National Shipbuilding Research Program
Advance Shipbuilding Enterprise

LARGE SCALE COMPUTER SIMULATION MODELING SYSTEM ENHANCEMENTS

Project Results Executive Overview

Prepared by:
LSMS Project Team

Submittal Date
February 24, 2012

TABLE OF CONTENTS

1 EXECUTIVE OVERVIEW

Prior to the development of the Large Scale Simulation Modeling System for Shipbuilding (LSMS) project, U.S. Shipyards did not have a fast, efficient way to analyze the effect of potential new ship construction business on their facilities and operations as an entire system. The initial LSMS project addressed this issue by deploying a yard-wide computer simulation modeling system that is useful for analyzing the effects of current and new ship production work on the shipyard's operations. The system included: 1) a yard-wide 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.

During the development of this landmark system, the project team identified a number of additional novel capabilities that would be of significant value to the users of the system but were beyond original project scope. To further extend the capabilities and efficiencies of the LSMS therefore, the objective of the Large Scale Simulation Modeling System Enhancements (LSMSe) project was to develop and deploy the following additional features to the LSMS:

- Optimization software using meta-heuristic procedures to guide the process unattended
- Stochastic abilities for modeling real-world variability in the inputs
- Rule sets and software for automated assembly definition and typing
- Parametric scaling software for product work content generation of new ship designs
- Enhanced user interfaces for new facility modeling and assembly definition capabilities
- Enhanced database management techniques for new capabilities

The project was awarded funding by the NSRP in May of 2010 and completed in February 2012 with the implementation of the enhanced system, LSMSe, at General Dynamics NASSCO in San Diego, CA.

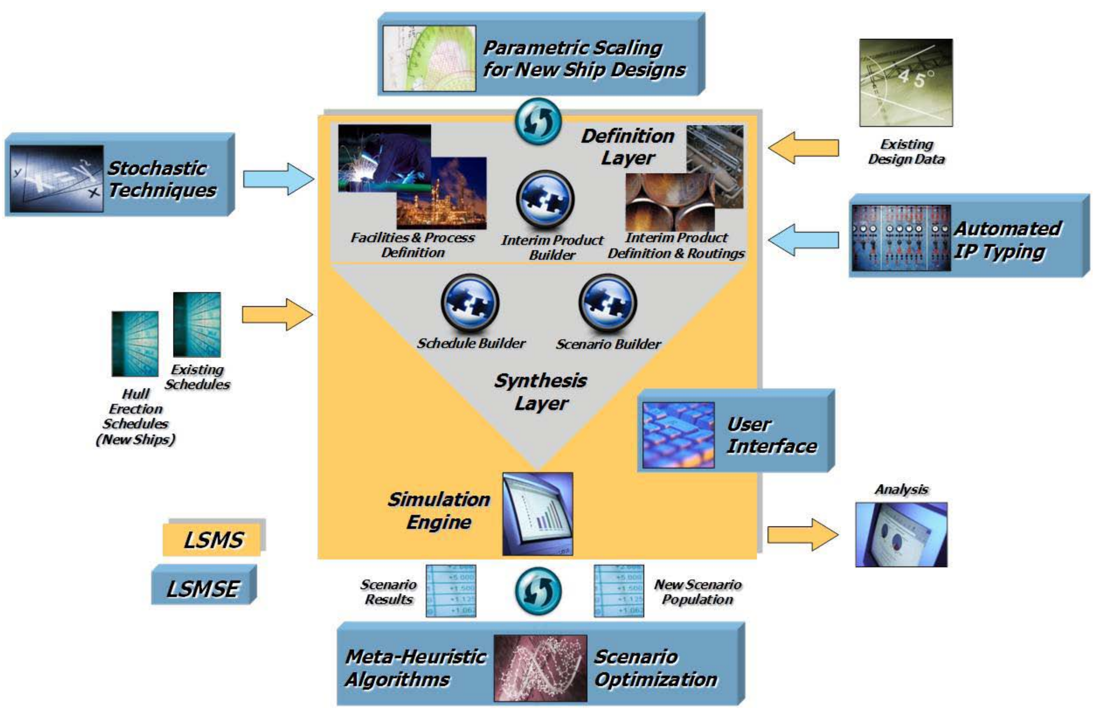

Figure 1: LSMSe Functional Diagram

2 CONTACT INFORMATION

Project Manager:
Jeff Schaedig
General Dynamics NASSCO
jschaedi@nassco.com
619-744-1215

Manager, Industrial Engineering:
John Horvath
General Dynamics NASSCO
jhorvath@nassco.com
619-544-8843

3 COLLABORATORS

Atlantec Enterprise Solutions (35% of labor hours)
Developed LSMSe enhancements for the Definition Layer applications including Automated Interim Product Typing (IP Typing) and Parametric Scaling for New Ship Designs shown in Figure 1. Modified the Definition Layer software to accept distributions as input for use in stochastic simulations.

Contact: Christopher Clark, christopher.clark@atlantec-es.com

Pennsylvania State University Applied Research Laboratory (28% of labor hours)
Developed the Optimization Routine Software (ORS) and guiding meta-heuristic algorithms shown in Figure 1. Participated in the development of the communication framework between the ORS and Simulation Engine.

Contact: Daniel Finke, daf903@arl.psu.edu

TranSystems Corporation (17% of labor hours)
Developed LSMSe enhancement modifications to the Synthesis Layer, Simulation Engine, and User Interface shown in Figure 1. Modified the Simulation Engine to accept distributions as input for use in stochastic simulations. Developed the communication framework between the ORS and Simulation Engine, as well as, the communication protocol between networked computers running simulations in parallel during optimization.

Contact: Andrew Stanevicius, arstanevicius@transystems.com

4 DESCRIPTION OF METHODOLOGY

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

1. Create a Functional Requirements Document defining what the enhancements need to do.
2. Prototype key elements selected from the functional requirements to gauge ability to meet the requirements and to test and demonstrate ideas.

3. Create a System Design Specification, laying out the enhancements' high-level architecture, data structure, interfaces, communication framework, and reports.
4. Build the software enhancements and integrate them with the core LSMS software.
5. Test the enhancements individually and as part of the integrated system.
6. Validate the system.
7. Create the software requirements / user documentation.
8. Implement the system at NASSCO.

5 RESOURCES NEEDED

In order to implement the enhancements of the LSMSe, a shipyard must first implement the core LSMS software. The composition of the prior LSMS project team was similar to that of the LSMSe project team described below. The LSMSe project team included:

- Two programmers experienced in the development of databases and user interfaces for the Definition Layer enhancements
- One software testing resource for the Definition Layer enhancements
- One programmer experienced in the development and testing of databases, user interfaces, simulation models, and network communication for the Synthesis Layer, Simulation Engine, and LSMSe User Interface applications
- Two programmers experienced in optimization principles, genetic algorithms, and software development/programming for the Optimization Routine Software
- One computer network administrator for installation of the software and updates
- 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 tasks. These additional resources were from the Master Planning and Industrial Engineering 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/LSMSe projects in their entirety from definition of functional requirements through construction and implementation of the enhanced system with their own resources would require the same number of resources to have the system designed and implemented within a four year period. The preferable alternative for the shipyard, however, would be to contract with the software development companies from the LSMSe project and install the as-built core LSMS and LSMSe enhancements wholesale or with some shipyard specific customization. Atlantec Enterprise Solutions, TranSystems, and Pennsylvania State University Applied Research Laboratory should be contacted for an estimate.

The LSMSe was installed on a PC for this project with the Definition Layer Database being located on a server (although the server was an optional architecture and not required). The recommended hardware and software resources required for the system include:

PC Hardware Resources

- Intel P4/Centrino or AMD XP/FX/Mobile, 2.8 GHz or faster (multiple core computers are recommended for optimization)
- 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

Software Resources

- Windows XP/2000 (Also tested with Windows 7 64-bit)
- .NET Framework 2.0 or greater (required for the LSMSe 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)
- Java version ≥ 1.6.0_11 (required for the Definition Layer Applications, Simulation Engine, and Optimization Routine Software)
- 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 programming of the LSMSe enhancements was managed using a software development matrix. The matrix was subdivided into milestones that were used for project planning and progress at regular intervals (typically a month). Each milestone was further divided into several sub-elements based on key functional areas of the enhancements with specific tasks being associated with each sub-element. Milestone matrices were created by each project team member for programming efforts in each of the enhancements. While this methodology could have been taken to any degree of detail, the approach for the LSMSe 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 each matrix containing seven milestones, with three to five sub-elements per milestone, and one to five tasks per sub-element. All matrices were coordinated so that the milestones supported each other through software and data development.

Scaled validation tests of the enhancements, identical in nature to how the software was intended to be used, were performed by the shipyard. Tests typically involved the input of data through the newly developed enhancement interface, operation on that data by the enhancement logic, producing results, and then reviewing the results or comparing them to a baseline set of data to determine whether or not a valid outcome was achieved.

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 LSMSe enhancements.

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

1. The shipyard could contract with the commercial organizations from the LSMSe project, Atlantec Enterprise Solutions, TranSystems, and Pennsylvania State University Applied Research Laboratory and implement the as-built LSMS system with the LSMSe enhancements. The core LSMS would have to implemented first followed by the enhancements. 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 or an alternate method of inputting product model data into the LSMSe, such as the spreadsheet-based tables used to input data into the LSMSe during the early testing stages, would have to be developed. This will add some duration to the implementation process which can be estimated by Atlantec Enterprise Solutions. With an adaptor or alternative data input method, time to implementation is estimated to be 8 to 10 months. This would include installation of the software, linking of product model and business systems to the LSMSe, data input, testing, and validation. A more formal assessment, however, should be obtained from Atlantec Enterprise Solutions, Pennsylvania State University Applied Research Laboratory, and TranSystems.

2. The shipyard could contract with Atlantec Enterprise Solutions, Pennsylvania State University Applied Research Laboratory, and TranSystems and implement a custom version of the LSMS and LSMSe enhancements by modifying the software created in this project to incorporate shipyard-specific customization. The modular architecture designed into the LSMSe 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 10 to 25 months depending on the level of customization, although a formal estimate should be obtained from Atlantec Enterprise Solutions, Pennsylvania State University Applied Research Laboratory, and TranSystems.

3. The shipyard could develop a custom LSMS with LSMSe enhancements 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 25 to 46 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

There are no foreseeable limitations or constraints to the implementation of the LSMSe at other shipyards. The scalable nature of the LSMSe 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 may have to build an adaptor to extract data from the yard’s product modeling system into the LSMSe or implement an alternate method similar to the spreadsheet-based tables utilized by NASSCO during LSMS development. Atlantec Enterprise Solutions created the adaptor between NASSCO’s product modeling system - Tribon and the LSMSe. A third option is to use the Parametric Scaling for New Ship Design software to develop a template library for the interim products in a current ship design and generate the simulation input data from those templates.

9 MAJOR IMPACTS ON SHIPYARD

The implementation of the LSMS and LSMSe enhancements did not negatively impact the use of or require modification to any of the external software systems providing data to the LSMSe since it was designed to communicate across interfaces to the external systems rather than being directly coupled to them.

Positive impacts include:

- The ability to analyze the shipyard as a system, understanding how a change in one aspect of the system such as labor pool size or work center dimensions affects the entire shipyard.
- The ability to analyze the shipyard in greater detail than previously possible with spreadsheet-based analysis methods.
- The ability to optimize a baseline scenario unattended, freeing the analyst to perform other tasks, or increasing the number of scenarios analyzed by making use of off-shift time.
- The ability to create detailed representations of potential new ship designs quickly using the Parametric Scaling for New Ship Designs software rather than modifying a current ship design data part-by-part or simply rolling over a "similar" ship as a placeholder in the analysis until detailed design information is available.
- The ability to understand how real-world variability will affect the planned outcome of a scenario by inputting ranges of values for duration and man hours rather than a constant number.
- The ability to grow and update the LSMSe to suit the needs of the shipyard over time through its modular design.

10 COST BENEFIT ANALYSIS/ROI

Savings achieved in the implementation of the LSMSe occur in two categories - reduction in recurring analysis labor costs, and savings achieved through the implementation of findings from the LSMSe analysis. It was anticipated that the implementation of the LSMSe can reduce recurring labor analysis costs by up to 75%. The initial findings from the LSMSe project support this value.

A greater return on investment is achieved, however, through the implementation of simulation/optimization 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 LSMSe 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. 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 facilitated the ability to add the enhancements to the core system in the LSMSe project.

2. Involve the shipyard in software reviews and testing as early as possible. While occasionally frustrating to both shipyard and software developer, early involvement provides the software developer with additional testing resources while allowing the shipbuilder to help guide development, ensuring that the end product is both robust and applicable to the needs of the shipyard.

12 TECHNOLOGY TRANSFER

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

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