R., Voß, S.: Operations research at container terminals: a literature update. OR Spectr. **30**(1), 1–52 (2007)

Steenken, D., Voß, S., Stahlbock, R.: Container terminal operation and operations research - a classification and literature review. OR Spectr. **26**(1), 3–49 (2004)

The Port of Los Angeles: Fenix Marine Container Terminal (2019). https://www.portoflosangeles.org/business/terminals/container/fenix-marine-services

TriCon Container-Terminal Nürnberg GmbH: Alles im Flow (2019). https://www.tricon-terminal.de/ueber-uns/tricon.html. Accessed 18 Aug 2019

United Nations Conference on Trade and Development: Review of Maritime Transport 2018, United Nations, [S.l.] (2019)

Witte, P., Wiegmans, B., Ng, A.K.Y.: A critical review on the evolution and development of inland port research. J. Transp. Geograph. **74**, 53–61 (2019)