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Introduction to BALTPORTS-IT: Applications of Simulation and IT-Solutions in the Baltic Port Areas

Eberhard Blümel, Fraunhofer Institute for Factory Operation and Automation (IFF), Magdeburg / Germany, bluemel@iff.fhg.de
Leonid Novitski, IDC Information Technologies, Riga / Latvia, idc@balva.lv

Abstract

The political changes in Europe have resulted in a rapid alternation of transport flows and of transport operations structure in the Baltic Port Areas of Associated Candidate Countries (Poland, Lithuania, Latvia and Estonia). The strategic use of e-work, advanced IT and simulation solutions provides real advantages in the development of logistic transport systems associated with Free Port areas. This paper provides an overview of the main results obtained in the project IST-2001-33030 BALTPORTS-IT "Simulation and IT Solutions: Applications in the Baltic Port Areas of the Newly Associated States" funded by the 5th IST Programme of the European Commission.

1. Introduction

The BALTPORTS-IT project is aimed at promoting and supporting the dissemination of knowledge gained during the execution of the successfully completed EC funded projects such as AMCAI, *Bluemel et. al. (1997)*, DAMAC-HP, *Bluemel et. al. (2000)*, and SPHERE, *Schmidt et. al. (1997)*, as well as its industrial utilisation and transfer of technologies, simulation models and information systems.
The political and economic of the future years in Europe require a major effort of reorganisation of logistic strategies of the Associated Candidate Countries (ACC). So it is very important to integrate the ports of these countries in European logistic chains. Necessary as well is an improvement of the ports´ competitiveness. Furthermore, Free Port Areas need to be developed in contrast to the now existing central control systems. Those Free Port Areas should be composed of port authorities, agencies, forwarders, trucking companies, stevedoring and insurance companies, customs authorities, banks, railway and warehousing companies. The infrastructure must be improved so that a fast and steady flow of goods can be guaranteed. In order to reach these goals, the partners want to re-design IT-processes and give simulation based decision support. The BALTPORTS-IT consortium consists of international partners from seven European countries, Fig.1. Scientists from universities and research institutes work together with experts from ports, maritime and IT-companies to develop methods and tools for the support of the reorganisation of Baltic Ports in the ACC.

Fig.1: Partners of the BALTPORTS-IT project

2. Objectives

The scientific objectives of the BALTPORTS-IT include:

- set-up of the Baltic sub-regional Competence Centre for promoting and supporting the distribution of research knowledge in the field of advanced IT solutions, logistics and simulation with maritime applications, Riga (Latvia);

- dissemination of research knowledge gained during the execution of the EC projects AMCAI, DAMAC-HP and SPHERE and regional projects in the field of IT-solutions and simulation of harbour managing;
- industrial customisation and exploitation of information and simulation systems by involving user groups;
- developing recommendations for the application of results and thus creating new market opportunities;
- creating opportunities for the training of specialists in maritime information systems design and port logistics by using web-based technologies and distance learning courses.

The results of the project include the industrial customisation of information and simulation systems in collaboration with user groups from the Baltic region in order to provide new approaches for:
- the non-monetary evaluation of general characteristics for port operations;
- the optimisation of logistic operations in container terminals;
- the optimisation of logistic processes in oil terminals;
- a methodology of marine information systems design.

3. Approach, solutions and technologies

The approach of the BALTPORTS-IT project consists of the following steps, Fig.2:
- customising the results of preceding projects (AMCAI, DAMAC-HP and SPHERE) for applications by generalising them;
- generalisation of the results of applications to find generalised methods for the redesign of IT-processes and simulation-based decision support;
- dissemination of the experiences made during the applications.

Customisation of simulation systems of container terminal operations and port processes as well as of maritime information systems obtained in the EC projects AMCAI, *Bluemel et al. (1997)*, and DAMAC-HP, *Bluemel et al. (2000)*, and the SPHERE-Project are among the main tasks of the project BALTPORTS-IT. Selected results are described in the following.

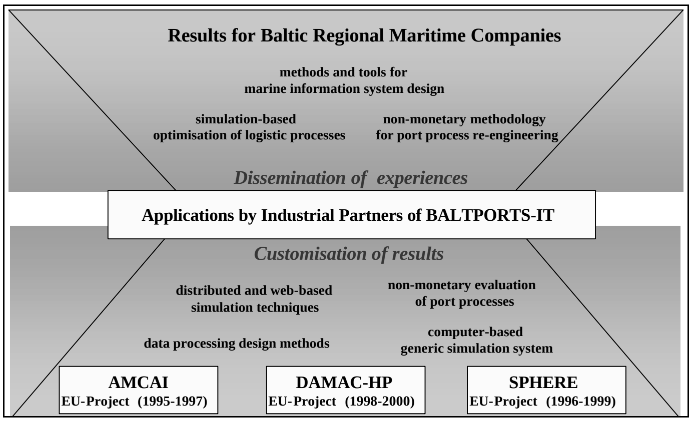

Fig.2: The approach of the BALTPORTS-IT project

4. Customisation of simulation and information systems

4.1. Application of simulation and modelling in Baltic port areas

Simulation was used for supporting managerial decisions at different levels of port operation planning and control, for instance, *Merkuryev et al. (2000)*:
- at the level of strategic planning, when designing a new terminal or redesigning an existing one: for the evaluation and comparison of different alternative decisions (e.g., related to planning terminal layout or updating terminal equipment);
- at the level of tactical planning, when optimising terminal operation by making decisions on management of resources (both labour and technical), taking into account schedules of vessels to be served during the considered period;

- at the level of operational planning and control, while planning the servicing of a specific vessel, taking into account cargo to be unloaded and loaded (e.g., berth planning, resource and yard allocation).

Simulation systems have been customised on the basis of the previous European and regional projects:

- the Baltic Container Terminal (BCT) Simulation System is based on a BCT simulation system that has been developed within the DAMAC-HP EU project;
- the Klaipeda Oil Terminal Simulation System is based on a simulation system that has been developed within a regional Lithuanian project;
- the Port Process Simulator is based on the SPHERE simulator that has been developed within the SPHERE EU project.

The considered simulation systems were customised in close co-operation with the port managerial staff in Riga (Baltic Container Terminal), Klaipeda (Klaipeda Port Authority and Klaipeda Oil Terminal) and Gdansk (Port of Gdansk and Gdansk Container Terminal), aiming to provide user-required characteristics of resulted simulation systems.

4.1.1. The Baltic Container Terminal Simulation System

The study concentrated on the logics of the basic technological and informational processes in the Baltic Container Terminal (BCT) serving operations. The modelling platform chosen was *Arena 5.0* of *Rockwell Software* since this software is well-suited for modelling statistically randomly distributed processes, which dominate in this model (e.g., vessel arrival schedule and the number of respective moves). This software also allows a good degree of dynamic visualization of process logics, which makes the model easy to comprehend and operate for users.

The logic of the BCT simulation system assumes a consequent rational detailed elaboration of processes, from general overview models down to more detailed ones with a developed hierarchical structure of embedded sub-models. The result of this approach, was the creation of a framework of four models, namely, *Merkuryev et al. (2002)*:

- *Model 1*: a general BCT model incorporated in the logical structure of agencies and other terminals (1st level of detailing);
- *Model 2*: a service processes model of every single vessel entering the port at up to three berths. This model portrays the logics of the simultaneous servicing of several vessels (up to three at a given time) and permits user changes in workload schedules as well as changes in the productivity of each individual resource;
- *Model 3:* a detailed model of every separate berth portraying in detail loading and unloading during every single move (container unit and re-stow containers) for a single vessel;
- *Model 4*: a detailed model of loading and unloading processes (included hatch covers) with underlying resource allocation and their monitoring with accuracy of up to 1 second.

Verification was performed using several traditional approaches including a walkthrough and involved independent as well as terminal specialists at both operational and managerial levels. Terminal management refined and approved the program logic, *Merkuryev et al. (2003)*. The model was calibrated by adjusting results from field measurement for time-lengths of the main technological operations to actually observed cycle times of terminal equipment. The model can be applied as a practical tool to assist management teams in the following tasks:

- real-time visualisation (monitoring) when changes in the BCT database are periodically transmitted to the model, which depicts the changes graphically;
- forecasting. Using the given input data, the model is run for k times, producing accumulated statistical averages and confidence intervals for future decision-making;
- statistical what-if analysis. A support tool for management to train personnel by simulating and analysing diverse work situations;
- adaptive control of vessel loading and unloading:
  ? the model is run with the input data corresponding to the incoming vessel queried from the BCT database,
  ? start/stop times of operations are recorded,
  ? at determined points in time, the manager queries the database and compares current data with

forecasts,

- ? should there be significant deviations, the current data is used further in the model,
- ? the forecast parameters are determined,
- ? should the forecast be unsatisfactory, the resources in the model are changed and the model is run again with the current data from the database,
- ? this algorithm is followed until an acceptable solution for resource use is found.

The BCT Simulation System was developed by the team from Riga Technical University (V.Bardachenko, Y.Merkuryev and A.Solomennikov) and the BCT (F.Kamperman).

4.1.2. Distributed and Web-based simulation

Web-based simulation is an approach in the area of simulation that combines general Internet-based technologies with simulation tools and methodologies. The main focus in this approach is the forms of the general architecture and their applications in the framework of harbour models.

The basic web architecture is a client-server structure and specific architectures for web-based simulations are instances of this basic structure. The simulation software user is the client and interacts with different servers:

- Remote execution of existing simulation models – The client invokes a web browser, specifies input parameters of the simulation model in a special HTML document, submits this document to the server and starts the simulation machine on the server. Rather little model flexibility is provided for the user. Time consuming simulations can be executed on high-performance simulation servers;
- Local execution of downloaded simulation models – The server operates as an applet server. The complete simulation model is downloaded to the client site and is executed locally. The simulation program must be executable in the heterogeneous computer environment (e.g. simulation programs based on Java applet);
- Execution of a modifiable downloaded simulation model – This is an extension of the previous two examples. The server operates as a model repository or a file server that provides the simulation model source code . The client can modify the model. The model is executed either locally (if the appropriate simulation system is available) or remotely on an application server. This way, not only data but also the source code of the model is sent to the server;
- Download of input data – The client owns the simulation model and the server acts as a data server that offers special input data for the simulation (e.g. state of the real system).

Having described the general architecture forms, the following three application oriented architectures for harbour models may be introduced:

- *Simulation-based information system* - Harbour authorities provide an information system for their customers. Since not all customer queries can be answered based on analytical methods, a simulation-based information system is used. The heart of the system is a simulation model of the harbour processes Customers cannot change or modify the model;
- *Internal model adaptation* – Simulation models are used for the day-to-day operation of the harbour terminal. They are used to evaluate system behaviour with respect to its capacity for new business parameters or changes in operating conditions. This allows harbour management to analyse throughput and identify bottlenecks. Models may need to be adapted to the new conditions. When this cannot be achieved by changing parameters, model source code must to be changed;
- *Preparing external data* – Simulation models may be supplied with information stored on an external server (e.g. weather and tide forecasts). In such a case, the simulation model operates as a client obtaining the information from the server.

HLA-based simulation. The distributed simulation approach provides interoperability mechanisms during simulation runtime. One of the most recent standards in distributed simulation is the High Level Architecture (HLA).

In the case of HLA-based simulation, two categories of interoperability can be considered:

- *Internal interoperability* – The simulation model is divided into several sub-models (federates) that usually run on different machines. This allows the flexibility to configure the simulation for different purposes and levels of detail;

- *External interoperability* – In addition to simulation federates, an HLA federation can also have non-simulation federates that are not directly involved in the simulation.

Taking into consideration the aforementioned possible approaches to maintaining interoperability in the harbour simulation environment, some particular solutions were examined. These solutions are based on experience gained at Gdansk Container Terminal, a part of the Port of Gdansk. So far, the simulation has been used in the harbour operations based on stand-alone solutions. However, as pointed out above the limits of this approach need to be overcome in order to increase flexibility and applicability. The increase in interoperability is thus a major issue in future modelling and simulation applications in the harbour. Simulation models have to be integrated using some form of distributed information technology so they can be used not only by the different, sometimes geographically separated departments in the Seaport Authority, but also by other companies, business partners and customers operating in the harbour area. Web-based and HLA-based simulation approach was proposed and evaluated by the team from Fraunhofer Institute in Magdeburg (M.Schumann) and Otto-von Guericke University Magdeburg (B.Gebert, T.Schulze).

4.1.3. Customisation of marine information systems

The analysis of marine information systems designing methods and tools allows outlining the problems that must be solved when creating appropriate methodology, *Ginters et al. (1998)*:

- involving users (customers) without special knowledge in IT area in the design process;
- using company business and data models;
- application of mathematical and simulation modelling to formalise different stages of the design and customisation processes.

Creating business models based on a preliminary information survey of an organisation is a necessary phase of information system customisation, *Novitsky et al. (2001)*. Building flexible information systems requires the use of an enterprise model and a model-based development approach, in which the information systems are built, based on the requirements represented in the model.

The methodology of business process design consists of the following stages:

- Information survey of an enterprise using the Business Systems Planning (BSP) method, *IBM Corporation (1975)*
  ? *Identifying the external environment*,
  ? *Identifying the internal environment*. This phase involves defining all the factors that influence the environment within which a business must operate at the present time and in the foreseeable future,
  ? *Business Planning*. The business plan defines objectives, competitive strategies, resource requirements and constraints for the organisation within the identified business environment,
  ? *Business System Analysis (BSA)*. The BSA identifies the structure of an enterprise, the functional areas, the functions and sub functions both in the present and in the future. The information required by these functions is analysed. User views are one source of information describing the data needs;
- Creation of formal business process specifications.

LIS Technology, *Ginters et al. (1998)*, or Piece-Linear Aggregate (PLA) mathematical formalism, *Pranevicius (1992)*, are employed at this stage. The methodologies were used to customise different information systems, Table I.

Table I: Applications of BSP, LIS and PLA

Enterprise / Application	Ventamonjaks	Klaipeda State Sea Port Authority	Klaipeda Oil Terminal	Insurance Company BALVA
Business process analysis and re-engineering	LIS	PLA	PLA	LIS, BSP
Simulation of oil terminal			PLA	
Incorporation of marine insurance IS into information management system				BSP, LIS

Customisation and application of marine information systems was done by the teams from Klaipeda University of Technology (KUT) and Klaipeda State Sea Port Authority (D.Makackas, V.Pilkauskas, H.Pranevicius, A.Zygus), from IDC IT and BALVA (L.Novitsky, V.Ragozin, M.Uhanova, E.Viktorova) and LIS and Ventamonjaks (E.Ginters, F.Rekners, A.Aumalis, L.Strujevics).

4.1.4. Other solutions

Among other solutions obtained within the frameworks of the BALTPORTS-IT project we can mention:

- Port Process Simulator from University of Ulster (F.-A.Schmidt, R.Yazdani). The idea behind the Port Process Simulator (PPS) is that a single software system in the form of a generic, customisable shell can simulate a complete port and its processes, i.e. infrastructure, suprastructure, aquastructure, equipment as well as the movements of ships and land vehicles. The simulator software can be applied to any port with the introduction of picture files of the port's approaches and layout. This is complemented by port-specific input data related to vessels, land vehicles and cargoes. The PPS has been applied to the ports of Gdansk, Klaipeda and Riga;
- The Klaipeda Oil Terminal Simulation System from KUT. The Simulation System of Klaipeda Oil Terminal evaluates two groups of characteristics. The first group of characteristics is used in queuing theory. Examples of such characteristics are occupation coefficients of embankments, platforms, reservoirs, etc. The other group of characteristics is used to analyse real-time systems, *Pranevicius and Makackas (2001):*
  ? Probabilities that a ship that has arrived finds the volume of oil needed,
  ? Probability that the time a ship remains in a harbour is less than some limit value, etc.
  To create the model of the Klaipeda harbour oil terminal, an aggregate approach was used to formalise terminal operation, *Pranevicius (1992)*. The ARENA simulation system was used to implement the simulation model software;
- A Non-Monetary Evaluation Methodology for Small and Medium-Sized Ports. The objective of the non-monetary evaluation methodology is to provide:
  ? A management and planning tool providing expressions of "usefulness" and indications of "how" and "where" to improve the efficiency of the port under investigation in terms of: its operational capability, and / or, its institutional, regulatory, managerial and operational frameworks,
  as regards local conditions and the expectations of the port community or the port authority involved.
  The anticipated results are:
  A generic methodology applicable to small and medium-sized ports supporting their operational planning and management by providing:
  ? Lists of port system components,
  ? Values describing the presence and operational performance of components,
  ? Ideal values or criteria for components,
  ? Preferences for components depending upon their contribution to the port system,
  ? Expressions of "usefulness" or utility,
  ? Indications of "where" and "how" improvements in the port efficiency can be achieved.
  A monetary economic appraisal of a port can only take entities into account that can be expressed in monetary terms. It cannot cater for the rather disparate nature of institutional, regulatory, managerial or operational frameworks involved in the management and the operation of a port or a terminal. Nor can it take account of the access to, the layout of and the cargo handling facilities existing in a port or terminal or the flows of commodities, vehicles, personnel and information. However, multi-attribute utility techniques (MAUT) are ideally suited for the task at hand and assisted in the required development on a "Non-Monetary Evaluation Methodology".
  During the project's workshops MAUT and its application were introduced by F.-A.Schmidt to personnel from the Port Authorities of Gdansk and Klaipeda and BCT to monitor the utility of the ports.

5. Setting up of the Baltic Sub-Regional Competence Centre in the field of logistics, advanced IT-solutions and simulation with maritime applications

5.1. Current state

The Baltic Sub-Regional Competence Centre (BSRCC) is a virtual structure aimed at bringing together industrial users, universities and research institutions around the common topic of, e.g. "Logistics, IT-solutions and Simulation with maritime applications".

Who can benefit from the services?

- Specialists in freight transport and freight transport related logistics;
- Port managers and port consultants;
- Specialists in IT-solutions;
- Specialists from companies operating in port areas in e.g. freight forwarding, stevedoring, banks, agents, insurance, customs, students and academic staff.

What are the services offered?

- Consulting in transport, logistics, marine insurance and IT-solutions, e.g. analysis of cargo flows, business process analysis and re-engineering, improvement of IT-solutions and facilitating business partnerships;
- Realization of research projects according to the requirements of user groups;
- Education: lectures, seminars and computer-based distance learning and training;
- Distance training courseware in logistics information systems;
- Providing simulation models of harbour processes to achieve more transparency of processes and to discover the potential for optimisation;
- Establishing a network of excellence for validation, generalization, and dissemination of research knowledge.

What are the advantages of collaborating with the Competence Centre?

- The BALTPORTS-IT project's partners can provide customers with different state-of-the-art solutions within a short time;
- A network of excellence created around the Competence Centre guarantees the necessary resources and high level of research;
- Collaboration with Competence Centre will help customers to increase the profitability of their businesses.

Power Point Presentations of the following solutions are accessible at the BSRCC Web-site (www.balticIT.com):

1. Simulation System of Container Terminal;
2. Port Process Simulator;
3. Simulation System of Oil Terminal;
4. Combining Simulation and Information Systems;
5. HLA- and Web-based techniques;
6. Non-Monetary Evaluation Methodology for Ports;
7. LIS Technology;
8. Marine Insurance Information System;
9. Teaching and Training in Logistics Information Systems;
10. Intermodal Database.

5.2. Prospects

During one of our next projects, for instance, eLOGMAR-M, the BSRCC infrastructure will be further developed and branch offices in the other Baltic States will be established. Another possibility for strengthening the role and possibilities of BSRCC is to include it in the project coordinated by Fraunhofer IFF/FhG, which is now under preparation. This project is devoted to setting up Trans-European Centre in Logistics and BSRCC could be considered as one of regional centres of the whole distributed offices' network.

6. Acknowledgement

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