Project #S2723
False Deck Panel Improvement

NSRP All Panel Meeting

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Project Team

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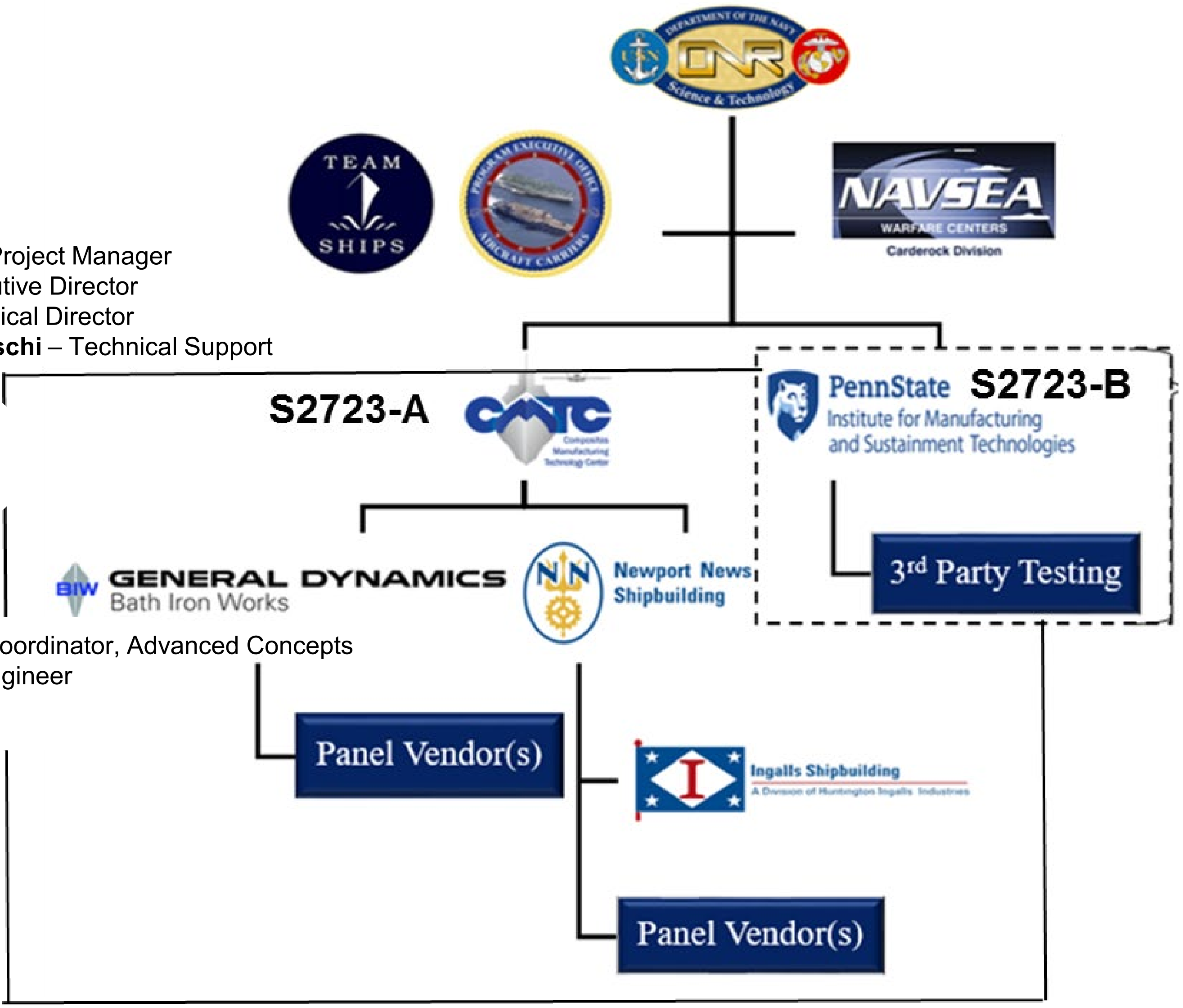

BIW:
Ken Brill(retired) – ManTech Coordinator, Advanced Concepts
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ONR:
Neil Graf - Program Officer (CMTC)
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NSWCCD
Dr. Maureen Foley – Technical Support
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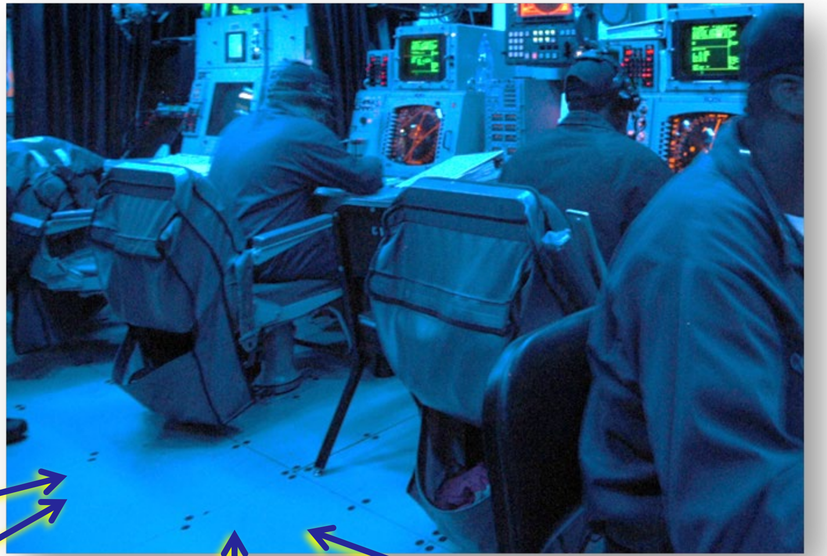
Tim Bair– Director

HII-NNS:
Harold Howard – FI Program Office
Glenn Dorsey – Program Manager FI & Physical Open Architecture

HII – Ingalls:
Ron McClellan – R&D
Austin Shaw – R&D

Overall Program Vision & Objectives

Figure 1: False Deck. Adapted from Wikimedia Commons (2009)



Evaluate various material and process technologies to improve design, provide a variety of panel design, reduce acquisition cost, reduce installation costs and increase supplier base for DDG 51, CVN, LHA, LPD, and other surface ship platforms.

Goal was to identify multiple material architectures that meet all surface fleet interior application requirements to leverage economies of scale.

8,000ft^2

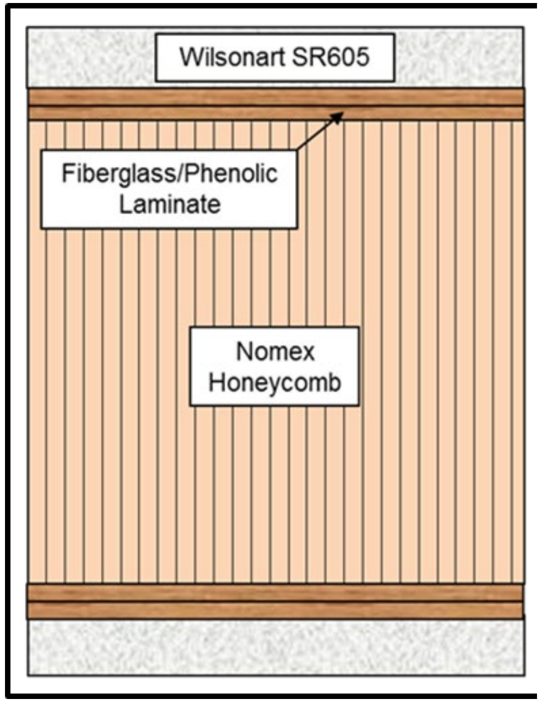
14,500ft^2

13,000ft^2

8,000ft^2

False Deck Panel: Improved Design, Reduced Costs, Fleet Commonality

Problem Statement / Project Objective



Nomex Core Deck Panel Issues In-Fleet

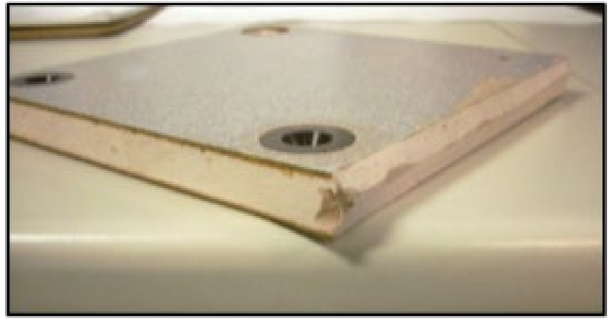
- **Problem Statement:**
  - The current honeycomb resin core Nomex® false deck panels necessitates a complex, labor intensive edge treatment and manual measurement process for false decking fabrication and installation. Wilsonart wear surface material edges chips and delaminate. This project seeks to reduce the cost and time associated with these processes.
- **Project Objective:**
  - Evaluate various material and process technologies to improve design, reduce acquisition cost, reduce installation costs and increase supplier base for the U.S. Navy surface fleet.

Issues occur in the Shipyards, and in the Fleet.

Issue Description – Current Aramid Honeycomb Panels

- **Form 1** panels are cut to fit around objects in the space and must be sealed using a multi-step edge sealant . Complex process of cutting and sealing is very labor intensive, especially when modifications occur to the space or when correcting templating errors. During installation and removal, delamination occurs.

- **Form 2** use standard panels with phenolic trim perimeter for the interior portions of each space and solid phenolic perimeter core. Difficulty in finding suppliers due to labor intensive manufacturing process, and costs have continued to rise (48%).

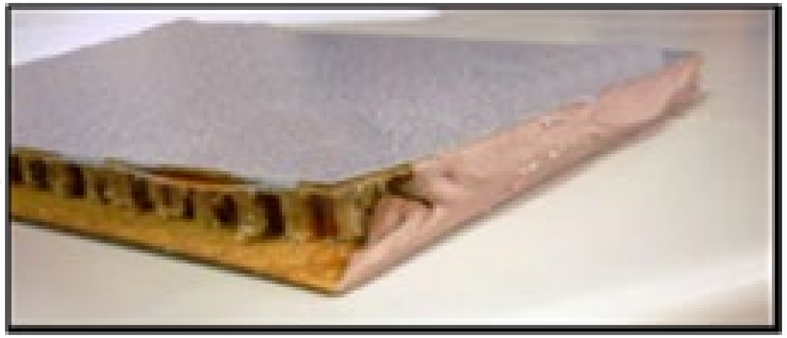


Form 1 grinding and smoothing edge treatment

Form 2 solid phenolic perimeter core

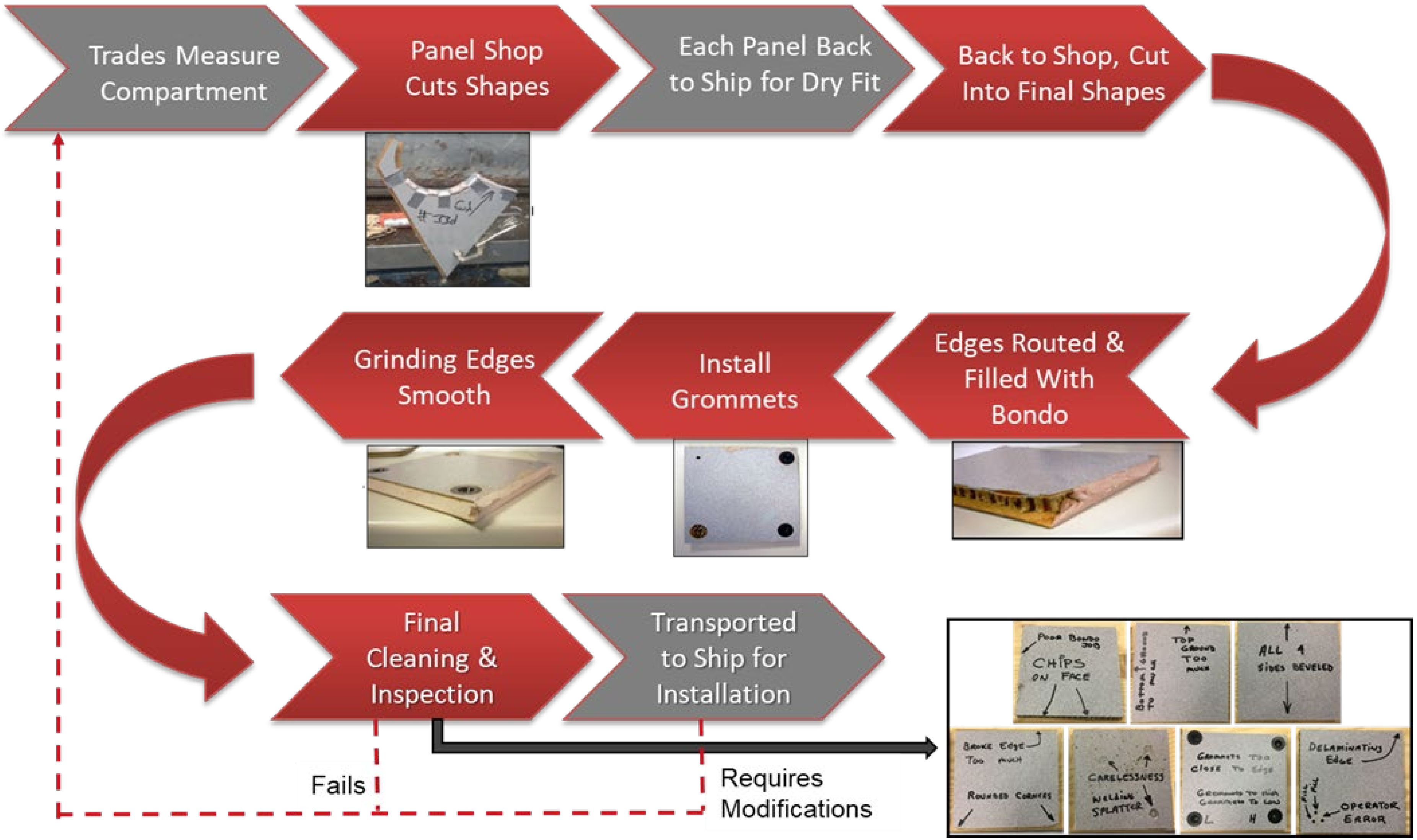
Issue Description –Wear Surface Material

- **Form 1** – Edge Routed & Filled with Bondo
  - Ground down too much Wilsonart
  - Beveled sides
  - Rounded corners



- **Forms 1 & 2** Durability Issues in the Fleet
  - Cracking
  - Chipping
  - Delamination

False Deck Installation Process – Standard Interface



Extended, Labor-intense, and Error Prone Process

False Deck Flexible Infrastructure – CVN / Surface Ships

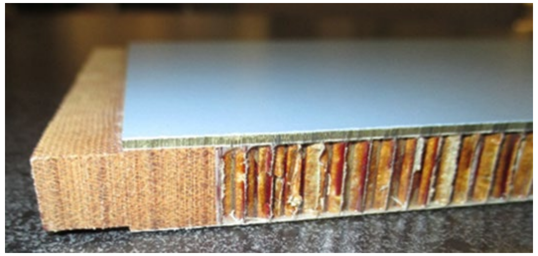
CVN Chief Technology Officer

Navy/Government Support

Technical Warrant Holders

Standard FI Deck Tile (cut to show internal Nomex)

- Nomex Honeycomb Core
- Face Sheets
- Double-Sided Use
- Phenolic Trim Perimeter



Solid FI Deck Tile

- Phenolic Core
- Face Sheets
- Double-Sided Use
- No Edge Treatment Required When Cut

Concerted effort since 2015 to develop specs and identify a new product

Consolidated efforts with false decking in 2017

Phase 1 Project Overview

Task 4 – Metrology

- Short-term Solution
  - Software package to transmit full-scale printable template required to cut around objects, needs to include required notes for special features, such as beveled and angled cuts
- Long-term Solution
  - Scanning solution to pass data from a CAD package to a Computer Aided Manufacturing (CAM) software system connected to a CNC machine

Task 5 – Sub-Scale Development and Testing

- Conducted Screening / Verification Evaluations on down selected architectures
- Conducted Go / No-Go Gate Review
- Selected architecture(s) for further verification and Full-Scale Demonstration activities

Phase 1 Project Overview, Cont'd

Task 6 – Full-Scale Demonstration

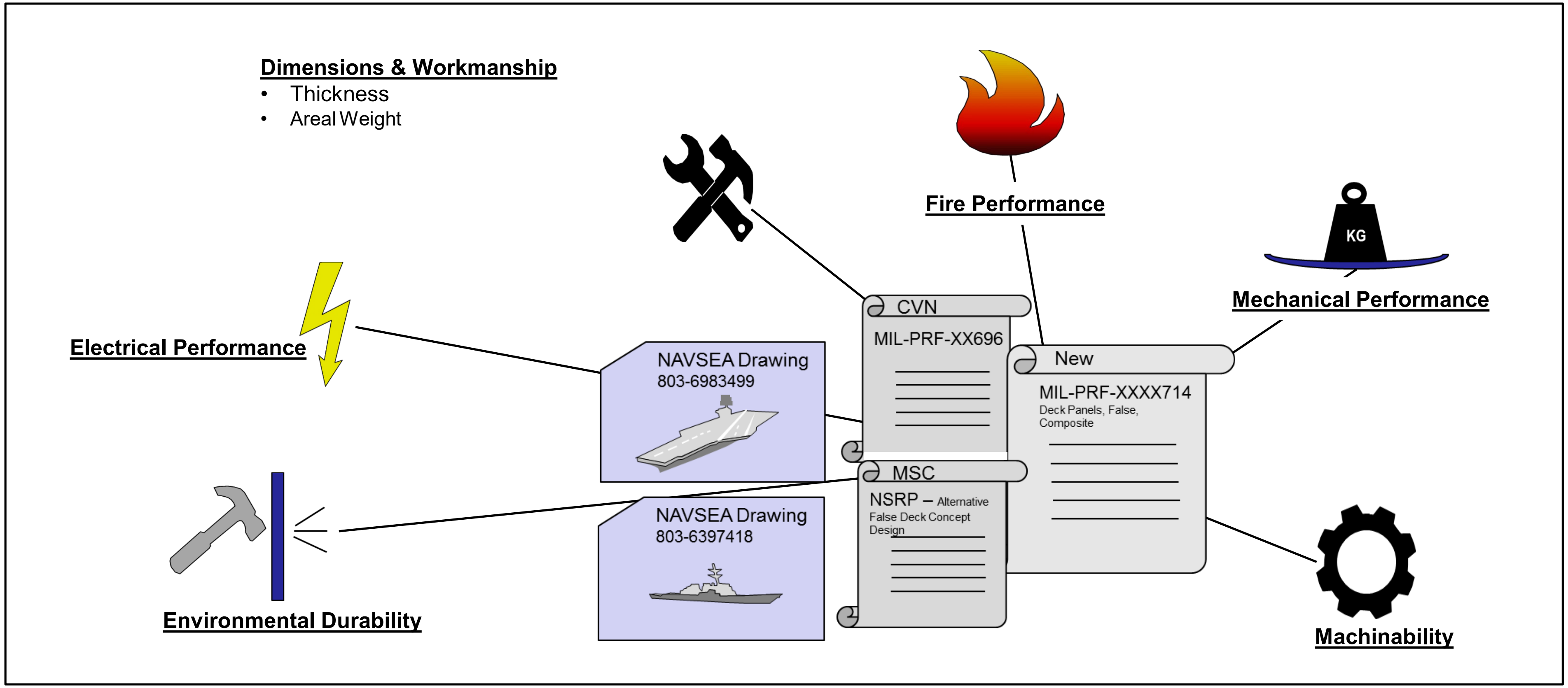
- Procured False Deck panels from selected vendors for evaluation
- Conducted verification evaluations (demonstration, inspection, analysis, & Testing) at ARL-PSU, NSWCCD, Third Party Test Facilities, and potentially other Naval Facilities
- Conducted Full-Scale demonstration events at BIW (DDG 51) and HII-NNS (CVN)

Task 7 – Program Management & Requirements Finalization

- Standard Program Management Activities
- Worked with NAVSEA to finalize comprehensive requirement set

Requirements Definition

MIL-PRF-XXXX714 Test Criteria



- Requirements reviewed for applicability to current and future panel options.
- Capitalized on lessons learned by Material Sciences Corporation and NSWCCD from their *Alternative False Deck Concept Design* NSRP project.

MIL-PRF-XXXX714 Details

Electrical Performance

Fire Performance
- Most Difficult – Two Tests
  - Core Only
  - Final Configuration

Environmental Durability

Mechanical Performance

Title	Test Standard
Dielectric	MIL-DTL-15562G, paragraph 4.6.11
Voltage	MIL-DTL-15562G, paragraph 4.6.10
Flame Spread	ASTM E162
Optical Density	ASTM E662
Fire Toxicity (Flame and Non)	ASTM E800 (flaming and non-flaming)
Water Resistance / Moisture Absor	ASTM D570
Resistance to Cleaning Agents	MIL-PRF-32170
Heat and Light Resistance	ASTM F1514 and ASTM F1515
Light Reflectance	ASTM D523
Impact Resistance	ASTM D7766, Procedure C
Slip Resistance	ASTM D2047
Wear Resistance	ASTM D4060
Rolling Load Resistance	CISCA - Recommended Test Procedure for Access Floors
Short Beam Shear Strength	ASTM C393, Three Point Bend Configuration
Long Beam Flexure	ASTM D7249, Four Point, Quarter Span Configuration
Sandwich Compression Strength	ASTM C365
Edgewise Compression Strength	ASTM C364
Flatwise Tensile Strength	ASTM C297
Maximum Panel Deflection Form 1	NA (Only one from either Form 1 or Form 2)
Maximum Panel Deflection Form 2	NA (Only one from either Form 1 or Form 2)

Subscale Testing in Accordance with MIL-PRF-XX714

Dimensions & Workmanship Requirements

Verifications Performed during Full-scale Installs at both GD-BIW and HII-NNS

1. A **thickness** of 0.560- inch +0.015- inch, -0.00- inch
2. Panels shall have a **horizontal symmetry** through the center of the panel, or non-symmetric panels that do not trap residual stress or causes the panel to warp
3. A **flatness** of 0.016- inch per foot with no open discontinuities
4. A **squareness**, the perpendicularity of the panels' edges shall not exceed 0.01- inch
5. The **color** shall correspond to solid or marble blue, gray, green, or that approved by the procuring activity
6. An **areal weight** is dependent on the areal weight classification of the false deck panel, preferable for the panel to be light as possible within the ranges provided below:
   a) **Areal Weight 1**. ≤1.84 (lb/ft^2)
   b) **Areal Weight 2**. >1.84 (lb/ft^2) ≤2.5 (lb/ft^2)
   c) **Areal Weight 3**. >2.5 (lb/ft^2) ≤4.1 (lb/ft^2)

Subscale Testing in Accordance with MIL-PRF-XX714

Fire Performance Requirements

Testing performed at NAVSEA Warfare Centers, Carderock Division

1. **ASTM E162 – <u>Flame spread index</u>**, maximum index of 25 with no evidence of melting, dripping, or flaming droplets (aramid core, 3/16”, 0.5 pounds per square feet (lb/ft^2) is permitted to use the flame spread requirement of 45)
2. **ASTM E662 – <u>Smoke optical density</u>,** maximum smoke optical density of 200 for both non-flaming and flaming, with no evidence of melting, dripping, or flaming droplets
3. **ASTM E800 – <u>Fire gas toxicity</u>** shall meet the fire gas toxicity requirements in accordance with T9070-AK-DOC-010/078 in both flaming and non-flaming modes, except the following limits shall apply:
    i. Carbon Monoxide (CO): 600 ppm maximum
    ii. Hydrogen chloride (HCL): 30 ppm maximum
    iii. Hydrogen cyanide (HCN): 30 ppm maximum
4. **<u>Fire gas immediately dangerous to life and health (IDLH) index</u>** shall be <1, calculated using the following equation:

$$I_{IDLH} = \frac{C_{CO}}{I_{CO}} + \frac{C_{CO_2}}{I_{CO_2}} + \frac{C_{HCl}}{I_{HCl}} + \frac{C_{HCN}}{I_{HCN}} + \frac{C_{HF}}{I_{HF}} + \frac{C_{H_2S}}{I_{H_2S}} + \frac{C_{SO_2}}{I_{SO_2}} + \frac{C_{NO_2}}{I_{NO_2}}$$

Chemical Compound	IDLH Values
Carbon Monoxide (CO)	1,200 ppm
Carbon Dioxide (CO2)	40,000 ppm
Hydrogen Cyanide (HCN)	50 ppm
Hydrochloric Acid (HCL)	50 ppm
Nitrogen Dioxide (NO2)	30 ppm
Hydrogen Sulfide (H2S)	100 ppm
Hydrogen Fluoride (HF)	100 ppm
Sulfur Dioxide (SO2)	12 ppm

Subscale Testing in Accordance with MIL-PRF-XX714

Mechanical Performance Requirements

Testing performed at Westmoreland Testing & Research in Youngstown Pennsylvania

1. ASTM C393 – **Short beam shear strength** –270 psi minimum

2. ASTM D7249 – **Long beam flexure** – minimum ultimate 225 pounds

3. ASTM C36 5 – **Sandwich compression strength** – minimum 900 psi

4. ASTM C364 – **Edgewise compression strength** – minimum 2,230 psi

5. ASTM C297 – **Flatwise tensile strength** – minimum 200 psi

6. Two **deflection tests** under 300 pound load
   1. Form 1 – Maximum 0.16- inch
   2. Form 2 – Maximum 0.20- inch

7. A **Form 1 Permanent deflection** under 1000 pound load – No signs of damage
8. A **Form 2 Permanent deflection** under 300 pound load – No signs of damage

Subscale Testing in Accordance with MIL-PRF-XX714

Electrical Performance Requirements

1. MIL-STL-15562G, Paragraph 4.6.10 – **Voltage** – Must Pass

2. MIL-DTL-15562G, Paragraph 4.6.11 – **Dielectric strength** – Minimum of 30,000 Volts AC

Environmental Durability Requirements

1. ASTM D570 – **Water resistance** – No warping, expansion, contraction with no signs of blistering, wrinkling, delamination, or

2. ASTM D570 – **Moisture resistance** – No warping, expansion, contraction with no signs of blistering, wrinkling, delamination, or discoloration

3. MIL-PRF-32170 – **Resistance to cleaning agents** – No warping, expansion, contraction with no signs of blistering, wrinkling, delamination, or discoloration

4. ASTM F1514 & ASTM F1515 – **Heat and light resistance** – Panel shall not have a measured change in color greater than 5 ΔE and shall show no appreciable delamination or signs of checking, cracking, or any other deterioration on its exposed surface
5. ASTM D523 – **Light reflectance** – Gloss rating of 25 – 35

Subscale Testing in Accordance with MIL-PRF-XX714

Environmental Durability Requirements, Cont'd

6. ASTM D7766, Procedure C – **Impact resistance** – No signs of chipping, cracking, splintering, blistering or delamination at an imparted energy of 150 inch-pounds (in-lb)

7. MIL-DTL-901 – **Shock resistance** – Resistance to damage or failure due to shock grade A for Form 1, and grade B for Form 2 (Not covered under the ManTech effort)

8. ASTM D2047 – **Slip resistance** – Static coefficient of 0.70 or better

9. ASTM D4060 – **Wear resistance** – Not exceeding 0.001oz loss

10. CISCA – **Rolling load resistance** – No splintering, blistering, or delamination under 300 pounds

Subscale Testing in Accordance with MIL-PRF-XX714

Machinability Requirements

The machinability of the false deck panel material shall be evaluated by performing a visual inspection of the cut surfaces after using standard hand-tools

Equipment Type	**Details**
Circular Saw	SSC model 5860-72:78 with 8 inch blade or Dewalt 7 ¼" Ripping Circular Saw Blade (36 number of teeth) or equivalent
Band Saw	No specific call out
Saber/Jig Saw	Milwaukee Brand Jig Saw with Carbide Blades or equivalent
Drill Press	Jet drill press 12 speed with 1 1/16 countersink drill bit, Walker drill press with countersink 3/8 drill bit or equivalent
Hand Drill	Makita 18V Cordless or equivalent
Router	Porter Cable or equivalent
Sanding	Files, 3 inch grinders, hand sanding blocks

Subscale Testing in Accordance with MIL-PRF-XX714

Interface Capability Requirements

Form 1 false deck panels capable of being attached to the supporting framework using polyamide plastic (nylon self-starting screws, ¼- inch FH20UNC-2A, 1 ½- inch long (or equivalent) Nylon ferrules, 5/16- inch inside diameter, Shurlock Corporation (or equivalent), SL 5229, may be installed (if necessary) in panels along the edges located on 12-inch maximum Centers. Ferules and screws shall be a flush fit and secured in to the panel using an epoxy adhesive, MIL-A-82720. Ferrule edges shall be ¼- inch ±0.030 from any edge.

Form 2 shall be capable of being placed on the flexible infrastructure deck track and help in place with the track cover, and all testing occurred at HII-NNS.

Task 4 – Metrology

Short-term Solution

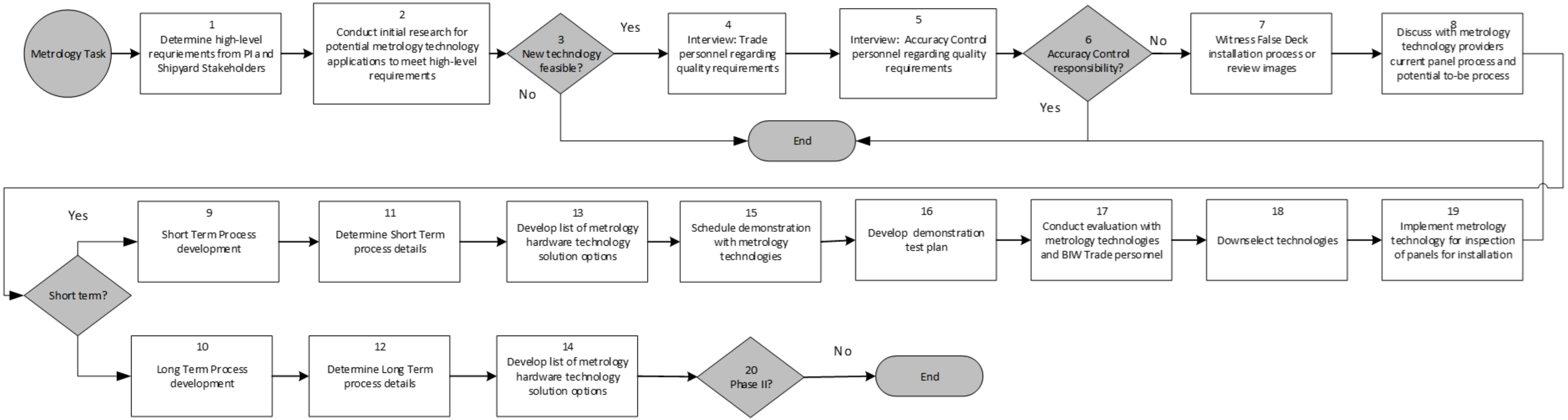
- Software package to transmit full-scale printable template required to cut around objects, needs to include required notes for special features, such as beveled and angled cuts.

Long-term Solution

- Scanning solution to pass data from a metrology package to a Computer Aided Manufacturing (CAM) software system connected to a CNC machine.

Metrology

- ARL used this flowchart to identify questions and best path forward towards identifying new metrology tool(s) for BIW and NNS-Ingalls
  - Occurred at both GD-BIW and HII-Ingalls
  - GD-BIW has purchased a tool, HII-Ingalls is down-selecting a tool



Metrology Device Selection

- Following on-site demonstrations of each of three down-selected devices, the ProDim Proliner was found to meet the accuracy requirements, the simplest to set up and use, and a reasonable price point.
- Accordingly, GDBIW selected the ProLiner 10iS for purchase and use. Key characteristics include:
  - Output produced in .DXF file format
  - Export files via thumb drive
  - Ability to save files by compartment name and number
  - Uses stylus pen type device for measurements
    - Stylus pen tethered to base unit via Kevlar wire
    - Uses second device (“clicker”) to establish taking the point reading
  - Offers a scanning mode to collect multiple points at once (works great for radius areas/odd shapes)

Long-Term Solution Test Method and Results

- Eleven panel pieces recorded as .dxf files were programmed and nested for cutting on the waterjet
- Several quality settings, regulating travel speed, were tested to determine optimal cut quality and rate, using the normal velocity stream rate of 55,000 psi
- The slowest travel speed of ~0.3 inches/second produced the best quality cuts (Figure 1). Rates of ~1.0 inches/second in some cases caused delamination of the aluminum and/or the wear surface (Figure 2)

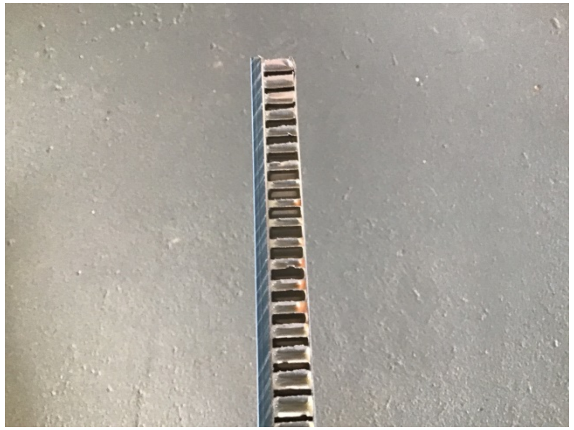
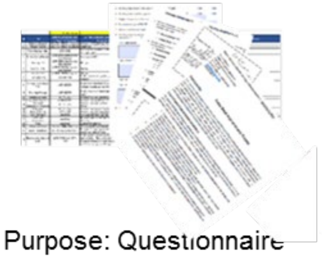


Figure 1 – Clean Edge on Slow Travel Speed

Figure 2 – Damaged Edge on Fast Travel Speed

Task 5 – Subscale Development & Testing

Product & Material Evaluations Identified Vendors & Materials



Purpose: Questionnaire
Sent to 20 Vendors

Distributed: Dec 2017
Returned: Jan 2018

Merged requirements for both False Decking and Flexible Infrastructure for Product Questionnaire

One Military Performance Specification Drafted with TWH Inputs (24 qualification tests)

MIL-PREF-XX696 merged with MIL-PRF-XXXX714 (TWHs were involved)

MIL-PRF-XX696
Performance Specification
Flexible Infrastructure

MIL-PRF-XXXX714
Performance Specification
DDG

Distributed: Dec 2017
Returned: Jan 2018

Reviewed 14 Returned Questionnaires – 10 Were Down-selected to Advance

CoA – Further Reduction – 7 panels selected

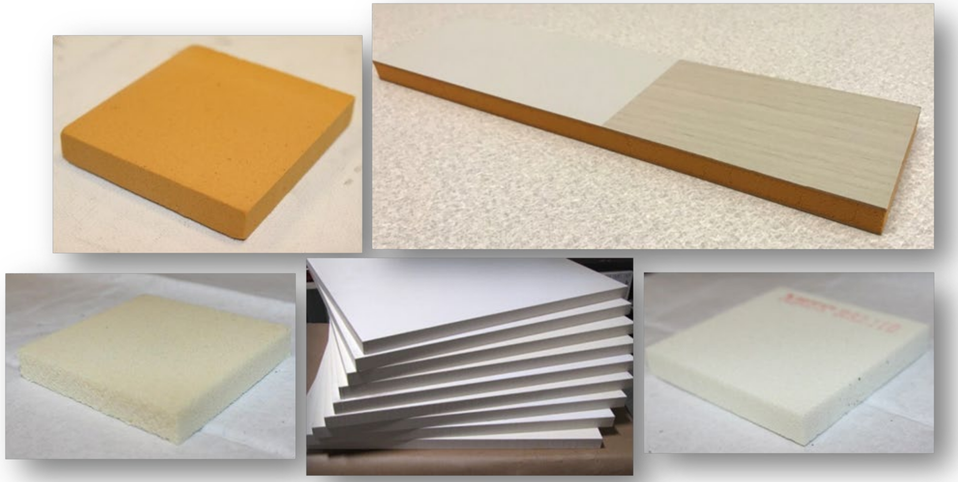
Sub-scale Testing to Occur at Carderock (FST), ARL-Penn State (Mechanical), 3rd Party Testing Labs

Sub-scale Material Requested: March 2018

Material Arrives for Testing: May 2018

Additional Panels Were Submitted & Tested During Project

Summary of New Panel Design Materials Evaluated



Cores
- Reinforced Polyurethane
- Phenolic Syntactic Foam w/ Glass Microspheres
- Architectural Phenolic Design Foam
- Closed Cell Thermoplastic Polymer Foam
- Balsa
- Aluminum Honeycomb
- PET Foam
- Epoxy Foam

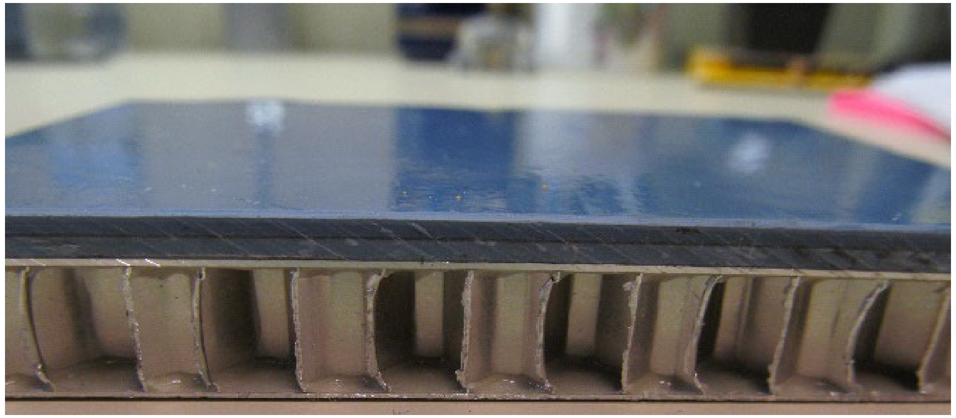
Wear Surfaces
- Fiberglass Veil
- Lonmat
- Proprietary Solutions

Face Sheets
- Fiberglass Reinforced Phenolic
- Fiberglass Reinforced Polyester
- GRP
- Aluminum

Most Vendors Did Not Include Wear Surfaces in Initial Design Submittals, False Deck Team Evaluated PEI, PEEK, PVDF, PVF, PVC

Twelve Vendors Submitted Test Articles

Aluminum Honeycomb Core Design



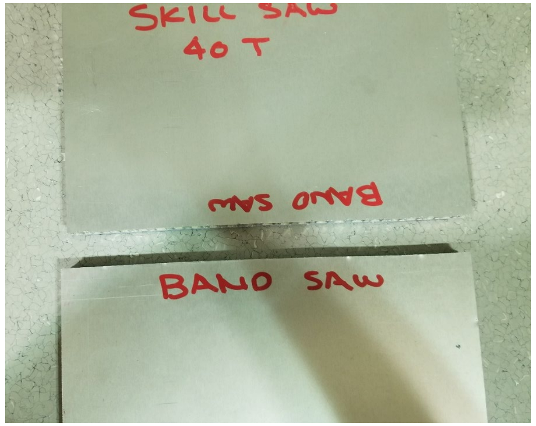
- Standard Interface Panel (no edge preparations) – cost and labor savings, increases weight by 0.11 psf compared to legacy panel
- Flexible Infrastructure Tile - cost savings and increased available supplier base

Summary of Test Results:

- Fire Performance – Not required
- Mechanical Performance - Passed
- Electrical Performance - Passed
- Dimensions and Workmanship - Passed
- Environmental Durability (limited testing required due to Lonmat already used in the Navy)
  - Rolling Load Resistance - Passed
  - Water Resistance - Passed
  - Moisture Absorption - Passed
  - Shock is ongoing with the shipyards
- Machinability - Passed

VASCIC Small Scale Demonstration - Aluminum Panels

Twenty-five (25) aluminum honeycomb panels were installed into the flexible infrastructure at VASCIC – Newport News for fit, form, and function.




Hole Saw and Grinder

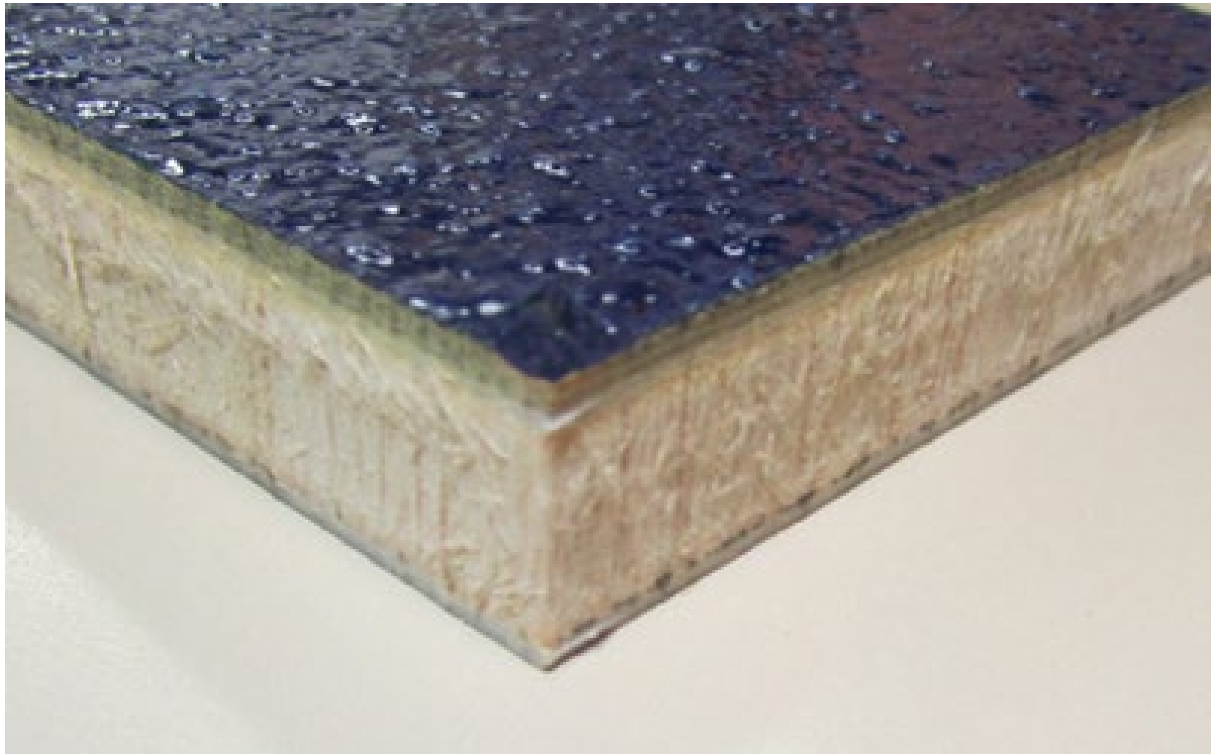
Panels were successfully cut with the following:

- Chop saw
- Skill saw
- Band saw
- Hole saw
- Grinder

After cuts were made there were no sharp edges to cut your fingers, a deburring tool was used to remove some material left behind from cutting

The panels fit perfectly inside the Flexible Infrastructure track, and track covers were installed without incident

Infused Balsa Core Designs



Proprietary Wear Surface Shown

Summary of Test Results:

- Fire Performance – Passed
- Mechanical Performance – Passed
- Electrical Performance – Passed
- Dimensions and Workmanship – Passed
- Environmental Durability –
  - Water Resistance – Passed
  - Moisture Absorption – Passed
  - Shock TBD with the shipyards
  - Machinability – Passed

Current Activities – Bath Iron Works

- Took receipt of the first 100 balsa panels in late February. Targeting DDG 122 for first installation.

- The balsa core panels ordered are 23% more expensive than the average cost of the aramid panels.

- Accomplished two small demos of the materials on DDG 118 and 120, however, no cost or schedule savings can be shown for those because they used a small quantity of both aluminum core and balsa core panels along with the regular aramid core panels.

- Still a significant savings per hull due to not having to transport, route, apply the bondo to seal the panel edges, grind, sand, clean, and transport the panels back again.. This projects to **over 5,000 man hours saved per ship**.

-

  Actuals will be updated to show for the install of this new balsa material across an entire ship(expected end of 2021).

Current Activities – HII-NNS

- In discussions to gain NAVSEA concurrence to add the spec to the CVN 78 Class Carriers.
- Implemented 2800 sq ft of the aluminum core panel on CVN73 (roughly 5 different areas).
- Comparing costs between CVN 72 and CVN 73, the aluminum core panel reflected a 52% procurement savings.
- Once approval is gained to implement on CVN78 class, similar procurement savings are projected(ECD end of 2021 for approval)

Conclusion

- Project facilitated a common material specification which will provide beneficial economies of scale for False Decking across Naval platforms both within and outside of DDG and CVN classes
  - MIL-PRF-32664 (released Sep 2020) allows for multiple vendors to qualify product(s) to further provide cost savings through industrial competition

- Defined a metrology solution that can be applied across multiple shipyards

Questions?