National Shipbuilding Research Program
Advance Shipbuilding Enterprise

# LARGE SCALE COMPUTER SIMULATION MODELING SYSTEM FOR SHIPBUILDING

## Project Results Executive Overview

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# 1 EXECUTIVE OVERVIEW

The "Large Scale Computer Simulation Modeling System for Shipbuilding" (LSMS) project developed and deployed a computer simulation modeling system for use in performing analyses of current and new ship production work on a shipyard's operations as an entire system. In addition to analyses of new business scenarios, the LSMS is capable of evaluating proposed process and facility improvements. The LSMS includes: 1) a yard-wide manufacturing simulation model, 2) user utilities to (re)define facilities, schedules, processes/routings, and interim products, and 3) links to product design and planning/scheduling data. The functional diagram for the LSMS is shown in Figure 1. The system utilizes defined work content metrics to quantify the requirements for each stage of construction and major "gateway" work centers and outputs the information to Excel, enabling shipyard management to quickly determine required throughput and efficiency to achieve cost targets, manning and shift requirements, work center and storage area requirements, interim product duration and process cycle time requirements, and optimum multi-ship block erection schedule offsets. The target user community for the LSMS includes planners, analysts, and managers rather than specially trained simulation modelers.

The scope of the project included the development of functional requirements, system design specifications, and prototypes of key components in Phase I (May 2008 to December 2008), and the construction, implementation, and validation of a fully functional large scale modeling system at General Dynamics NASSCO in Phase II (January 2009 to March 2010).

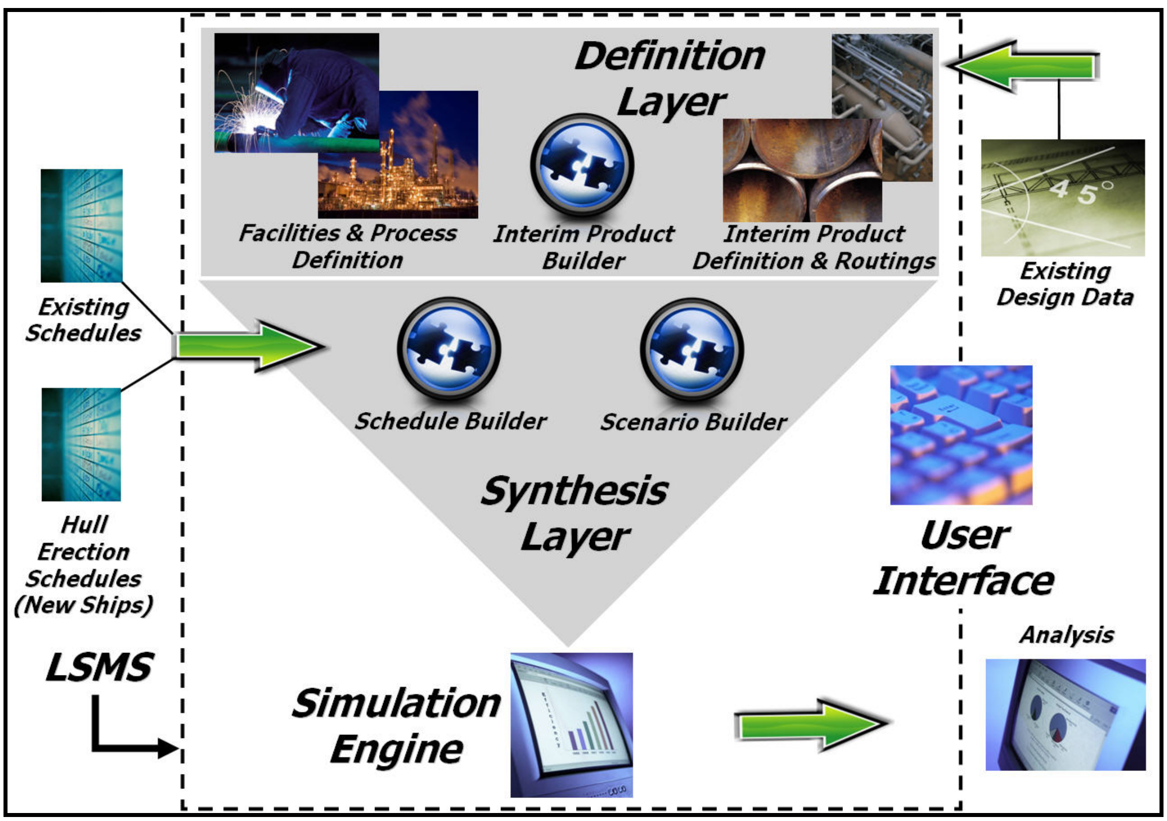


**Figure 1: LSMS Functional Diagram**

## 2 CONTACT INFORMATION

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## 3 COLLABORATORS

Atlantec Enterprise Solutions (20% of labor hours)
Developed LSMS software applications to define facilities and product data (Definition Layer applications in shown Figure 1). Developed product modeling system adaptor and interface.
Contact: Natalie Lechnowskyj, Natalie.Lechnowskyj@atlantec-es.com

TranSystems Corporation (25% of labor hours)
Developed LSMS software applications to define schedule, transportation path networks, and simulation scenarios (Synthesis Layer applications shown in Figure 1). Developed LSMS user interface and simulation model (LSMS User Interface and Simulation Engine applications shown in Figure 1).
Contact: Andrew Stanevicius, arstanevicius@transystems.com

ShipConstructior Software USA (5% of labor hours)
Reviewed LSMS specifications for broad product modeling system applicability.

Bender Shipbuilding Company (5% of labor hours)
Reviewed LSMS specifications for broad industry applicability.

## 4 DESCRIPTION OF METHODOLOGY

The methodology followed to design, construct, and implement the LSMS is common to most software development projects:

1. Create a Functional Specification defining what the software needs to do.
2. Create an Initial Design Specification, laying out the high-level architecture, data structure, interfaces, and reports.
3. Prototype key modules based on the Initial Design Specification to gauge ability to meet the requirements of the Functional Specification and to test and demonstrate ideas.
4. Create a Final System Design Specification utilizing results of the prototyping, detailing the system architecture, system test plan, and for the simulation model, a validation plan.
5. Build the software system.
6. Test and validate the system.

7. Create the software requirements / user documentation.
8. Implement the system at NASSCO.

## 5 RESOURCES NEEDED

The LSMS project team included two programmers experienced in the development of databases and user interfaces for the Definition Layer applications, two software testing resources for the Definition Layer applications, three programmers experienced in the development and testing of databases, user interfaces, and simulation models for the Synthesis Layer, Simulation Engine, and LSMS User Interface applications, one computer network administrator for installation of the software and updates, and one project manager experienced in simulation modeling, software design, software application testing, and project management. Additional resources from the targeted user community were also required to provide their expertise during the development of the functional requirements, definition of specifications, testing, and validation phases. These additional resources were from the Master Planning, Engineering, and Production departments. While not a requirement, some members of the user community had training in basic simulation modeling techniques which proved helpful.

Another shipyard replicating the LSMS project in its entirety from definition of functional requirements through construction and implementation of the system with their own resources would require the same number of resources to have the system designed and implemented within a two year period. The preferable alternative for the shipyard, however, would be to contract with the software development companies from the LSMS project and install the as-built LSMS wholesale or with some shipyard specific customization. Atlantec Enterprise Solutions and TranSystems should be contacted for an estimate.

The LSMS was installed on a PC for this project. The recommended hardware and software resources required for the system include:

<u>PC Hardware Resources</u>

- Intel P4/Centrino or AMD Athlon XP/FX/Mobile, 2.8 GHz or faster
- 4 GB RAM, PC2100 or faster
- Network card ≥ 1GBit/s
- Medium range 3D Graphics card (ATI/NVidia), ≥ 1280x1024 resolution
- CD-ROM or DVD drive or USB-2.0-Port

<u>Software Resources</u>

- Windows XP/2000
- .NET Framework 2.0 or greater (required for the LSMS User Interface)
- Microsoft Office 2003 or greater (required for output reporting, schedule input, business system input)
- Microsoft Visio 2003 or greater (required for the transportation network definition)
- Anylogic Version 6.4.0 - runtime version (required for the Simulation Engine)
- Java version ≥ 1.6.0_11 (required for the Definition Layer Applications and Simulation Engine)
- Java3D Version ≥ 1.5.2 (required for the Definition Layer Applications)
- Atlantec ES Topgallant® Suite of software ( these are the Definition Layer Applications)

## 6 EVALUATION AND ANALYSIS METHODS

The overall project was managed through the use of a high level project schedule. The build of the LSMS was managed using a software development matrix. The matrix was subdivided into milestones at one-month intervals. Each milestone was then divided into several sub-elements based on key functional areas of the LSMS with specific tasks being associated with each sub-element. While this methodology could have been taken to any degree of detail, the approach for the LSMS project was to develop milestones, sub-elements, and tasks at a level that was a gauge of progress while allowing any potential adjustments in follow-on milestones to easily occur. This degree of detail resulted in a matrix for each team member containing roughly seven milestones, with seven to eight sub-elements per milestone, and one to five tasks per sub-element. Milestone matrices were created for the Definition Layer, Synthesis Layer, Simulation Engine, User Interface, and Data Collection effort. All matrices are coordinated so that the milestones support each other's inputs and outputs.

The accrued benefits for the deployment and utilization of this tool will take place after the ASE project period of performance. The project was structured, however, to include the development and execution of an integrated validation and testing task during Phase 2. Results of this validation scenario developed and run in the simulation model were compared to historical data on NASSCO shipbuilding operations in 2008. The results of the simulation model were within 10% of the 2008 historical values for several key metrics.

## 7 TIME ESTIMATE

This project was a twenty-three month effort from definition of functional requirements and creation of the design specifications through the construction, testing, validation, and implementation of the LSMS.

Implementation of the LSMS at another shipyard could be accomplished through one of three paths:

1. The shipyard could contract with the commercial companies from the LSMS project, Atlantec Enterprise Solutions and TranSystems, and implement the as-built LSMS system. Depending on the product modeling software of the shipyard, an adaptor to extract product data from the product modeling system may have to be created. This will add some duration to the implementation process which can be estimated by Atlantec Enterprise Solutions. With an adaptor, time to implementation is estimated to be 5 months, although a formal estimate should be obtained from Atlantec Enterprise Solutions and TranSystems.
2. The shipyard could contract with Atlantec Enterprise Solutions and TranSystems and implement a custom version of the LSMS by modifying the software created in this project to incorporate shipyard-specific customization. The modular architecture designed into the LSMS allows modules of code to be "unplugged", changed, and then "plugged" back into the system without reprogramming the entire system. A shipyard could add yard-specific customization in this manner. Time to implementation in this case is estimated to be from 5 to 15 months depending on the level of customization, although a formal estimate should be obtained from Atlantec Enterprise Solutions and TranSystems.
3. The shipyard could develop a custom LSMS from the ground up by creating unique functional requirements and design specifications, and building the system with their own resources or subcontractors. Using this project as a template, time to implementation is estimated to be from 15 to 20 months depending on size of the system, availability of resources and data, and whether or not alternate modeling strategies were investigated and prototypes created.

## 8 LIMITATIONS OR CONSTRAINTS

The scalable nature of the LSMS allows any size shipyard to implement the system. Additionally, the modular system architecture facilitates the potential customization of interfaces and programming. A shipyard implementing the system will have to build an adaptor to extract data from the yard's product modeling system into the LSMS. Atlantec Enterprise Solutions created the adaptor between NASSCO's product modeling system - Tribon and the LSMS. Access to the ShipConstructor product modeling system data was also demonstrated as part of LSMS project; however, the development of the adaptor itself was not undertaken as part of the project scope.

It is highly recommended that any shipyard implementing an LSMS have product modeling and business systems in place with data that is accurate and up to date. The use of a particular software for these systems is not a requirement as the LSMS uses a neutral text format for interfacing with the business systems and an adaptor can be created to interface with the product modeling system. The information within the systems, however, must be current, well organized, and accurate to minimize manual intervention in readying the data for use in the simulation model.

## 9 MAJOR IMPACTS ON SHIPYARD

The implementation of the LSMS did not impact the use or require modification to any of the external software systems providing data to the LSMS as it was designed to communicate across interfaces to the external systems rather than being directly coupled to them. The capacity analysis process was positively impacted, however, as the analysts now have the ability to understand not only how a change to a facility, process, resource, product, or schedule in a particular work center affects the work center itself, but how those changes potentially affect all work centers within the shipyard. This ability ensures that savings achieved in one area of the shipyard are not mitigated by upstream and downstream work centers, or that the constraint has not been merely moved elsewhere in the yard. Furthermore, better capacity analysis estimates are provided because of the greater level of detail utilized in the LSMS leading to lower schedule risk in forward-looking predictions.

## 10 COST BENEFIT ANALYSIS/ROI

Savings achieved in the implementation of the LSMS occur in two categories - reduction in analysis labor costs, and savings achieved through the implementation of findings from the LSMS analysis. It is anticipated that the implementation of the LSMS can reduce labor analysis costs by up to 50%. The initial findings from the project support this value.

A greater return on investment is achieved through the implementation of simulation findings or avoidance of errors identified with the simulation. Depending on the type of analysis performed, the time-averaged savings achieved can total in the millions of dollars per year, as the LSMS has the ability to analyze the effects of adding new work centers, new equipment, and new processes to the shipbuilding process, determine its optimized configuration, and identify the minimum capital investment necessary to achieve the targeted results with the effects being understood both locally and as part of the larger shipbuilding process.

## 11 LESSONS LEARNED

1. Anticipate and design for the large volume of data necessary to drive a full shipyard simulation model. The LSMS project team performed well in this area. The simulation model validation exercise included 40 work centers through which over 650,000 parts were processed. Information on processes, resources, and schedule had to be defined for each part and work center. To keep the volume of data developed, processed, and managed from becoming burdensome, special attention was paid to the design of the LSMS user input screens to aid in data input, the programming of the LSMS was tested for performance during development, and the methodology in modeling the shipyard was balanced between utilizing data at a level high enough to minimize volume and detailed enough to produce accurate results.
2. Design the system to be modular and to communicate across defined interfaces to allow for parts of the system to be removed, changed, and plugged back in without having to reprogram the entire system. This philosophy was maintained from the start of the LSMS project and significantly expedited changes in the software when programming issues were found. Additionally, it allowed the Definition Layer applications and the Synthesis Layer applications to be developed in parallel with test data for the simulation model being loaded in through a temporary application written in Excel that performed the basic functions of the Definition Layer while development of those applications continued.
3. Involve the shipyard in software reviews and testing as early as possible. NASSCO became involved in the review of the software once development of the individual applications had been completed by Atlantec Enterprise Solutions and TranSystems, but before the start of integrated system testing. During the review of the software, NASSCO discovered system integration issues within the individual applications due to misunderstandings of the functional requirements. These issues had to be corrected, leading to a delay in the start of integrated testing and validation. Earlier NASSCO involvement in the review and testing of the individual application modules would have been preferred, fostering communication between the user community and developers on programming issues and expectations for functional requirements at a point in the application development when changes are most easily made.

## 12 TECHNOLOGY TRANSFER

Technology transfer for the project has already been accomplished through technical presentations and demonstrations of the software at NSRP joint panel meetings and ShipTech 2010. In addition, the utilization of two commercial software development companies on the project provides the industry with experienced resources to replicate the LSMS either wholesale or with shipyard-specific customization.

Within NASSCO, LSMS training is being provided by the project team to members of the targeted user community in the use of the system with the Industrial Engineering Department overseeing its continued utilization and providing support with questions and recommendations for future updates to the software.