Proceedings of the 1999 Winter Simulation Conference
P. A. Farrington, H. B. Nembhard, D. T. Sturrock, and G. W. Evans, eds.

OPERATIVE REQUIREMENTS AND ADVANCES FOR THE NEW GENERATION SIMULATORS IN MULTIMODAL CONTAINER TERMINALS

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ABSTRACT

The paper outline the evolution of container terminal requirements for simulation and the potential of new advanced techniques in the integration with these aspects; the authors present application examples and experimental results that maximized the impact of these new concepts in real complex port realities.

1 INTRODUCTION

Port Terminals are a very fast evolving reality: market changes continuously shift their attention to different issues and requires a very quick reaction capability.

In this are new active subjects are showing up and becoming very competitive just based on strategic boundary condition if their organization capability can successfully afford the market challenge.

The ports are very intensive production realities respect to regular facilities: 24h work time per day, 365 days working in a year, all-weather operations are just some of the stressing factor of this sector; port facilities involve big investments and require special operative and management skills.

From organizational point of view port activities involve so many entities that becomes very difficult to co-ordinate the teams (public authorities, maritime authorities, terminal operators, shipping companies, transportation companies, railways, labor unions etc).

In this sector the containers are obviously the most dynamic and complex to be manage: the meaning of complex here correspond to the possibility to get good profit margin based on a smart management, while errors can become very dangerous: just to provide a very direct example it sufficient to consider Rotterdam and Genoa harbours, in the beginning of ’70 the two realities was handling similar quantity of containers while after only 10 years Rotterdam traffic growth up to 10 time Genoa container movements (Fleming 1997).

Due to the complexity of container port management it becomes evident that the simulation can be very effective as support for this area (Bluemel 1997); at the moment the actors of this market and, so, the potential users of simulation are divided in two categories: large operators and new subjects.

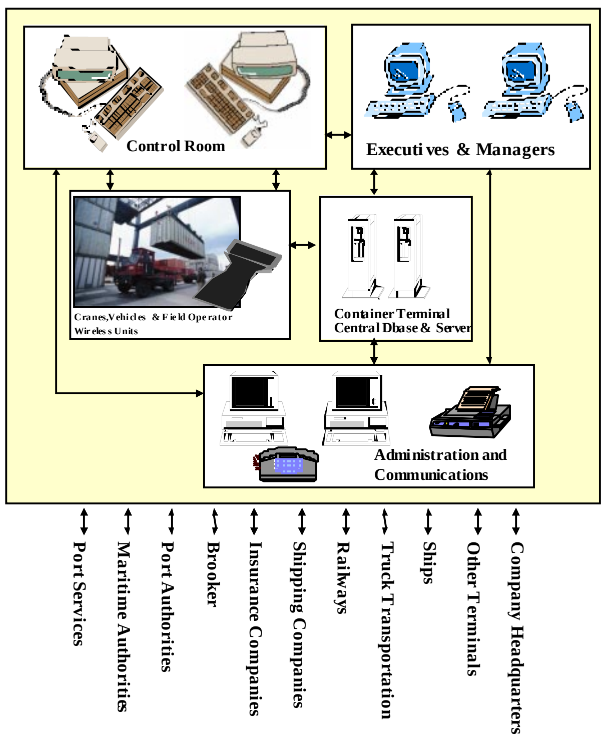

Figure1: Container Terminal Situation

The first ones are attracted by modeling just because in order to get continuous improvements in the service and costs they require to introduce new facilities and procedures in the pre-existing scenarios, so the impact of this changes need to be properly evaluated in order to guarantee the operative functionality.

It's very interesting to note that recently the major operators act several M&A (merge and acquisitions) on existing facilities in order to move to a world-wide terminal service from the traditional port based service.

The new subjects are very interesting potential users: the globalization today promote strongly new areas just based on market changes, and so new facility can become in short time very attractive for maritime traffics: to transform this potential in a real fact obviously it's requested a very quick and correct reaction so simulation study normally are required for supporting this targets (Bruzzone 1999).

Few years ago during a convention about harbour and maritime simulation the major private Italian ship owners point out that the theoretical cost for transport goods on a ship is reducing to zero due to a continuous ships dimension growth, however this kind of gigantic transoceanic traffic introduce new needs and requirements (Bruzzone et al.1996).

Today the traffic flow in European Ports, especially in Mediterranean area is moving very quickly increasing transshipment and feeder flow of containers.

The handling cost is going down for the improvements in communication and control and due to the high level of competitiveness among the different terminal and companies.

2 THE SIMULATION REQUIREMENTS

The authors will focus their attention in the emerging requirements for container terminal users.

In effect there are many tools and commercial simulation example focusing to container terminals (fig. 1); however mostly of them are just computational support devoted to the estimation of single operation (i.e. calculation of total ship time based on planning of operations). Therefore the terminal operation involves many interactions: many terminals, or at least the more interested in simulation, are operating with several cranes on several ships concurrently, and probably at the same time they complete import and export operation with trucks and freight trains (Koh et al. 1994).

The traditional packages normally support just operative short terminal planning considering each task as a stand alone procedure; for instance provide analysis and estimation related to a ship unloading/loading without considering interactions with other ship at the quay.

Obviously in the real system the interactions are the critical issues; some of the principal aspects involves:

- interference among yard cranes (i.e. transtainers)
- interference among dock cranes (i.e. portainers)
- interference among connections units (i.e. straddle carriers)
- interference among containers
    - Containers blocked by others on the ship
    - Containers blocked by others on the yard
- access problems (i.e. containers vs constackers)
- etc.

The complexity of the real port terminal requires non-linear modeling quite always, so the resulting models are not suitable for effects superimposition (Hayuth et al. 1994); due to these reasons isolated planning normally provides very approximated results and requires to be compensated by the large experience of human planners.

If we consider the organizational structure of a container terminal, as easily summarized in figure Figure1, it's evident that many subject are actively involved in the management with very peculiar targets; the simulation can be very useful for these actors however in order to multiply his effectiveness it necessary to create full scope simulators.

However the author's experience demonstrates that the operative constraints for simulation models in this sector are very hard to be satisfy creating large full-scope simulator; so the emerging approach is to create many different models, or to re-adapt existing ones, that will be able to interact in a general common framework (Bruzzone , Merkuriev, Novitsky 1998).

The interoperability issue in effect can downsize the development times and costs and at the same time improve the verification, validation and especially accreditation process of the simulator; this last issue is very important in order to transform the software tool in an effective decision support (Giribone et al.1994); the graphic and animation must be consider as a mandatory requirement to guarantee final users about consistency and correctness of the results both the during development and the operation management (Teo 1993).

The VV&A (verification, validation and accreditation) of a OO simulator or of a federation of simulator is a complex issue: in any case the final user needs to be involved in several tests and to receive completed and detailed documentation including:

- Simulation Effectiveness Boundary Ranges
- Confidence of Simulation Results
- Statistical Analysis of Stochastic Factors
- Independent Variable Description
- Target function Description
- User Manual
- Formal Description of Conceptual Model
- Statistical Validation & Verification
- Case Study Testing Report
- etc.

Summarizing some of the problems that can be addressed by computer simulation in port terminals we can identify several major categories:

- Supply Chain
  - Hub Structure Re-Organization (i.e. replanning of feeder activity of a group of terminals) (De Ruit et al.1995)
  - Facilities Improvement (i.e. evaluating multimodal transportation) (Bontempi et al.1997)
- Terminals
  - Equipment & Regulations
    - Design (i.e. design of a new facilities) (Ottjes et al.1994)
    - Re-engineering (i.e. adding a new equipment/system) (Mosca et al.1993)
  - Management
    - Operative (i.e. dock planning) (Mosca et al.1996)
    - Strategic (i.e. yard management policies) (Bruzzone A.1993)
  - Training
    - Operators (i.e. portainer drivers) (Bruzzone A. 1999)
    - Managers (i.e. yard planner) (Mosca et al. 1994)

The suggestion for the requirements is to generate specific models able to be both stand-alone and interoperable. Object Oriented Design and Analysis (OODA) could be considered a reference approach for modelling in this area, and it provides very good reward (i.e. reusability as demonstrated in the application example the it's proposed in the paper) for the additional development time, based on author's experience.

The simulation of harbour processes is normally based on stochastic discrete-event models, however combined simulation for some specific application is a growing sector (Nevins et al. 1998).

For the interoperability it suggested to pay attention to the new emerging and consolidating standards (i.e. High Level Architecture, HLA); these approaches however seem until now very dynamic and quite unstable in order to guarantee industrial investments so probably the correct approach is to integrate this concept, but to pay great attention to the operative issues considering regular industrial development time and costs. Efficiency of the models must be checked versus the possibility to become interoperable with other units, this will simplify the architecture improving the efficiency (Rizzoli et al.1997).

Terminal simulators frequently need to access large very dynamic database (i.e. optimization of yard problem, or design of a new automatic partking system) (Bruzzone A.G. 1993); this requires good efficiency and for this reason could be preferable to develop high efficient models instead than duplicating operative and strategic tools; in effect this second approach is often used in this reality, therefore the database access is pretty critical also for strategic issues due to the very dynamic nature of this market, so it is suggested to don't make large investments in developping simple high level models with no operation capabilities not directly linked with lower level units.

The link to the field requires probably to guarantee integration through low level routines in C/C++.

The maintainability of terminal simulator must be very good, due to the fact that frequently, based on author experience, they are continuously improved for be adapted to the evolution of the MIS.

It's interesting to note that until now the maritime sector don't seems very dynamically introduced in the ERP (Enterprise Resource Planning) revolution that characterize the manufacturing and service areas and that it is connected with Y2K (millenium bug) and globalization (multi-currency issues and Euro introduction in Europe); this is mostly due to the high robustness required for the port terminal MIS (Management of Information System) and the high level of current integration respect to other sectors; however in the future it is expected also a growth in the direction of fully integrated management systems so the simulator will be requested to be connected and interoperable with such systems.

The available performance on low level platform can maximize the diffusion of simulation tools also in port environment introducing the concept of desk simulators directly usable from decision makers for some evaluation and at same time feasible for conducting complex experimental analysis or optmization processes (Thiers et al. 1998).

Figure 2 provides a good example where to applied the above mentioned concepts.

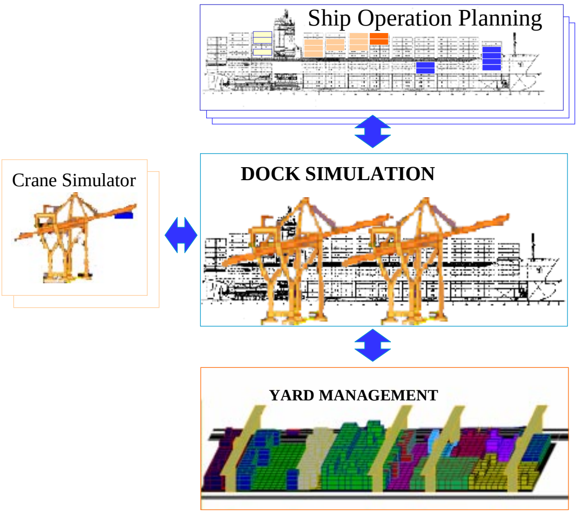

Figure 2: Integration Example for Dock Simulation

A dock simulator for container terminal needs to be integrated with operative planning of ships and yard management; a good approach could be to develop a model able to interact with three models: cranes objects, yard model and ship model; the optimization and operative support can be devoted to dock planning in stand-alone mode (for a draft and quick "what if" analysis), but it could be possible to estimate in this way also his combination with yard activities (for strategic analysis of container handling procedures or for effective optimization of the terminal.

The decision support and optimization for this area need to be based on advanced experimental statistical techniques, due to the fact that "what if" can't be sufficient for analyzing interactions among the factors.

3 ADVANCES FOR TERMINAL SIMULATORS

A winning characteristic is to have inborn the possibility to operate in remote way on easy accessible low level platforms and to several levels of the network. To think, in fact to a strongly integrated system, often induces to consider inevitable remarkable investments that sometime render precious and delicate the system, in so far as the effort to create approaches based on architectures of low level constitutes an effective guarantee for one capillary dissemination of the methodology.

Intranet/Internet are an optimal channel for handling most of the interactions among terminal stakeholders, at least where laws, regulations and security issues allow to use this channel; so the simulators for this application are expected to be able to provide web support in term of sharing results, interacting with multiple users, inter-operate with distributed models in a wide area internal or external network (Bruzzone et al.1998).

So web based modeling has to be considered one of the most reliable and immediate improvements for terminal simulators; his direct effect will be to spread-out in the whole community of stakeholders (internal and external) the direct use of simulation software without requiring special investments and installation.

The web-based approach can be very important to push forward in the direction of interoperability due to the cost saving that are related.

Obviously the security problems and the continuously evolving nature of languages and standards must be consider during estimation of development times as a potential obstacle; the author experience. in this application area, demonstrates that the gain can be much larger than the problems.

The use of AI (artificial Intelligence) integrated with simulation can provide a very powerful support for critical decision making (i.e. combined yard/dock planning) (Bruzzone , Signorile 1998).

4 AN APPLICATION EXAMPLE

The following real case proposed demonstrates as the evolution of the requirements and the complexity of the problem can be effectively afforded with the proposed modeling and analysis techniques.

Data are presented in anonymous format for their confidential nature, but they are related to an improvement project for a group of terminal in Mediterranean sea (Giribone et al.1996).

4.1 General Considerations

In the past a change appear in the analysis philosophy of transports management. It has been passed from a local approach- where every relation is studied stand alone and the results are combined based on linear hypothesis- to a wide area analysis in which the resources being are shared cooperating in order to guarantee a strong saving in terms of infrastructures and management. This new mentality demands the creation of coincidence networks able to support the proper management of parallels operations.

The requirements have evolved for guarantee a optimization not limited to some local aspects, but a process in a position to identify the best configuration of the system for improving the performance, considering in detail in an elevated number of factors and interactions.

As already seen in the previous paragraphs a reliable approach to the problem imposes a way to operate in a wide distributed area among, emphasizing the interoperability concepts, the parallel interactivity. The model is expect to resort to heterogeneous instruments that must find a mutual integration.

The authors present an example lead on a real case of maritime transport management and its facilities; the simulator package proposed was devoted to study different kind of maritime goods, especially the model was successfully used on containers and oil products.

The project, that has been released few years ago, introduces interesting cues of integration between simple models and interoperability to various levels; so it constitutes an interesting *ante litteram* example of the proposed methodology.

More recently the authors have been involved in the application of the above mentioned methodologies using new technologies in the port terminal sector and some project are on-going for more ambitious results: it's interesting to note that also if development time and the simulation efficiency are heavily improved for using more advanced tools, the basic simulation requirements and approach looks quite similar.

In effect the model is composed by several objects that grouped at intermediate level represents in effect a full port terminal: the hierarchical approach guarantee in effect to keep easy the component structure (also for complex entities such as a container terminal) and to combine that in a set of interacting simulators (today the word *federation* could be used very properly) just interacting in a wide framework as happen in the real system. The proposed system has been completely developed using OODA; the implementation based on OOP (Object Oriented Programming) maximizes the simulator coding and the possibility to integrate different author's pre-existing simulation libraries, objects and modules.

4.2 The Requirement Evolution

The project origins are pretty far from the final application where it was applied; in effect this simulator was commissioned in the beginning as support for VTS for new harbours by a radar company, after that it evolved in order to satisfy more wide users: it's interesting to outline that the proposed approach guarantee this flexibility allowing to address this new issues with low additional efforts in term of modeling and model verifying & testing.

In effect the original interest that has been found in the last years in the field of the vessel control systems it can be summarized as following:

- The necessity to avoid the serious pollution risks and to increase the navigation safety level;
- The knowledge that today technological elements of system had high reliability and good prices;
- To maximize and optimize the EDI (electronic data interchange) for ships and port management in order to reduce waiting times and costs.

So this simulator was developed as decisional support for port management and traffic analysis due to his capability to consider terminal operations as well as travelling issues. The evolution of model required to afford a more strategic issue related to regional area traffic analysis; in this case one of the more interesting problems to afford inside the simulation model, was the identification of area activity level and performance based on ship behaviour , good types and quantities etc. Such analysis concurs to resolve two different kind of problems: the first one, assigned to an area whichever to choice of the customer, to verify the cargo flows in transit and to determine if the area turns out strategically to the aims of the traffic. This analysis induces considerations on the opportunity to upgrade terminal structures and/or harbour facilities in order to reduce the waiting times and improve the whole regional efficiency. The second problem is related to the identification, analysis and check of zones related to an high density of traffic in order to reduce the overall risks (i.e. collision, domino effect in harbour accidents). Both these problems have been resolved by means of the definition of an Area Objects Network inside the simulation kernel and through the implementation of three control algorithms who concur to establish if the Object Ship is or not inside of an area. Finally this simulator turned out to become a support for identify the convenience of terminal equipment and management policy improvements.

In effect using this simulation package for addressing this question, obviously the final target function becomes much more interesting than just the local terminal optimization: the performance in effect in this case measure the effectiveness of the terminal under analysis respect other realities and considering cooperative relations with other ports in the area; in effect most of the large operators have several terminal operating in an area and evaluating improvements it's critical to identify how to reassign and balance the changes in their network and respect partners and competitors.

4.3 The Experimental Results

To realize a "Simulation Environment " means to be able to organize flexible simulation models, such way to integrate descriptions of processes and information available to different degrees of detail. Particular attention has been played in the development of the several interfaces between the objects that determine the maritime and land traffic during import/export operations. A hierarchical structure has been adopted and the system was designed to collect specific dynamics models and eventually new ones in relation to the real world requirements; the model has been designed also in order to be able to access real-time data from sensors and external real systems in order to get information about terminal and traffic existing situation. (Bruzzone, Giribone 1996)

In assuming a dynamic organization is therefore obvious the necessity to respect the criterion of the modularity. In the case in study it is assumed that the logic that determines the interaction between several the objects is events driven: a simulation engine has been developed in order to guarantee the synchronization of the different processes and the efficiency of the simulator.

The kernel of this simulator is a group of models that reproduces the evolution and behavior of the Maritime Traffic inside ports and terminals and outside during navigation and waiting times. The models that implement the harbor traffic management strategies have been interfaced with models that implement possible VTS systems (Vessel Traffic Supervision). At the same time analysis modules are included in order to supply indications about the system performances and information on the high risk areas situation.

In this approach Objects Oriented Programming has concurred the necessary operating flexibility allowing to have different scenarios and characteristics of the simulated environment. The system is constituted mostly by these components:

- Geographical Referencing System,
- Routing Generation and Allocation System ,
- Back Traffic Generation System (statistically based and stochastic driven),
- Planned Traffic Generation System,
- Harbor Operations Management System,
- Terminal Management Generator,
- Events Generation System,
- Navigation Module (Object Ship Behavior).

The simulation model is structured as illustrating in Figure 3. Starting from a geographic reference base, a harbor set, their terminal configuration, and a routes outline; for each ship the system start to simulated the various process and its connected operation. The geographic system allows to construct a graphical representation for the simulation results by reporting coordinates Latitude and Longitude. Two operating modalities are previewed: *extended model* run, where is possible to simulate the processes of income of the ship, approaching to the dock, start-up of terminal operations, loading - unloading, import and export and successive leaving the harbor; the other with *reduced model* run where it is assumed that the ships wait in the port a certain time defined on statistics module; this mode is devoted to study large areas traffic (i.e. all the Mediterranean oil or container traffic for one year).

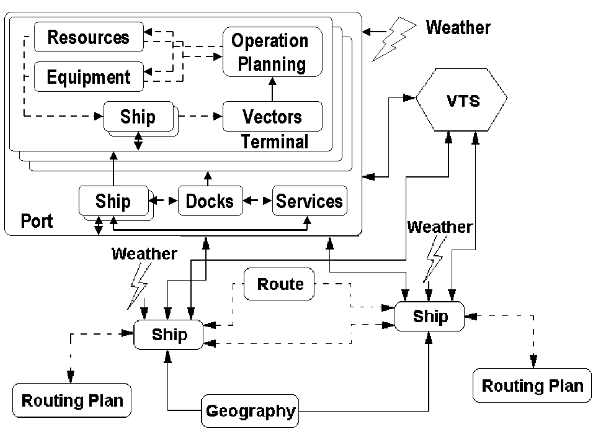

Figure 3: General Simulation Models Coordination

To statistically validate the simulation models integrated in this package it was used real historical data about goods traffic: for instance it was possible to check to model on the total oil traffic flow (raw oil, oils, hydrocarbons, gasoline, etc.) in all the Italian ports on base of data given by ISTAT (Italian Institute for Statistics); the authors have taken in account the 18 Italian harbors that process oil products and represents over 90% of the total traffic; these harbors corresponds to approximately 142 million long tons of oil traffic per year,. Opportune parameters were tuned inside the model in order to faithfully express the weather behaviour and stochastic events involved in the terminal activities. In order to speed-up this validation just three major ship classes have been considered, respectively:

- large tonnage ships - over 150.000 tons
- medium tonnage ships - 50.000 to 150.000 tons
- small tonnage ships - under 50.000 tons

Every single ship operation are simulated, berthing to the destination harbor in the correct terminal, loading and unloading activities considering the harbor service availability (i.e. tugs) and terminal availability (i.e. docks) and all the travelling issues.

All the operative times (i.e. loading and unloading) are introduced in according with opportune statistical distributions and characteristics. For every simulation run almost 70 ships in each of the three predefined origins (Gibraltar , Suez and Tunis) were generated with different intensities in relation to the effective market scenarios. To the aims of the statistically validation of the model it has been provided to achieved a series launches changing every turns the random seeds; every simulation run duration was in advance fixed in 500 days. The MSpE time behavior is presented in Figure 4 and indicate that system reaches the steady state after approximately 170 simulated days (Giribone et al.1994); the comparison with historical data provided matches exactly with the simulation results considering the corresponding statistical confidence band.

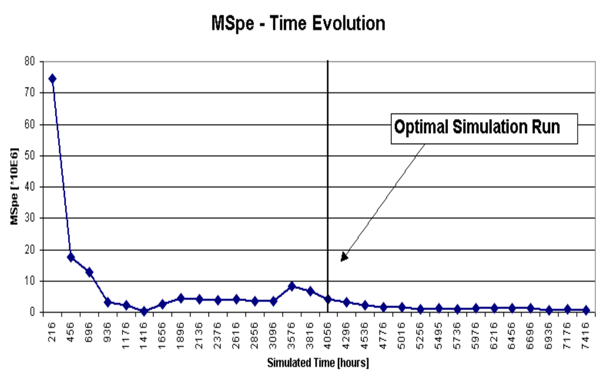

Figure 4: MSpE Time Evolution Diagram

Once statistically verified and validated versus historical data, the model has been tested in order to render it useful for the final users and scenario analysis. All the performed experiences and tests have confirmed the simulation package correctness so it has been completely validated and accredited, so it results completely ready for being used.

The following experimental campaign corresponds to an experimental analysis for studying container terminal improvement in a wide context.

In order to analyze the whole system and to build the response surface The proper approach to this problem, in order to consider high level interactions among the different independent variable is to plan simulation runs based on the Design of Experiments (DOE); in this case the authors proposes a simulation campaign based on Central Composed Design (CCD) (Bruzzone et al. 1998).

Table 1: Principal Effect Codification

Factors	**Variable**	**Meaning**
A	X1	Loading and unloading times
B	X2	Number of ships in the model
C	X3	Number of docks in the port A

Aim of the experimentation phase is to formulate mathematical relations that tie the input variable to the output ones and identify the proper influence of each factor and their combinations on the target functions.

The relationship that is working between the output variable and the independent ones can be metamodeled by the Response Surface Methodology (RSM), using the regression techniques. In order to approximate such function it has been chosen a 2nd order surface according to the follow indicated model.

$$Y_n = \beta_0 + \sum_{i=1}^{k} \beta_i X_i + \sum_{i=1}^{k} \beta_{ii} X_i^2 + \sum_{i=1}^{k-1} \sum_{j>1}^{k} \beta_{ij} X_i X_j + \varepsilon_n$$

Y_n The n-th target function
X_i The i-th independent variable
ε_n Experimental error related to Yn
β_i 1st order polynomial coefficients
β_{ji} 2nd order polynomial coefficients

Subsequently to the calculation of the beta coefficients, it has been carry out the significance and the lack-of-fitness (LOF) tests, by means of the Fisher's test, through the ANOVA analysis; these allows respectively to check if the polynomial regression is a proper approach to the specific set of results and if this new metamodel approximately with sufficient precision the simulators, with specific attention to his experimental error.

The indicated three independent variables have been considered, first two are much more meaningful in the study of the wide traffic problem while the third is related to terminal improvements.

These variables are:

- ❖ X1 Time employed by each ship for loading and unloading operations in the cooperating terminal of the area (A & B)
- ❖ X2 Traffic Intensity
- ❖ X3 Number of docks in Terminal A

The following objective functions have been monitored, in relation to previous independent variables:

- ❖ Y1 Terminal A: Occupation Coefficient [0..1]
- ❖ Y2 Terminal A: Mean Ships Queuing [h]
- ❖ Y3 Terminal A: Mean Arrival Interval [h]
- ❖ Y4 Terminal B: Occupation Coefficient [0..1]
- ❖ Y5 Terminal B: Mean Ships Queuing [h]
- ❖ Y6 Terminal B: Mean Arrival Interval [h]

Target function Y1 and Y4 provide detailed information about the exploitation resources state, Y2 and Y5 measure the speed and efficiency of terminal operations and, finally, Y3 eY6 represent the traffic intensity and so they correspond to a risk level and additional requirements in harbour services (boat-men, tugs, pilots etc.) (Villefrancheet al.1994). In presented tables and figures are introduced the experimental campaign results. Due to the presence of three independent factors it is impossible to present the complete graphic results in single figure, therefore simply 3D surface graph, made by plotting the response surfaces obtained considering just 2 input and using the third as fixed parameter provides an easy understanding of system behaviour (fig. 5); the figure presented use as independent variable X1 and X2 maintaining X3 fixed to its center value; demonstrating the saturation condition for the dock of terminal A.

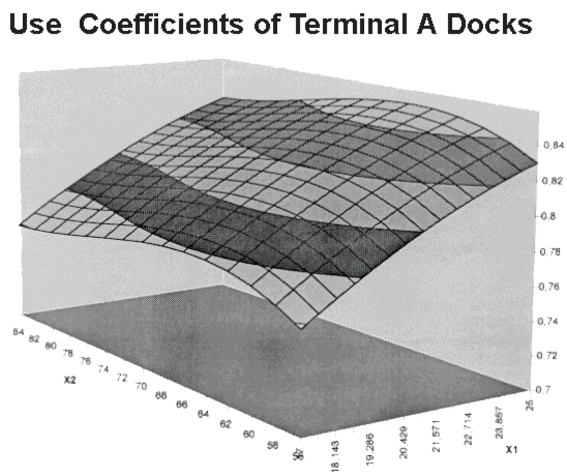

Figure 5: Reponses Surface Methodology Results

5 NEW APPLICATIONS AND EXAMPLES

Moving to more recent projects, the authors are active in different research lines for maritime simulation and there active projects related to the general criteria presented in the paper.

Just a short outline of some of these activities can confirm the importance of the issues addressed in this paper from final user point of view.

MOSLES is an extension of a previous project (“Safety First”) commissioned by Italian National Harbour Services (tug owners, pilots and boat-men) for safety in ship handling and operations; this model is based on a special virtual environment operating on low level platform (PC) that allows real-time/faster-than-reality full interactive simulation of ship operation in harbours; this environment is used both for training (real-time mode) and for safety and operative procedure design and optimization (faster-than reality automated mode) (Bruzzone et al.1997). MOSLES (Modelling & Simulation Logistic Educational Support) is focusing is attention to create an educational support for logistic operators in terminal containers: crane drivers, truck drivers, yard planners etc; in this case the industrial partner (CFLI) is a consortium of public authorities (Venice, Livorno) large private companies (VTE PSA) and small and medium size enterprises: the basic idea is to substitute previous existing expensive simulation system with a lean federation able to satisfy multiple requirements operating in a distributed environment; the education of operators in this area is very critical and the training over a geographical network with central remote supervision is consider very important.

Currently the authors from DIP University of Genoa and the CFLI are promoting this project in order to get partners and users in Europe for properly tune the system on final user needs.

MESA (Maritime Environment for Simulation Analysis) is another environment that is proposed for risk analysis in ports and it is just based on the integration of completely different external simulators (i.e. models for explosions, fires and oil spills) in order to access to common Databases and real information; the necessity of combining complex models in an usable package for environmental agencies, civil protection and authorities (i.e. coast guard, port authorities) is pushing forward in the development of this tool (Bruzzone et al.1999).

POSEIDON (Port Simulation Environment & Interactive Design for Organisation and Networking) was completed just last year by and represents a very interesting experience in web-based modeling applied to port oil terminal; the results obtained both in term of efficiency and final-user potential demonstrates that this area can be very effective in development of future generation harbour simulators; in order to guarantee reusability issue the model was developed and tested in application to large oil terminals, in Italy and in Baltic sea (Bruzzone et al.1998).

6 CONCLUSIONS

The innovative aspects proposed in this paper have been already experimented in other application sectors; in particular the experience in military area is very interesting and demonstrates the effectiveness of such approaches (simulation federations, interoperability, networking, downsizing structures and models etc.). However the industrial area is a little bit different; the budget normally is quite reduced and the economic result needs to be clearly defined, achievable and measurable, frequently in short term.

So the efforts in improving the modeling capability in this sector need to be cost effective from final user point of view; this requires an evolution of both vendors/providers and users in defining model requirements and use procedures.

The harbor terminal are due to their nature a very good application field for this technologies and several projects are already active. The experimental results provided demonstrate the effectiveness of such approach in reusability, flexibility, modeling time and performance estimation.

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