NEW CONTAINER TERMINAL TECHNOLOGIES

Radović Miloš [a,*], Avramović Strahinja [a], Vukosavljević Petar [a]

[a] University of Belgrade, Faculty of Transport and Traffic Engineering, Serbia

Abstract: *In this paper, there are presented some of the technologies that are implemented in container terminals as response to globalization and new requirements in terminals. The innovations that are analyzed are implemented to meet requirements for increased productivity and efficiency in subsystems of container terminals. Conceptual systems presented in this paper are linear motor conveyance system (LMCS), automated guided vehicles (AGV), automated storage and retrieval systems (AS/RS), overhead grid rail system (GRAIL), speedport, superdock, flow-through gate, portnet and teustack.*

Keywords*: Container terminal, new technologies, automation*

1. INTRODUCTION

As a result of globalization, international trade has greatly increased and maritime transport obtained central role in the world trade. Consolidation of goods using containers, reduces number of operations with goods, improves safety of goods, reduces risks of damaging and loss of goods and allows faster transport of goods.

Since April 1956, when Malcolm McLean transported fifty-eight 35 foot containers, container transport is developing constantly. In last two decades, maritime container transport has a growth of 7% to 9% per year, while other types of maritime transport have a growth rate of 2% per year (Crainic & Kim, 2007). Economical effects of massive container transport by vessels, led to very fast increase of capacity and size of vessels, from feeder vessels, to big intercontinental vessels and in 2010. these vessels had capacity of 12.000 TEU, and currently there are vessels with capacity of 19.000 TEU. Parallel with development of container transport and container vessels, there was development of technologies and organizational concepts of container terminals worldwide.

Need for faster loading and unloading of vessels, as well as requests for faster turnover, are great problems for container terminals. In order to answer to new requests, container terminals developed new technologies and they are developing methods for continuous optimization and automatization of logistics processe. Usage of decision support systems and reaching of given targets, requires identification and tracking of key performance indicators (KPI) which can be classified as follow (Meersman et al., 2004): service oriented (they track level of service which is given to users of terminal and they are usually expressed as time of turnover of vessels and trucks; they include berth service time (e.g., vessels turnover time and vessels berthed on time) and time which vehicles spend in terminals) and productivity oriented (they track volume of traffic inside of terminals; they include growth of TEU per year, usage of crane (number of TEU

[*] mradovic9@hotmail.rs

which are serviced by crane, per year), crane-productivity (moves per crane, per hour) and land utilization (TEU stored per year per hectare)).

2. TECHNOLOGICAL INNOVATIONS IN CONTAINER TERMINAL SYSTEMS

In container terminals, there are three types of handling operations (Kim et al., 2012): vessel operations related to container vessels, hinterland operations which include operations with trucks, trains, management of empty containers, and operations related to warehousing or yard storage of containers. In order to achieve higher efficiency, terminals are seeking for innovations which they can implement to their subsystems for every type of handling operations. Shorter time spent in terminals by vessels can be achieved by using more cranes for loading and unloading operations from vessel to land and vice versa, by making longer quay side so a larger number of vessels can be at port at same time, by high level of synchronicity between transport and handling equipment, by having sufficient number of expert manpower, by fast and efficient processing of paperwork and by using automated systems for guidance and finding of free space where containers can be stored, etc.

Technological innovations have to be developed and used in terminals, so terminals can respond to increased number demands of clients with great efficiency and quality. Terminal must be understood and seen through its subsystems and regarding of that, decision about implementing new technologies can be made. The success of particular technology is based on meeting specified criteria (Kim et al., 2012). The first criterion is flexibility. Proposed technology should be applicable with as less modification as possible and easily adaptable to constant changes of situations and logistics environments in the terminal. One of the criteria is costs that, in addition to the cost of implementation, include operating costs. The potential of innovation should be the less dangerous to the environment, which leads to criterion for lower energy consumption and lower emissions of harmful gases, which is related to transport system at first place (Geerlings & van Duin, 2011; Kim et al., 2012). The last criterion is that particular innovation should return from faulty into the working state, in short period of time and that particular innovation is simple for maintenance.

Technologies which are related to transport subsystems have daily contribution on development of terminal and are based on lowering retention time when handing over containers in terminal, optimizing traveled distance, and lowering power consumption and environment pollution. One of the latest innovations is usage of „multilifting“ mode, which is term related to simultaneous handing of multiple units. Technologies that improve transportation system are automated guided vehicles (AGV) and linear motor conveyance system (LMCS). As storage space requirement has increased, stock size has increased significantly. Before globalization took hold, in early days of container terminals, on-chassis systems and forklifts were the major handling systems. The height of stacks of containers in terminals was from one to three tiers. Then, straddle carriers became popular for usage in container terminals. As result of straddle carriers usage, the height of stacks was from two to three tiers. Today, yard cranes are the most popular handling equipment in container terminals and they allow stack height of four to six tiers. One thing that is also innovation is placement of multiple cranes per particular storage area (Kim et al., 2012; Vis & Carlo, 2010.), which is already implemented in container terminal in Hamburg, Germany, which is currently under construction. This terminal will have three cranes per storage area. Trend of increasing the number of cranes per storage area is caused by increased density of storage area, so a larger number of cranes is necessary in order to achieve fast flow of containers through the terminal. However, there is problem with this trend which has to be solved and that problem is primarily related to compatibility and synchronization of large number of cranes, which represents a great task for future. Innovations that are used in terminals and have impact on improving storage systems are automated storage and retrieval systems (AS/RS) and overhead grid rail system (GRAIL) which also improves receiving and shipping operations, as well as Superdock. Innovations in domain of receiving and shipping operations are based on using new information technologies, at first place. Identification of vehicles is completed by computers and observing the improvements in this area, innovations are yet to come. Innovations which have successful use in terminals are flow-through gate and portnet.

3. TECHNOLOGIES OF CONTAINER TERMINALS

This section provides concepts of new technologies in container terminals. Some of these systems are verified by construction and by testing of the prototypes.

3.1 Linear Motor Conveyance System (LMCS)

Linear Motor Conveyance System represents an innovative solution for the containers inside the terminal. The unique characteristics of this system transfers are supported linear motor that moves on rails fixed network path. The link between the cranes witch working on the vessel and gantry cranes that carry operations at container storage area is carried out "shuttle" vehicles which transport containers to and from storage area using linear motors installed in infrastructure. Positioning "shuttle" vehicle below the cranes is done by management information systems (Zečević & Tadić, 2015). Benefits of LMS system in relation to the automatic guided vehicles are lower maintenance costs, less investment, easy integration into the existing infrastructure and the ability to work in all weather conditions. Other advantages of this system are high positioning accuracy, high reliability, and robustness of the equipment. Also, this system is environmentally friendly because instead of diesel fuel and oil, is using electricity (Kim et al., 2012). One of the drawbacks of this system is large initial investment costs. Due to the limited number of transport routes for the transfer vehicle routing flexibility is significantly lower compared to AGV system (Ioannou et al., 2000).

3.2 Automated storage and retrieval systems (AR/RS)

AS/RS are computer controlled systems with extreme accuracy operating in very narrow aisles. The two major components of this system are the machines for storage and retrieval and storage racks. At the entrance to each aisle there is pick up/delivery station. The station is usually located at one end on the lowest level of each aisle. AS/RS increases capacity of warehouses, reduces the workforce, provides high throughput and allows random access to the target container without any manipulation operation. This system does not require a large area, and expanding of the storage space can be achieved by increasing the number of floors. This is very useful when space is limited and expensive. The disadvantages of this system are the high costs of construction, as well as that the malfunction of one machine leads to stopping of all operations in the particular aisle (Kim et al., 2012).

3.3 Overhead Grid Rail (GRAIL)

GRAIL provides a high productivity, high density of container storage and efficient transport operations. This system consists of electrical "shuttle" vehicles used for storage operations on the terminal storage area, as well as transport from quayside to yard area. Shuttle vehicles are moving on rails which are located above yard, at particular height. The switching mechanisms at the end of each rail allow the shuttles to move from one rail to the next. In addition, it is possible for shuttles to move containers directly between the quay and the rail station by extending the rail from the quayside to the rail station.

The connection points between quay cranes and shuttles are the elevated automated platforms below the quay cranes, where the quay cranes operation and shuttle operation are decoupled, that is, quay cranes pick up or place containers without caring about shuttle arrivals, and the shuttles put down or pick up containers without waiting for the arrival of quay cranes. This decupling reduces the waiting time for equipment. Driving area for the shuttles is moved to the overhead space. This makes it possible to save the space wasted on aisles and avoid the interference of container transporters with container stacks on the ground and with the traffic of manually operated trucks. However, a more complicated control system should be provided and a high investment cost would be required (Kim et al., 2012).

3.4 Speedport

The concept of "speedport" is an extension rail of the Grail system via ship. The concept of the handling system of speedport terminal is based on the idea that resembles a spider web. Network and this system is a series of moving cross-console covering the entire system at the container terminal. Under this network, moving large number of independent transport-handling unit called spiders that affect containers with special pliers (Zečević, 2006). A large number of spiders can work together on the same boat or the same distance from the plateau, which contributes to higher throughput and the better functioning of the system.

This system enables handling of approximately 470 TEU per hour for a vessel with capacity of 6,600 TEU. Total time of loading or unloading of ships of the same capacity with all operations, in the speedport terminal is about 14 hours. In conventional terminals with loading and unloading on both sides, that time is approximately 22 hours, with a one sided operations, that time is approximately 44 hours. Speedport can handle between 2.5 and 3 million TEU per year, which is significantly higher than in conventional container terminals (terminals in the conventional technology with the double-sided loading about 2 million, and with the technology of a one-sided loading, about 1.2 million TEU) (Zečević, 2006). On the downside, the cost of building facilities and buying spiders are very high. There are several technical problems such as the lack of flexibility when it comes to different types of ships. Spiders need to carry enough cable that can reach deep into the cells when it comes to large container ships (Kim et al., 2012).

3.5 Superdock

The concept of "Superdock" originated as a need for economically and environmentally advanced container terminals in the ports of Los Angeles and Long Beach (Alba & Risemberg, 2011). This system includes the drive conveyor rail, universal storage systems, harbors of great length and several cranes working on the vessel handling. The rails are designed for trains, which allow them to directly access the storage site. This principle allows you to change the mode of transport from road to rail. Application of "Superdock" concept reduces noise and pollution also reduces congestion during handling of intermodal units between ships and trains or trucks. This concept reduces operating costs and improves performance related to handling (Kim et al., 2012). It is estimated that this system will eliminate 70% of the trucks to and from the port (Alba, 2012). On the other hand, this concept requires high investment costs and there is problem with control and management of this complex system, as well.

3.6 Flow-Through Gate

The Flow-Through Gate which was introduced in 1997 is a fully automated system that identifies container trucks and gives drivers instructions within 25 seconds. It handles an average traffic flow of 700 trucks per peak hour, and 9,000 trucks per day. After a manifest is submitted through portnet, the fully automated and paperless process at the gate clears trucks entering the port within 25 seconds, with the following steps: The truck arrives at the in-gate; The driver taps his PSA on the and verifies his identity through a fingerprint biometric reader or keys in his personal identification number; The truck is than weighed at the weighbridge; The gate picks up the truck's identity from the in-vehicle unit at the dashboard; The gate's container number recognition system captures the container number via closed-circuit television cameras; The system checks the driver's identity, truck's identity, weight and the container number against the manifest and clears the truck for entry; The system sends a message to the driver's mobile phone or mobile data terminal on the exact position in the yard where the container will be stacked. (www.singaporepsa.com).

3.7 Portnet

Portnet system (PSA) helps the entire port and shipping community to increase productivity and efficiency through the greater use of information technology and the Internet. Through constant technological innovation, Portnet has consistently been positioned at the forefront of e-business operations in the maritime and shipping industry. Portnet is the world's first nation-wide business to business which provides the logistics industry with a single sign-on network portal. Through it, PSA has connected shipping lines, haulers, freight forwarders and government agencies, helping them to manage information better and synchronize their complex operational processes.

From managing complex transshipment processes of shipping lines, supporting slot exchanges among alliance partners, enabling companies to monitor performance and make critical business decisions, integrating port documentations seamlessly with the haulage processes and workflow to providing a documentation portal between shipping lines and shippers, portnet simplifies and synchronizes millions of processes for customers moving their cargo. Over 10,000 integrated users rely on the system's unparalleled capability to provide real-time, detailed information on all port, shipping, and logistics processes crucial to their businesses. Portnet processes more than 220 million transactions a year. (www.potrnet.com)

3.8 Teustack

Teustack is handling and storage system for 20 foot and 40 foot, standard and refrigerated containers and upon request for other types of containers, such as high cube containers. Containers are handled by cranes which unload them from vessels. After unloading container from vessel, crane deposits it on the purposely allocated reception device. Once container is deposited, the crane is free to release spreader and start a new cycle. The cycle time of crane is reduced because of short vertical transportation time and elimination of non-productive waiting time. After loading of container on reception platform, that platform moves to first free storage location and returns back to receive new container. This platform is called turn and distributor. Inside of teustack terminal there are shuttle machines. Shuttles provide horizontal movement of containers at each floor of teustack terminal. Shuttles are similar to turn and distributor platforms. Vertical transport in testacy terminal is achieved by elevators which are equally distributed along the aisles. Once it reaches destination floor, the container is stored by shuttle which takes it to its final destination in the teustack terminal. All movements are carried out at the same time on different floors. This allows system to separate horizontal and vertical movements in terminal. Containers stored in teustack terminal can be accessed at any time. Operations on shipping containers from terminal are as same as on storing containers, in opposite order. Usage of teustack systems brings obvious space saving benefit. Eight levels enable to store 6400 TEU in 25.000 square meters versus approximately 100.000 square meters required for conventional storage on two levels. Teustack system has 70% greater productivity than conventional solutions, as well as enhanced safety and reliability (www.youtube.com).

4. CONCLUSION

This paper has reviewed technological innovations which have a goal to enhance productivity and efficiency of container terminals. Increasing service demands and „super vessels“ with great capacity represent a challenge for container terminals that, to remain competitive, need to minimize retention of containers in terminal, but as well to service as many containers as required. It is necessary to establish which the system is not achieving satisfaction results, and on that basis, as soon as possible decides on implementing some of the innovations. When making these decisions, the most important part is to determine if the system is going to improve productivity and efficiency in accordance with invested funds, whether system fits in existing logistics environment, what degree of flexibility system has and whether container terminal can be adapted for that particular innovation. There is no doubt that in the technological age we live at the moment will progress and evolution is yet to come.

ACKNOWLEDGMENT

This paper was written on the basis lectures about container terminals, subject Intermodal transport. We take this opportunity to thank Prof. Slobodan Zečević and Asst. Prof. Snežana Tadić for their advices, help and support while developing this paper.

REFERENCES

[1] Alba, D., (2012). The GRID project (green rail intelligent development), Planet Forward, The George Washington University, Washington, DC.

[2] Alba, D.J., Risemberg, R., (2011). How would the ports stack up? Los Angeles Business Journal. http://labusinessjournal.com/news/2011/sep/05/how-would-ports-stack/.

[3] Crainic, T.G., Kim, K.H., (2007). Intermodal transportation, in C. Barnhart, G. Laporte (eds), Handbooks in Operations Research and Management Science, 14, 467–537.

[4] Geerlings, H., van Duin, R., (2011), A new method for assessing CO2-emissions from container terminals: a promising approach applied in Rotterdam, Journal of Cleaner Production, 19(6/7), 657-666.

[5] Ioannou, P.A. et al., (2000), Cargo handling technologies, Final Report, Center for Commercial Deployment of Transportation Technologies, Los Angeles, CA.

[6] Kim, K.H., Phan, M.H.T., Woo, Y.J., (2012). New Conceptual Handling Systems in Container Terminals, Industrial Engineering & Management Systems, 11(4), 299-309.

[7] Meersman, H., de Voorde, E.V., Vanelslander, T., (2004). Transport objectives, instruments and indicators, Technical report, Department of Transport and Regional Economics, University of Antwerp.

[8] Zečević, S., (2006). Freight terminals and freight villages (in Serbian), Faculty of Transport and Traffic Engineering, University of Belgrade, Serbia.

[9] Zečević, S., Tadić, S., (2015). Intermodal transport lectures (in Serbian), Faculty of Transport and Traffic Engineering, University of Belgrade, Serbia.

[10] Vis, I.F.A., Carlo, H.J., (2010). Sequencing two cooperating automated stacking cranes in a containner terminal, Transportation Science, 44(2), 169-182.

[11] www.portnet.com

[12] www.singaporepsa.com/our-commitment/innovation

[13] www.youtube.com/watch?v=SkhGf1gxEBM