LOGISTICS SETUPS IN A THIRD-GENERATION PORT

Yulia Panova [1,2]
[1] Department of Logistics and Commerce, Faculty of Railway Operation and Logistics, Emperor Alexander I St. Petersburg State Transport University, Moskovsky prospect 9, 190031, Saint Petersburg, Russia;
[2] Department of E-Commerce, Luoyang Normal University, 6 Jiqing Rd., Yi Bin District, Luoyang City, Henan Province, China, E-mail: panovayulia87@gmail.com

Per Hilletofth[1,2]
[1] Department of Industrial Engineering and Management, School of Engineering, Jönköping University, P.O. Box 1026, SE-551 11, Jönköping, Sweden;
[2] Jönköping, Sweden and Department of Industrial Engineering and Management, University of Gävle, SE-801 76, Gävle, Sweden, E-mail: prof.p.hilletofth@gmail.com

ABSTRACT

This paper investigates the feasibility of different logistics solutions, or so-called setups, in a third-generation port. To achieve this, a simulation model imitating the work of a real third-generation port was developed. Four experiments with different logistics setups (the size and number of shipped consignments to the port, dispatching time, deployed truck fleet, etc.). have been configured and evaluated in the simulation model. The research shows that effective material transfer from the plant to the port can be provided, if a pull- system is applied instead of traditional push-system. This approach allows goods to be delivered just-in-time with the minimum costs of labour and material resources.

Keywords: logistics, port generations, just-in-time concept, simulation modelling, pulling systems.

1. INTRODUCTION

Ports constitute a vital part of the transportation system (Gonzalez-Aregall, 2017; Kuznetsov & Galin, 2015). The role and function of the port within the transportation system have evolved in recent years (Jakomin, 2003; Lee & Lam, 2015; Notteboom & Winkelmans, 2001; Tran et al, 2012). Nowadays, it is possible to distinguish the five port's types or generations (Jakomin, 2003; Montwiłł, 2014; Tran et al, 2012; Tran et al, 2011; UNCTAD, 1999). A first- generation port primarily includes cargo handling (loading, unloading) functions, serving as interchange point, while a second-generation port besides cargo handling function also provides customer-oriented commercial functions (Angeliki, 2005; Unescap.org, 2019). A third-generation port, additionally to previously mentioned, has logistics and distribution functions with predominant container specialization services (Angeliki, 2005; Jakomin, 2003; Lam & Song, 2013; Tran et al, 2011).

It could be assumed that information sharing technologies and total quality management practices are still held value for the third-generation ports, as well. By the third phase of the development, ports became logistics centres, providing value-added services for customers. Therefore, just in time (JIT) principles of logistics, ensuring smooth flow of services and cargo are required in the third-generation of ports. These logistics solutions, or so-called setups, reduce unnecessary waste of resources, first and foremost, cargo lead time, ultimately bringing the reduction of total costs and price, with a corresponding increase in productivity and profit (Tran et al, 2011).

Therefore, this study aims to investigate the feasibility of different logistics setups in a third-generation port. To achieve this, a discrete event simulation model of a real third-generation port was developed in AnyLogic. A logistics system consisting of a manufacturer co-located with the port of Ust-Luga (Russia) was used as an example. The manufacturer exports to Sweden. Four experiments with different logistics setups were configured and evaluated by the simulation model. The input for the simulation model comes from various databases and was implemented through constant and random variables.

The remainder of this paper is structured as follows. Section 2 provides a literature review on port development via different generations with an emphasis on logistics setups in ports. Section 3 considers the simulation modelling case: Ust-Luga port, which transforms to the status of the third-generation port. In Section 4, the findings highlight the application of the just-in-time (JIT) approach, which is natural for the 'pulling type' logistics system considered in the case.

2. LITERATURE REVIEW ON THE PORT DEVELOPMENT PRACTICES

Since the 1950s the ports' roles have been changed every decade. By 60s, the functions of 1st generation ports (1GP) were built in solid forms. Their extension from primarily cargo handling continued in forthcoming years to commercial and industrial functions, adhered to the 2GP, which were developed in 1960-70s. Then, 3GP appeared (Angeliki, 2005; Jakomin, 2003; Lam & Song, 2013; Tran et al, 2011), with predominant container specialization and emphasis on logistics and distribution functions that afterwards transformed into integrated forms. As a result, 4GP as nodal points of international supply chains evolved during 1990-2000s (Montwiłł, 2014; UNCTAD, 1999).

In the fourth-generation ports, logistics and distribution functions transformed into integrated forms, bringing lean and agile practices into focus (Tran et al, 2011). The fifth- generation ports referred in the literature as nodal points of international supply chains (Montwiłł, 2014; UNCTAD, 1999), where the application of lean manufacturing and six sigma approaches still considered as relevant (Tran et al, 2011). Some others works identify the sixth-generation ports with environmental protection law, integration of economic interest of the entire port community, as well as further standardization of information sharing technologies (Kaliszewski, 2018).

Many researchers proved that the conceptualization of ports development from a logistics and supply chain management perspective is reasonable and justified (Bichou & Gray, 2004; Lam & Song, 2013; Marlow & Casaca, 2003; Panayides & Song, 2009; Song & Panayides, 2012; Tran et al, 2011; Tran et al, 2012). Recent studies of ports integrated into a network also consider quality management practices in terms of a just-in-time approach, quick response, lead- time management, lean and agile logistics (Lam & Song, 2013; Marlow & Casaca, 2003; Tran et al, 2011; Tran et al, 2012). To minimize costs, the principles of integrated logistics in the organization of deliveries of products from the plant to the port for further export can be used (Panova, 2011). Just-in-time strategy (JIT) is one of the main strategies for integrated logistics planning in supply chains (Dybskaya et al, 2008; Lukinskiy, 2008). It was introduced by the Japanese automobile concern Toyota and widely used in the 1960s (Waters, 2009).

Logistic systems that use the principle of the just-in-time concept are 'pulling' systems in which the placing of orders for the replenishment of stocks of material resources (Lukinskiy et al, 2016a) or finished products occurs when their quantity in certain parts of the logistics system reaches a critical level (Lukinskiy et al, 2016b; Waters, 2009). In this case, stocks are 'pulled' through distribution channels from suppliers of material resources or in the company's distribution system. In a traditional process, each operation has a timetable of work that must be finished in a given time. Finished items are then 'pushed' through to form a stock of work in progress in front of the next operation. The 'push' and 'pull' systems are applied to the concept of dry ports acting as buffers for import-oriented or export-oriented seaports, respectively (Notteboom & Yang, 2017; Panova, 2009; Panova, 2016; Rodrigue, 2008; Roso, 2009).

3. SIMULATION MODELLING

The 'pull' system can be used to arrange the efficient maritime export operations, the delivery of sandwich panels to the port from the plant. In the current study, that is the Betset plant, specializing in single- and multi-layer wall panels that is located in the vicinity of Ust-Luga port (Dp.ru, 2016a; 2016b; Betset.fi, 2016). Its products will be delivered to Sweden from Russia via the port of Ust-Luga to Stockholm. Ust-Luga port is expected to become the core of the transport and logistics cluster of the Russian North-West region (Isaeva, 2017; Makrushina, 2016; Neustroeva, 2011). Current analysis of existing cargo flows showed that the port is on the 2nd place in Russia in terms of processing the entire range of goods, and on the 6th place by processing high-yield cargo transported in containers (Russia's Merchant Seaports Association, 2016).

For the simulation of a complex system (plant – port) and corresponded integration of production and transport processes, the discrete-event modelling has been used in AnyLogic, which is one of the most common simulation systems developed in Russia and distributed abroad. AnyLogic software provides four approaches to simulation (system dynamics; discrete-event modelling; modelling of dynamic systems; agent-based modelling) or their combination within one model (AnyLogic.ru, 2019; Ekyalimpa et al, 2016; Hilletofth & Lättilä, 2012). In the model, the material, financial and information flows were considered as dynamic entities that occur with some periodicity and are transformed in the process; while resources, e.g. equipment, stocks, etc. that provide the business process were treated as static entities,

The aim of the simulation of the system under consideration was to design and analyze the production system of the enterprise located in the vicinity of the port, as well as to plan the supply of products to the port with allowance for the 'pulling type' of logistics system. Therefore, for each dispatch, it was necessary to determine the transit time to the port. Then, in the reverse order, taking into account the moment of the start of the discharge of the first batch in the port, the time to start loading the panel trucks in the plant had to be calculated, taking into account the loading capacities in the warehouse of the plant. If the shipping lot is large, then, assuming the number of available trucks used to deliver cargo to the port, as well as the speed of transhipment, the next approach moment was calculated, based on which the loading time of the remaining trucks was determined.

On Figure 1, the top line with the blocks of the process modelling library describes the delivery of panels to the port, while the bottom line reflects the process of the ship loading. The model includes the two Event blocks. With the help of one Event, the arrival of the vessel at the set time was generated, and with the second Event, the loading operations was immediately activated after the arrival of the vessel. Hold blocks fix the moment, when the accumulation of the shipping consignment is provided (hold) and the vessel is ready to perform loading operations (hold1).

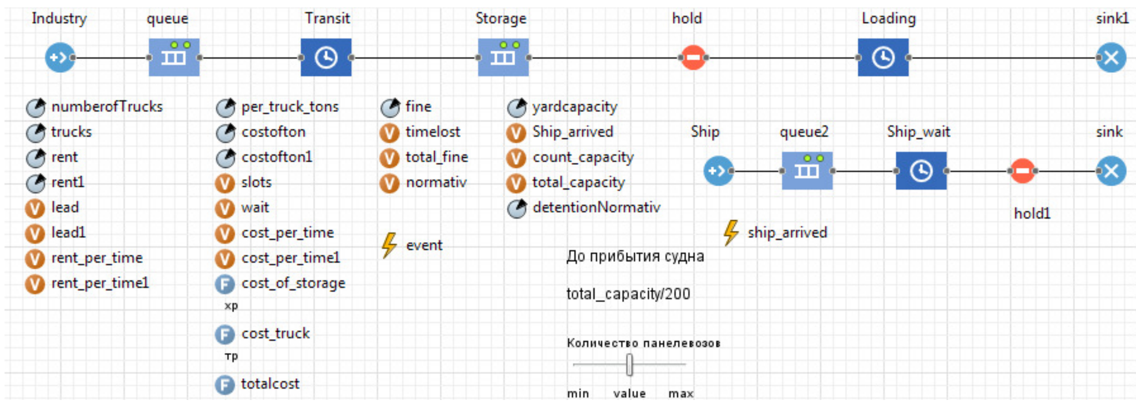

Figure 1. Discrete-event model of ship consignment accumulation.

For the development of the model, it was assumed that finished products from the storage zone of the manufacturer will be sent to the port of Ust-Luga employing road transport. To deliver the ship's batch to the port (3000 m$_2$ in size), there are 5 trucks available. Since ship consignment equals 3000 cubic meters and one panel is 3.75 cubic meters, then, 800 panels should be sent to the port. To solve this task, the following input data for the model was taken into account (Table 1).

Table 1. Input data of the model.

Parameter	Value	Constant/ Random Variable
Time for one delivery from the plant to Ust-Luga	On average 4 hours, taking into account the empty voyage	Described by triangular distribution (min time - 3.5, mode - 4, and max - 4.5)
Loading time of each panel block per vessel (4 panels in the block)	On average 15 minutes	Described by triangular distribution (min time - 12, mode - 15, and max - 16)
The number of trucks	5 units	Fixed value
The cost of truck operation	1000 Rubles per hour	Fixed value
The cost of renting additional truck-panellists	1500 Rubles per hour	Fixed value
The amount of tone transported by one truck	16 tones	Fixed value
Cost of storage of one ton	5 Rubles/hour for 3 days, from the 4$_{th}$ day - 50 Rubles/hour	Fixed value for each period
The capacity of the storage area in the port	the maximum value equals the size of the ship consignment, 800 panels or 3000 m$_2$	Fixed value
Preferential time of the ship's idle time	1 hour after the laytime expiration (24 hours)	Fixed value
The penalty for idle time	6500 Rubles for 1 hour of demurrage	Fixed value

4. FINDINGS

Based on the analysis of the model output, the best option for the organization of the integrated operations between the manufacturer and Ust-Luga port is when the consignment to the port is delivered in two parts 'A' and 'B' instead of the option of delivering the whole ship consignment ('A'+'B'=100%) from the plant to the port before the arrival of the vessel. That is to say, the delivery of the first part of the shipping consignment 'A' from the plant to the port should be done just in time of the vessel arrival, while the remainder of the cargo (part 'B' of ship consignment) needs to be supplied to the port at the required time, i.e. when the vessel is already moored to the berth and the consignment of cargo 'A' is under transhipment to the vessel.

In the current model, before the vessel arrives, the first part 'A' of ship consignment (85%) is delivered to the port by the trucks-panellist. This option allows ensuring almost thorough continuity of ship loading and reduces fines due to time lost on waiting. The second part of ship consignment 'B' (15%) arrives during the loading of the remaining cargo from the first consignment 'A'; such a parallel organization of work is provided by the minimal use of resources (5 trucks-panellists). Therefore, the total cost is 31% less than in the first experiment, where the entire ship consignment ('A'+'B') is delivered to the port before the arrival of the vessel.

Also, the option of arranging the delivery of ship consignment to the port, when the first part of the ship's batch 'A' equals 85%, is three times cheaper than the other, third alternative, which assumes the delivery of the first part of the ship's batch 'A' in the volume of 80% of the whole ship consignment to the port. The reason for such difference is that when delivering the smaller first part of the shipping consignment to the port, the entire second part of the shipping batch (20%) cannot be delivered on time due to the limited number of resources used (5 trucks- panellists). Therefore, continues loading operations with the ship cannot be provided, leading to an unproductive idle time of the ship and additional costs due to fines.

If to propose the fourth alternative, that is, to lease additionally 3 trucks in order to deliver the remaining 20% of the ship consignment from the plant to the port on time, rather than with the delays, as in the third alternative, then the cost will increase. They will be 5% higher than in the best option with consignment arrangement in 85% and 15% delivery parts, when the transportation of the remaining second part of the shipping consignment ('B'15%) can be provided by minimum number of resources, 5 trucks-panellists, at the required time. Thus, the application of logistics system, which is 'pulling' by nature, and assumes the use of the just-in-time (JIT) approach allows the smooth transfer of the materials from the plant to the port. By doing so, the process of transhipment can be continuous and paired with the efficient use of the allocated material resources (vessel, trucks, and cranes) and their lead time.

5. REFERENCES

Angeliki, P. (2005). The Way a Third Generation Port Can Boost Local Employment: The Case of Piraeus. *European Research Studies*, 8(3-4), 22-44.

AnyLogic.ru. (2019). About the program. Accessed 08-02-2019 http://www.anylogic.ru/

Betset.fi. (2016). Official website of Betset. Accessed 01-06-2017 http://www.betset.fi/fi/info.html

Bichou, K., & Gray, R. (2004). A logistics and supply chain management approach to port performance measurement. *Maritime Policy & Management*, 31(1), 47-67.

Casaca, A. C. P. (2005). Simulation and the lean port environment. *Maritime Economics & Logistics*, 7(3), 262-280.

Dp.ru. (2016a). Investments - The Finnish company Betset Oy sold a plant for the production of panels to investors from Kazakhstan. *Business St. Petersburg-Online Gazette*. Accessed 01-06-2017 https://www.dp.ru/a/2016/02/10/Evro_menjajut_na_tenge

Dp.ru. (2016b). Exports - Petersburg plant Betset began to export to Sweden panels for the construction of houses. *Business St. Petersburg-Online Gazette*. Accessed 01-06-2017 https://www.dp.ru/a/2016/10/31/Panelnij_jeksport

Dybskaya, V.V., Zaitsev, E.I., Sergeev, V.I., Sterligova, A.N. (2008). *Logistics: Integration and Optimization of Logistics Business Processes in Supply Chains,*. Moscow, Russia: Eksmo Publishing House.

Ekyalimpa, R., Werner, M., Hague, S., AbouRizk, S., & Porter, N. (2016). A combined discrete-continuous simulation model for analyzing train-pedestrian interactions. *Proceedings of the 2016 Winter Simulation Conference (IEEE Press*), 1583-1594.

Gonzalez-Aregall, M., Bergqvist, R., Monios, J. (2017). Port Initiated Measures for more Sustainable Transport -a Hinterland Perspective. *Proceedings of the conference: Port Initiated Measures for more Sustainable Transport -a Hinterland Perspective,* Madrid, Spain, 1-3.

Hilletofth, P., & Lättilä, L. (2012). Agent based decision support in the supply chain context. *Industrial Management & Data Systems*, 112(8), 1217-1235.

Isaeva, N.V. (2017). *Formation of the Cargo Base of Ust-Luga Port with Allowance of the Principles of Integrated Logistics*. Mater thesis, Petersburg State Transport University, Russia.

Jakomin, I. (2003). New function of seaports: Logistics and distribution. *Promet-Traffic & Transportation*, 15(1), 1-5.

Kaliszewski, A. (2018). Fifth and sixth generation ports (5GP, 6GP) – evolution of economic and social roles of ports. Accessed 05-04-2019 https://www.researchgate.net/publication/324497972_FIFTH_AND_SIXTH_GENERATION_PORTS_5GP_6GP_-_EVOLUTION_OF_ECONOMIC_AND_SOCIAL_ROLES_OF_PORTS

Kuznetsov, A. L., & Galin A. V. (2015). Genesis of models of ports development in modern transport science. *Vestnik of the State University of the Marine and River Fleet of Admiral S.O. Makarov,* 2(30), 141-152.

Lam, J. S. L., & Song, D. W. (2013). Seaport network performance measurement in the context of global freight supply chains. *Polish Maritime Research*, 20(Special Issue), 47-54.

Lee, P. T. W., & Lam, J. S. L. (2015). Container port competition and competitiveness analysis: Asian major ports. In *Handbook of ocean container transport logistics*, Switzerland: Springer, Cham.

Lukinskiy, V. S. (2008). *Models and Methods of Logistics Theory*. Peter, St. Petersburg, Russia.

Lukinskiy, V.S., Lukinskiy, V.V., & Pletneva, N.G. (2016b). *Logistics and Supply Chain Management*. Moscow, Russia: Yurayt Publishing.

Lukinskiy, V.S., Panova, Y., and Soletskiy, R. (2016a). Simulation modelling of supply chain with allowance of reliability. *Russian Journal of Logistics and Transport Management*, 3:2, 49–60.

Makrushina, E.A. (2016). The role of the port-industrial cluster of Ust-Luga in the spatial development of the region, *Internet-journal "Naukovedenie*", 8(2), Accessed 02-06-2017 URL: https://cyberleninka.ru/article/v/rol-portovo-promyshlennogo-klastera-ust-lugi-v-prostranstvennom-razvitii-regiona

Marlow, P. B., & Casaca, A. C. P. (2003). Measuring lean ports performance. *International journal of transport management*, 1(4), 189-202.

Montwiłł, A. (2014). The role of seaports as logistics centers in the modelling of the sustainable system for distribution of goods in urban areas. *Procedia-Social and Behavioral Sciences*, 151, 257-265.

Neustroeva, N.A. (2011). Mechanisms of the formation of industrial clusters. *Russian Entrepreneurship*. 5, 52-56.

Notteboom, T. E., & Winkelmans, W. (2001). Structural changes in logistics: how will port authorities face the challenge? *Maritime Policy & Management*, 28(1), 71-89.

Notteboom, T., and Yang, Z. (2017). Port governance in China since 2004: Institutional layering and the growing impact of broader policies. *Research in Transportation Business & Management*, 22, 184– 200.

Panayides, P. M., & Song, D. W. (2009). Port integration in global supply chains: measures and implications for maritime logistics. *International Journal of Logistics: Research and Applications*, 12(2), 133-145.

Panova, Y. (2011). Potential of Connecting Eurasia through Trans-Siberian Railway. *International Journal of Shipping and Transport Logistics*, 3(2), 227–244.

Panova, Y. (2016). *Public-private partnership investments in dry ports – Russian logistics markets and risks*. Doctoral thesis, Lappeenranta University of Technology, Lappeenranta, Finland.

Rodrigue, J.-P. (2008). The Thruport concept and transmodal rail freight distribution in North America. *Journal of Transport Geography*, 16(4), 233–246.

Roso, V. (2009). *The Dry Port Concept,* Doctoral Thesis, Chalmers University of Technology, Göteborg, Sweden.

Russia's Merchant Seaports Association (2016). All cargoes of Russia. *Journal of Seaports*, 1(92), 76–88.

Song, D. W., & Panayides, P. (2012). *Maritime logistics: a complete guide to effective shipping and port management*, Kogan Page Publishers, London, UK.

Tran, H., Cahoon, S. and Chen, S.L. (2012). Quality management for seaports integrated in supply chains. *Int. J. Shipping and Transport Logistics*, 4(4), 376-388.

Tran, H., Cahoon, S., & Chen, S. L. (2011). A quality management framework for seaports in their supply chains in the 21st century. *The Asian Journal of Shipping and Logistics*, 27(3), 363-386.

UNCTAD. (1999). The fourth-generation port, UNCTAD Ports Newsletter, 1999, No. 19, p. 10, Accessed 05-04-2019 http://unctad.org/en/ Docs/posdtetibm15.en.pdf

Unescap.org. (2019). Value-added services of logistics centres in port areas. Accessed 15-03-2019 https://www.unescap.org/sites/default/files/pub_2194_ch3.pdf.

Waters, D. (2009). *Supply Chain Management: An Introduction to Logistics,* Palgrave, London, UK.