Ship Design and Material Technologies Panel Break Out

Monika Skowronska, Panel Chair

Anti-Trust Rules

- Regarding your company's and/or your competitor's **product & services**:
  - Do not discuss current or future prices.
  - Do not discuss any increase or decrease in price.
  - Do not discuss pricing procedures.
  - Do not discuss standardizing or stabilizing prices.
  - Do not discuss controlling sales or allocating markets for any product.
  - Do not discuss future design or marketing strategies.

Anti-Trust Rules

- Regarding your company's and/or your competitors' selection of their **supplier companies**:
  - Do not discuss refusing to deal with a company because of its pricing or distribution practices.
  - Do not discuss strategies or plans to award business to remove business from a specific company.
- Regarding your company's and/or competitors' **trade secrets**:
  - Do not discuss trade secrets or confidential information of your company or any other participant.

NSRP SDMT Leadership

Extended Team

Major Initiatives

Information, Design, & Integration	Ship Production Technologies	Infrastructure, Logistics, & Sustainment

Panels

Ship Design & Material Technologies	Electrical Technologies	Workforce & Compliance
Ship Warfare Systems Integration	Planning, Production Processes & Facilities	Sustainment
Business Technologies	Surface Preparation & Coatings	
	Welding Technology	

Ship Design & Material Technologies Panel

Chair: **Monika Skowronska** (NASSCO)
Vice Chair: **Victoria Dlugokecki** (Naval Consultant)

Ship Design and Material Technologies Panel's Mission

The SDMT Panel focuses on providing increased capabilities and cost reduction initiatives across the complete spectrum of design processes and the identification of materials and technologies to support rapid and efficient development, construction, sustainment, and disposal of ships and their components.

* 2025 Technology Investment Plan updates

SDMT Panel Business

- Panel Membership
  - Attend 2 meetings in a 2 year time period
  - Members receive voting rights
  - Maximum 1 vote for each organization
  - 2 votes if the organization is holding an NSRP leadership position
- 2025 Panel Project Solicitation
  - Summer Meeting Project Pitch Session – 5min
  - US Shipyard requirement – for endorsements reach out early
  - Multiple yards preferred
  - NAVY Support

Future Activities: Summer Meeting

- **BT/SDMT/Sustainment Joint Panel Meeting**
  - June 24th - 26th, 2025 – Honolulu, HI
- **Agenda items we are working towards:**
  - Pearl Harbor Shipyard (iLab)
  - Pacific Shipyard International
  - University of Hawaii
  - Local Hawaiian Shipbuilding and Ship Design Companies: PacMar, Makai, Oceanit

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
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4:30 PM	Closing Remarks	Monika Skowronska, SDMT Panel Chair
5:00 PM	**Adjourn**	

NSRP | National Shipbuilding Research Program

Navy Standard Bookend Fixtures for Shock Testing

(NSRP Project 2024-335-001)

SDMT Panel Meeting at NSRP All Panel Meeting
26 February 2025

Distribution unlimited

Data Category B

Agenda

- Problem Statement / Goals / Objectives
- Project Participants
- Project Status
- Bookend Test Fixture Designs
- Test Results
- Next Steps / Project Wrap up
- Questions

Problem Statement

- When shock testing common equipment like valves, eductors, and other “in-line pipe” components, bookend test fixtures are typically designed and fabricated by a certified shock test facility. The bookend fixture designs are considered, “non-standard” and require submission of associated drawings, models, and analyses to the Delegated Approval Authority for review and approval prior to execution of testing.
- This is a costly process which adds labor and delays which could be avoided if there was an option to utilize a Navy Standard, pre-qualified bookend fixture.

Goals / Objectives

- The goal of this project is to create up to four, qualified Navy Standard Bookend Shock Test Fixtures for “in-line pipe” components to be used on Lightweight and Medium-weight Shock Test Machines.
- The objective is to reduce cost and schedule associated with shock test fixture development for all shock hardened, US Navy Ships.

Tasking

- Review Bookend Test Fixture designs used in previously approved Lightweight and Mediumweight Shock Testing.
- Determine maximum and minimum sizes / weights of components to support.
- Determine common interfaces to support (ANSI Standard flanges, hardware, etc.).
- Design and analyze test fixture designs.
- Perform Lightweight Shock Testing on a bookend fixture (at Ingalls).
- Compare shock data to analysis.
- Review results with the Navy Delegated Approval Authority (NSWCCD / NAVSEA 05P).
- Create Navy Standard Drawings of each Bookend Test Fixture for inclusion in the next revision of MIL-DTL-901.

Project Participants - NSRP

Jim House – Senior Program Manager
ATI / NSRP

Victoria Dlugokecki – Program Technical Representative

Project Participants - NAVSEA 05P / NSWCCD

Tom Brodrick – Senior EM, Shock – Submarines

Domenic Urzillo – DAA Submarines

Project Participants – Gibbs & Cox (Leidos)

Mike Poslusny - Project Manager

Mike Parnin – Design

Allison Vella – Engineering

Nikki Washington - Contracts

Dominic Price - Drafting

Terrence Nelson- Drafting

Project Participants – Ingalls Shipbuilding

Michael S. Thompson – Mechanical Engineer

Jamie Breakfield – Project Manager

Project Participants – NASSCO
(Unfunded Observer)

Nour Chihwaro – Electrical Engineer

Dr. John Moatsos – Principal Engineer

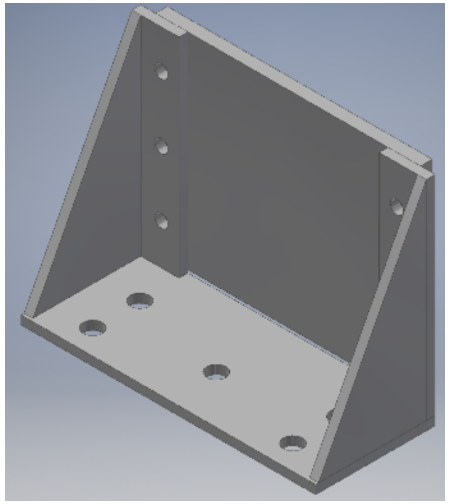
GENERAL DYNAMICS
NASSCO

Project Status

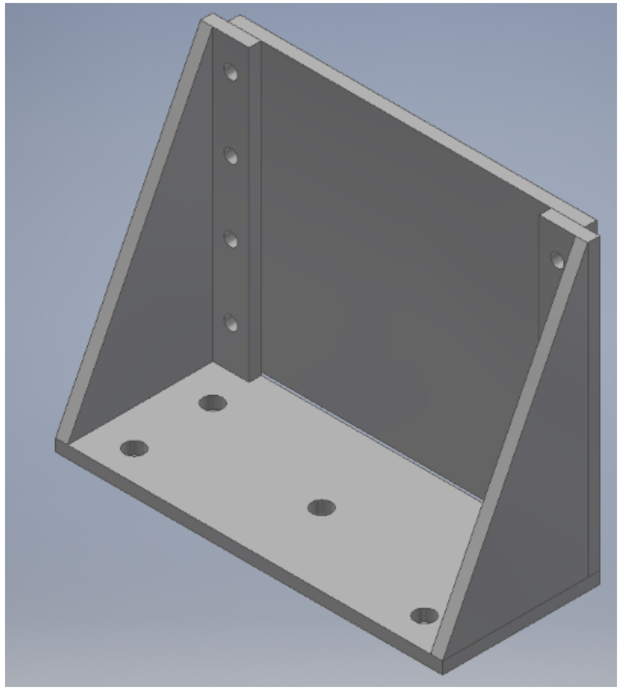
- Awarded in mid January 2024
- Project kicked off 7 March 2024
  - Contract struggles, Ingalls joined the project in June 2024 (lessons learned for next time).
  - No Cost extension approved through March 15th, 2025.
- March – June 2024
  - Investigated sizes and weights of typical valves, strainers and other “in-line” pipe components.
  - Determined that three bookend fixtures would support typical items (Small, Medium & Large).
  - Designed the Medium Bookend Fixture and performed a modal analyses.
- June – August 2024
  - Fabricated the Medium Bookend Fixture and performed Lightweight Shock Testing.
  - Modified the analysis to match test results and validate fixture performance.
- September – December 2024
  - Finalized Medium Bookend Fixture and designed Small and Large Bookend Fixtures.
  - Obtained Navy concurrence of Small and Medium Fixture Designs.
- January – March 2025
  - Finalized Large Bookend Fixture Design and presented Modal Results to the Navy.
  - Improved the Large Fixture Design.
  - Created drawings for each fixture and are working on the Final Report.
  - Submit Final Drawings and Report by 15 March 2025.

Bookend Test Fixture Designs

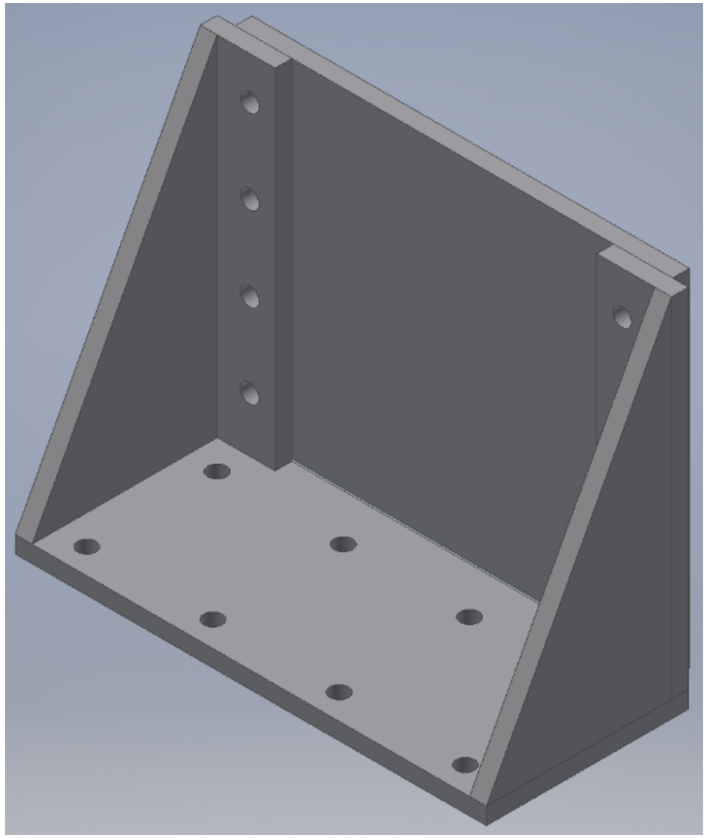
Small Fixture



Medium Fixture



Large Fixture



Bookend Test Fixture Designs

- Incorporate re-usable interface plates.
  - Modal analysis and natural frequency of each interface plate meets MIL-DTL-901E and as requested by NSWCCD (above 160 Hz for LW; above 90 Hz for MW).
- Bookend dimensions and weld tolerances ensure easy installation of interface plates using standard wrenches and tools.
- Interface plates allow for pressurization of pipe components using standard NPT fittings / clearance holes.
- The Small and Medium Bookend Fixtures easily adapt to the Lightweight Shock Machine (LWSM) on Test Fixture 4A, 4C or 11C.
- All three fixtures can interface with the MWSM, utilizing an adapter plate.
  - Providing an example adapter plate design in the drawing notes for the Large Fixture.
- Designed to support the weight of standard in-line pipe components while staying within the limitations of each shock machine.

Final Bookend Test Fixture Designs

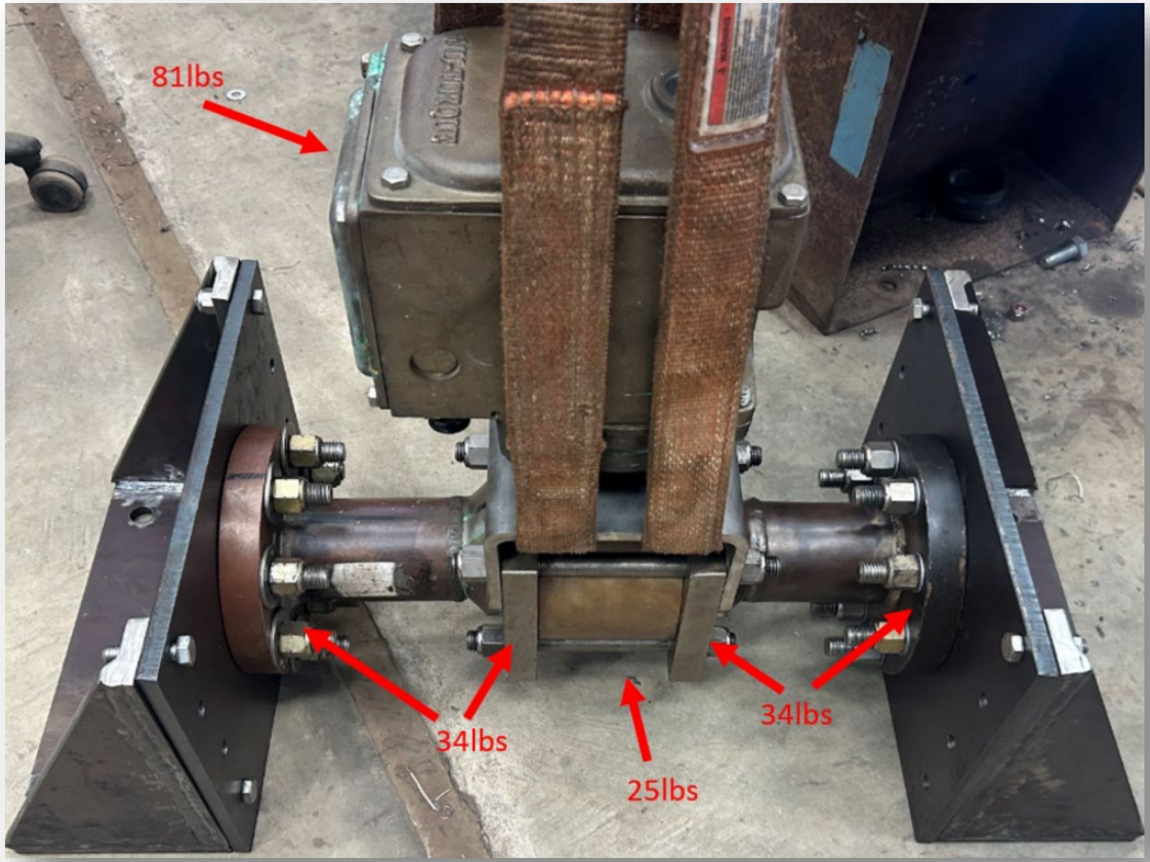
- Small bookend fixture
  - Suitable for up to 3″ nominal OD pipe components.
  - Size: 12.5″W x 9.375″H x 5.375″D, 30 lbs. per fixture.
  - Payload: up to 100lbs.
  - Fabricated with 3/8″ steel (A36).
- Medium bookend fixture
  - Suitable for up to 6″ nominal OD pipe components.
  - Size: 16″W x 12.5″H x 7″D, 63 lbs. per fixture.
  - Payload: up to 200 lbs. per LWSM requirements (on Test Fixture 4A).
  - Fabricated with 1/2″ steel (A36).
- Large bookend fixture
  - Suitable for up to 12″ nominal OD pipe components.
  - Size: 28″W x 21.75″H x 13″D, 370 lbs. per fixture.
  - Payload: up to 1,500 lbs. per MWSM requirements.
  - Required to use an adapter plate (above 90 Hz) to mount to the MW Machine.
  - Fabricated with 1″ steel (A36).

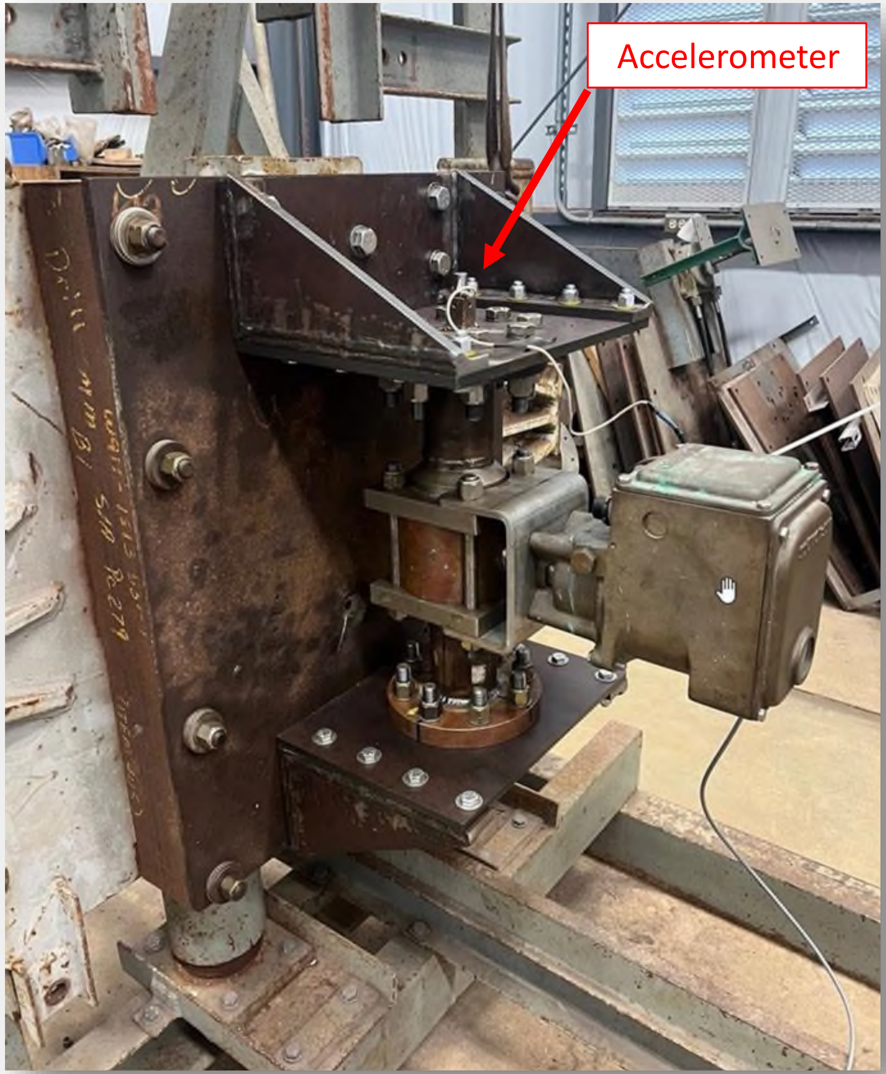
Lightweight Shock Testing of the Medium Fixture

- Ingalls fabricated the Medium Fixture and performed the testing using their LWSM.
- 1ft and 5ft blows Vertical Blows were performed with a single bookend to determine bookend stiffness.
- 3ft and 5ft blows Vertical Blows were performed with a representative payload (175 lbs).
- An Accelerometer was installed in the center of the interface plate.
- Testing / Shock Data acquisition was successful.

Note: Shock Data and Analysis Results are available by request (Limited Distribution).

Shock Test Setup





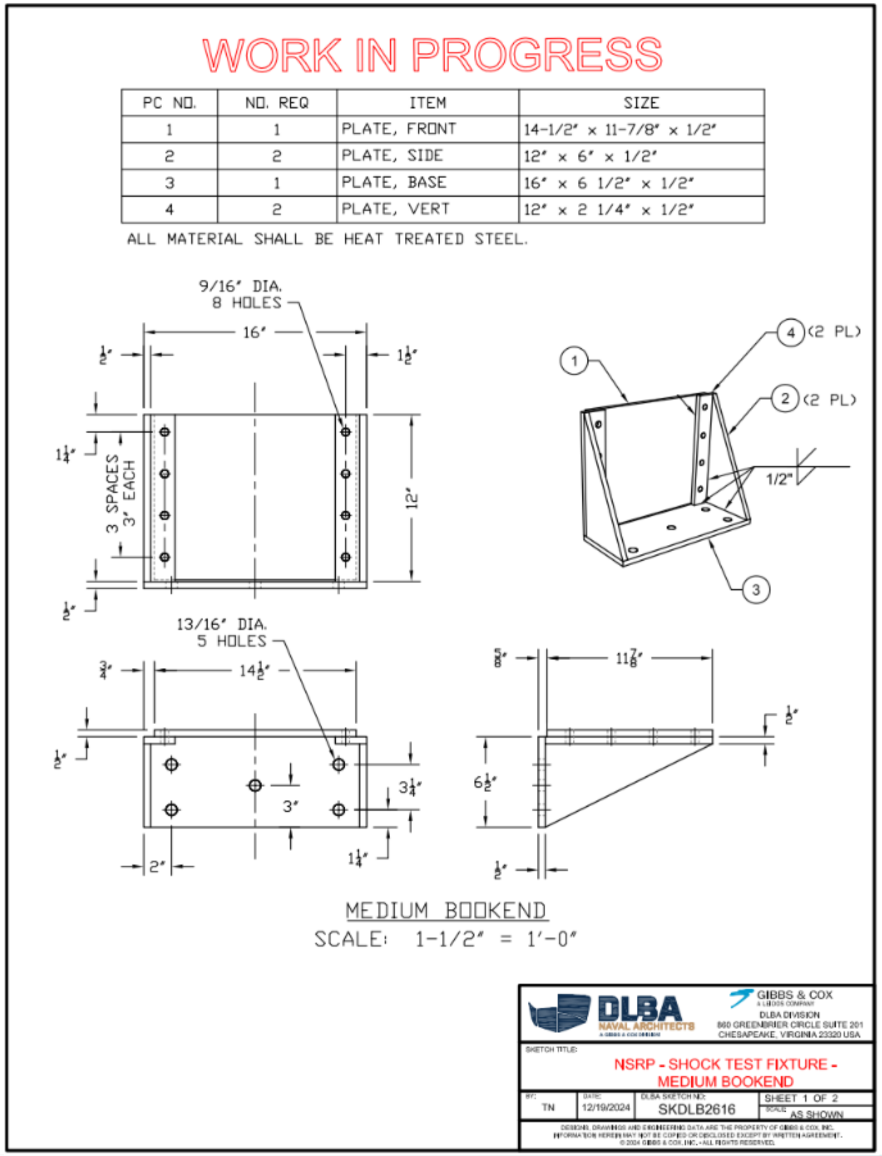
Lessons Learned from Shock Testing

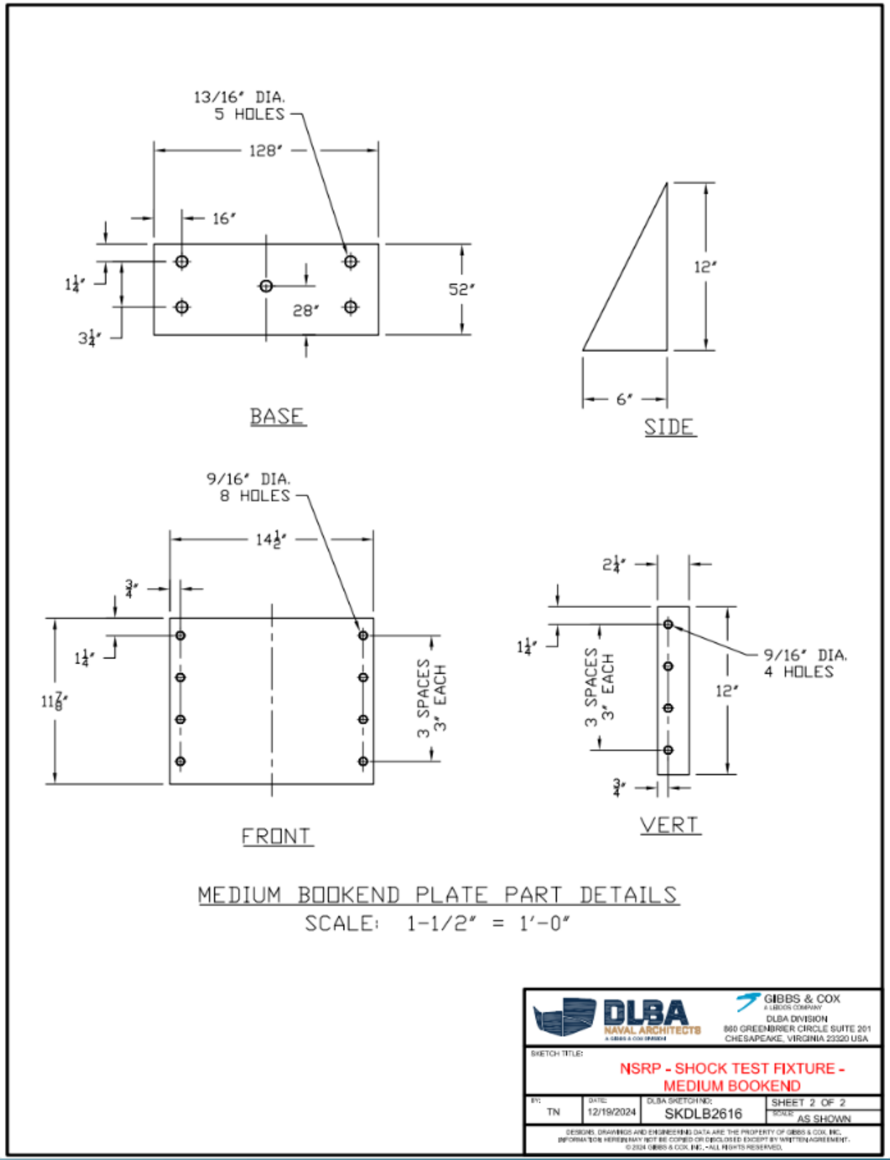
- Bookend frame needs to be wide enough to accommodate washers and avoid weld interference.
  - Also allows installation of interface plate on either side of the frame to provide additional room for valve installation (additional 1" in depth).
- The addition of test fixture mounting bolts creates extra work after blow 1 due to re-tightening efforts for mate-in surfaces.
  - Improve bookend designs to minimize the number of bolts on the base of each fixture
- Modify the analysis to include Test Fixture 4A to better represent the shock test configuration.
  - The new analysis duplicated shock data results and validated the bookend test fixture design.

Navy Standard Drawings

- Created fabrication drawings for the Small, Medium and Large Bookend Test Fixture Designs.
  - Contains part details, dimensions, materials, hardware, weld types and fabrication details.
  - Drawings include payload limitations and the approved applications for each fixture in the General Notes Section.
  - Providing *AutoCad* files to NSWCCD for inclusion in the next revision of MIL-DTL-901.
  - Including PDFs of each drawing in the Final NSRP report.
  - Although the intended approval is for "in-line pipe" components, the fixtures may be used for duct mounted, HVAC components and other applications upon Navy concurrence.
- Once included in MIL-DTL-901, the Bookend Test Fixtures will be considered "Navy Standard"; eliminating the need for approval.
  - After submission of the final NSRP report and Navy approval of the test fixture designs, the drawings may be dispersed to U.S. Navy approved Shock Test Facilities for utilization. We will work with the Technical Authorities to optimize usage prior to the next release of MIL-DTL-901.

Drawing Example





Next Steps / Project Wrap Up

- Finalize the Navy Standard Drawings of the Bookend Fixtures with application notes.
- Obtain Navy concurrence (in writing).
- Submit the Final Report (unlimited) with the following Appendices:
  - LW Shock Report (limited).
  - Analysis Results (limited).
  - Data comparisons (limited).
  - Final Drawings (unlimited).
- Project add-on: Determine the % of material that can be removed from the re-usable interface plates while still meeting frequency requirements.
  - "Swiss Cheese" phenomena that occurs when re-using plates for many tests.
  - Include results in the Final Report.
- Technology Transfer:
  - Today's presentation and the distribution of the Final Drawings to NSRP and NSWCCD. Upon Navy concurrence the drawings may be requested and utilized by all Navy approved Shock Test Facilities.

Questions

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NSRP All Panel Meeting - Charleston, SC

Ship Design & Material Technologies Panel Meeting

February 26, 2025

NSRP FY24 Panel Project (PP2407)
Data-Centric Detail Design and Drafting Process Improvements

GREG KANGAS

PRESIDENT

GREG.KANGAS@HAWKTECHINC.COM

Distribution Statement A: Approved for public release; distribution is unlimited.

Project Team

Technical/Contracts Lead:
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Program Technical Representative (PTR):
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Project Participants:
Hawk Technologies – Greg Kangas
Fincantieri Marinette Marine – Craig Nelson
Ingalls Shipbuilding – Carey Eddins

ATI Project Technical Manager:
Jim House – Advanced Technology International

Subcontractor Support:
4th Mogul – Pete Anderson

HAWK TECHNOLOGIES

Revolutionizing Engineering Excellence:

A Case Study on Continuous Improvement for Shipbuilding Detailed Design - Drafting

Our NSRP R&D project concludes:

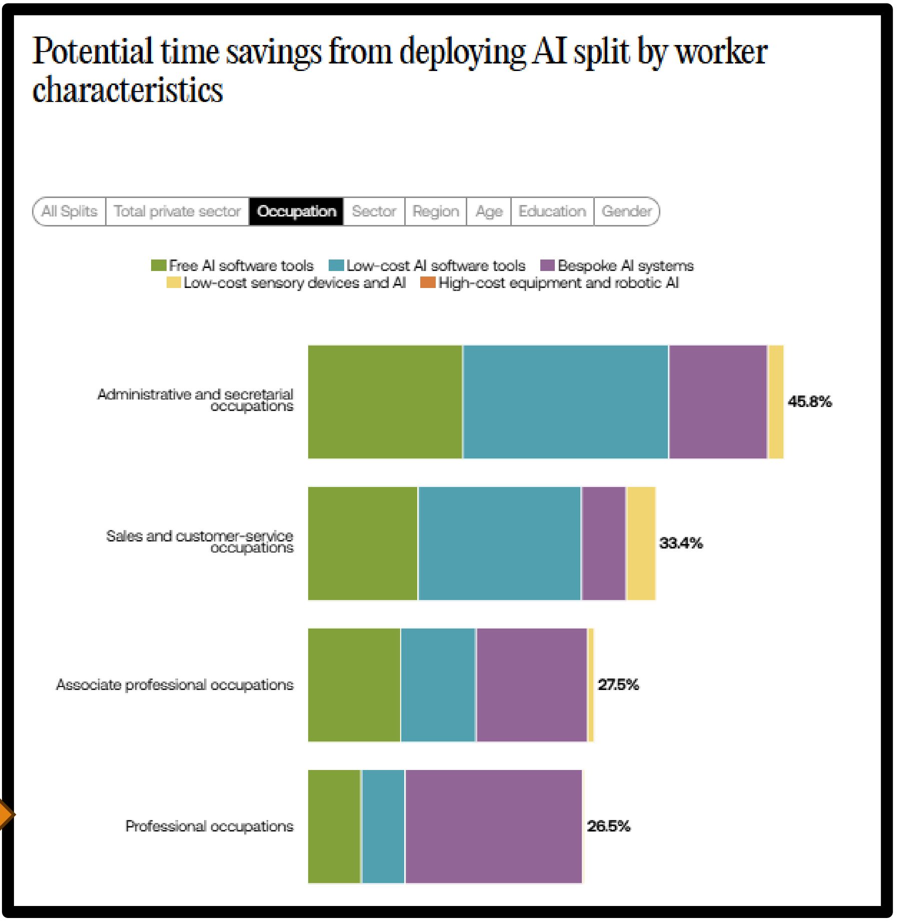
- Shifting **from traditional manager-led evaluations** to **real-time data-driven insights** offers an effective way to empower continuous improvement for personnel and processes.

- A data-centric approach supports the **rapid adoption of new technologies**, particularly **integrated learning, automation, and AI**.

- The **savings** quantified through data analysis can be **strategically reinvested** to further drive technology, supporting **ROI-driven decision making**.

Artificial Intelligence implementation

- **Data-centric workflows enable mass deployment of AI into professional occupations**
  - Professional occupations have potential time savings of 27% to 46% due to deploying AI within workflows
  - https://institute.global/insights/economic-prosperity/the-impact-of-ai-on-the-labour-market



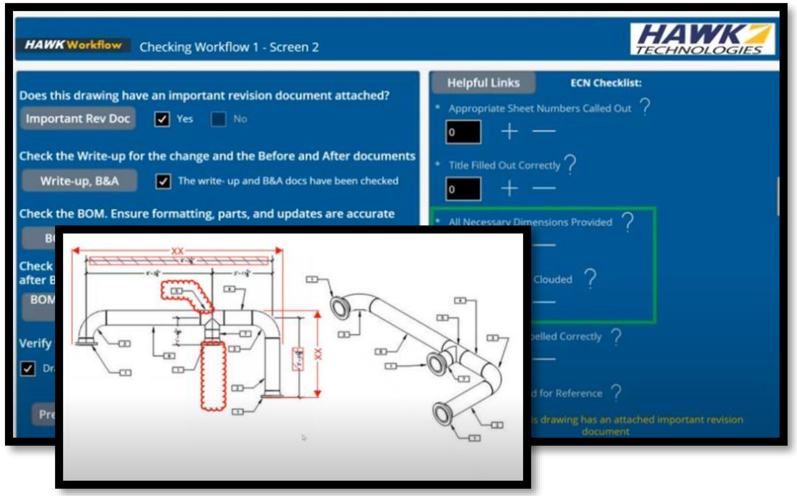
Workflow and Dashboard: **Projected Savings in Drafting**

- **50% reduction in drafting errors**
- **10% reduction in overall drafting/checking labor**
- **10X ROI in the first year**
- ***Enabling widespread deployment of AI, unlocking additional 27% - 46% savings in labor***
- ***Training up in days or weeks instead of months***

Drafter Workflow

Live Dashboard

Checker Workflow



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Case Study: Data-centric Process for Drafting

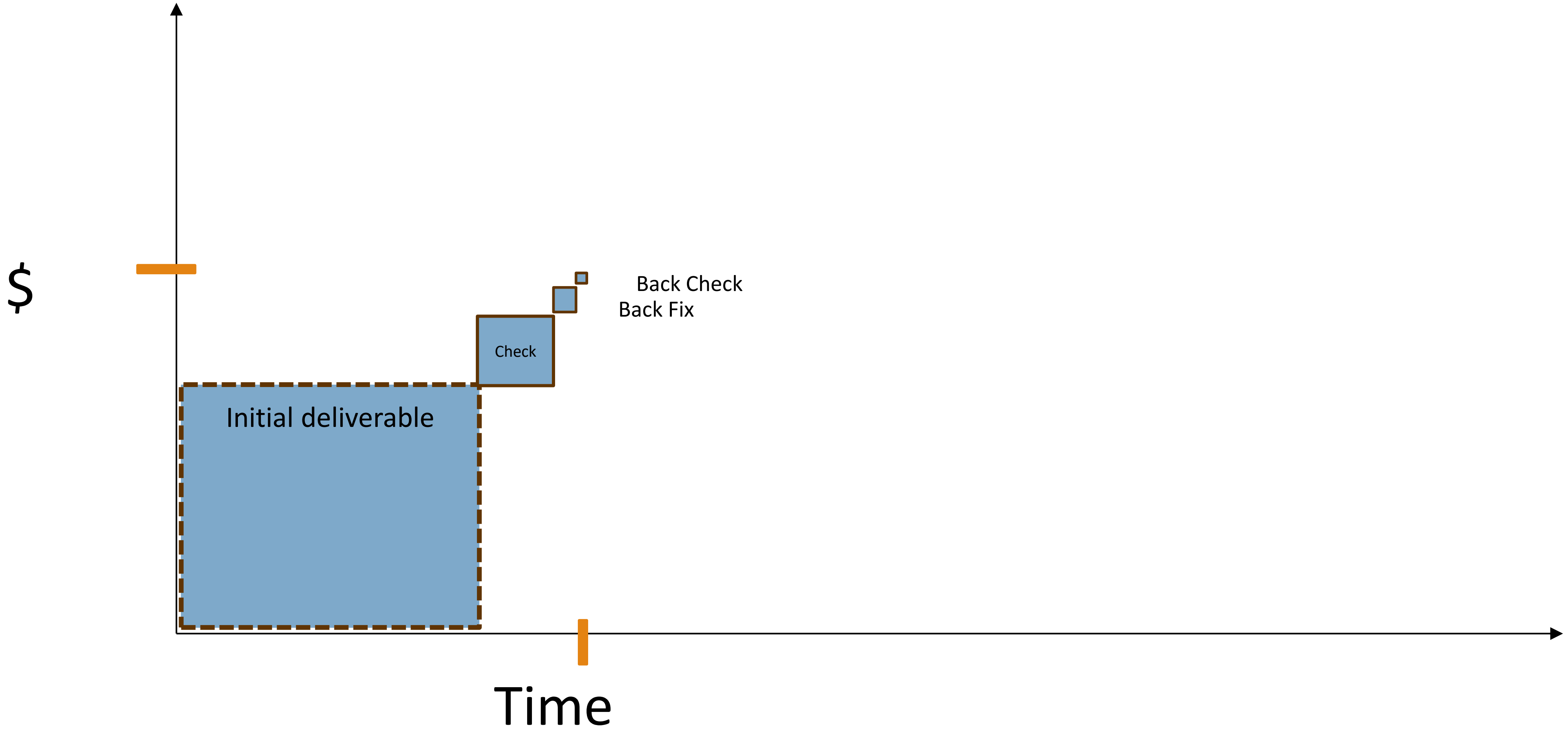
Case Study: FMM Checker Data

- Checker recorded errors for each ECN checked
- Data was compiled over 237 ECNs
- 20 drafters

Case study: Drafters

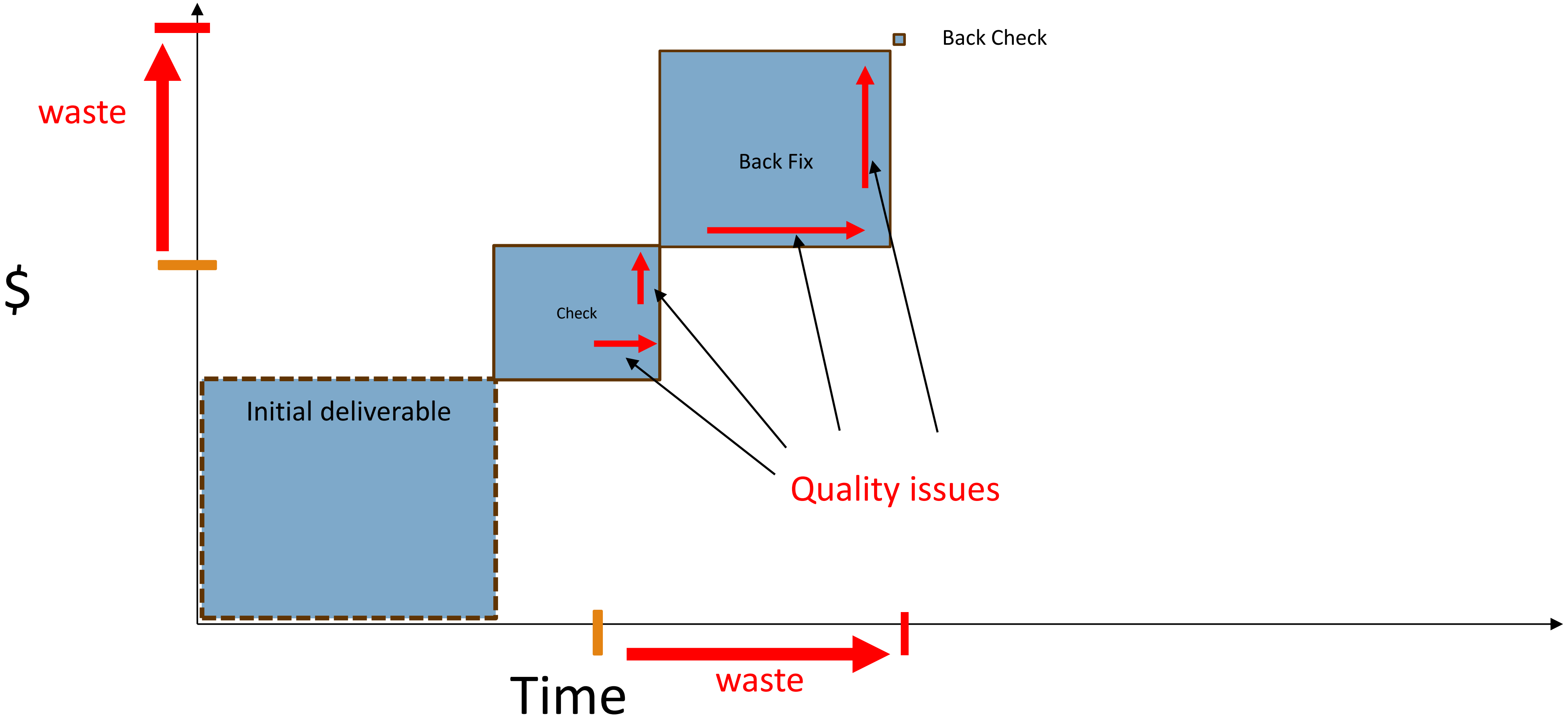
- **50% Reduction in Drafting Errors, 10% reduction in labor hours**
  - Achieving improved group average [Error Count per Page] can **reduce group drafting error rate by 50%**
    - This is a reachable goal using data-centric solutions based on pilot study on control group of drafters with wide range of experience
  - Projected **savings of 10% across entire group** due to error reduction
    - (50% reduction of 20% of group’s time spent dealing with errors and check)
  - 10% rule: Example - 20-person group
    - 10% of 40,000 hours is a **projected savings of 4,000 hours per year,**
    - 10% of 4,000 hours saved in year 1 is **400 hours to implement**

Cost/Time Diagram:
Drafting Workflow (Baseline)



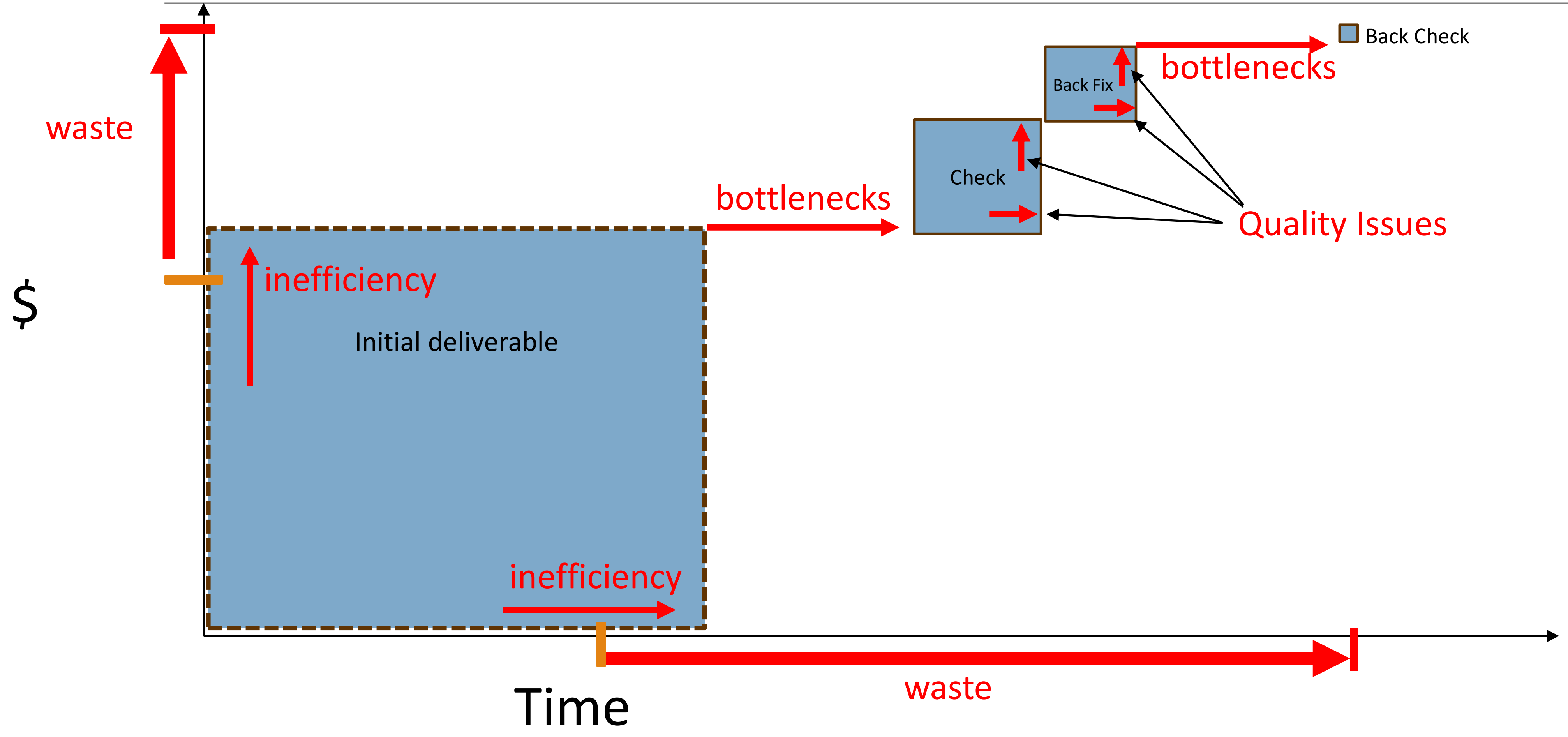
Cost/Time Diagram:

Drafting (Quality issues)



Cost/Time Diagram:

Drafting (Quality issues, inefficiencies, bottlenecks)



Common Issues in Shipbuilding Drafting

Skilled labor shortages

Personnel bottlenecks

Lack of KPIs

Cost overruns

Process bottlenecks

High timeline to train

Performance tough to quantify

Deliverable quality issues

Knowledge silos

Where do we start?

Late deliverables

Inconsistencies from new hires, remote workers, contractors

Undocumented processes

Quality tough to quantify

Common Issues in Shipbuilding Drafting

Knowledge

- Skilled labor shortages
- Knowledge silos
- High timeline to train
- Personnel bottlenecks

Process

- Process bottlenecks
- Undocumented processes
- Inconsistencies from new hires, remote workers, contractors

Data

- Lack of KPIs
- Performance tough to quantify
- Quality tough to quantify

Cause

- Cost overruns
- Late deliverables
- Deliverable quality issues

Effect

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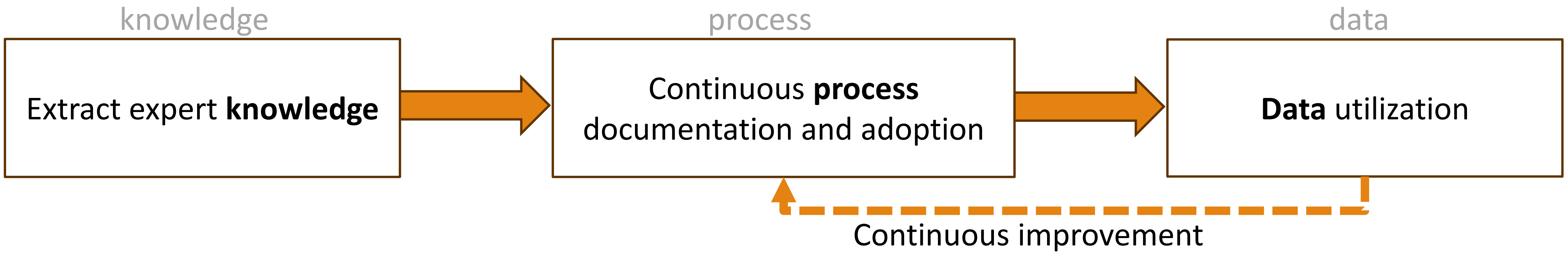
Customized Engineering Workflows



Customized Engineering Workflows

knowledge

Extract expert **knowledge**

process

Continuous **process** documentation and adoption

data

Data utilization

Continuous improvement

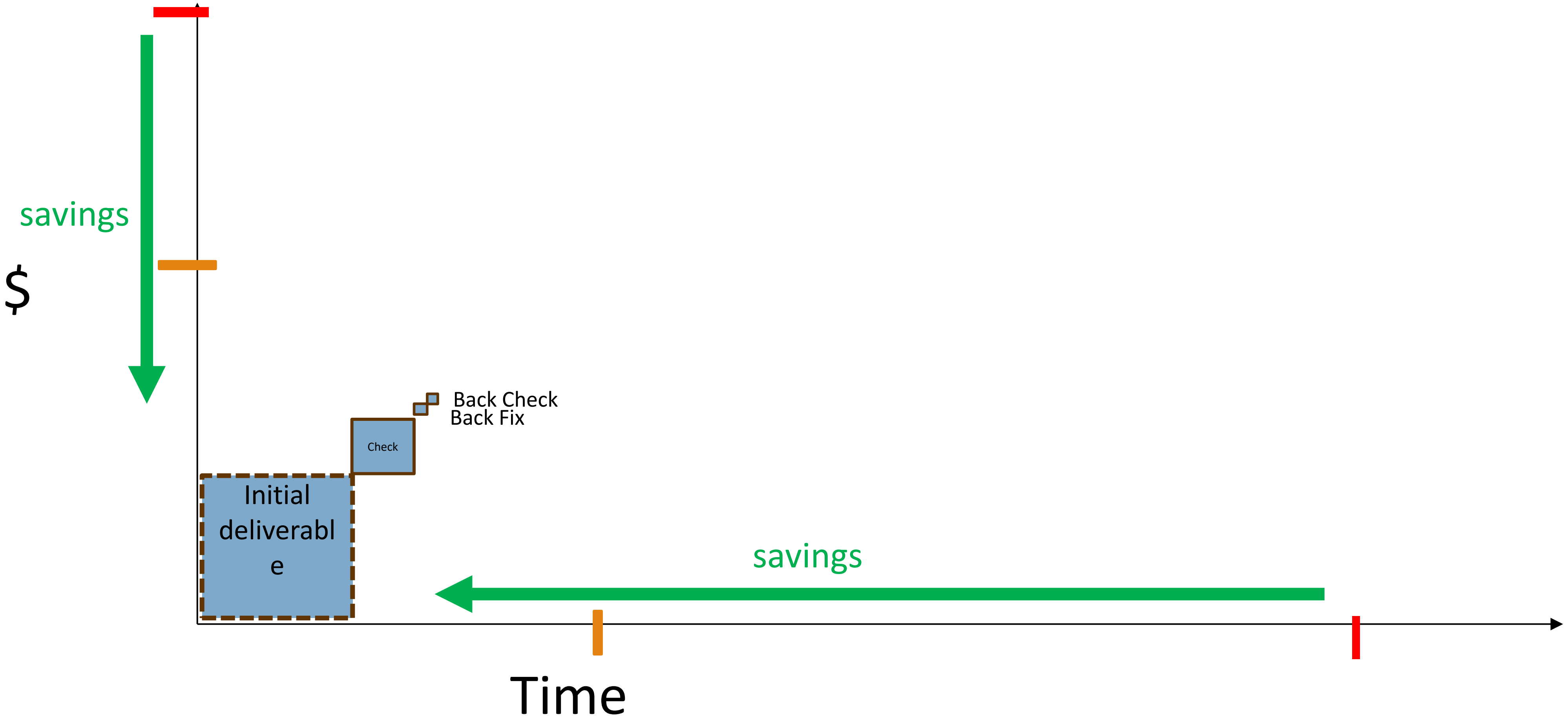
Knowledge extraction
- Dedicated workshops
- Knowledge extraction workflow

Dedicated Workflow Apps
- App for every workflow
- Embrace automation

Dashboards
- Real-time insights
- Metrics for all
- Small data, big data

Cost/Time Diagram:

Intelligent Workflows, Automation, Data-centric Improvements



Demo Videos

Workflow App and Dashboard

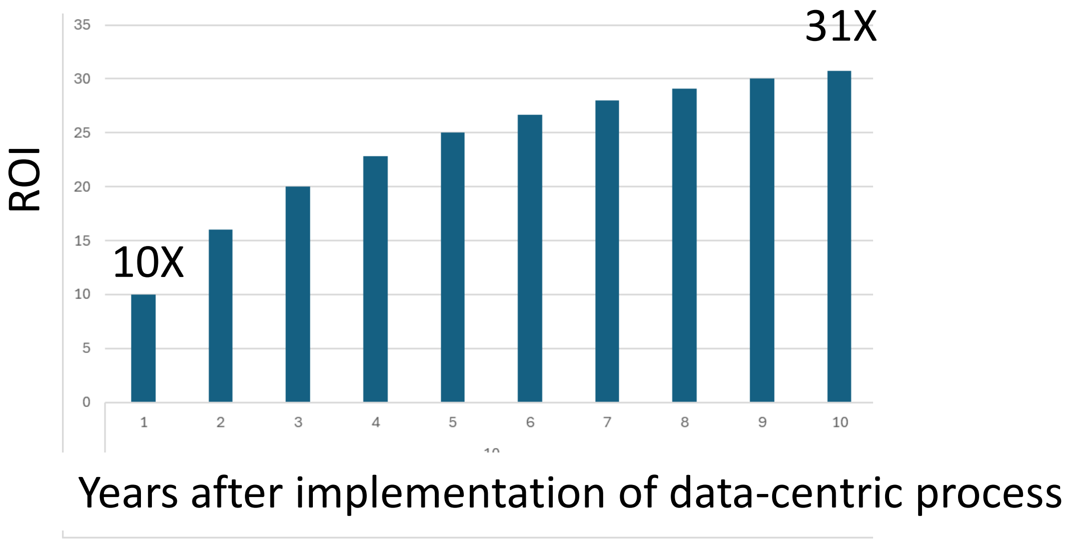
https://youtu.be/NGMuCCJ6vE4

Integrated Learning and Automation

https://youtu.be/xVq97x--ajQ

How much does it cost to implement?

- ROI Model – Data-centric Workflows and Dashboards
  - Year 1: 10 X ROI
  - Year 10: 31 X ROI
  - Implementation Cost <10% of Year 1 cost savings
    - Example: 4000 hours cost savings, <400 hours to implement
  - Maintenance Cost <2.5% of yearly cost savings
    - Example: 4000 hours cost savings, <100 hours to maintain



Path Forward - Scalable

Implement Data-centric Workflow for Piping Checkers

Take a percentage of the realized savings, re-purpose budget towards implementing more workflows (piping drafter, piping design, structural, electrical, shock, etc)

Repeat for other engineering workflows

Seed Project:
Start taking data

Analyze, re-seed

Repeat

Implementation Questions

- Dashboards and Workflows
    - **How much <u>additional</u> savings can be realized through live access to productivity data [hours per sheet]?**
    - **Can we reduce the amount of time spent on training and track it?**
    - **What is best platform for implementation of data-centric workflows for each shipbuilder?**
        - *Power Apps / Power BI*
        - *SAP*
        - *Web-based stand-alone*
        - *Other?*

Future Plans for Data-Centric Workflows

- **Navy STTR Proposal** – *Automated Expert Extraction and Micro-Process Workflow Builder Suite using Artificial Intelligence*
  - Automating the creation of technical processes from expert knowledge, streamlining the workflow development process and enhancing efficiency in engineering and manufacturing.
  - Collaboration with Michigan Tech University, Wildwood Coatings
  - Endorsed by Huntington Ingalls
- **Continued Development**
  - Shipyard app testing and refinement
  - SAP integration
  - Workflow integration with Artificial Intelligence
- **<u>Ready to implement data-centric workflows into shipbuilding engineering groups</u>**

Q&A

Greg Kangas

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NSRP Cyber Ready Ships – Project Progress and Framework Details

FY24 Panel Project (PP24-12)

Veneela Ammula | February 26, 2025

Agenda

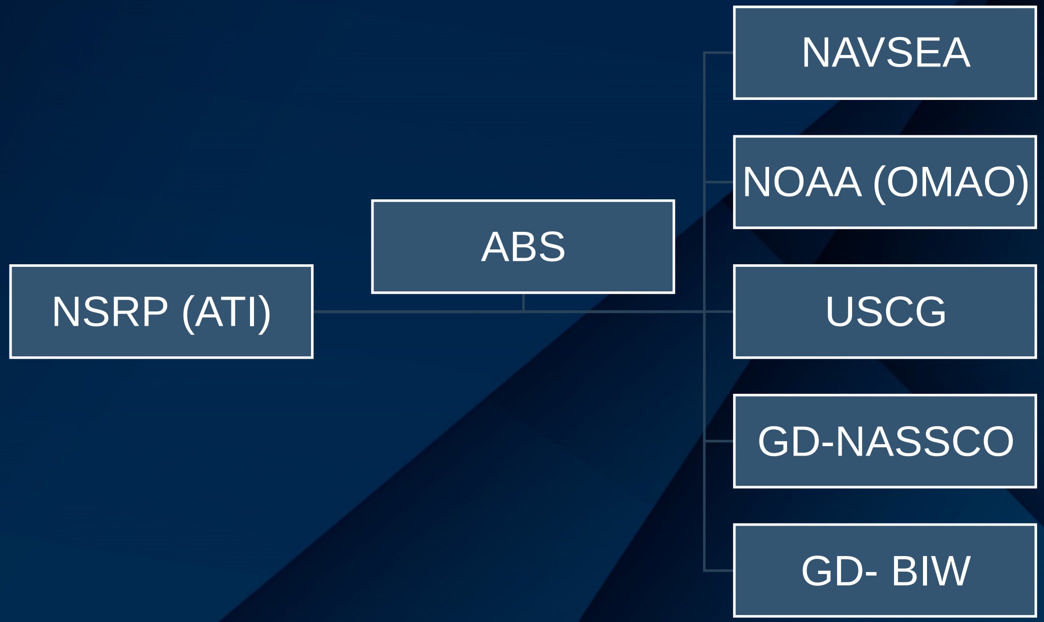
1. Project Overview and Stakeholders
2. Project Task Progress
3. Framework Structure
4. Next Steps
5. Questions

Project Overview and Stakeholders

Project Overview: Delivering a Cyber Ready Framework

- A cyber ready guidance framework and implementation roadmap that is agnostic to specific technology and vendors/tools
- ABS leads this strategic effort in collaboration with GD-BIW, GD-NASSCO and the support of the shipbuilding community to develop a recommended roadmap and overall implementation framework
- Recommended framework can be referenced by the shipowners in newbuild specifications for providing clarity to shipbuilders for cybersecurity during ship construction and ship delivery

Project Stakeholders



- NSRP (ATI) – National Ship Research Program Advanced Technology International
- ABS – American Bureau of Shipping
- NAVSEA – Naval Sea Systems Command
- NOAA (OMAO) – National Oceanic and Atmospheric Administration Office of Maritime and Aviation Operations
- GD-NASSCO – General Dynamics National Steel and Shipbuilding Company
- GD-BIW – General Dynamics Bath Iron Works
- USCG – United States Coast Guard

Project Task Progress

Project Tasks

01 Task 1

Documenting cybersecurity compliance requirements

02 Task 2

Document compliance procedures/methods followed by shipyards to meet cyber requirements

03 Task 3

Industry workshop to review compliance requirements and obtain information on compliance processes followed by the industry

04 Task 4

Develop a roadmap for delivering cyber ready ships in the most cost-effective and efficient manner

05 Task 5

Host a government/industry workshop presenting the cyber ready ship framework

06 Task 6

Finalize the roadmap for implementation of cyber ready ships

Activity for Tasks 1 and 2: Mapping

NIST CSF V 2.0

Map to Other Standards

- DODI 8510.01
- ABS CS-G, CS-Ready
- IACS UR E26/E27

DODI 8510.01 Task	Task Outcomes	ABS CS-G Task	IACS E26 Task	ABS CS-Ready Task	IACS E27 Task
P-1 Risk Management Roles	Individuals are identified and assigned key roles for executing the RMF			1. Identity or identities of the person or persons responsible for cybersecurity	
P-2 Risk Management Strategy	A risk management strategy for the organization that includes a determination and expression of organizational risk tolerance is established	Security Program Establishment - CRMS Draft/Final		5. The SBI develops a comprehensive FDD describing the cybersecurity risk management system (CRMS)	
P-3 Risk Assessment - Organization	An organization-wide risk assessment is completed, or an existing risk assessment is updated				
P-4 Organizationally-Tailored Control Baselines and CSF Profiles (Optional)	Organizationally-tailored control baselines and/or CSF profiles are established and made available	Security Program Establishment - P&P/Controls Requirements			
P-5 Common Control Identification	Common controls that are available for inheritance by organizational systems are identified, documented and published	Security Program Establishment - P&P/Controls Requirements			
P-6 Impact-Level Prioritization (Optional)	A prioritization of organizational systems with the same impact level is conducted				
P-7 Continuous Monitoring Strategy - Organization	An organization-wide strategy for monitoring control effectiveness is developed and implemented				
P-8 Mission or Business Focus	Missions, business functions and mission or business processes that the system is intended to support are identified	Initial Profiling - System to Mission Allocation			
P-9 System Stakeholders	The stakeholders having an interest in the system are identified				
P-10 Asset Identification	Stakeholder assets are identified and prioritized	Initial Profiling - Automation Systems Asset Inventory	1. Inventory of CBSs and networks onboard		2. CBS asset inventory
P-11 Authorization Boundary	The authorization boundary (i.e. system) is determined		2. Security Zones	4. Network diagram(s) indicating system physical and digital boundaries	3. Topology diagrams
P-12 Information Types	The types of information processed, stored and transmitted by the system are identified				
P-13 Information Life Cycle	All stages of the information life cycle are identified and understood for each information type processed, stored or transmitted by the system				
P-14 Mission-Based Cyber Risk Assessment	A system-level risk assessment is completed or an existing risk assessment is updated	Security Program Establishment - FCI: Architectural Risk Assessment			
P-15 Requirements Definition	Security and privacy requirements are defined and prioritized		IACS UR E26 Cyber Resilience of Ships		4. Description of security capabilities

Map to Stakeholders Documents

- Gather direct requirements from GD-BIW, GD-NASSCO
- Send survey, identify which tasks they meet and other tasks not discussed

Draft Mapping

- Used for preparation of the industry workshop
- Building block for cybersecurity elements of the framework
- Adaptable and flexible

Activity for Tasks 3 and 4: Framework Drafting

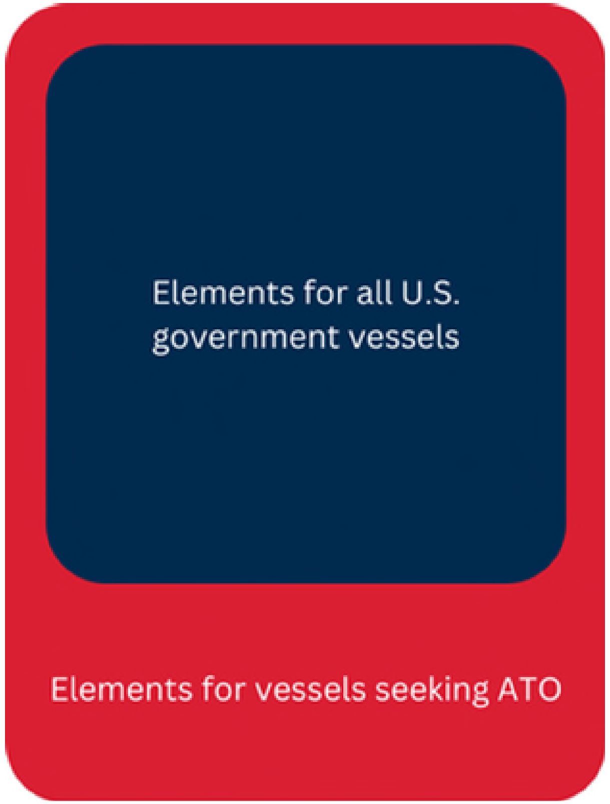
- Task 3 activities
  - ABS hosted a virtual industry workshop on September 26, 2024.
  - Various stakeholders, including shipyards and system designers, attended the workshop.
  - ABS presented the cybersecurity requirements and artifacts along with the stakeholder responsibilities during the ship construction phases.
  - Participants asked questions about the direction of the framework and provided suggestions for the cyber ready framework.
  - Participants filled out the survey about how they are currently addressing their cybersecurity requirements.

- Task 4 activities
  - ABS reviewed the submitted documents by all project participants and, based on discussions, started drafting the framework document.
  - The framework document was shared with all project participants for comments.
  - Comments received were addressed to update the cybersecurity framework.

Framework Structure

Framework Structure

- Broken up into two sections
  - Cybersecurity elements for all U.S. vessels
  - Cybersecurity elements only for U.S. vessels desiring ATO on ship’s control systems



Element Structure

Element #: Element Title

Description: General description of Element, based directly on NIST CSF

Element details:

i. Specific details or expectations of element

ii. Specific details or expectations of element

Responsible parties: Shipyard or supplier

Documentation: Which documents need to be created in the element

Shipbuilding phase where the element is initiated: Design or construction

Shipbuilding phase where the element is applied/implemented/maintained: Design, construction or commissioning

Framework Details

25

Elements for all U.S. vessels

10

Additional elements for vessels seeking ATO

42

Documents detailed in the elements

40

Pages in the framework

The framework only addresses the design, construction and commissioning phases. The operational phase is outside the project's scope.

Examples of Elements

All Vessels

- Identification of stakeholders
- Cybersecurity training
- Supplier selection
- Asset inventories
- Data protection
- Configuration management

ATO Vessels

- Security categorization
- Asset inventories – Data privacy impact level
- Control selection and implementation
- Data protection – Boundary defense

Note that some elements from All Vessels are expanded on in ATO Vessels

Example: All Vessel Element

Element 8: Network Diagrams

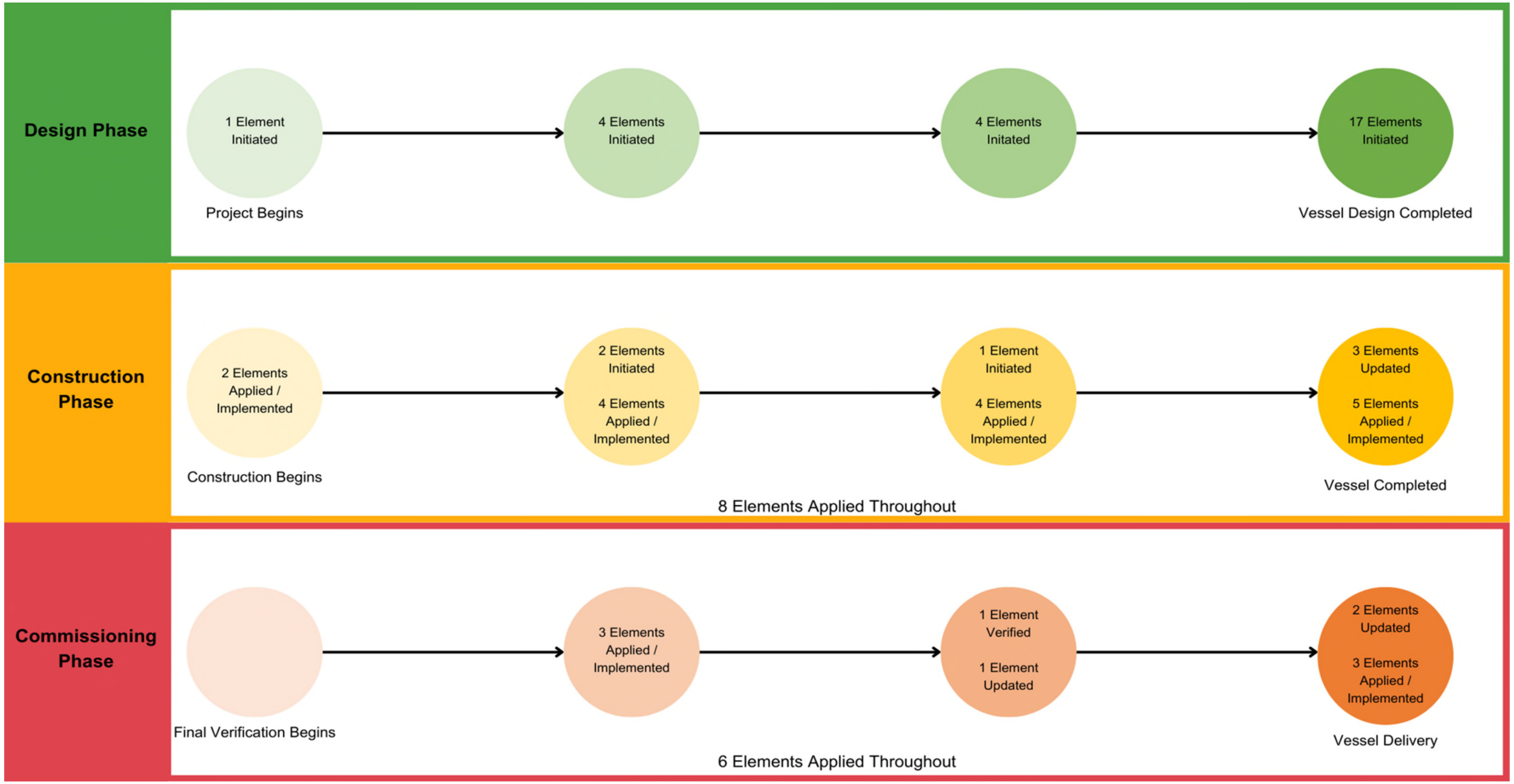
- Description: Representations of all the vessel’s network communication and internal/external data flows are established and maintained.
- Element details:
  - i. Network topology diagrams are developed and maintained throughout the design and construction of the vessel.
  - ii. These diagrams should include the types of data flowing through the network.
  - iii. Any locations where data flows in from external sources or out to external sources are clearly identified.
- Responsible parties: Shipyard
- Documentation: System interface agreements, logical and data flow diagrams
- Shipbuilding phase where the element is initiated: Design
- Shipbuilding phases where the element is maintained: Construction or commissioning

Example: ATO Element

Element 27: Security Categorization

- Description: A security categorization is performed for each system.
- Element details:
  - i. The system is categorized as low, medium or high based on the impact of confidentiality, integrity and availability. This categorization considers the types of information processed by the system.
  - ii. System categorization specifies which enclaves the system falls under.
  - iii. All security categorizations are thoroughly documented.
- Responsible parties: Shipyard or shipowner
- Documentation: Security categorization form
- Shipbuilding phase where the element is initiated: Design

Cyber Ready Ship Development Roadmap



Cyber Ready Ship Development Roadmap

Design Phase	Beginning	Element 1: Identification of Stakeholders
	First Third	Element 2: Risk Management and Tolerance (Initiated) Element 5: Supplier Selection Element 11: Change Management (Initiated) Element 20: Secure Software Development (Initiated)
	Second Third	Element 6: Supply Chain Risk Management (Initiated) Element 12: Incident Response Plans (Initiated) Element 17: Configuration Management (Initiated) Element 23: Incident Communication (Initiated)
	End	Element 3: Cybersecurity Policies (Initiated) Element 4: Cybersecurity Training (Initiated) Element 8: Network Diagrams (Initiated) Element 9: Identifying Cybersecurity Vulnerabilities (Initiated) Element 13: User Identification and Authentication (Initiated) Element 14: Physical Access (Initiated) Element 15: Data Protection (Initiated) Element 16: Data Backups (Initiated) Element 18: Security Logging (Initiated) Element 19: Unauthorized Software Installation (Initiated) Element 21: Resilience and Availability (Initiated) Element 22: Continuous Network/Personnel Monitoring (Initiated) Element 27: Security Categorization Element 30: Control Selection and Implementation (Initiated) Element 31: Boundary Defense Capabilities (Initiated) Element 33: Cross-Network Monitoring (Initiated) Element 34: Incident Communication – Off-Vessel Lines (Initiated)
	Throughout	
Construction Phase	Beginning	Element 4: Cybersecurity Training (Applied - Builders/Suppliers) Element 26: Supplier RMF Artifacts (Applied)
	First Third	Element 7: Asset Inventories (Initiated) Element 13: User Identification and Authentication (Implemented) Element 14: Physical Access (Implemented) Element 19: Unauthorized Software Installation (Implemented) Element 28: Asset Inventories – Data and Categorization (Initiated) Element 31: Boundary Defense Capabilities (Implemented)
	Second Third	Element 10: Risk Assessment and Response (Applied) Element 15: Data Protection (Implemented) Element 22: Continuous Network/Personnel Monitoring (Implemented) Element 24: Recovery Plan (Initiated) Element 33: Cross-Network Monitoring (Implemented)
	End	Element 7: Asset Inventories (Updated) Element 8: Network Diagrams (Updated) Element 18: Security Logging (Implemented) Element 21: Resilience and Availability (Implemented) Element 28: Asset Inventories – Data and Categorization (Updated) Element 30: Control Selection and Implementation (Implemented) Element 32: Resilience and Availability Element 34: Incident Communication – Off-Vessel Lines (Implemented)
	Throughout	Element 2: Risk Management and Tolerance (Applied) Element 3: Cybersecurity Policies (Applied) Element 6: Supply Chain Risk Management (Applied) Element 11: Change Management (Applied) Element 12: Incident Response Plans (Applied) Element 17: Configuration Management (Applied) Element 20: Secure Software Development (Applied) Element 23: Incident Communication (Applied)
Commissioning Phase	Beginning	
	First Third	Element 9: Identifying Cybersecurity Vulnerabilities (Applied) Element 25: Security Testing Element 35: Control Security Testing
	Second Third	Element 10: Risk Assessment and Response (Verified) Element 24: Recovery Plan (Updated)
	End	Element 4: Cybersecurity Training (Applied - Operators) Element 7: Asset Inventories (Updated) Element 8: Network Diagrams (Updated) Element 16: Data Backups (Applied) Element 29: Risk Response Implementation
	Throughout	Element 2: Risk Management and Tolerance (Applied) Element 3: Cybersecurity Policies (Applied) Element 11: Change Management (Applied) Element 12: Incident Response Plans (Applied) Element 17: Configuration Management (Applied) Element 23: Incident Communication (Applied)

ABS

Project Benefits

Help shipyards, shipowners and U.S. government agencies to:

- Improve cybersecurity postures for the ships as the full supply chain will be involved in this framework during different phases
- Better prepare government fleet owners/operators to complete cybersecurity certifications and gain ATOs

Cost Benefits

- The budget for the cybersecurity framework will be included in the initial stages of the ship construction, which will reduce the cost compared to cybersecurity considerations made at later stages or after ship construction (estimated cost reduction is ~20%).
- Implementing the cybersecurity elements will reduce the risk of cyberattacks. However, as the financial impact of each cybersecurity attack varies, the exact cost-benefit ratio in this case cannot be estimated.
- Standardization: Using a common framework aids the communication between various parties within the industry for project and requirement definitions. Costs associated with these efficiencies are not easily quantified but can have significant value.

Next Steps

Activity for Task 5 and 6: Finalizing Framework

Framework presented to a broader audience in today's meeting

Collect feedback

Finalize the framework

Questions?

www.eagle.org

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**	

Develop a Welding Fast-Analysis Solver for Shipbuilding Applications

Yu-Ping Yang, Steven T. Scholler, Jamie Breakfield

Ingalls Shipbuilding, a division of HII

Ingalls Shipbuilding, a division of HII

- **Largest manufacturing employer** in Mississippi
- **Major contributor** to the economic growth of Alabama and Mississippi
- **Largest supplier** of U.S. Navy surface combatants
- **Simultaneously building 4 classes** of ships
- **Comprehensive life-cycle services** for CG 47, LPD 17 and LCS class ships

***America*-class**
Large Deck Amphibious Assault Ships

***San Antonio*-class**
Amphibious Transport Dock Ships

***Arleigh Burke*-class**
Aegis Guided Missile Destroyers

***Legend*-class**
National Security Cutters

11,000
employees

800
acre shipyard

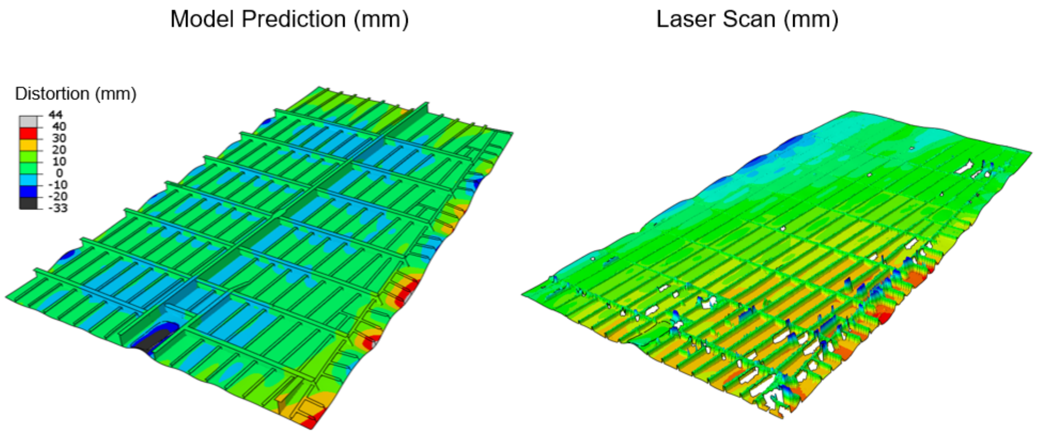
Many
third- and fourth-generation shipbuilders

Project Team

- HII Ingalls Shipbuilding
  - Steve Scholler, Yu-Ping Yang, James Breakfield
- Austal USA
  - Shawn Wilber
- Oak Ridge National Laboratory
  - Zhili Feng, Jian Chen
- Hexagon
  - Fernando Okigami, Jeff Robertson
- General Motors
  - Hassan Ghassemi-Armaki
- ATI (NSRP Program Administrator)
  - Ryan Schneier, Project Manager
- HII Newport News Shipbuilding
  - Alicia Harmon, Program Technical Representative

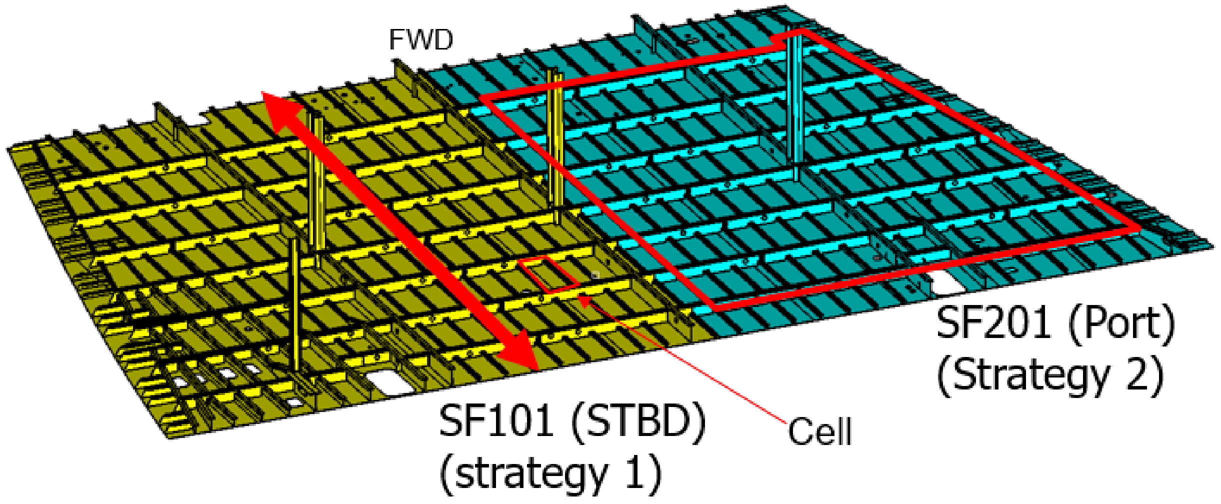
Project Team

- Materials are exposed to significant thermal and mechanical stresses during welding that affect dimensional accuracy, production schedules, labor hours (fitting, welding, rework, etc.) and structural performance
  - Many variables influence the stresses and resulting impacts
- Numerical analyses that simulate the thermal and mechanical stresses are time-consuming
  - Simulations to optimize welding sequences and minimize impacts are currently cost-prohibitive
  - Production uses other metrics for weld sequencing that do not usually consider thermal stress



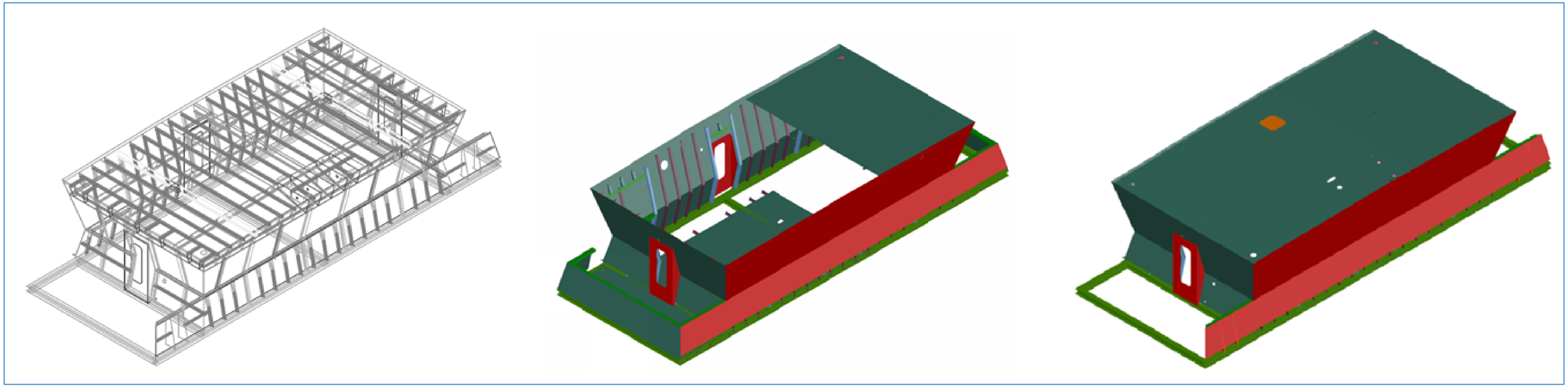
Need Statement: Stiffened Panels

- Robotic welding is increasingly used in panel construction
- Weld sequencing is currently optimized for travel time, not distortion reduction
- Due to the complexity of non-linear thermo-elastic-plastic analyses, a fast finite element analysis (FEA) solver is needed to optimize weld sequence for distortion reduction efficiently



Need Statement: Unit Assembly

- Units are much more complex than stiffened panels
- Due to computational time, current analysis tools are not practical for full-unit assembly analysis



DR-Weld: Digital Reality Welding Simulation

- ORNL developed high-performance computational code (DR-Weld) that drastically speeds up high-fidelity welding simulation
- The code has been successfully used in in design, engineering and fabrication optimization of welded structures in the automotive and energy industry sectors
- The project team is leveraging the work of ORNL to develop a fast solver to optimize the welding sequence of ship structures

Project Goals & Desired Outcome

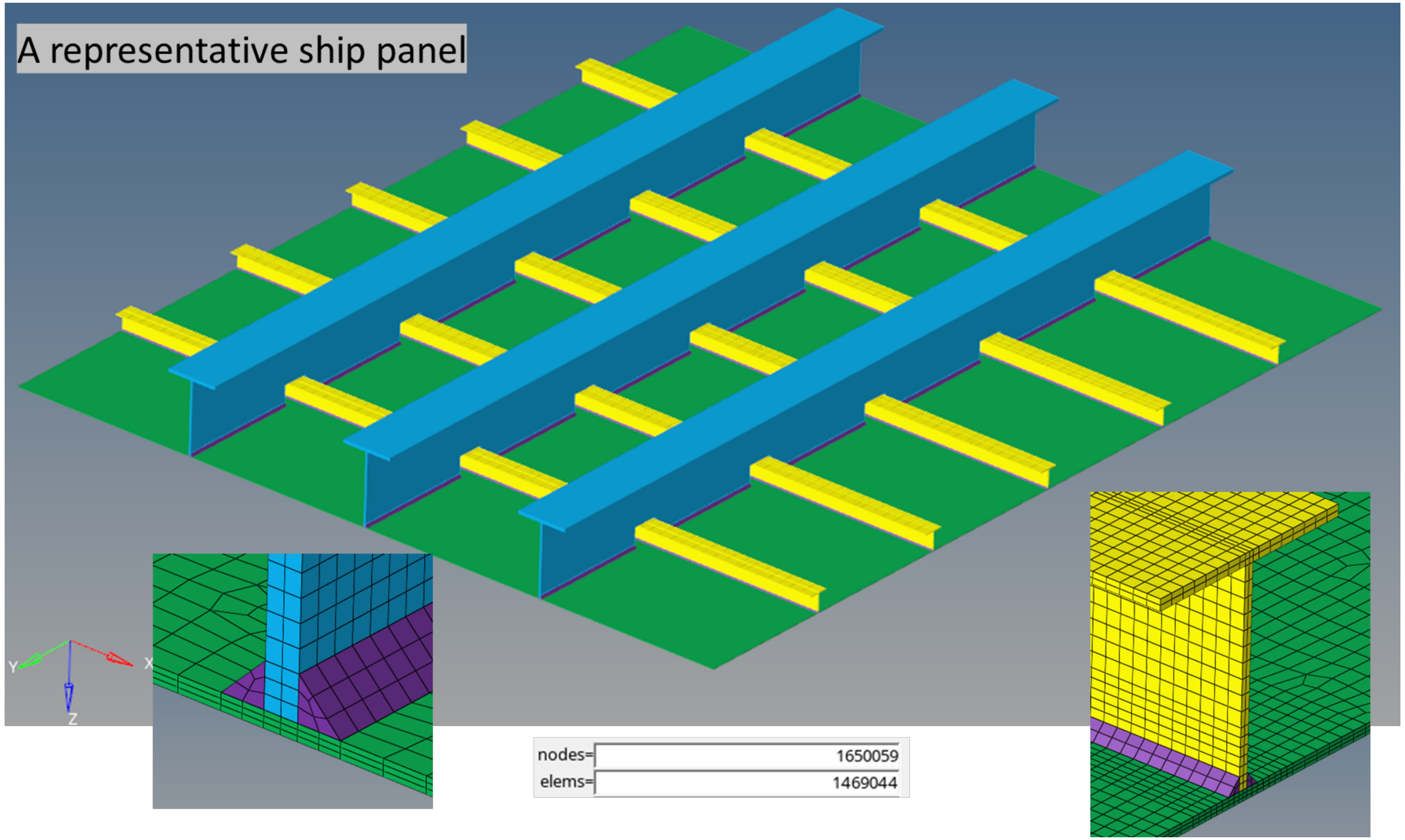
Goals:

- Adapt the DR-Weld transient elastic-plastic finite element analysis (FEA) solver developed by Oak Ridge National Laboratory (ORNL) for the automotive and nuclear industries to support shipbuilding applications
- Apply the FEA solver to simulate fabrication of production panels, unit assemblies and alignment critical foundations to examine its feasibility, effectiveness and accuracy
- Modify solver based on shipbuilding process simulation results

Desired outcome – A transient elastic-plastic FEA solver for welding simulation that will be feasible in a shipbuilding environment

Evaluate DR-Weld on Panel Structures

- A representative ship-panel structure was built to test DR-Weld



Technical Gaps

- DR-Weld can only run eight-node solid element
  - Six-node solid elements are needed to add in DR-Weld to simulate a complex
    ship structure
- DR-Weld does not include shell elements which are mainly used in the design of ship structures
- DR-Weld does not have a user-friendly graphical user interface
- DR-Weld does not have a thermal solver to predict temperature
  - DR-Weld has only a mechanical solver to predict stress and distortion with external temperature input data

Technical Approach to Develop a Fast Solver for Shipbuilding Application

Phase I. Develop a Fast Solver for Panel Structures

- Develop a shell-element based fast solver
- Develop a preliminary version of graphical user interface (GUI)
- Simulate the weld process of a production panel

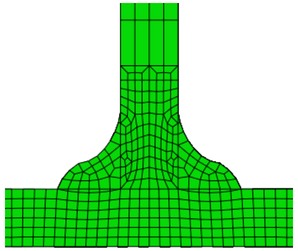
Phase II. Extend the Solver to Complex Structures

- Develop software requirements for complex structures
- Improve the software for welding sequence optimization of complex structures
- Optimize welding sequences in complex structures

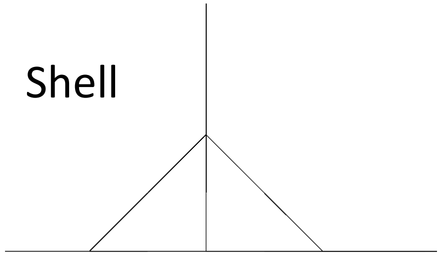
Shell Welds for Welding Simulation

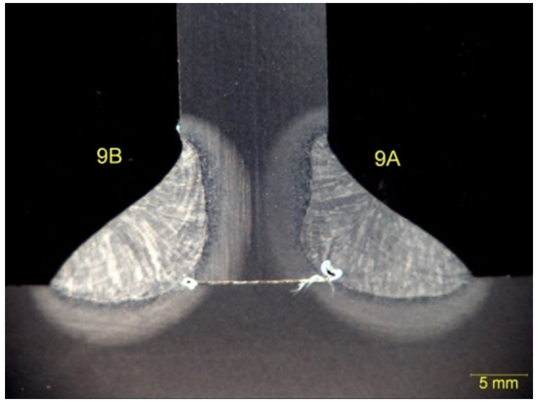
- Shell elements for welding simulation have been widely used since 2000
- Similar distortion can be predicted with both solid elements and shell elements

Solid



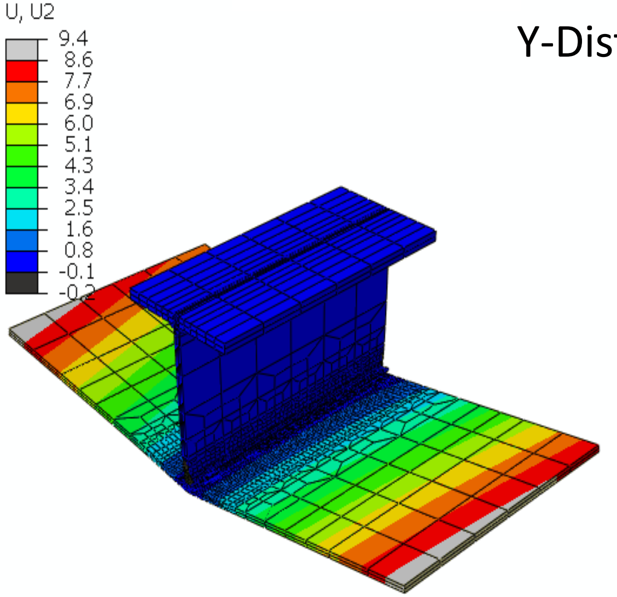
Shell

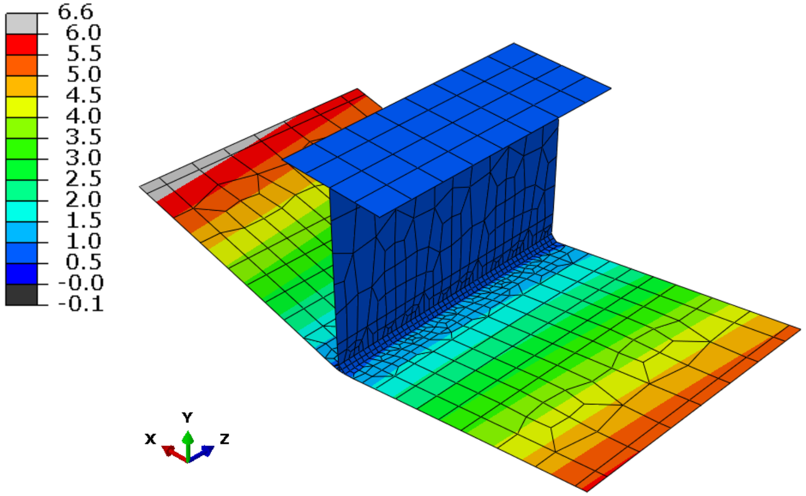




Fillet Weld Cross Section

Y-Distortion (mm)

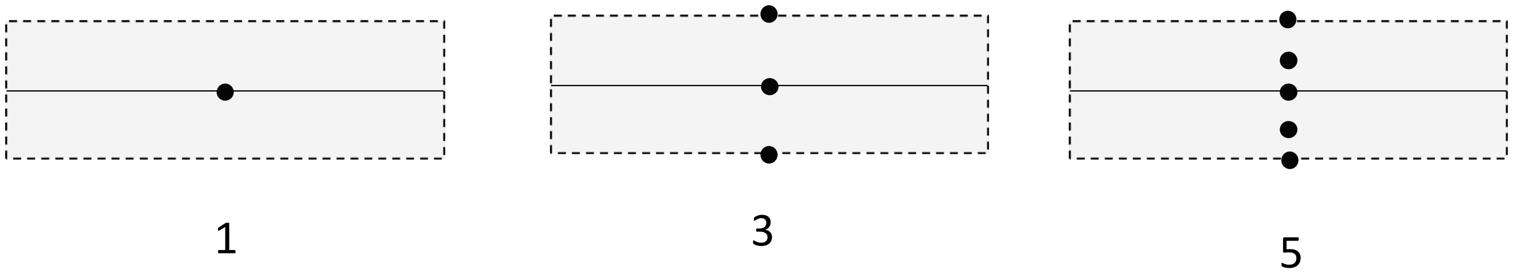




Shell Elements Implementation

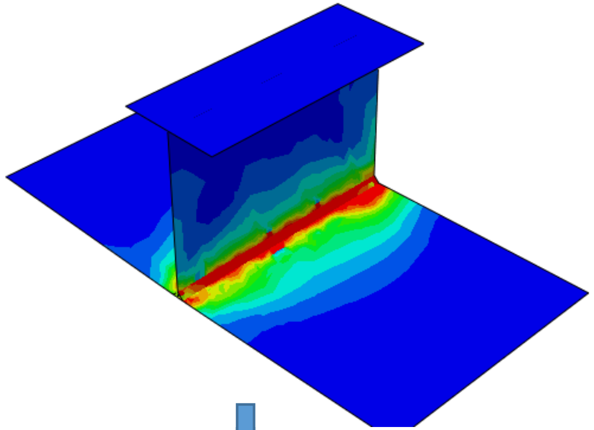
- Four shell element types were completed:
  - *S4*: 4-node full-integration
  - *S4R*: 4-node reduced-integration
  - *S3*: 3-node full-integration (degeneration of S4)
  - *S3R*: 3-node reduced integration (degeneration of S4R)
- All elements supports multiple *through-thickness* integration by Simpson Rule (number of *through-thickness* integration points: 1, 3, 5, 7, …)

Number of through-thickness integration points

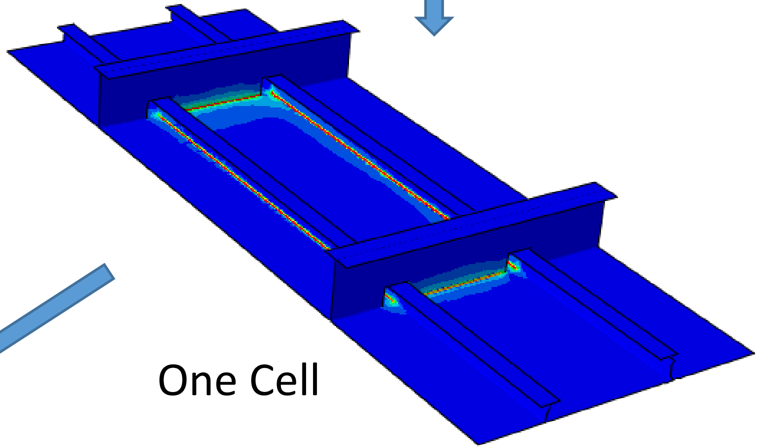


Testing Process:
A Step-by-Step Approach

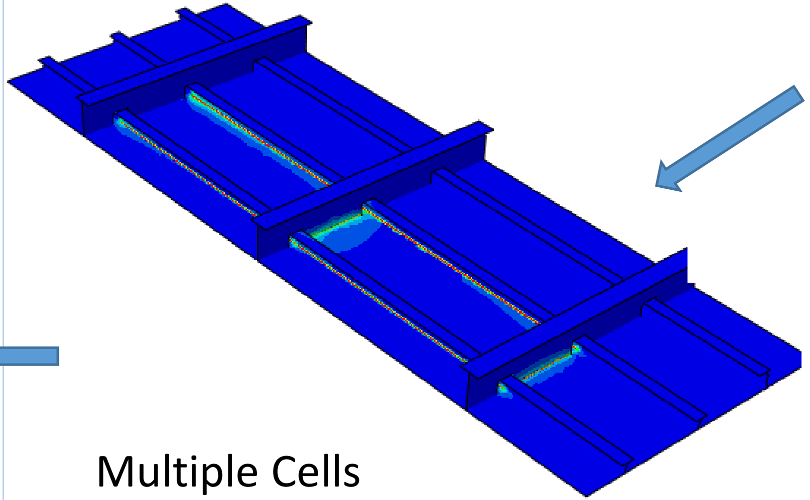
- DR-Weld will be developed and tested in four steps to reach the Phase-1 goal
  - Step 1: One-Tee Model
  - Step 2: One-Cell Model
  - Step 3: Multiple-Cell Model
  - Step 4: The Production Model



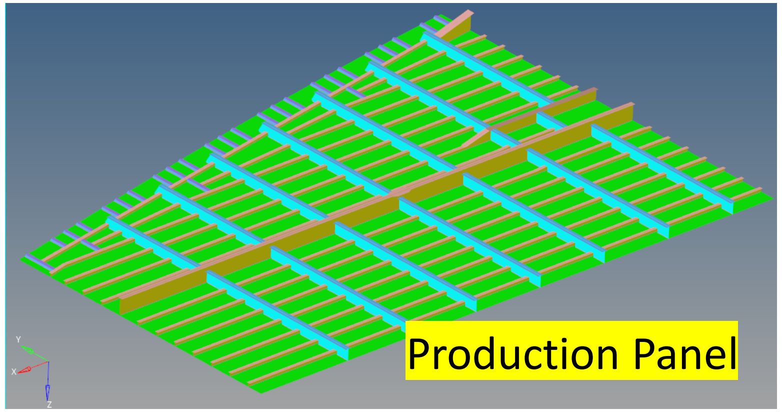
One Tee



One Cell

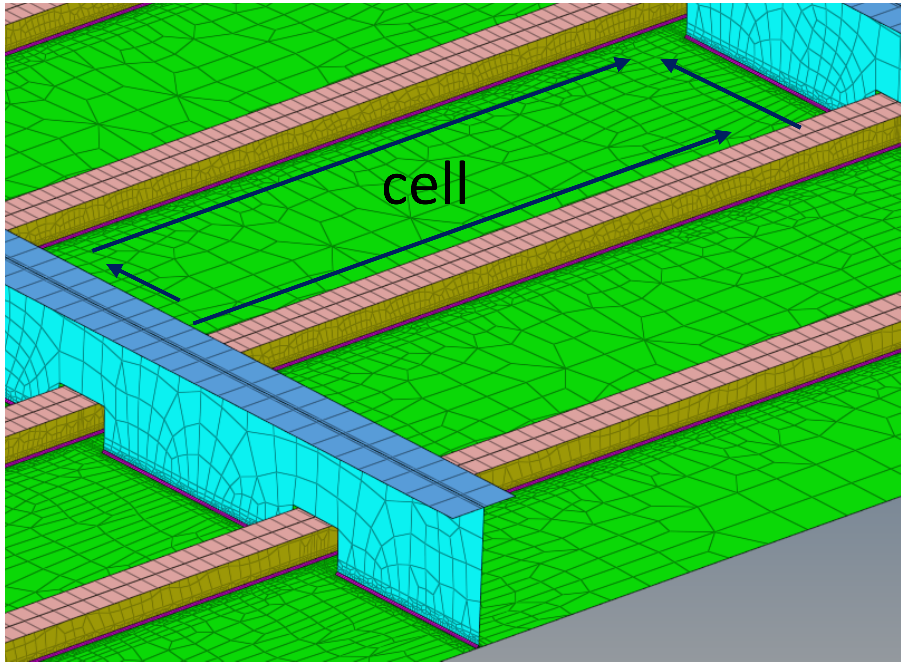


Multiple Cells



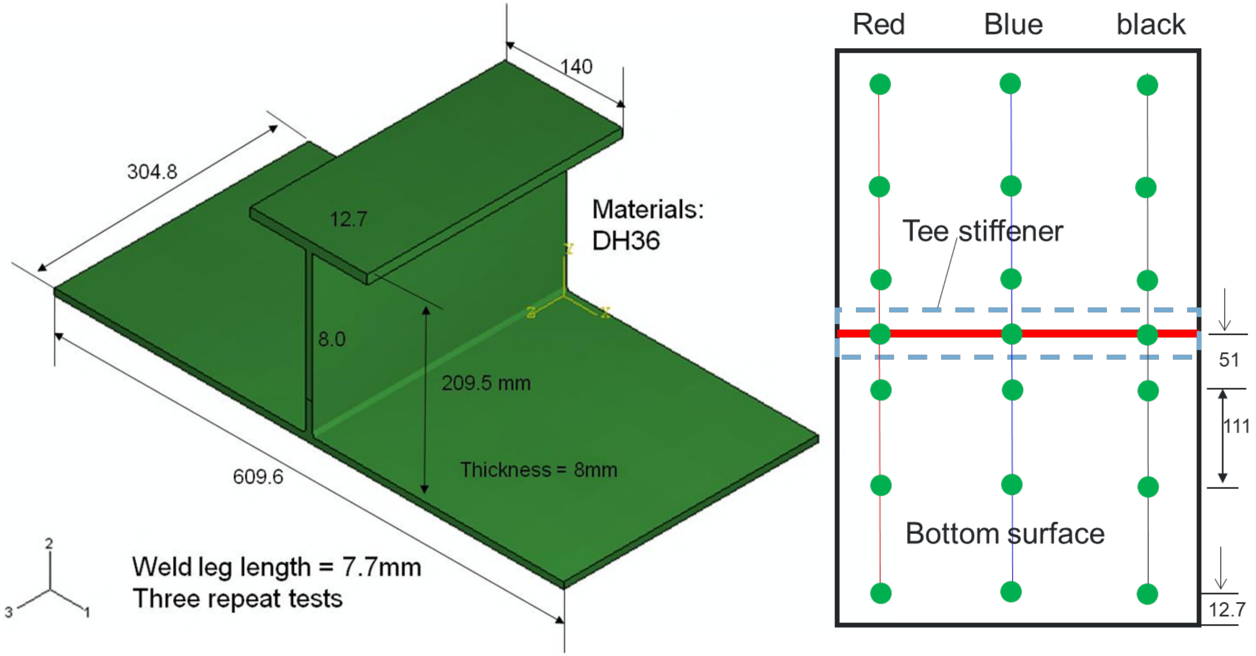
Welding the Selected Production Panel

- The production panel includes about 150 welding cells
- Four robots are used to weld the panel simultaneously
- Robots move from one weld cell to another so the cooling time between welding cells is small
- The residual temperature from previous weld cells will affect the temperature of the following cells, which may contribute to the effect of welding sequence on distortion



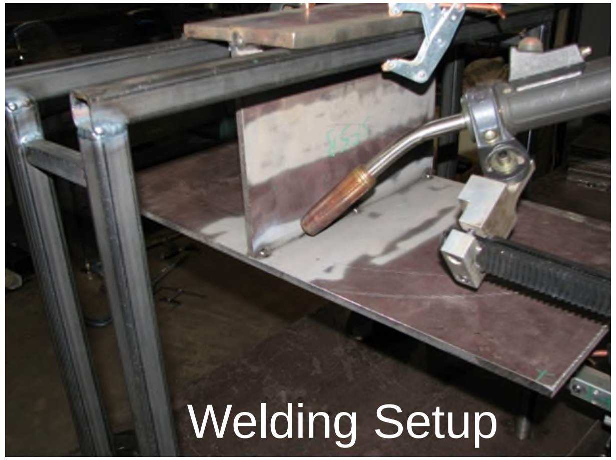
Analyze One-Tee Model

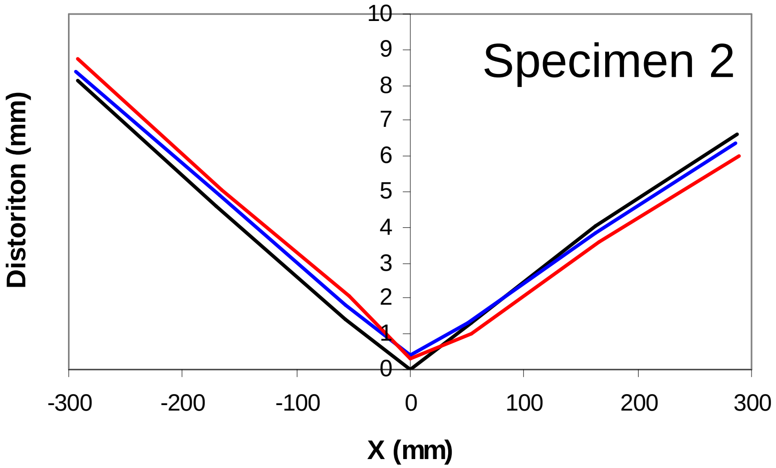
- One-Tee model is critical to verify the accuracy of DR-Weld prediction
- DR-Weld prediction will be compared with the experimental data and Abaqus prediction



- **Distortion measurement**
  - Specimen 1: Left = 9.7mm; Right = 6.2mm
  - Specimen 2: Left = 8.4mm; Right = 6.4mm
  - Specimen 3: Left = 8.9mm; Right = 5.9mm
- **Average**
  - Left = 9.0mm; Right = 6.2mm
  - **Average left and right: 7.6mm**

*Abaqus – A finite element analysis software



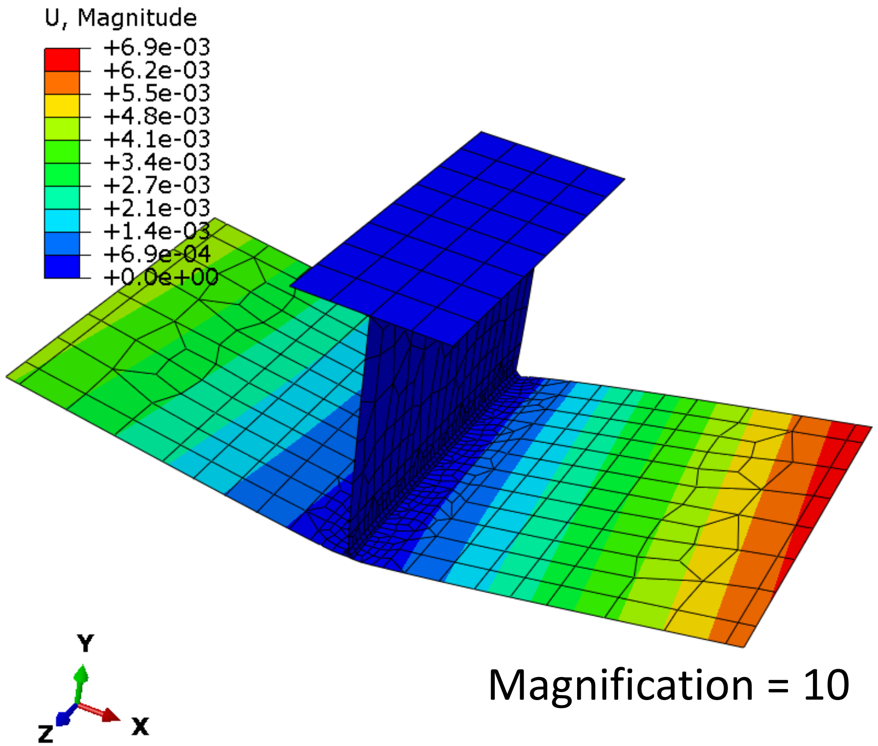


Ref. Y. P. Yang and R. Dull, 2018 Fabtech conference.

Verification of Abaqus Prediction

- Abaqus has been widely used to predict distortion induced by welding processes and previously validated extensively against as-built production panels
- Abaqus prediction will be used to check the accuracy of DR-Weld prediction on the one-cell model and the multiple-cell model
- Abaqus prediction has been verified on the one-Tee model
  - Abaqus predicted a similar distortion shape as observed in the experiment
  - The predicted distortion magnitude was close to the experimental measurement

Distortion (m)

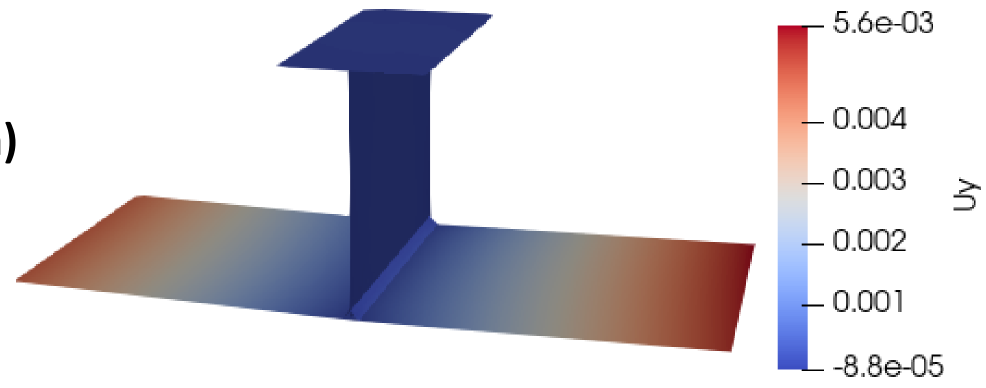


Abaqus Predicted Distortion

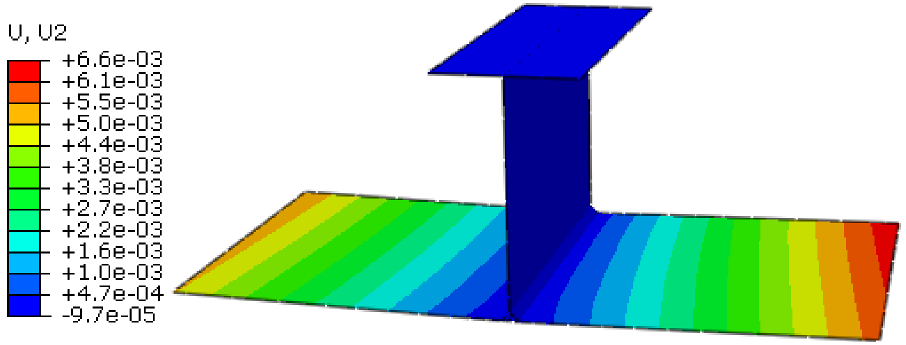
One-Tee Model Comparison between DR-Weld and Abaqus

- DR-Weld can predict the similar distortion as Abaqus
- DR-Weld predicted distortion magnitude is smaller than Abaqus

Distortion (m)

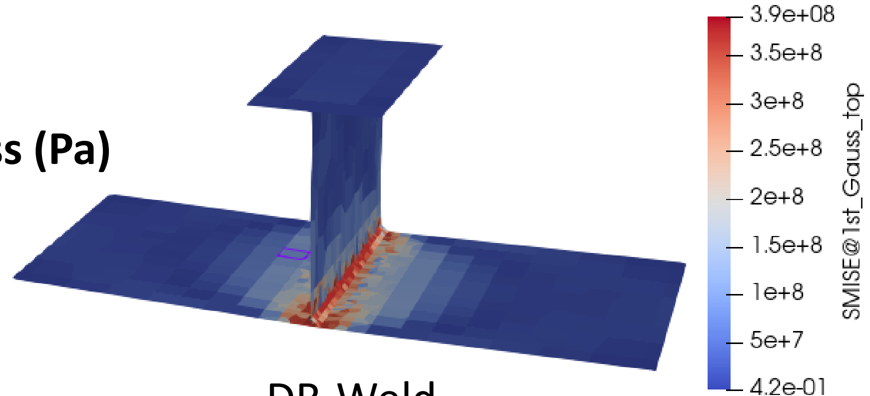


DR-Weld

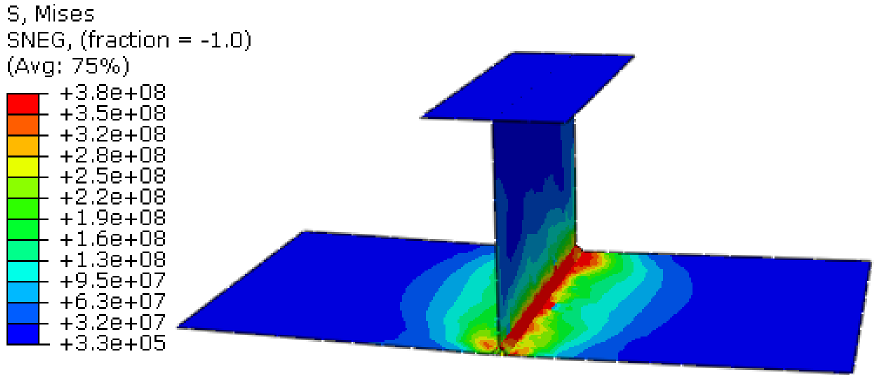


ABAQUS

Residual Stress (Pa)



DR-Weld

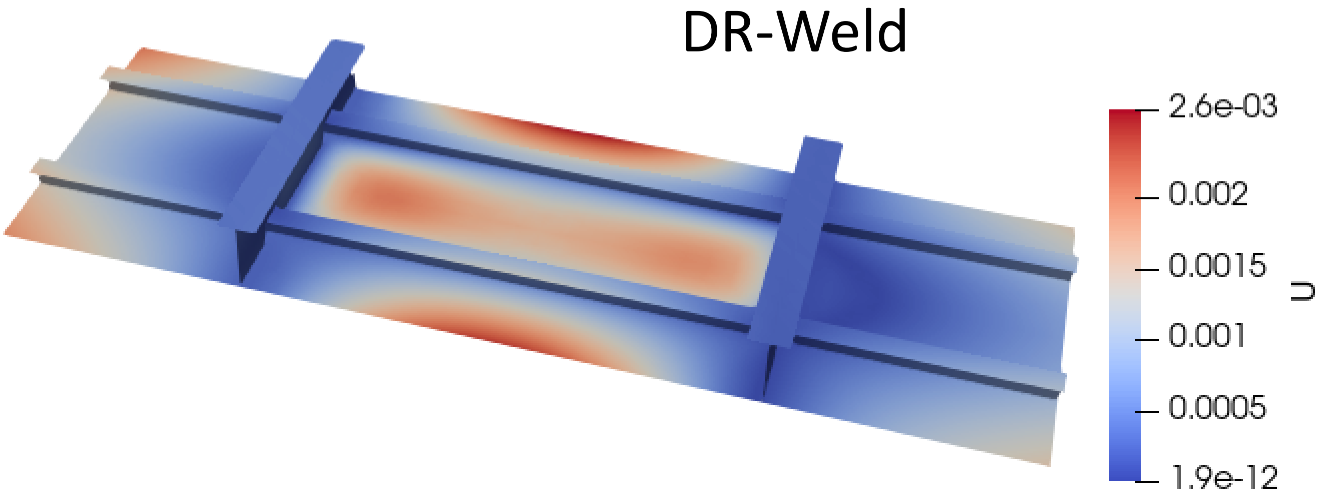


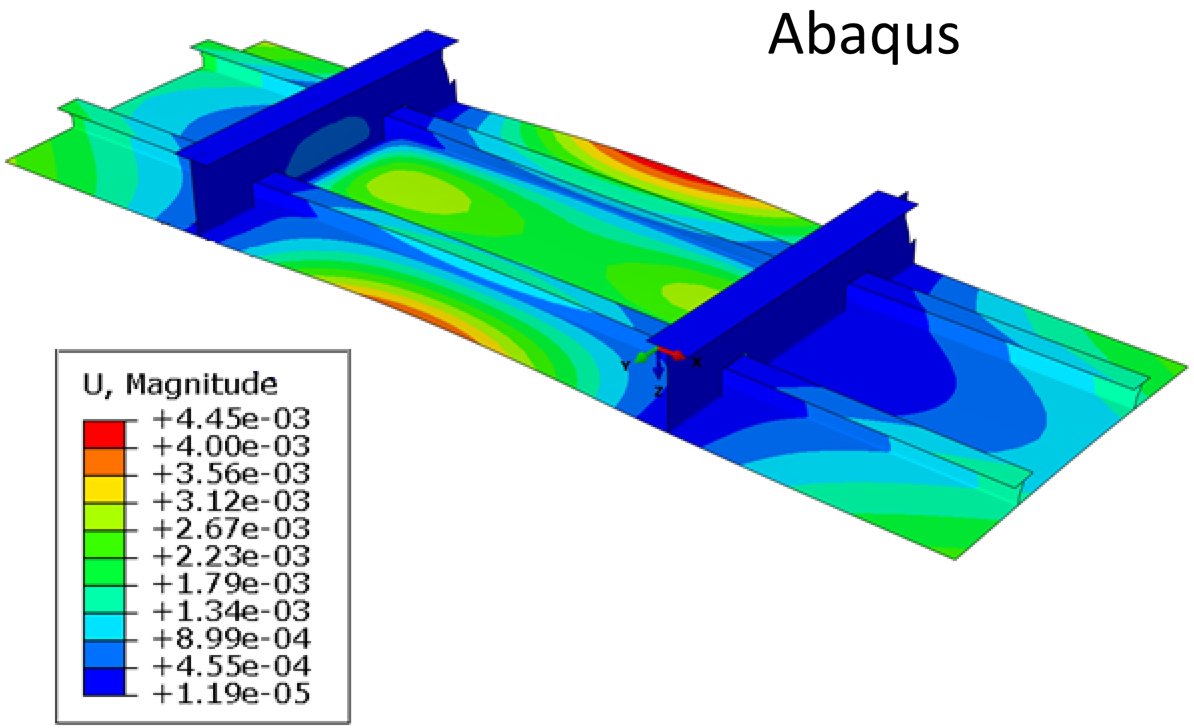
ABAQUS

One-Cell Model Comparison Between DR-Weld & Abaqus

- DR-Weld can predict similar distortion as Abaqus
- DR-Weld predicted distortion magnitude is slightly smaller than Abaqus

Distortion (m)

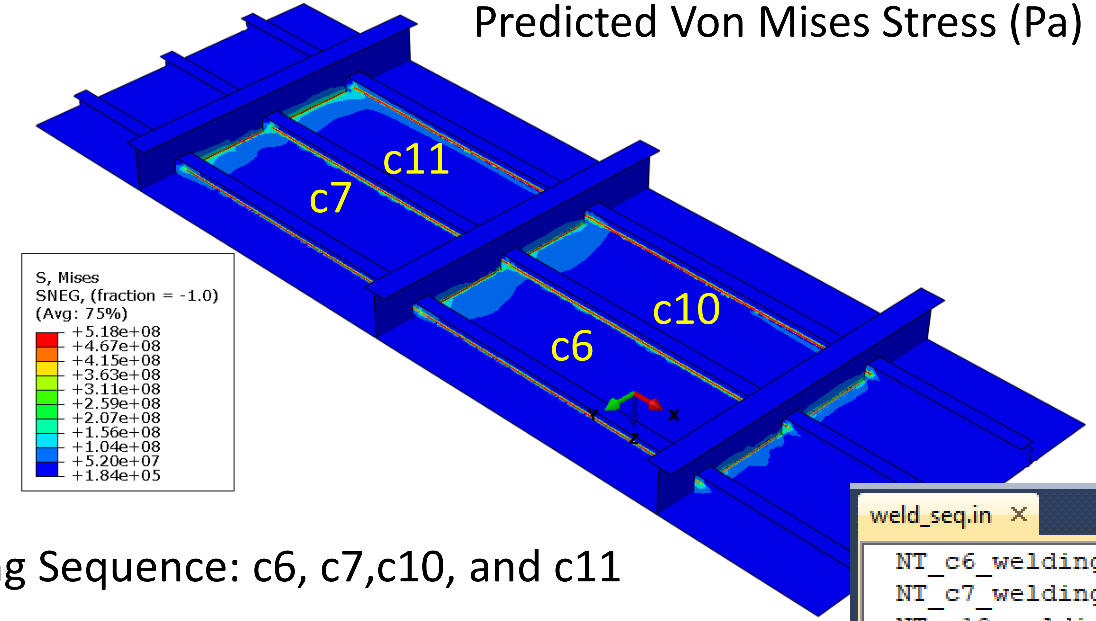




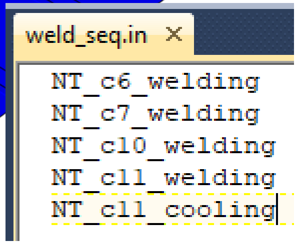
Analyze Multiple-Cell Model

- Temperature at each welding cell was predicted using Abaqus separately
  - The residual temperature from previous cell welding was ignored in this analysis
- Each-cell temperature was read into Abaqus according to the welding sequence to predict stress and distortion, which will compare with DR-Weld predictions

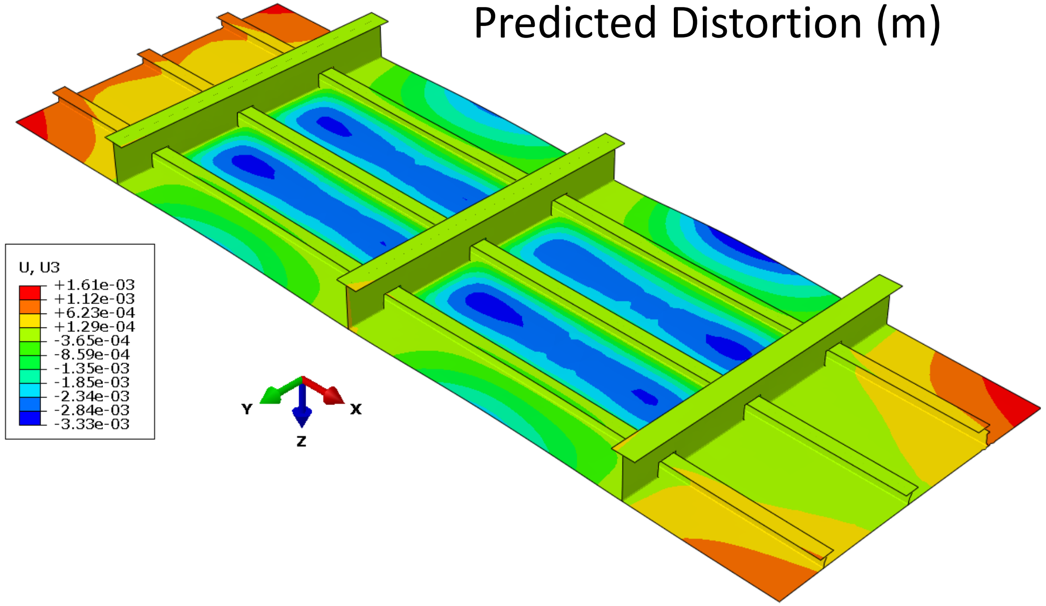
Predicted Von Mises Stress (Pa)



Welding Sequence: c6, c7,c10, and c11



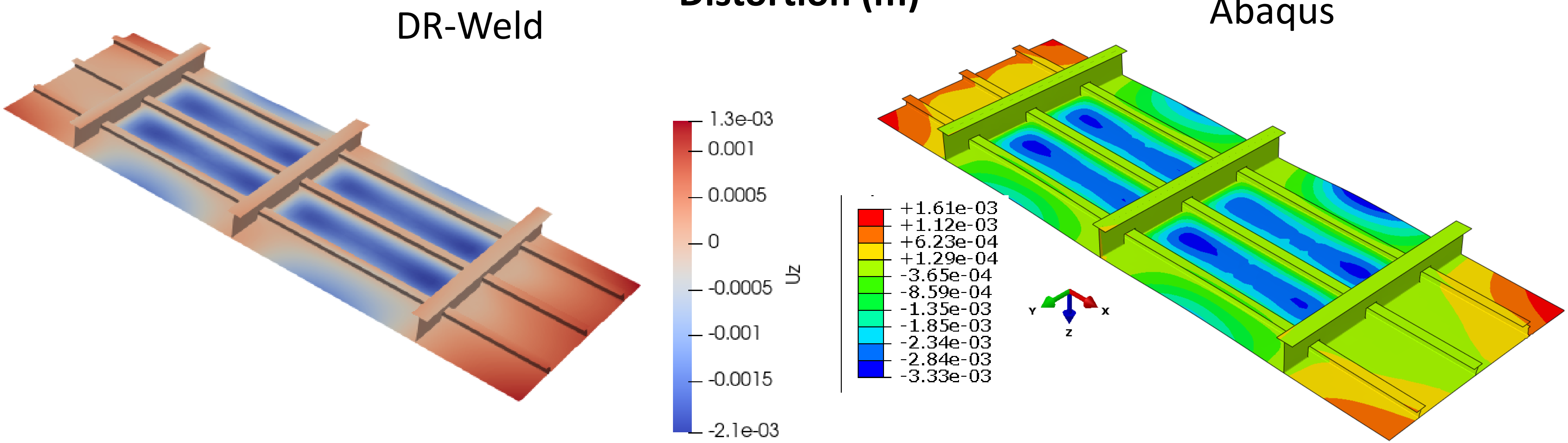
Predicted Distortion (m)



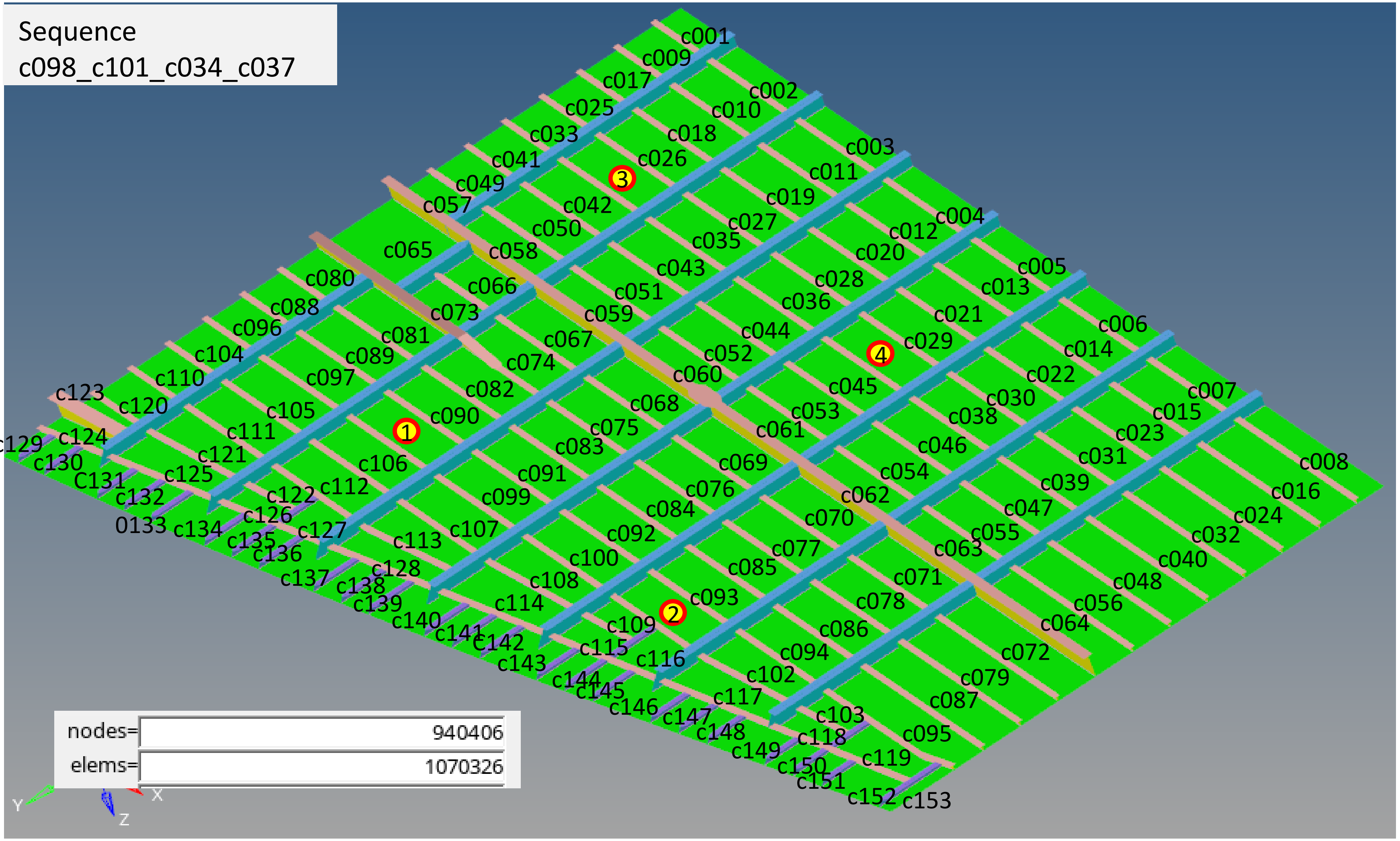
Multiple-Cell Model Comparison Between DR-Weld & Abaqus

- DR-Weld can predict the similar distortion as Abaqus
- DR-Weld predicted distortion magnitude is slightly smaller than Abaqus

Distortion (m)



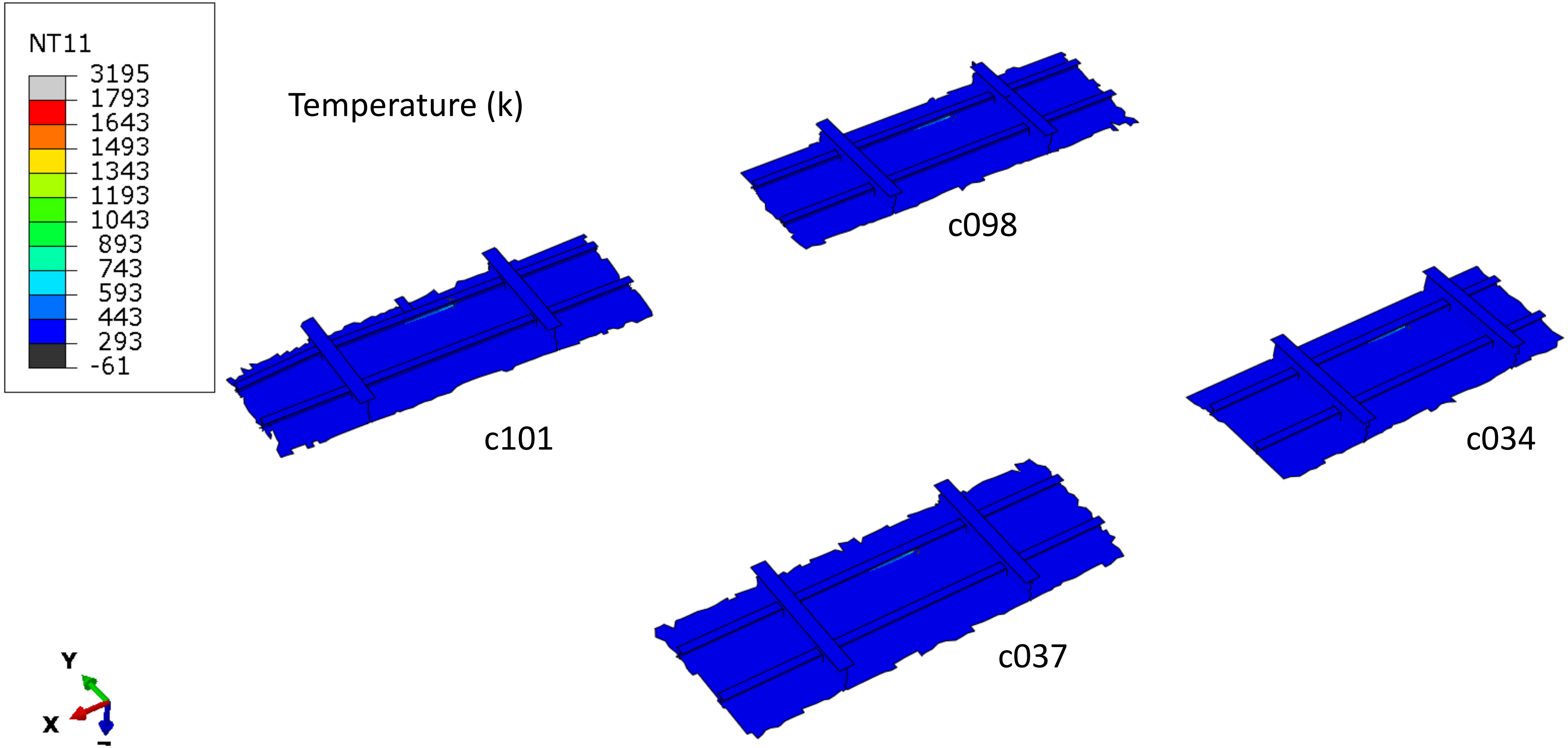
Analyze a Panel Structure



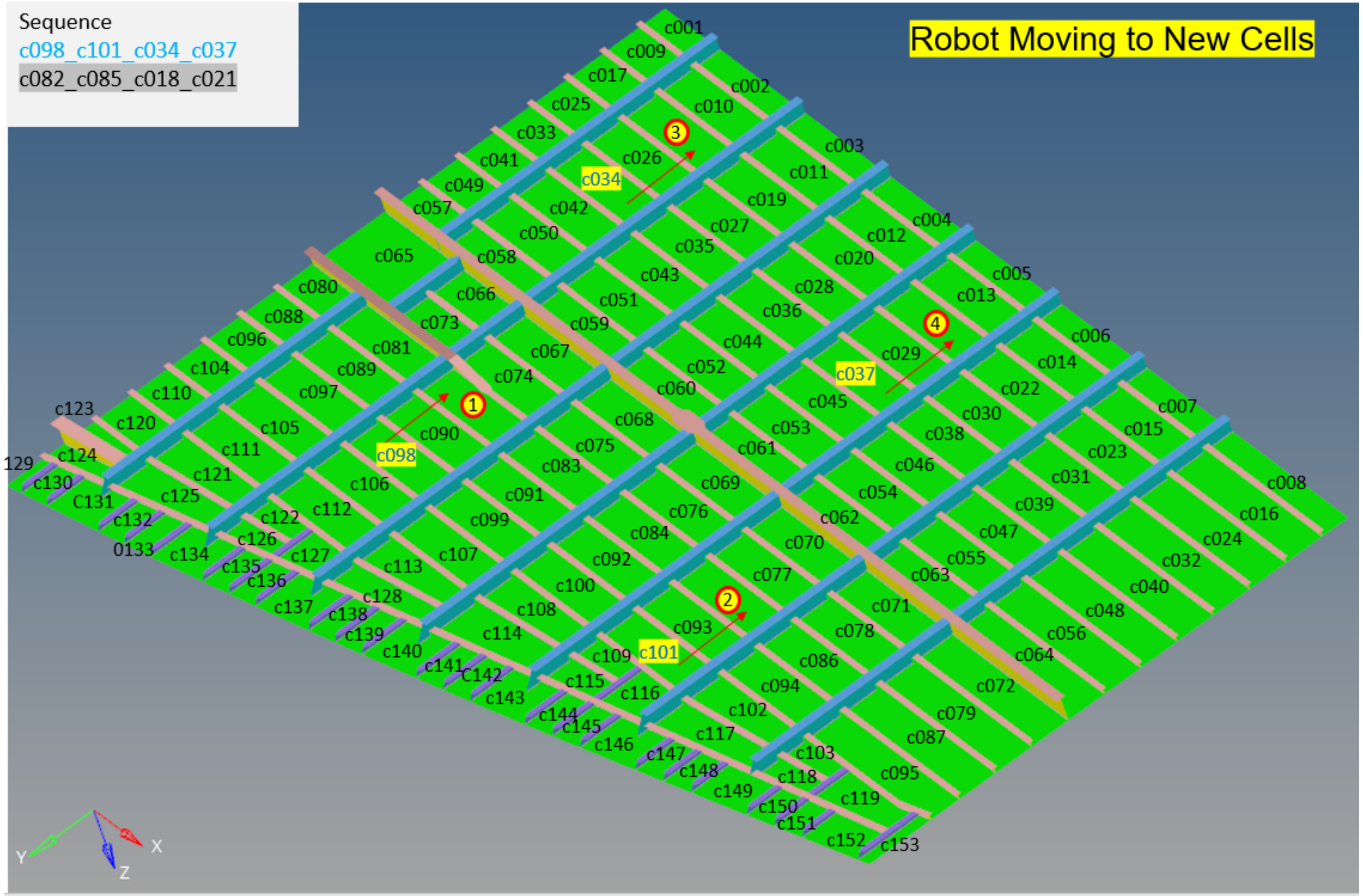
- 154 cells
- Welding with 4 robots

Predicted Temperature for c098_c101_c034_c037

- Four local areas were selected to predict temperature

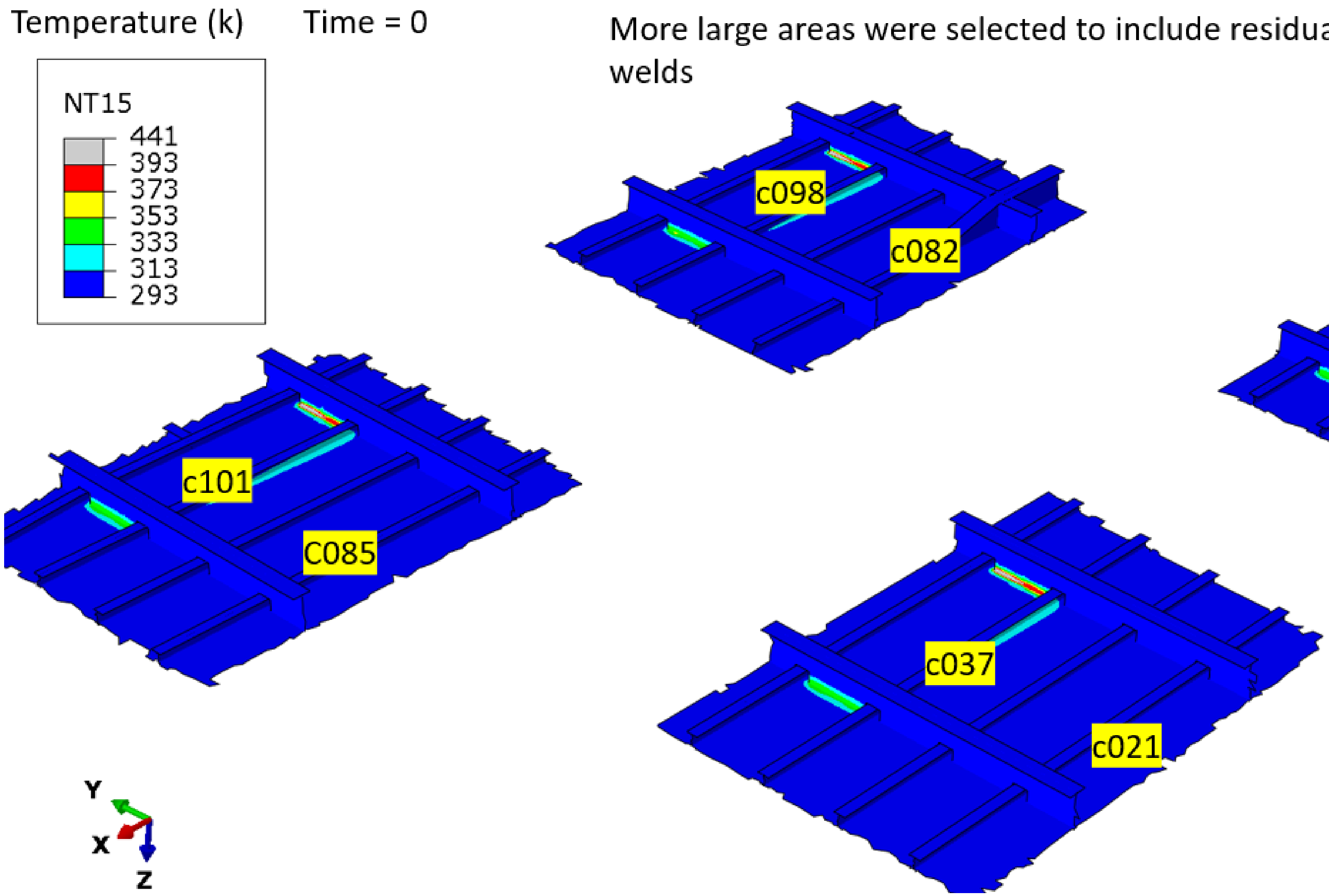


Robot Moving to New Welding Cells



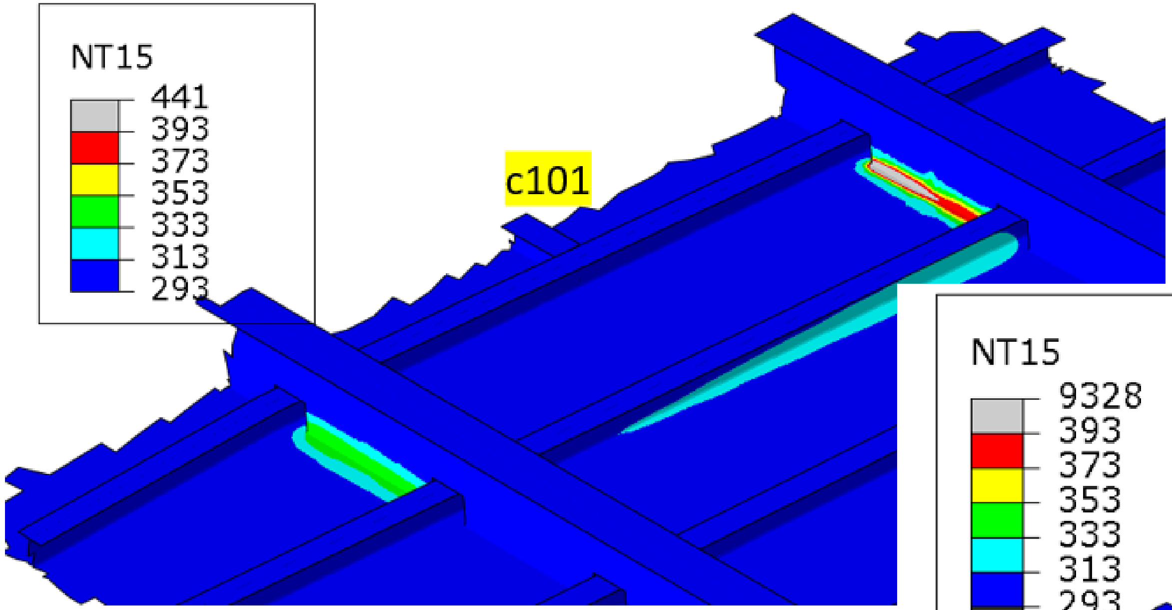
Residual Temperature From Previous Welds

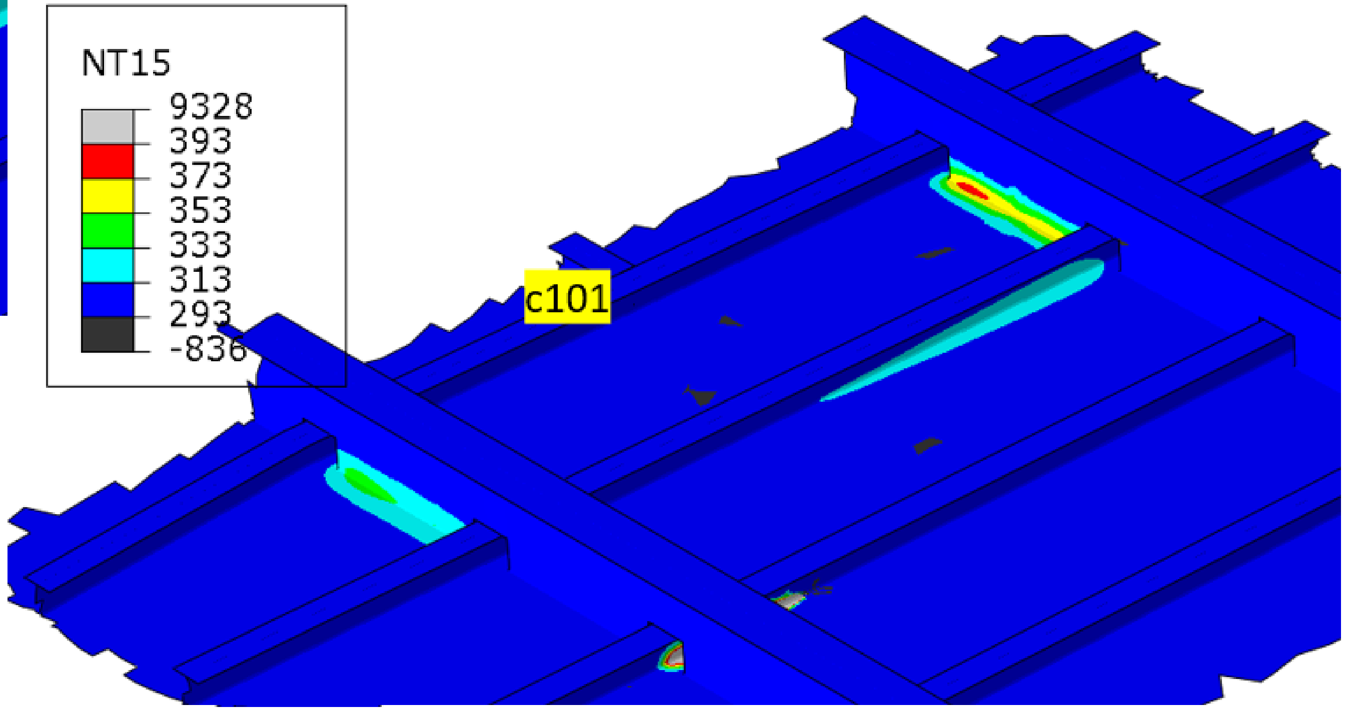
More large areas were selected to include residual temperature from previous welds



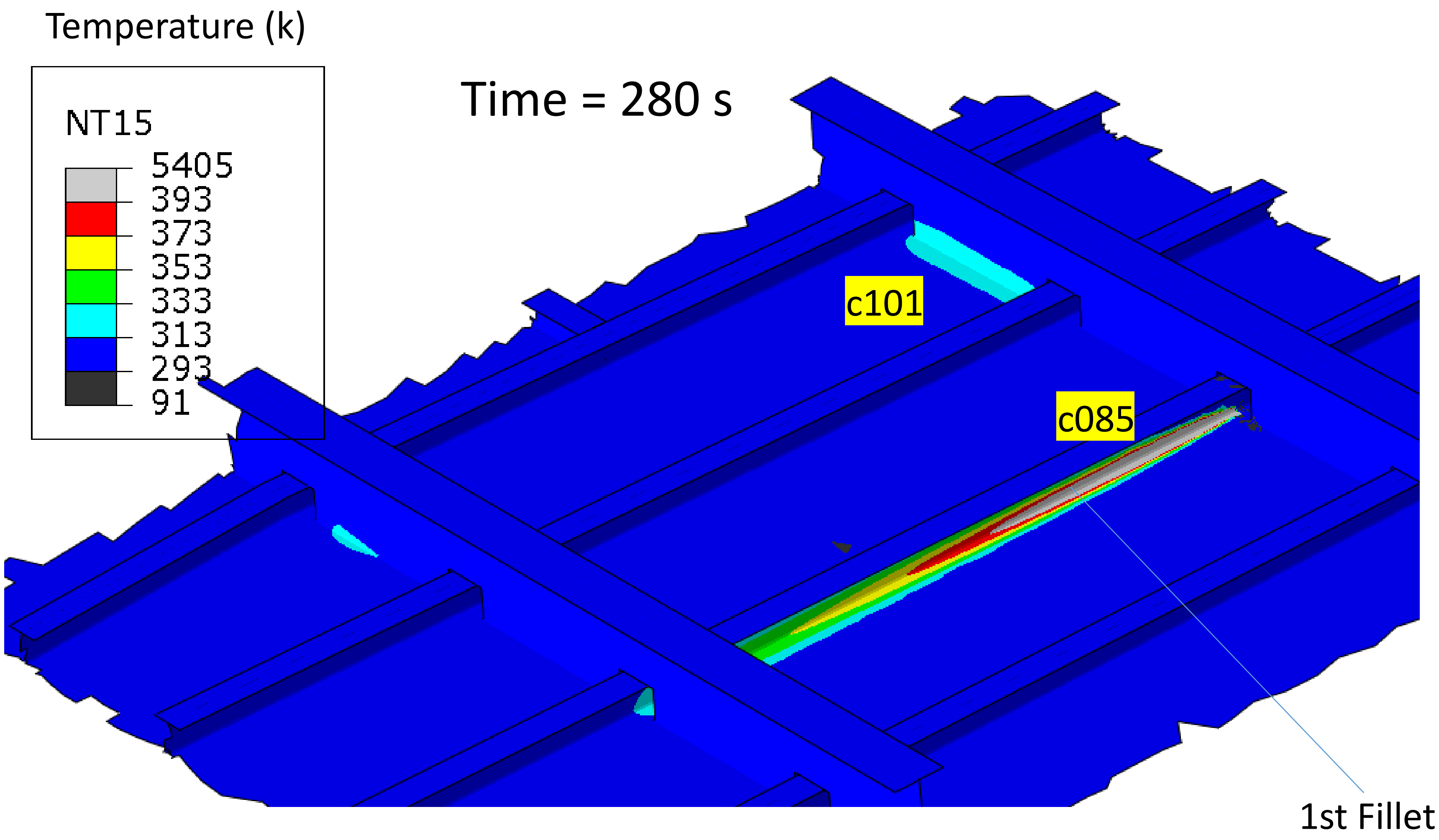
Cooling of Previous Welds

Temperature (k)

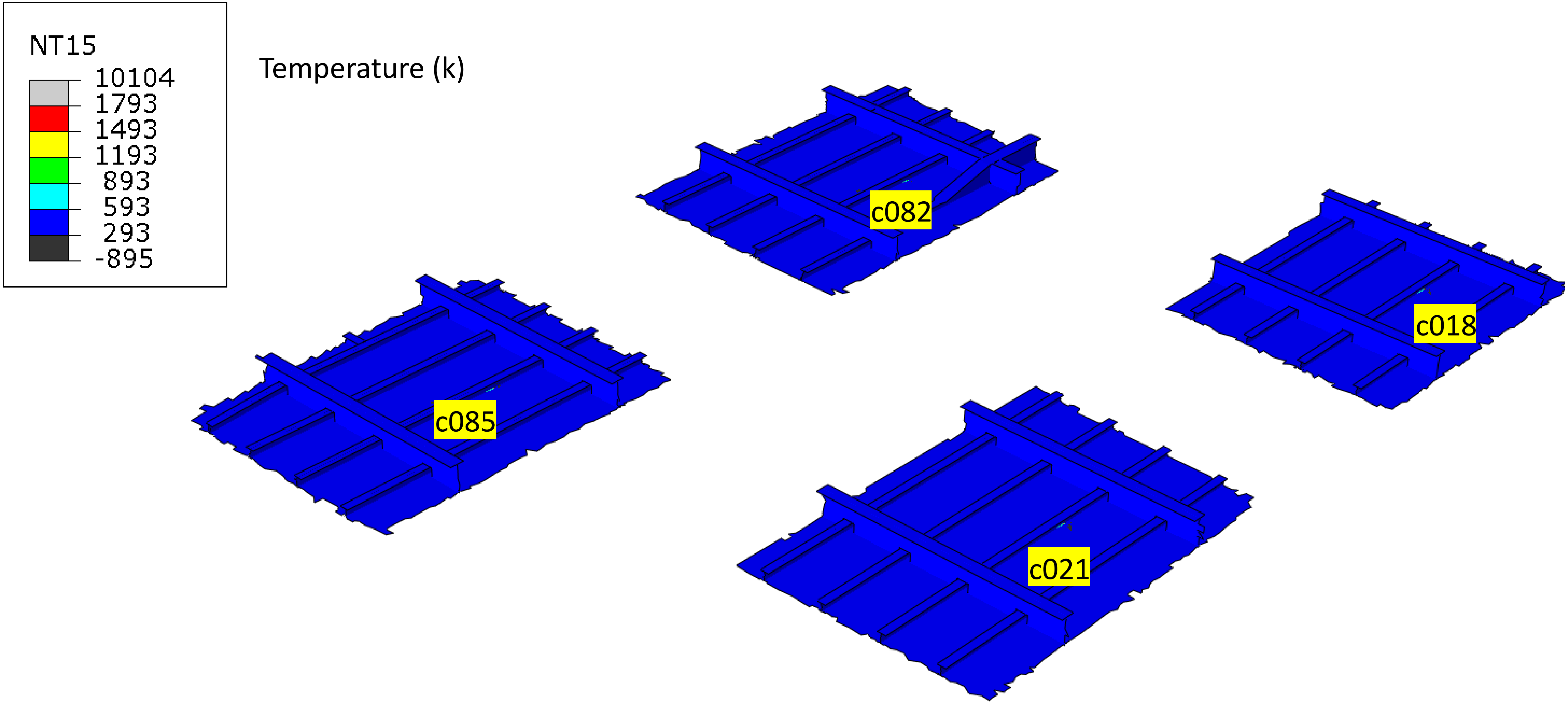




Previous welds cool to near room temperature after welding the first fillet of c082

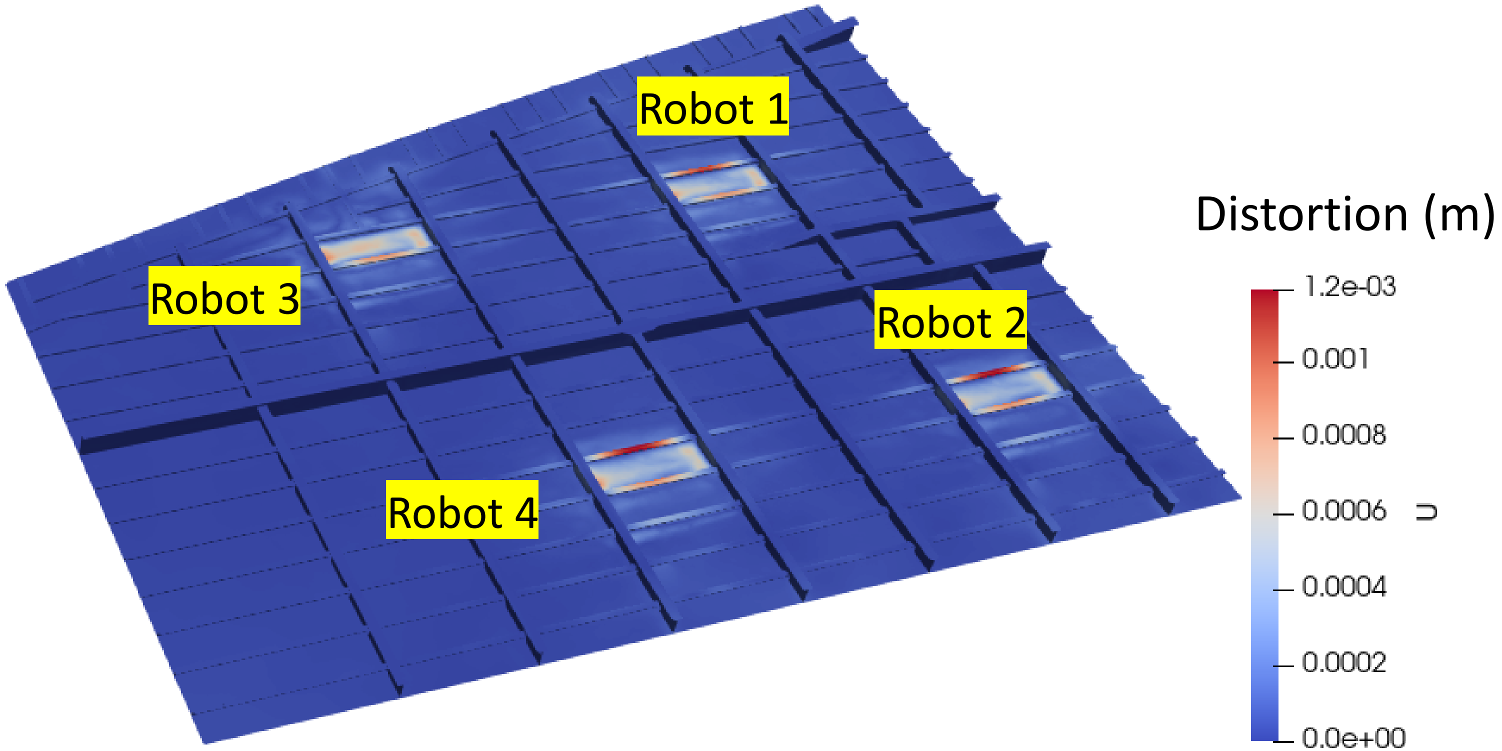


Temperature Animation:
Predicted Temperature for c082_c085_c018_c021



DR-Weld Analyze the Full Panel

- Refining the current version of DR-Weld (CPU version) to reduce memory requirement from 40GB to 20GB
- Reduced computational time from 100+ days to ~10 days (estimated)



DR-Weld Analyze the Full Panel

- To obtain another 10x speed-up or higher
  - Further optimize the algorithm to map nodal temperature input to integration points
    - Or pre-process the nodal temperature to integration temperature input prior to the start of the simulation
  - Convert it to GPU code

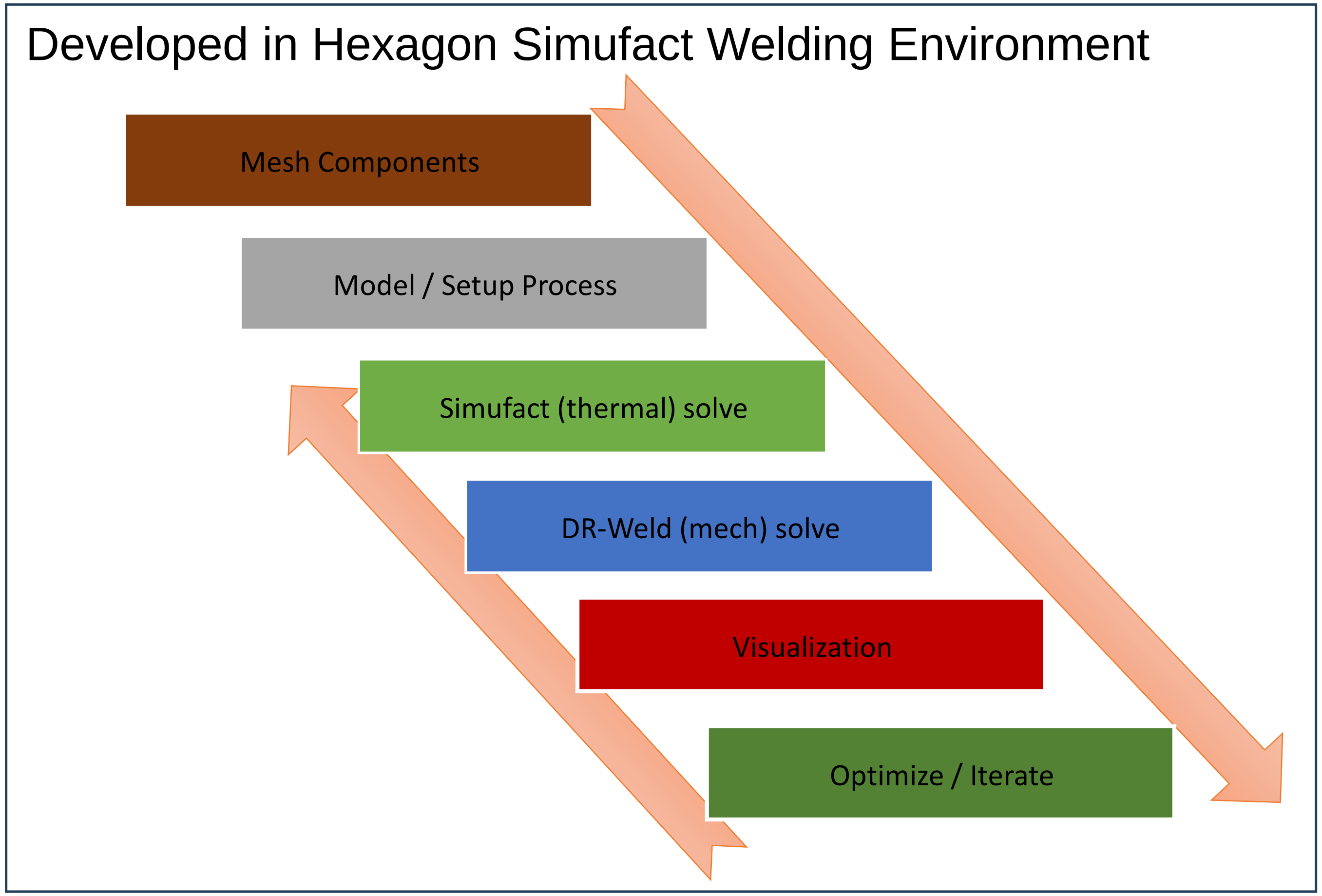
GUI Development

Desired Outcome

- Helps engineers solve the problem without spending time modeling
- Process is expedited by modeling automation
- Software interprets results and provides suggested improvements or iterates to a solution

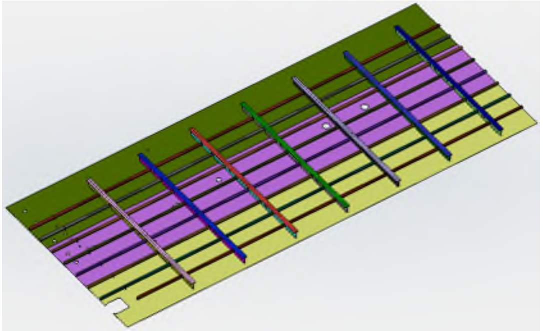
Measures of Effectiveness

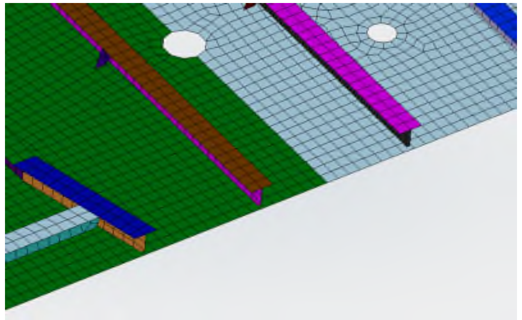
- Fast – need metric
- Easy to use
- Accessible to ME's
- One software installation

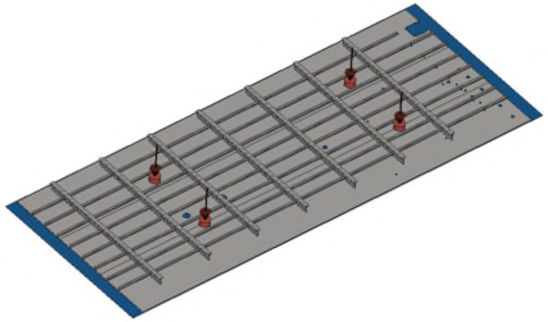


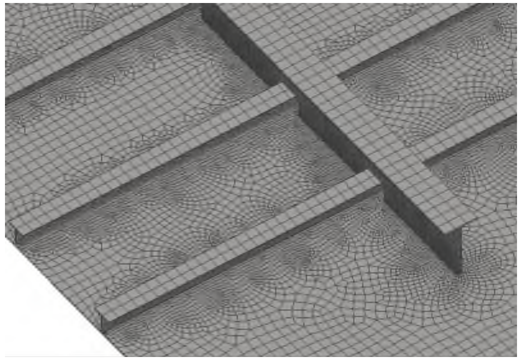
Workflow – Shipbuilding Subsection

CAD Cleanup → **Meshing (global)** → **Model Setup** → **Meshing (auto-refinement)**

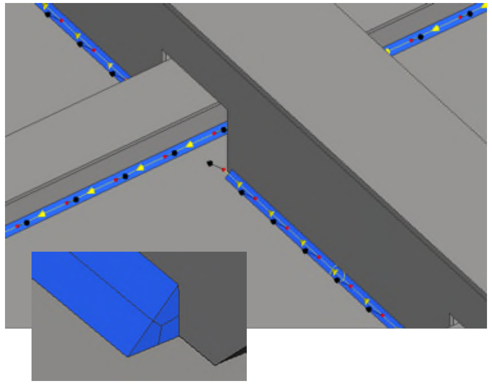


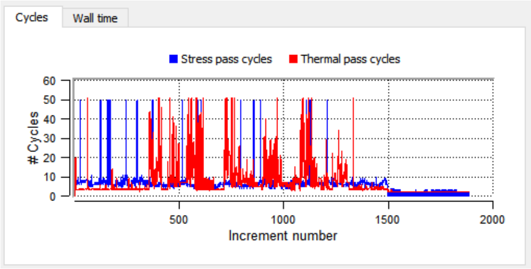


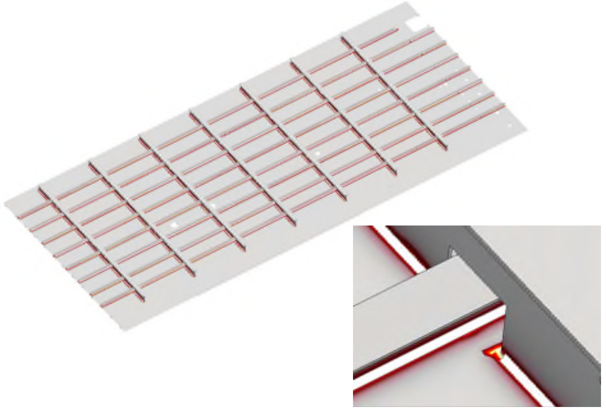




Bead Creation → **Solve** → **Post-Processing** → **Model Iterations**







Summary

- A fast solver for welding simulation is under development by leveraging ORNL code, DR-Weld
- DR-Weld is further developed for shipbuilding applications by adding shell elements
- A step-by-step approach was taken to develop the fast solver. DR-Weld is able to predict reasonable distortion trend and magnitude as measured in experiment and as predicted by Abaqus.
  - One-Tee Model
  - One-Cell Model
  - Multiple-Cell Model
  - Full Panel Model
- DR-Weld showed the ability to simulate a full panel with transient elastic-plastic analysis with a good accuracy and fast speed, which is impossible with other FEA software.

Thank you for your attention
This concludes the presentation

Questions?