BOTTLENECKS OF INLAND CONTAINER TERMINALS

Mateusz Zajac, Franciszek J. Restel[a],
[a] Wroclaw University of Technology

Abstract: Availability of the intermodal transport chain depends on the proper functioning of the container terminals, including their ability to perform cargo handling infrastructure, cost- effectiveness and scope of services, quality and reliability. Increasing number of intermodal operators make that competitiveness becomes crucial issue to survive in the market. New objectives and performance measures need to be identified and employed to evaluate the performance of a container terminal. The aim of article is to show the most important elements of container warehousing and its impact on process availability and productivity. The article threats problems on inland intermodal terminals.

Proper operation of the intermodal transport chain depends on the proper functioning of the terminals, including their ability to perform cargo handling infrastructure, cost- effectiveness and scope of services, quality and reliability. Modern combined transport terminal is more than a simple transshipment point. It develops in the creation of centers freight with a wide range of services.
Simulation tests confirmed that the storage process guided by specific rules may result in a significant reduction in energy demand in the course of handling containers. Depending on the size of the node handling, the degree of use and speed of movement of the intermodal units can be a saving of up to 50%.
This article is a presentation of the progress of work on the project , which aims to develop a practical method that allows to use the knowledge to creating the functionality of intermodal transport terminal, taking into account the characteristics of its work, including efficiency, effectiveness, reliability, safety, ecology.

Keywords: Container terminal availability, terminal operation, terminal maintenance

1. MOTIVATION

After the difficult years of 2008-2010 container transport becomes stronger. In Poland it is visible seeing more and more new container handling transshipment points. Currently, the total container turnover in the market of intermodal transport is estimated by the owners of intermodal companies over 2.0 million TEUs per year (for comparison, in 2007, there are approximately 1.4 million TEU).
Facing of the White Paper on Transport recommendations (document leading transport policy in Europe) the increase of intermodal transport seems to be natural phenomena, nevertheless as a logistics process requires scientific work and research. The effect of which is to strengthen the competitiveness of intermodal transport to the traditional road to the carriage of highly processed goods.
Modern combined transport terminal is more than a simple transshipment point. It develops in the creation of centers freight with a wide range of services [3], [5]. Sea terminals are to be run in such a way as to reduce to a minimum residence time of the loading units within the terminal. Using sophisticated technology, handling, such as full automation of the process can substantially reduce the time of cargo handling, eliminate errors, increase the level of safety and reliability[1], [2], [4]. These technologies are extremely expensive and are not widely used. In smaller ports, high throughput is achieved by streamlining operations. The inland terminals link transport and storage functions. Problem in intermodal transshipment hubs is linked with choosing appropriate method of container warehousing [10], [11]. Very often it is necessary to move container several times from one point to another during process of storage. The results are more expensive container service and probability that containers can't be easy available then are needed.
The increase in intermodal transport is a natural phenomenon in the face of the *White Paper on Transport* recommendations. Nevertheless, intermodal transport as a logistics process requires

scientific work and research, the effect of which is to strengthen the competitiveness of intermodal transport to the traditional road to the carriage of highly processed goods.
Intermodal technology functioning is mainly based on experience in Poland. Over the years, intermodal transport was underrated way of transporting goods. Its principal advantage lies in combining functionality with the ability to cargo transport and storing in intermodal transshipment point. Intermodal transport technologies are shown in [6]. Design rules container terminals are presented in the [9]. Both publications are land-based container terminal.
Both the technology and design rules terminals do not show know how to manage the movement of cargo units inside the terminal. However, the functioning of the inland container terminals is far different from the typical container ports on which there is a lot of information in foreign literature [12].
Sea terminals are to be run in such a way as to reduce to a minimum residence time of the loading units within the terminal [8]. This is due to the need for high bandwidth as a result of the conditions established infrastructure and container turnover. Using sophisticated technology, handling, such as full automation of the process can substantially reduce the time cargo handling, eliminate errors, increase the level of safety of the process. These technologies are extremely expensive and are not widely used. In smaller ports, high throughput is achieved by streamlining operations. One of the solution is increasing tariff for storage of cargo at the port [15].
The inland terminals, as mentioned previously, links Transport and storage functions. In this case, the tariff for the storage of empty containers or loaded is decreasing. Both types of containers are stored within a storage space. Problem in intermodal transhipment hubs to adopt an appropriate method of storage of intermodal units, the implementation process container depots, so that there was no need of their translocation to another storage location. In reality Polish intermodal hubs, stacking containers and large volume of financial and intuitive decision-making, such situations often occur. This is the reason for the formation of additional costs and sometimes even necessary, adjusting the container several times.
In the international literature, little space is devoted to the theme of inland terminals. Generally it is a showcase of new technologies intermodal attempt to analyze their applicability, detailed technical solutions. There is no literature on the process of storage. There have been no analysis of the arguments has to be taken into account when storing. Do not analyzed the information contained in the transport documents for their use in the management of places components in intermodal transshipment node. We can say that this area of knowledge is not recognized, and the practice sets the rules in force here.
The remainder of this article outlines basic procedures performed during the reception and dispatch of goods to and from the container terminal. The principles of selecting the places of storage containers, and indicated the formation of any disruption to the service container terminal.

2. THE NEED FOR QUALITY IN USE OF INTERMODAL TRANSPORT

The proper functioning of the whole chain of intermodal transport depends largely on the proper functioning of the terminal, including first and foremost on their ability to perform cargo handling infrastructure, cost- effectiveness and scope of services, quality and reliability. Modern combined transport terminal is more than a simple transshipment point. It develops in the creation of centers freight with a wide range of services.
EU report [13] the most characteristic tendencies in the development of combined transport terminals in Europe include, among others:
• transition from isolated terminals to integrated logistic centers freight handling the " hub " of the terminal for combined transport as a key location in the center, while the development of a network of medium and even small terminals with maximum loading process automation;
• concentration of resources to improve service processes in terminals, especially automated cargo handling, cargo handling technology standardization and implementation of complex information technology systems .
Combined Transport Development Strategy in Poland (Published in 2004) shows such the need to develop innovative technologies for intermodal terminals. In turn, released in 2006 by the General Department for Energy and Transport of the European Commission's publication " In search of the

slide Intermodality efficiency growth" simply points to the need for research projects focused on solving the problems of intermodal transport in order to increase its efficiency and wider dissemination.
Mentioned basic needs include:
• improving the quality of services with a focus on the creation of information technologies in the management of terminals,
• looking for ways to achieve synergies between the supply chain for intermodal transport
• further harmonization and interoperability between transport modes, manifested in new technologies, transport and handling of intermodal loading units.
Among the solutions sought European Commission proposes to focus on the work of, among others:
• identify problems and bottlenecks in the operation of intermodal terminals
• identification of tasks to increase efficiency of intermodal terminals , and these tasks with the help of state institutions and businesses.
Conducted by the author identification of multimodal transport operators in Poland have indicated that postulates presented above are still very relevant. For many years, one can observe the dynamic growth of transported cargo units in Poland related to intermodal transport . They are expected to be a solution that will allow for further sustainable development of transport in Poland. These are primarily solutions for qualitative and quantitative evaluation of the work, analytical tools, and tools that enable better management of the company in the operational field.

3. CHARACTERISTICS OF PROCEDURES FOR ENTRY AND CONTAINER

Most intermodal trans-shipment hub located inland supports two modes of transport : road and rail transport (in CEE is difficult to discern the terminal supports three modes of transport) . Thus, in the following section describes the procedures for entry and exit of containerized cargo by rail and road.
The procedure for the adoption of the terminal
Container train is the most Anticipated few days prior to arrival at the terminal. Notification is sent by e-mail in the form of a list containing the most common train number, wagon number, the number of the container located on the wagon, the gross weight of the container, information on the place of delivery, round trip, Incoterms rule, etc.
Composition station when you arrive at the container terminal is checked for possible damage units (document interchange) . If the damage is not aware of the physical follows the adoption of containers on the terminal - and start unloading of storage.
Similarly, the procedure will adopt the container by road. Adoption of the container terminal road transport is also most frequently preceded by notification . This time, most workers make advising terminal based on the order issued by a company that provides container terminal . After the formal notification of the completion of the notification and the safety formulas tractor -trailer carrying a container can enter the loading area. The driver shall be submitted together with the accompanying documents to the person carrying out the inspection of container for damage unit load. Then, if no evidence of deficiencies is awarded to the terminal. The driver is required to set up a set in the space where the container is picked up.
Upon notification by the trustee cargo container needs material is taken from the site and loaded onto a semi-trailer containers. Then , before leaving the terminal , the driver is equipped with special set of transport documents. The driver also receives an instruction from the load unit and therefore an indication of the customs , trance journey to the customer and the procedures for the transfer of cargo transport. The driver is well informed about the details of the date for delivery of the cargo.

4. PRINCIPLES IN CONTAINER STORAGING

The ground terminals loaded containers are stored mostly to three layers to four layers vain. The storage yard in a terminal is usually divided into rectangular regions called storage blocks or blocks. A typical block has seven rows (or lanes) of spaces , six of Which are used for storing containers in stacks or columns, and the seventh reserved for truck passing . Each row typically Consists of over twenty 20 -ft container stacks stored lengthwise end to end . For storing a 40 -ft container stack , two 20 -ft stack spaces are used.

Load distribution and hence the allocation of storage is done by machine operators . This is done on the basis of their experience and relying on the information derived from public goods . Basic information to be taken when allocating loads are:
• whether the container is empty, loaded , refrigerated, tank , ADR / RID;
• the size of the container,
• the expected storage time charge on the terminal ,
• the recipient,
• the gross mass,
• operator.
The essential art of machine operators to memorize and consistently putting in a storage container so as not to turn the download does not require adjustment of the upper layers of containers . This task is difficult and involves unreliability . This problem increases the lack of information from one of the main customers of schedule downloads terminal at the time of arrival of containers by rail to unload the cargo units . As a result, the containers are unloaded in free space components (cached) , and after being informed of the date of delivery segregated and placed in the correct order.
Schedules cargo operations are difficult to define because they vary depending on the sender or recipient, traffic conditions , etc. , although this time the service should be as short as possible. Therefore, previous planning manual handling is often very difficult , if not impossible , due to random factors beyond the control of the operator terminal. To transfer the containers in the number of hours between scheduled transport services large batches , the temporary storage of containers is essential. Meets the buffer function terminals. Unfortunately, the container terminal is limited capacity and technology used transport units , thus piling up more layers to increase capacity. This increases the number of containers in the landfill , but very often difficult to locate the container , and the effective execution of transhipment operations on it. As the number of handled cargo units , there are new problems . With little turnover of the cargo container to find the company was not a problem for those involved in the physical handling of cargo. Today, however, the terminal supports more load and hence there is a possibility of a problem to locate the container that is to be assigned. During the deployment analzy intermodal cargo transshipment node can watch two indicators:

- rotation ratio
- the intensity of use of the component.

Rotation ratio is the number of container shifts performed per unit time with respect to one component of the terminal. This means that the residence time of the free- space component may be relatively short, but the number of containers in a given location may be large. This means that the area is heavily used, but due to the large rotation load . Achieving high turnover ratio is desirable for marine terminals, where it counts the technical efficiency of the transport process and land-based terminals , where the number of occupied seats begins to cause complications in the implementation of the basic functions of transport. The intensity of the storage is a busy time of the landfill by the same unit load per unit of time. The smaller the value of this ratio the greater the rotation of the loading unit is characterized by a terminal.

5. DISRUPTION OF TRANSPORT OR STORAGE

5.1. Disruption in yardplanning

While making decision in yard planning system on container movement, there are three important factors that are usually taken into account before one:

- costs of operation,
- time of operation,
- discrepancy, that process of transshipment will finish successfully.

Lets focus on discrepancy, as a factor close to dependability (risk) issues. This factor can be characterized as probability, that task given by yard manager will be done without delay, reliable.
There are different reasons treating different matters that should be taken into account when talking on task success. Obvesly there are some conditions prescribed to machines, its operators and tasks. Figure 1 shows simple loop of dependings in decision making and achieving success in container

transshipment. Starting from ‘Task success” it is assumed, that all information about machine and persons are delivered to yard planner with information on task status. This element gives opinion to yard planner about resources – technical and human. Using information from that two different sets is ready to make decisions, that treat:

- operator,
- machine.

In case of operators yard planner decisions have influence on their behavior, stress, ect. However planner’s position gives opportunity to make orders, suiting operator, machine and present task condition. In case of machines, yard planner has influence on maintenance decision. The result of the decision is change in availability or reliability and maintainability performance. More details are presented on figure 2.

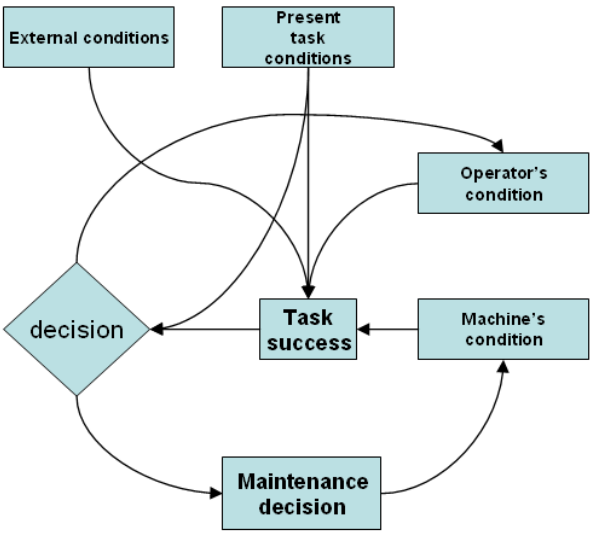

Figure 1. Fundamental relation in container yard operation

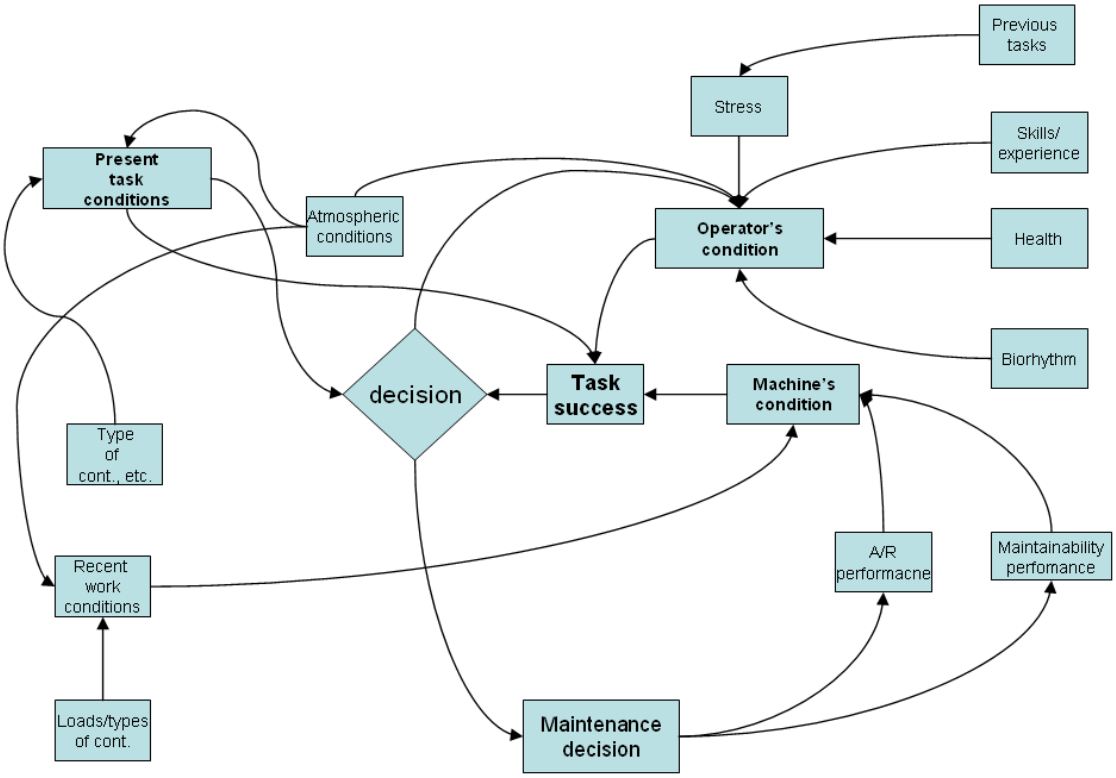

Figure 2. Extended graph of relation in container yard operation

Operator's condition is result of its skills, experience, stress or even atmospheric conditions. As it can be seen there are different modes of deciding factors, which have to be translated to common denominator. There are some open questions: how to measure stress, skills or health. Naturally there is also another question about importance of each measure/factor.

5.2. Causes and effects of disturbances

In the course of identifying the operation of intermodal transshipment node highlighted the potential for any interference during cargo delivery to the recipient. Table 1 contains the name of the fault, the cause and the possible consequences of its occurrence. Ratings shown in the table are subjective. The significance of risk determines the impact of the phenomenon on the possibility of carrying out the action with a positive result at a given time. The greater the delay resulting from the immanent danger the higher the significance of the threat. The possibility of risk reduction is an appropriate opportunity to guide the process in order to reduce the occurrence of a hazard.

Table 1 Causes and effects of disturbances during operation of the unit load. Subjective evaluation.

Description of disruption	**Cause**	**The significance of the risk**	**The possibility of reducing the risk**
Damage to the stage prior to the adoption of transport container terminal	Technical	high	impossible
Damage to the stage inside the terminal cargo handling	Technical	high	high
Customs Clearance	organizational	medium	high
Congestion in the course of delivery to the customer	Technical or organizational	medium	low
The problem of finding the container at the landfill	organizational	low	high
Problems with the development of transport documentation	Technical	low	high
No trailers	Technical or organizational	medium	high

As it can be seen from the table there is no practical possibility of enclosing the transport process of disruption in the event of damage to the unit load on the delivery of cargo to the terminal. But within it, and further beyond, the behavior of the relevant technical and organizational conditions can contribute to reducing the risks. Among the factors that could be somewhat overcome by the implementation of this project is to

- The problem of finding the container at the landfill,
- The problem with the development of transport documentation.

6. CONCLUSIONS

Contemporary challenges for the transport of lead by monitoring parameters such as efficiency , productivity, quality and safety. This can be done by streamlining the demand for transport services , even within the systems already considered environmentally friendly . This will ensure that they maintain both business and cares for the environment at the same time economically rational.

The practical effect of study is to prepare a computer program to support operations in intermodal transshipment node . The developed program will support the decision of the Broadcasting space for container storage sued to obtain the following benefits:

- reducing the number of operations at the terminal intermodal,
- reducing energy needs during handling unit loads at the terminal intermodal,
- Shorter handling unit loads,
- Increased machine productivity within the terminal handling by reducing machine cycle times .

Acknowledgements
The results presented in this paper have been obtained within the project “The model of operations in intermodal terminal” (contract no. POIG.01.03.01-02-068/12 with the Polish Ministry of Science and Higher Education) in the framework of the Innovative Economy Operational Programme 2007-2013

References

[1] Ambrosino D., Caballini C., Siri S.: A mathematical model to evaluate different train loading and stacking policies in a container terminal. Maritime Economics & Logistics (2013) 15.
[2] Boysen N., Fliedner M., Jaehn F.: A Survey on Container Processing in Railway Yards. Transportation Science (2011) Volume: 47 Issue: 3.
[3] Braekers K.: Optimization of empty container movements in intermodal transport. 4or-A Quarterly Journal Of Operations Research (2011) Volume: 11.
[4] Gambardella L. M., Rizzoli A. E., Zaffalon M. (1998). Simulation and planning of an intermodal container terminal, *Simulation* 71. 1998.
[5] Olivo A., Di Francesco M., Zuddas P.: An optimization model for the inland repositioning of empty containers. Maritime Economics & Logistics (2013) Volume: 15
[6] Nowakowski T., Kwaśniowski S., Zając M.: Transport intermodalny w sieciach logistycznych. Of Wyd. PWr, Wrocław, 2008.
[7] Nowakowski T., Werbinska-Wojciechowska S.: *Means of transport maintenance processes performance : decision support system*. Carpathian Logistics Congress, CLC' 2012: congress proceedings, Jesenik, Czech Republic, November 7th-9th 2012. Ostrava : Tanger, cop. 2012.
[8] Steenken D., Voss S. Stahlbock R.: Container terminal operation and operations research - a classification and literature review, *OR Spectrum* 26. 2004.
[9] Jakubowski L.: Technologie prac ładunkowych, Warsaw University of Technology, Warszawa, 2003.
[10] Zajac P.: Can the raising of energy consumption of information interchange be a factor that reduces the total energy consumption of logistic warehouse system?, Production engineering innovations and technologies of the future, Edward Chlebus (ed.), 2011. s. 79-89, International Conference "Production Engineering 2011", Wrocław, 30 June-1 July 2011.
[11] Zajac P.: The choice of parameters of logistic warehouse system, with taking the energy into consideration, Selected logistics problems and solutions, Katarzyna Grzybowska, Paulina Golińska (eds.). Poznań : Publishing House of Poznan University of Technology, 2011. s. 107-120
[12] Vatanabe I: Contaier terminal Planning. Theoretical approach, WCN Pubishing 2005;
[13] A Quality strategy for combined transport.
[14] Combined Transport Development Strategy in Poland (in (polish), 2004 przez Generalny Departament Energii i Transportu przy Komisji Europejskiej publikacja„*In serach of efficiency to suport intermodality growth*
[15] Vis I. F. A., de Koster R.: Transshipment of containers at a container terminal: An overview, *European Journal of Operational Research* 147, 2003.