

# SIMULATION OF OPERATION OF A MEDIUM SIZED SEAPORT. CASE STUDY: PORT OF GDANSK

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## KEYWORDS

Maritime application, port operation, container terminal simulation

## ABSTRACT

This is the description of the activities and results obtained while performing the task 4.2 in the BALTPORTS-IT EU FP 5 project. The aim of this task is to improve the logistics processes at the Port of Gdansk using the simulation-based approach. The simulation has been used as a support tool to analyze the existing container terminal (Gdansk Container Terminal). In the future the tool will be also used to support the design of a new container terminal.

## TOOLS AND METHODOLOGY

The simulation-based approach has been divided into several steps. At first we had to make a selection of tools and build a methodology for further activities. After an introductory analysis it was decided to use a custom-built software tools for simulating the port activities. This was the only kind of tools that could possibly meet our requirements. The general-purpose simulation software was considered as not appropriate in this case. The research team composed of WUT and Port of Gdansk members was given a simulation application – port simulator, an analysis, simulation and visualization program. However, it lacked several important features from the point of view of achieving our goals and it had to be substantially improved. One such improvement was prepared by WUT team at the beginning of the project. We have developed a small, but very helpful application for translation of output files. Other improvements are still under construction by UU team.

Our work within the task 4.2 of BALTPORTS-IT Project was concentrated on nine main steps explained below:

- Get the knowledge of the tools and develop short manuals for simulation program,
- Develop an example input data for first simulations,
- Make the example simulations,
- Process, analyze and visualize the results of above simulations,
- Get the real input data (existing infrastructure of Port Gdansk) for simulations,
- Make the simulations with real input data,
- Verify the simulation model by comparing the simulation results with existing situation,
- Perform optional system calibration,

- Run suitable 'final' simulation

## Port Simulator

A port simulation application is a large and powerful analysis tool for port logistic processes. However, it is still under construction and needs a lot of care and attention when being used. Simulator gets input data about port, runs simulation and provides statistic output data. Input data is divided into two categories:

- global point of view data, global relations of complex port's operation,
- local point of view data, more detailed, corresponding to particular port's elements.

Every simulation run is divided into several sequences, performed one by one.

- Read-in port's maps and calibrate them,
- Locate the approaching paths, port's channels, basins, etc.,
- Enter types and numbers of cargoes,
- Define port's terminals and land infrastructure,
- Define vehicles,
- Enter global data i.e. flexibility of terminal personnel working hours,
- Define the end time of simulation,
- Run simulation,
- Write simulation results to output files.

Examples of simulation sequences screens are presented below on Fig.1-4.

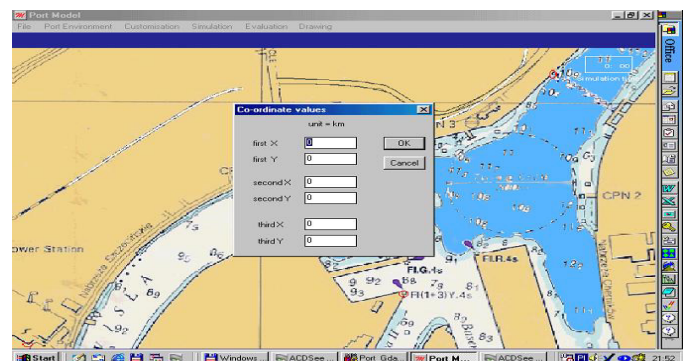


Figure 1. Calibration of Port's map

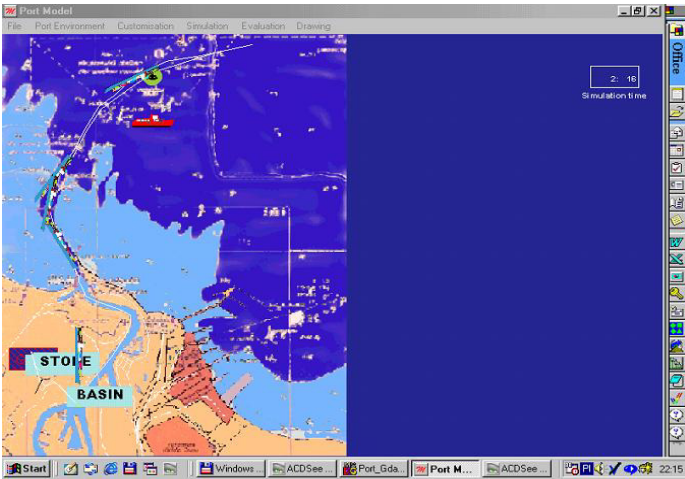


Figure 2. Approaches view, Port's seaside map

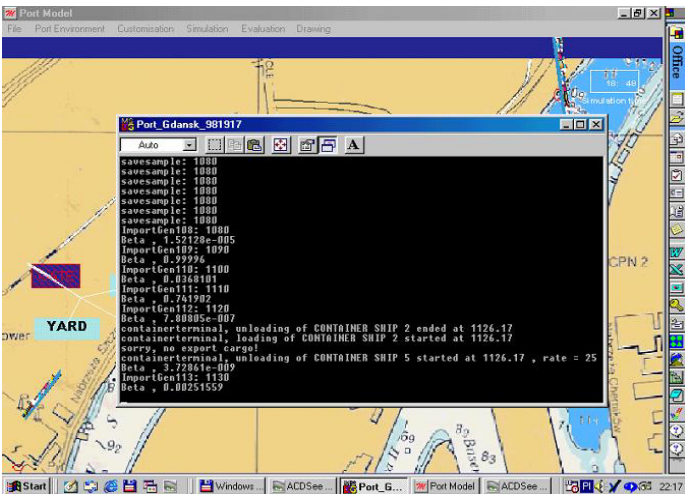


Figure 3. Direct output of the simulation data to console window



Figure 4. A map of the infrastructure of small container terminal.

On Fig.4 one can see from the right hand side: store, yard, gate and from the left-hand side: basin, channel, etc.

### MS Excel Application

As a data analysis tool a MS Excel spreadsheet has been used. MS Excel is a powerful application, useful for making various kinds of calculations. With Excel we can do analysis of numerical data and view the results in wide range and number of charts. We have decided to use this application because it is widely used for similar purposes, it is easily available and the spreadsheet is a really universal tool. In the beginning of work, Excel capabilities were used in the following way. Output files from simulation, past preprocessing are imported directly to spreadsheet. This is the base for calculations of demanded factors, making charts, data regrouping in sets.

1	2	3	4	5	6	7	8	9	10	11	12
name	period	period number	period end time	cargo type (queue)	number of shipments in	mean of number of shipments in	standard deviation of number of shipments in	variance of number of shipments in	time weighted mean of number of shipments in	time weighted standard deviation of number of shipments in	time weighted variance of number of shipments in
sklad1l	period	1	1440	kontenerQ	2,000	1,500	0,500	0,250	0,690	0,743	0,552
sklad1l	cumul	1	1440	kontenerQ	2,000	1,500	0,500	0,250	0,690	0,743	0,552
sklad1l	period	2	2880	kontenerQ	0,000	0,000	0,000	0,000	2,000	0,000	0,000
sklad1l	cumul	2	2880	kontenerQ	2,000	0,750	0,250	0,125	1,345	0,371	0,276
sklad1l	period	3	4320	kontenerQ	1,000	3,000	0,000	0,000	2,935	0,247	0,061
sklad1l	cumul	3	4320	kontenerQ	3,000	1,500	0,167	0,083	1,875	0,330	0,204
magazyndl	period	1	1440	kontenerQ	0,000	0,000	0,000	0,000	0,000	0,000	0,000
magazyndl	cumul	1	1440	kontenerQ	0,000	0,000	0,000	0,000	0,000	0,000	0,000
magazyndl	period	2	2880	kontenerQ	0,000	0,000	0,000	0,000	0,000	0,000	0,000
magazyndl	cumul	2	2880	kontenerQ	0,000	0,000	0,000	0,000	0,000	0,000	0,000
magazyndl	period	3	4320	kontenerQ	0,000	0,000	0,000	0,000	0,000	0,000	0,000
magazyndl	cumul	3	4320	kontenerQ	0,000	0,000	0,000	0,000	0,000	0,000	0,000

SIMULATION 1											
sklad1l	period	1	1440	kontenerQ	2,000	1,500	0,500	0,250	1,155	0,870	0,757
sklad1l	cumul	1	1440	kontenerQ	2,000	1,500	0,500	0,250	1,155	0,870	0,757
sklad1l	period	2	2880	kontenerQ	1,000	3,000	0,000	0,000	2,416	0,493	0,243
sklad1l	cumul	2	2880	kontenerQ	3,000	2,250	0,250	0,125	1,786	0,682	0,500
sklad1l	period	3	4320	kontenerQ	1,000	4,000	0,000	0,000	3,429	0,495	0,245
sklad1l	cumul	3	4320	kontenerQ	4,000	2,833	0,167	0,083	2,334	0,619	0,415
magazyndl	period	1	1440	kontenerQ	0,000	0,000	0,000	0,000	0,000	0,000	0,000
magazyndl	cumul	1	1440	kontenerQ	0,000	0,000	0,000	0,000	0,000	0,000	0,000
magazyndl	period	2	2880	kontenerQ	0,000	0,000	0,000	0,000	0,000	0,000	0,000
magazyndl	cumul	2	2880	kontenerQ	0,000	0,000	0,000	0,000	0,000	0,000	0,000
magazyndl	period	3	4320	kontenerQ	0,000	0,000	0,000	0,000	0,000	0,000	0,000
magazyndl	cumul	3	4320	kontenerQ	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Figure 5. Formatted simulation results in Excel window

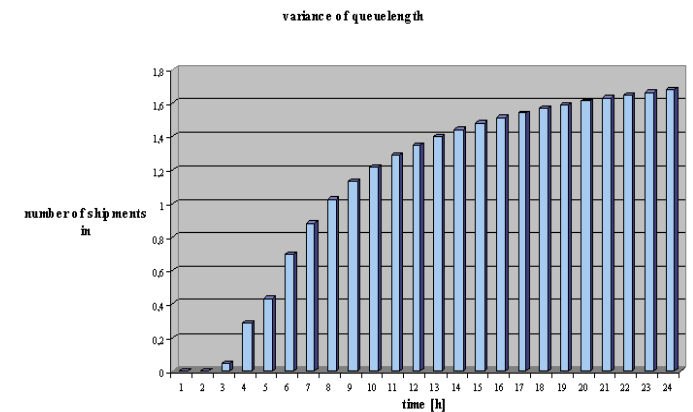


Figure 6. Changes of an example factor 'variance of queue length' (as a function of time)

### MS PowerPoint Application

Simulation results are compiled in sets of factors and various types of charts. To present this we convert these to the set of slides using the format of Microsoft PowerPoint presentation, a program that we are using to make slideshows. This solution reduces the costs, of preparing the presentations and also allows a simple distribution of presentation files, because of the widespread use of MS Office package.





## WHAT PORT SIMULATOR CAN DO?

A simulation program generates four output files. All of these files have standard ASCII text format:

- 1) file containing data of storage and yard usage, StorData.out,
- 2) file containing data of terminal equipment usage, ResData.out,
- 3) file containing data of simulated vehicles usage, Vehcall.out,
- 4) file containing some additional information, results.txt.

Files one to three contain more than ten specific factors. These factors are related to simulated parts of port (storage, crane, quay, etc.) at the constant time interval. Below we can see the list of the most important factors contained in the reports, in example week-reports.

### Set of output files factors

a) file StorData.out

factors in:

- number of shipments in
- mean of number of shipments in
- standard deviation of number of shipments in
- variance of number of shipments in
- time weighted mean of number of shipments in
- time weighted standard deviation of number of shipments in
- time weighted variance of number of shipments in

b) file ResData.out

factors in:

- number of times number of units of resource allocated was updated
- mean of number of units of resource allocated
- variance of number of units of resource allocated
- standard deviation of number of units of resource allocated
- time weighted mean of number of units of resource allocated
- time weighted variance of number of units of resource allocated
- time weighted standard deviation of number of units of resource allocated
- number of customers, which had to wait
- mean of queue length
- variance of queue length
- standard deviation of queue length
- time weighted mean of queue length.

c) file Vehcall.out

factors in:

- DWT
- Draught on arrival at the port
- Draught on departure from the port.
- Arrival time at the pilot on the approaches
- Anchoring times on the approaches if it takes place
- Arrival time off berth
- Arrival time at the berth
- Start of unberthing procedures
- Departure time from the berth
- Departure time after leaving the pilot on the approaches
- Time used for clearing of the vessel and crew.
- Vehicle turnaround time

As we can see all the usable output data are statistic data. On the basis of this data it is possible to make statistic analysis of port's functionality (like a complex organization and separated parts).

## PRACTICAL CONCLUSION OF SIMULATIONS

Using the port simulator plus above tools (in full functional versions), the methodology assumed and suitable (realistic) input data we can support re-engineering processes referred to infrastructure of Port Gdansk. We can give the answers to questions like: "what will happen when ..." in statistic sense, i.e.:

- What would be the change in a ship waiting time to unload after an increase in the area of yard by 10%, 25%, 50%,
- What effect the reduction / increase of one gantry crane has on terminal functionality,
- How an additional road to the terminal improves the economic factors,
- What is the number of optimal front lift trucks in current container terminal.

Figure 10 contains an example of analysis of change a number of berths with respect to change a number of ships served to the yard.

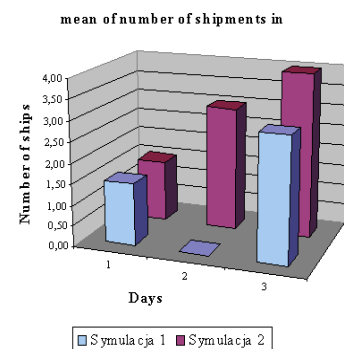


Fig.10. Example of analysis.

## CONCLUSIONS

The simulations performed give some guidelines as to how to proceed with port operation improvement. Several factors, like number of berths, number of port basins, number of gantry cranes etc. were taken into account and one may notice the influence of new investments in the port infrastructure, aquastructure and equipment on the operation capabilities. The results obtained are preliminary, but even they show clearly that some investments in the existing terminal equipment and setup can improve the situation significantly in terms of loading/unloading time, ship queue or number of shipments. The future work will be concentrated on the detailed simulation-based analysis of all the factors in question and their detailed effect on the port operation both in qualitative and quantitative terms. This will be possible when the new, improved version of the port simulator software is available.



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