Ship Design and Material Technologies Panel Break Out

Monika Skowronska, Panel Chair

NATIONAL SHIPBUILDING RESEARCH PROGRAM™
Taking Shipbuilding and Repair to the Next Level

Today's Agenda

Time (EST)	Presentation	Speaker
1:00 PM	**Convene Meeting**	
1:00 PM	Panel Chair Welcome/Panel Chair Update	Monika Skowronska, SDMT Panel Chair
1:15 PM	PP: Navy Standard Bookend Fixtures for Shock Testing	Mike Poslusny, Gibbs and Cox
1:45 PM	PP: Data-Centric Detail Design and Drafting Process Improvements	Greg Kangas, Hawk Technologies
2:15 PM	PP: Industry Recommended Framework and Implementation Roadmap for Delivering Cyber-Ready Ships	Veneela Ammula, ABS
2:45	**Break**	
3:00 PM	RA: Develop a Fast Analysis Solver for Weld Sequencing	Steven Scholler, Ingalls
3:30 PM	RA: Increase Steelwork Throughput and Reduce TOC by Leveraging Structural Design Optimization Tools Integrated with Process-Oriented Work-Content Tools for Preliminary Design	Tobin McNatt, MAESTRO Marine LLC
4:00 PM	RA: Lift Ship III	Darren Guillory, SSI
4:30 PM	Closing Remarks	Monika Skowronska, SDMT Panel Chair
5:00 PM	**Adjourn**	

National Shipbuilding Research Program (NSRP)
FY24 Research Announcement Project (RA 24-03)

"Increase Steelwork Throughput and Reduce TOC by Leveraging Structural Design Optimization Tools Integrated with Process-Oriented Work-Content Tools in Preliminary Design"

NSRP Ship Design & Material Technologies Panel Meeting

26 February 2025

NSRP
NATIONAL SHIPBUILDING RESEARCH PROGRAM™
Taking Shipbuilding and Repair to the Next Level

Agenda: NSRP RA 24-03 Project Review

- **Project Team**
- **Project Overview**
- **Project Tasking Review**
  - ***Task 1. Structural design for increased steelwork throughput via lean design optimization.***
  - ***Task 2. Software to automate Navy Design Criteria evaluation.***
  - ***Task 3. Advanced structural modeling via interface with Altair HyperWorks software.***

NSRP RA 24-03 - Project Team

- **MAESTRO Marine LLC**
  - *Project Lead; Naval Architects and Software Developers*
- **Fincantieri Marinette Marine**
  - *Shipbuilder with strong Concept/Preliminary through Functional and Detail Design*
- **Altair Engineering Inc.**
  - *Global leader in computational science and engineering simulation software tools.*
- **American Bureau of Shipping**
  - *Major U.S. Ship Classification Society and Technical/Safety Authority*
- **U.S. Coast Guard, Surface Forces Logistics Center**
  - *Depot Level USCG Maintenance and Engineering Center*
- **Robert Keane – Ship Design USA, Inc.**
  - *Former U.S. Navy Chief Naval Architect; Advisor for ship design tools and methods*
- **Peter Jaquith – P. Jaquith & Associates**
  - *SME in Lean Design and Design for Production*
- **SPAR Associates, Inc.**
  - *SME's in ship cost-estimating and production planning*

The project team represents:

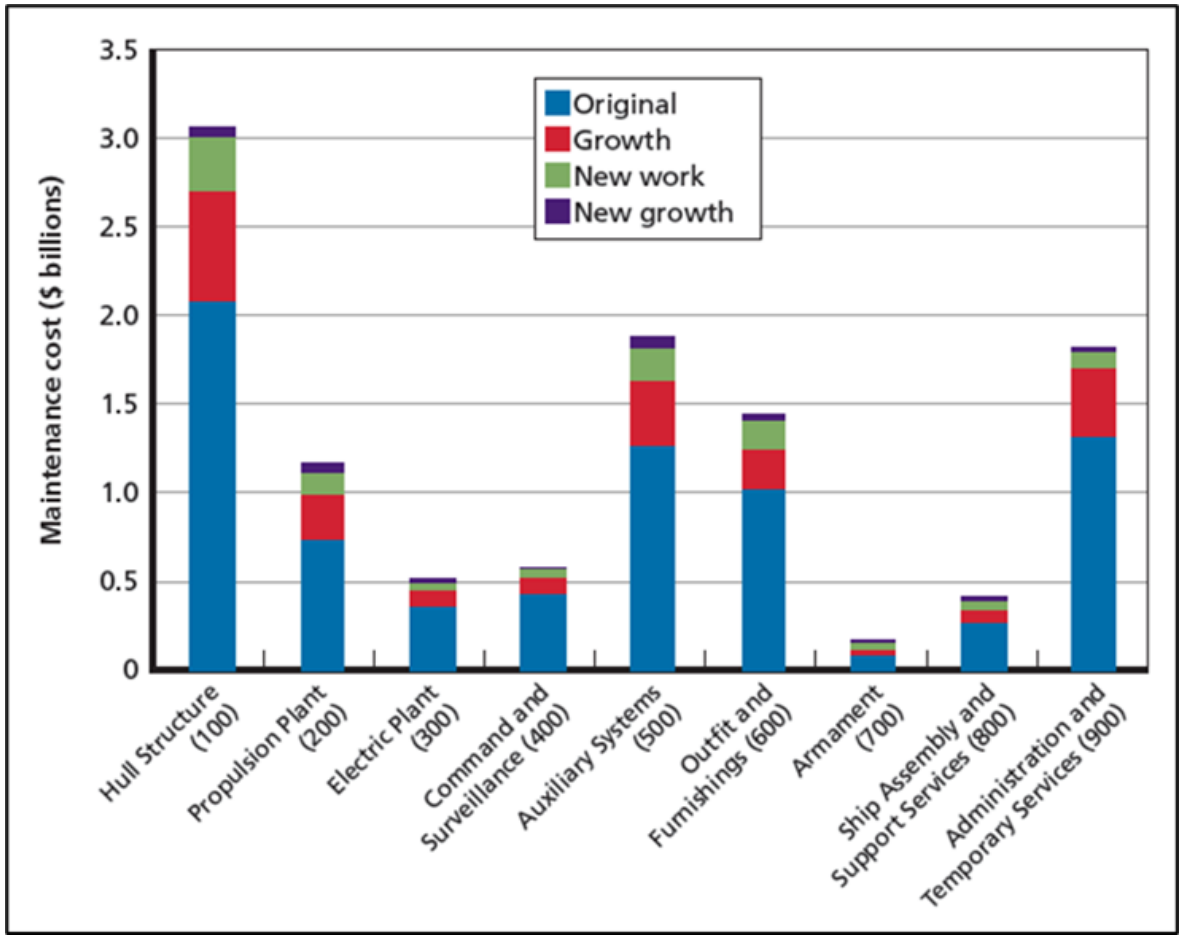
- The U.S. shipbuilding enterprise including a key shipbuilder
- A global leader in engineering simulation software tools
- A major Government ship engineers, owners and operators
- The major U.S. Ship Classification Society
- Ship design, lean design, production planning and cost estimating specialists
- And is primed by the developers of the software being leveraged for the project.

Overview 1 - Project Rationale

Project Rationale

- U.S. Government Accountability Office (GAO) reported in its March 2020 GAO-20-2 Report, "Increasing Focus on Sustainment Early in the Acquisition Process Could Save Billions".
- Navy and USCG ships experience excessively high in-service structural maintenance and repair costs.
- Corrosion wastage, heavy weather damage and fatigue cracking lead high structural TOC.
- This in spite of ships being designed using traditional methods to U.S. Navy structural design criteria.
- Improved structural design space exploration tools can mitigate these excessive costs and also generate positive ROI for structural fabrication.

The project addresses these issues with enhanced design tools for preliminary and contract structural design to complement traditional and Ship Spec required methods.



Group 100 Hull Structures Leads U.S. Navy Surface Ship Depot Maintenance Costs by ESWBS, 2003-2015
[2017 RAND Report 1187]

Overview 2 - Project Objectives

Project Objectives

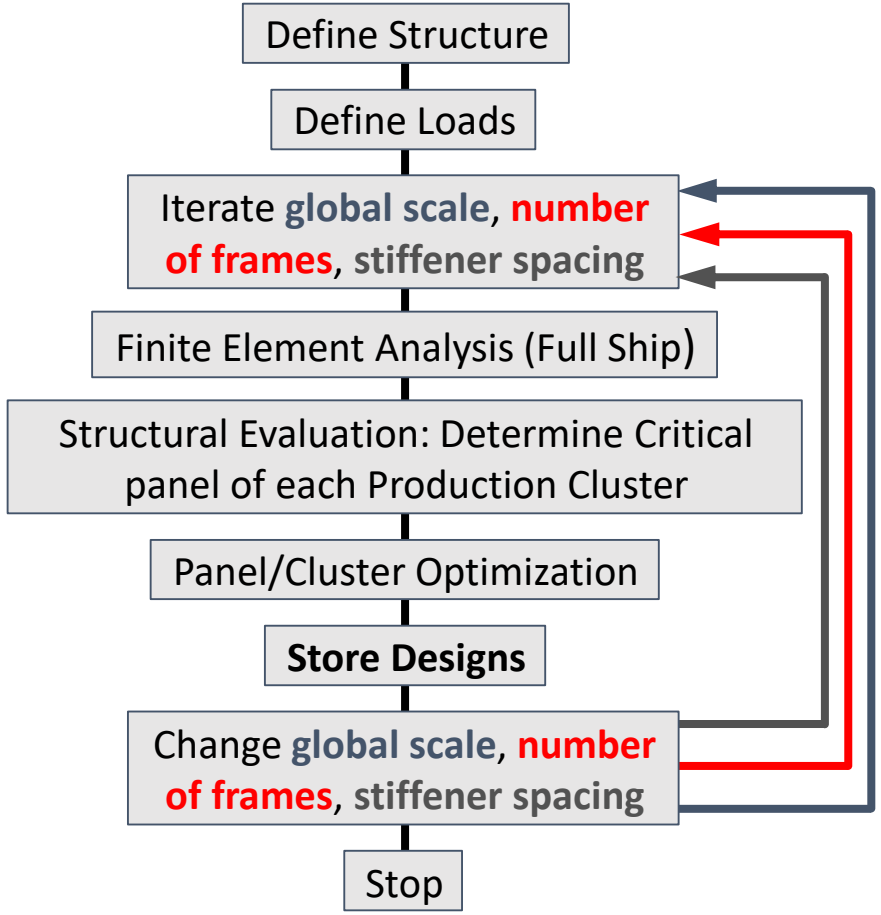
- **Objective 1.** Enhance ship structural design for increased steelwork throughput.
- **Objective 2.** Automate U.S. Navy Structural Design Criteria Evaluations.
- **Objective 3.** Develop advanced structural modeling and rigorous structural design space exploration to ensure structural integrity performance and reduce excessive SWBS 100 TOC.
- Leverage these capabilities through an integrated structural optimization software toolset.

Structural design practice today is largely unchanged from the processes developed decades ago and still in use for the ships in today's fleet.

Past structural designs for today's fleet have not withstood the demanding operating environment, resulting in excessive TOC and lost availability

Overview 3 - Technical Approach

- Enhance full ship structural optimization successfully completed under NSRP RA 21-11 with *preliminary and contract design capabilities*.
- Increase steel throughput using lean design principles and fabrication process models.
- Automate U.S. Navy structural design criteria to facilitate design space exploration.
- Develop collaboration with high-fidelity Altair HyperWorks software for structural modeling and analysis.
- Leverage the existing MAESTRO software codebase to support enhanced structural design space exploration.



MAESTRO's Unique Optimization Workflow

This Technical Approach produces practical design tools that: reduce fabrication cost through lean design; reduce in-service structural failures; reduce in-service corrosion degradation; increase life expectancy of applied coatings; and reduce total ownership cost.

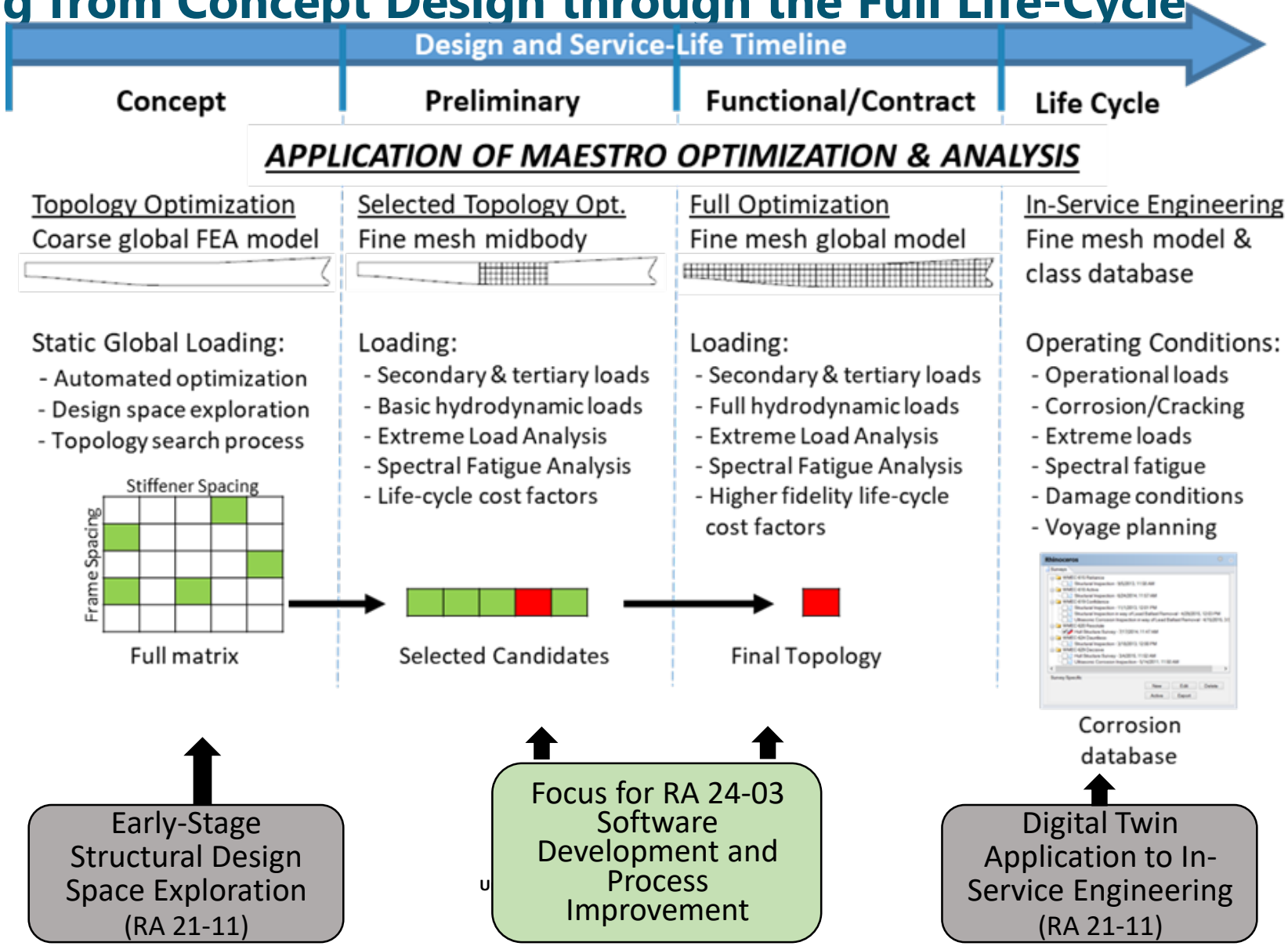
Overview 4 - Project Deliverables, Benefits and ROI

Deliverables/Benefits/ROI

- **Deliverables** in the form of commercial grade software tools for industry usage.
  - Task 1. Structural design for increased steelwork throughput via lean design optimization.
  - Task 2. Software to automate Navy Design Criteria evaluation.
  - Task 3. Advanced structural modeling via interface with Altair HyperWorks software.
- **Benefits:** Reduce structural fabrication costs; use high-fidelity design space exploration to design more robust structures that reduce TOC.
- **ROI:** mitigate the excessive and well-documented structural repair and maintenance costs due to heavy weather damage, fatigue damage, and corrosion degradation.
- **U.S. Navy annual corrosion cost exceeds $2B.** The RA 24-03 project will build on high ROI shown for predecessor NSRP RA 21-11 showing ROI=76 (Design/Construction) and 77 (In-Service Savings) (NSRP target ROI=2).

These tools will be ready for distribution and use by the U.S. Shipbuilding Enterprise at the completion of the RA project. Many shipbuilders (GD/BIW, HII Ingalls Shipbuilding, Fincantieri Marinette Marine), U.S. Navy, U.S. Coast Guard SFLC, and design firms already use the MAESTRO software.

Overview 5 - Technology Transfer: Provide Higher-Fidelity Structural Engineering from Concept Design through the Full Life-Cycle



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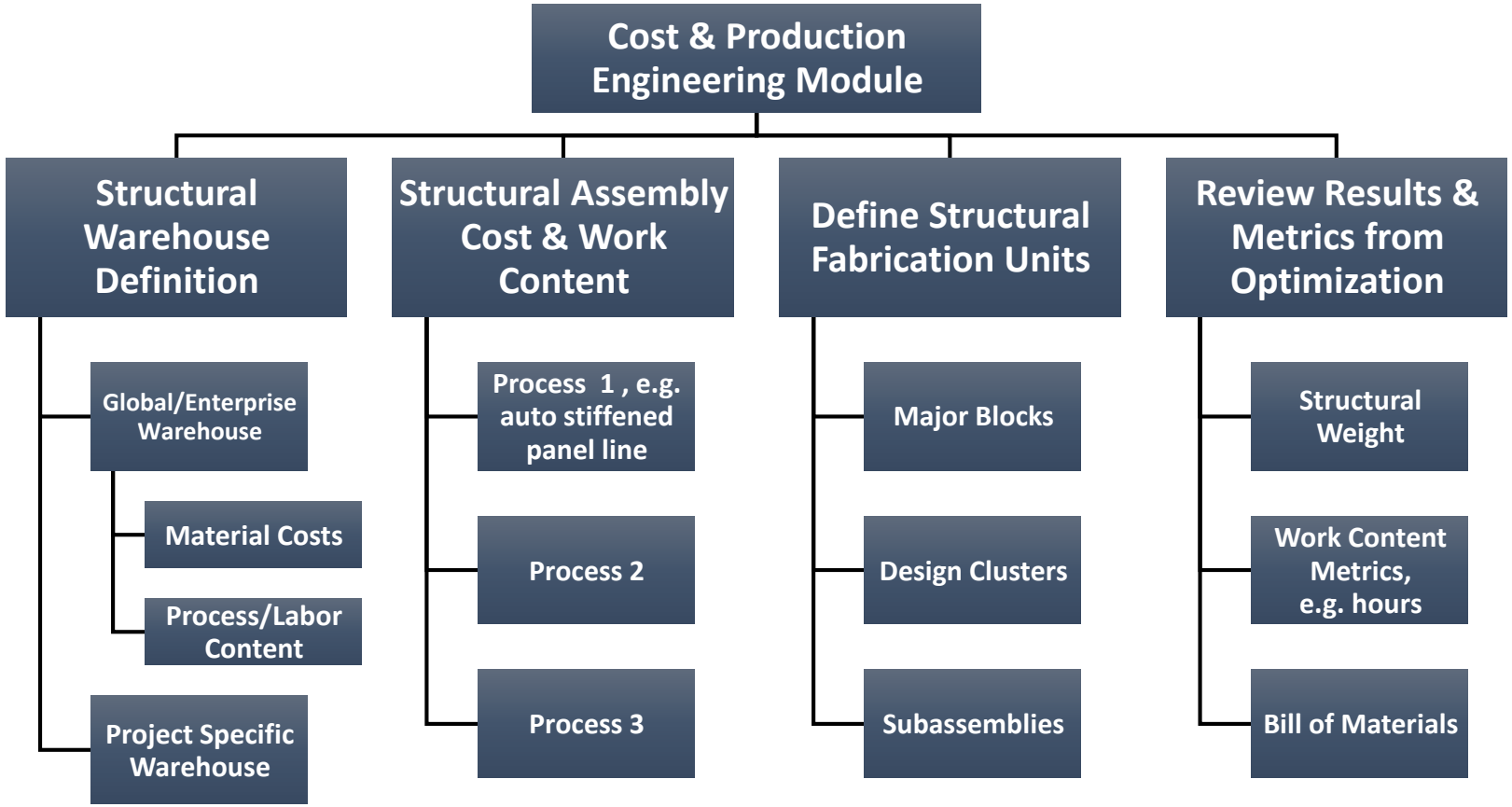
Task 1. Enhance ship structural design for increased steelwork throughput

- Task 1 leverages the MAESTRO finite element software to implement tools for use during Preliminary and Contract Design that can support increased steel production throughput.
- The modeling and analysis will use finer mesh models than are used in early-stage design.
- Tools will be developed to model capacities and capabilities of shipbuilder steel fabrication process lanes, so production engineers can assign structural subassemblies and components to appropriate lanes.
- The process models will generate work-content metrics for the structural design to support optimization metrics that reflect steel production throughput.
- Tools will also be developed to support engineering structures for reduced numbers of plate types and profiles, simplifying the inventory and fabrication processes.

This task will enable collaboration between shipbuilder production engineers and structural design engineers.

Task 1. Enhance ship structural design for increased steelwork throughput
Cost & Production Engineering Module Functional Blocks



This Functional Model or Work Breakdown Structure is the Objective of Task 1. These functions are present in the current form of MAESTRO and the Task 1 goal is to further enhance the effectiveness for improved ship structural design with reduced costs.

Task 1. Enhance ship structural design for increased steelwork throughput Structural Optimization Metrics

- **Initial Production Engineering Analysis**
  - Total Weld Length (including chocks, brackets, collars, etc.) and excluding flange welding on purchased built up profiles)
  - Total Structural Intersections
  - Total Coating Surface (tanks & non tanks)
  - Total Structural Weight
- **Detail Work Content Analysis**
  - SPAR metrics for Work Content and Cost Analysis
    - Hours per Meter of weld for Manual Welding
    - Hours per Meter of weld for Automation Work Centers
    - Hours per Square Meter for Blasting
    - Hours per Square Meter for Paint systems
    - Hours per Metric Ton for Structural Interim Products
  - SPAR work content and cost methods/algorithms can be generalized in new MAESTRO interfaces with key data input by MAESTRO users: shipbuilders, design firms, and Government.

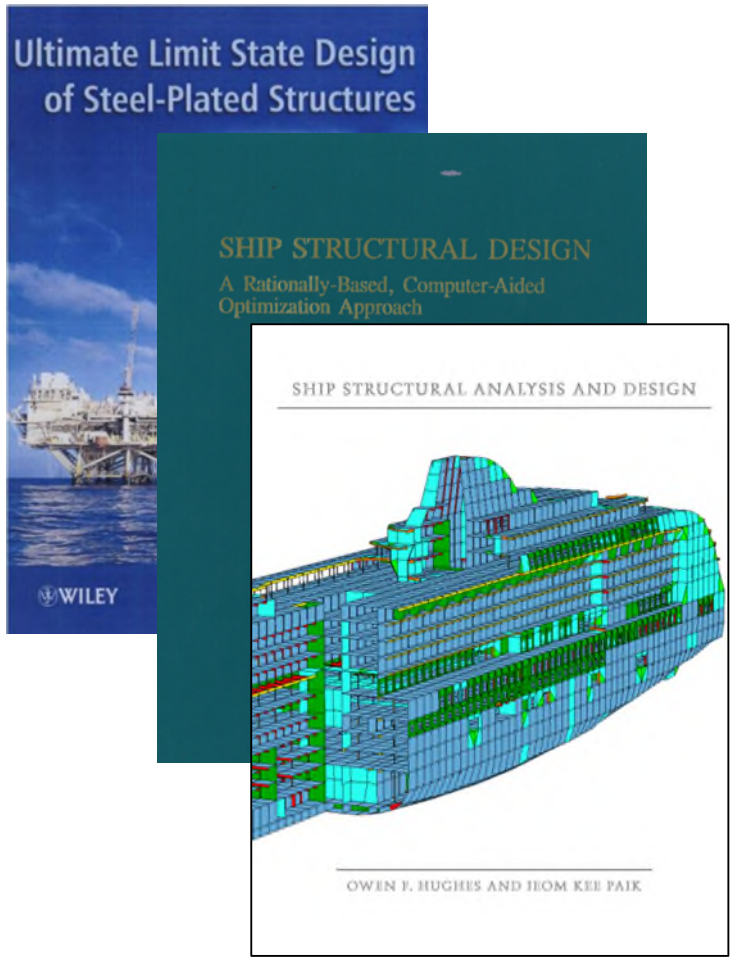
Task 2. Integrate and Automate U.S. Navy Structural Design Criteria

- U.S. Navy's Structural Design Criteria based on DPC100-4/Mil-HDBK-519 will be integrated into MAESTRO.
- The MAESTRO-based criteria will enable the design criteria to be automatically evaluated for all structural members of a full ship finite element model instead of spot-checked with Excel sheets for selected members as in current design practice.
- In addition, the minimum work content optimization algorithm in Task 1 will be integrated with the design criteria so that structural cost and work content can be included with weight in the multi-objective optimization process.
- The integrated criteria checks will use the existing MAESTRO limit-state evaluation paradigm which will automate the use of the 2D-based criteria to serve as constraints supporting structural design and optimization using a 3D finite element model.
- This provides an effective solution to automating the comprehensive application of Navy structural design criteria into an advanced ship structure optimization system.

This task automates U.S. Navy structural criteria checks for the full ship using 3D finite element analysis models.

Task 2. Integrate and Automate U.S. Navy Structural Design Criteria Automated Local and Full Ship Structural Limit-State Evaluation

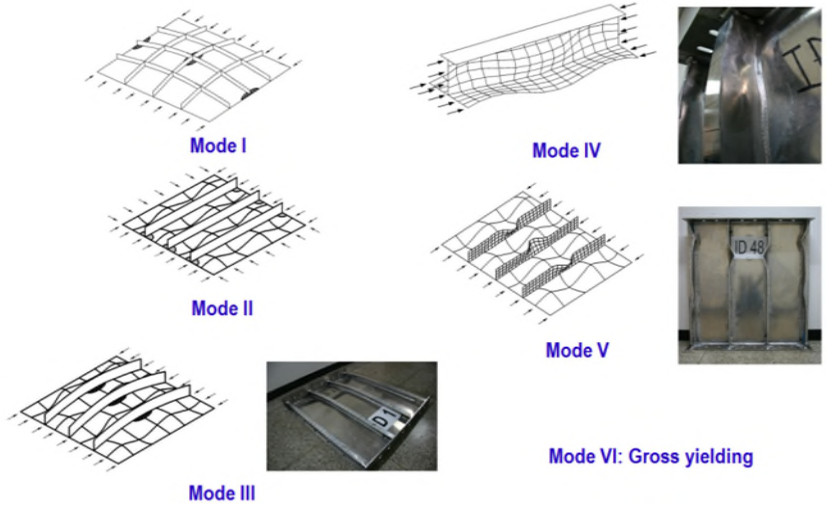
- Structural response (stresses, deflections) is not sufficient for ship structural design and optimization
- MAESTRO evaluates the entire structure for local and global limit states, e.g., panel and beam buckling, hull girder ultimate strength
- Several sets of local structural limit states are available:
  - ABS – Steel Vessel Rules w/DLA
  - ABS – HSC
  - ABS – Offshore Buckling Guide
  - U.S. Navy DPC100-4/MIL-519
  - Hughes – Ship Structural Design
  - Paik – ALPS/ULSAP
- Global (hull girder level) limit states include Paik's ALPS/HULL and Dow's ProColl
- Limit-States also provide constraint-base for MAESTRO's structural optimization process

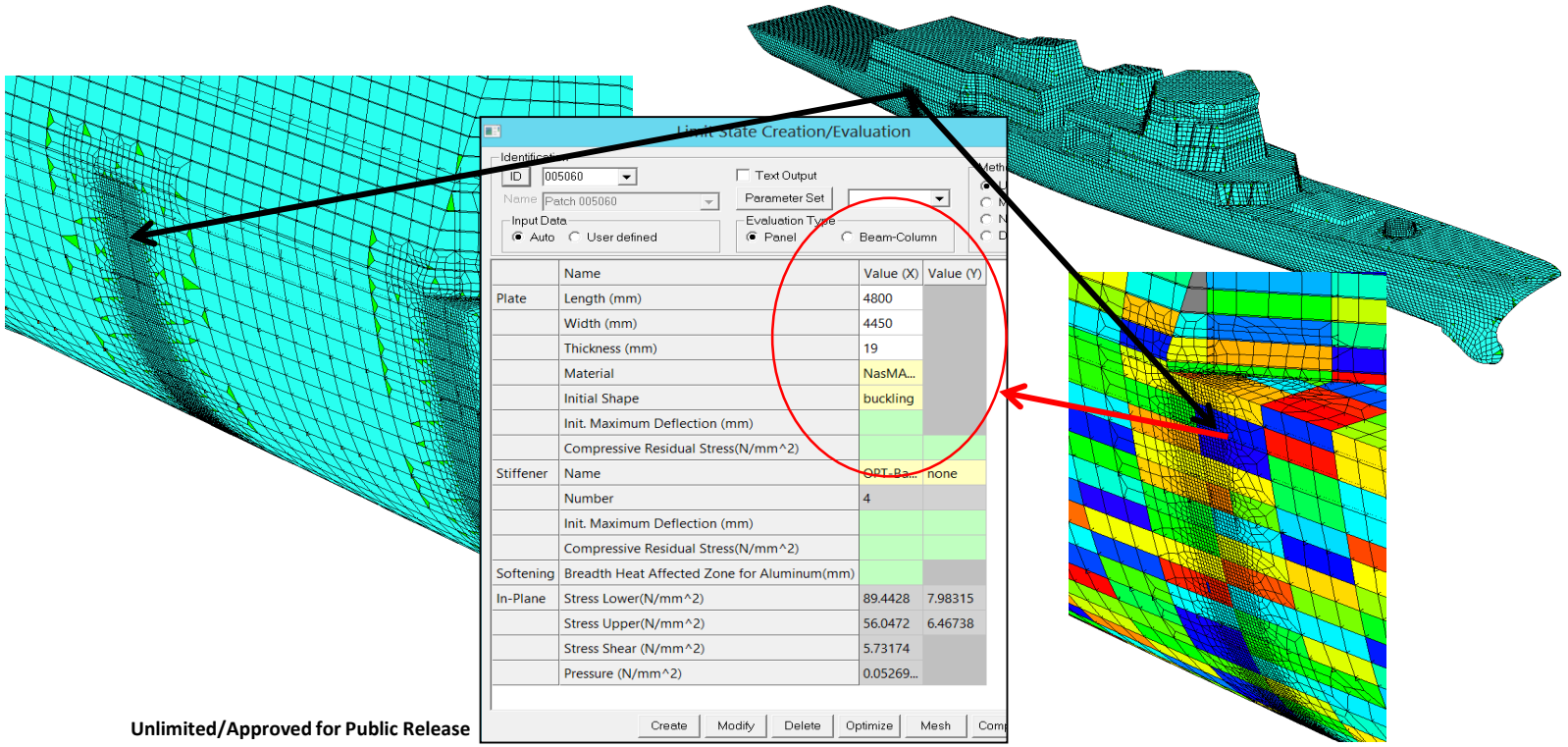


Textbooks addressing the theoretical basis of MAESTRO's analysis and optimization process

Task 2. Integrate and Automate U.S. Navy Structural Design Criteria Automated Limit-State Entity Definition and Full Ship Structural Evaluation

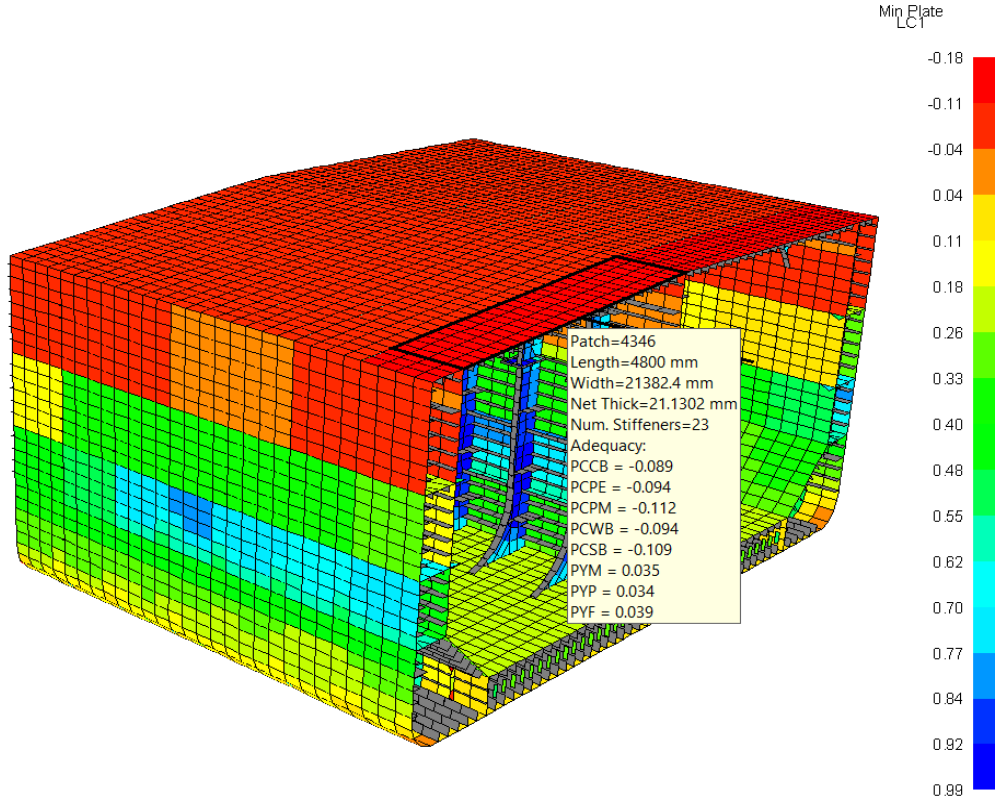
- Automatically collects plate and beam elements into limit-state (e.g., buckling) entities
- Represents the stiffened panels and correct panel parameters
- Design Criteria are automatically evaluated for the full ship and for all load cases
- Supports Safety Authority/Classification design criteria compliance

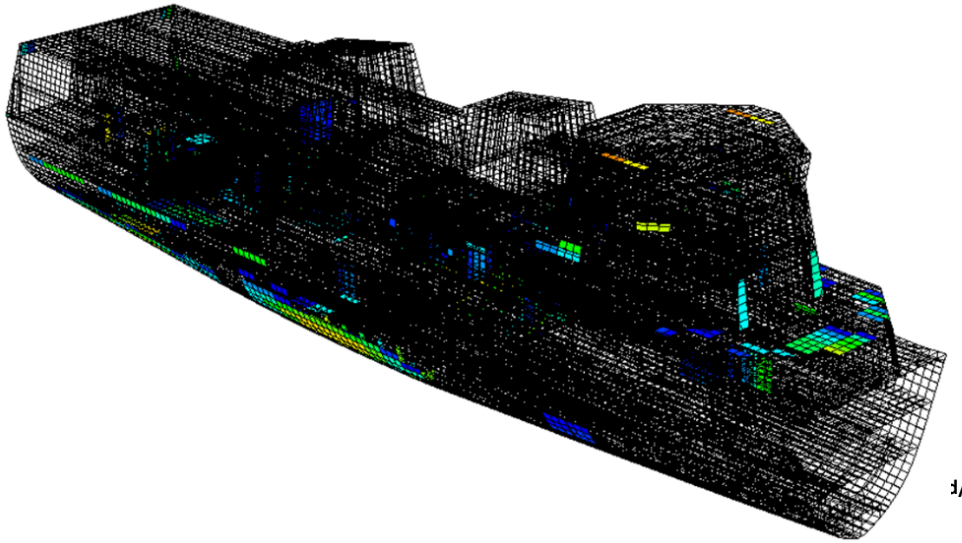




Task 2. Integrate and Automate U.S. Navy Structural Design Criteria Automated Limit-State Panel Definition and Full Ship Structural Evaluation

- The working stresses from each load case are evaluated against the limit values to assess the performance of the entity against the design criteria.
- Process routinely involves several thousand limit state evaluation patches or entities for a global ship structure and is a routine component of the post-processing of the finite element analysis results.
- Through automating this process, the U.S. Navy structural design criteria will be checked for every structural component for the full ship finite element model for every load case.





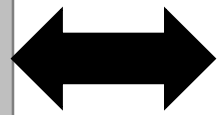
Task 3. Advanced Structural Modeling and Rigorous Design Space Exploration

- Integrate or interface the MAESTRO toolset with the Altair HyperWorks structural finite element design tools to provide:
  - State-of-art modeling for complex ship structures
  - Rigorous ship structural design space exploration
  - Higher fidelity 3D finite element analysis.
- This combined package will be seamlessly integrated with MAESTRO's potential-flow hydrodynamic loading analyses tools.
- Task 3 objectives include:
  - Design robust structures that reduce structural damage under extreme loads (e.g., heavy weather)
  - Reduce and prevent structural fatigue damage in-service
  - Optimize the structural configuration to significantly increase the effectiveness of initial coating applications and improve coating maintenance through the service-life to minimize corrosion wastage damage.

Task 3. Advanced Structural Modeling and Rigorous Design Space Exploration
MAESTRO – Altair HyperWorks Integrated Workflow

MAESTRO

- Ship-centric mass-properties definition
- FEA oriented hydrostatics and static design waves
- Unique automated limit-state/failure evaluation
- Integrated seakeeping and hydrodynamic loading
- Safety Authority design extreme load cases and spectral fatigue analysis
- Structural optimization for safety compliance, reduced weight, improved production



ALTAIR HYPERWORKS

- Structural modeling and analysis
- Results hosting and visualization
- Local structure optimization
- Reduced structural weight
- Collaborative structural optimization and decision making
- Innovative, profitable ship designs
- Through-life structural digital twin

Questions or Comments?

MAESTRO Marine LLC

Tobin McNatt
tobin.mcnatt@maestromarine.com

410-829-4272

www.maestromarine.com

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5:00 PM	**Adjourn**	

LiftShip3 (RA 2019-483-10)

Darren Guillory

NSRP All Panel Charleston NC

February 26th

TEAM:

SSI (Lead)

Fincantieri Marinette Marine

Austal USA, Inc.

Ship Architects, Inc.

Genoa Design International, LTD

ATA Engineering

Altair Engineering

NAVSEA NSWC Carderock

Benefits of the LiftShip Projects

- **Automation and efficiency**
- **Cost reduction**
- **Improved decision making**
- **Innovation and the ease of adoption**

Benefits of the LiftShip Projects

❖ Automation and Efficiency

- The projects have helped to automate large-scale lift preparation and analysis, which if adopted, can significantly reduce the man-hours associated with (FE) mesh generation, analysis, and the creation of lifting arrangement drawings

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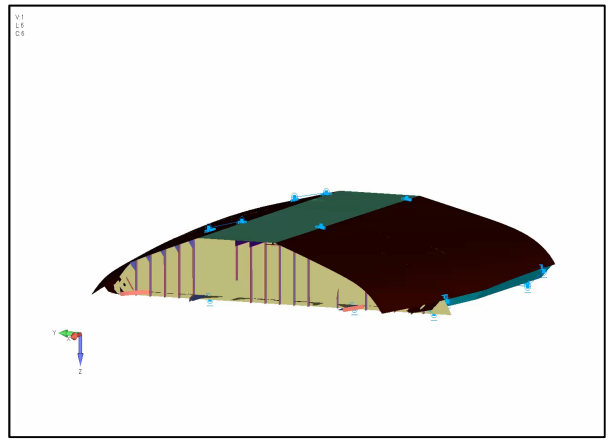

Benefits of the LiftShip Projects

❖ Cost Reduction

- **Rapid model creation:** Complex models are ready for meshing and analysis in hours which leads to cost savings and efficiency.
- **Multiple scenario analysis** : possible for optimal lifting configurations.
- **Time savings :** 40:1 to 60:1 in FEA model generation, transforming man-months of work into days.

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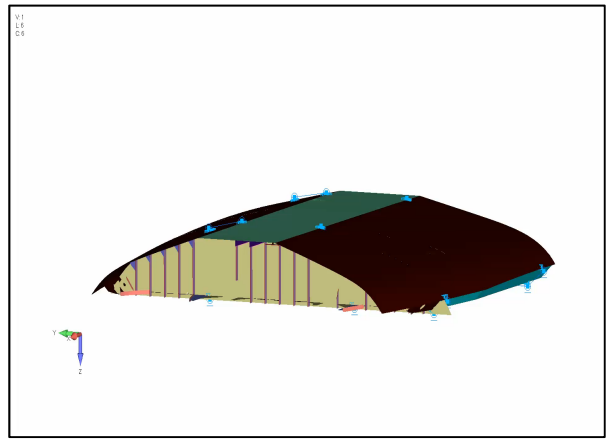
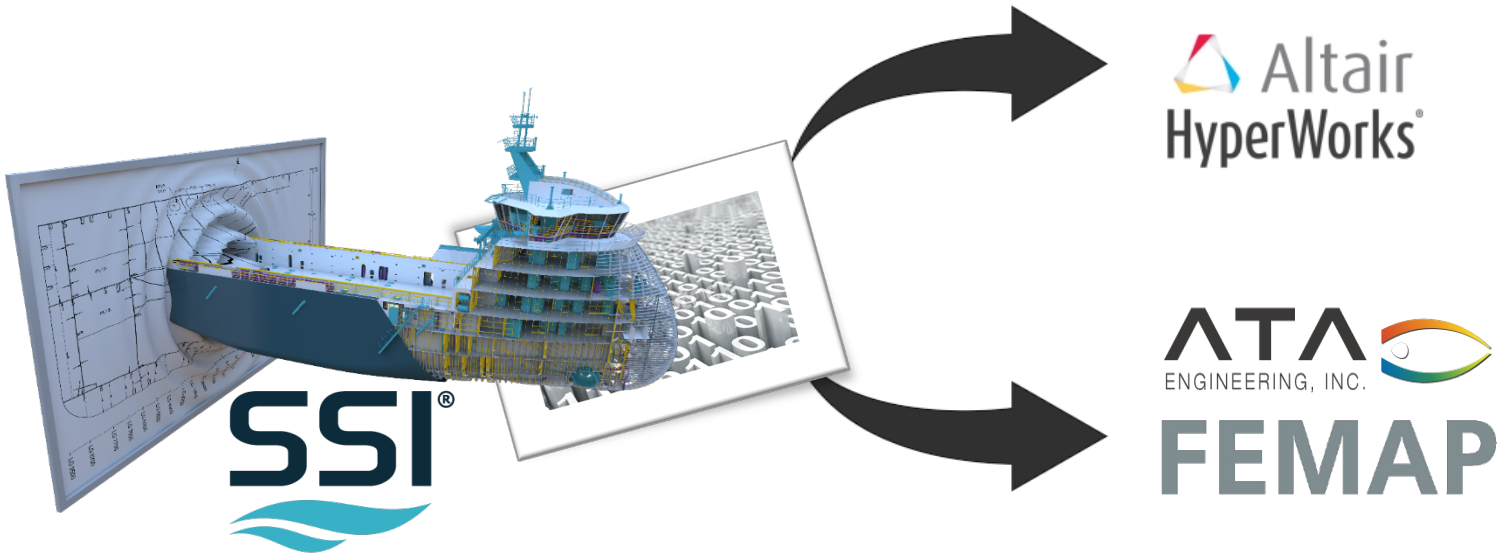


Benefits of the LiftShip Projects

- **Improved Decision Making**
  - These projects have enabled the presentation of FE Analysis results in a clear and concise manner, aiding shipyard engineers in determining the feasibility of lifts and making informed decisions.



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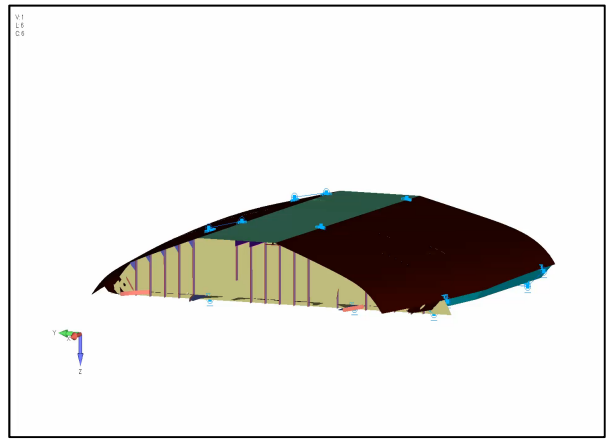

Benefits of the LiftShip Projects

- **Innovation and Ease of Adoption**
  - These projects have enabled the shipyards the framework to adopt benefits identified by the program using toolsets they already have in place.
  - Each of the software participants have included these capabilities within their core offerings.

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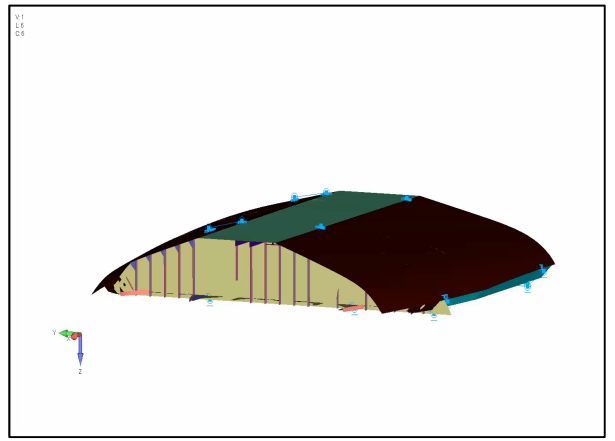


Project Background LiftShip (2018-438)

May 2018- April 2019

NSRP ASE INVESTMENT: $1.1M

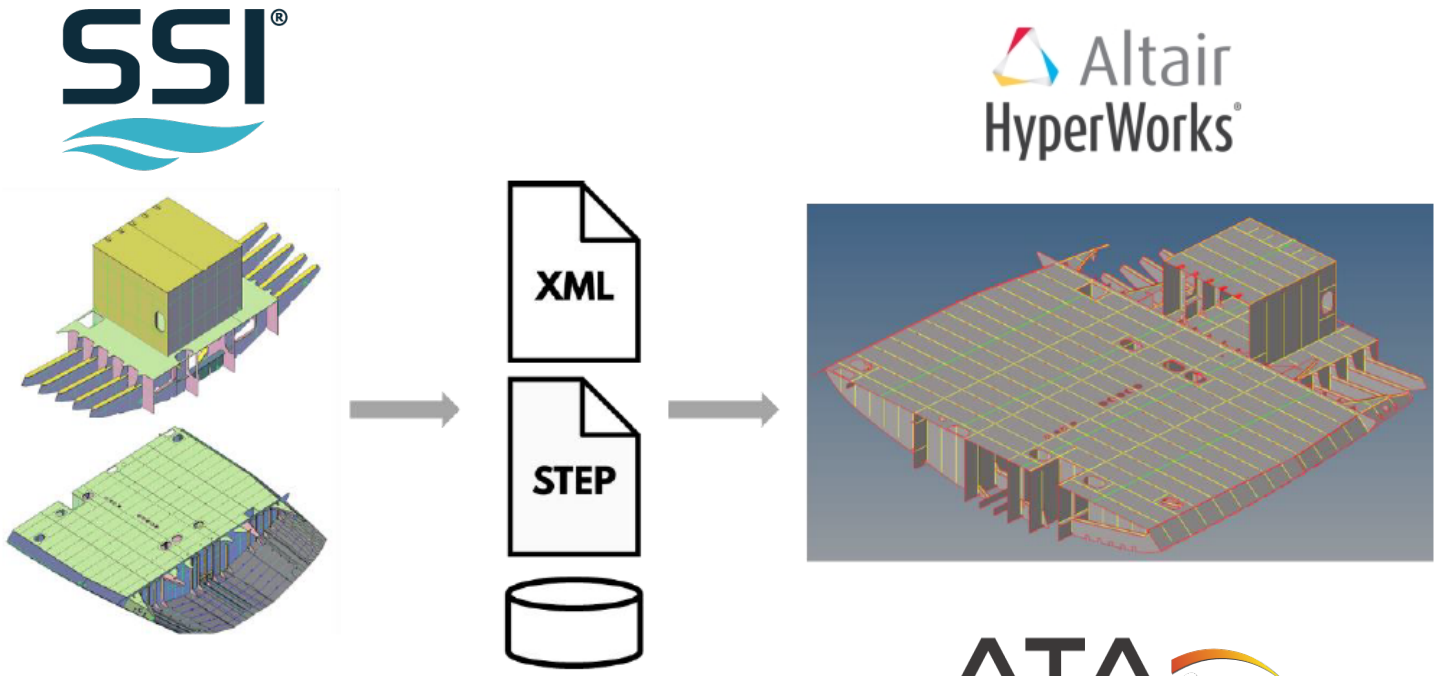
INDUSTRY INVESTMENT: $1.7M

Project Team:

- ShipConstructor Software USA, Inc.
- Austal USA
- Bollinger Shipyards Lockport, LLC
- Conrad Shipyard, LLC
- VT Halter Marine
- Ship Architects, Inc.
- Altair Engineering
- ATA Engineering

Project Background LiftShip(2018-438)

- Objective: To automate the process of preparing and analyzing large-scale lifts, and to generate comprehensive lift packages that include production drawings, Bill of Material, and other necessary components.
- Technology Areas: The project focused on several technology areas, including the generation of lift package output drawings from ShipConstructor, exporting models for FEA, and identifying deformation limits to ensure the appropriateness of lifts.
- FEA Integration: It aimed to integrate FEA into the lift analysis process, providing feedback on the feasibility of lifts and potential deformations.
- Benefits: The project sought to reduce man-hours associated with FE mesh generation, analysis, and the creation of lifting arrangement drawings, ultimately leading to cost savings.



Completed Successfully

Project Background LiftShip2 (2019-451-003)

September 2020 – August 2022

NSRP ASE INVESTMENT: $1.8M

INDUSTRY INVESTMENT: $1.1M

Project Team:

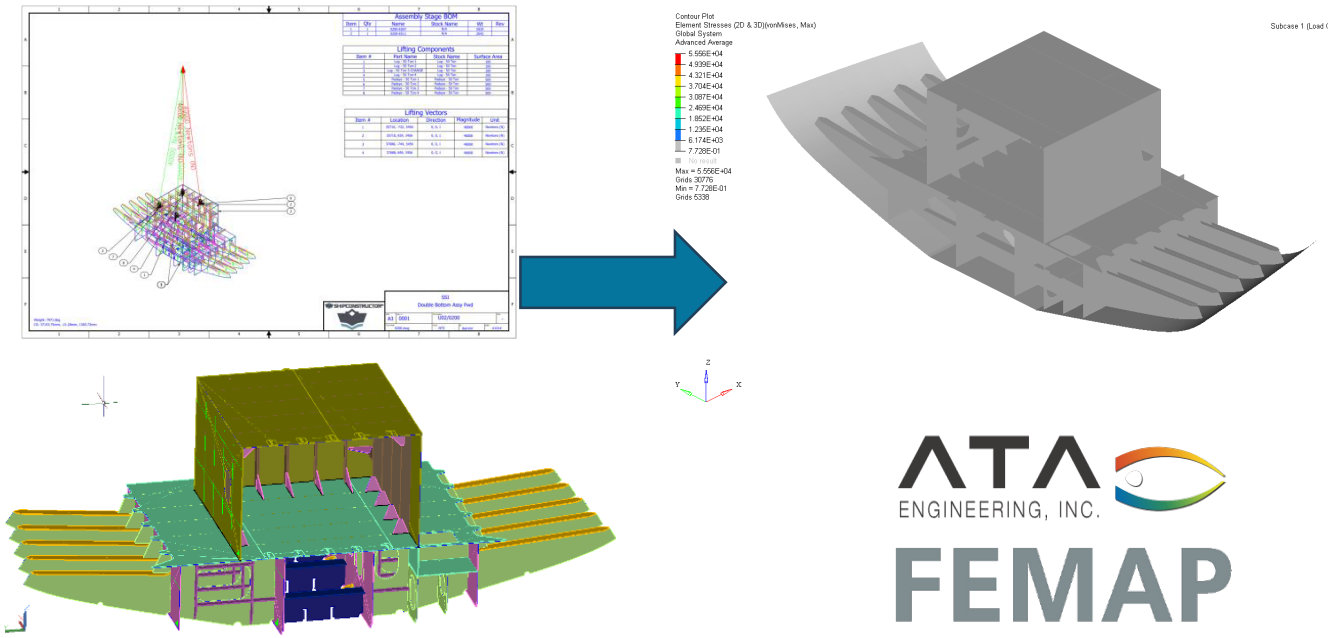
- ShipConstructor Software USA, Inc.
- Ingalls Shipbuilding
- VT Halter Marine
- Austal USA
- Genoa Design International
- Ship Architects, Inc.
- ATA Engineering
- Altair Engineering

Project Background LiftShip2(2019-451-003)

- Objective: To enhance the process of complex lift and turn operations and providing a more efficient and user-friendly FEA experience.
- Technology Areas: Enhancement of the FEA software to improve its efficacy in complex lifts & turns while ensuring seamless data integration with ShipConstructor as well as visualization tools of the FEA results.
- FEA Integration: Automated Model Generation, Scenario-based analysis, and Level of Detail Management.
- Benefits: Efficiency, Accuracy, Usability, and Cost-effectiveness.

SSI®

Altair HyperWorks®



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Completed Successfully

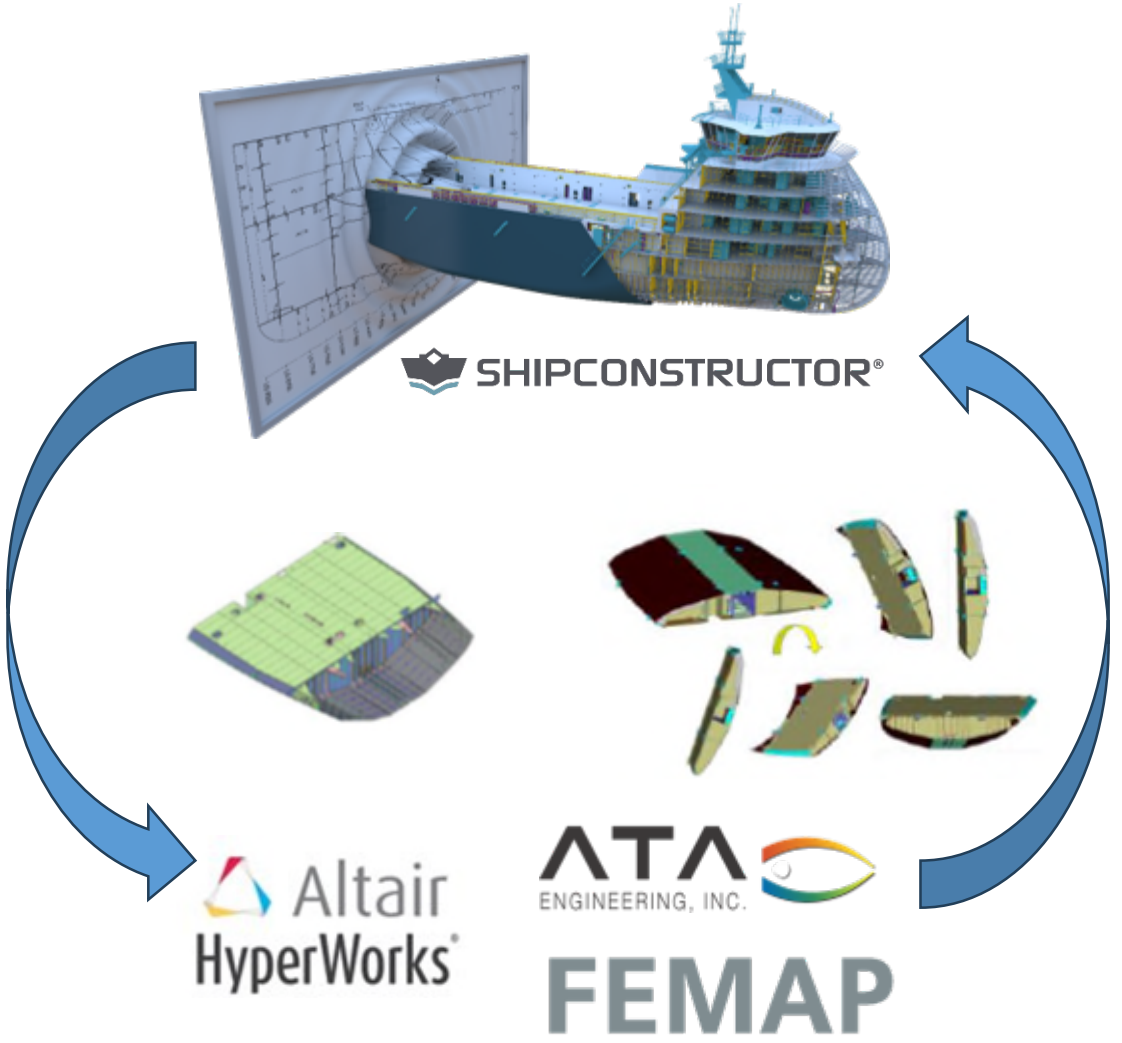
LiftShip3 (2019-483-010)

May 2023 – May 2025

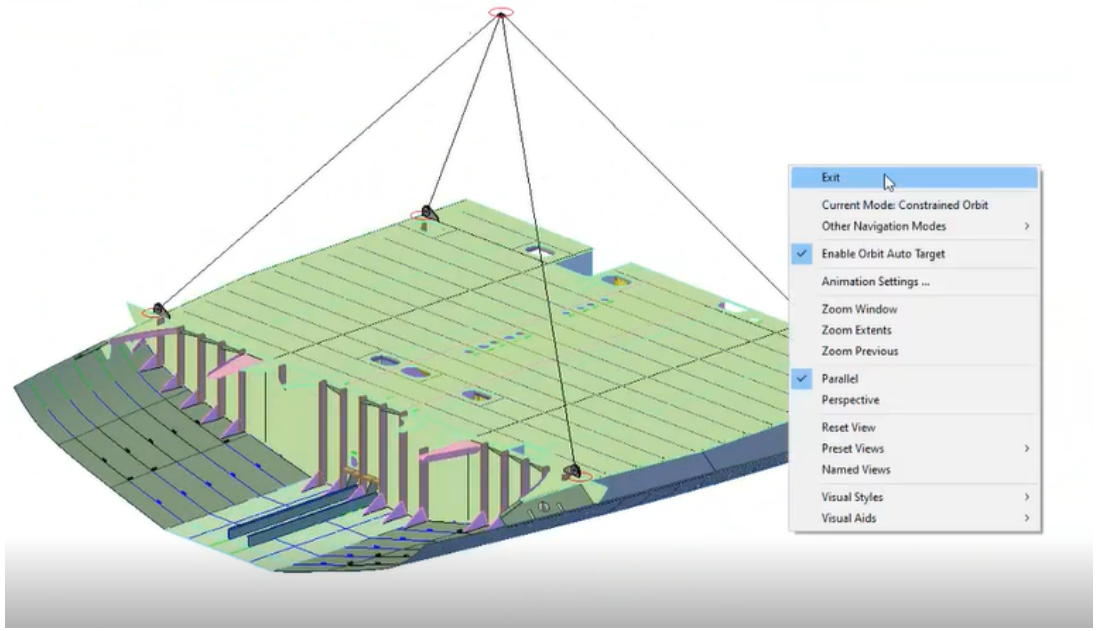
NSRP ASE INVESTMENT: $981K

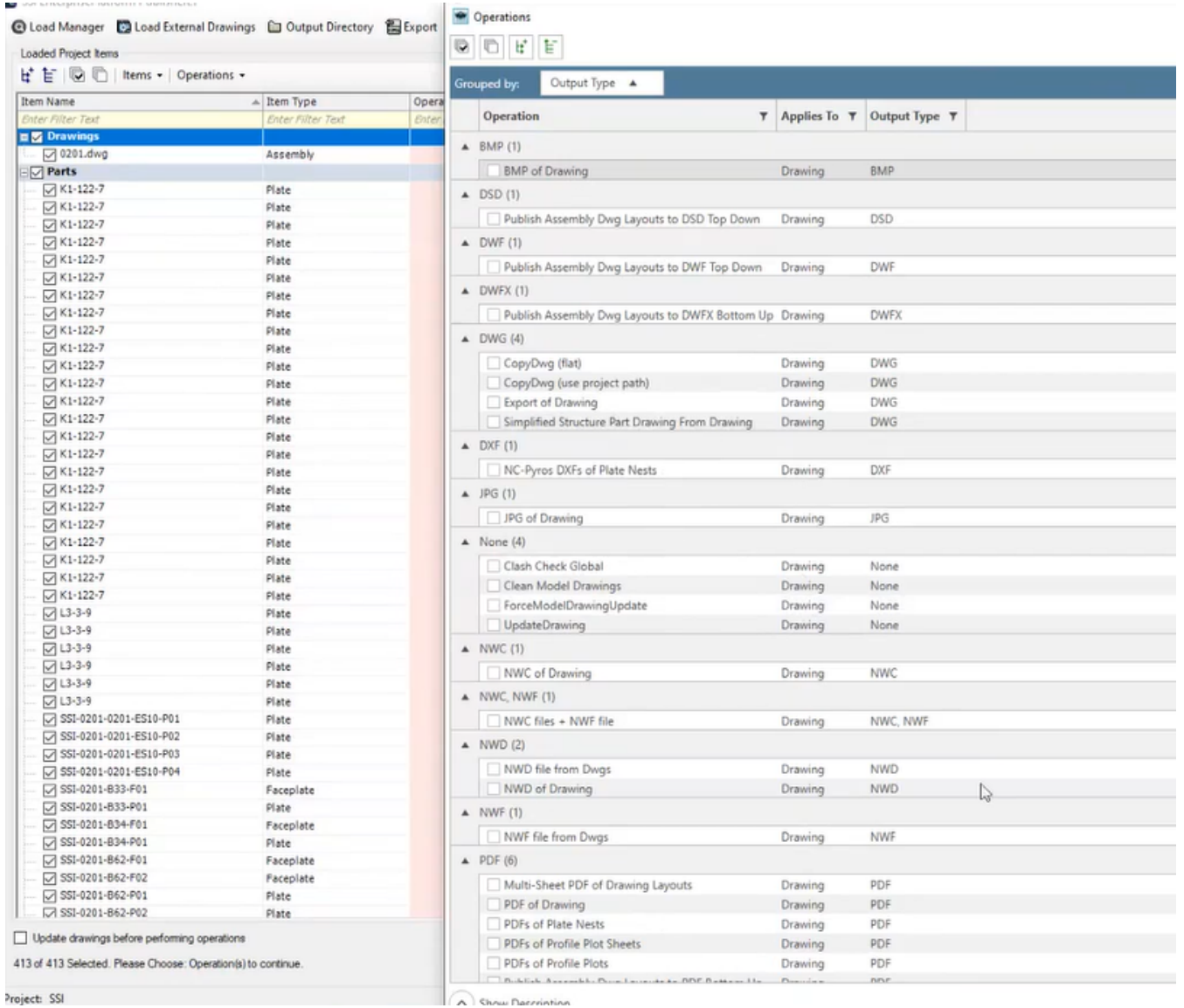
INDUSTRY INVESTMENT: $1.2M

- Objective: The project's objective is to build upon the success of the previous LiftShip projects by increasing the technical functionality of data transfer between 3D models and Finite Element Analysis (FEA) software.
- Project Overview: LiftShip3 focuses on allowing structural changes identified through FEA to be incorporated back into the ShipConstructor 3D design model early in the design process.
- Goals: The project aims to synchronize changes in FEA back to the production model to support output drawings, leading to shorter design times and streamlined design evaluation processes.
- Benefits: By enhancing data transfer and model synchronization, LiftShip3 proposes to allow designers to find innovative uses for lifting structures and further ease the design process.



LiftShip3 Development

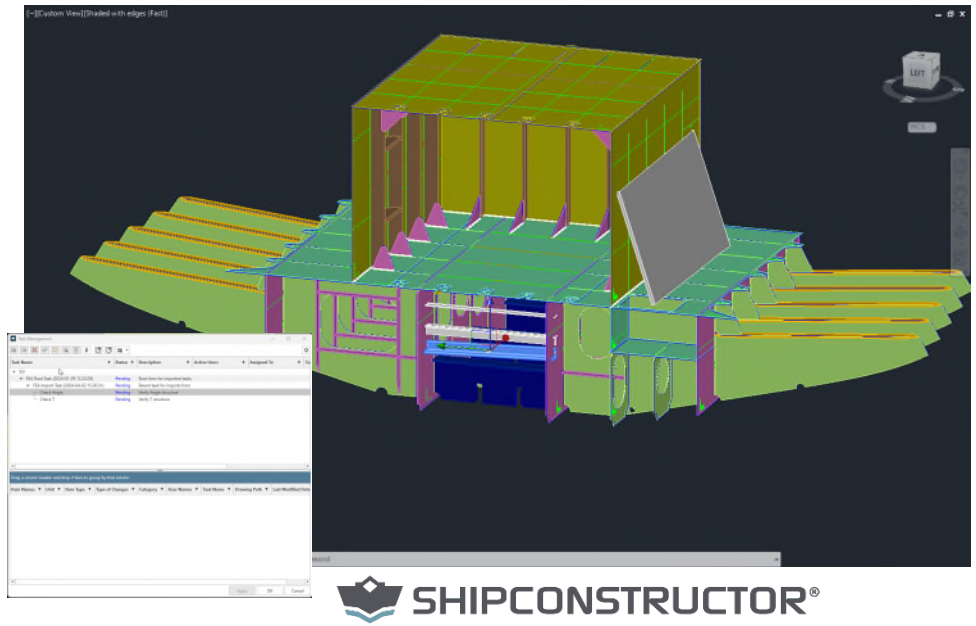


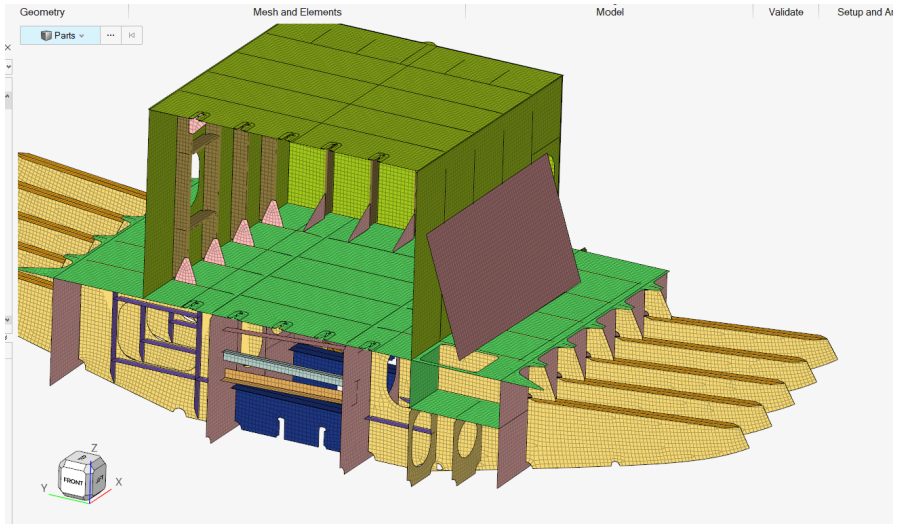


LiftShip3 Development

Post Analysis Import from FEA

Plate Parts
Stiffeners
Generated Tasks in SSI





Altair HyperWorks

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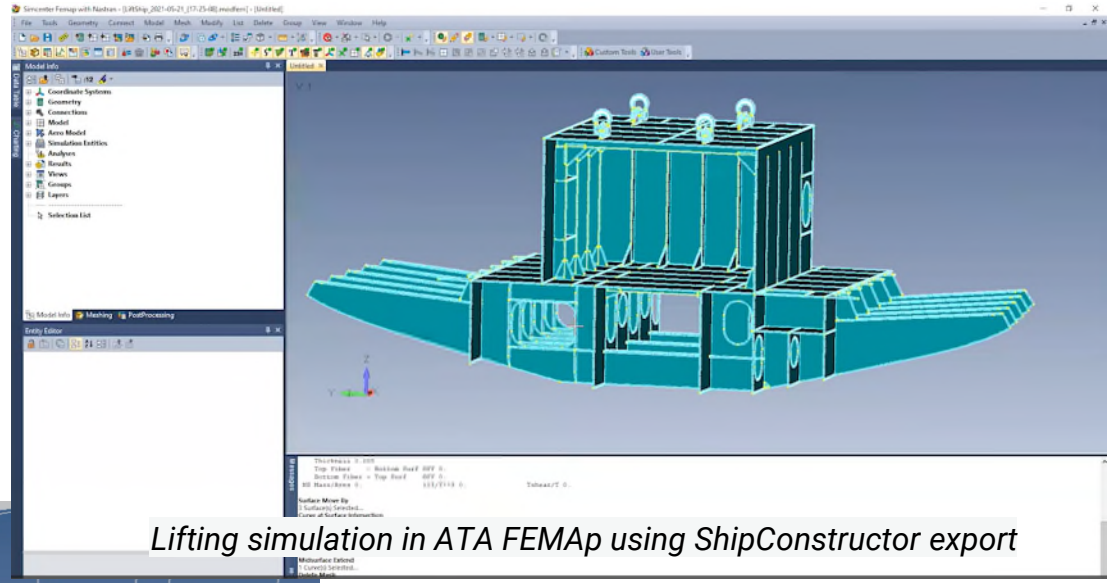
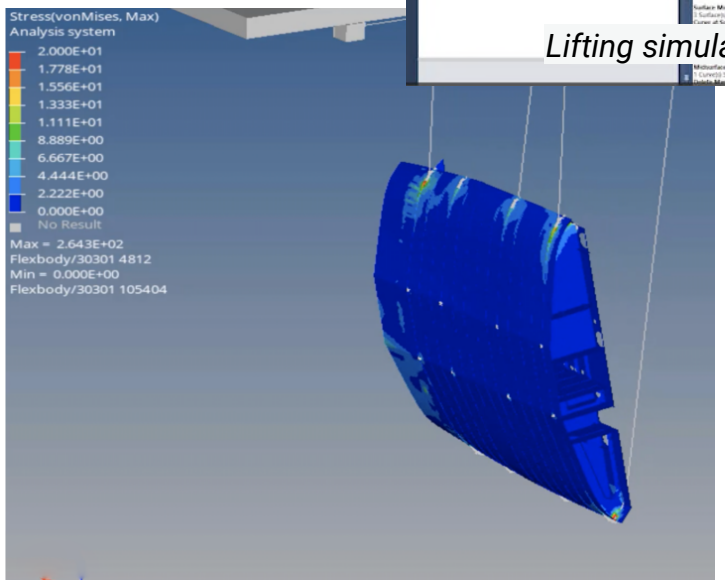
LiftShip3 Capabilities Available in SSI 2025R2.1

SSI 2025R2.1 builds on how shipyards can take advantage of Finite Element Analysis (FEA). Teams can now utilize FEA workflows to automate and refine lift preparation and analysis, enhancing safety and precision.



Lifting simulation in ATA FEMAp using ShipConstructor export

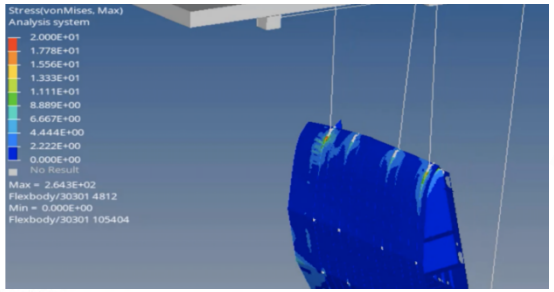


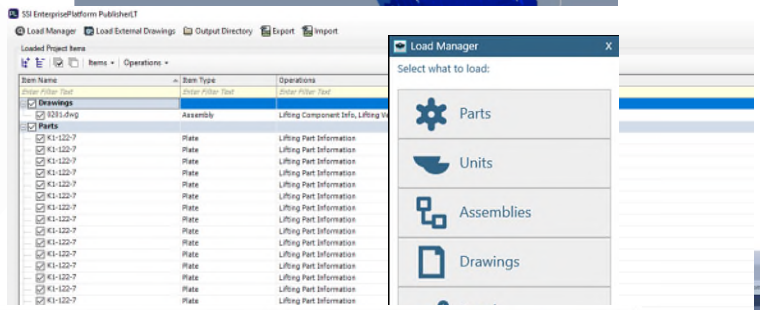
Lifting simulation in Altair HyperWorks using ShipConstructor export

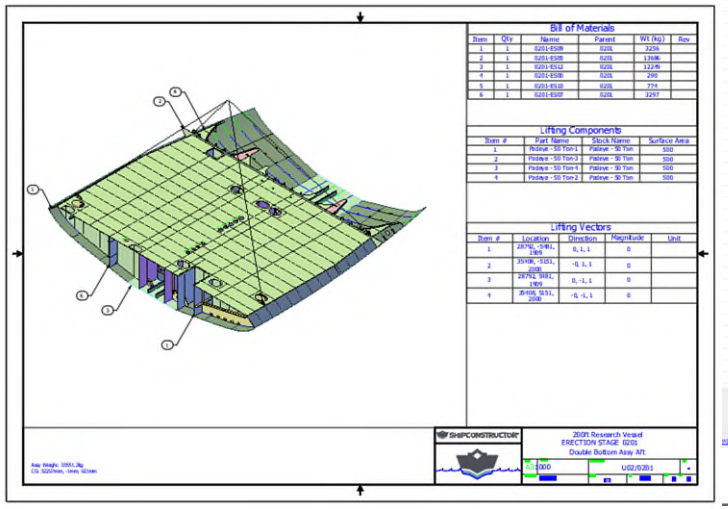
LiftShip3 Capabilities Available in SSI 2025R2.1

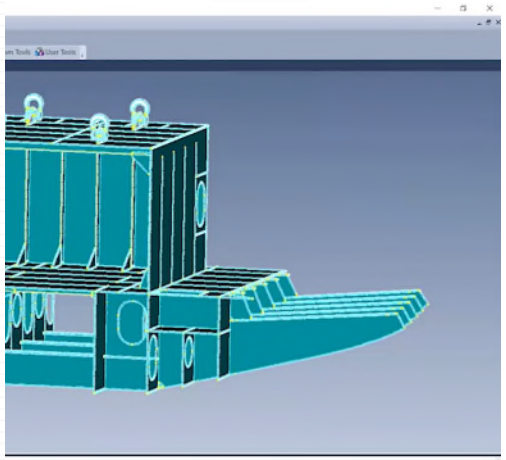
Workflows include:

- Creating lifting and turning assembly drawings and preferred stock list within ShipConstructor.
- Generating lifting and turning packages with EnterprisePlatform.
- Exporting the lifting packages into FEA tools like HyperWorks and FEMAP.
- Importing the data created by the FEA Analyst back into ShipConstructor to update the Product Model and production drawings.









LiftShip3 Phase2 Activities

- Software vendors have provided the latest software to team members.
- SSI has provided the PSV project to run test scenarios for team members.
- Shipyards and design team members have set up the test environment with the latest versions of software.
- The team has set up recurring meetings for test environment feedback and development strategies.
- Software vendors have simplified the workflow and documented the process for training.
- SSI is set to host a final workshop in April 2025.
- Project to conclude in May 2025.

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Questions