ISSN 0554-6397
Pregledni članak
(*Review article*)

Peter Čerin
E-mail: peter.cerin@gmail.com
ACTUAL I.T. d.d., Ferrarska ul. 14, 6000 Koper, Slovenia
Bojan Beškovnik
E-mail: beskovnik@fpp.uni-lj.si
UL FPP, Pot pomorščakov 4, 6320 Portorož, Slovenia

Impact of Container Vessels Capacity 15.000 TEU and More on Existing Container Terminals

Abstract

The study analyses the impact of modern container vessels with capacity of 15.000 TEU[1] and more on existing container terminals. Necessary adjustments of terminals are discussed through the aspect of port infrastructure, superstructure and connection with hinterland. The emphasis is on defining the necessary adjustments to enable the berthing of vessels with capacity 15,000 TEU or more. The research highlights the key elements of the container terminal's enhancements in the Port of Koper, which already receives vessels with a capacity of 15,000 TEU, but encounters restrictions on the acceptance of even larger vessels and larger quantities of containers. The research highlights technical and technological adjustments also through the aspect of intervention and the impact of updates on the environment, the necessary financial inputs and the time component of implementation. The article presents findings that are important for further development of container services and terminals in the North Adriatic area.

Keywords: container terminal, sea ports, ultra large container vessels, infrastructure, superstructure

1. Introduction

Container throughput is in constant growth, although it has not been increasing as drastically as it has two and more years ago. In the first 4 months of year 2019 average growth of throughput was 2.6%, whilst two years ago it was astounding 7% [1]. The growth of container throughput is motivating vessel owners to use even larger vessels, which should reduce the overall transport costs per TEU. Container vessels of different generations differ in size and capacity, so a well thought approach of receiving and operations of each vessel is required [2]. The introduction of container vessels of

1 TEU - twenty-foot equivalent unit

15,000 TEU and more enables the optimization of voyage numbers, but also imposes the technological pressure on existing container terminals, which are expected to have the appropriate infrastructure and superstructure to enable such vessels berthing and ensure high productivity. The primary objective is achievement of shortest possible stopover of container vessels in ports, whereby terminal operators have to devise models of effective management [3].

Modernisation of terminal infrastructure and superstructure for accommodation of ever larger vessels has been thoroughly researched and this researches already define different aspects of strategical, tactical and operational adjustments needed. Jong Sil (2017) [4] highlights the pros and cons of large container vessels and their impact on port infrastructure and superstructure. Merk, Busquet, and Aronietis (2015) [5] state that when receiving container vessels of 15,000 TEU and more, ports encounter obstacles such as depth adequacy at navigable channels and berths and their maintenance; adequate barrier systems at river ports; the appropriate height of the bridges and the appropriate length and load capacity of the operational shore. Qiang, Jinxian, and Suyi (2016) [6] identify the impact of large container vessels on operations at the container terminal with a focus on container terminal planning and development, which involves planning the necessary infrastructure and superstructures. Imai, Nishimura, and Papadimitriou (2013) [7] analyse the design of berthing subsystem infrastructure to achieve higher productivity, highlighting the benefits of channel berthing, but this technology requires a special adaptation of the port infrastructure and higher investment compared to the conventional way of working on the berthing subsystem. In addition to the technological adaptation of the berthing subsystem, technological adaptations are also required on the storage area and handover subsystems for rail and road vehicles [8].

The aim of the research is to highlight key infrastructure and superstructure adjustments to the container terminal needed to enable the terminal to accommodate container vessels of over 15,000 TEU. Study presents the necessary modernization guidelines for the Port of Koper to accept vessels with a capacity of over 15,000 TEU. Kocjan (2017) [9] states, that Luka Koper d.d. has already completed important projects to accept container vessels with a capacity of 15,000, but further adjustments will be required as annual container traffic is expected to reach 2 million TEU by the year 2030.

2. Impact of container vessels of 15,000 TEU and more on the infrastructure and superstructure at existing terminals

Since the appearance of the first container vessel “Ideal X” in 1956 to the present day, the development of the container vessel fleet has experienced six major turning points that have impacted the market. Each new generation represented an increase in the capacity of the vessel, which resulted in a reduction of cost per container unit (TEU). The improvement of vessels to be more efficient came from the market, as demand for container transport was on the rise, in parallel with the growth of the economy [10].

Container vessels experienced a real breakthrough at the beginning of the 21st century, when Maersk introduced the E-Class of container vessels with a capacity of between 11,000 and 14,500 TEU. In 2013, Class E container vessels were upgraded and referred to as triple E. These vessels have a capacity of more than 18,000 TEU [11]. The dimensions of Class E and Triple E container vessels present significant challenge for ports, as container terminals need to upgrade infrastructure and superstructure whilst ensuring the optimization of technological processes.

2.1. Technical characteristics and positive impacts of container vessels of over 15,000 TEU

Container vessels with capacity of over 15,000 TEU differ in comparison with smaller vessels, especially in terms of carrying capacity, which increased by 118% and weight of the vessel, which increased by 85%. Other vessel features, such as engine power, hull length and width differ by less than 10% [2]. Another important feature is the draft of the vessel, which, despite more than double the vessel's capacity, increased by only 10%. A comparison of the key technical differences between Class S (1997) and Triple E (2013) vessels is shown in Table 1.

Table 1: Comparison of technical characteristics between Class S and triple-E container vessels [2]

	S-Class	Tripple-E-Class	Difference %
Build year	1997	2013	
Capacity	8.400 TEU	18.270 TEU	+118
Gross weight	105.000 t	194.000 t	+85
Power	55.681 kW	59.360 kW	+7
Speed	25 knots	23 knots	-8
Length	397 m	400 m	+1
Width	56 m	59 m	+1
Draft	14.5 m	16 m	+10

Container vessels of the new generation or vessels with capacity of over 15,000 TEU enable economies of scale, encourage vessel owners to organize in partnership organisations and produce less negative environmental impacts. Higher load capacities have the effect of reducing operating costs per TEU and reduce overall time of supply chains. It is difficult for an individual vessel owner to fill the entire vessel with their own containers therefore vessel owners are forming so called alliances. The alliance enables the combination of facilities and services on the same voyage, which results in space sharing and reduction of operating and port costs. Larger vessels also have a positive impact on reducing greenhouse gas emissions and the energy efficiency of the transport process [4].

2.2. Impact on container terminal infrastructure and superstructure

The infrastructure and superstructure of a container terminals are composed of elements on and through which technological processes are carried out, such as manipulations, transports, takeovers and dispatches, and the storage of full and empty containers. When designing the infrastructure capacity and superstructure of a container terminal, guidelines must be followed to prevent potential under or overloading pre-sizing the terminal. Consideration should be given to the annual container throughput, the estimated number of vessels in arrival, the ratio of import and export containers, the size and frequency of arrival of container vessels, the expected container detention time, the purpose and direction of container cargo flow, the method of container land transport, etc. [12][13].

Container terminals are considered to be dynamic, most commonly consisting of three subsystems, berth subsystem, storage area subsystem and the handover subsystem [14]. The effects of container vessels carrying more than 15,000 TEU reflect each of the subsystem differently. In terms of adapting infrastructure and superstructure, the greatest emphasis is on building an appropriate berth subsystem, since this subsystem is in direct contact with container vessels. The other two subsystems feel the pressure of the larger container vessels only indirectly, with greater demands for static and dynamic infrastructure capacity. Properly sized infrastructure and superstructure equipment is reflected as ability to quickly process both subsystems and achieve higher productivity. At the same time, the terminal operator has to have the overview of funds invested in order to ensure cost-effectiveness of the entire system and the transport chain [15].

2.2.1. Berthing subsystem

The berthing subsystem represents the intersection between the sea and land of the container terminal. On the infrastructure and superstructure of the berthing subsystem, all processes related to the container vessel are carried out, such as receipt, berthing, unloading and loading operations. Adapting the berthing subsystem to ever larger vessels poses great challenge for ports. The port must provide adequate depth at entrance channel of 18m or more and 14.5m or more at a berthing side. To deepen and maintain required depth often requires large financial investments, especially in harbour with high level of sediment. Older container terminals were not planned for receiving of ULCV (Ultra large Container Vessels), so they face the challenge of ensuring the proper length and capacity of the operational shore. If the existing berths are not extended, the larger number of simultaneous berthing of smaller feeder vessels will be disabled.

Container vessel larger than 15,000 TEU requires larger and taller container cranes, which put more strain on the berth. The container crane, with a reach up to 23 container rows on vessel, strains the berth surface with 2,721 kN[2] per m² of berthing surface. On top of this formula, we have to add the strain of full containers, which burden the berth with a force of 75 kN per m2. The recommended load-carrying capacity of the berth must therefore withstand loads up to 100 kN per m2 of operating surface [4].

Terminals designed to accommodate smaller container vessels are most often equipped with container cranes with a capacity of up to 20 container rows per vessel, which is not sufficient to accommodate a fully loaded vessel with more than 15,000 TEU. Replacement of smaller cranes with larger ones costs around 10 million EUR per unit. The process of unloading and loading of container vessel with a capacity of over 15,000 TEU is about 20% longer than that of a smaller vessel. To operate with smaller and larges vessels with same service time and higher productivity, terminal has to invest in container cranes with better manipulation technologies.

2.2.2. Storage area subsystem

The storage area subsystem is intended for temporary storage of containers to transport them to recipient (either with vessel, train or truck). The storage area is organized according to space availability and prevailing container flows. The warehouse area is divided into parts intended for export (containers to be loaded on vessel) and intended for import (containers to be transported by land). A container block in storage area is made up of container rows, as well as the number of containers that determine the length of the container block (bays) and the height of the container block (tiers). The organization of container blocks depends on the equipment used to perform the container manipulations. At newer construction terminals, block placement is often perpendicular to the berth, if space permits. The decision to place blocks perpendicular to the berth depends on the prevailing flow of goods [16].

Frequent arrivals and departures of container vessels of over 15,000 TEU increase the need for storage area and the quickest possible manipulation at that area. The container terminal has two possible solutions to manage the saturation of the storage area. First possible solution is upgrade of superstructure of the storage area with technology allowing increase of the container density. Storage area density can be increased by stacking containers into height, which in turn requires the introduction of bridge cranes (Rubber Tired Gantry Cranes - RTG and Rail Mounted Gantry Cranes - RMG), which allow stacking of containers up to fifth height and organization of storage area with minimal space loss [17]. Another way of managing storage capacity is through a commercial pricing policy that shortens the free time of container storage or increases the cost of storage.

2 kN - Kilo Newton

2.2.3. Handover subsystem

The handover subsystem is an infrastructure part of a container terminal where containers are picked up and transported via land routes. The handover subsystem is divided into two areas in terms of infrastructure, namely the truck handover point and the railway handover point. Handover point is also connected with external traffic routes which are not part of the port system and on which the port most often does not have a direct development impact.

The efficient handover infrastructure ensures the quality of the container receiving and dispatch process, especially at times before and after the arrival of container vessel. The handover point for road vehicles must have sufficient entry and exit lanes, which must cross as few times as possible. On the railway side, a handover site with an adequate number of tracks must be provided to accommodate multiple train compositions at the same time. From a technological point of view, it is very important that the entrances and exits of trucks and other means of transport are planned and coordinated as much as possible [18].

The subsystem utilizes advanced technologies that enable efficient identification of containers and means of transport. At railway and road receiving points, portals are equipped with OCR[3] technology that enables the vehicle to be identified without stopping it. Port also uses electronical truck arrival announcement through system VBS[4], which is an online platform that allows management of truck entrances and preparation of containers for smooth operations.

3. Challenges of the Container Terminal in the Port of Koper

The Port of Koper is a Slovenian port located in the northern part of the Adriatic Sea. The port is strategical point for the hinterland markets of Austria, Slovakia, Hungary, Poland, South Germany, Croatia, Bosnia and Herzegovina, Serbia, Romania, Bulgaria and Slovenia [9]. The port consists of 12 terminals (Container terminal, Car and RO-RO terminal, General cargo terminal, Reefer terminal, Timber terminal, Dry bulk terminal, Silo terminal, Alumina terminal, Iron ore and coal terminal, Liquid cargoes terminal, Livestock terminal, Cruise terminal) and is completely under the management of Luka Koper, d.d. through a concession contract issued by the Republic of Slovenia [19]. In 2018 the overall throughput volume was 24,048,618.00 tonnes and it is steadily increasing. The increasing trend is particularly noticeable for container throughput. Container throughput in 2018 was 988,499 TEU, making it leading container terminal in North Adriatic [20].

3 OCR - Optical Character Recognition

4 VBS - Vehicle Booking System

3.1. Container terminal

The container terminal has an operational shoreline of 596 m in length, which can accommodate vessels up to 14.5m in draft. The static storage capacity is up to 30,000 TEU. The infrastructure of the handover area for the land arrival of containers is equipped with handling tracks with a total length of 4,600 m and allows simultaneous reception and manipulation of five parallel train compositions. The train tracks are 700 m long. Handling is performed by using RMG work technology. The berthing subsystem utilizes Panamax, Post-Panamax and super post-Panamax container cranes. The port of Koper has the highest productivity by container crane on the eastern Adriatic coast. Productivity has almost doubled in the last ten years [21]. Container handling is performed with bridge cranes, forklifts and RMG cranes. Horizontal transport connecting the three subsystems is carried out with 61 container tugs [22].

Vessels up to 400m in length are accepted at berth, but only one such vessel and one smaller feeder vessel can be operated at a time. Given the current frequency of arrivals of container vessels and the establishment of two direct container services from the Far East, operations have to be carefully planned in advance using confirmations of operational slots. It is impossible to dock two vessels of 12,000 TEU and 15,000 TEU capacity at the same time. At other times, smaller feeder vessels of up to 5,000 TEU capacity are served at the terminal.

The storage area subsystem measures 180,000 m2 at the marine part of the terminal and can store up to 30,000 TEU. Due to limited area and inability to expand the storage area, all operations are performed with RTG bridge cranes. These technologies enables increase of density at storage area, with containers stacked up to the fifth row in height.

Reception of containers arriving at or being transported by land are handled at the handover subsystem. The container terminal has two receiving points, a railway, which is located directly next to the storage area and is equipped with RMG technology and a truck service point for road vehicles. The container terminal established a regular rail services with hinterland markets, delivering to the port 80 to 90 block trains per week. To ensure the overall efficiency, technology of handover subsystem is of key importance.

3.2. Expectations of intermodal transport participants

Port of Koper is part of transport route from Far East to the Mediterranean and Adriatic Sea. On this route, vessel owners are mainly using vessels of 8.000 TEU capacity since 2014. In year 2014 CMA CGM (at the time they were part of alliance called ‘’3P Network’’ with Maersk and MSC) started using vessel CMA CGM Cendrillon with capacity of 8.500 TEU and length of 334 meters, but in year 2019 Maersk started using even larger vessel, Maersk Hamburg with capacity of 15.000 TEU.

Due to increase of volume, we can also notice the increase of rail providers connecting Koper with hinterland terminals (Dunajska Streda, Budapest, Krems etc.). Noticeable is also increase of volume, traditionally transported via northern ports, for markets such as Southern Germany, Poland, even Netherland, Belgium and UK.

The port of Koper follows the expectations of all users, especially the shipping lines. In the last five years, the terminal has deepened the seabed of the entrance channel and of berthing area. They purchased super post-Panamax cranes to provide higher productivity of the berthing subsystem. On the subsystem of the handover point for the railway, the construction of additional manipulative tracks for the reception of train compositions and the introduction of RMG technology have increased the productivity of the technological process of servicing railway wagons. The equipment of the storage area subsystem has been upgraded with additional E-RTG portal elevators and additional storage areas in the southern part of the first pier.

3.3. Bottlenecks upon receiving vessels of 18,000 TEU capacity and more

The container throughput trend for the Port of Koper until 2030 indicates that it will continue to grow and eventually reach 2 million TEU per year. The throughput of 2 million TEU will not be possible unless Port of Koper continues with investment plan for expansion of the port, which includes modernization of infrastructure and superstructure. There are two options for receiving container vessels of 18,000 TEU capacity: either adaptation of existing container terminal or construction of completely new container terminal at a new location. By modifying or extending the first pier, which is already underway since 2018, the container terminal will acquire the appropriate length of operational shore required for secure berthing of container vessels with capacity 18,000 TEU and more. In order to achieve the expected productivity of berthing subsystem, the length of operational shore at container terminal must ensure simultaneous reception and handling of at least two container vessels at the same time (mother vessel and smaller feeder).

To ensure safe entry of vessels, berthing area has to be further deepened to at least 16 – 17 meters. Superstructure of berthing subsystem has to be equipped with additional post-Panamax cranes in order to achieve shipping lines expected operational time in Koper port. (Table 2).

Table 2: Comparison of the existing situation and the required condition of the berth subsystem for container vessels 18,000 TEU and more [23].

	Existing status or properties of the container terminal in Koper	Reception requirements for a container vessel of capacity 18,000 TEU and more
Berth length	596 m, (696 m – after completing the extension on first pier)	Min. 450 m
Draft on berth	15,5 m	Min. 16 – 17 m
No. of berths	4	Min. 1 respectively 2 (still for the feeder vessel)
No. of super post-Panamax cranes (in 1st pool)	2	9 - 11 (optimally according to the TEU volume per vessel)
No. of post-Panamax and Panamax cranes	7	0 for vessels capacity 18,000 TEU; depending on the berthing area for feeder vessels.

Identified modification of the berthing subsystem ensures that the port can accept container vessels of 18,000 TEU capacity and more, whilst taking into consideration the correlation with other subsystems. Rail and road connections have an important role and must enable swift flow of containers out of the system. Increasing the capacity of container handling by rail should be treated with special attention, since current throughput of up to 100 trains per day does not support the continued growth of container throughput via Koper. The construction of the second track should increase the capacity of container train handling. Construction of a new truck terminal and direct connection of the port with the highway is also needed to ensure faster container handling and to minimize or eliminate congestions on existing routes.

There is also another option, the construction of a new container terminal. In accordance with National Spatial Plan for Koper port it should be located on third pier. The new container terminal would have a throughput capacity of 1 million TEU and operational coast length of 1,060 m. Construction of the terminal requires high financial input, which Port of Koper cannot provide on their own.

4. Financial and environmental aspects of container terminal modifications

The analysis of container terminal's modification needed to operate the vessels with capacity 18,000 TEU indicate different levels of performance impact. Each modification of individual subsystem is shown through financial, time and environmental point of view.

The modernization of the berthing subsystem has major impact on marine ecosystem, since all operations, such as extending the operational shore, deepening the seabed and ensuring the berthing strength, are carried out with direct operations in the sea. In addition to the impact on marine ecosystem, the impact of increased throughput and increased noise of manipulation on the environment must be taken into account. Container terminal is located near the central part of the city and increasing noise will adversely affect the quality of life in the city centre. Modernization of the berthing subsystem is financially demanding project, since it is necessary to construct the operational shore on previously placed pilots, fill up and consolidate it. Deepening of the shore will require underwater mining and removal of rubble. Container cranes are also important financial expense. A complete replacement of container cranes (the purchase of 7 super post-Panamax cranes) would cost about 70 to 90 million EUR. During the construction work on the berthing subsystem, we can expect accessibility issues and decrease of productivity which will impact financial aspects of whole container terminal. The complexity of interventions and provision of financial resources to modernize the berthing subsystem is assessed at a very high level, which in turn also affects the timeframe of necessary modifications (Figure 1).

The model in Figure 1 shows the impact estimates of the updates on each subsystem. Impact assessments are ranked on a scale of 0 - 4, where they represent:

- grade 0 - no effect, unpainted trapezoid;
- grade 1 - low impact, only the trapezoid is coloured green;
- grade 2 - medium influence, coloured second trapezoid yellow;
- grade 3 - high impact, third trapezoid is painted red.

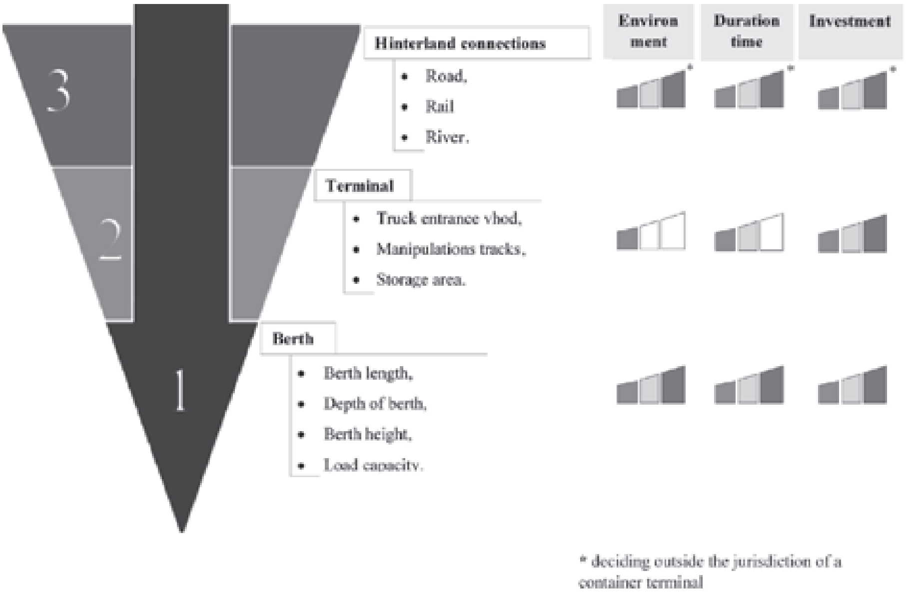

Figure 1: Ranking of environmental impacts, duration and investment in the infrastructure and supra-structural adaptation of the terminal to vessels of over 15,000 TEU [23].

Modifying the elements of land part of container terminal has little impact on the environment, since all the elements are within the port area. Environmental impact can be expressed in the form of additional environmental interventions near the port, material disposal and increased noise with increased workload. The foreseen works for the construction of new manipulation tracks, the entrance to the terminal and the increase of storage area are shorter than the construction of the extended berth. In addition, by constructing a berth in the hinterland, new storage areas for full containers are being acquired. From a financial point of view, these are very demanding projects that are financially demanding, as the increase of storage area requires new loading equipment (RMG, RTG), investment in OCR technology for detection of vehicles and containers at the gate-in, etc. is required. The terminal may operate at a slightly reduced capacity at the time of modification and may risk minor congestions, which will not be so pronounced due to short period of constrictions.

The port does not have a direct impact on modifications of connections with the hinterland, since these investments are mostly managed by state authorities or concessionaires. Upgrading the hinterland connections depends on the country's transport policies and development strategies. However, they should be highlighted in the port's development strategy, as they are a key element for the success of other identified port investments. Modernization of roads has a major environmental impact, as new roads can affect the life in animal habitats, quality of agricultural land and water protected areas. To construct new traffic routes we need substantial financial resources. To acquire such resources, the development strategy and political will must be present, which also need to be based on realistic expectations of hinterland markets. Upgrading transport routs is very time-consuming, especially due to many participants involved and need to consent to the modernization project. This are undoubtedly projects for many years at national level.

The study underlines that the highest priority level of terminal modification should be allocated at the berthing subsystem (level 1). This is followed by the land part of the terminal, where Port of Koper will have to update manipulation tracks, increase the storage area and construct additional entrances to the port or to the terminal. Even though updating the hinterland connections is an environmentally, financially and time-consuming project, from the perspective of a port or a terminal can be ranked at third place, because in most cases it is beyond the competence of the port management.

5. Conclusion

With the aim of reducing operating costs per unit transported and increasing its competitive advantage, shipping companies have begun to introduce large container vessels with capacity of 15,000 TEU. The appearance of large container vessels has had a major impact on existing ports, which are facing the need to adapt and modernize container terminal infrastructure and superstructure. The port must modify all three subsystems (berthing subsystem, storage area and handover area), with focus on berthing subsystem. At berthing subsystem, it is important to ensure adequate depth of the seafloor, the height and carrying capacity of the shore and the length of the operational shore. Providing adequate superstructure at the berthing location ensures that productivity and operational time of a large container vessel will be approximately the same as that of smaller container vessels currently operated at terminal.

The port of Koper has already completed certain upgrades of container terminal to accept container vessels of 15,000 TEU, but the study points out that the terminal does not have the necessary infrastructure and superstructure to accept 18,000 TEU vessels. Vessel owners will undoubtedly want to engage even larger vessels on the southern shipping route, especially if the trend of shifting freight flows for Central Europe to the northern Adriatic ports continues. The most demanding modifications will be made at the berthing, from all three impacted aspects (environmental, financial and temporal). Adjustments on the land side of the terminal will also be very financially challenging, but will have a slightly lower environmental and time impact. Also important will be the upgrades to the hinterland infrastructure, especially to the railway, where the state will have to provide around 1 billion EUR for construction of second track between Koper and Divača. Given the projected trends for Koper to reach 2 million TEU of throughput by 2030, certain investments in the infrastructure and superstructure of the terminal will undoubtedly be needed.

References

1. DUFFIN ERIN: *„Global growth in container vesselping from April 2017 to April 2019"*, Statista (2019).
2. TWRDY ELEN: *„Trendi v pomorstvu in njihov vpliv na razvoj pristanišč",* RS Ministrstvo za izobraževanje, zananost in šport (2017).
3. KOUROUNIOTI KOUROUNIOTI IOANNA, POLYDOROPOULOU AMALIA & TSIKLIDIS CHRISTOS: *„Development of Models Predicting Dwell Time of Import Containers in Port Container Terminals – An Artificial Neural Networks Application",* Transportation Research Procedia (2016).
4. BAIK, JONG SIL: *„The Study on Impacts of Mega Container vessels on Ports. Pan-Pacific",* Journal of Supply Chain Management (2017).
5. MERK, OLAF; BUSQUET, BENEDICTE & ARONIETIS RAIMONDS: *„The Impact of Mega-Vessels",* OECD (2015).
6. MENG, QIANG; WENG, JINXIAN & SUYI, L: *„Impact Analysis of Mega Vessels on Container Terminal Operations",* Transportation Research Procedia (2017).
7. IMAI, AKIO; NISHIMURA, ETSUKO & PAPADIMITRIOU, STRATOS: *„Marine container terminal configurations for efficient handling of mega-containervessels",* Transportation Research Part E: Logistics and Transportation Review (2013).
8. HOSSEIN GHAREHGOZLI, AMIR; ROY DEBJIT & DE KOSTER RENÉ: *„Sea container terminals: New technologies and OR models",* Maritime Economics & Logistics (2016).
9. KOCJAN, ALEŠ: *„Trgi Luke Koper",* Luka Koper, d.d. (2017).
10. KHOITRAN, NGUYEN & HAASIS, HANS-DIETRICH: *„An empirical study of fleet expansion and growth of vessel size in container liner vesselping",* International Journal of Production Economics (2015).
11. RODRIGUE, JEAN-PAUL; COMTOIS CALUDE & SLACK BRIAN: *„The Geography of Transport Systems",* 4th Edition. New York (2017).
12. GULER, NIL: *„Containerization and terminal area requirements",* Pomorski zbornik (2001).
13. KOZAN, ERHAN: *„Optimum Capacity for Intermodal Container Terminals",* Transportation Planning and Technology (2006).
14. MEISEL, FRANK: *„Seaside Operations Planning in Container Terminals",* Physica-Verlag, A Springer Company (2009).
15. SÁNCHEZ, RICARDO J.; HOFFMANN, JAN, MICCO; ALEJANDRO; PIZZOLITTO, GEORGINA V.; SGUT, MARTÍN & WILMSMEIER, GORDON: *„Port Efficiency and International Trade: Port Efficiency as a Determinant of Maritime Transport Costs",* Maritime Economics & Logistics, Springer (2003).
16. WIESE, JORG; SUHL, LEENA & KLIEWER, NATALIA: *„Planning Container Terminal Layouts Considering Equipment Types and Storage Block Design",* Handbook of Terminal Planning, Springer (2011).
17. PETERING, E.H. MATTHEW: *„Effect of block width and storage yard layout on marine container terminal performance",* Transportation Research Part E: Logistics and Transportation Review (2009).
18. XIAOJU, ZHANG; QINGCHENG, ZENG & WENHAO, CHEN: *„Optimization Model for Truck Appointment in Container Terminals",* Procedia - Social and Behavioral Sciences (2013).
19. RS MINISTRSTVO ZA PROMET: *„Koncesijska pogodba",* Republica Slovenija (2008).
20. PORT OF KOPER, D.D.: *„Statistika pretovora",* PORT OF KOPER (2019).
21. BEŠKOVNIK, BOJAN; TWRY, ELEN & BAUK, SANJA: *„Developing Higher Berth Productivity: Comparison of Eastern Adriatic Container Terminals"*, Promet - Traffic & Transportation (2019).
22. PORT OF KOPER, D.D.: *„Container terminal*", Port of Koper (2019).
23. ČERIN, PETER: *„Prilagoditev kontejnerskega terminala za sprejem kontejnerskih ladij 18.000 TEU in več",* Magistrsko delo, UL FPP (2019). Nikola Vladimir, Ivan Lončar, Ivica Ančić, Ivo Senjanović