Sustainment Panel Update

Kirsten Walkup, Panel Chair

General Dynamics-Bath Iron Works

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

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.

Mission – Updated Language

"The Sustainment Panel has the mission of reducing the cost of ship logistics and sustainment activities to include repair, maintenance and modernization while increasing operational availability for manned and unmanned vessels. Panel focus will be placed on advancing technologies, materials, processes and procedures that realize greater efficiencies in lifecycle sustainment. The Panel also includes researching and evaluating opportunities for implementation of digital tools, new technology, and processes to increase fleet readiness."

Focus – Updated Language

7.3.2.4 Explore opportunities to leverage artificial intelligence/machine learning (AI/ML), and emerging technology for shipyard planning, operations, and execution:

1. Promote and develop AI/ML tools bridging technology gaps between design, planning, execution, and budgeting activities
2. Demonstrate data sciences and analytical tools and resources to achieve optimal level of planning to include shipyard availability staff skill sets
3. Optimize shipyard operations and/or execution through identification of inefficiencies, waste, and risk
4. Rapidly evaluate collected data and ~~trend analysis~~ use predictive analytics to in turn develop actionable best practices, tools, and processes with the goal of decreasing the impact of unplanned events and improve planning capabilities
5. Identify and introduce technologies enhancing first-time quality for data-gathering and design processes informing availability execution
6. Promote integration of mobile and digital devices aimed at accelerating the execution of procedures by providing technical guidance at the point of need. Examples include mobile 3D work instructions, XR devices, wireless pier-side connectivity, instant communication technologies, and local tooling/material locators, etc.

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Focus Areas - Updated Language

7.3.2.5 Incorporate sustainment considerations in the design phase of ~~manned and unmanned~~ vessels and components to support ship maintenance and modernization of hull, mechanical, and electrical as well as mission system infrastructure:

1. Develop improved design tools to standardize shipbuilding design practices across shipyards that facilitate sustainment
2. Develop innovative methods to leverage the use of existing equipment and components in modernization design efforts to minimize cost and in-service availability time
3. Identify and pursue advanced materials ~~(composites)~~ and processes that reduce~~s~~ the burdens associated with cost and longevity
4. Improve accuracy of engineering and design products supporting ship modernization and upgrades
5. Evaluate existing commercial advanced technologies for application in shipbuilding, modernization and repair
6. Leverage advanced technology to assist remote personnel to accurately determine locations of potential interferences when designing for modernization and ship upgrades
7. Develop ~~mobile~~ pier side facilities and the enabling technologies to facilitate ~~unmanned~~ vessel~~s~~ repair and modernization
8. Increase efficiency by leveraging best practices and technologies against material waste and unnecessary duplication during the planning and execution phases

Focus Areas - Updated Language

7.3.2.6 Implement new inspection and maintenance processes to support minimal time in availabilities:

1. Incorporate emerging technologies to advance inspection, sustainment and improved reliability
2. Evaluate digital ~~support~~ tools and processes to reduce time in availability
3. Develop capability to automate detection, non-destructive inspection, and assessment of corrosion and delamination on vessels
4. Mature capabilities for problem identification and rapid repair of ~~critical~~ shipboard systems ~~such as propulsion and steering system components~~
5. Adapt comprehensive production planning systems to develop an integrated plan tailored to short duration availabilities
6. Perform qualification efforts for advanced technologies that will be more reliable and/or require less maintenance than legacy technologies
7. Develop extended reality (XR) capabilities that can enhance ship check and planning processes

Focus Areas - Updated Language

7.3.2.7 Explore, develop, and implement processes to address supply chain limitations:

1. Investigate alternative additive manufacturing technology and materials to mitigate issues with parts obsolescence and/or long lead times
2. Develop data analytic and predictive modeling methods that support early identification of potential supply chain issues
3. Utilize technology to address supply gaps in the execution of Quality Management Systems such as welding, Non-Destructive Testing, shock and vibration
4. Evaluate the available supply chain and the competing program demands
5. Develop training methods to improve literacy, fluency, interpretation of Navy standards such as standard items, ship specification, and General Specifications of Overhaul of Surface Ships (GSO)

6. Leverage advancing technologies such as AI/ML to identify alternative supply chain resources with the intent of relieving bottlenecks during execution

Sustainment Panel Projects

2024 Panel Projects

- Enhanced 3D Mapping & High-Bandwidth Mesh Radio Projects – Cleo Robotics
- Team Members: GD – Bath Iron Works

- Fire Protection Shipboard/Intumescent Coatings – Hepburn & Sons
- Team Members: Hepburn and Sons, Fincantieri Marinette Marine, STI, NSWC Carderock, Southwest Research Institute

- Body Cooling Technology Study – HII - Ingalls Shipbuilding
- Team Members: HII - Newport News, GD – Bath Iron Works

2025 Panel Projects

- Defect Characterization of Navy Ship Structures with Active UMI – Antech
- Team Members: Norfolk Naval Ship Yard

- Evaluation of Digital Twin Technologies for In-Situ Ballast Tank Inspection – Southwest Research Institute
- Team Members: HII – Ingalls Shipbuilding, HII – Newport News Shipbuilding, BAE - Jacksonville

Project Proposals, *Estimated* Timelines

FY26 Panel Projects

4/2025
- Solicitation Released

8/2025
- Whitepapers Due

9/2025
- Deadline for Panel Chairs to submit up to three White Papers and one joint White Paper to ATI

11/2025
- Panel Officer Presentations and ECB Selection

RA26 Projects

3/2025
- Solicitation Released

7/2025
- Summary Proposals Due

7/2025 - 8/2025
- Technical Evaluation

9/2025
- Virtual Presentations and ECB Selection

Building “Failure Data & Prediction Models” for Ship Construction & Sustainment Support

NSRP All-Panel Meeting
RA Project Presentation
February 25-27, 2025, Charleston, SC

Presenters:
Subrat Nanda; ABS
Mark Debbink; HII-Newport News Shipbuilding

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

ABS HII

Project Overview

- Prime/Lead:
  - American Bureau of Shipping (ABS
- Team Members:
  - Newport News Shipbuilding (HII-NNS)
  - Ingalls Shipbuilding (HII-Ingalls)
- Government Participants:
  - NAVSEA 05Z with NSWC Philadelphia & USCG Surface Forces Logistics Center
  - NOAA, MSC
- Duration
  - 18 months, 2 phases with go-no/go review
- NSRP RA Project 2024-01

Subrat Nanda; Chief Data Scientist
•Joined ABS in Jan 2018
•20+ years of Industrial AI experience
•Artificial Intelligence | Machine Learning | Prognostics & Health Management | Statistical & Risk Modelling | Digital Twins

OBJECTIVES:

- **Provide a failure data readiness/quality assessment and develop a roadmap for government fleet owner/operators and shipyards to:**

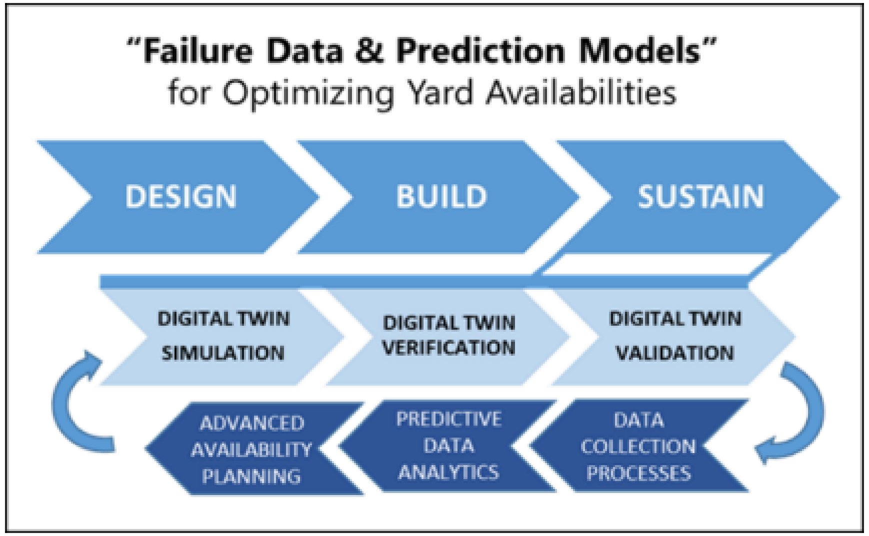
  (1) Optimization yard availabilities and

  (2) Provide feedback to follow-on vessels using advanced data analytics of available ship condition.

- **Lay the foundation for increased use of advanced data analytics that reduce:**

  (1) The cost and improve the predictability of scheduling for yard availability periods for ships and

  (2) The total cost of ownership of ships produced and sustained by yards, especially due to unrecognized vulnerabilities and material conditions that lead to failures.



HII ABS

Significant Benefits:
Reduce the cost and improve the predictability of scheduling for yard availability periods for ships, and eliminate recurring failures within a vessel class by addressing critical system issues during new construction of subsequent ships, providing major savings for government owner/operators and shipyards while also improving mission availability.

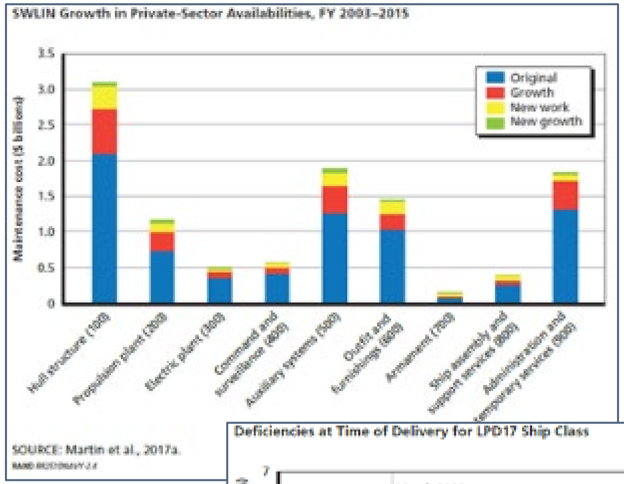
Benefit 1: Reduced Costs for Government Owner/Operators Tied to Unrecognized System/Equipment Conditions.

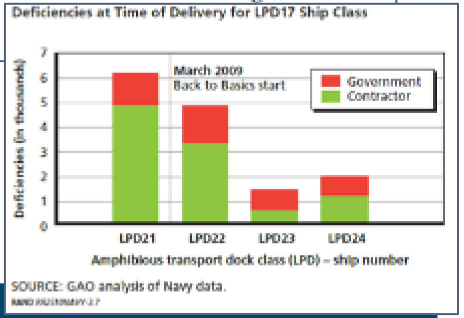
- Reduce Growth Work During Availabilities, and/or
- Reduce Subsequent Damage/Defect-initiated Availabilities.

Benefit 2: Value of Operational Days That Would Have Been Lost to Extended Availabilities Because of Unrecognized Conditions.

Benefit 3: Value to Shipyards from Improved Predictability of Yard Availabilities.

Benefit 4: Value to the Government Owner/Operators and/or Shipyards Generated by Mitigating Equipment/System Issues in Subsequent Ship Construction.

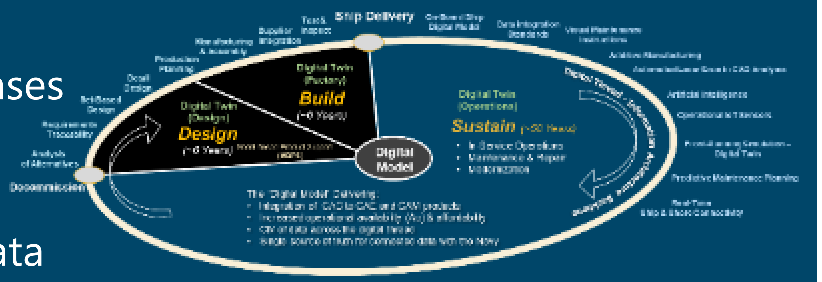




ROI:
Foundational steps for unlocking value of data analytics to improve ship construction and sustainment (>100x the cost of this project)

Deliverables:

Phase 1: D1 - Report on Failure Data Sources, Availability, Quality, & Potential Uses
Phase 1: D2 - Recommendations on Necessary Data Improvements
Phase 1: D3 – Representative Data Sets for Data Analytics Demonstration Cases



Go-No/Go review

Phase 2: D4 - Roadmap for Advanced Data Analytics of Failure/Condition Data
Phase 2: D5 - Example Application Demonstration Cases
Phase 2: D6 - ABS Industry Guidance Publication on Leveraging Data Analytics to Optimize Yard Availabilities and Improve New Ship Construction
Phase 2: D7 - Webinar(s) for Government & Industry on best practices
Phase 2: D8 - Final Report Documenting Research Process & Demonstration Results

ABS will summarize the research work in a new ABS guidance publication on ***Leveraging Data Analytics to Optimize Yard Availabilities and Improve New Ship Construction*** to help disseminate lessons learned through the project across government agencies and industry. Additionally, ABS will provide one or more webinars for government and industry on best practices identified. Finally, ABS will document the research project in an NSRP final report.

Project – Ship Type Data Selected for Evaluation

We selected the LPD 17 ship class because:

- We have access to all operational LPD 17 class ships through OARS, anything operational last 9 years
- We have access to any system test failures from factory-acceptance through delivery, since we have the construction contract
- Because we have the maintenance contract, we also have knowledge and data on repairs while ships in operation come in for MRO
- Since the ship class has a history and continues to be built, we would theoretically have access to failure data at all ages of ship hulls

Accessing Data

Open Architectural Retrieval System - OARS – maintained by NAVSEA logistics center

- All fleet data from all hulls go into that Database.

DCACA Program (Old Term) Data collection, analysis, and corrective actions

FRACAS (New Term) = Failure reporting analysis and corrective actions

- ❑ Each ship class has their own list of what are the mission-critical systems to track, per ship specification
- ❑ We track by Part number. Systems could have multiple parts.

OARS – Data Structure

Program Class	Period of Failure Tracking	Equipment & Failures Track	Failure Type	Report forms	Solution
Any Naval Ship	Latest 9 years, from delivery to operation	EVERYTHING	EVERYTHING	Database	(we just run query and it produces result)

OARS – Ship Programs & Data (Ingalls)

Program Class	**Period of Failure Tracking**	**Equipment & Failures Track**	**Failure Type**	**Report forms**	**Solution**
DDG-51 (all hulls DDG 113 and follow)	Factory Testing (prior to receipt) thru Build thru Sale to Navy + 1yr	Mission essential Equipment: Gen, engine, A/C plant, fire pumps, etc.	Equipment fail test. Not accidents.	SDRL, NCR. AWR (post delivery).	PC returns to vendor (repair) or rebuy. RTS, TMR, ship out, Return-PO.
LHA (all hulls)	Factory Testing (prior to receipt) thru Build thru Sale to Navy	Mission essential Equipment: Gen, engine, A/C plant, fire pumps, etc.	Equipment fail test. Not accidents.	SDRL, NCR.	PC returns to vendor (repair) or rebuy. RTS, TMR, ship out, Return-PO.
LPD (all hulls)	Factory Testing (prior to receipt) thru Build thru Sale to Navy	Mission essential Equipment: Gen, engine, A/C plant, fire pumps, etc.	Equipment fail test. Not accidents.	SDRL, NCR.	PC returns to vendor (repair) or rebuy. RTS, TMR, ship out, Return-PO.
Coast Guard Cutters	Not Required	Not Required	N/A	N/A	N/A

The ABS Condition-Based Program

RAW DATA

Maintenance records, sensor readings, and performance metrics

DATA DRIVEN INSIGHTS

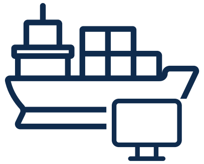
Advanced analytics on asset health, reliability, and predict potential failures

DIGITALLY CONNECTED

Maintenance teams and ABS are connected

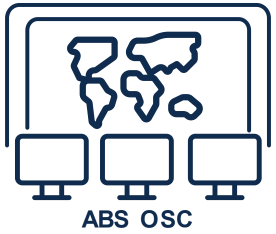
MAINTENANCE OPTIMIZATION

Proactive Maintenance & Spares Optimization

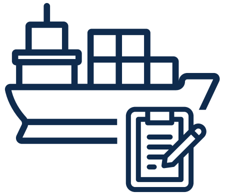


Drydock Maintenance Planning

CLASS AND REGULATORY VERIFICATION



Remote digital verification via ABS Operations Support Center

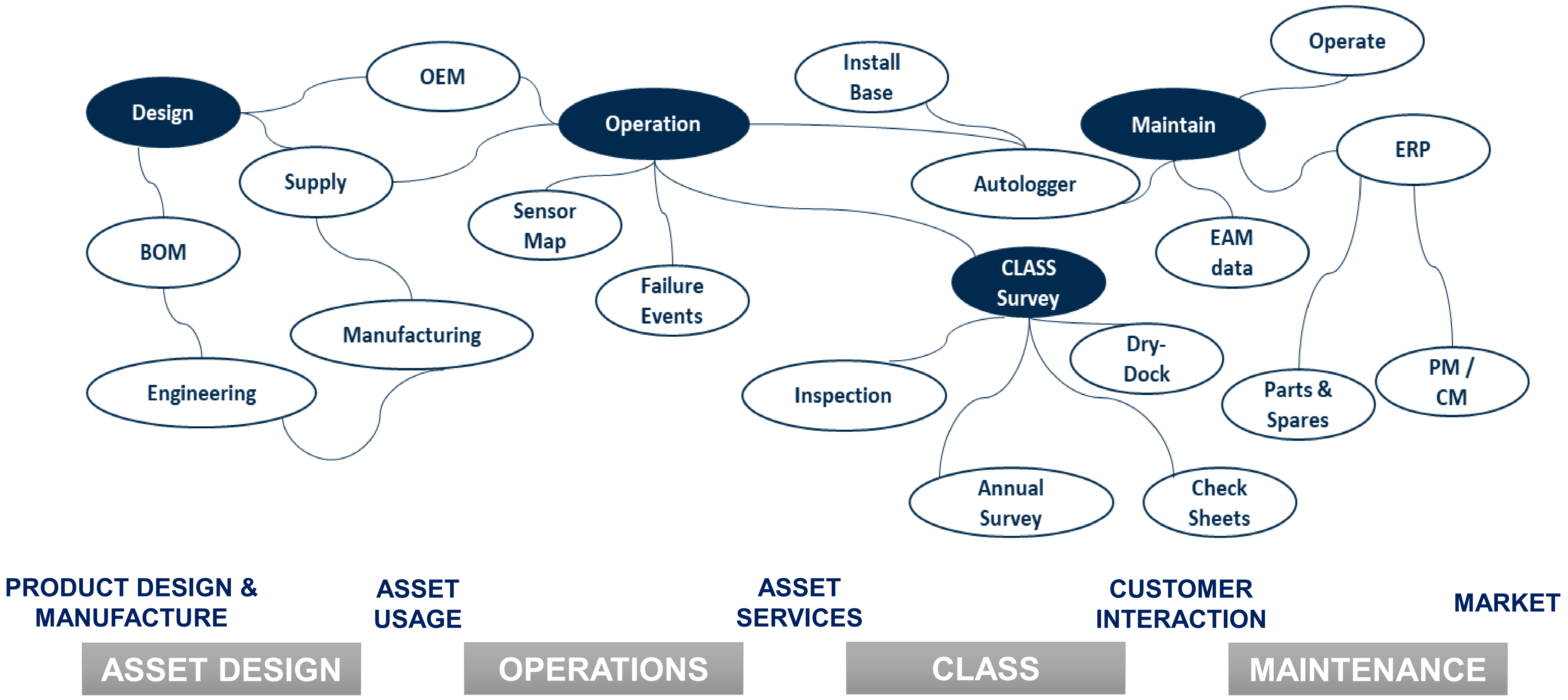


Streamlined Survey Planning Document with reduced onboard verification time

ABS Objectives

1. ***Leverage insights for Class credit***
2. ***Minimize and optimize onboard Survey scope***
3. ***Enhance the customer experience & ease of Class***

Data or *'Data Hairball'?*



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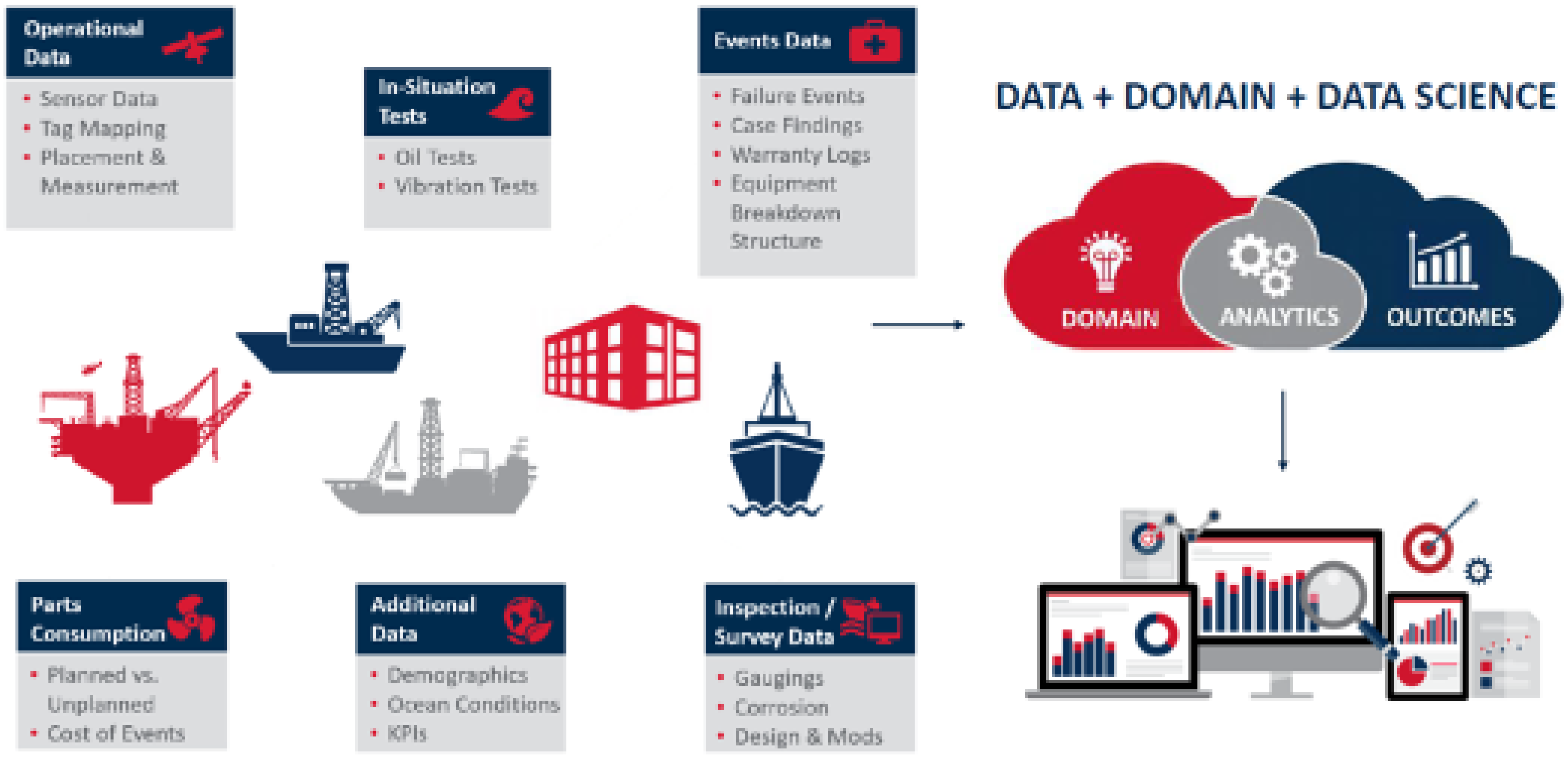
Data...what?


Operational Data
Sensor Data
Tag Mapping
Placement & Measurement
In-Situation Tests
Oil Tests
Vibration Tests
Events Data
Failure Events
Case Findings
Warranty Logs
Equipment Breakdown Structure
DATA + DOMAIN + DATA SCIENCE
DOMAIN
ANALYTICS
OUTCOMES
Parts Consumption
Planned vs. Unplanned
Cost of Events
Additional Data
Demographics
Ocean Conditions
KPIs
Inspection / Survey Data
Gaugings
Corrosion
Design & Mods

What Does AI Based Machinery Analytics Give Me?

Anomaly Detection

Insights to make data-driven operational & maintenance decisions (active and pro-active)

- Detect incipient issues (prior to potential failure) -> reduce unplanned failures
- Identify target areas for closer monitoring
- Augment upcoming planned maintenance -> condition based
- Plan for corrective action (when failures confirmed) -> flexibility

Disposition

- Provide most likely / actionable i/p
- Continuous program improvement
- Identify additional components or failure modes

RAMS

Insights for Planning & Optimization

- understanding system reliability & trends
- identify bad actors and/or systemic FMs
- detect emergent reliability related risks
- perform vessel to vessel benchmarking
- Insights for ABS surveyors: inputs to PCM; targeted & focused
- identify data quality issues
- Additionally, potential insights using CMMS data:
- parts and spares
- maintenance cycles
- vessel operations

Salient Features

- 1. Data-driven tools to augment customer’s decision making
- 2. Insights to assist with planning, maintenance scoping and operational inputs
- 3. Customer-ABS current processes undergo ***no*** change…only data-driven insights to support decision making
- 4. Perform continuous improvement in algorithms and data quality processes

Reliability & Availability Risk Analysis

Operational RAM enhancement

Quantify operational RAM risks

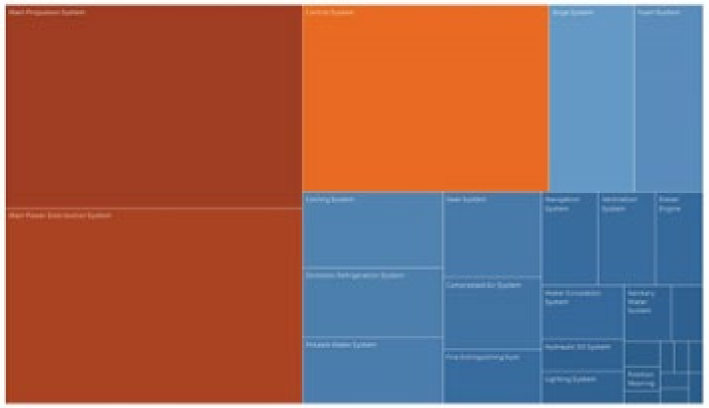
- Benchmark current reliability of major sub-systems.
- Identify emergent reliability risks
- Provide reliability trends over time
- Quantify the relative risk in reliability amongst multiple maintenance facilities

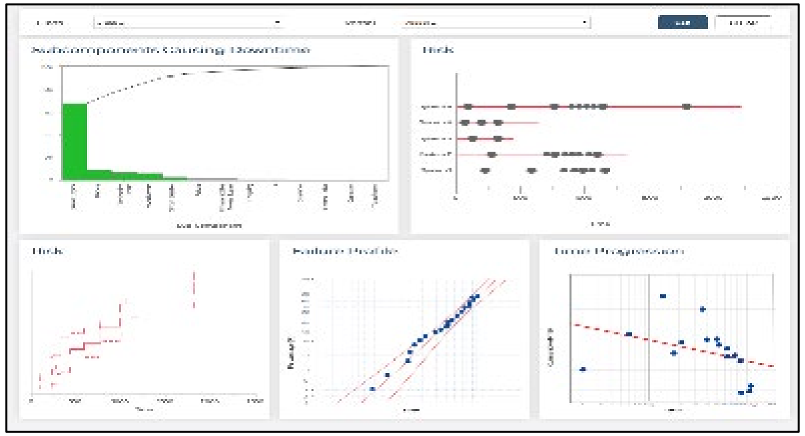
Quantify Asset to component level risks

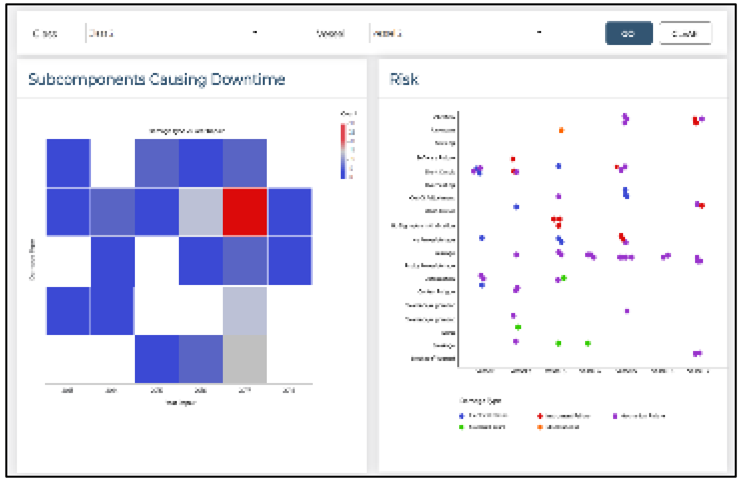
- Statistical & Risk models to benchmark baseline reliability risks
- Fleet wide risk assessment
- System to Component level models

People or Process or Product ?

- Identify main factors causing RAM risk
- Data improvement







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Sensor Based Anomaly Detection

Detecting anomalous signatures for proactive maintenance planning

Performance Analysis

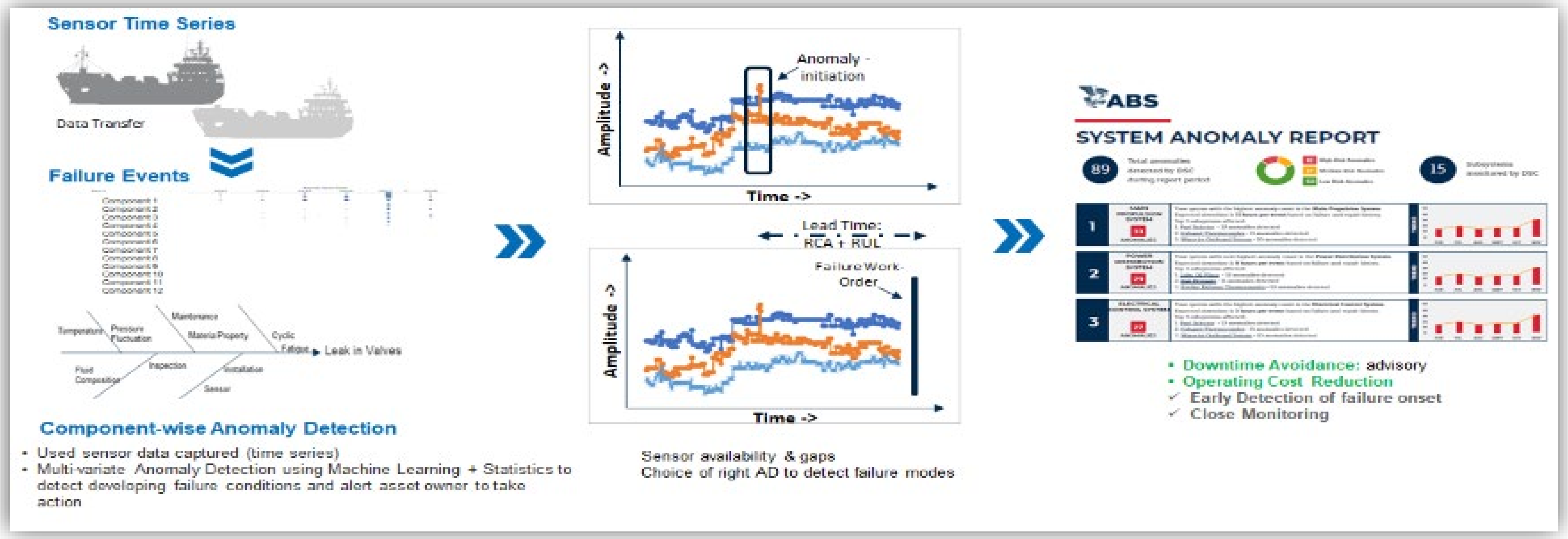
- Detailed analysis of an asset’s or fleet of assets machinery performance

Collect additional data

- Fusion of sensor, survey and customer data
- Signature analysis and pattern mining

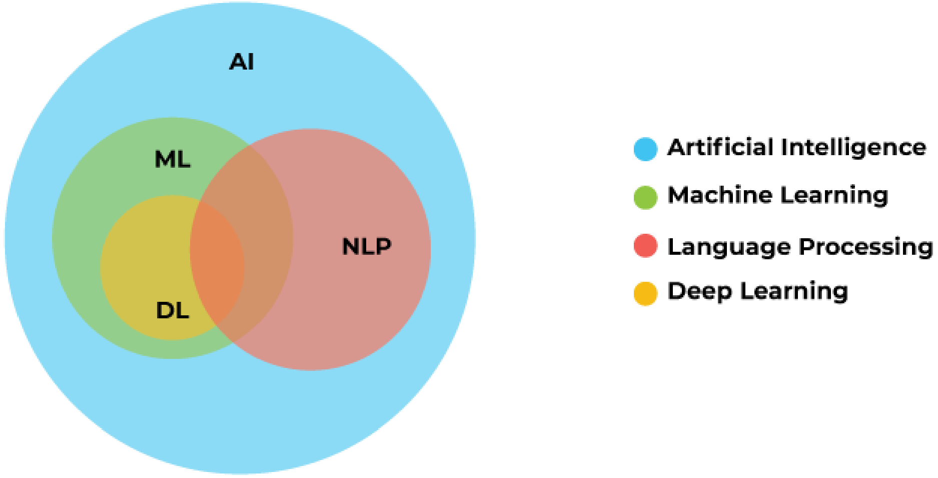
Identify, monitor and predict anomalies

- Reoccurring reports and alerts of identified anomalies



NLP Overview and Objectives

- NLP (Natural Language Processing) is a field of artificial intelligence which enables computers to understand, interpret and generate language.
- Some common tasks:
  - Text Classification
  - Machine Translation
  - Named Entity Recognition
  - Summarization
- Objectives:
  - Ingest and prep. the data
  - Determine processes by which key data will be extracted from text
  - Explore data-driven insights into common failure modes for machinery
  - Provide solutions and next steps for to reduce downtime and improve reliability



ML	DL
Simple (regression, tree based)	Complex (neural net, transformer)
Interpretable	Black box
More preprocessing	More contextual understanding

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Training Data

Where is our data coming from?

- The training data comes from multiple sources that have been labeled by an SME
- Supplemented with a few thousand rows of LPD-17 data

Which columns are we looking at when it comes to model training?

- We're focused on the text columns; columns which SME uses for classification task

What systems are we looking at?

- Main propulsion diesel engine
- Ship service diesel generator
- Main reduction gears
- Seawater cooling system
- Freshwater cooling system
- Fuel oil system

84%

Job Summary	Description	Solution
1B MPDE LOP FASTENERS	DURING NORMAL OPERATION, (SHIP DATA REMOVED from PRESENTATION)	S/F RECOMMENDS (REMOVED)
JW EXP. TNK TLI OOC	DURING ROUTINE MAINTENANCE, SHIP DATA REMOVED from PRESENTATION)	SHIP'S FORCE WILL (REMOVED)

HII ABS

Process: Normalization and Feature Engineering

Normalization:
- Misspellings
- Abbreviations/entity linking
  - ooc -> out of compliance
  - xfrmr -> transformer
  - ER04 -> engine room #4
- Spaces/NoSpaces
  - Mpdecrankcase -> mpde crankcase

Feature Engineering:
- How can we make features as meaningful as possible?

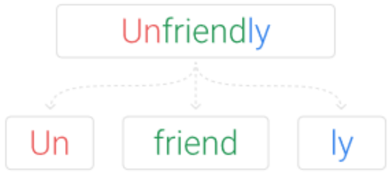
Job Summary	Description	Solution
1B MPDE LUBE OIL FASTENERS	DURING NORMAL OPERATION, (SHIP DATA REMOVED from PRESENTATION)	S/F RECOMMENDS (REMOVED
JACKET WATER EXPANSION TANK TANK LEVEL INDICATOR	DURING ROUTINE MAINTENANCE, (SHIP DATA REMOVED from PRESENTATION)	SHIP'S FORCE WILL (REMOVED

NAVSEA S6430-AE-TED-010

NAVSEA HANDBOOK S9233-DL-HBK-010

$\left.\begin{matrix}\\ \\ \end{matrix}\right\}$ Technical Document

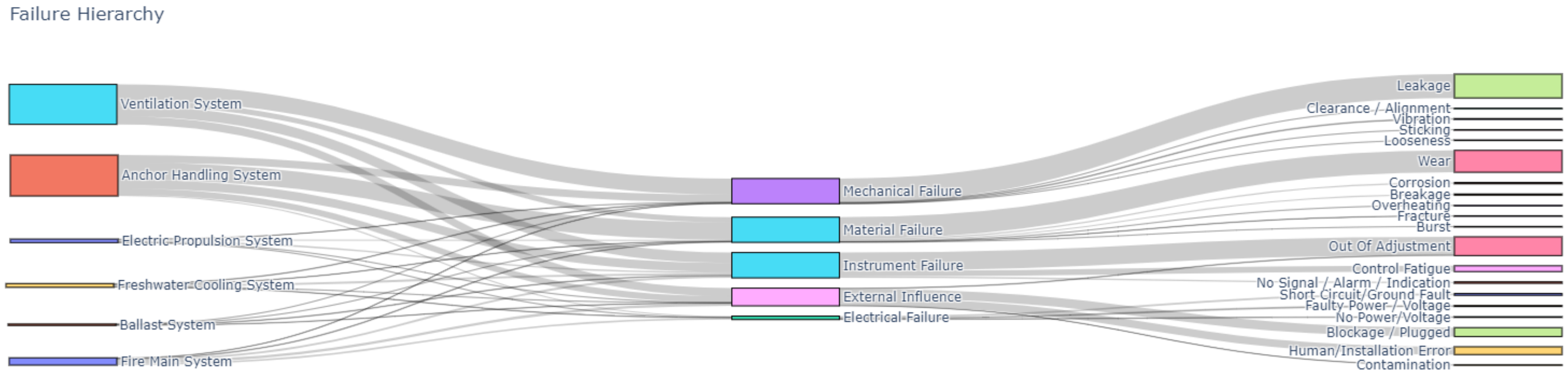
Process: Modeling and Output



Final Data Prep:
- Lemmatize/Tokenize/Vectorize/Encode

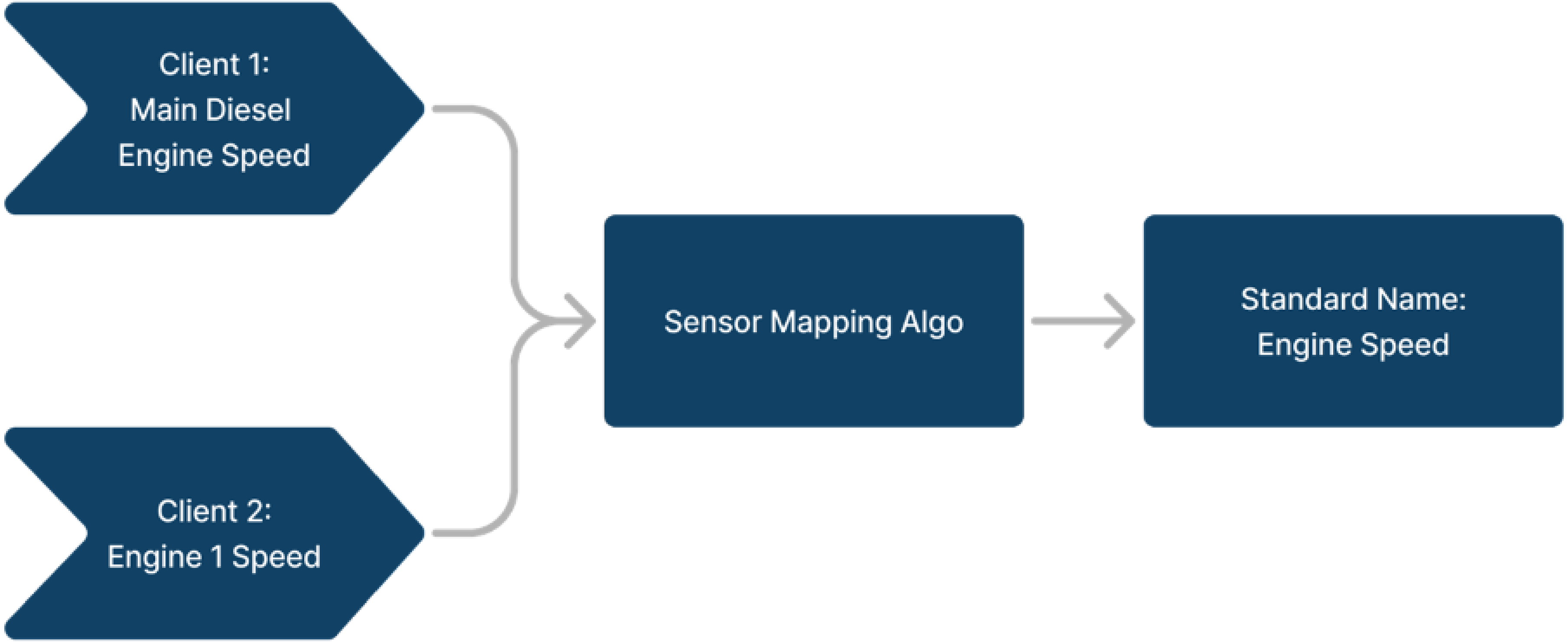
Modeling:
- Use a combination of regression, tree-based models, neural network and transformer models
  - Dependent on task and performance
  - Pipelines developed for end-to-end process

Output:
- Classification
- Visualizations
  - Cyclical patterns
  - Trends over time
  - Correlation
  - Outliers
  - Inter-fleet comparison
- Recommendations



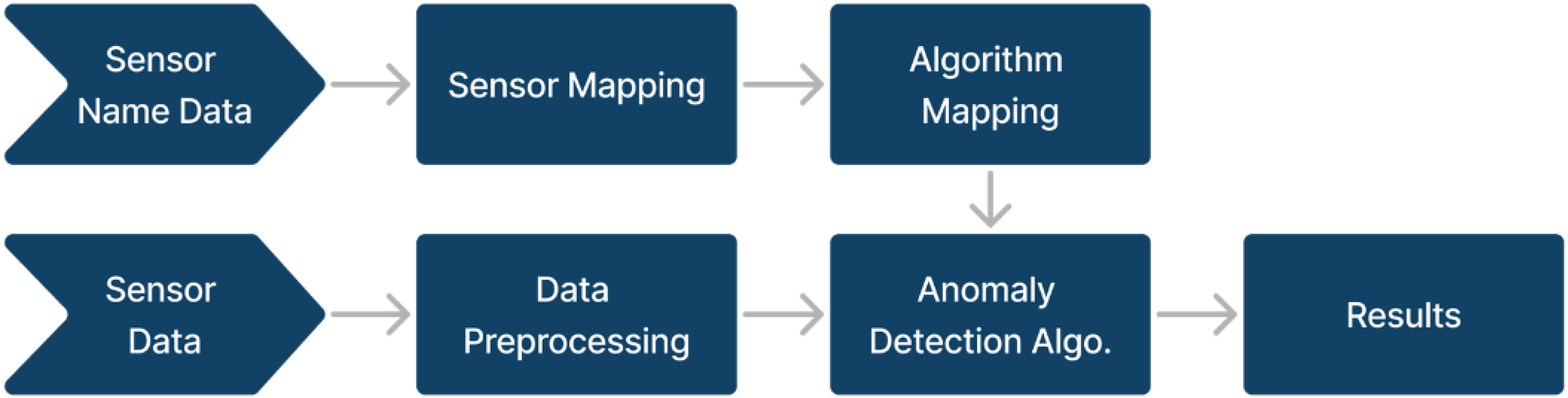
Sensor Mapping

Purpose: Mapping different sensor names to a single system



Sensor Mapping in the Pipeline

- Important process for using our Anomaly Detection algorithms
- Pulls the correct sensor data to use in algos



Preparation for Data Driven Decision Making

01 Getting Started

- Brainstorm Focus Areas
- Data collected & installed base
- Focus Area to Data Collection and VV

02 Pre-Processing

- Data Quality
- Start over the ‘Y’
- RAMS
- Reliability, Sensors, Machinery

03 Milestone & Data Gaps

- Findings
- Data Gaps
- Collection Plan

04 Dependence on Technology

- Iterative & Continuous Upgrades

05 Resistance to Change

- Cultural Barriers
- Change Management

06 Regulatory and Compliance

- Documentation and Reporting

Key Lessons Learned

AI-based CBM is for YOUR assistance only!

What will I do and get?
Why should I trust?

DATA ACQUISITION
- Resolution
- Connectivity

DATA QUALITY
- Fleet Variation
- Instrumentation
- Context-based

CHOICE OF AI METHOD
- Data Types
- Bias VS Variance
- Complexity
- Maintainability
- Explainability – trust!

CBM PLATFORM CHOICE
- Orchestration
- Consumption
- HMI and UX for PHM

CBM ADOPTION
- User Training
- Shelf-life of an analytic
- Drive Credibility
- Fatigue
- Feedback

Summary:

We will enable the ability to unlock the power of failure/condition data sets through advanced analytics, including tools such as Artificial Intelligence (AI) and Machine Learning (ML) as well as more traditional reliability engineering techniques, by

(1) alignment of the many stakeholders engaged in the availability planning / execution process,

(2) Providing the critical technical insights to identify and address early failures for planned and scheduled corrective action, and

(3) providing a feedback loop to eliminate vulnerabilities during construction of subsequent ships in a vessel class.

We will provide a failure data readiness/quality assessment tool to improve ship availability work identification process and accurately schedule to reduce unscheduled work and time-at-dock.

Body Cooling Technology Study for Shipyard Worker Safety and Performance

Final Project Report 02/25/2025

Karen Cassidy, HII – Ingalls Shipbuilding

Body Cooling Technology Study - Outline

- Planning and Testing
  - Team, Objectives, Key Tasks and Deliverables
  - Stakeholder Analysis Process, KPIs, 3 Work Scenarios
  - Market Survey, Garment Selection and Purchasing
  - Test Plan Development, Activities and Schedule
- Data Analysis and Interpretation
  - Data Preprocessing and Data Analysis Methods (optional)
  - Test Results and Feedback from the Volunteers
  - Observations and Interpretation of Results
  - Implementation Plan

<u>Multi-SY Team:</u>
HII Ingalls Shipbuilding
HII Newport News SB
Bath Ironworks
Pearl Harbor Naval SY
ATI & NSRP reps

Team, Objectives, Key Tasks and Deliverables

- Prime/Lead
  - HII – Ingalls Shipbuilding
- Team Members
  - HII – Newport News Shipbuilding
  - Bath Iron Works
  - Pearl Harbor Naval Shipyard (unfunded participant)
- Objective
  - Explore commercially available and high TRL developmental body cooling technologies, for improved safety and performance of shipyard workers
- Duration
  - 12 Months (2/2024-2/2025)
- Key Tasks
  - Select test garments based on cooling technologies and methods
  - Pilot test several options and assess key parameters for heat relief, comfort, ergonomics, and health safety
  - Draft potential implementation plans and costs
  - Assess financial feasibility to make body cooling widely available to shipbuilders
- Deliverables
  - Stakeholder analysis, with KPIs
  - Market survey of available products
  - Test plan for pilot demonstration
  - Test results
  - Implementation plan
  - Final report

Stakeholder Analysis Process & KPIs

- Study performed:
  - Interviewed 28 participants from 4 shipyards: Newport News, Ingalls, Bath Ironworks, Pearl Harbor NSY
  - Half were shipyard workers from Operations and Maintenance teams; half were shipyard experts from Environmental Health & Safety, Human Resources, Research & Development, and Labor Relations

- Key Performance Indicators (KPIs):
  - Fire-retardant/flame-resistant – approved for hot work
  - Not bulky, i.e. not prohibiting or restricting movement
  - Not producing water from room-air condensation
  - Worn over clothing vs. worn under jumpsuit; tethered vs. free-moving
  - Cooling method and technology (convection, evaporation, phase change, etc.)
  - Material phase-change temperature (for PCM, water/ice, etc.)
  - Made/manufactured/shipped from a U.S. company
  - Durability, longevity, maintainability, affordability and ownership

<u>Question Categories</u>

- Part 1: Environmental Health & Safety
- Part 2: Operational Conditions
- Part 3: Prior or Anticipated Use of Cooling Garments

- Some common features would be evaluated for each of the body cooling garments tested

Three Test Scenarios for this Study

Scenario 1:

- **Cooling garments are worn under a jumpsuit**
- Needed for stationary work; worker can be tethered to compressed air source
- Example of worker:
  - Paint Blasters
  - Grinders

Scenario 2:

- **Cooling garments are worn under worker PPE**
- Needed for active, full mobility work
- Example of worker:
  - Firefighters
  - Hazmat Teams
  - Welders

Scenario 3:

- **Cooling garments need to be lightweight, affordable, and provide SPF coverage**
- Needed for full mobility work in small spaces
- Example of worker:
  - Machinery
  - Electrical
  - Piping

Garments Selected by Underlying Technology

Phase Change Materials (PCM)

Materials that store thermal energy. When they absorb heat, they melt (solid to liquid) and must be recharged (frozen) to be used again.

- WATER/ICE changes phase at 32 deg F; easy to access but uncomfortably cold on skin surface
- PCM used in cooling vests melts at 65 deg F; more comfortable and takes longer to melt

CONDUCTION – PHASE CHANGE

Forced Air Cooling

Forced air flow picks up moisture and cools the skin

- TDA cooling shirts have a battery-operated fan attached to the hip which blows air through channels in the shirt and out to environment
- ALLEGRO vests use compressed air (supplied by shop air) plus a vortex tube attachment, which separates warm/cool air then cool air blows through the vest

CONVECTION – VORTICITY

Wet Cooling Materials

AKA "Hydro Active" technology for wet cooling. The garments are wetted prior to wearing, which accelerates natural evaporation (due to exposure to the human body) to cool down the body.

EVAPORATION – PHASE CHANGE

Dry Cooling Materials

AKA "Vapor Active" technology for dry cooling features. The material wicks away sweat off the skin, dispersing out the moisture over a greater surface area so it evaporates faster. User feels cool and dry.

EVAPORATION – WICKING

Test Garments for 3 Scenarios

Technology Legend

PCM
Hydro (wet)
Forced Air
Vapor (wick)

Testing Scenario 1

8450 Low Profile Vortex Cooling Vest (forced air)

8300 Vortex Cooling Vest (forced air)

Full Mask Vortex Cooling Respirator (forced air)

Testing Scenario 2

HyperKewl Hydro-Active Orange Vest

TDA Prototype Cooling Shirt (with Fan)

GlacierTek PCM Cool Vest

Baseline against TechNiche Vests

Testing Scenario 3

Mission Hydro-Active Safety Shirt

Mission Hydro-Active Helmet Liner

Tech Niche Hydro-Active Helmet Liner

Tech Niche Hydro-Active Neck Shade

Mission Hydro-Active Bandana

Ergodyne UV Dry Wicking Long Sleeve

Arctic Cool Wicking White Shirt

Mission Vapor-Active Beanie

Hydro-Active Wet Feel vs. Vapor-Active / Wicking Dry Feel

Test Plan Development

- Garments were purchased in order of speed-to-acquire
  - This became S3 then S2 then S1
- Project team members identified volunteers for testing; provided them with a garment and a questionnaire
- Most tests ran an average of 7 days, with some at 1-day and some 21+ days
  - Two exceptions: 3-months (3.4 Bandana) and 4-months (3.7 Mission safety shirt)
  - Total 1800 man-days tested plus these 2
- Some volunteers tested multiple garments in series (not together)

NSRP
National Shipbuilding Research Program

Questionnaire for Body Cooling Garment Testing

Please think about these questions while you are testing the products. This questionnaire will be filled out and collected when you are done testing. If you have any questions or need to drop off the questionnaire please contact Paulina Phillips. (228) 935-6876

Demographics

1 What is your Name:
2 What is your Department:
3 What is the Body Cooling Garment you are testing?
4 Date(s):
5 Shifts Tested (AM, PM, Both)
6 What kind of work do you do?
7 What is the shipyard location of where you'll be testing?
8 Is that indoors, outdoors, in an open building, in the sun or shade, or onboard a ship
9 Was your work environment cooler, the same, or hotter than ambient outdoor air?
10 How long did you wear this garment? *(Total days and hours per day)*

Assessment

(For scale, 1 is very negative, 2 somewhat negative, 3 neutral, 4 somewhat satisfied, 5 very satisfied)

11	Did the garment condensate / collect moisture?	*Yes or No*
12	Did you feel wet while wearing the garment?	*Yes or No*
13	Did this product fit well into your work attire requirements?	*Yes or No*
14	Did the garment keep you cool for a full work shift?	*Scale 1-5*
15	Did the garment interfere with your ability to perform your work?	*Scale 1-5*
16	Did this make an improvement in your work day comfort?	*Scale 1-5*
17	Do you think the garment would fit multiple body types?	*Scale 1-5*
18	Were you satisfied with the cooling effectiveness if this garment?	*Scale 1-5*
19	Do you think the garment enhances your personal safety?	*Scale 1-5*
20	Do you think the garment enhances your job productivity?	*Scale 1-5*
21	Was the garment fast and easy to put on and remove?	*Scale 1-5*
22	If this was readily available, would you use this garment?	*Scale 1-5*
23	Do you have any general feedback or comments? Please describe below. Thank you!	

Test/Activity Timeline 2024-25 (Actual) and Temps

MAR-APR 24 | MAY | JUN | JUL | AUG | SEP | OCT | NOV-DEC | JAN-FEB 25

Stakeholder Analysis

Market Survey

Develop Test Plan

Order Garments

Test Scenario 3 (6/20-8/16)

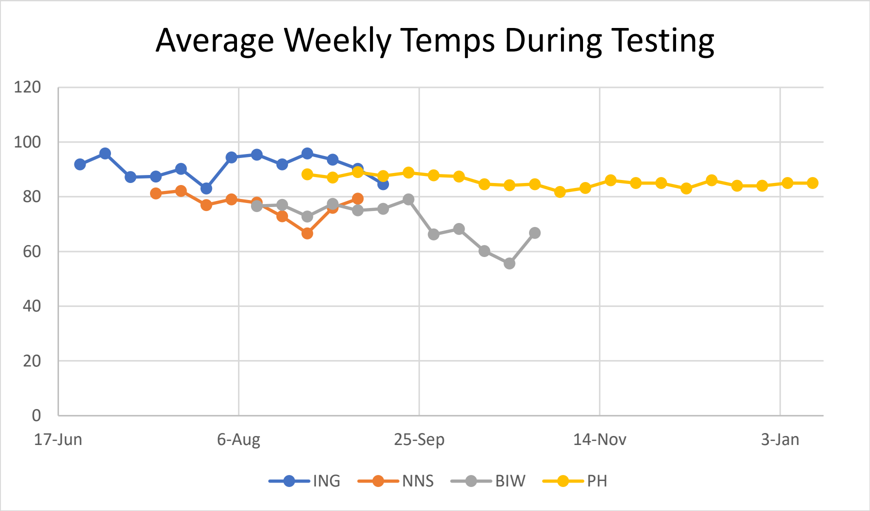
Test Scenario 2 (7/22 – 9/5)

Test Scenario 1 (9/4 to 1/10)

Data Analysis

Implementation Plan

Test Report and Final Report



Body Cooling Technology Study - Outline

- Planning and Testing
  - Problem Statement, Objectives
  - Stakeholder Analysis, Work Scenarios and KPIs
  - Market Survey, Garment Purchasing
  - Test Plan Development, Activities and Schedule
- Data Analysis and Interpretation
  - Data Processing and Data Analysis Methods (optional)
  - Test Results and Feedback from the Volunteers
  - Observations and Interpretation of Results
  - Implementation Plan

S	Test Article Number/name	Tests
1	1.1 Allegro 8300 vest	12
	1.2 Allegro 8450 low profile vest	14
	1.3 Allegro 9902 Respirator	0
2	2.1 TDA black shirt	10
	2.2 GlacierTech PCM Vest	20
	2.3 TN/HK Orange Evap Vest	11
	2.4 TN/HK Blue Ice Vest	6
3	3.1 TN/HK Beanie /Helmet Liner	13
	3.2 Mission Beanie/Skullcap (VA)	25
	3.3 Mission Beanie/Helmet Liner (HA)	21
	3.4 Mission Bandana	26
	3.5 TN/HK Neck Shade FR	22
	3.6 Ergodyne LS Sun Shirt	21
	3.7 Mission Safety Shirt (HA) yellow	27
	3.8 Mission Perform Shirt (VA) Red	6
	3.9 Arctic Cool Wicking Shirt White	12
	Sum Total Samples	257

Data Processing and Data Analysis Methods

- Results from Questionnaires were digitized; score 1 low, 5 high
  - All results concatenated into array; one data sheet per column
- Comments addressed separately, summarized per garment
- Data standardization
  - For example, garments names conform to a consistent name like "2.4 GlacierTech PCM Vest" vs. 'grey vest' or 'cooling vest grey'
- Modified Q15
  - Both question and response for Q15 were flipped, so that a positive response is represented by score of 5; therefore for all Q's, a score of 5 is positive
- Transpose so one data sheet per row; enables sorting
  - Can sort responses by shipyard, garment ID, question, etc.
- Table has average value of each analyzed garment for that question
- Built bar charts to compare and understand results

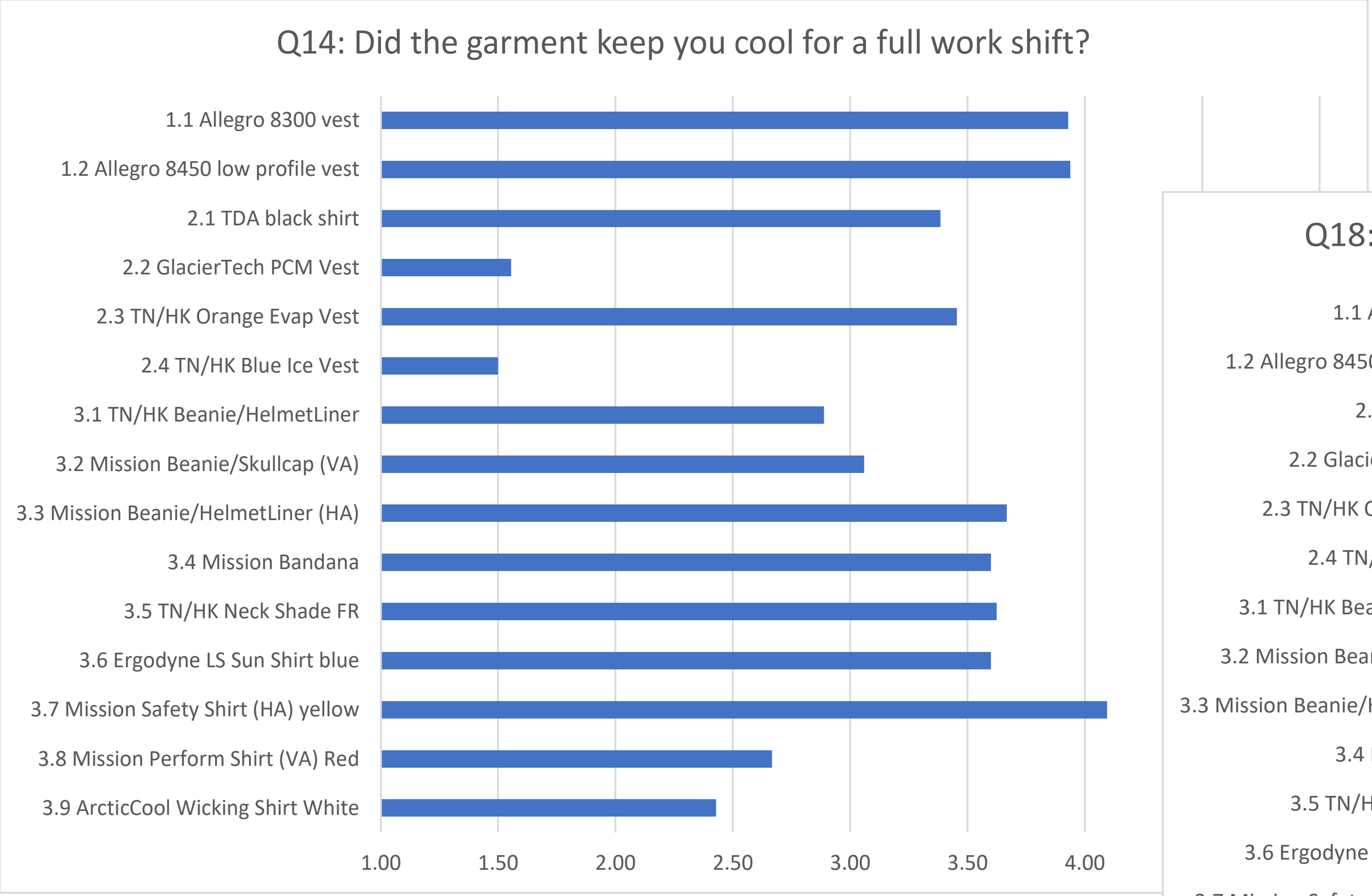
Results: Average Score of Each Garment for Each Question

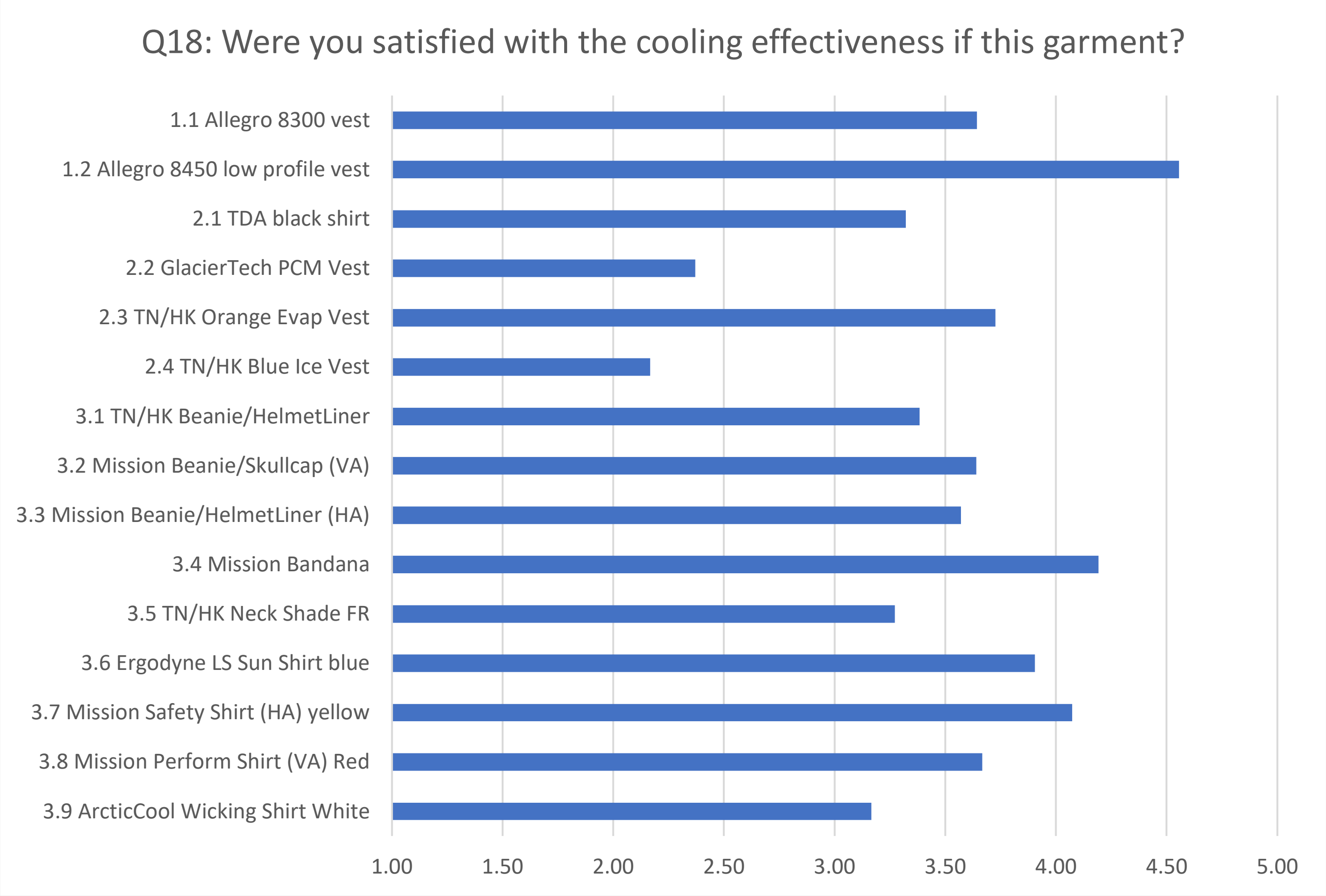
Garments in Column, Questions in top row, Responses rated from low agreement (1) to high agreement (5)	Cool for full work shift?	Not interfere with work	Iimprove my comfort	Multiple body types?	Effective cooling?	Enhances my Safety?	Enhances my Productivity?	Fast/easy to put on?	If available, would I use?	Sample Size (N)	# Questions averaged 4+
1.1 Allegro 8300 vest	3.93	2.71	2.71	2.64	3.64	2.36	2.71	3.07	2.57	12	0
1.2 Allegro 8450 low profile vest	3.94	2.56	4.06	3.56	4.56	3.22	3.61	4.06	4.19	14	4
2.1 TDA black shirt	3.38	3.15	3.85	2.29	3.32	2.15	3.23	3.31	3.00	10	0
2.2 GlacierTech PCM Vest	1.56	3.68	2.31	2.89	2.37	1.96	2.19	3.38	2.69	20	0
2.3 TN/HK Orange Evap Vest	3.45	4.08	3.70	3.55	3.73	3.60	3.60	4.00	4.00	11	3
2.4 TN/HK Blue Ice Vest	1.50	3.67	2.00	2.83	2.17	1.50	1.83	3.83	1.67	6	0
3.1 TN/HK Beanie/HelmetLiner	2.89	3.92	2.77	4.11	3.38	2.00	2.44	4.33	3.15	12	2
3.2 Mission Beanie/Skullcap (VA)	3.06	3.12	3.20	4.24	3.64	2.53	2.71	4.65	3.56	17	2
3.3 Mission Beanie/HelmetLiner (HA)	3.67	2.52	3.48	4.20	3.57	3.07	3.13	4.87	4.10	15	3
3.4 Mission Bandana	3.60	2.69	3.92	4.35	4.19	3.55	3.40	4.75	4.54	20	4
3.5 TN/HK Neck Shade FR	3.63	2.59	3.55	4.13	3.27	3.63	3.13	4.00	4.05	16	3
3.6 Ergodyne LS Sun Shirt blue	3.60	3.14	3.81	4.47	3.90	2.73	3.53	4.53	3.90	15	2
3.7 Mission Safety Shirt (HA) yellow	4.10	3.00	3.93	4.52	4.07	3.57	3.67	4.90	4.15	21	5
3.8 Mission Perform Shirt (VA) Red	2.67	2.83	2.83	3.33	3.67	3.00	2.17	3.67	3.33	6	0
3.9 ArcticCool Wicking Shirt White	2.43	2.83	2.92	4.00	3.17	2.57	2.43	4.29	3.00	7	2

Volunteer Testers’ Feedback

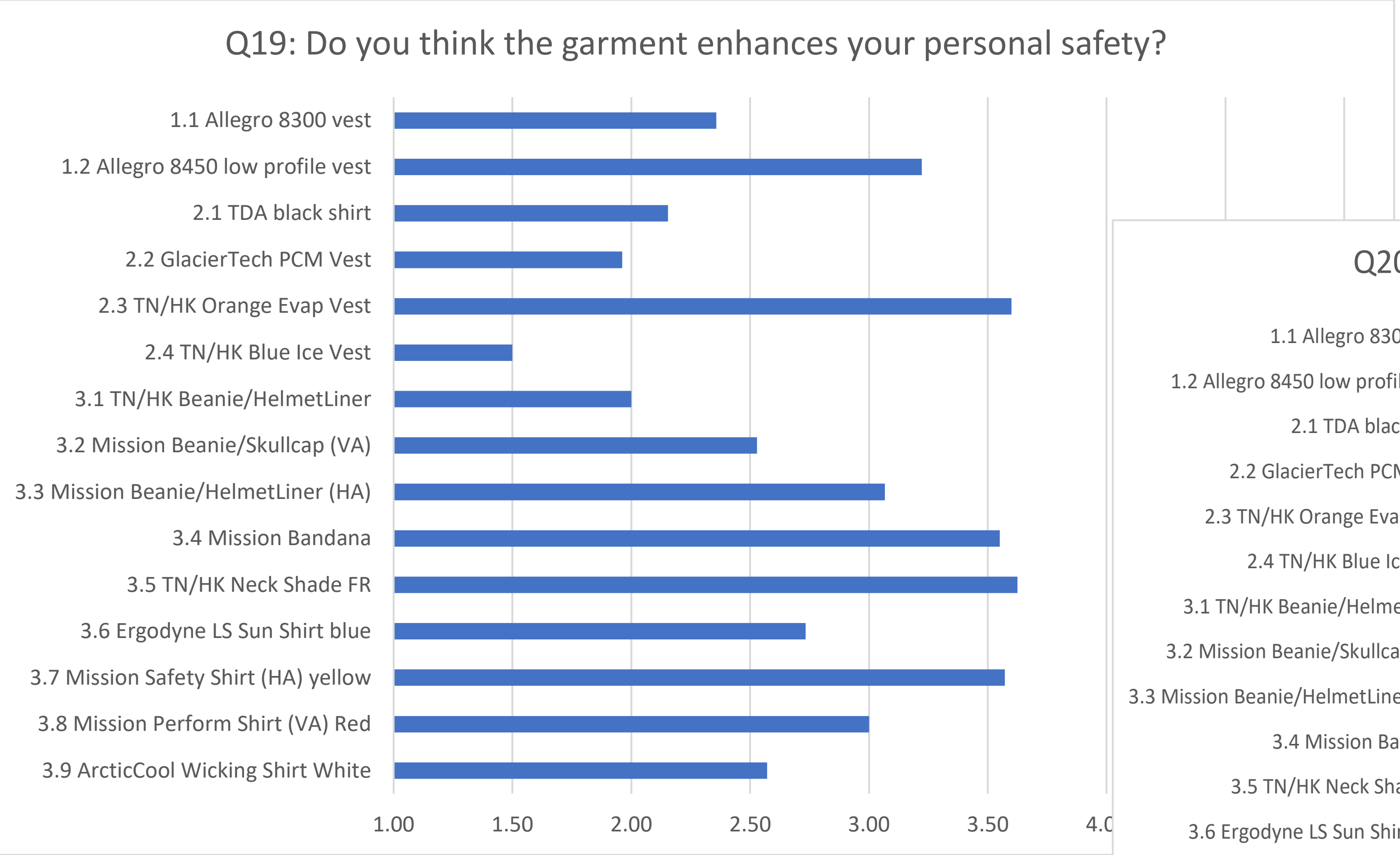
- Item 1.1, Allegro 8300 [Forced air] Vest
  - The vests were big and bulky; vest and air hose didn’t fit well under overalls. Testers were excited to test the vests in extreme heat. Vests provided relief that helped them to be more productive and improved work efficiency, for a long time. They were noisy but it was worth the relief. The 8300 vests were boxy on small frame users. Liked the low profile version better.
- Item 1.2 , Allegro 8450 Low Profile [Forced air] Vest
  - Similar comments as the 8300 with these exceptions: The vests were ideal for stationary working in the shop. Small frame users noted the vests were more effective at cooling due to slimmer fit. Suggestion to suspend the hose, reducing trip hazard.
- Item 2.1, TDA Black Shirt
  - The leg strap was restrictive due to the detachment feature; it was easy to remove the strap. It could be difficult to maneuver through the hatches with the battery pack on because it was big and bulky. It worked well when doing light work, but did not cool the whole body down and sweat still accumulated.
- Item 2.2, GlacierTech Phase Change Material (PCM) Vest
  - Depending on the type of work the craft worker does, the ice packs could last anywhere from 1-4 hours. Wearers in the inner bottom of the ship noticed that their ice packs lasted about an hour. If they were used during the hotter part of the days, they noticed relief. It did feel cooler when the packs were cold, but they were left damp when the vest [ice packs] thawed out.
  - It would be nice to have multiple packs to exchange and coolers available to freeze the ice packs in the middle of their work shifts. They suggested making the ice packs out of another type of gel/icy material to stay cold longer.
- Item 2.3, Techniche/Hyperkewl (TN/HK) Orange Evaporative Vest
  - Some wearers really liked these and felt the vest was refreshing. Other wearers felt that this garment left them feeling muggy. There was an [odd or unpleasant] smell associated with the vest after it had been worn once and had not properly dried. It was a hassle wetting the vest and rinsing out the excess water. Wearers didn’t like feeling wet all day.
- Item 2.4, TN/HK Blue Ice Vest
  - These didn’t last longer than 3 hours. They suggested buying multiple packs to trade out so they could get more hours of relief. Note: Ingalls shipyard workers tested these in the prior year and some verbal feedback was that it became wet and attracted dust or was too cold on the skin.
- Item 3.1 TN/HK Beanie (blue)/Helmet liner
  - Some wearers thought the product worked great and was refreshing; some thought it was very thin and didn’t tend to work, while one wearer experienced a headache due to it being too tight. Wearers generally said it took some getting used to wearing. One individual felt if it was issued out with PPE, he’d feel encouraged to wear it and thought we may see productivity increase with time.
- Item 3.2 Mission Beanie/Skullcap (Vapor Active)
  - Wearers were not in favor of how tight the skullcaps were. They did say the caps absorbed the sweat very well and fit well under hardhats. Unfortunately, it made their heads slick and their hardhats tended to fall off while they wore the skullcaps.
- Item 3.3 Mission Beanie/Helmet Liner (Hydro Active)
  - Wearers said they would buy these. Said they were comfortable and overall had a nice cooling effect. One wearer said it was tight.
- Item 3.4 Mission Bandana
  - This garment had numerous positive reviews. Wearers seemed to love its versatility. They liked that when they wetted the bandana and wore it, the bandana had a nice cooling effect. They said it’s big enough to cover their whole head and they felt cooler and less sweaty while wearing it. Some said the bandanas tend to dry quickly. Some said they didn’t have to wet it very often for it to stay cold throughout the day. Many said they’d buy this and that it’s a “must have for summers.” One wearer said it would be nice for welding attire if it was fire-retardant.
- Item 3.5 TN/HK Neck Shade (Fire Resistant)
  - Many wearers loved the sun coverage on their necks. They would wet it, but felt it provided good cooling affects even without being wet. The open concept allowed a breeze to cool them off while they wore the neck shades. One wearer said he noticed a difference in his level of stamina while wearing it throughout the week.
- Item 3.6 Ergodyne Long Sleeve Sun Shirt
  - They liked that these were lightweight and tended to dry quickly. The shirt soaked up sweat and provided cooling relief. Some suggested turning it into a hoodie to include neck coverage. The only complaint was that it didn’t seem to do much when it was placed under long-sleeves when used for welding purposes. Some requested it be fire-retardant. One wearer said he would purchase several of these for personal use.
- Item 3.7 Mission Safety Shirt (Hydro Active) in yellow
  - Most wearers said it was a great shirt. It was comfortable to wear, it collected moisture, provided a good cooling effect and was very versatile. They wish it would have been fire-resistant and they didn’t like the color. One wearer noted it helped with productivity and he was able to focus longer and better.
- Item 3.8 Mission Performance Shirt (Vapor Active) in red
  - This seemed to prevent sweat along the torso but not the arms. Wearers said they would have preferred if this were long-sleeve.
- Item 3.9 ArcticCool Wicking Shirt in white
  - Many wearers did not care for the color. They said the white got dirty too quickly. They didn’t feel it was appropriate for heavy construction. It was too thin and delicate. It seemed well made, but didn’t seem to provide much of a cooling effect.

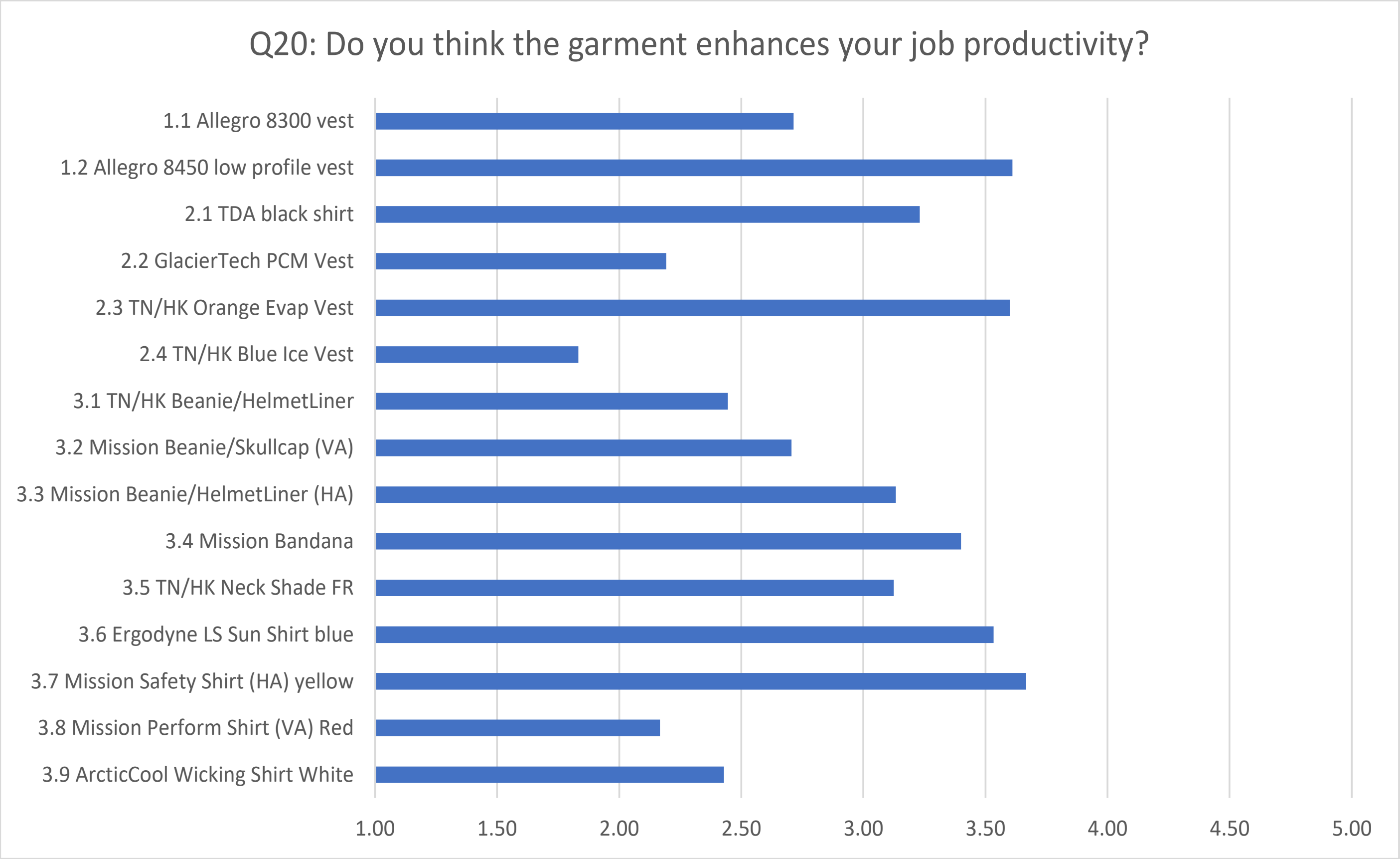
Test Results (Garment Avg. Scores for Q14, Q18)



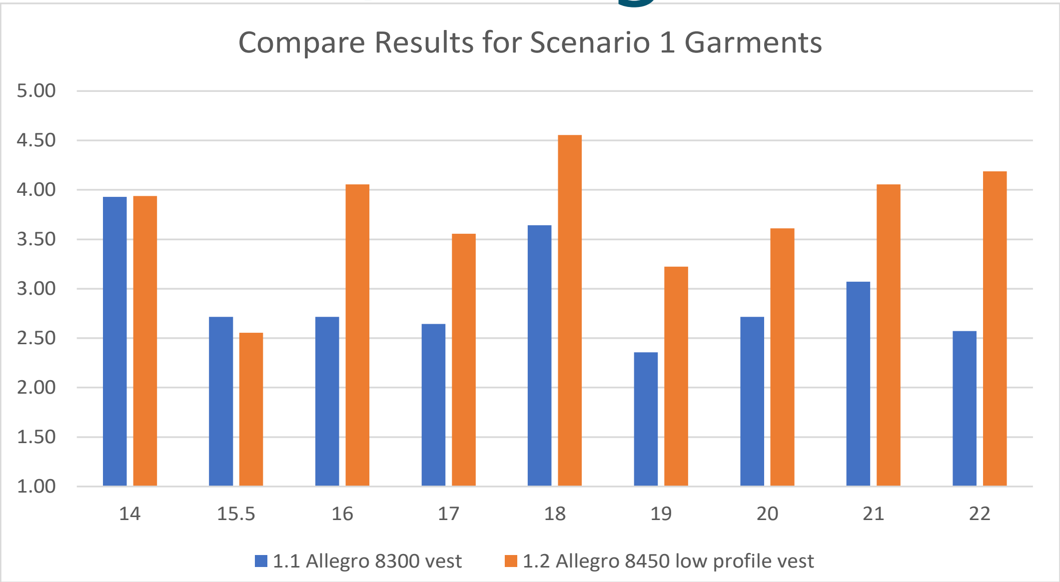


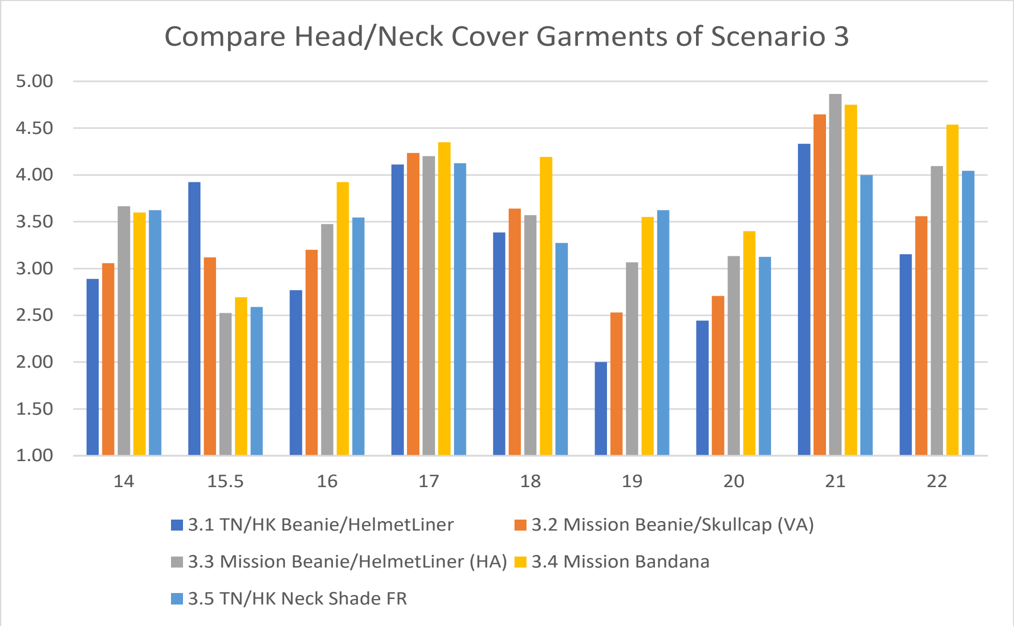
Test Results (Garment Avg. Scores for Q19, Q20)

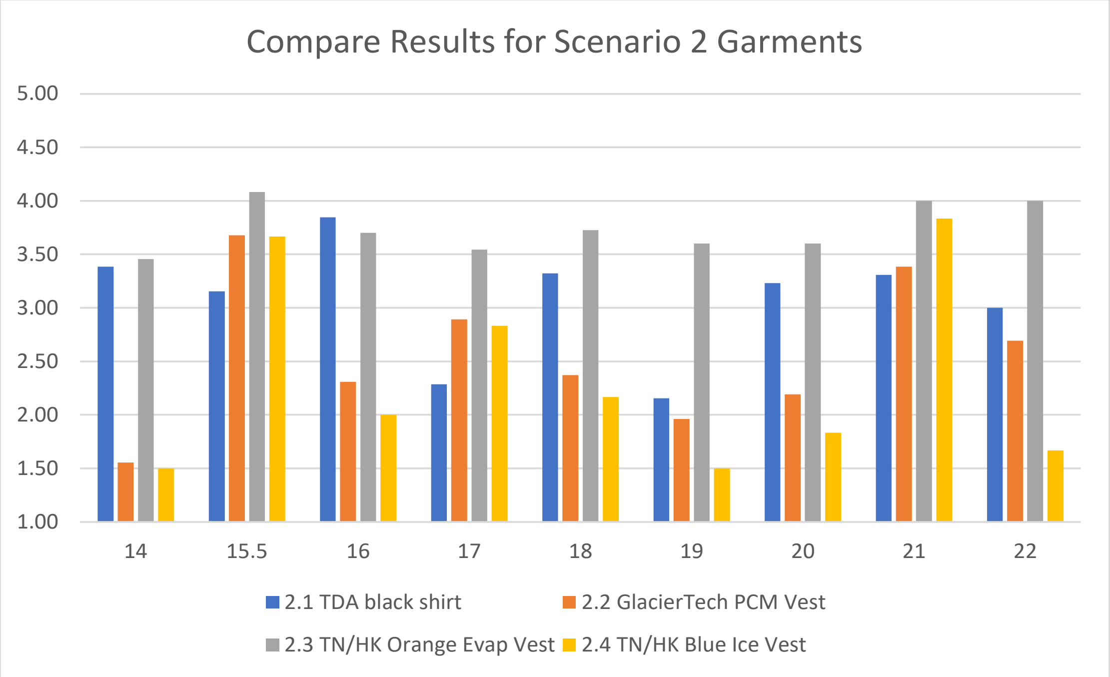


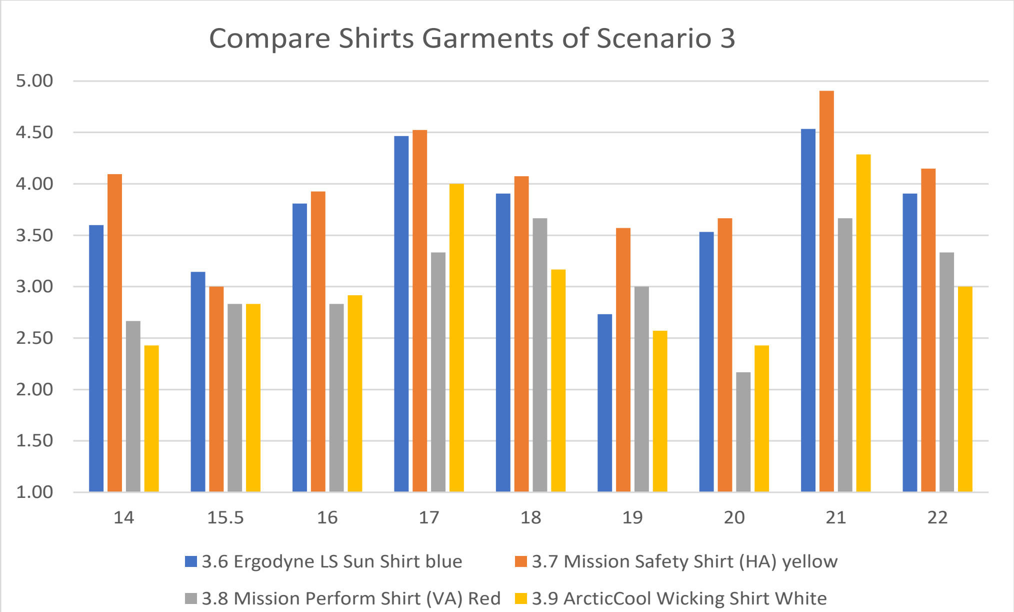


Test Results (Average Scores vs. Question Number)

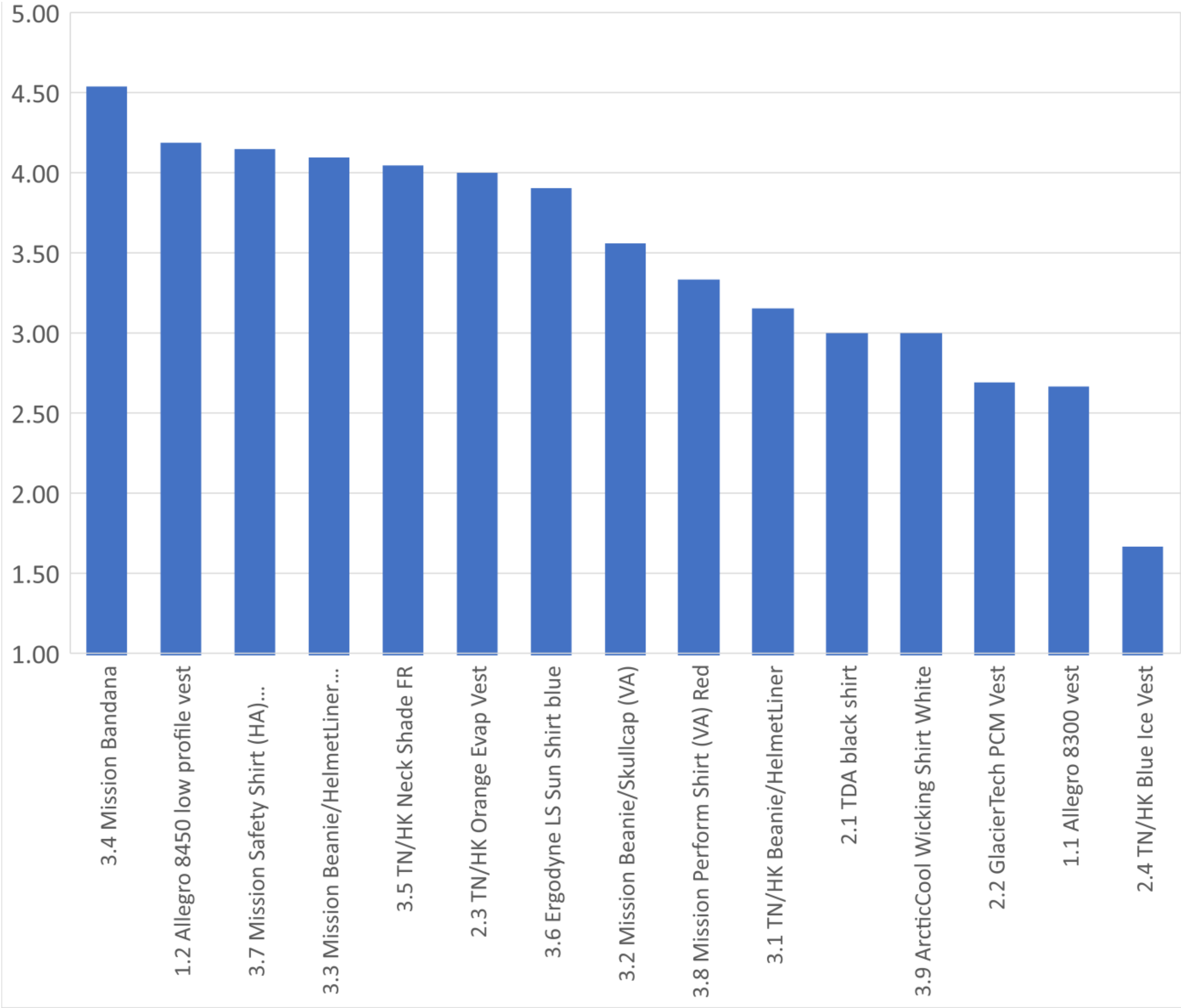








Test Results: Most Likely to be Adopted



Pareto of Question 22, “If available, would you use this garment?” vs. average score (1 low to 5 high) of each garment

Top scores were

- Item 3.4 Mission Bandana
- Item 1.2 Allegro 8450 low profile vest
- Item 3.7 Mission Safety Shirt (HA)

And several other garments scored well

Summary of Results

- The top three scoring garments overall were:
  - 3.4 Mission Bandana was most likely to be used and scored high in most categories
  - 1.2 Allegro 8450 low profile vest scored best for comfort and cooling effectiveness
  - 3.7 Mission Safety Shirt (HA) yellow scored best for all-day endurance

Work Scenario	Body Cooling Garment Tested	Q22 Avg. Score	Price per Garmen
1) Forced Air Vest	1.2 Allegro 8450 low profile vest	4.19	$$$
2) Mobile Vest	2.3 TN/HK Orange Evap Vest	4.00	$$
3/ Head Cover (three options)	3.4 Mission Bandana	4.54	$
	3.3 Mission Beanie/Helmet Liner (HA)	4.10	$
	3.5 TN/HK Neck Shade FR	4.05	$
3/ Shirt (2 options)	3.7 Mission Safety Shirt (HA) yellow	4.15	$$
	3.6 Ergodyne LS Sun Shirt blue	3.90	$$

$	= under $20	Highly Affordable
$$	= $20-60	Affordable for Many
$$$	= $60-$250	Less Affordable for Most
$$$$	= over $250	Least Affordable

- Effective cooling garments can be found in all price ranges
- Affordable shirts and head coverings can benefit a broad group of users
- Vests for scenario 1-2 may be outside of what individuals can pay out-of-pocket
- These are the recommended items for initial pilot implementation in shipyards

Implementation Plan Concepts

- The team addressed a number of questions and recommendations

Thank you to NSRP and All the Participants!

ROLE	ORGANIZATION	PERSON	TIME ZONE
Project Lead/Prime	Ingalls Shipbuilding	Karen Cassidy	Central
Industry Team Members	Ingalls Shipbuilding	Paulina Phillips	Central
	Newport News Shipbuilding (NNS)	Ean Greene	Eastern
	Bath Ironworks (BIW)	Scott Christman	Eastern
Participating Navy Stakeholder	Pearl Harbor Naval Shipyard (PHNSY)	Shayla Deitch	Hawaii (East-6H)
NSRP Project Technical Rep (PTR)	NSRP Sustainment Panel	Kaipo Crowell	Hawaii (East-6H)
NSRP Program Manager	Advanced Technologies International (ATI)	Steve Gaschler	Eastern
Advisor	TDA Research Inc.	David Eisenberg	Mountain

Thank You for your participation.

Discussion…

Evaluation of Digital Twin Technologies for In-Situ Ballast Tank Inspection

Cody Porter

Overview

- Problem Statement
- Project Goals and Objectives
- Related Work
- Project Plan
  - Project Participants
  - Project Overview
  - Project Challenges
- Summary

Problem Statement and Project Goals / Objectives

Problem Statement

Problem: Inspection and repair of ballast tanks onboard US Navy vessels is a significant maintenance task

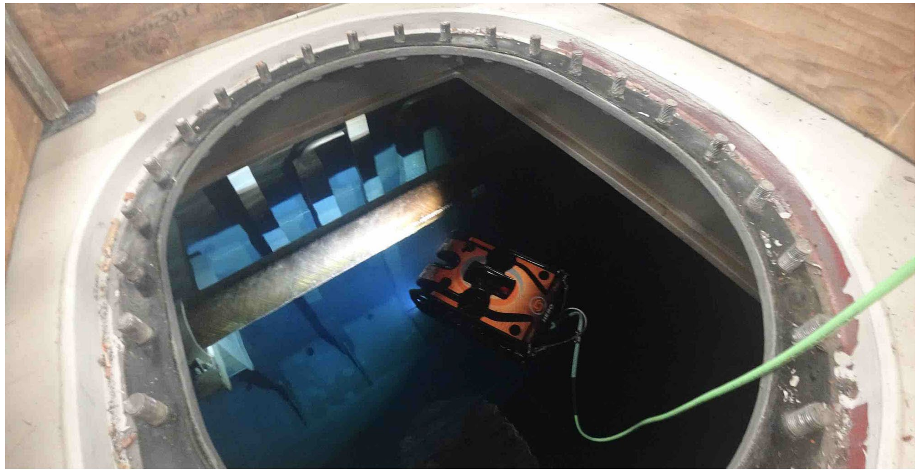
- State of tank unknown until drained
- Delays repair plans and scheduling

Credits: karelstudio/depositphotos.com

Problem Statement - Continued

Current state of the solution:

- Underwater Robotic Vehicles are an appealing solution to avoid draining tanks.
- Timely data to prevent schedule delays / unplanned work
- Commercially available platforms in use now
  - Not yet rigorously tested. Mostly visual confirmation



Courtesy USN

Project Goals and Objectives

Goal: Determine the viability of existing 3D mapping methods on Commercial Off-the-Shelf (COTS) underwater inspection robots by precisely analyzing their behavior.

Objectives:

- Outfit a suitable underwater inspection robot for use in filled ballast tanks.
- Test existing 3D mapping software in ballast tanks to determine accuracy, reliability, and relative performance.
- Report 3D mapping algorithms for immediate use.
- Summarize the performance characteristics and limitations of platform, software, and calculate return on investment for use in ballast tanks prior to docking.

Background and Related Work

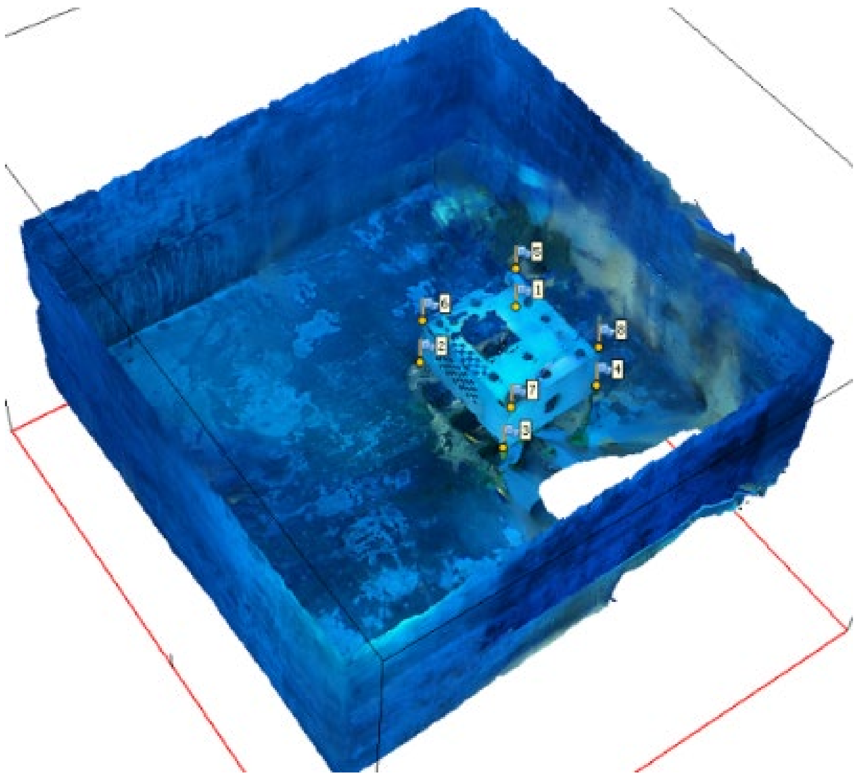
Related Work

NSRP

- Previous research in 3D mapping of subsea structures

SwRI

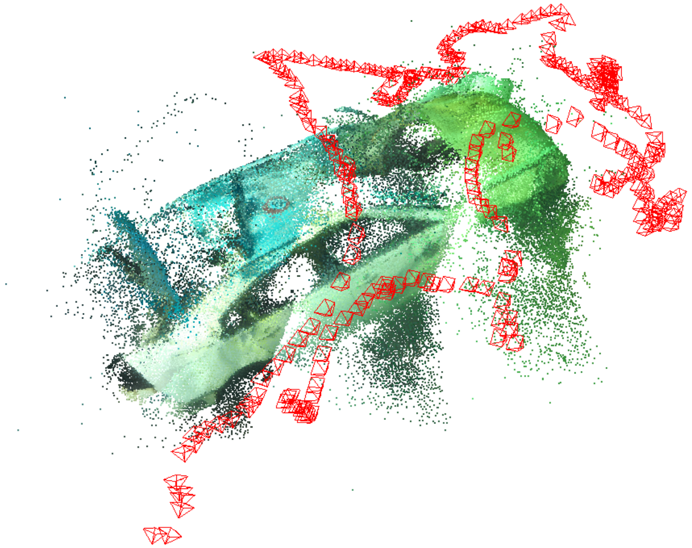
- Internal Research in 3D mapping of submerged structures
  - Use of Stereo Cameras, Sonar, and other sensors
  - Tested with multiple submerged structures.
  - Real-time and processed results available



SwRI-generated render of a small tank submerged within a larger structure. Render generated in post-processing.

Related Work – SwRI

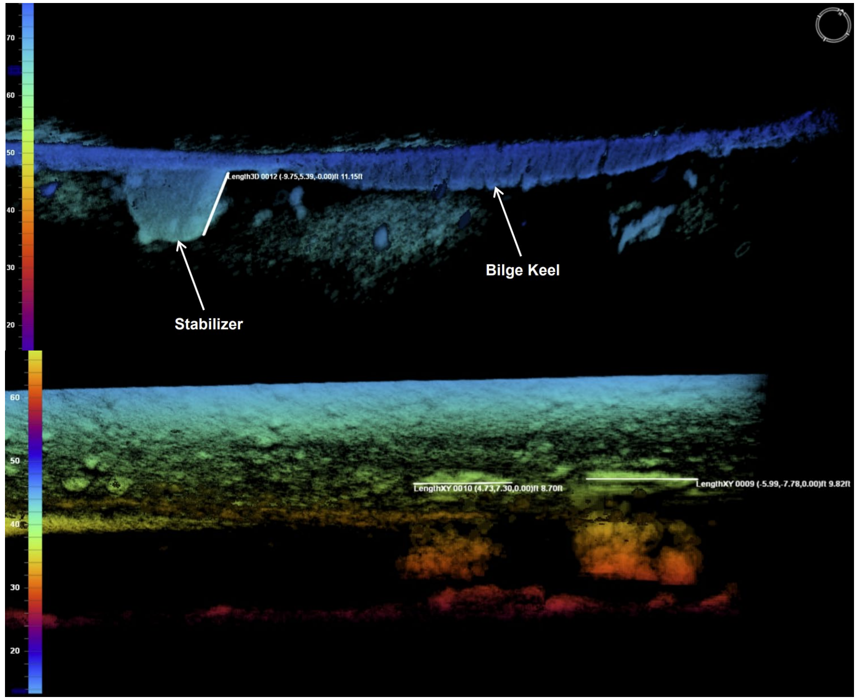
- Mapping of car submerged for a preliminary real-world test.
- Data collected in summer, midday with decent water visibility



Related Work - Navy

US Navy

- NAVSEA research on 3D Hull Mapping
  - Position Tracking to achieve ±6" accuracy along hull
- Ballast Tank Inspection at Puget Sound
  - VideoRay Pro4 – Visual only, no modeling.



Courtesy USN

Project Plan

Project Participants

- Southwest Research Institute – Technical Lead
- Ingalls Shipbuilding – Participating Shipyard
- Newport News Shipbuilding – Participating Shipyard
- BAE Jacksonville Ship Repair – Participating Shipyard

Project Overview

The overarching objective is to evaluate and qualify existing technologies in a new application and confined space environment.

Tasks:

- Survey Target Tanks at participating shipyards & identify inspection requirements.
- Acquire robotic inspection platform and integrate with necessary sensors.
- Ballast tank data collection at shipyards.
- Analyze mapping performance and determine the most viable algorithm.
- Present results and write a guide for adoption and use.

Project Challenges

- Unique operation environment
  - Confined space
  - Inside of a larger, non-static structure
  - Uncertain water quality, turbidity
    - Sonar usage should mitigate effects
- Hardware integration
  - New Sonar module (Waterlinked 3D-15 sonar)
  - Deep Trekker Photon

Summary

Summary

- Ballast Tank inspection is a critical but slow process in the repair procedure.
- The deployment of submersible robotic platforms can improve this process
- This project aims to qualify existing technologies in a new context
  - Emphasis on mapping software that can be applied to many robotic platforms.
  - Set procedure so that generated maps can be continuously updated and referenced.
- Seek to understand procedural needs and challenges that arise from the operating environment.

Defect Characterization of Navy Ship Structures

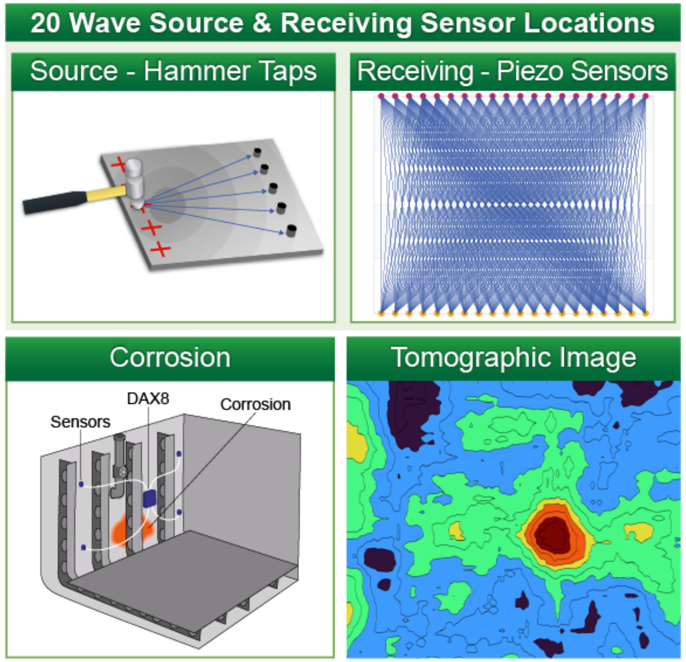
with Broad Spectrum Active Ultrasonic Mode Imaging

PANEL PROJECT SPECIFICS

Develop and demonstrate the technical feasibility of Ultrasonic Mode Imaging (UMI) to interrogate no less than 20 ft. X 20 ft. of Naval ship structure to identify areas of corrosion and associated thinning as might be carried out during inspections related to those mandated by pertinent Maintenance Requirement Cards (MRC) and the “Corrosion Control Assessment and Maintenance Manual” (CCAMM).

Project Title: Defect Characterization of Navy Ship Structures with Broad Spectrum Active Ultrasonic Mode Imaging

Panel Affiliation: Sustainment

PROJECT IMAGE	OBJECTIVE
	Demonstrate the technical feasibility of an active UMI system with a 20-foot range capable of locating corrosion and plate thinning under coatings and coverings in Navy ship metallic structures with penetrations with a high impact on reducing Naval shipyard NDT&E costs. Goals to meet the objective are: 1. Using FEA, develop theoretical dispersion curves to account for the effects of penetrations on the ability to measure thickness of plate structures, optimize the sensor array and sources configuration to ensure adequate coverage of the plate in the most cost-effective manner, and produce tomographic images that display the results. 2. Conduct field tests at a shipyard to demonstrate the ability to find defects in 20-foot plate structures with penetrations.
BENEFITS/ROI	**PROJECT INFORMATION/FINANCIAL**
Significantly reduce the man-days associated with MRC and CCAMM inspections performed by both public and private shipyards and other maintenance activities to inspect in-service ship structures for corrosion and wall thinning. Advance to TRL of the UMI system from a TRL 4 to a TRL 5. ROI is TBD.	**Project Lead**/Team Members: Steve Robinson/Dr. Steve Ziola, Gerald Addison, Jim Brice, Jacob Evory, Sterling Kauahi, Zain Khan, Keith Labelle, Bryan Martin, and Mike Pitchford. <u>Duration</u>: 12 months Program Funds: $200,000 Cost Share: Public Sector: $0

PROJECT GOALS

- Demonstrate the feasibility and applicability of a non-conventional method of Nondestructive Testing (NDT).
- Demonstrate a method of structural interrogation that will not require significant interference, coating/covering removal (such as paint or insulation) and will characterize defects in way of penetrations.
- Demonstrate that new technology is available that can save structural evaluation man hours.
- Demonstrate a structural interrogation method that will afford a Nondestructive Test (NDT) technician with a precise tomographic imaging of structural inconsistencies

PROJECT PLAN

- Employ custom built advanced electronics, specially constructed, extremely sensitive, piezoelectric sensors, and digital processing programs, to include machine learning, that provides timely, precise data evaluation and depiction.

- Capitalize on Finite Element Analysis (FEA) modeling to account for surface irregularities, such as penetrations, to guide the analysis development.

- Take advantage of the existing NAVSEA COOPERATIVE REASEARCH AND DEVELOPMENT AGREEMENT (NCRADA) with Norfolk Naval Shipyard (NNSY) that affords Antech access to the NNSY Controlled Industrial Area (CIA) to include production shops, mockups and in yard availabilities.

- Carry out feasibility testing on structural mockups and shipboard.

- Work with appropriate NNSY personnel to assess potential time and cost savings.

DRY DOCK AND DRYDOCKING TECHNOLOGICAL ADVANCEMENTS

World Class Upgrades in support of Modern Shipyards

Agenda

- DM Consulting Overview
- 21st Century Industry Improvements
  - Physical Support Systems
  - Information Technologies
- Benefits
- Implementation
- Conclusion

DM Consulting

DM Consulting Team

- Established in 2000
- Dry Dock Experts
- Recognized worldwide as the leading authority on drydocking and training
- 200 years of combined drydocking experience
- 5,000 dry docking operations
- Customers from 500 organizations and 6 continents
- Industry connections to leading technologies

Background

- Integrate new technology into dry docks and drydocking
- Benefits (see adjacent tables):
  - Time – cut dock preparation time by 50% for each docking
  - Environmental – reduce material waste 50%
  - Costs – reduce material/labor costs by 60%
  - Risk – safer operations

Time Breakdown	Conventional System Time	Mechanical Shores Time
Gathering Info	2 Days	2 Days
Calculations	2 Days	2 Days
Cut SB to shape	7 Days	-
Place KB	7 Days	7 Days
Place SB	7 Days	-
Operation	1 Day	1 Day
Total	26 Days	12 Days

Material Breakdown	Conventional System Materials	Mechanical Shores Materials
KB	50% Waste	50% Waste
SB	50% Waste	-
Total	50% Waste	25% Waste

Cost Breakdown	Conventional System Costs	Mechanical Shores Costs
KB Materials	$25k	$25k
SB Materials	$75k	-
Labor	$100k	$50k
Total	$200k	$75k

Current Drydocking Methods

21st Century Industry Improvements

Physical Support Systems

- Modern side supports
- Chains
- Rubber block caps
- In-haul systems
- Other Shipyard Facility Modernizations

Information Technologies

- Laser Scanning and block positioning systems
- 3D hull scanning
- Calculations software
- Block contact indicator
- Control systems
- Centering system

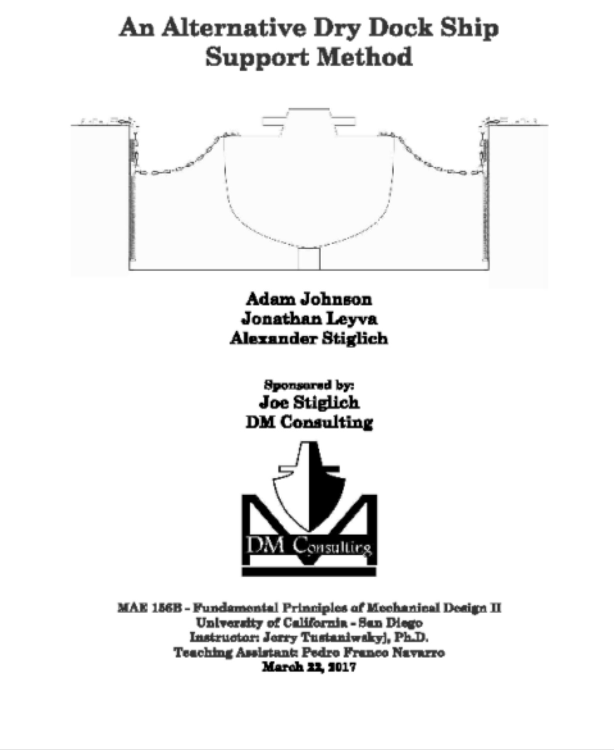
Physical Support Systems

- <u>Modern Side Supports</u>
  - Bilge support
  - Towers
  - Shores
  - Chains
- Existing systems available off-shelf
- Shorter dock preparation time (no side blocks)

Physical Support Systems

Chains

DM Consulting Research


An Alternative Dry Dock Ship Support Method

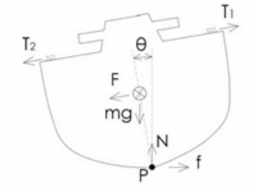
Adam Johnson
Jonathan Leyva
Alexander Stiglich

Sponsored by:
Joe Stiglich
DM Consulting

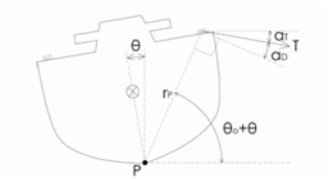
MAE 156B - Fundamental Principles of Mechanical Design II
University of California - San Diego
Instructor: Jerry Tustaniwskyj, Ph.D.
Teaching Assistant: Pedro Franco Navarro
March 22, 2017

Engineering analysis

Dynamic Analysis



FBD of Vessel Rotating About Point P



Important Angles and Geometric Parameters

➢ **System of equations:**

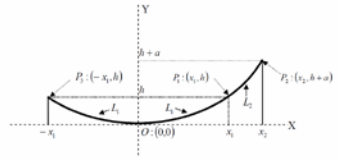
$\leftarrow + \; \Sigma F_x: F \times \cos\theta - f - T_1(\theta) \times \cos\theta_o + T_2(\theta) \times \cos\theta_o = ma$

$\uparrow + \; \Sigma F_y: -F \times \sin\theta + N + T_1(\theta) \times \sin\theta_o + T_2(\theta) \times \sin\theta_o - mg = ma$

$\curvearrowleft + \; \Sigma M_P: KG \times F - r_P \times T_1(\theta) \times \cos\alpha_D + r_P \times T_2(\theta) \times \cos\alpha_D + mg \times KG \times \sin\theta = I\alpha$

Catenary Analysis

The catenary curve is a curve described by hyperbolic cosine function (cosh). Tension can not be algebraically isolated given end point geometry so must be numerically solved



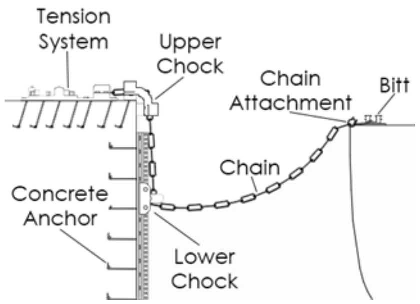
$$d = \frac{(l^2 - a^2)(a + 2h) - 2 \times l\sqrt{h(a+h)(l^2 - a^2)}}{a^2} \operatorname{atanh}\left(\frac{a^2}{l(a+2h) - 2\sqrt{h(a+h)(l^2 - a^2)}}\right)$$

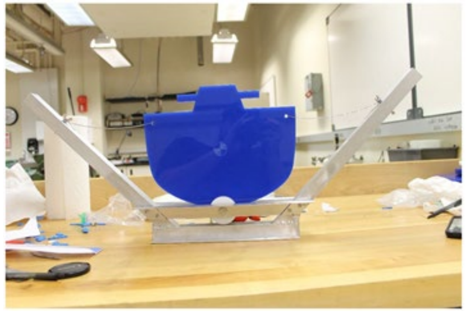
$$l_1 = -\frac{h \times l + \sqrt{h(a+h)(l^2 - a^2)}}{a}$$

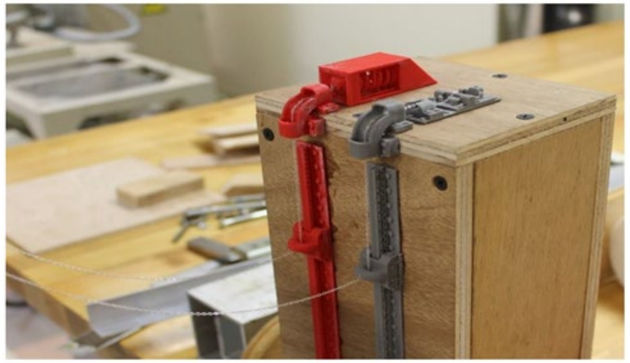
$$\mu = \frac{2h}{(l_1^2 - h^2)}$$

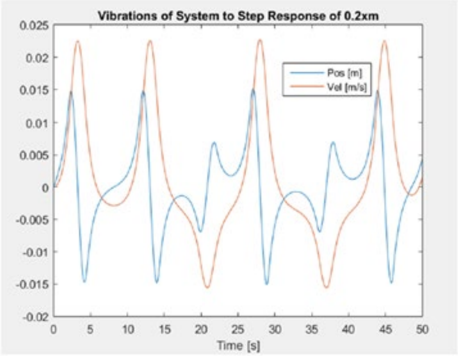
where μ= A dimensionless parameter of the catenary

Scale Modeling and Testing









Physical Support Systems

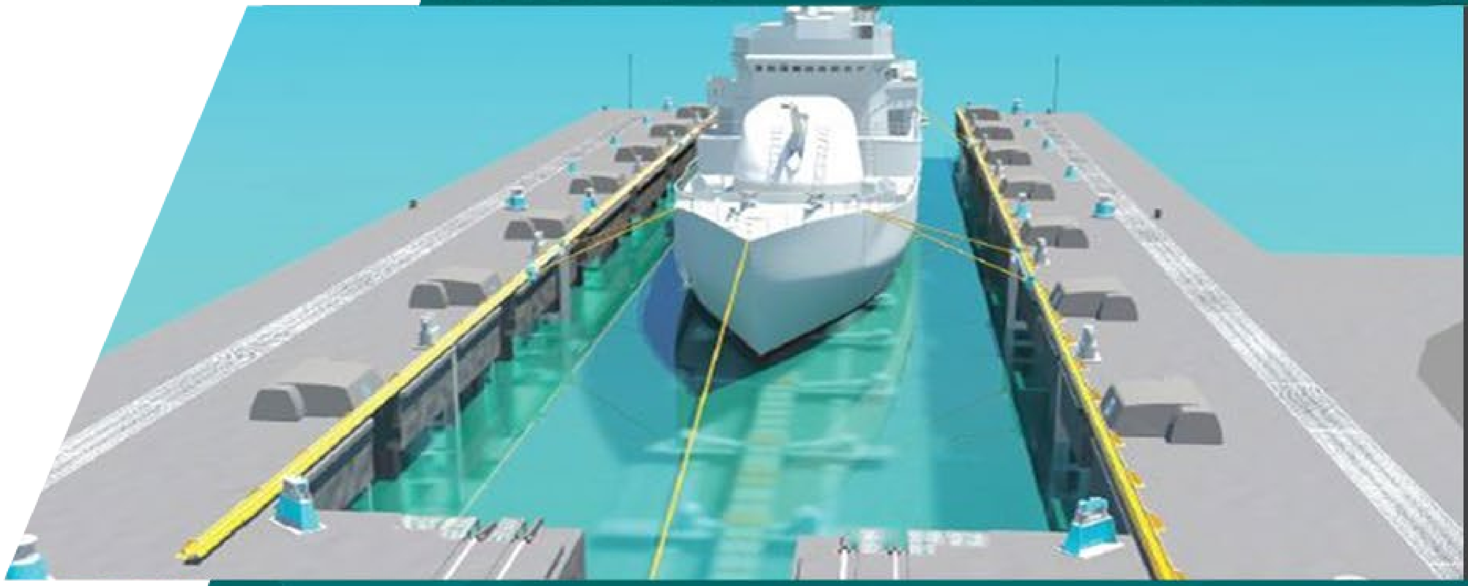
Rubber Caps

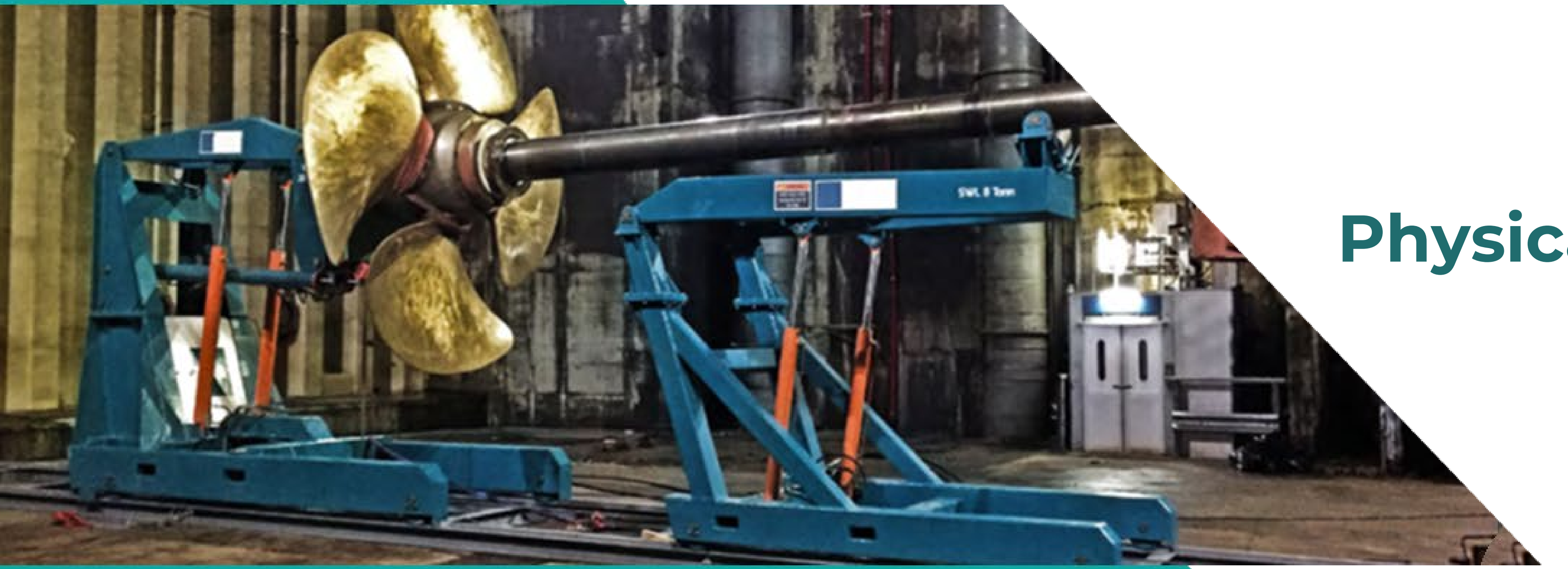
- DM Consulting research

Physical Support Systems

In-Haul Systems

- In-use several locations
- Several systems installed
- Reduced man-hours
- Controlled hauling in operation
- Quick and precise positioning





Physical Support Systems

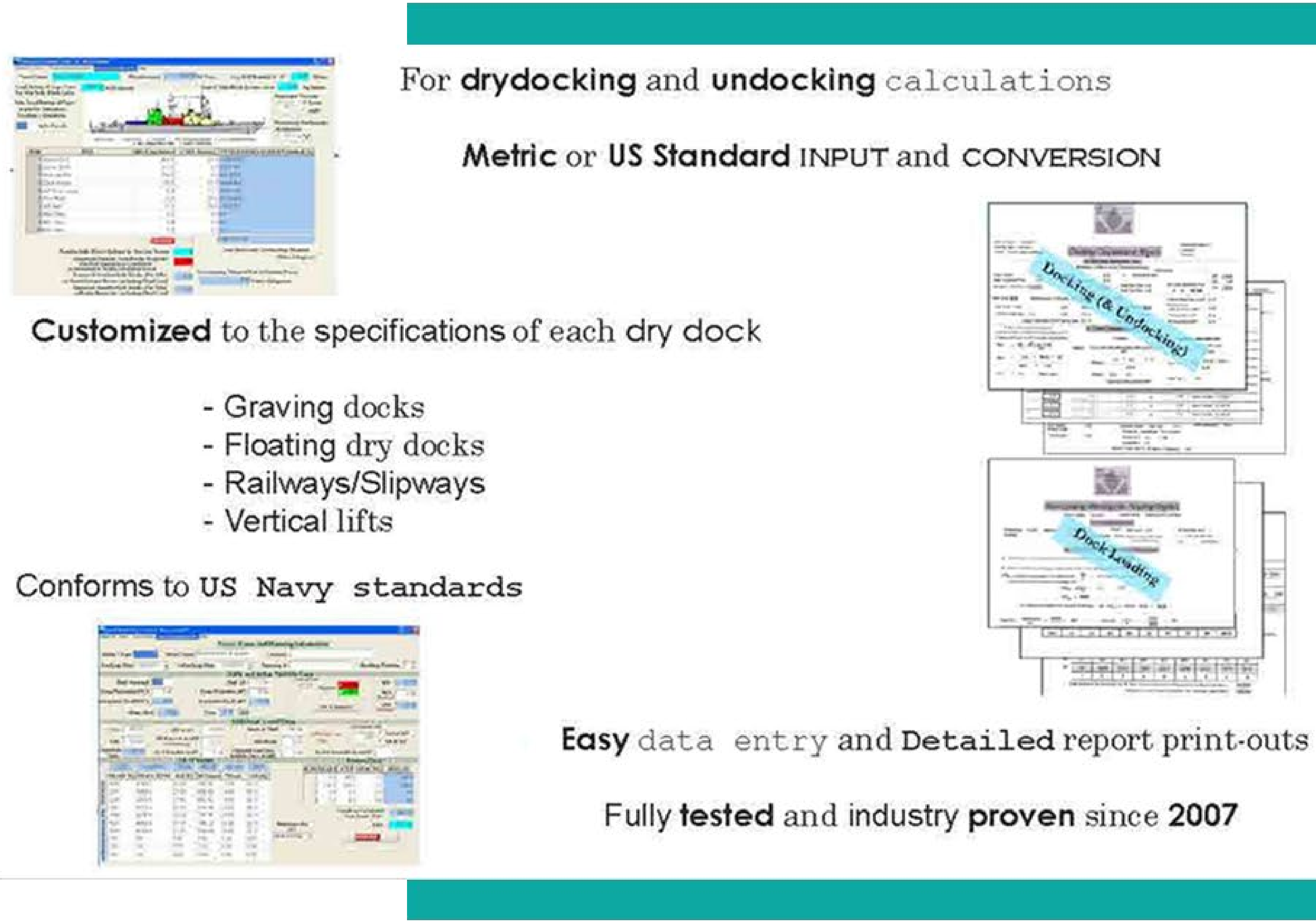
Other Shipyard Facility Modernizations

- Propeller removal systems
- Thruster removal systems
- Automated paint removal systems

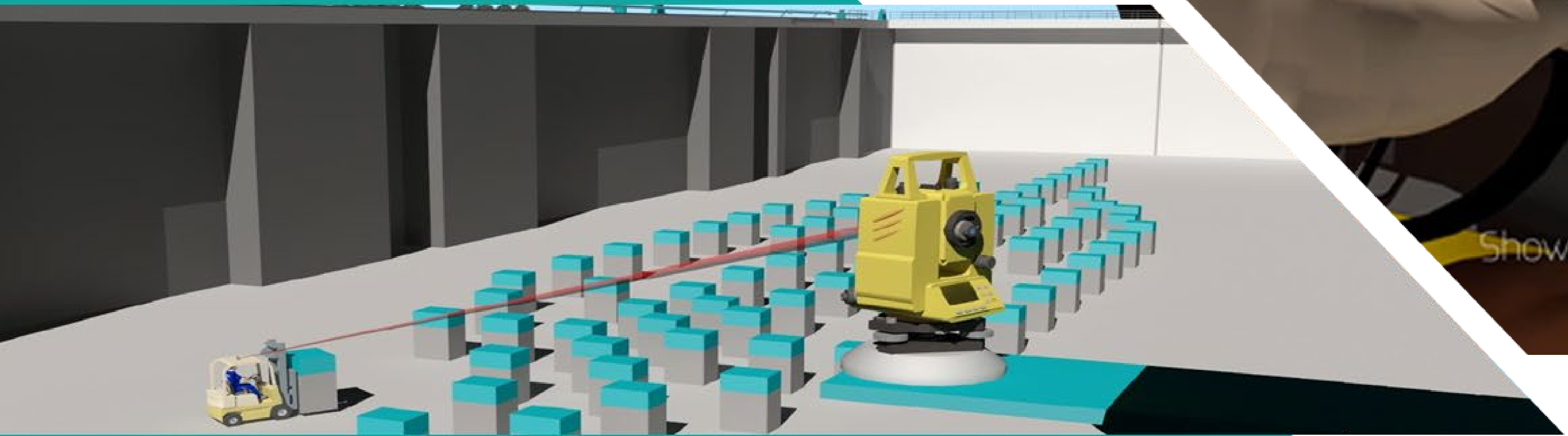
Information Technologies

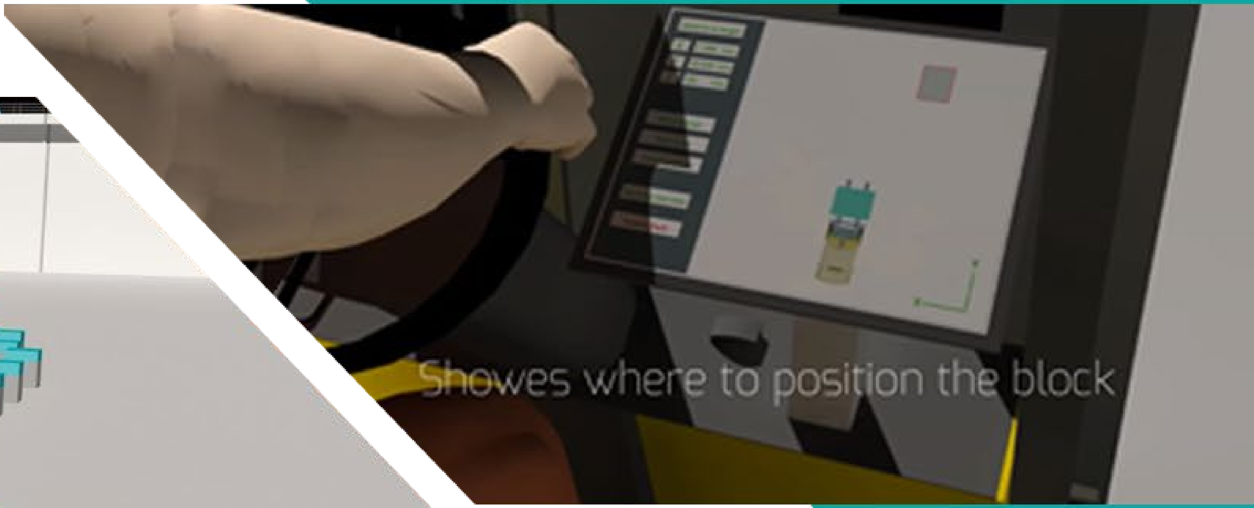
Dock Master Software

- User-friendly Dry Dock Calculations Software
- DM Consulting Engineered by Dock Masters for Dock Masters



Information Technologies





Laser Scanning System

- Digital verification and 3D mapping of blocks
- Significant time savings
- Reduces human error
- Blocks could be positioned autonomously or aided by scanning system

Information Technologies

3D Hull Scanning

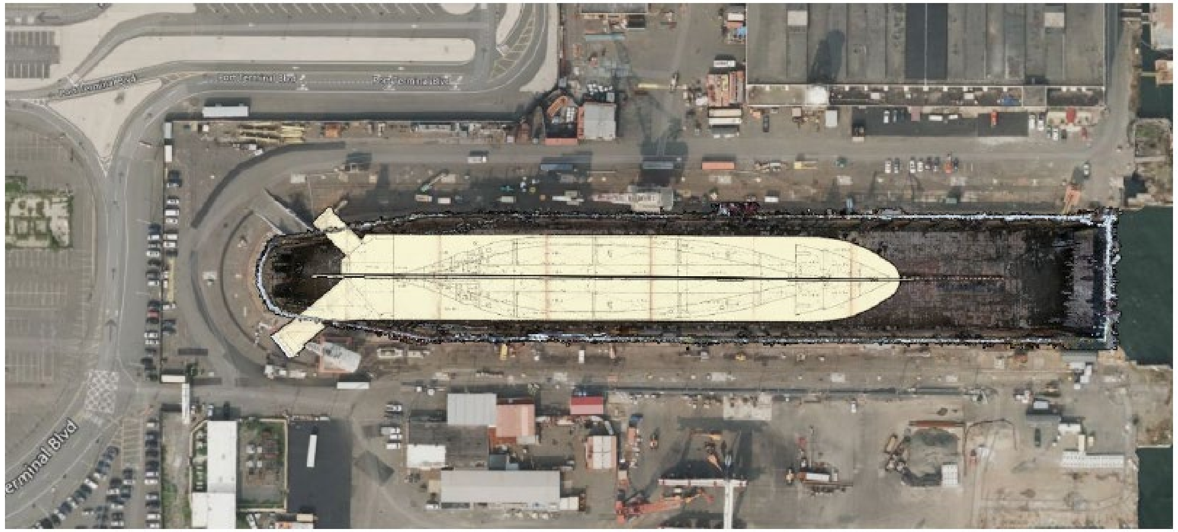
Underwater or Above Water Scans

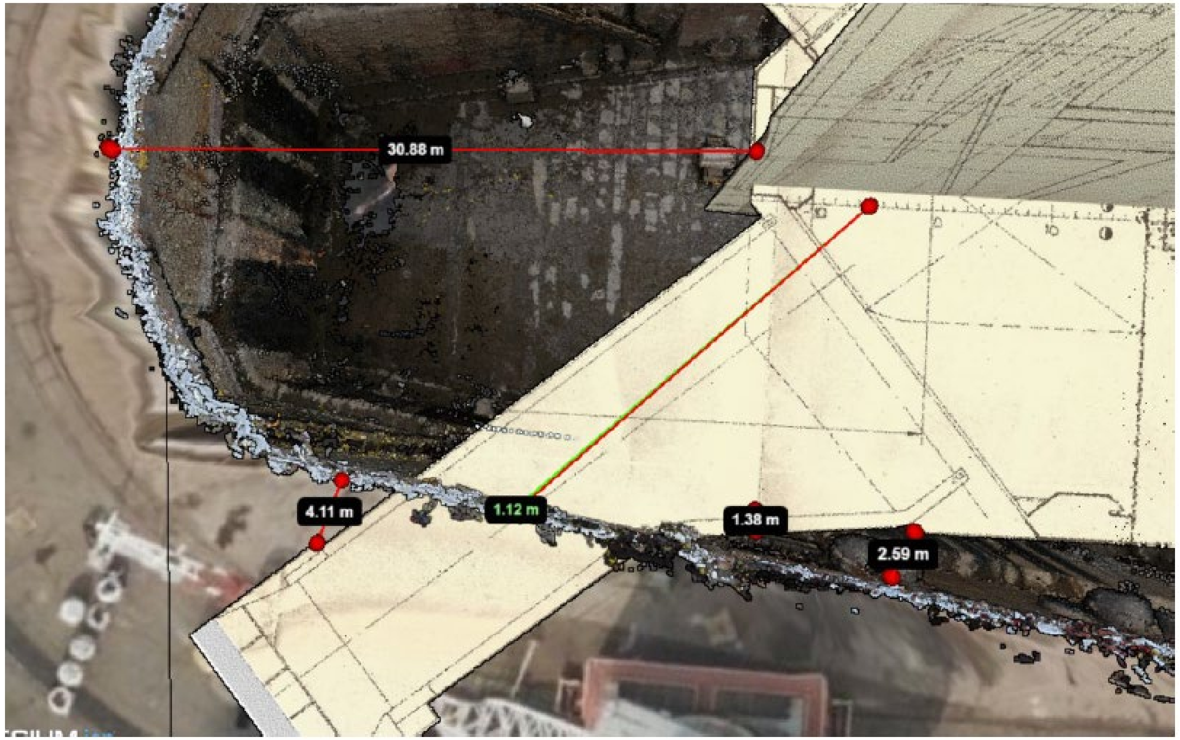
DM Consulting has a patent

Use Cases:

- Docking Feasibility
- Docking Plans
- Hydrostatic Curves
- Blocking Plans
- Projection Mapping
- Damaged Vessels

Reduces uncertainty and risk

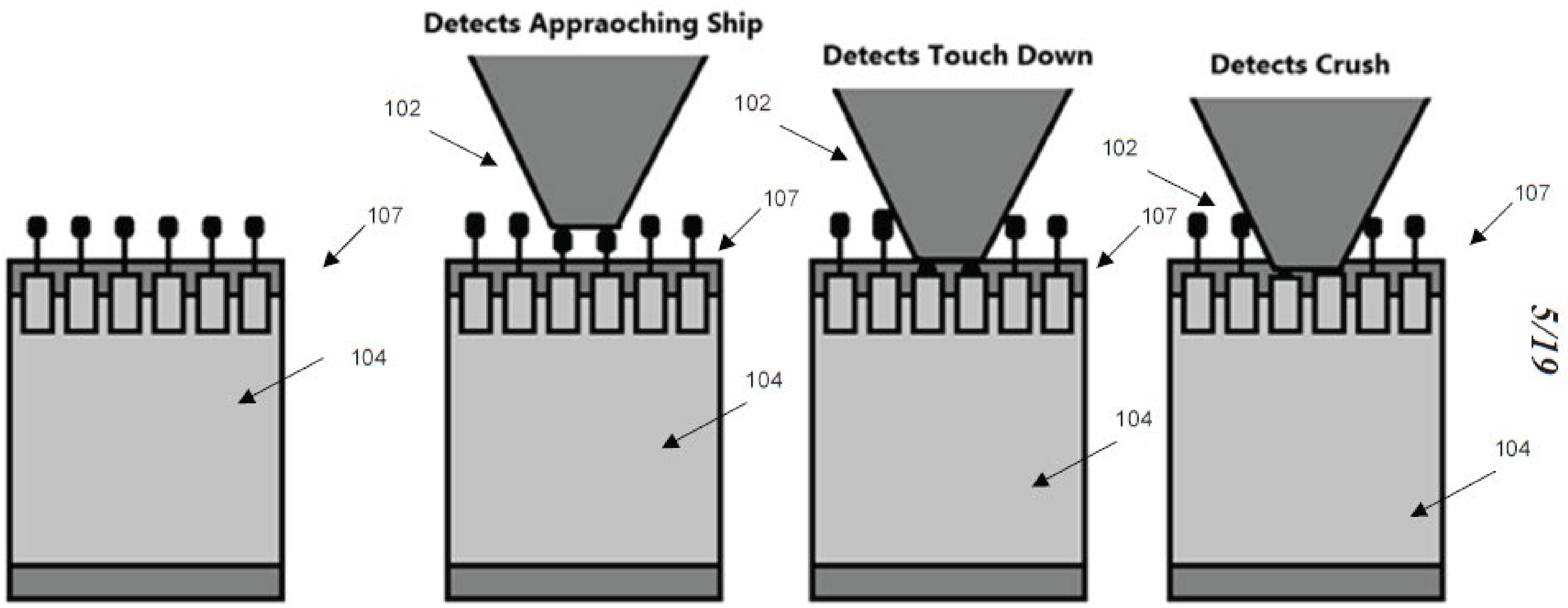




Information Technologies

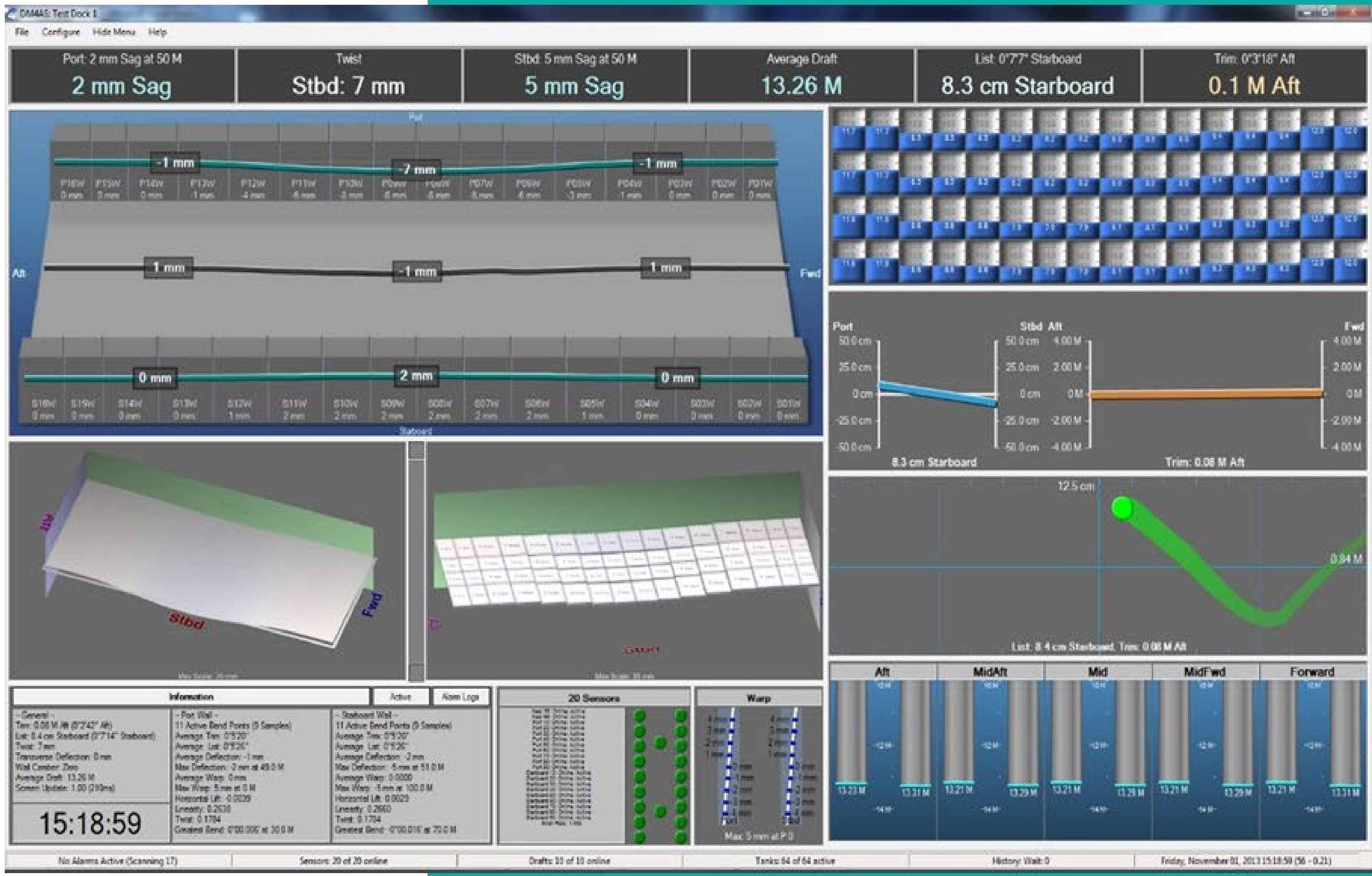
Block Contact Indicator System

- DM Consulting Design
- Now with positioning data (patent pending)



Other Information Based Systems

- FDD Control Systems
- Automated centering Systems



Potential Benefits

- **Time** – cut dock preparation time by 50% for each docking (eliminate side blocks)
- **Environmental** – reduce material waste 50% by utilizing reusable block caps
- **Costs** – reduce material/labor costs by 60% (eliminate side blocks)
- **Risk** – safer operations

Time Breakdown	Conventional System Time	Mechanical Shores Time
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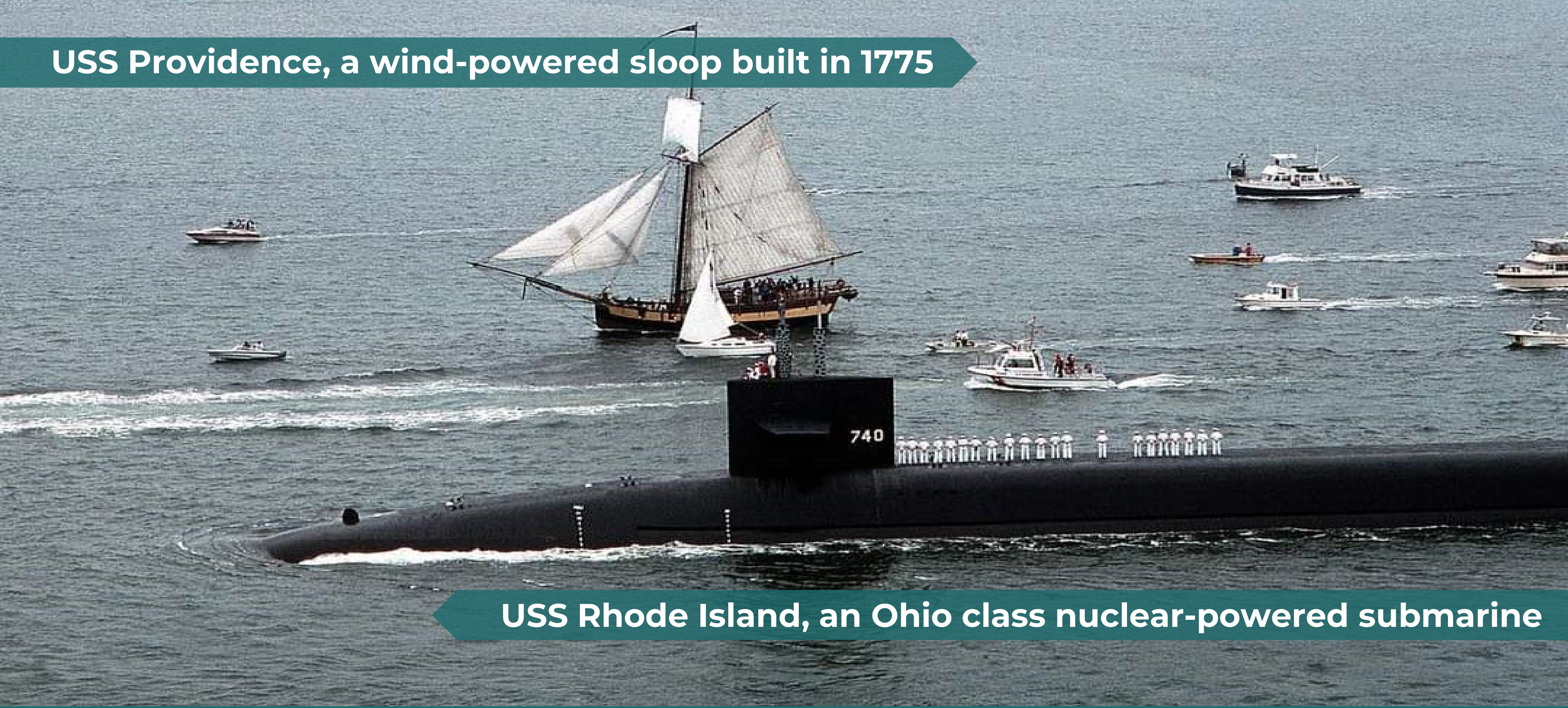
Implementation

DM Consulting can be your Modernization Consultant

- DM Consulting products
- Industry Connections
- Research and Analysis
- Technical Proposal Evaluations
- Application



These vessels are drydocked with the same technology!

DM Consulting

DM Consulting

- What we do:
  - Technology
  - Training
  - Operations
  - Consulting/Engineering
  - Evaluations/Analysis
  - Expert testimony
  - International Conference

Alex Stiglich
Alex@DryDockTraining.com
+1-858-774-1270

Verification of Fire Protection of Shipboard Electric Cables Using Intumescent Coating

NSRP All-Panel Meeting

25 – 27 February 2025

Presented By: David Rice

Hepburn and Sons LLC

NSRP Panel Project

To support the continuing advances in fire protection and affordability, the project will provide initial screening of Specified Technologies Inc. (STI) Marine Cable Coating (MCC)

Name	Organization
Steve Gaschler	ATI
Kirsten Walkup	GDBIW
David Rice	Hepburn and Sons
Stan Bovid	Hepburn and Sons
Julia Keiser	Hepburn and Sons
William Jones	STI
Jacob Phelps	FMM
Karen Carpenter	SwRI
Wes Duchene	NSWCCD
Chris Mealy	NSWCCD
Ravi Singh	NSWCCD

Problem Statement:

Fires aboard US Navy ships have resulted in damages of more than $4 billion from 2008 – 2022[1]. Layered fire prevention, detection, and response efforts are necessary to reduce the risk.

1- GAO-23-105481, April 2023

Problem Analysis

- Major Fires Review provided holistic evaluation of Navy fire prevention and protection systems
  - 12 significant issues addressed
  - 7 strategic recommendations
  - 56 corrective actions and recommendations for lasting impact

(2.B.3.a) Fund the assessment, implementation, and outfitting for both back-fit and forward-fit ships, of improved fire-prevention features and materials, and advanced firefighting equipment. The assessment should include but not be limited to: **(1) the use of intumescent paint (especially in the highest risk areas of ships);** … **Improve the timeline of integration and installation of these systems as applicable shipboard and ashore.**

Intumescent Products

- Intumescent process releases gases as part of a chemical reaction triggered by thermal exposure

- Gas production with solid structure combines to form the char layer

- Char layer provides insulation and protection

- Products exist in various forms including sealants, paints, bricks, pillows and more.

Why Cable Coating?

"After flash over, the fire grew quickly in intensity by consuming secondary combustibles and spread to adjoining locations via wireways and outboard frame bays."

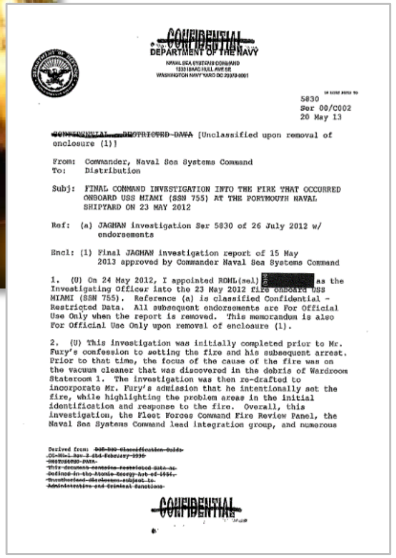
- COMNAVSEA ltr 5830 SER 00/C002 20 May 13, Page 51 para 14.

"Fire extensively damaged cables and cableways spanning the entire length of BONHOMME RICHARD" & "The entire 4 MILLION feet of combat systems and C5I cabling would require replacement." SECTION IX.

- RESULTING CONDITION OF BHR. Para 1044.

"The presence of an electrical ground resulted in the erroneous report by some watch standers that this was the cause of the fire. This electrical ground was more likely caused by the fire as it melted electrical cable insulation of live wires."

- CHAPTER 3. SECTION I. A. 2. BHR Command Investigation



~~CONFIDENTIAL~~

DEPARTMENT OF THE NAVY

NAVAL SEA SYSTEMS COMMAND
1333 ISAAC HULL AVE SE
WASHINGTON NAVY YARD DC 20376-0001

5830
Ser 00/C002
20 May 13

~~CONFIDENTIAL RESTRICTED DATA~~ [Unclassified upon removal of enclosure (1)]

From: Commander, Naval Sea Systems Command
To: Distribution

Subj: FINAL COMMAND INVESTIGATION INTO THE FIRE THAT OCCURRED ONBOARD USS MIAMI (SSN 755) AT THE PORTMOUTH NAVAL SHIPYARD ON 23 MAY 2012

Ref: (a) JAGMAN investigation Ser 5830 of 26 July 2012 w/ endorsements

Encl: (1) Final JAGMAN investigation report of 15 May 2013 approved by Commander Naval Sea Systems Command

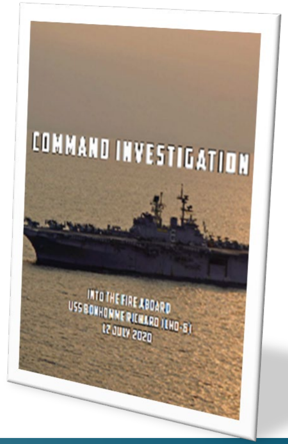
1. (U) On 24 May 2012, I appointed RDML(sel) [redacted] as the Investigating Officer into the 23 May 2012 fire onboard USS MIAMI (SSN 755). Reference (a) is classified Confidential - Restricted Data. All subsequent endorsements are For Official Use Only when the report is removed. This memorandum is also For Official Use Only upon removal of enclosure (1).

2. (U) This investigation was initially completed prior to Mr. Fury's confession to setting the fire and his subsequent arrest. Prior to that time, the focus of the cause of the fire was on the vacuum cleaner that was discovered in the debris of Wardroom Stateroom 1. The investigation was then re-drafted to incorporate Mr. Fury's admission that he intentionally set the fire, while highlighting the problem areas in the initial identification and response to the fire. Overall, this investigation, the Fleet Forces Command Fire Review Panel, the Naval Sea Systems Command lead integration group, and numerous

Derived from:

~~CONFIDENTIAL~~

https://www.navsea.navy.mil/Portals/103/Documents/FOIA-PII/ReadingRoom/201411130821.pdf



Marine Cable Coating

Two critical functions:

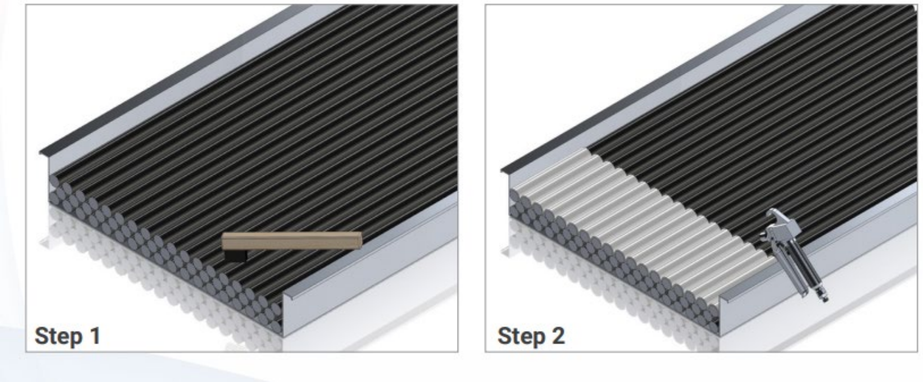
- Protect the ship
  - Minimize flame spread
  - Provide additional time for coordinated fire response
- Keep systems operational
  - Prevent cables from shorting causing additional damage
  - Deliver power and communications to critical systems

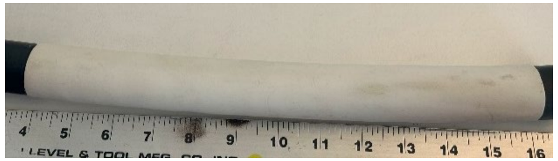
Helmet-cam view inside BHR published in Command Investigation into the Fire Aboard BHR

Damaged cableways published in Command Investigation into the Fire Aboard BHR

Specified Technologies Inc Marine Cable Coating (MCC)

- STI provides a suite of fire protection systems
- Intumescent products used throughout product line
- MCC is latex based product that can be applied using standard painting equipment
- Application can be completed by shipyard workers, contractors, or ship forces





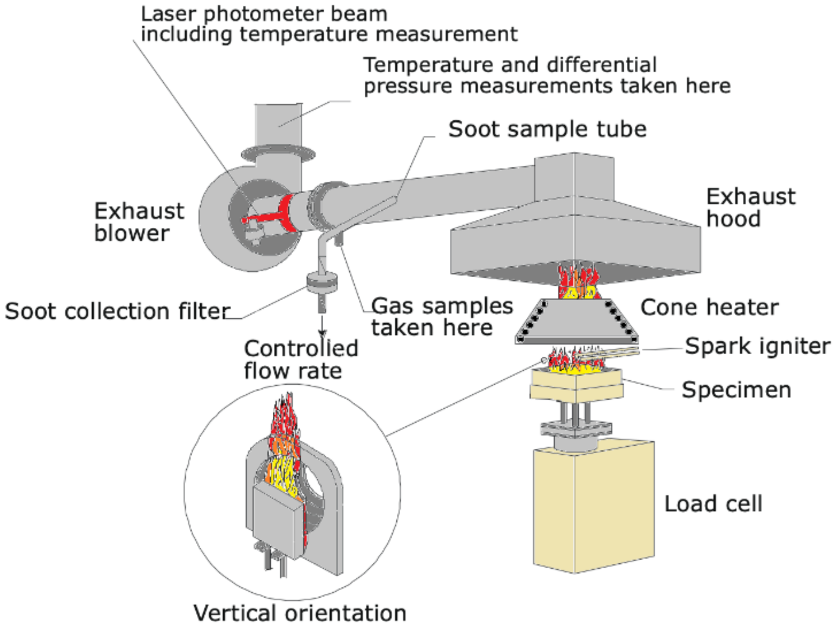
William Jones
Marine Manager, North America
(850) 572-1852
wjones@stimarine.com

STI Specified Technologies Inc.
We engineer peace of mind.

Testing Overview

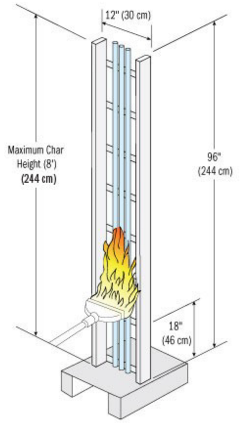
NAVSEA Cone Calorimetry Testing (ASTM D6113):

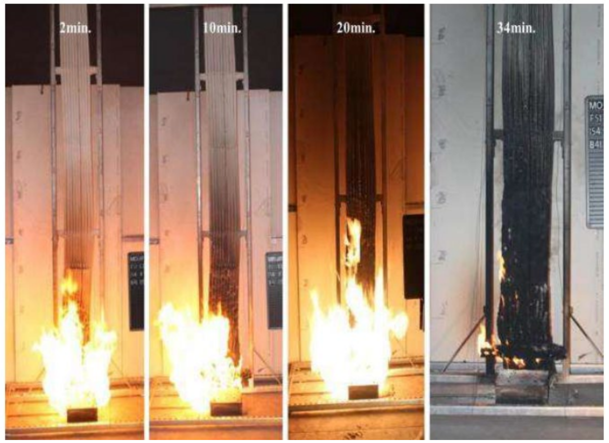
- Evaluate MCC for Heat Release Rate, Smoke Release rate, Mass Loss Rate
- Compare combinations of coatings on cables:
    - Uncoated (baseline)
    - MCC
    - Paint
    - Paint + MCC
    - MCC + Paint



SwRI Modified UL 1666 Testing:

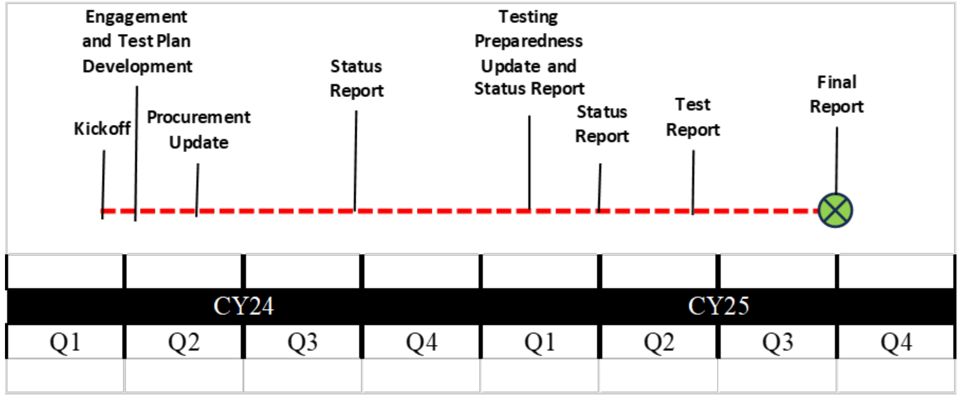
- 154 kW fire exposure
- Vertical orientation of samples representing 2 story run
- Considered worst case scenario for flame spread
- Baseline and coated cables for comparison





Current Status

- All subcontracts executed (STI, FMM, SwRI)
- Test scope defined and reviewed with SwRI and NSWCCD
- FMM has procured the approximate 600 feet of cable necessary for test execution
  - LS2SWU-12 per MIL-DTL-24643/33G
- STI has delivered MCC to FMM
- STI has provided virtual training on recommended equipment configuration and application
- FMM established internal coating instructions, QA procedures, and shipping plans
- Finalizing paint crew schedule



Path Forward

- Once coated, cables will be distributed to testing sites and evaluated against baseline
- Project team will review data and recommend next steps in transitioning MCC for shipyard application
- Establish risks, benefits, and costs associated with implementation across shipyards