Using Isight Simulation Automation Tools to Reduce the Cycle Time for Ship Structural Analysis Process

Simulia Community Conference

Sean Murphy, P. E.
Allyn Boday
Ingalls Shipbuilding
Agenda

• Introduction

• NSRP Modeling and Simulation Project

• Benefits of Isight

• Example of Isight at Work
  – Foundation Analysis Part 1 – Model Conversion
  – Foundation Analysis Part 2 – Analysis Automation
  – Foundation Analysis Part 3 – Optimization

• Conclusion/Questions
Introduction

• Since 2007, a team of shipbuilders and software vendors have been conducting two National Shipbuilding Research Program (NSRP) projects entitled Improved Methods for the Generation of Full-Ship Simulation/Analysis Models 1 & 2 (M&S)

• The objective of the two projects was to reduce the cycle time required to develop large scale full ship analysis models for strength, stress, shock, and acoustic simulations and assessment

• The team consists of:
  • General Dynamics/Electric Boat Corporation (EB)
  • Huntington Ingalls Industries/Ingalls Shipbuilding (HII)
  • TechnoSoft Inc (TSI)
  • Dassault Systémes Simulia Corporation
  • Product Data Services Corp. (PDSC)
Goal: Analysis Process Improvement

Utilize Just the Right Amount of Analysis

Improved Processes Require Balance

Simple

Rules-Based Design
Point-and-Click Methods Design Re-Use

Simplified Analysis

Mid-Range

Spectrum of Analysis Options

Isogeometric Analysis

DDAM, Static Analysis

Specialized Analysis

Simulation Models

Complex

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Current Modeling and Simulation Processes

Designs Developed in CAD environment
- 3-D Product models
- Surface Models
- 2-D Drawings

Analysis
- Seaway Loads
- Weapons Effects

Analysis Modeling Space
- Generate Analysis Model Geometry from Design Information

Finite Element Model
- Models built using Shell and Beam Elements
- Correct Mass Distribution Required for Dynamic Analysis
Phases of the Analysis Process

Percentages of Analysis Process

- CAD Model Phase:
  - Acquire CAD Data: 4%
  - Create Solid Model: 20%
  - Convert Solid Model: 32%

- CAE Model Phase:
  - Mesh: 12%
  - Clean Mesh: 4%
  - Loads and Constraints: 4%
  - Assemble Final Model: 8%

- Simulation Phase:
  - Run Simulation: 4%
  - Post Process: 4%
  - Archive Results: 0%
Summary of Milestones

• Improved Methods for the Generation of Full-Ship Simulation/Analysis Models 1 (2007)
  – Proof of Concept Modeling with Simulia’s Isight software

• Improved Methods for the Generation of Full-Ship Simulation/Analysis Models 2 (Phase 1- 2008-2009)
  – Expanded Proof of Concept Modeling with Simulia’s Isight software

• Improved Methods for the Generation of Full-Ship Simulation/Analysis Models 2 (Phase 2- 2010-2011)
  – Benchmark Modeling with Simulia’s Isight software (Shock, Signatures, Structures, Piping, etc.)

• Improved Methods for the Generation of Full-Ship Simulation/Analysis Models 2 (Phase 3- 2011-2012)
  – Enhancement Evaluation with Simulia’s Isight software (Shock, Signatures, Structures, Piping, etc.)
  – Similia’s Isight software implementation into Shipyard Processes
Areas of Evaluation

Engineering Department

- Specialty Engineering
  - Noise, Shock, and Vibe
  - Signatures
  - HSI
- Field Engineering
- Program Engineering
- Hull Technical
  - Structures
  - Naval Architecture
  - Weight Control
- Marine Technical
  - Propulsion
  - Auxiliaries/Piping
  - HVAC
- Electrical Engineering
  - Electrical Systems
  - Combat Systems
Specific Processes that have been evaluated in Isight

- Completed Evaluations
  - Whipping Analysis
  - Longitudinal Strength Analysis
  - Post Processing/Data Reduction
  - Analysis Post/Processing
  - Linearized Stress Analysis
  - Ship Weight Distribution
  - Pipe Shock Test Specimen Design
  - Pipe Hanger Support
  - Bolt Stress Calculations
  - RCS Analysis
  - Foundation Analysis
  - Optimized Foundation analysis
Benefits of Isight

• 4-Fold Cost Avoidance Tool
  – Schedule Reduction
    • Significant interoperability with other software packages
  – Reduction of Manual Errors
    • Allows for semi-automation
  – Optimization capability
    • Allows for more in-depth comparison of design variations
  – Archived Documentation
    • Improved Communication
    • Increase in configuration management
    • Training tool
### Interoperability with other Software Packages

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Reduction of Manual Errors

Whipping Analysis and Longitudinal Strength Simflow
Comparison of Design Variations

Stress Linearization Simflow (socket weld fitting)
Comparison of Design Variations

- Allows for more in-depth comparison of design variations
  - Allows for Sensitivity studies
  - Better correlation of data points
  - Allows for multivariable studies

Comparison of P-13 Analysis for the TRT with Pipe Size, $B_{leg}$ weld size and insertion as variables

Isight Analysis Results

DM-RM-MT10 Analysis Results
Archived Documentation

Build Geometry Program File

Construct Model and Analysis

Create RCS Analysis File

Modify RCS Analysis File

Run RCS Analysis

Change Variable to a Different Value

Add Coords to Femap - Build Femap Program File

Create RCS Analysis File

Add Modifications to Analysis File

Run RCS Analysis

List of Coordinates

Loop

Radar Cross Section Simflow
Training and Configuration Management

- **Training**
  - Step by Step process visibly laid out
  - Relevant variables highlighted

- **Configuration Management**
  - All Variables that change are defined.
  - Inputs and results can be easily archived
Foundation Analysis using the Isight Software
• **Foundation Analysis**
  – Specifications requires all foundations for Grade A and B equipment to be analyzed for shock
  – Analysis performed are static loading, modal, and DDAM
  – Analysis is schedule dependant
    • Foundation information comes from CAD model
    • Structure group may get 100 foundations to analyze at one time with an expected 2 week turnaround
    • Average analysis time is 24 hours.*

* 24 Hours per foundation for 100 foundations in two weeks would require 30 full time analysts
Using Isight to meet schedule demands

- Foundation Analysis broken into 3 parts
  - Part 1 – Model Conversion
    - Proof of Concept developed by Simulia using CATIA
  - Part 2 - Analysis Automation
    - Isight Simflow developed by Ingalls Shipbuilding
  - Part 3 - Optimization
    - Semi-Automated Isight Simflow being developed by Ingalls Shipbuilding
Foundation Part 1 – Model Conversion

- **NSRP M&S 2 Phase 2**
  - Simulia developed proof of concept using CATIA V5

- **NSRP M&S 2 Phase 3**
  - Simulia to improve on using proof of concept software
  - Possible development with Ship Constructor (Dependent on Ship Constructor effort)
  - Software Evaluation (Task 3) may provide capability

- **Objective:**
  - Neutral input file (STEP, etc)
  - Neutral export file (BDF file, INP File, etc).
Foundation Analysis Part 2 – Analysis Automation

Meshed FEA Model → Static Analysis run (NASTRAN) → Fatal Errors?

Yes → STOP

No → Static Input Mod.

Report: List of all global and local Failures

Model Evaluation

DDAM Input Mod. & Run

Mode Shape Images

Modal Analysis (first 10 modes)

Modal Analysis While Loop

%Modal Mass Req’d?

>80% → Completed

<80% → Not Complete
Current setup simply checks the maximum Von Mises stresses against the general global membrane allowable.
• Calculated stresses should be based on Von Mises Failure Theory

• Design stresses categorized as “general” or “local” and as “membrane” or “membrane + bending”

• Will require some user input/engineering judgment

• Local stress – occurs in regions of load application or structural discontinuity
  – Considered local if localized stress exceeds the general allowable for less than 10% of the “effective area” of the load carrying member
  – Nodal stresses at points of stress concentrations are unlimited (e.g. corners, cutouts, point loads, etc…)
  – If the above criteria are not met, the stress is categorized as general
Foundation Analysis Part 2 - Stress Evaluation

- Determine Parameters
- Develop Envelopes
- Extract Stress Info
- Run Analysis
- Run UERD Macro
- Results Processing
- Envelope Track
- Time History Track
- Modal Frequency Track
Foundation Analysis Part 3 - Optimization

• Optimization based on results from Foundation Simflow

• Optimization - Semi- Automated
  – Based on the DDAM stress criteria
  – Still requires some evaluation from analyst

• Optimization Options
  – Reduced Weight
  – Reduced Piece Parts and Welding
  – Full Optimization (Does not account for standard structural member sizes or increases in welds)
Objective is to add optimization capabilities to foundation simflow in some capacity to maintain structural adequacy and minimize weight (may work better for some foundations than others)

Can modify plate thicknesses, beam element properties, etc…

Basic foundation optimization yielded a ~35% decrease in weight while still meeting the applicable general stress criteria.
Isight Simflow Evaluation

Breakdown of Analysis Hours

- Optimized
- Isight
- Existing

- Develop Model
- Add Analysis parameters
- Run Analyses
- Evaluate Results
- Write report and archive
- Optimize Solution
Isight and meeting demand schedule

- Isight can help engineering meet design and manufacturing schedule need dates with little change to existing process.
Summary

• Ingalls Shipbuilding examined approaches for reducing cycle time required to develop large scale, full-ship analysis models for strength, stress, shock, and acoustic simulations and assessment

• Isight was used on 10 simflows from throughout the Ingalls Shipbuilding Engineering Department
  – Experienced a 4-fold cost avoidance
  – Also helped meet schedule demands of many analyses required in a short time

• Isight software allows for semi-automation of the Foundation Analysis
  – Can reduce analysis time by up to 33%

• Optimization of the Foundation Analysis can be performed with little additional time
  – Requires the use of Isight’s Optimization Capability
  – Requires some preplanning with the finite element model
  – Engineering judgment still required to be make optimization realistic.
Questions??