The Center for Naval Metalworking presents the Navy ManTech Project

S2890 – Inner Bottom Transformation

(A collaboration effort between ONR, CNM, and Ingalls)

POP December 2021 – May 2024

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For additional information contact: https://cnm.ati.org/contact-us/

Agenda

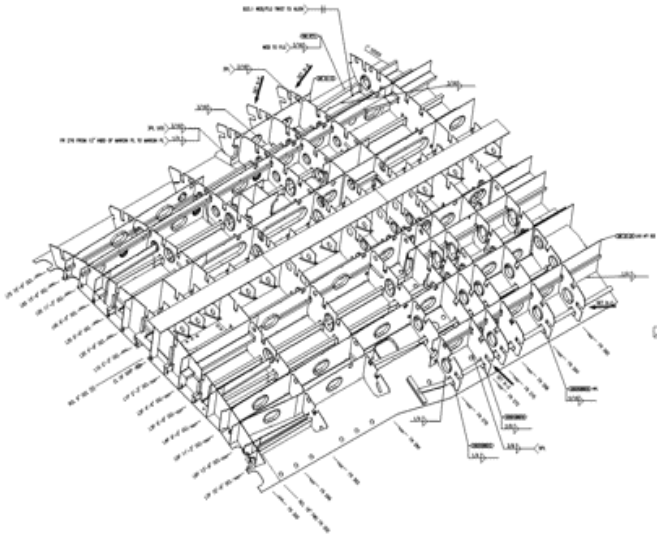
- Acknowledgements
- Background
- Objective
- Benefits
- Technical Approach
- Results

Acknowledgements

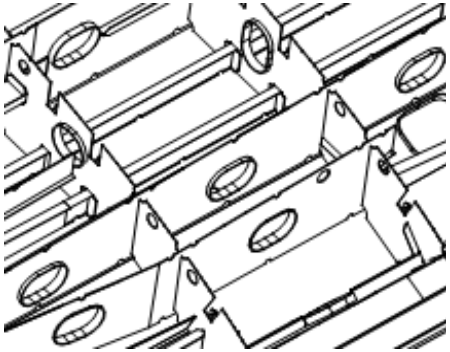
- **Project funding provided by the Office of Naval Research (ONR) Navy ManTech Program**
- **Navy ManTech program oversight provided by**
  - ↗ Jeff Farren – Program Officer
  - ↗ Daniel Reed – Project Manager
  - ↗ Jeremy Brougher – Technical Director
  - ↗ Paul Blomquist – Sr. Technical Advisor
- **Ingalls Shipbuilding**
  - ↗ Ron Wilson – Project Manager
  - ↗ Gary Rosetti – Technical Lead
- **NAVSEA 05P4**
  - ↗ Chris Rodgers – TWH Structural Integrity Carriers and Large Deck Amphibs
- **Naval Surface Warfare Center Carderock Division**
  - ↗ Joe Saunders
  - ↗ Jessica McDonald

Background

- Ship's hull inner bottom assemblies are large and complex structures
- Current manufacturing practices are labor intensive in approach and technique. Construction is expensive and consumes a long build cycle time
- Limited / no use of mechanized welding machines
- Poor ergonomics and working conditions for the shipbuilders (cramped spaces, dark, poor ventilation, difficult to access)



Complexity of Inner Bottom Construction



Inner Bottom Access Openings and Service Penetration

Objective

- Ingalls proposes to transform the requirements and processes for construction of U.S. Navy surface ship inner bottom assemblies. Technically proving (with TWH consensus) unreinforced openings and slotted construction meet the performance requirements, to facilitate a change in constructions requirements. If successful this will lead directly to major construction process changes and will enable future robotic process applications.

  1. Study / tests to validate eliminating the reinforcing collars around openings in Inner Bottom structural supports (beyond 36 inched in web depth).
     - A structured grillage test comparing reinforced and unreinforced openings
     - Data to upgrade and further develop FEA
     - Data to modify the appropriate Navy Shipbuilding specifications and Design data Sheets
  2. Study / tests to validate using slotted construction for longitudinal and transverse Inner Bottom members
     - Fatigue testing and comparison to previous fatigue testing for non–slotted construction.
     - Data to upgrade and further develop FEA
     - Data to support modifying the appropriate Navy Shipbuilding specifications and Design data Sheets

Benefits

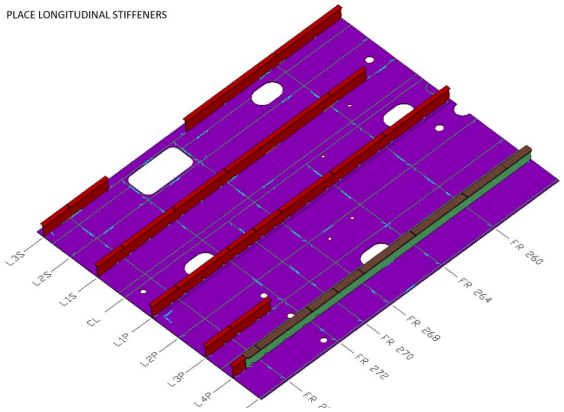
- **By eliminating reinforcing rings and implementing slotted construction techniques, Ingalls expects to be able to**
  - ↗ Decrease labor costs
    - ↗ Less parts to fabricate, store, transport, assemble, weld, inspect, paint
    - ↗ Less parts to fit and weld together due to slotted construction methods (elimination of collars and combining intercostals)
  - ↗ Decreased steel material costs
    - ↗ Elimination of reinforcing rings
- **Application of these new construction processes has the future potential to apply not only to Ingalls platforms, but to <u>any surface ships constructed to Navy standards (DDG, LHA, LPD, CVN, T-AO, FFG, etc.)</u>**

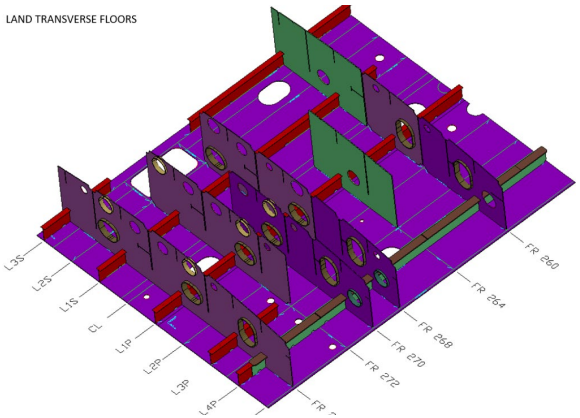
Technical Approach

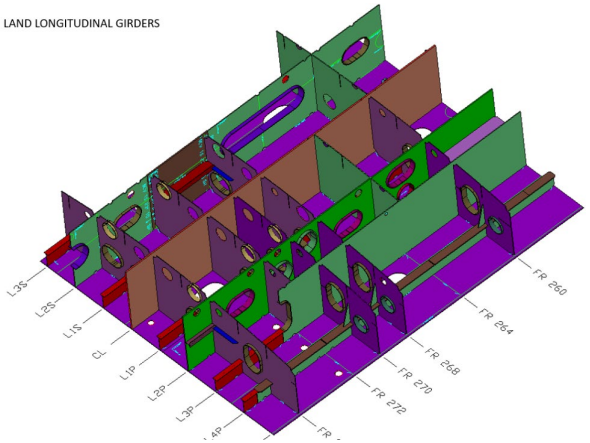
CENTER FOR NAVAL METALWORKING

Slotted Construction Concept

Place Longitudinal Stiffeners → Land Transverse Floors → Land Longitudinal Girders







INGALLS SHIPBUILDING
A Division of HII

NAVY MANTECH
Manufacturing Technology Program

Technical Progress

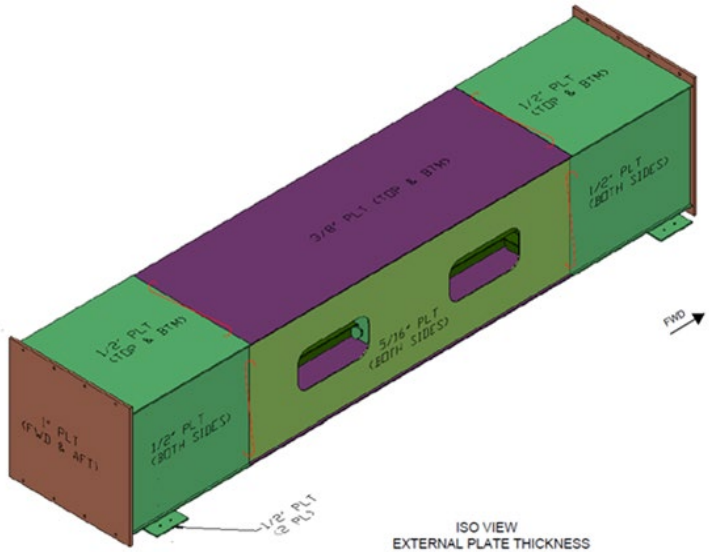
Unreinforced Openings Test Plan Development

- Review Baseline and Past Studies - Complete
  - The project team worked with Ingalls Engineering, Industrial Engineering and Production to define the current construction process for fabricating and installing reinforcing rings at Ingalls. Recent studies were reviewed, including a previous Ingalls' IRAD effort that included FEA work on inner bottom openings and extensive discussions with the TWH.
- Develop Test Plan – Complete
  - NSWCCD has unique Navy ship structural expertise and will work closely with the project team, to finalize test plans. Project work developed as part of the Ingalls' IRAD study will be leveraged as a starting point to further develop and finalize the unreinforced openings test plan. A consensus will be reached around parameters for test articles and test processes for compression buckle test prototypes.
- Review and Approve Test Plan – Complete
  - The project team will review and obtain consensus with the TWH for the test plan. This consensus is necessary to assure acceptance of test results as criteria for adjusting construction parameters. An Inner Bottom Unreinforced Openings Test Plan.

Technical Progress

Reinforcing Ring Testing

- Test Article Design – Complete
  - Test specimens were designed in accordance with test plan requirements and the University of Texas requirements.
  - Ingalls developed models and shop drawings for fabrication. Test specimens were 49in x 43in x 19ft-8in ordinary steel (OS) box beams capped at either end with 50.5in x 49in x 1in thick plate. 5in x 4in x9.5# T-stiffeners at the centerline of the top and bottom plates run the length of the beam. Ring diaphragms are located within the specimen 4ft-2in from either end cap. Half-inch thick flat plate transverse bulkheads are located at the longitudinal center and 8ft-8.75in from the longitudinal center in each direction. The support span is 17ft-6in, centered on the mid-span of the test specimen. A model of the design of an unreinforced test article can be seen below.



ISO VIEW
EXTERNAL PLATE THICKNESS

Technical Progress

Reinforcing Ring Testing

- Build Test Articles – Complete
  - A total of 8 test articles were fabricated by an Ingalls subcontractor. Three reinforced, three unreinforced and one back up unreinforced test articles were fabricated.
  - Ingalls engineering, welding engineering and accuracy control personnel provided oversite and inspections throughout the build process.
  - Material characterization tests were completed on samples from the material used to fabricate the test articles. Tensile tests, longitudinal and transverse to the plate rolling direction were completed at Ingalls. These results would later be input into the FEA model to provide more accurate results.

Fabrication in process

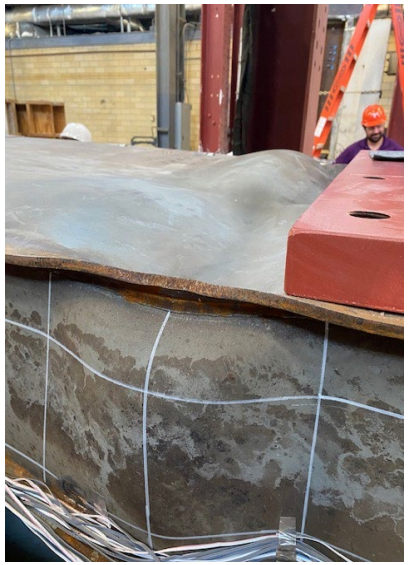
Fabrication Complete

Technical Progress

Reinforcing Ring Testing

- Testing – Complete
  - Testing began at the University of Texas on 7/6/22 and completed on 9/14/22.
  - The University of Texas accommodated observation of the test set up and testing by Ingalls, ATI and representatives from NSWCCD and facilitated a pretest review, performed the test and recorded the test data.
  - Testing occurred until test article failure.

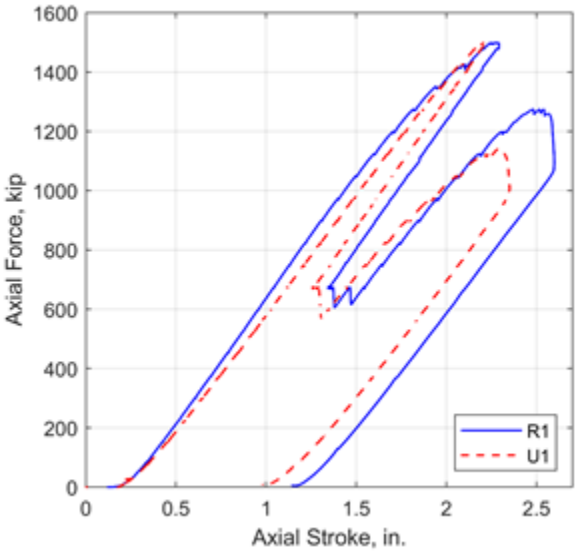
Reinforced Opening Specimen #1 Installed in the Test Fixture

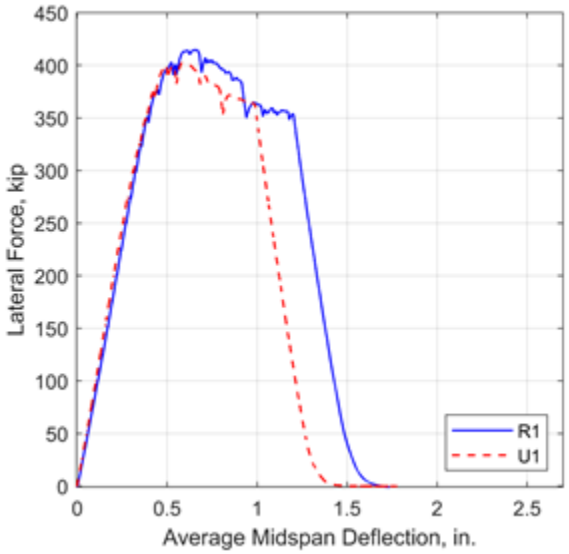


Technical Progress

Reinforcing Ring Testing

- Testing Results



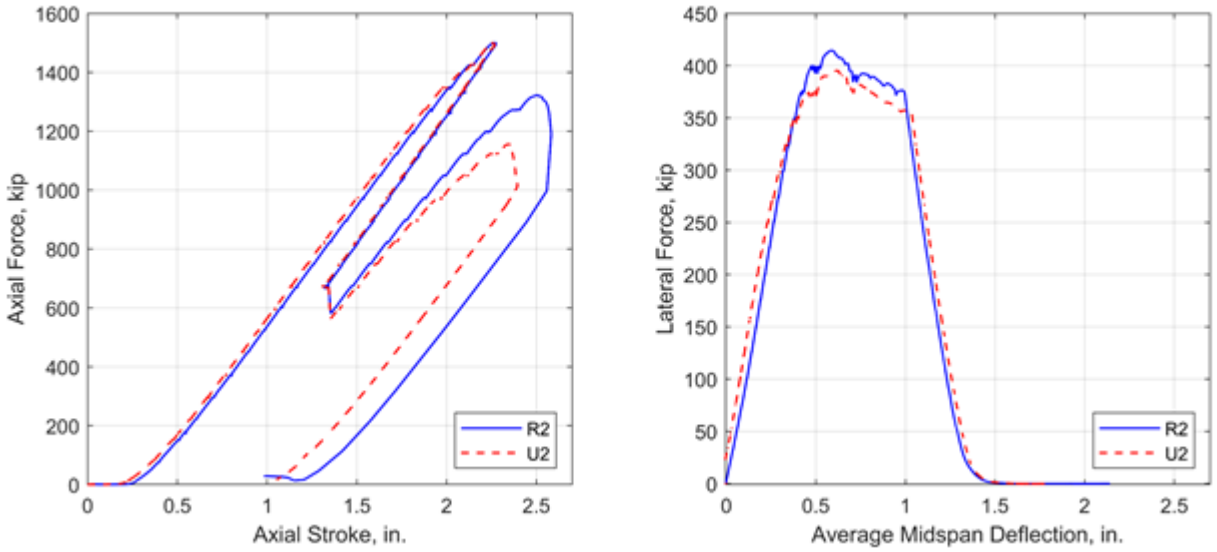


Combined Displacement-Force Plot R1 and U1

Technical Progress

Reinforcing Ring Testing

- Testing Results

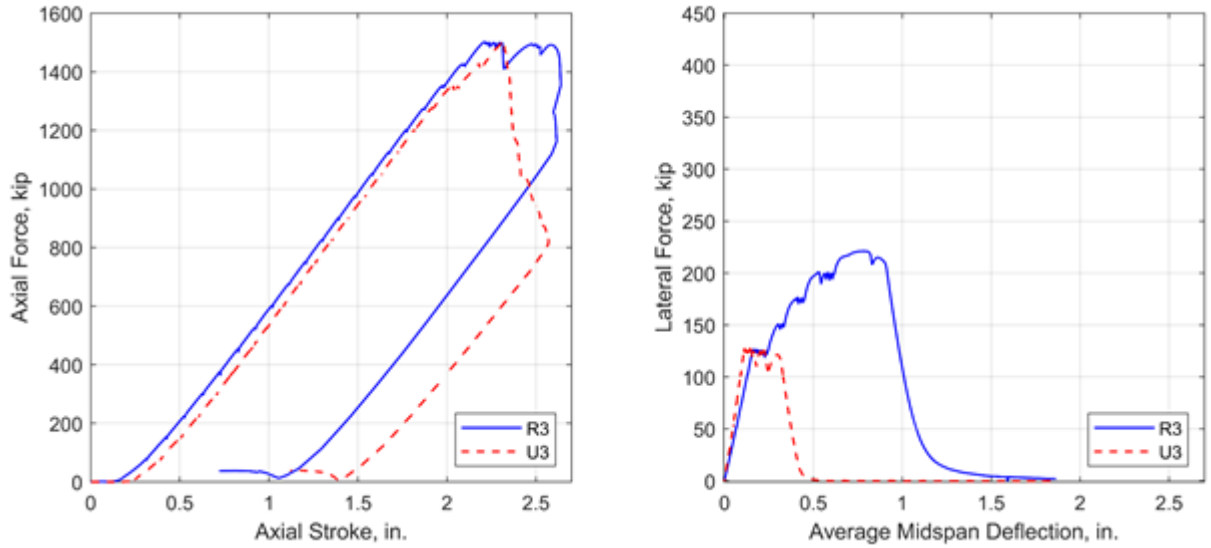


Combined Displacement-Force Plot R2 and U2

Technical Progress

Reinforcing Ring Testing

- Testing Results



Combined Displacement-Force Plot R3 and U3

Technical Progress

Reinforcing Ring Testing

- Testing Results Discussion
  - Ingalls, Navy Tech Warrant and NSWCCD are currently engaged in meetings to determine the path forward for the full results analysis and criteria to remove reinforcing rings on LHA 9 followed by DDG and LPD.

Technical Progress

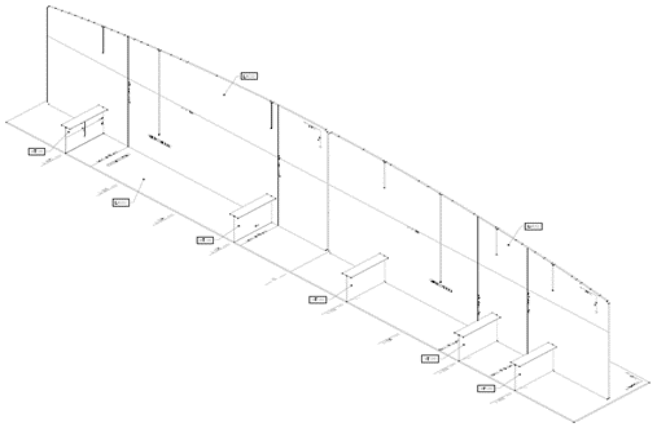
Slotted Construction Test Plan Development

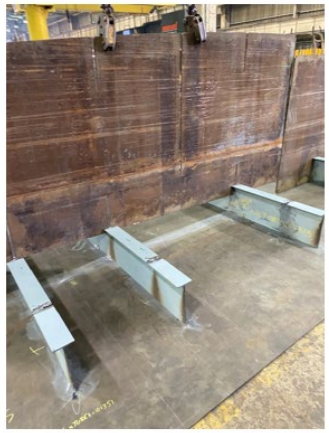
- Review Baseline and Past Studies – Complete
  - The project team will work with Ingalls Engineering, Production and Manufacturing Engineering, craft foremen, and craft to understand the current construction process at Ingalls. Recent studies will be reviewed including a recent submarine ManTech Slotted Study, the IRAD projects accomplished in Ingalls' IRAD including FEA work on inner bottom openings and slotted joints, and extensive discussions with the TWH.
- Subtask 3.2 – Develop Test Plan – Complete
  - NSWCCD has unique Navy ship structural expertise and will lead finalization of test plans working closely with the TWH and the Ingalls project team including engineering. Project work developed as part of the Ingalls' IRAD study will be used with NSWCCD as a starting point to further develop and finalize the slotted construction test plan. A consensus will be reached around parameters for test articles and test processes for fatigue and possibly ultimate capacity test coupons.
- Subtask 3.3 – Review and Approve Test Plan - Complete
  - The project team will review and obtain consensus with the TWH for the test plan. This consensus is necessary to assure acceptance of test results as criteria for adjusting construction parameters.

Technical Progress

Slotted Construction Test Plan Development

- Develop Test Plan – Complete
  - Prior to completion of the slotted design and test plan Ingalls designed and fabricated a small scale slotted demonstration test article to identify any manufacturing, lifting and handling, and fitting tolerance issues
  - There were no issues with lifting and handling the transverse floors with slots.
  - There were fit up issues in setting one of the transverse floors over the slots in the corresponding stiffeners primarily due to the placement accuracy of the stiffeners forward and aft.
  - The overall test was a success in identifying the challenges associated with manufacturing and assembling slotted construction. This data will be beneficial when fabricating the larger scale shock/UNDEX test articles in Phase II.

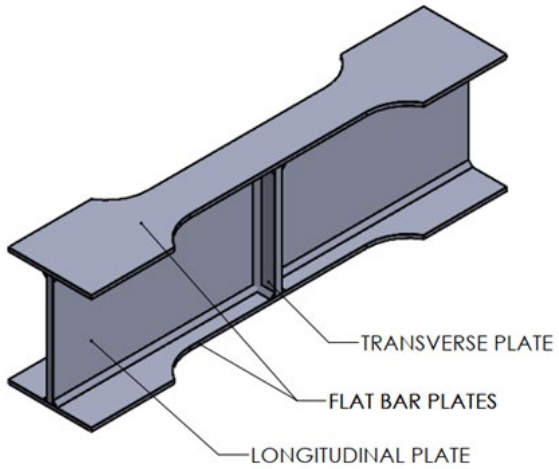




Technical Progress

Slotted Construction Test Plan Development

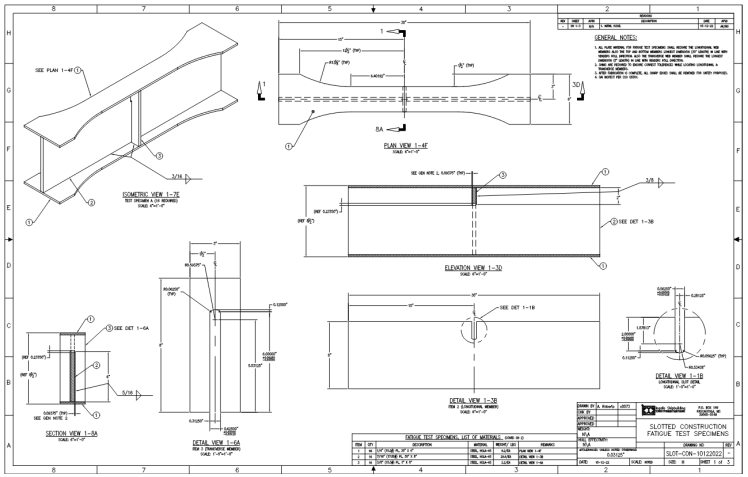
- Review and Approve Test Plan – Complete
  - Fatigue testing will be performed using four different constant stress ranges, varying plate thicknesses, and slot width tolerances to evaluate the fatigue performance. The fatigue test stress cycle will consist of constant amplitude testing using a fully reversed loading.
  - The plan is to test 48 total specimens.
  - Specimens will be comprised of a slotted longitudinal plate welded to a slotted transverse plate with flat bar plating welded to the top and bottom of the longitudinal plate. Specimens will be fabricated with two different longitudinal plate thicknesses, two different longitudinal root gaps, and using HSLA-65 material all detailed in the fatigue test matrix.
  - The test specimens will be slotted to 25% of the longitudinal member depth and 75% of the transverse member depth.
  - Tests will be conducted to failure, with failure defined as when the axial compliance of the specimen at least doubles, or runout defined as 20 million cycles.
  - Final data review will develop the mean S-N curve and design curves that are two standard deviations below the mean S-N curve, for use in judging fatigue performance relative to existing fatigue details used in longitudinally continuous cruciform construction.

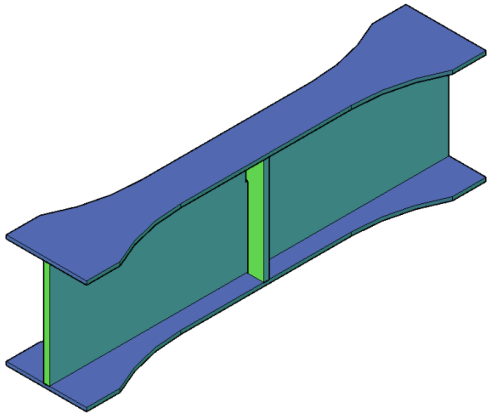


Technical Progress

Slotted Construction Testing

- Fatigue Test Specimen Design is complete. Ingalls has completed detail design drawings.
- Fatigue test fixture design is in process at NSWCCD with an ECD of Feb 23
- Material for the test specimens has been cut and is awaiting assembly as of Jan 23.

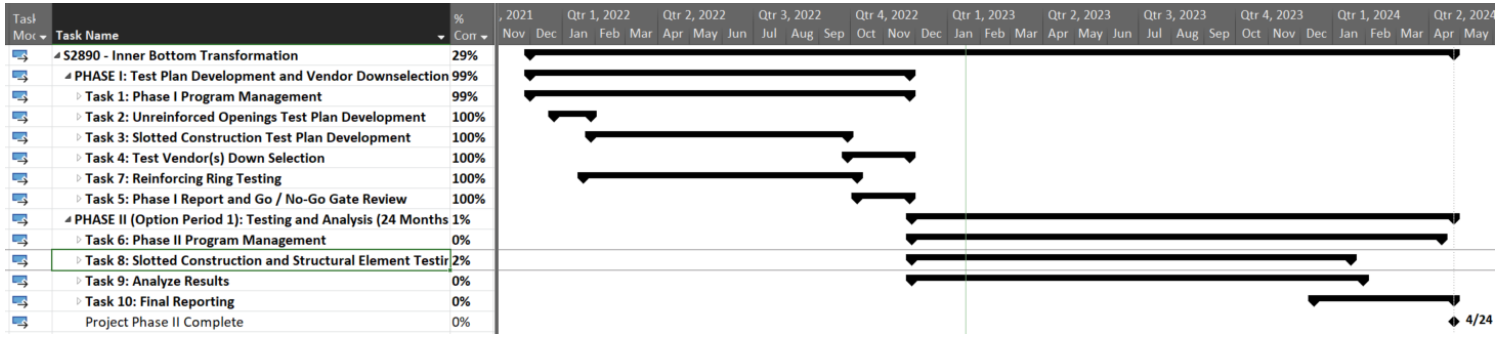




Fatigue Test Specimen
Final Design

Status

Task No.	Description	Percent Complete
1	Phase I Program Management	100%
2	Unreinforced Openings Test Plan Development	100%
3	Slotted Construction Test Plan Development	100%
4	Test Vendor Down Selection	100%
5	Phase I Report and Go / No-Go Gate Review	100%
6	Phase II Program Management	5%
7	Reinforcing Ring Testing	100%
8	Slotted Construction Testing	10%
9	Analyze Results	0%
10	Final Reporting	0%



Results

- Projected 5-year Savings = $15M (All Ingalls Platforms)
- DDG 5 Year ROI = 0.24
- All platforms Ingalls 5 Year ROI = 2.36

Application of these new construction processes has the future potential to apply not only to Ingalls platforms, but to any surface ships constructed to Navy standards.

Questions?

CENTER FOR NAVAL METALWORKING

NAVY MANTECH
manufacturing technology program

Simplifying Inner bottom construction by reducing parts and improving design to increase efficiencies

Project Number: S2890

Title: Innerbottom Transformation

Performing Activity: Center for Naval Metalworking (CNM)

Objectives: Transform the requirements and processes for construction of innerbottom assemblies. This will lead directly to major construction process changes, improved efficiencies, and will enable future robotic processes.

Start / End Dates: Dec 21 – May 24

Project Cost:

ManTech Investment: $3.0M

Weapon System: DDG-51

Performing Entities:

- Navy ManTech – Program Oversight
- CNM – Project Management / Technical Oversight
- PMS 400D – Project Oversight
- HII-Ingalls – Project Lead

Technical Achievements:

Dec	**21**	**Project Initiation**
Mar	**22**	**Unreinforced Openings Test Plan Report**
Sep	**22**	**Slotted Construction Test Plan Report**
Oct	**22**	**Unreinforced Openings Test Report**
Nov	**22**	**Phase I Go / No Go Report**
Sep	23	Slotted Construction Test Report
Nov	23	Manufacturing Parameters Report
Jan	24	Final Business Case
Mar	24	Implementation Plan
May	24	Final Report
May	24	Test Articles and Accessories

Implementation:

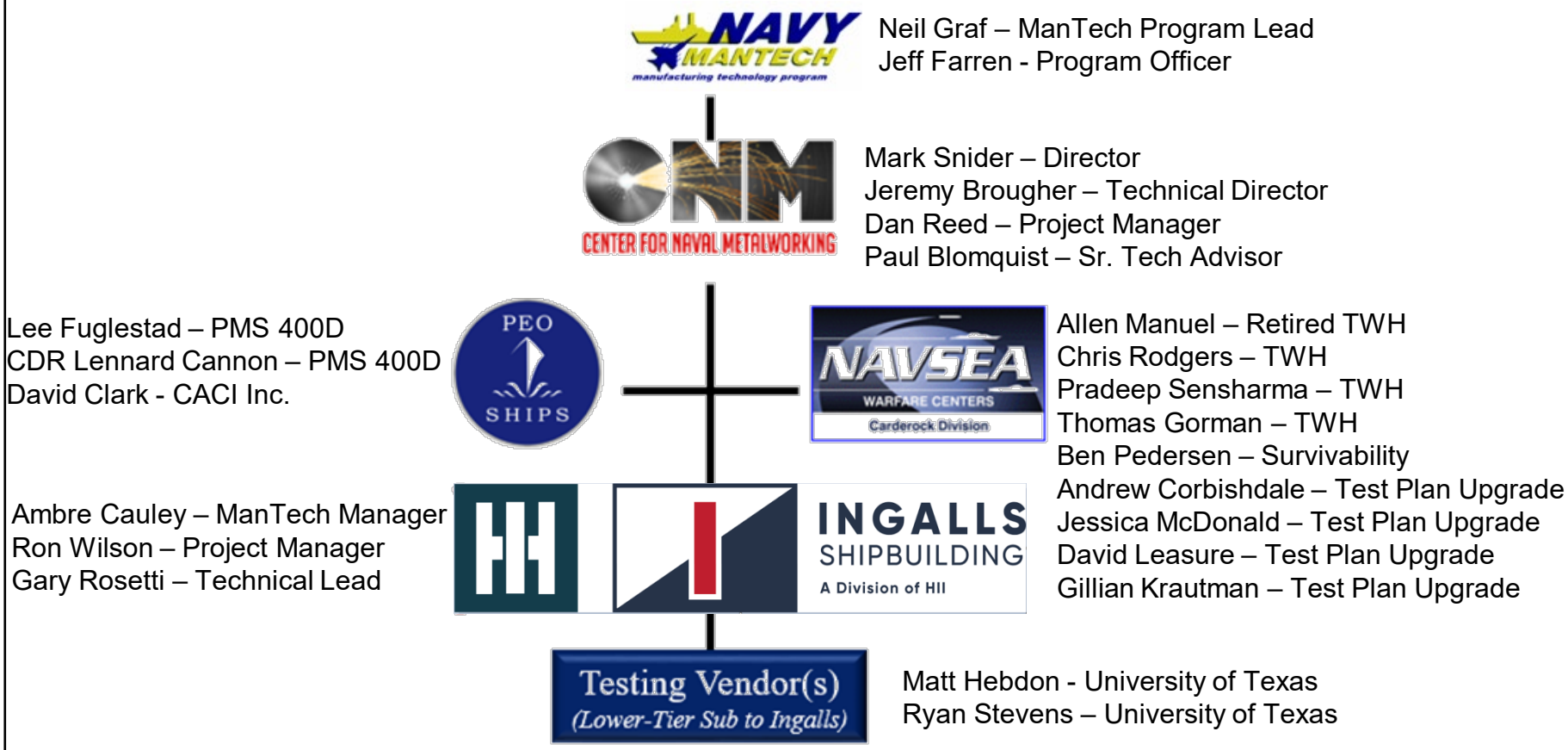
System: DDG-51
Site: HII-Ingalls – Pascagoula, MS
Schedule: Q4 FY24
Status: On track (DDG 137, LHA 9, LPD 33, NSC 12)

Cost
Schedule
Technical

Payoff:

- Reduced labor for assembly, welding, painting, and material handling
- Reduced material Waste associated with reinforcing rings and rework.
  - Savings:
    - Projected DDG per hull: $1.26M
    - Projected DDG 5-year savings: $5.68M
    - Projected All Classes 5-year savings: $15.40M
    - Projected 5-year DDG ROI: 0.24
    - Projected 5-year All Classes ROI: 2.36

Integrated Project Team



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The TEAM

CNM is a government/industry/academia partnership. Organizations and individuals from a variety of disciplines are engaged as needed to solve technical challenges and improve manufacturing processes.

The MISSION

CNM will identify, develop, and deploy metalworking and related manufacturing technologies to reduce the cost and time to build and repair key naval platforms and other relevant industries.

The MODEL

CNM is a Navy ManTech Center of Excellence, with single point contracting through ATI. Teamed with the Edison Welding Institute (EWI), CNM provides robust capabilities to address the DoD manufacturing industrial base , including state-of-the-art metalworking labs and deep expertise in key technology areas. From virtual project management to innovative prototypes, CNM delivers tailored solutions.

Prepared under ONR contract N00014-16-D-4001 as part of the Navy ManTech Program