ON INTEGRATION OF SIMULATION INTO IT SYSTEMS OF PORT OF GDANSK

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Abstract: The management of all the activities in a seaport is always supported by ICT (Information and Communication Technology). The ICT applications can be different depending on the financial and technical possibilities in a given location. Port Management and Information System is one of the many ICT applications supporting maritime economy (maritime administration and harbor master offices, shipping industry, ports and their business partners). In the paper the influence of ICT used on various sea port facilities and the simulation of port processes, with special emphasis on container terminals, is analyzed. The paper deals with the integration of a simulation-based method of analysis and improvement of the logistic processes in the container terminal at the Port of Gdansk (Poland). The real-life data of the terminal have been fed into the simulator and the obtained model has been validated through the comparison of its results with the operational data of the terminal. The model built has been used for further simulations to check the scenarios for future development of the terminal.

Keywords: Simulation, ITC maritime systems, container terminal.

INTRODUCTION

The Port of Gdansk is a medium size Baltic seaport with a total cargo handling of over 17 million tons. Information and communication technology (ICT) applications form an important part in the Port of Gdansk management and operation infrastructure.

Port Management and Information Systems are some of the many ICT applications supporting maritime economy (maritime administration and harbor master offices, shipping industry, ports and their business partners) in the case of the Port of Gdansk. List of ICT applications in broad scope is very long and includes - for example:

- Marine Information & Navigation Systems (including VTS and AIS - automatic identification system);
- Port Community System;
- Port Management Information System (including EDI);
- Port Monitoring & Reporting System (including safety and security);
- Port Data Communication Network & Broadcasting System;
- Port Terminal Stevedoring Systems;
- Port Customer Systems (Shipping Agents, Forwarding Companies, Customs Agencies etc.)
- Radio Voice Communication and Wireless Data Transmission/Access;
- Simulation systems.

The application of new hand-held devices to port logistics - being in the scope of many on-going activities - is connected directly with the information systems used on the port authority level and port stevedoring and port service companies, for example mooring/tugs/towage, pilots, among others.

Computerized information systems used on those levels should be analyzed for any integration activity projected in the port area. There are three main applications in the Port of Gdansk, which are interesting from the integration of simulation system point of view:

- DYSPORT - Vessel/Cargo Information & Clearing System;
- "GTK" - Gdansk Container Terminal System;
- "PGE" - Gdansk General Cargo Terminal System (including Port Free Zone Information System).

Other "internal" PGA (Port of Gdansk Authority) and "external" systems are not included in this paper.

GDANSK CONTAINER TERMINAL INFORMATION SYSTEM – GTK IS

Gdansk Container Terminal (Dzieliński et al., 2002; Dzieliński et al., 2003) is one of the main terminals in the port. Its present throughput is about 40000 TEU, but it is still under development as the container traffic is increasing. Moreover, there are

plans to build a completely new container terminal with a much higher handling capacity. For the purposes of development of an existing terminal a simulation-based approach seems to be an attractive way of predicting, planning and designing (Amborski and Dzieliński, 2002). Therefore, it is interesting to show the interaction of the existing GTK IS with the simulation software used in the terminal. In this section the main features of the GTK IS are presented.

The existing GTK IS has the following main functions: database supporting terminal management and terminal partners; container handling software system for container pickups, deliveries and customs clearing. It delivers information for terminal management, planning, control and connectivity with the port community. The system provides terminal operators with the simple tools they need to efficiently and cost-effectively manage all areas of a terminal operation, including container inventory, import and export transactions, gate operations, statistical reporting, and Web-based customer service (in the near future).

Main users - partners:

Forwarders:
- notification of containers
- container service status control

Terminal dispatcher's office:
- all documents concerning container operations entry and processing;
- status of containers control: notified containers, IN and OUT operations, storage control etc.
- uses container details like size, weight, vessel, and discharge port to automatically select the most logical storage location for each container. This helps to organize the terminal yard in a way that reduces the need for re-handling;
- almost real time data entry to drive the processes accurately. Decision on where to put a box should be made as it comes in through the gate when all the information is available to make the right decision;
- dispatcher can match containers with owners and consignees, specify container slots, issue sequential work assignments to yard equipment operators and give truckers selected points for pickup and drop-off;
- optimizes time and yard (depot) space;

Port Chief Dispatcher's Office and Terminal Management Requirements:
- automatic data transfer (once a day reporting): loaded and unloaded containers;
- cargo in containers
- statistics & analysis.

Customs Office Requirements - data exchange.
EDIFACT Messages for/from shipping lines: generating & processing.

Future development:

- transmission of standard electronic messages from various port users - replacing paper documentation currently received and reviewed upon delivery or release of containers at the port gates.
- forwarders, customs agents and trucking companies will send advance notice of transactions, including details of the driver and truck that will handle the transaction, so that the system will have the necessary information available to process before the truck arrives at the port terminal;
- new handling and ICT technology makes the port or terminal's container volume going up, and up. In one year (last year of being involved in this business) container load went up from few thousand TEU to more than 40,000 TEU;
- new functions of the system for further development.

GDANSK GENERAL CARGO TERMINAL OPERATIONS – PGE IS

Another important terminal at the Port of Gdansk is the one which handles general cargo - PGE. Main PGE Terminal features are as follows:

- handles every type of non - containerized cargo including general cargo, ro-ro (+ personal vehicles), bulk commodities, steel, grain, dry bulk materials, heavy lift and special vehicles;
- can handle any type of forest products, palletized cargoes, bagged cargoes, and more (has been developed to handle break-bulk and general cargo);
- PGE is a very large (in terms of area covered) terminal with storage and warehousing space for light manufacturing, an active foreign trade free zone etc.

The main functions of the PGE Information System include: data base supporting terminal management and terminal partners. The system provides terminal operators with the simple tools they need to efficiently and cost-effectively manage all areas of a terminal operation, including cargo inventory, import and export transactions, gate/rail operations, statistical reporting, and Web-based customer service (in the near future).

The "PGE-IS" operating system is to coordinate the loading and discharge of cargo with the right workforce, equipment, trucker/rail wagons, warehousing, empty storage/sheds and documentation.

Cargo Information Services will provide EDI and web services on cargo bookings, freight releases, delivery data and import/export information

Main users - partners:

Shipping agents:

• notification of vessels and cargo (Import)

Forwarders:

• notification of vessels and cargo (Export)

• cargo loading/unloading status control

Terminal dispatcher's office:

- all documents concerning cargo operations & entry to the port and processing;
- status of cargo control: notified cargo, storage In and Out operations, inventory control etc.
- Dangerous Cargo storage and inventory;
- uses cargo details like size, weight, vessel, and discharge port to select the most logical storage or vessel location for each cargo. This helps to organize the terminal yard in a way that reduces the need for re-handling;
- almost real time data entry to drive the processes accurately. Decision on where to put cargo or moor the vessel should be made as it comes in through the gate or through the approach channel when all the information is available to make the right decision;
- dispatcher can match cargo with owners and consignees, specify trailers (ro-ro), issue sequential work assignments to yard equipment operators and give truckers or railways dispatcher selected points for pickup and drop-off;

• optimizes time and storage space;

Port Chief Dispatcher's Office and Terminal Management Requirements:

- automatic data transfer (once a day reporting): loaded and unloaded cargo;
- dangerous cargo;
- statistics & analysis.

Customs Office Requirements - data exchange.XML/EDIFACT Messages for/from shipping agents and forwarders: in future - generating & processing.

Future development:

- transmission of standard electronic messages from various port users - replacing paper documentation currently received and reviewed upon delivery or release of containers at the port gates.
- forwarders, Customs agents and railways/trucking companies will send advance notice of transactions, including details of the driver and truck that will handle the transaction, so that the system will have the necessary information available to process before the truck/ train arrives at the port terminal;
- new functions of the system for further development:

It is worth mentioning that the simulation software thus far used mainly in GTK can be without too much effort also integrated into the PGE IS environment.

GDANSK CONTAINER TERMINAL SIMULATION SYSTEM

In this section we describe the use of port Process Simulator, to simulate the operation of the Gdansk Container Terminal. As mentioned above also the operation of other types of terminals can be easily simulated using the same tools and environments. The main activities described so far were aimed at simulation-based analysis of the current container terminal operations, at the identification and evaluation of possible improvement variables and criteria, and at the simulation-based improvement of the logistics processes (Amborski and Dzieliński, 2002).

The work on the simulation of real port operations started with the Ulster's Port Process Simulator described in (Dzieliński et al., 2002; Dzieliński et al,. 2003). As it is generic in nature, the simulator needed quite a lot of work in order to customize it for the use at a particular harbor environment, i.e. the Port of Gdansk.

Upon completion of customization, the simulation program represented the port operations in general and Gdansk Container Terminal in particular. This way we could come to the main issue of our work, i.e. the simulation of the Gdansk Container Terminal operation and its simulation-based improvement. However, at first it has been necessary to evaluate the simulator itself in terms of its accuracy in representing the real operations of the terminal.

One of the issues in question here was whether the simulator could represent the real state of the Container Terminal operations. To answer this question we assumed as an hypothesis that the Port Simulator could accurately describe the operation of the terminal, provided the simulator with real data obtained from container terminal, and made two statistical verification tests: the Pearson's and the Kolmogorov's test.

Gdansk container terminal – a case study of simulation-based approach

The Container Terminal at the Port of Gdansk is a large and complex, living organization. Inside this structure we can see logistic processes at many levels of terminal operation. For us, the important

processes are located at the highest level – main logistic processes. The main logistic processes of the Gdansk Container Terminal are described at the simple scheme presented in figure 1. In the simulations we have considered five main processes (the total number of simulated processes is hard to evaluate, because some of them are composed of several sub-processes making a complete model of simulators):

- import / export cargoes from sea to land side,
- moving cargoes between ships and yard,
- moving cargoes between yard and land vehicles,
- process of ships service,
- process of land vehicle service.

These processes are operating with a large number of variables, mostly invisible for simulator users (because these variables are based on the simulator internal events, which are not important for the user).

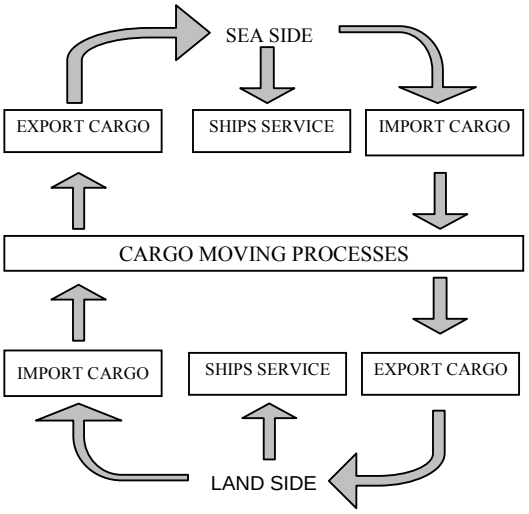

Figure 1: Container terminal logistics processes

SIMULATION OF DIFFERENT SCENARIOS

After obtaining the knowledge of the real state of the Gdansk Container Terminal we decided to build a suitable simulation model. This model was used to produce a simulation called 'BASE'. The results from the BASE simulation represent real state of the Terminal. Generally, the following algorithm was used:

a) get real state data,

b) make a model,

c) make a simulation,

d) verify the simulation results with real state,

e) if verification is not satisfied, modify the model and go to point 'c',

f) modify ONE variable or criterion at BASE simulation,

g) make a new simulation,

h) analyse the differences between Base simulation,

i) go to point 'f'.

Notice, that only one variable is changed at one time. Different scenarios are customized as models derived from the BASE model by changing one variable or criterion. It is then possible to generate a large number models of that kind. To solve this problem in our investigations we have concentrated on the following areas of port activities:

1. berths,
2. yard,
3. gantry cranes,
4. container ships,
5. yard gantry cranes,

From several scenarios representing the above groups of activities we describe here three exemplary scenarios. More examples can be found in (Dzieliński et al., 2003).

Scenario one:

From time to time rail wagons at the land side of the terminal wait a long time to be served. The Terminal Authority decided to increase the number of rail tracks by one. How does that impact the rail wagons service time?

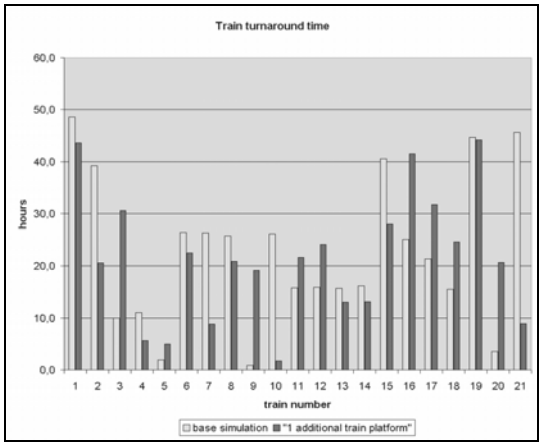

Figure 2: Train turnaround time for scenario one

The results of this study are shown in figure 2. The third train platform has no surprising effect. There are some changes in the trains turnaround times but their impact is minimal.

Scenario two:

Terminal cranes have malfunctioned and are working with maximum 50 % of their efficiency. Analyze the influence of such an event to cargoes transport efficiency. This time we are in an emergency situation. Some parts of cranes are damaged and non-functional. Of course, there is small probability of damage of all cranes because of container terminal existing tree cranes:

a) Mobile Crane 'Famak One' (KONE type)
b) Mobile Crane 'Famak Two' (KONE type)
c) Mobile Crane Liebherr

Possibility of damage of all three cranes is very small.

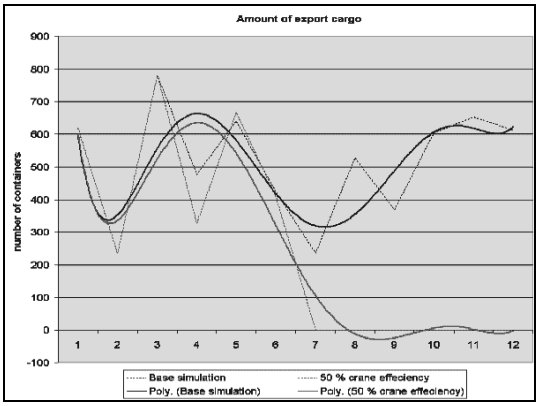

Figure 3: Amount of export cargo for scenario two

The results of this analysis are shown in figure 3. One can see that the number of ships served by terminal decreased. As might be expected, in a wide range of time, number of ships served by terminal is halved.

Scenario three:

This is similar situation. At this time the Terminal Authority decided to increase the length of the existing rail tracks.

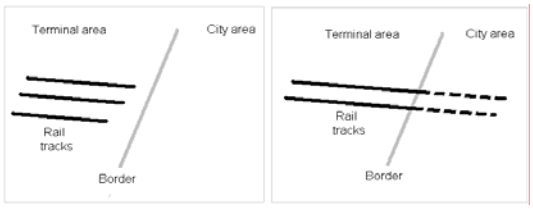

Figure 4: Differences between conceptions of length improvements of rail tracks

Notice that in the existing terminal structure an increase in length is more difficult option. One can see the results of this simulation in the following graph:

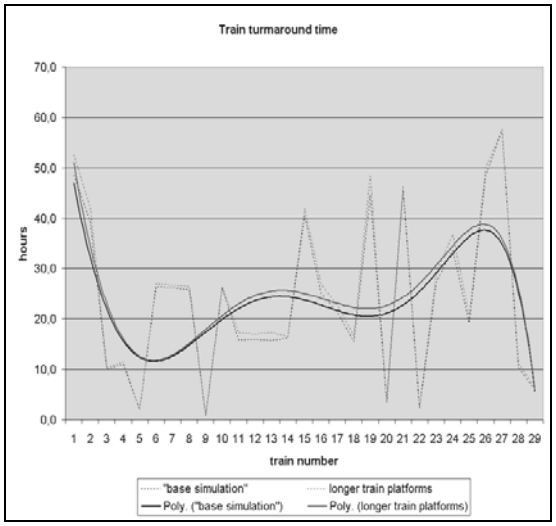

Figure 5: Train turnaround time for scenario three

No significant effect can be observed, possibly because the increase in the length of the train platforms is not large enough.

SIMULATION RESULTS

The simulation results were analyzed from the point of view of possible recommendations to the GTK management. These recommendations were meant to improve the operations of the terminal with the most cost-effective measures.

The analysis is performed using a MS Excel application. The output data from the simulation (after post processing) are imported into a spreadsheet. In the next step graphs are generated to visualize the change of the variable under consideration. At the beginning graphical sheets are best suited for general analysis. Trends and dependencies between variables can easily be seen and interpreted. More in-depth analysis can be achieved using the computational capabilities of MS Excel formulae for better accuracy.

In summary, the simulation results provide some guidelines as to how to proceed for the improvement of port operation. Several factors, like number of berths, number of port basins, number of gantry cranes, among others, were taken into account and one may notice the influence of new investments in the port infrastructure, aqua structure and equipment on the operation capabilities. The results obtained are preliminary, however they clearly show that some investments in the existing terminal equipment and set-up can significantly improve the performance in terms of loading/unloading time,

ship queue or number of shipments (Amborski, 2004).

The partners from the Gdansk Container Terminal developed a business strategy for GCT. In the near future they will plan several investments. It is expected that the simulator will also be a useful tool to analyze these future investments. The GCT Authority is especially interested in the following results from simulations:

- Amount of import cargo
- Amount of export cargo
- Vehicle turnaround time
- Number of shipments in
- Total amount of cargo
- Mean number of units of resources allocated
- Number of customers who had to wait

These factors are especially useful from a practical point of view. Cargo flow and ships movement are very important for every manager who works at the container terminal.

There are two possible investment areas to be considered in the near future:

Area one – Quay.

Current length of quay is suitable to serve any type of vessel (in the Port of Gdansk). But the terminal can serve only one ship at a time. To save customers time and expand the overall terminal operability the Port Authority plans to enlarge the length of quay. The simulation confirms that longer quay will be able to serve two ships at one time.

Area two – Handling equipment

Currently in the terminal there are three 'ship to shore' type cranes. This number is enough for current quay and cargo movement. However, as simulations show the increased length of quay force the terminal operator to increase the number of cranes. Two cranes at two berths will be optimal.

Area three – Yard

Higher level of cargo movement determines higher level of yard usage. Since, according to the simulation results the current yard area will not be enough it will need expansion. Fortunately it is not a serious problem to expand this area. The terminal Authority reserved suitable land for future expansion of the yard.

CONCLUSIONS

A simulation-based approach has been used to analyse and improve the logistic processes in the Port of Gdansk. The part of port under consideration was the Gdansk Container Terminal, and the simulations were designed to reflect the traffic of containers in the terminal. The simulation software used is a part of the information system used by GTK. The Port Process Simulator adopted, after customization, proved to be a useful tool for assessing and predicting the behavior of the container terminal. After the verification of the simulator using real data, the tool has been used to simulate the present operation of the existing terminal. The simulation results formed a reference point for further simulation-based considerations. Based on this reference, several operation scenarios have been prepared and fed to the simulator. Each simulation scenario took into account changes in one of the important terminal variables at a time, without changing other parameters. This way the analysis of the simulated scenarios gave the justification for possible changes in the organization or new investments plans for the terminal. This allowed to prepare the recommendations to the terminal management on how to improve the operation and the logistics of the terminal. This type of simulation-based approach may also be used as a design support tool for the new container terminal, which is now under preparation in the Port of Gdansk (Amborski, 2004). This terminal with a significantly greater throughput and situated in the Northern Port part of the Port of Gdansk will eventually replace the existing one.

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