Develop and Implement ‘World Class’ U.S. Material Standards and Parametric Design Rules to Support Commercial and Naval Auxiliary Ship Construction

Project Final Status Report

by

National Steel & Shipbuilding Co.

on

June 16th 2004

Maritech ASE Project #99-21
Technology Investment Agreement (TIA) 20000215

Category B Data - Government Purpose Rights
Approved for Public Release; Distribution is Unlimited
Material Standards & Parametric Design Rules

- Team Members
Major Accomplishments

Material Standards & Parametric Design Rules

- Developed Functional Volume Design Approach and Training Software
- Enhanced Proteus IDNA Software
- Developed CID Architecture
- Developed Standards Library
- Developed Design Rules and Templates
- Applied Lean Design to Shipbuilding
- Training Materials Published
- Workshops conducted
Strategic Vision

Material Standards & Parametric Design Rules


This process applies standardization to material, equipment, design, material selection, cost estimating, interim products, arrangements, zone designs and whole-ship designs.
Expected Benefits
Material Standards & Parametric Design Rules

- **Five-fold** increase in the throughput of preliminary designs and cost estimates that a shipyard can produce in response to market inquiries

- **33% reduction** in cost and cycle time for pre-production processes during the contract, transition, and detail design phases.
**Expected Benefits**

Material Standards & Parametric Design Rules

---

**Reduce Material Cost and Cycle Time**

**Typical Suezmax Tanker Schedule USA & Europe**

- **USA**
  - Contract/cut steel: ~30 months
  - Cut steel/keel lay: ~10 months
  - Keel/launch: ~3 months
  - Launch/delivery: ~1 year

- **European**
  - Contract/cut steel: ~20 months
  - Cut steel/keel lay: ~15 months
  - Keel/launch: ~1.5 months
  - Launch/delivery: ~14 months

- **Added value**
- **Material and equipment**
Typical Design and Engineering Cycle
Time in the USA

**Engineering**

- **Contract Definition** (6-8 Months)
  - Guidance Documents
  - Ship Specification
  - General Arrangement
  - Machinery Arrangement
  - Midship Section/Scantlings
  - Key System Diagrams
  - Equipment List

- **Transition Definition** (6 Months)
  - Structural Steel and Outfitting Interface
  - Systems Engineering and Detail Engineering Interface

- **Total System Development**
  - Structural Steel
  - Piping Systems
  - Electrical Sys.
  - HVAC

- **Outfit Scope Defined**
  - Production Information
  - Outfit Product Breakdown
  - Budgeting

- **Detail Definition/Planning and Budgeting** (1-1.5 Years)
  - Material & Labor
  - Budgets by Group

**Estimating**

- **Words Into Scope** (2-3 Months)
  - Scope * Rate = $
  - Scope:
    - Spec Matl.
    - Inquiries
    - Tons of Steel/Weld
    - Ft
    - Feet of Pipe
    - Feet of Cable
    - Ft² Vent Duct
    - Ft² Paint Surface
    - Metal Outfit Parts

**Contract Award**

- **Steel Scope Defined**

**Time**

- **8 - 12 Months**
  - Contract Definition
  - Functional Definition

- **18 - 24 Months**
  - Transition Definition
  - Detail Definition/Planning and Budgeting
**Contract Definition**
(Built from Project Specific Templates)

- Guidance Documents
  - Ship Specification
  - General Arrangement
  - Machinery Arrangement
  - Midship Section/Scantlings
  - Key System Diagrams
  - Equipment List

- System Development
  - Structural Steel
  - Piping Systems
  - Electrical Sys.
  - HVAC

- Producability Issues:
  - Defining and Locating Outfit Material
  - Defining Structural Steel Product Breakdown

**Estimating**
Apply Material and Labor Rates linked to projects specific templates.

**Proposed Process**

- **Eng/Estimating Integration**
  - 3 - 4 Months

- **Contract Award**
  - 3 Months

- Steel & Outfit Scope Defined
  - Contract Definition (3 Months)

- Estimate (1 Month)

- **Detail Definition**
  - 3 Months

- Production Information
  - Finalize Outfit/Steel Product
  - Breakdown
  - Budgeting

- Scope of Work by Interim Product and System

- Material & Labor Budgets by Interim Product

Scope of Work is an input to the estimating process.
Problems with the Existing Design Process

Creates “custom” design solutions that are:

- Intrinsically of “lower technical confidence” and “higher commercial risk”.
- At a price that is well above the expectations of the international market.
- At a cost that makes the shipyard uncompetitive.
- With excessive design cost and lead time.
Standard v Custom Design

Material Standards & Parametric Design Rules

- Custom design increases the amount of design effort.
- Produces expensive products.

- Repeatably:
  - Decreases design effort.
  - Produces standard products.

- Customly:
  - Increases design effort.
  - Produces custom products.
Standard v Custom Design

Material Standards & Parametric Design Rules

Level of design effort

- Standard design
- Custom design

Reduces the amount of design effort

Decreases Time and Cost for ALL

Repeatable design

Custom design
Project Accomplishments

Material Standards & Parametric Design Rules

- **Task 1 - Methodology Templates & Guides**
  - Project Methodology template, revised
    » Provided a detailed project plan
  - Lean Methodology Guide
    » Conducted two industry workshops
    » Provided hands-on experience in applying DFMA principles
  - Software Methodology Guide
    » Provided guidance for software development (any project)
  - Education and Tech Transfer Guide
    » Provided guidance and sets expectations
Project Accomplishments

Material Standards & Parametric Design Rules

• **Task 2 - Common Item Database (CID)**
  - Develop and Populate CID with Spec & Non-Spec Material/Equipment
    » Defined commercial shipyard data requirements
    » Defined business process & procedures
    » Defined organizational requirements
    » Defined part equivalency process & procedures
    » Defined CID architecture
    » Populated CID with over 650 products from more than 730 suppliers (over 740 product types in 45 product categories)
    » Product catalog development - Identified over 200 Data templates at the functional volume level with over 400 associated product templates
CID and the Design Process

Material Standards & Parametric Design Rules

Systems Engineering Process

Common Items Database
- Ship Types
- Primary Zones
- Secondary Functional Zones
- Interim Product
- Spec Equipment
- Non Spec Equipment

Spatial Engineering Process
- Whole Ship Design
- Primary Zone Design
- Secondary Functional Zone Design
- Interim Product Design
CID and the Design Process

Material Standards & Parametric Design Rules

INTERIM PRODUCTS
- FUNCTIONAL VOLUMES
- ASsembled PRODUCTS
  by
  * Structural zone
  * Machinery zone
  * Bow zone
  * Accommodation zone
  * Cargo zone
- STANDARDS
- DESIGN RULES & TEMPLATES

STORE OF KNOWLEDGE

Common Items Database
- INTERIM PRODUCTS TEMPLATES DESIGN RULES

DESIGN PROCESS
- Project 21 Smart Product Model
  - COST ESTIMATE
  - NAVAL ARCHITECTURE
- COST ESTIMATE
- NAVAL ARCHITECTURE
CID Architecture

Material Standards & Parametric Design Rules

- Gatekeeper
- Product Catalog
- Project Database
**Project Accomplishments**

Material Standards & Parametric Design Rules

- **Task 3 - Develop a Set of Nationally Acceptable Material & Design Standards (outfit & structure)**
  - 960 steel and outfit standards delivered
  - Over 1200 standards submitted to project team for review

- **Delivered Standards**
  - 252 Structural Standards
  - 708 Outfitting Standards
    - 95 Electrical Standards
    - 134 Metal Outfit Standards
    - 391 Piping Standards
    - 88 HVAC Standards
Types of Standards
Material Standards & Parametric Design Rules

- Parts Standards
- Interim Product Standards
  - Groups of parts or assemblies
Life Rails

Material & Design Standards

Material Standards & Parametric Design Rules
Before

Light Standoff
Reduction of Parts/Work
Content & Increased Functionality

After

Material & Design Standards
Material Standards & Parametric Design Rules

<table>
<thead>
<tr>
<th>ITEM</th>
<th>MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>STANDOFF</td>
<td>STEEL</td>
</tr>
</tbody>
</table>

Illustrations of light standoff before and after design changes.
Material & Design Standards

Material Standards & Parametric Design Rules

Cargo Door Baseline Design

- Grease Fittings (2)
- Overhead Lock
- Locking Actuator (2)
- Hydraulic Pump Station
- Controller
- Hydraulic Actuator
- Cargo Door
- Limit Switch (2)
Material & Design Standards

Material Standards & Parametric Design Rules

Cargo Door Re-design

Accumulator

Light & Horn Ass’y

Self-locking hydraulic actuator

DOOR

Lap Joint

Limit Switch (2)

Door frame with sill

Hydraulic pump & controller ass’y
Cargo Door Improvements

- Modular door & frame fully assembled and tested
- Lap joint to bulkhead
- Single lip seal
- Integrated control box
- Latching hydraulic cylinders
- Accumulator instead of hand pump

Parts Reduction  > 40%
Operations Reduction  > 40%
Task 4 - Develop Technical Approach for Early-Stage and Parametric Ship Design Tools

- Identified and evaluated existing tools
- Developed Proteus/Spar Flagship software suite
  » Integrated the Herbert stability & hydrostatics toolset
  » Industry workshops conducted to demonstrate the parametric “Smart Product Model” (SPM)
  » Paper and demonstration presented at SPS Ypsilanti (2001)
Initial Design Tools
Material Standards & Parametric Design Rules

- **GCRMTC / MR&S Design Synthesis Model**
  - Defines principle characteristics based on owner requirements

- **Proteus / Spar Flagship suite**

- **SPM infrastructure**

<table>
<thead>
<tr>
<th>Software Product</th>
<th>Functional Area</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>FastShip</em></td>
<td>Hullform Design</td>
</tr>
<tr>
<td><em>GHS/SDS</em></td>
<td>Hydrostatics and Stability</td>
</tr>
<tr>
<td><em>NavCad</em></td>
<td>Resistance and Powering</td>
</tr>
<tr>
<td><em>MAESTRO</em></td>
<td>Structural Modeling / Design</td>
</tr>
<tr>
<td><em>ESTI-MATE</em></td>
<td>Cost Estimating</td>
</tr>
<tr>
<td><em>PERCEPTION</em></td>
<td>Production Planning</td>
</tr>
</tbody>
</table>
Parameters include top level owner's requirements, classification and limiting dimensions, naval architecture design parameters, ship characteristics, cost and labor analyses.
Smart Product Model (SPM)

Material Standards & Parametric Design Rules

The SPM is linked to stand-alone tools for detailed design and analysis.
Cost ESTIMATE Model

Material Standards & Parametric Design Rules
Design Process Development

Material Standards & Parametric Design Rules

CID

- Standard Interim Products
- Material Standards
- Ship Data
- Catalog of Design Rules

Standard Type Data

Design Tools

Accom Design Estimate

SPM

“Producible” Design Package

“Confident” Cost Estimate
Project Accomplishments

Material Standards & Parametric Design Rules

- **Task 5 - Develop Metrics and Rules for ‘Whole-Ship’ Design**
  - Developed metrics that characterize design and cost estimating processes for three generic ship types that are representative of the product mix for a medium-size US shipyard
    - Container ship
    - Product/Crude Tanker
    - RO/RO Trailer Ship
  - Rules catalog development, over 500 rules captured
Design Rule Hierarchy

Material Standards & Parametric Design Rules

Design Rules Functional Volume Design

Design Rules & decision making criteria

Design Process Hierarchy

Whole Ship
Zonal Definition
Functional Volume Definition
Product Definition

Minor Assemblies (Work Packages)
Major Assemblies
Block Assembly
Zone Assembly
Whole Ship

Production Process Hierarchy
Task 6 - Develop Zone Design Rules & Material Templates

- Generic Interim Products Defined
- Developed Design & Material Templates and Rules for each Ship Zone (Structure, Cargo, Machinery, Accommodations.)
- Defined Functional Volume Design method and processes
  » Integrated design and cost estimating process
  » Conducted training on methodology at Industry workshops
  » Two technical papers presented at SNAME Ship Production Symposium
Functional Volume Design

Material Standards & Parametric Design Rules

Design Process Application
Existing Design and Estimating Process

Material Standards & Parametric Design Rules

Words and Pictures are converted to SCOPE and Dollars

Scope

$ $$ $$

Bid Level Estimate

Machinery Arrangement

Key System Diagrams

List of Equipment

Electric Load Analyses

Trim and Stability

Midship Section

Structural Analyses

Construction Profile & Deck Plans

Resistance & Propulsion (Model)

 Maneuvering (Model)

Stability

$ $

Section

Analyses

Capacity Plan & Stowage Arrgt.

Contract Spec

Vendors List

electric Load Analyses

Key, PurchaseSpecs

file: g:\group\seng\hull\wfd\visio\wfd0024.vsd
• Scope defined late
  • Therefore Estimating defines notional scope
• Many aspects of “design definition” are really “rework”
  • Rework is associated with information quality
  • Improving information quality reduces rework and shortens design cycle
Integrates pre-contract activity to communicate SCOPE by using templates

- *Design* - visibility and responsibility for SCOPE
- *Estimating* - responsibility for rates and CER’s

Together they drive out cost and eliminate re-work

- Risk is minimized - technical, cost, & schedule
- Schedule is reduced
Task 7 - Validation Effort

Baseline Design selected as NNS Double Eagle Class Tanker
- Contract design package submitted
- Produced a video and an electronic photo file of the vessel

A COMPLETE SHIP DESIGN WAS NOT VALIDATED
Project Accomplishments
Material Standards & Parametric Design Rules

• **Task 8 - Technology Transfer & Education**
  
  • **Module 1** Background/Need for Project
    
    Module 1.1 Current State of Art/Lean Principles
    Module 1.2.1 Ship Design Toolset
    Module 1.2.2 Information Systems

  • **Module 2** Material & Equipment Standards
    
    Module 2.1.1 Use of Standards
    Module 2.1.2 Data Base Mgt – CID Part Equivalency
    Module 2.1.3 Data Base Mgt – CID Audit Process
    Module 2.1.4 Data Base Mgt – Data Element Dictionary
    Module 2.1.5 ABS/USCG Approvals
    Module 2.2.1 Specification Equipment Standards
    Module 2.2.2 CID Spec. Equipment Standards
    Module 2.2.3 CID Non-Spec. Equipment Standards
Task 8 - Technology Transfer & Education

Module 3 Parametric Design Rules & System Tools
- Module 3.0 Improved Pre-Production Processes
- Module 3.1 Introduction to Design Process
- Module 3.2 Parametric Ship Design Tool
- Module 3.6 Design & Material Templates
- Module 3.7 Interim Products
- Module 3.11 Accommodations & Deckhouse

AccomDesign Software
- Module A1 Software Operating Instructions
- Module A2 Software Use Example
Project Accomplishments

Material Standards & Parametric Design Rules

- **Task 9 - Prepare Project Reports & Deliverables**
  - 37 workshops and presentations conducted at Ship Production Symposia, NSRP Panel meetings, Project participant status reports and SNAME meetings at the national level.
  - 8 Journal papers written
  - Posted over 50 project deliverables on project web sites
    » nsrp.org
    » usashipbuilding.com
  - University classes and independent study work has been presented at U of Michigan & U of Washington
  - One Master’s Thesis at the University of Washington
  - Developed ACCOM Design training software
  - Completed 12 Education and Training Modules
Potential Further Developments

- **Verify Functional Volume Design Approach Through Full Implementation**
  - A Methodology template has already been delivered

- **Continue Rules and Templates Development**
  - Further Develop Macro Standards for Integrated Products Across the Whole Ship

- **Demonstrate Applicability to Naval Ship Design**

- **Leverage On-going Developments with E Commerce and Common Parts Catalog Use**

- **Application of Expert Systems to Design Process**