2017 All Panel Meeting
March 7-9, 2017
Charleston, SC
Dr. Julie Christodoulou

Director of the Naval Materials Division, Sea Warfare and Weapons Department, ONR
Warfighting Capabilities Enabled by S&T Investments

Portfolio is balanced across near, mid and long term S&T investments.

CNR’s S&T Investment Priorities

- Directed Energy/Electric Weaponry
- Cyber
- Electromagnetic Maneuver Warfare
- UxS Maneuver Warfare
- Synthetic Biology/Bio-Inspired Technologies

Focus

1-2 years
Quick Reaction S&T (SwampWorks, Experimentation) ≈ 8%

2-4 years
Technology Pull (FNCs, ManTech, TechSolutions) ≈ 30%

4-8 years
Technology Push (Leap Aheads, Innovative Naval Prototypes) ≈ 12%

5-20 years
Discovery & Invention
(Basic and Applied Science) ≈ 50%

Broad-Based Basic/Applied Research

Current Fleet/Force

Fleet/Force in Development

Future Fleet/Force

Distribution A. Approved for public release; distribution is unlimited. DCN# 43-2499-17
Integrated theoretical, computational and experimental programs to understand and develop the physics, chemistry, materials and processing that confidently meet critical naval needs

**High Performance Functional Materials**
- Power Generation & Energy Storage Materials
  - Electrochemical Materials
  - Polymeric and Organic Materials
- Piezoelectric Materials

**High Performance Structural Materials**
- Structural Metallic, Structural Cellular and Composite Materials
- High Temperature Turbine and Ultra-high Temperature Materials
- Welding and Joining
- Optical Ceramics

**Environmental Quality**
- Anti-fouling Release Coatings
- Solid and Liquid Waste Treatment

**Optimization from Design thru System Life**
- Computer Aided Materials Design
- Scarce Element Mitigation Strategies
- Solid Mechanics and Fatigue
- Non-Destructive Evaluation and Prognostics
- Additive Manufacturing
- Integrated Computational Materials Engineering
Historical Perspective

The Pursuit of Computation-guided Experimentation in Materials Research

1988
- COTA: Advanced Materials by Design

1989
- NRC: Materials Science & Engineering for the 1990s

1995
- DOE: Advanced Strategic Computing Initiative

1999
- DARPA-AIM

2001
- AFOSR-MEANS

2004
- ONR-D3DDS

2008
- DOE-CMS&C

2010
- NSTC-AMP

2011
- NSTC-MGI

2012
- NSTC-AMP

2013
- NSTC-NNMI

Adapted from T. Pollock, July 2011

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Airplane Development vs Airplane Material Development

Airplane Dev

Market

Airplane Study

Launch

Firm Config.

Build

EIS

Materials Dev

Materials Need ID’d

R&D

Scale-Up

Design Allowables

Prod. Ready

Previous Dev Efforts

Time (Years) →

5-7 Years

2-3 Years (ideal)

8-10 Years (reality)

Adapted from J. Cotton, April 2012

Production Materials Orders

2-3 Years (ideal)

8-10 Years (reality)

Previous Dev Efforts

Materials Need ID’d

R&D

Scale-Up

Design Allowables

Prod. Ready

Adapted from J. Cotton, April 2012
Microstructure

The Center of the Universe

$Ti\alpha–\beta$ microstructure

... for some
Mechanical Properties

Common Engineering Concepts?

Reality?

EBSD image

MIL-HBK-5H

Adapted from D. Furrer, April 2013

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Accelerated Insertion of Materials

Distributed Design for Performance and Manufacturing

Disk CAD model (at GE Evendale, OH)

PRECIPICALC : γ’ Model (Model Run at Questek, Chicago, IL)

Strength models (Models Run at U. of Michigan Ann Arbor, MI)

Objective: Estimate fracture load and location.

Heat treatment model run at GE-CRD, Schenectady, NY.
Process model at Laddish, Milwaukee, Wis)

Precipitate Size Distribution

Reppich Model
Brown and Ham Model

2000 - 2004

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AIM Materials Development

Efficient use of models, experiments, and experience reduces design challenges and enables performance probability distribution predictions and reliable confidence levels.
Accelerated Insertion of Materials

Full AIM tool demonstration at the component level

Integrated tool & models reduced development and test cycle by greater than 50%

Performance

Allowing concurrent optimization of processing/microstructure and disk geometry enabled

~ 20% Part Weight Reduction &
~ 19% Burst Speed Increase

2000 - 2004
Dynamic 3-D Digital Structure

Applying the ICME methodology to materials research

Focused on Tools

Develop and demonstrate the fundamental research approaches and tools necessary to provide a computational basis for materials processing and behavior

Key Technical Thrusts

– Characterization and digital representation of microstructure
– Simulation and prediction of microstructure evolution in response to processing and/or use environment
– Tools for integration of computation and experiment

2004 - 2009
High fidelity 3-D synchrotron imaging techniques and robust phase field modeling capture anisotropy effects

Quantified Observations & Greater Understanding

- The morphological evolution of a grain depends only on its local ensemble of grains.
- The mobilities of a grain’s boundaries can vary by orders of magnitude and depend strongly on the grain boundary normal.
- Even without accounting for anisotropy in the grain boundary energy, surprisingly accurate morphologies and topologies in the isotropic regions of the experimental dataset are predicted.

E. Lauridsen, Risø-DTU; P. Vorhees, Northwestern U  2004 - 2009
Tri-Beam Electron Microscope

Rapid serial sectioning and characterization

Femtosecond laser ablation, coupled directly to Electron Back-Scatter Diffraction (EBSD) to obtain 3-D microstructures.

T. Pollock, U Michigan & UC Santa Barbara  2004 - 2009
Quantification of Particle Spatial Nonuniformity

Simulations
- LEAP Cu (1-10 nm)
- PrecipiCalc-3D Cu (2-8 nm)
- FIB/SEM TiC (0.1-0.5 mm)

Experiments
- LEAP Cu
- Met/LOM TiN (1-10 mm)

Spatiallyzer-N

Mean number of particles in selected sampling volume

PrecipiCalc-3D TiC (0.1-0.5 mm)

FIB/SEM TiC (0.1-0.5 mm)

Spatiallyzer-L

LOM TiN: Bi-Modal

More clustering with increasing aging time

random

Herng-Jeng Jou, QuesTek 2004 - 2009

Mean number of particles in selected sampling volume

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3-D Cracktip Reconstruction

Mod4330
Integrated Computational Materials Engineering (ICME)

**Processing**
- Post-weld Treatment and Paint Bake
- Joining
- Working/Aging
- Cooling
- Hot Rolling
- Homogenization
- Solidification
- Melt Practice

**Structure**
- **Matrix Phase**
  - Solid-Solution Strengthening
  - Grain Structure
  - Dislocation Structure
- **Stable Second Phase**
  - Constituent Phases (1-10 μm)
  - Dispersoids (0.05-0.5 μm)
- **Robust Precipitates**
  - Stable High Temperature Dynamic
- **Grain Boundaries**
  - Segregation Control
  - GB precipitate avoidance
  - Precipitate Free Zones

**Properties**
- **Base Strength**
- **Heat Affected Zone Strength**
- **Environmental Resistance Stress Corr. Cracking Intergranular Corrosion**
- **Formability**

**Performance**

*NRC Report on ICME (2008)*
National Attention

Materials Genome Initiative for Global Competitiveness

1. Incentivizing open paradigms of sharing and access of tools
2. Facilitating the development of innovation ecosystems and access to all stakeholders
3. Driving innovation techniques across computation, informatics and experimentation
4. Catalyzing a shift in culture across the entire materials continuum and scaling the movement

...This initiative offers a unique opportunity for the United States to discover, develop, manufacture, and deploy advanced materials at least twice as fast as possible today, at a fraction of the cost.

President Barack Obama, 24 June 2011
Announcing the Advanced Manufacturing Partnership
Innovative Manufacturing Institutes

Advanced Manufacturing Partnership

- Digital Manufacturing and Design Innovation Institute (DMDII) (2014)
- The Institute for Advanced Composites Manufacturing Innovation (IACMI) (2015)
- Advanced Functional Fabrics of America (AFFOA) (2016)
- Clean Energy Smart Manufacturing Innovation Institute (2016)
- Rapid Advancement in Process Intensification Deployment (RAPIDS) (2016)
- The National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL) (2016)
- Advanced Tissue Biofabrication Manufacturing Innovation Institute (ATB) (2016)
- Advanced Robotics Manufacturing (ARM) (2017)

http://manufacturingusa.com
Reap not only the benefits of improved fuel economy but also achieve an improved vehicle

Lightweighting: The process of reducing the weight of a product, component, or system for the purpose of enhancing certain attributes, notably
(1) performance capability,
(2) operational supportability, and
(3) survivability.

Recommendations
• Digital design tools for systems engineering
  – Keep up with evolving requirements
  – Speed development time
  – Increase system flexibility
• Focus work on demonstration articles
• Emphasize affordable manufacturing technology
Lightweight Innovations for Tomorrow

Objectives
• Metal Foci: Al, Mg, Ti, other modern metals
• Four themes
  – Production Scale-up (MRL 4-7)
  – Shorten Design-to-Production Cycle
  – Affordable Manufacturing Processes
  – Tools, Skills, Knowledge for Manufacturing Workforce, from Design to Manufacturing
• Integrated design, metals processing, and manufacturing of PRODUCTS

Approach:
• Establish partnerships with industry program managers and manufacturing technology developers
• Require early identification of key performance parameters (KPPs) and co-development of component and manufacturing processes enabled by ICME
• Engage community colleges and industrial training programs to ensure an able workforce

Warfighter Benefits/Impacts
• Improved maneuverability, transportability, speed, and range of military vessels, vehicles, and systems
• Increased payload capacity (weight)
• Reduced fuel consumption and costs, including support requirements
• Enhanced affordability – avoid “boutique” alloys and processes by enlarging manufacturing base
**Melt-5a Thin Wall Ferrous Castings**

*Manufacturing innovation for lightweight ductile iron castings*

**Potential for Revolutionary Change**
- Efficient design optimization
  - 30-50% weight reduction with equivalent strength
- Highly capable new processing equipment and developing technologies
- Non-standard advanced compositions
  - Enable 2-4 mm wall thickness
- Improved modeling and predicting

**Measurable Impact: Automotive example**
- Average vehicle weight: 3000 lbs.
  - Cast Iron: 333 lbs.
- Assume 40% reduction:
  - Cast Iron: 199.8 lbs.
  - Additional 133.2 lbs. removed
- Reduced weight results in reduced vehicle loads leading to secondary weight reductions
Melt-5a Thin Wall Ferrous Castings

Strategic analysis and approach

Product, process and material development for
- New ductile iron alloy
- Cast prototype parts
- As-cast and machined wall thickness reductions
- Weight reduction

![Image of cast part](image)

<table>
<thead>
<tr>
<th></th>
<th>Current Production</th>
<th>LIFT Design</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight (lbs.)</td>
<td>Min Thickness (mm)</td>
</tr>
<tr>
<td>As-cast</td>
<td>17.4</td>
<td>10</td>
</tr>
<tr>
<td>Machined</td>
<td>12.1</td>
<td>6</td>
</tr>
</tbody>
</table>
Melt-5a Thin Wall Ferrous Castings

Exploiting unique LIFT capabilities

Product Design and Manufacturing
• 3D printing, simulation support, trials (Grede)
• Machining development (Eaton)

ICME
• Design and material optimization (PDA)

Societies / Associations
• Chemistry development, research (AFS)

University
• Chemistry, modeling, trials, characterization (MTU)
• Cost modelling and impact (MIT)
• ICME oversight and guidance (UM, OSU)
Demonstrate Advanced Manufacturing Capabilities to Enable Systems with Key Attributes:

- Lightweight
- Reliable
- Survivable
- Fuel Efficient
- Affordable (broad market demand)
- Flexible (increased margin for growth)
John Carney

Director, Affordability Initiatives Division and Navy ManTech Program, ONR
Navy ManTech Program
Impacting Key Platform Affordability

John Carney
Director, Affordability Initiatives and Navy ManTech (ONR 03T AI)
8 Mar 2017
Vision: Integrated approach from S&T basic research through industrial base preparedness (6.1 through 6.3) to address manufacturing and affordability in manufacturing for DoN systems

6.1 – Manufacturing Science
Novel manufacturing technologies and control methods to produce critical new and replacement parts on-demand

- Cyber-Enabled Manufacturing Systems for Direct Digital Manufacturing (CeMS-DDM)

Dr. Richard Fonda, NRL

Budget: $0.725M

6.2 – Mfg Applied Research
Scale-up and development of emerging manufacturing process innovations for product-related S&T programs (FNCs) to reduce cost of fielding new capabilities

- Azimuth and Inertial MEMS Disk Resonator Gyros
- Additive Manufacturing

Paul Huang, ONR

Budget: $0.931M

6.3 - Mfg Technology (ManTech) Program
Acceleration of manufacturing technologies to reduce total ownership costs for DoN systems. Focused on acquisition cost reduction for 5 key acquisition platforms.

John Carney, ONR

Budget: $56.7M
ManTech Investment Strategy

• Addressing affordability (acquisition and life-cycle)

<table>
<thead>
<tr>
<th>Affordability Initiatives</th>
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<tbody>
<tr>
<td>PEO (Subs)</td>
</tr>
<tr>
<td>VIRGINIA COLUMBIA</td>
</tr>
<tr>
<td>PEO (Ships)</td>
</tr>
<tr>
<td>DDG 51 Class</td>
</tr>
<tr>
<td>PEO (Carriers)</td>
</tr>
<tr>
<td>CVN 78 Class</td>
</tr>
<tr>
<td>PEO (JSF)</td>
</tr>
<tr>
<td>F-35</td>
</tr>
<tr>
<td>PEO (A)</td>
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<tr>
<td>CH-53K</td>
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</tbody>
</table>

• Investment Strategy focused on largest DoN acquisition programs as determined by:
  - Total acquisition funding
  - Stage in acquisition cycle (remaining years of acquisition)
  - Platform cost reduction goals
  - Cost reduction potential for manufacturing

ManTech - making a significant impact on affordability, highlighted by recent implementations and cost savings
Centers of Excellence

- Executed through Centers of Excellence (COEs)
  - Execute projects; manage project teams
  - Collaborate with acquisition program offices / industry to identify and resolve mfg issues
  - Develop and demo mfg technology solutions for identified Navy requirements
  - Facilitate transfer of developed technologies

**New Award**

- **Electro-Optics Center (EOC)**
  Operated by Penn State Univ
  Freeport, PA

- **Electronics Manufacturing Productivity Facility (EMPF)**
  Operated by American Competitiveness Institute (ACI)
  Philadelphia, PA

- **Composites Manufacturing Technology Center (CMTC)**
  Operated by Advanced Technology International (ATI)
  Greenville, SC

- **Center for Naval Metalworking (CNM)**
  Operated by Advanced Technology International (ATI)
  Summerville, SC

- **Navy Metalworking Center (NMC)**
  Operated by Concurrent Technologies Corporation (CTC)
  Johnstown, PA

- **Institute for Manufacturing and Sustainment Technologies (IMAST)**
  Penn State University
  State College, PA

- **Energetics Manufacturing Technology Center (EMTC)**
  Naval Surface Warfare Center – Indian Head (NSWC-IH)
  Indian Head, MD

**COE Legend**

- Contracted
- Government

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Affordability Initiatives

Affordability Assessments / Recognized Cost Savings

- **Affordability Assessments (estimate of total savings per hull)**
  - Have acquisition Program Office-approved process for assessing cost savings of current ManTech portfolio
  - Assess both acquisition and life-cycle savings semi-annually

- **Recognized Cost Savings (by Shipyard)**
  - Recognized savings/hull for projects in portfolio that have either implemented to date or are in the process of implementing
  - Measurement of progress against estimated total savings per hull
  - Submitted by the applicable shipyard annually
    - Will be expanding to air Affordability Initiatives in future

<table>
<thead>
<tr>
<th>Platform</th>
<th>Acquisition Affordability Assessment - Aug 2016</th>
<th>Recognized Cost Savings - Jan 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Navy ManTech Investment ($M)</td>
<td>Probable EROM Cost Reduction per Vehicle ($M)</td>
</tr>
<tr>
<td>CVN 78 Class Carrier</td>
<td>$26.13</td>
<td>$39.54</td>
</tr>
<tr>
<td>DDG 51 Class Destroyer</td>
<td>$55.06</td>
<td>$27.22</td>
</tr>
<tr>
<td>VIRGINIA Class Submarine (VCS)</td>
<td>$86.81</td>
<td>$48.62</td>
</tr>
<tr>
<td>Columbia Class Submarine (CCS)</td>
<td>$5.68</td>
<td>$4.96</td>
</tr>
<tr>
<td>F-35 Joint Strike Fighter (JSF)</td>
<td>$41.79</td>
<td>$0.41</td>
</tr>
<tr>
<td>CH-53K</td>
<td>$5.20</td>
<td>$0.04</td>
</tr>
</tbody>
</table>
VIRGINIA Class Submarine Affordability Initiative

Navy ManTech Portfolio Specifics:
• Current portfolio of approx. $86M
• Projected acquisition savings: $48.6M/hull
  – Cost savings to date: $35.7M/hull
  – 41 implemented projects per Electric Boat (1/2017)
• Projected class maintenance/repair cost savings: $100+M

Extended affordability focus to COLUMBIA Class Submarine (CCS)

Won 2013 DOD Value Engineering Achievement Award
• Letter of appreciation from HON Frank Kendall, USD (AT&L) – Jun 2014
• Presented to ONR ManTech, VCS Production Cost Reduction Team (PMS 450), and Electric Boat – Oct 2014

Annual Navy ManTech Budget returned with yearly VCS cost savings of >$70M
COLUMBIA Class Submarine (CCS) Affordability Initiative

- Extended affordability focus to CCS
  - Some VCS-developed technology directly transferable
  - Some COLUMBIA-only projects

- Current portfolio of approx. $5.7M
  - 9 active or completing projects

- Projected acquisition savings: $4.96M/hull
  - Cost savings to date: $2.7M/hull
  - 3 projects with EB recognized savings (not yet implemented - no boat in procurement yet)

- Working with EB / PMS 450 to determine which VCS-implemented projects are applicable to CCS and determining ManTech-facilitated savings
Navy ManTech Portfolio Specifics:

• Investment: $55.1M to date (51 projects)
• Total estimated acquisition cost savings: $27.2M/hull
• Recognized cost savings to date: $16.0M/hull
  – 16 projects implemented or in process of implementation

• FY17 / FY18 planning cycles in work in coordination with HII-Ingalls and BIW
Background:
• CVN in Investment Strategy prior to switch to affordability in FY06
  – Older projects largely focused on performance improvement, weight and center of gravity reduction, and TOC reduction

• Switch to affordability focus FY06 for FY07 start
  – Majority of projects now affordability-based but still a few more performance-based

Navy ManTech Portfolio Specifics:
• Investment: $26.1M to date (41 projects)
• Total estimated acquisition cost savings: $39.4M/hull
• Recognized cost savings: $17.7M/hull
  – 11 projects implemented or in process of implementation

• FY17 / FY18 planning cycles in work in coordination with NNS
Future - Innovation

• Renewed emphasis on innovation with move to 6.3 PE
• For FY18, initiated planning cycle with COE innovation briefs
• For FY19, updating process to two-step virtual approach
  1. Shipyard briefs on shipyard vision for technology or production areas
  2. COE innovation responses by technology or production area

– Goal is increased dialogue on shipyard strategy and directed innovation
• Significant effort in digital shipbuilding across the production cycle
  – Digital in Design for Manufacturing (DFM) / Design for Production (DFP)
  – Digital in Bill of Materials (BOM)
  – Material Planning / Tracking
  – Production Planning / Control
  – Digital Work Instructions
  – Production Operations Efficiencies (AR/VR, CAM, Image Production)
  – Quality Control
Digital in DfM/DfP and BOM

Dynamic Change Awareness
Platform: DDG 51
COE: NSAM
Est. Savings: $3.3M/DDG 51 hull
$2.3M/LHA hull
• 10% reduction in pipe outfitting manhours
Status: Active
Implementation: 3Q FY17 - Ingalls

Automated Part Detail Extraction (RR)
Platform: DDG 51
COE: NSAM
Est. Savings: $503K/hull
• Reduction in labor hours required to extract / validate part details from design tool
Status: Active
Implementation: 3Q FY17 - Ingalls

Creating dashboard views from a PLM for engineering, planning, supply chain, and production control.

Streamlining process for drawing detail extraction, eliminating manual ‘touch points’ for data capture and management.

Creating dashboard views from a PLM for engineering, planning, supply chain, and production control.
Enhanced Task Assignment
Platform: DDG 51
COE: NSAM
Est. Savings: $813K per DDG 51 hull
  • Increase craft productivity by >10,000 hrs
Status: Active
Implementation: 4Q FY17 – Ingalls

Improved Cable Lay & Sequencing Tool
Platform: VCS / CCS
COE: NSAM
Est. Savings:
  • $274K per VCS hull - 10% reduction in cable lay / sequencing
  • $2.7M per CCS hull - 10% reduction in cable design / sequencing
Status: Active
Implementation: 2Q FY17 – Electric Boat

Streamlining task assignment and progressing work by automating processes to improve productivity
Digital in Digital Work Instructions

**DDG Digital Storyboarding**

- **Platform:** DDG 51
- **COE:** NSAM
- **Est. Savings:** $2.7M per DDG 51 hull
  - Cycle-time reduction and increased process efficiency
- **Status:** Completed
- **Implementation:** In Process - Ingalls

**Mobile Computing for Design Build**

- **Platform:** VCS
- **COE:** NSAM
- **Est. Savings:** $910K per VCS hull
  - 2.5% improved efficiency for employees / trades personnel in their daily activities
- **Status:** Active
- **Implementation:** 3Q FY18 – EB Quonset Pt

Reducing duration of current paper-based processes by eliminating conversion of digital data to paper and any associated delays

Creating tools and processes to enhance EB’S lean work package, structural fabrication, and outfitting system
Digital for Production Operations
Efficiencies

Digital Paint Tool & Process Optimization
Platform: DDG 51
COE: NSAM
Est. Savings: $349K per DDG hull
  • Reduction in time to validate bills and to perform Hull Billing and Change Paper Maintenance Activities
  • Reduction in error rate resulting in rework
Status: Active
Implementation: 3Q FY18 - Ingalls

Augmented Visualization for Welding
Platform: DDG 51
COE: EOC
Est. Savings: >$1.5M per DDG 51 hull
  • Improves learning curve to welder proficiency
  • Improved productivity and first-time quality
Status: Pending Award
Implementation: Anticipated FY19 - Ingalls

Creating unified digital data tool to optimize paint management process
Provides for improved visibility during the welding process
Digital in Quality Control

Efficient Identification of Plate Defects

Platforms: CVN 78, DDG 51 and LHA Class ships

COE: NMC

Goal: 3-D inspection technologies to reliably and repeatedly identify surface defects on steel plates in a shipbuilding environment

Estimated Savings:

- $3.5M cost reduction over a five-year period for CVN 78 Class at NNS
- $650K cost savings over a five-year period for DDG 51 and LHA Class at Ingalls

Status: Completed

Implementation: HII-Newport News (FY17) / HII–Ingalls (FY18)
Navy ManTech Web Site

  - Project Book (snapshot of all projects active during past FY)
  - Points of Contact Directory

- **Navigation** – [www.onr.navy.mil](http://www.onr.navy.mil); click on “03T Transition” under Directorates heading; and click on “Manufacturing Technology”
Larry Brown
LIFT Institute Executive Director
Manufacturing USA: LIFT Overview

National Shipbuilding Research Program
2017 All Panel Meeting
Charleston, South Carolina

March 8, 2017

Presented by Lawrence E. Brown – Executive Director
“There is no purpose, to which public money can be more beneficially applied, than to the acquisition of a new and useful branch of industry; no Consideration more valuable than a permanent addition to the general stock of productive labour.”

Alexander Hamilton
*Report on Manufactures*
December 5, 1791

Program assessment by Deloitte
“This study found that Manufacturing USA is a valid approach grounded in a portfolio of technology-centric Institutes”.

*Manufacturing USA – A 3rd Party Evaluation of Design and Progress – January 2017*
When You Think of Detroit...

You May Only Think of the “Motor City”
... But Detroit Does Ships Too

Commissioning of the USS Detroit (LCS 7)
October 22, 2016

“It is only fitting that the United States Navy honors the City of Detroit and its legacy as “The Arsenal of Democracy.” – Ash Carter, Former Secretary of Defense
What is LIFT?
Mission

**LIFT will ...**

Accelerate the development and application of innovative lightweight metal production and component manufacturing technologies to benefit the US transportation, aerospace and defense market sectors.

**LIFT Vision ...**

Ensure that the U.S. is the world leader in the application of innovative lightweight metal production and component/subsystem manufacturing technologies. Ensure a robust talent pipeline for metals manufacturing.
What is Lightweighting?
How Does LIFT Lightweight?

• Lightweighting does not mean just a simple material swap

• The key is to reduce the weight of a component while maintaining – or increasing – its performance

• LIFT achieves lighter weights by:
  • Rethinking the design
  • Changing the production process
  • Substituting materials
If It Moves People Or Goods...

By Land...

In the Air...

Or on the Sea

It Can Be Lightweighted To Move:

Further, Faster, and More Efficiently
LIFT’s Missions

Technology Development & Transition

Education and Workforce Development
Our Technology Scope
Working Across the Spectrum of Metalworking Processes

Priority metal classes and are:
- Advanced High-Strength Steel, Titanium, Aluminum and Magnesium

Our six pillars of technology development:
- Melt processing
- Powder Processing
- Thermo-mechanical processing
- Low Cost, Agile Tooling
- Coatings
- Joining and Assembly

Including eight crosscutting themes:
- Integrated Computational Materials Engineering (ICME)
- Design
- Life-cycle analysis
- Validation / Certification
- Cost modeling
- Supply chain
- Corrosion
- Ballistic / Blast
Our Technology Portfolio
Working across transportation, aerospace and defense industries

- All projects have applications crossing **at least two industry sectors**

- All projects are:
  - Identified and prioritized by industry partners
  - With input from government agencies to ensure deployment plans are in place

- Technology Roadmaps created and continue to evolve

- Projects authorized to-date: ~$42M
Current Technology Projects

**Agile**
- Agile Fabrication of Sheet Metal Components with Assured Properties

**Coatings**
- Integrated Database and Computational Models for Corrosion-Resistant Microstructural Design
- Electrochemical Deposition of Metals Using Ionic Liquids

**Joining and Assembly**
- Robust Distortion Control Methods and Implementation for Construction of Lightweight Metallic Structures

**Melt Processing**
- Developing and Deploying Thin-Wall Ductile Iron Castings for High Volume Production
- Thin-Wall Aluminum Die Casting Development

**Powder**
- Development of Cost-Effective, Advanced Mechanical Alloying, Powder Consolidation Processes for Aluminum MMCs

**Thermo-Mechanical Processing**
- Integration of ICME with Legacy and Novel TMP Processing for Assured Properties in Large Titanium Structures
- Processing for Assured Properties in Al-Li Forgings by Development
- Friction Stir Extruded Tubing
## Developing and Deploying Thin Wall Ductile Iron Castings for High Volume Production (Melt 5A)

### Problem
- The ability to cast thin wall ductile iron (DI) castings in a high rate production environment (up to 100,000 units per year) is critical to leveraging the high stiffness and strength afforded by these materials.

### Goals and Benefits
- **Goal:** Develop the processes required to bring thin wall, vertical green sand molded DI castings to high volume production.
- **Benefit:** Improved methods and alloys provide ability to decrease wall thicknesses by 50% and component weight by 30%-50% depending on structural loading.

### Approach
- Utilize test part to calibrate and assess vertical green sand molding line
- Develop ICME analytical methods and calibrate them to actual production parts
- Optimize production line to enable 1.5 mm casting thickness
- Design, optimize, and fabricate tooling for first production component

### Progress
- Characterization of base DI and anticipated improvement complete
- Differential case modeling complete
- Weight reduction is 38% - 40% as currently optimized
- As cast wall thickness is 2.5mm
- As machined wall thickness is 1.5mm
- Sample castings show excellent mold fill w/o carbide formation

---

**Team Members:** Grede, Eaton, AFS, Comau, PDA, MTU, UM, MIT

**Period of Performance:** 6/9/15 thru 6/24/17 (Phase 1)
LIFT - TMP-3a: Integration of ICME with Legacy and Novel TMP Processing for Assured Properties in Titanium Structures

Problem

- Widespread application and use of titanium alloys in military and commercial systems is typically hindered by the high cost of these materials and long development times.
- Currently a “trial and error” approach is used that is necessitated by the lack of robust analytical tools.

Goals and Benefits

- Goal: Develop computationally based tools that will reduce by 50% both the time and cost for materials development, component design, and manufacture.
- Benefit: Ability to manufacture components with enhanced local properties using ICME/manufacturing procedures vs. “trial and error” resulting in increased affordability and faster transition to market.

Approach

- Develop advanced V&V analytical models that improve the prediction of material properties, structural performance and fatigue properties of titanium components.
- Integrate models to create a Manufacturing Simulator that will replace the traditional “trial and error” methods currently used.

Progress

- Computational models established for prediction of microstructure and heat treat to support solid state welding
- LFW trials have been initiated
- Characterization studies underway

Team Members: GE, Boeing, SFTC, OSU, UM, UNT, Purdue, SwRI, EWI

Period of Performance: 10/8/15 thru 12/21/17

Transportation Sector
- Air (Primary)
- Land / Sea (Secondary)

Component
- Turbine Engine Blisk (primary)
- Machining Preforms (primary)

Primary Benefit
- Up to 50% reduction in design time and material costs
- Weight savings approaching to 25 lbs. per engine
**LIFT- Robust Distortion Control Methods and Implementation for Construction of Lightweight Metallic Structures (Joining-3)**

**Problem**
- Modern lightweight designs often pose significant new challenges in construction due to reduced flexural rigidity or extensive local buckling distortions during construction.
- The objective is to develop distortion prediction models and validate distortion mitigation strategies for increasing the final quality of lightweight steel fabrication processes.

<table>
<thead>
<tr>
<th>Goals and Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Goal: Distortion prediction tools: validated suite of integrated FEA tools for designers to optimize producibility in new construction.</td>
</tr>
<tr>
<td>• Benefit: Optimization of legacy designs that are distortion prone. Best practices for designers. Distortion control strategies: Shop floor-level guides.</td>
</tr>
</tbody>
</table>

**Approach**
- Phase 1: developing multi-length scale ICME distortion models of strategies/ recommendations for facilities improvements.
- Phase 2: validating and refining distortion control methodologies developed in Phase 1.
- To determine cost benefits, cost-effectiveness of distortion control methods demonstrated on selected components will be quantified through a detailed cost analysis.

**Progress**
- Kick-off was January 26-27 of 2016
- Baseline NSC unit 4130 has completed production and all data necessary for modeling and analysis has been collected
- The DOE for the test-articles is well underway with analysis being conducted
- Material classification has been tested and input into the ICME models
- Cost modeling has generated the data necessary to create the final model and plan for final model generation is underway

---

**Team Members:** Huntington-Ingalls, ABS, Comau, Tenneco, ESI NA, NAVSEA 05, NSWC-CD, OSU, UM, MIT, EWI

**Period of Performance:** 12/15/15 thru 12/16/17 (Phase 1 & 2)
The LIFT Manufacturing Center
HQ Facility ... Transformation
Detroit-based manufacturing research centers plan $47 million in upgrades

By Dustin Walsh

Two federal research institutes in Detroit will invest $47 million in equipment and upgrades over the next two years.

The Lightweight Innovations for Tomorrow and Institute for Advanced Composites Manufacturing Innovation plan to acquire and install new equipment to allow research and development projects in lightweight metals and advanced composites, the institutions said in a joint press release Friday. LIFT will invest $20.5 million and IACMI will invest $18 million. Some of the equipment includes: a flexible-robot joining cell; a linear friction welder; prepreg equipment; induction processing, etc.

The Michigan Economic Development Corp. is providing the $8.5 million toward building upgrades.

The institutes were established in 2014 under an initiative from the Obama administration recently renamed Manufacturing USA to advance manufacturing technologies and processes. LIFT — led by the University of Michigan; the Columbus, Ohio-based manufacturing technology 501(c)(3) nonprofit EWI and Ohio State University — is funded with a $70 million, five-year grant from the U.S. Department of Defense and $78 million from a consortium of 70-plus universities, businesses and organizations. IACMI is funded by a $70 million grant from the U.S. Department of Energy and $15 million from the MEDC and others for five years.

"Our co-investment and collaboration with LIFT strengthens our manufacturing ecosystem of automotive partners in Michigan — and helps to redefine Detroit as a prospering region for vehicle advancement," Craig Blue, IACMI CEO, said in a press release.
LIFT HQ Layout

Total Facility Area: 100,000 sq. ft. – Manufacturing Lab: ~ 87,000 sq. ft.
LIFT Center Capabilities

- Quality & Met Lab
- Machine Shop
- Extrusion Press
- Hydroforming Press
- Stamping Press
- Multi-Robot Joining Cell
- Hot Isostatic Press
- Metal Injection Molding
- Tilt-Pour Casting
- Linear Friction Welding
**Linear Friction Welding** is a solid state process in which one part moves in a linear motion at high speed and is pressed against another part held stationary. The resulting friction heats the parts, causing them to forge together.

The **LF35-75** is a 35 ton oscillating, 75 ton forge capacity (150,000 lbs down to 10,000 lbs) universal machine capable of solid state welding a variety of materials, sizes, and geometries.

- **Superior joint quality**
  - Does not melt the parent material.
- **Energy efficient**
  - As much as 20 percent lower than conventional welding processes.
- **Ecologically friendly**
  - Does not emit smoke, fumes, or gases.
- **Eliminate block machining with “near net shape” joining**
  - Use expensive material only where needed.
- **Forged-quality welds for complex geometries of nearly any metal type**
  - Can join dissimilar metals not compatible using conventional welding methods.
- **Quick welding process meets the demands of any supply chain**
  - At least twice and up to 100 times as fast as other welding techniques.
- **Minimal joint preparation reduces prep time and speeds up production**
  - Machined, saw-cut, and even sheared surfaces are weldable.
- **Defect-free welding decreases waste and saves money**
  - Machine-controlled process. no melting, solidification defects do not occur, eliminating gas porosity, segregation, or slag inclusions.
- **Scalable welding sizes for any magnitude of applications**
  - Welding process is completely scalable to produce any size weld.

MTIwelding.com
Education & Workforce Development

Building a confident and competent manufacturing workforce

We Believe:

Bringing “mind to market” is only possible if we have the talent to put that new idea or new technology to work in our economy.

So LIFT’s vision, to be the world leader in lightweighting manufacturing, can only be realized if we develop the educated and skilled workforce necessary to use new technologies and innovative processes.
1. Be Demand and Data Driven
   • Conduct regular demand-supply-and-gap analyses on workforce needs in LIFT region

2. Be Transformational for Sustainable Results
   • Invest to have an impact on the education and workforce development systems

3. Drive From the Bottom Up
   • Invest in state and local initiatives

4. Strategically Focus
   • Target areas where there are clear disconnects between demand for and supply of skills

5. Link and Leverage Available Assets
   • Capture initiatives to build educational pathways linked to stackable credentials and bridges across the educational continuum
Workforce Investments Made

• Over 34 investments made

• Impacting:
  • K-12 students
  • Veterans
  • Middle School and High School Teachers
  • College Students
  • Adult students

• Partnering with:
  • K-12 schools
  • Manufacturers
  • Community Colleges
  • Universities
  • Community Organizations

*Projects authorized to-date: ~$14M*
Proud Member of the Manufacturing USA

Learn More At: http://lift.technology

Follow Us at: @NewsFromLIFT

Partnership for Manufacturing Innovation
Abraham Boughner

Lead Systems Engineer for USCG Engineering Support/NAVSEA 05D4
NSRP National Shipbuilding Research Program

Heavy Polar Icebreaker Replacement Program
7 March 2017
Charleston SC
Question:

• How does the Shipbuilding Industrial Base view the latest Polar Icebreaker Acquisition compared to typical surface ship design and construction?

Feedback Requested:

• Research into an understanding of the cost, schedule and technical risks associated with icebreaker construction.
Focus Areas:

- Ship Design and Design for Production
- Production Engineering and Planning
- Production methods
- Supply Chain and Material Management
- Organization and Structure
Top level commitment

• Adm. Richardson, Chief of Naval Operations
  “if we neglect the fact that we’re going to be operating in the Arctic as we design this new class of ship, that’s just narrow thinking on our part,“

• Adm. Zukunft, Commandant, US Coast Guard
  “We’re really encouraged by what’s in the president’s budget right now” in terms of icebreaker funding.
  “Our industrial complex and a number of shipyards have said we can build this in the United States, and I’m quite confident they can.”
Beyond 2030, Sustained operations in the Arctic Region
Identify future platforms and their engineering requirements that will operate in open water and shoulder seasons by mid 2020s.

- Surface combatants
- Auxiliaries
- Maritime Prepositioning Squadron
Coast Guard awards Polar Icebreaker Design Study Contracts

- Jay Stefany, Executive Director of the Navy’s Amphibious, Auxiliary and Sealift Office

“The U.S. Navy is working collaboratively with the Coast Guard to develop “a robust acquisition strategy that drives affordability and competition, while strengthening the industrial base”

- Congressman Duncan Hunter (R-CA) is campaigning to fund six icebreakers to help the Coast Guard patrol the Arctic.
## Notional Heavy Polar Icebreaker Acquisition Schedule

|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|

### Industry Studies (Full and Open, Multiple Awards)
- RFP Development
- Proposal Dev
- Source Selection
- Industry Studies (Multiple Technical and Trade-off Studies)
- Contract Award

### Trade-off Analysis & Affordability Assessment
- Desired Delivery Date

### Design and Construction (Full and Open, Single Award)
- RFP Development
- Proposal Dev
- Source Selection
- Design
- Construction of Lead Ship
- Construction of Second Ship
- Construction of Third Ship
- Draft Spec Release
- Draft RFP Release
- RFP Release
- Government-led Model Testing
- Contract Award & LLTM for Lead Ship
- LLTM for Second Ship
- LLTM for Third Ship
# Icebreaker HEALY Lessons Learned

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY85 – FY90</td>
<td>Government led design Baseline Contract Design</td>
</tr>
<tr>
<td>Mar 1991</td>
<td>RFPs sent to over a dozen shipbuilders</td>
</tr>
<tr>
<td>Oct 11, 1991</td>
<td>Two proposals received. Both well in excess of available funding</td>
</tr>
<tr>
<td>Mar 16, 1992</td>
<td>Cancellation of Solicitation</td>
</tr>
<tr>
<td>Nov 10, 1992</td>
<td>Contracts awarded for Engineering Design Baselines (EDB)</td>
</tr>
<tr>
<td>Jul 15, 1993</td>
<td>DD&amp;C contract awarded</td>
</tr>
</tbody>
</table>

Drivers of excessive cost included:

- Lack of modern producibility considerations
- Extensive use of Government/military requirements and standards
- Sole source specification of major equipment

---

Lack of early industry engagement set the program back nearly 2 years
What’s different about icebreakers?

• **Design**
  
  • Designed and built in the US once every generation
  • Not a robust commercial market
  • Limited Modeling and Simulation tools
  • Limited cost estimating basis for unique systems
  • Requirements trades
    • Icebreaking vs. Seakeeping vs. Efficiency vs. Cost
What’s different about icebreakers?

• **Production**
  • Complex hull geometry
  • Relatively thick plate with tight and deep frame spacing
  • Podded propulsors?
  • Medium Voltage electrical system?
  • Limited Supply Chain
    • Domestic Sourcing challenges
  • Low temperature issues
    • Deck equipment
    • Electronics
    • Insulation
Unique Hullform
Compound Curves
Complex Structure
Podded Propulsors
Medium Voltage Electrical Systems
What else?
Design Criteria

- Ice Class Rules
- Polar Code
- Structural Design Criteria
- Material Selection
- Seakeeping vs. Icebreaking
- Machinery Installations
  - Vibration, Ice impacts
  - Low Temperature environment
  - HVAC
  - Ballast water
  - Sea Chest Design
  - Ice accretion
  - Deck machinery
Icebreaking Resistance and Powering

- Multiple analytical icebreaking resistance models available - Predictions can vary widely by methodology
- Physical scale model testing in ice essential to reduce technical uncertainty and program risk
- Full scale ice trials required for final validation of analytical and scale model testing
Previous Related NSRP Projects

- Evaluation of Model-Based Engineering and Advanced Forming Technology for Complex Hull Manufacturing
- Naval Vessel Ice Capability Optimization Effort
- Design Space Navigator For Steel Beam-Stiffened Plate Structures
- Development and Evaluation of ICS Welding Technology for Thick Plate
- Portable Video System for Limited-Access Shipbuilding Welds
How Much Does an Arctic Ship Cost?

The most significant shipbuilding project to support Arctic route operations is the construction of sixteen 300m long, 170,000 cu. m. Arctic LNG Carriers being built in South Korea by DSME for operation on the Northern Passage, with the first scheduled to come online in 2016 for regular transport between the Yamal LNG project based in the estuary of the Ob River and Asia. The ships are custom designed “Double Acting” vessels powered by three 15MW Azipods for a total power of 45MW. While final costs of the ships have not been publicly released, professional estimates suggest that each ship will cost in the region of $300m, a 50% premium versus the cost of a similarly sized LNG carrier. Increased cost for Arctic Ops is driven by:

- Additional Steel
- Additional Power
- Protection of deck equipment
- Ballast tank heating
- Insulation in housing
How does the Shipbuilding Industrial Base view the latest Polar Icebreaker Acquisition compared to typical surface ship design and construction?
Institute for Manufacturing and Sustainment Technology

Tim Bair
Agenda

- ARL/Materials & Manufacturing Office
- iMAST Overview
- Example Projects & Quad charts
  - Coating Technology
  - Sustainment Technologies
  - Materials Technologies
  - Metals Technologies
Established in 1945 by the Navy post WW II

Technology Areas

- Undersea Weapons
- Undersea Vehicles/UUV’s
- Hydrodynamics and Structures
- Acoustics & Quieting
- Comms and Information
- Power and Energy
- Navigation
- Materials/ Manufacturing

Largest Interdisciplinary Research Unit at Penn State – 1140 faculty/engineers, staff, students

Designated an University Affiliated Research Center by DoD in 1996

“…maintains a special long-term strategic relationship with DoD for technology development and engineering applications.”
In support of ARL’s UARC Core Competency in Materials and Manufacturing Science, to be a source of innovative technology solutions – materials, process, manufacturing, design, and logistics technologies for affordable, high performance DoN and DoD platform structures and systems

**Competencies**

- Materials Science
- Modeling and simulation (process, design, manufacturing)
- Component analysis and design
- Prototype fabrication
- Sensor system design, development, integration
- Enterprise system software architectures, engineering

**Examples of Transitioned Technologies**

- **Composite CVN EHF Yardarm** Transitioned to HINN
- **Cost and Capability Trade Capability** Transitioned to DoN, DoD sponsors
- **Advanced Logistics Technologies** Transitioned to USMC, USA
- **Laser cladding technology** Transitioned to PHNSY

**Notes**

- Distribution Statement A. Cleared for Public Release.
Materials and Process Technology Development

- **New materials/processes**
  - AM Technology
  - Multifunctional composite structures
  - Field assisted sintering technology
  - LASCELL Structures
  - Metamaterials (RF, acoustic)

- **Coating technologies**
  - Polymer coating designs
  - Polymer composite shaft coatings
  - Polymer cavitation resistant coatings
  - High temp non-skid coatings
  - Cold spray erosion, corrosion, wear
  - Laser-based metal, MMC coatings
  - Hot corrosion, erosion, TBC coatings for engines – EB/PVD, Cathodic Arc
Analysis/Design

- Component analysis & design
  - VCS MSW pump (acoustic tailored), CVN composite Island Structure, HMMR

- Concept design trade tool development
  - Technology assessments in weapons, ground vehicles, satellite applications

Component, Platform Manufacturing Technology

- Metals
  - AM, laser processing, FAST, cutting, welding, coating/cladding

- Composites
  - Autoclave, fil. wind, RTM, VARTM, joining/assy

- Process & Production modeling, simulation, engineering
iMAST Overview

Institute for Manufacturing and Sustainment Technology (iMAST) established February 1995 as one of the Navy ManTech program’s Centers of Excellence

Located at Penn State’s Applied Research Laboratory, iMAST partners with industry, DoD, and the University to solve advanced weapon system issues.

iMAST provides a focal point for the development and transition of cost saving new manufacturing processes and equipment in a cooperative environment with industry, academia and Navy acquisition programs.

iMAST also supports Navy ManTech with cost avoidance reduction projects within the Repair Technology (RepTech) program aimed at supporting shipyards and DON depots.
• ManTech projects aimed at saving acquisition funds on major Navy programs
• Ideas usually from the shipbuilders/OEM’s
• Collaboration with the OEM and another ManTech COE typical
• Semi-Annual reviews of progress with OEM and program office designed to track progress and ensure implementation path still valid
• VCS examples on following slide for iMAST and collaborative projects, past and present
Acquisition Program Support: or “What have you done for me lately?”

ARL Penn State VCS program cost reduction contributions:

- Savings per hull = $23.1 M
- Total VCS savings = $410 M
- ManTech funding = $24 M

→ 17:1 savings

Material Management $5.40M
Design For Production $3.60M
Outfitting Process Improvement $5.00M
Improved Production Engineering $0.68M
Outfitting Tooling & Processing $0.74M
Sheet Metal Processing $0.10M
Composite MSW Impeller $0.40M
Polycan Fabrication $0.80M
Cladding Workcell $0.23M
Composite Sail Cap $0.34M
Composite Sail Cusp $TBD
Fire Safe Resins $TBD
Improved Welder Productivity $2.50M
Pipe Shop Reengineering $1.21M
Improved Topside Nonskid $0.08M
Trade Friendly Metrology $0.86M
Critical Resource Planning $.33M
VA Payload Mod. Fairings $TBD
(Active project)

VCS Total Per Hull Savings $23.1 M
Repair Technology

- Repair Technology (RepTech) Projects: Addresses repair, overhaul and sustainment functions that emphasize manufacturing processes and advancing technology as a component of Navy ManTech.

- RepTech projects target fielded weapon systems and provide the process and equipment technology needed to repair and maintain fleet assets. Implementation of RepTech projects target naval depots, shipyards, Marine Corps logistics bases, intermediate maintenance activities and contractor facilities responsible for the overhaul and maintenance of fleet hardware.
### Maintenance & Sustainment

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-53</td>
<td>Helicopter Blade Refurbishment</td>
<td>$830K</td>
</tr>
<tr>
<td>F-18</td>
<td>Cold Spray Repair</td>
<td>$370K</td>
</tr>
<tr>
<td>AV-8</td>
<td>Add Mfr’ing Repair</td>
<td>$250K</td>
</tr>
<tr>
<td>LIF NDE</td>
<td></td>
<td>$2.9M</td>
</tr>
<tr>
<td>LAV</td>
<td>Crack Detection</td>
<td>$4.2M</td>
</tr>
<tr>
<td>688</td>
<td>Vertical Launch System Repair</td>
<td>$3.8M</td>
</tr>
<tr>
<td>688/VCS</td>
<td>Surface Treatment Repair</td>
<td>$1.7M</td>
</tr>
<tr>
<td>Submarine</td>
<td>Align/Inspection</td>
<td>$1.6M</td>
</tr>
<tr>
<td>VCS</td>
<td>Shaft Repair Process</td>
<td>$170K</td>
</tr>
<tr>
<td></td>
<td>Shaft Seal Refurbishment</td>
<td>$4.3M</td>
</tr>
<tr>
<td></td>
<td>Retractable Bow Plane Coating</td>
<td>$4.75M</td>
</tr>
<tr>
<td>Improved</td>
<td>Topside Nonskid</td>
<td>$670K</td>
</tr>
<tr>
<td>Hover</td>
<td>&amp; Depth Valve</td>
<td>$800K</td>
</tr>
<tr>
<td>UHP</td>
<td>Dual Track Removal</td>
<td>$360K</td>
</tr>
<tr>
<td>CVN</td>
<td>Low Loss Launch Valve</td>
<td>$340K</td>
</tr>
<tr>
<td>All Ships</td>
<td>In-Situ MSW/ASW Repair</td>
<td>$730K</td>
</tr>
<tr>
<td></td>
<td>Acoustic Detection</td>
<td>$1.0M</td>
</tr>
<tr>
<td></td>
<td>Cold Spray Repair for Ships</td>
<td>$250K</td>
</tr>
</tbody>
</table>

**Total Cost Avoidance Per Year**

$29M
Below quad charts are a sample of iMAST ManTech and RepTech projects that are currently active or recently completed.
### Coatings/Mfr’ing Process: Plasma Spray System Improvements

**Before and after pictures showing classic plasma spray failure and new process after significant qualification testing.**

<table>
<thead>
<tr>
<th>Project Number:</th>
<th>S2449</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performing Activity:</td>
<td>iMAST/ARL Penn State</td>
</tr>
<tr>
<td>Objective:</td>
<td>To optimize and implement a thermal spray coating solution on cylinder rods on submarines.</td>
</tr>
<tr>
<td>Start / End Dates:</td>
<td>JAN 2013–DEC 15</td>
</tr>
<tr>
<td>Project Cost:</td>
<td>$1.2M</td>
</tr>
<tr>
<td>MANTECH Investment:</td>
<td>$877K (iMAST)</td>
</tr>
<tr>
<td>Cost Share:</td>
<td>$326K (NSAM)</td>
</tr>
<tr>
<td>Weapon System:</td>
<td>Submarines</td>
</tr>
</tbody>
</table>

#### Pay Off
- Savings across life cycle approximately $300M
- Elimination of seal replacements
- Extension of seal lifetimes
- ManTech ROI = 8:1
- Reduced Total Ownership Cost of System
- Eliminate need for emergent dry docking and replacement of seals.

#### Performing Activities:
- COE: iMAST/ARL Penn State and NSAM
- Commercialization Partners: General Dynamics Electric Boat
- Implementing Organization: General Dynamics Electric Boat

#### Technical Achievements:
- The full scale test bar passed long term testing and survived over 4,500 cycles of testing at General Dynamics Electric Boat with no measurable wear. This equates to over 70 years of ceramic coating service life.
- An improved surface finish has been tested and improved seal life has been obtained.
- The selected vendor has completed qualification testing and obtained NAVSEA approval for production.

#### Implementation:
- System: Submarine
- Site: GD-EB and Navy Undersea Warfare Center-Keyport
- Schedule: APR 2016
- Status: Transitioned/Implemented
### Project Number: S2723
### Title: False Deck Panel Improvement

<table>
<thead>
<tr>
<th>Performing Activity:</th>
<th>ARL/IMAST, CMTC, BIW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objectives:</td>
<td>Down-selection of new material and/or streamline false deck panel fabrication</td>
</tr>
<tr>
<td>Start / End Dates:</td>
<td>JAN 17 – SEPT 18</td>
</tr>
<tr>
<td>Project Cost:</td>
<td>$1.1M</td>
</tr>
<tr>
<td>MANTECH Investment:</td>
<td>$500K</td>
</tr>
<tr>
<td>Weapon System:</td>
<td>DDG 51</td>
</tr>
</tbody>
</table>

**Performing Activities:**
- Performing Activity: iMAST, CMTC, BIW
- Program Office: PMS-400D
- Implementing Organization: General Dynamics Bath Iron Works

**Technical Achievements:**
- BIW hosted a working group meeting
- Reviewed steps to fabricate, measure, edge treat, and install using current processes
- Project team searched documentation for historical data and current design requirements
- Researched requirements for technical performance and testing

**Implementation:**
- System: Surface Fleet, False Decking
- Site: BIW
- Schedule: Tech Dev: (JAN 17)  
  Tech Demo: (JUN 17)
- Status: Pending

**Payoff:**
- Reduce labor-intensive fabrication and installation cost
- Reduce delamination of the panel during installation and removal operations
- Reduce acquisition and life-cycle cost

Example false deck panel fabrication

Distribution Statement A. Cleared for Public Release.
### Project Information

<table>
<thead>
<tr>
<th><strong>Project Number:</strong></th>
<th>R2721</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Title:</strong></td>
<td>Fire Safe Resins</td>
</tr>
<tr>
<td><strong>Performing Activity:</strong></td>
<td>iMAST / ARL Penn State</td>
</tr>
<tr>
<td><strong>Objective:</strong></td>
<td>Qualify a composite material for use inside the pressure hull.</td>
</tr>
<tr>
<td><strong>Start / End Dates:</strong></td>
<td>Oct 2014–Dec 2016</td>
</tr>
<tr>
<td><strong>Project Cost:</strong></td>
<td>MANTECH Investment: $25K</td>
</tr>
<tr>
<td><strong>Weapon System:</strong></td>
<td>Submarines and other ships</td>
</tr>
</tbody>
</table>

#### Performing Activities:
- iMAST - ARL Penn State – Fire Test Panel Fabrication
- CMTC hosted parent project with ARL technical performer

#### Technical Achievements:
- Manufacturing Technology was developed that results in low cost, high performance, fire safe composites suitable for use inside a pressure hull.
- To complete the qualification process, an iMAST follow-on project was conducted that fabricated fire test articles, including an ISO 9705 full scale room test.
- The test was successfully executed and feedback from the TWH established it as qualified.

#### Implementation:
This RR project supported the production of full scale test articles to be installed for fire testing (see pictures) and was needed to qualify this new material as eligible for application inside submarines. This project supported the CMTC parent project with the same name.

#### System:
- Future subs

#### Site:
- New London CT, Electric Boat

#### Schedule:
- TBD

#### Status:
- Completed

#### Payoff:
- TBD based on actual applications in future designs and redesigns.

**FST test of the new FSR panels. Result: success!**
# Sustainment: Topside Non-skid Removal

**Project Number:** S2494  
**Project Title:** Improved Topside Non-Skid Removal for Submarines  
**Performing Activity:** iMAST/ARL Penn State  
**Objective:** Develop tool(s) capable of removing nonskid from Submarines without causing damage to Special Hull Treatment (SHT).  
**Start / End Dates:** FEB 2012 – MAR 2014  
**Weapon Systems Affected:** Submarines

## Performing Activities:
- iMAST/ARL Penn State – Project Lead  
- PMS-392, PMS-450 – Program Offices  
- PSNSY & PHNSY – End-users / Stakeholders  
- NAVSEA 05P2 – TWH  
- NSWCCD - TA  
- Commercialization partners – Terydon, Inc.  
- Implementing Organization(s) – PSNSY & PHNSY

## Technical Achievements:
- Successful nonskid removal from two active hulls SEP12/JAN 13  
- SHT safety testing at PSNSY & IMF FEB 14  
- PMS 392 & TWH approved process and funded upgrades JUN 14  
- Designed and manufactured Beta Prototype JUN 16

## Implementation:
- **System:** Submarines  
- **Sites:** Puget Sound Naval Shipyard  
- **Pearl Harbor Naval Shipyard**  
- **Schedule:** FY14/Q2 (Transitioned to 392 project)  
- **Status:** Active: Implementation on target. Direction has been provided by NAVSEA design requirements and implementation.

## Payoff:
- **Cost avoidance:** $672K per year (2 repair jobs/year)  
- **Labor reduction:** $95K per nonskid repair job  
- **Material cost reduction:** $210K per nonskid repair job  
- **Eliminate Containment:** $32K per nonskid repair job  
- **5-Year ROI:** 6:1

---

Distribution Statement A. Cleared for Public Release.
Sustainment: UHP Dual-Track Crawler System for Coating Removal

Project Number: S2599
Project Title: SHT/MIP Removal Using UHP Dual-Track Crawler System
Activity: iMAST/ARL Penn State
Objective: Develop, test, demonstrate, and implement a dual-track UHP water jet system for removal of coatings from submarines
Start / End Dates: SEP 2014 – SEP 2017
Project Cost: $632K
MANTECH Investment: $632K
Cost Share: $ 0K
Weapon Systems Affected: Submarines

Performing Activities:
- iMAST/ARL Penn State – Project Lead
- PMS-392, PMS-450 – Program Offices
- End-Users / Stakeholders - All Navy Shipyards (PSNSY&IMF Lead)
- Commercialization partners – Terydon, Inc.
- Implementing Organization(s) – PSNSY&IMF & PHNSY&IMF, PNSY

Technical Achievements:
- Fabrication of alpha prototype completed and tested in Lab
- Motion-controller noise in large scale application identified and mitigated
- Dual-Track UHP SHT/MIP Removal system successfully demonstrated on mockup in shipyard environment
- All four public yards pushing for rapid introduction/transition

Implementation:
System: Submarines
Sites: PSNSY&IMF & PHNSY&IMF, PNSY
Schedule: FY17/Q2 (production trials PNSY or NNSY)
Status: Active

Payoff:
- Cost avoidance: $120K per yard / per year
- Labor reduction: $360K per year
- 5-Year ROI: 3.5 : 1
Early Electrical Fault Sensing for Preventative Maintenance

Perfoming Activities:
- iMAST - ARL Penn State – Technology Modifications
- PEO Carrier/NAVSEA 05 – Technical/Implementation Assistance
- Subcontractor(s): NNSY/CTRL/NRL
- Commercialization partner – CTRL

Technical Achievements:
- Shore-based testing of CTRL UL101 system at KEMA.
- Data collected and under analysis. Early indications show relationship between low torque connectors and acoustic signal.
- Non-energized acoustic and modal testing on panel at KEMA showed positive response indicating potential use within closed electrical enclosures.

Implementation:
- System: Electrical Distribution Panels
- Site: NNSY
- Schedule: TBD, FY16/Q3 expected
- Status: Active

Payoff:
- Early warning of impending electrical faults.
- Enabling inspection capability for distribution panels under full load.
- Improved personnel safety (fire prevention).
- NAVSEA 05 estimated: $10.3M/5yr maintenance cost avoidance.
- ManTech 5-year ROI = 16.
## Metals: Wire Support Spring Improvement

<table>
<thead>
<tr>
<th>Project Number:</th>
<th>R2713</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Title:</td>
<td>CVN Wire Support Spring Improvement</td>
</tr>
<tr>
<td>Performing Activity:</td>
<td>iMAST / ARL Penn State</td>
</tr>
<tr>
<td>Objective:</td>
<td>Develop heat treatment to eliminate premature failures of the wire support springs and develop a test method to identify springs that will fail.</td>
</tr>
<tr>
<td>Start / End Dates:</td>
<td>MAR 2016 to SEP 2016</td>
</tr>
<tr>
<td>Project Cost:</td>
<td>ManTech Investment: $75K</td>
</tr>
<tr>
<td>Weapon System(s):</td>
<td>Aircraft Carriers / Mark 7 Arresting System and Advanced Arresting Gear</td>
</tr>
</tbody>
</table>

### Performing Activities:
- iMAST: Project Mgmt/Technical Development
- Stakeholder: PMA251 IPT Lead for Fielded Recovery Systems (Andy Sussman)
- Technical Assistant: NAVAIR Lakehurst (Caleb Bonilla)
- Implementation: NAVAIR Lakehurst

### Technical Status:
- Fracture surface analysis proved evidentiary and indicated weakness due to forging variation not hydrogen
- Metallographic analysis including optical, SEM and TEM complete on the existing material lots to differentiate 1998, 2004, 2010 lots
- Consensus is that the difference in performance between the various lots due to a difference in grain size and embrittlement induced by phosphorous
- Spring from 2016 lot is expected to perform similarly to the older springs indicating potential for catastrophic failure

### Implementation:
- **System:** Aircraft Carriers
- **Site:** NAVAIR Lakehurst

### Quantitative Benefits:
- Produce springs that have an extended life
- Projected ROI > 7 (based on preventing one aircraft mishap but not including cost of bad springs) $500K

### Qualitative Benefits:
- Reduce spring failures / extend spring life
- Prevent damage to aircraft
- Prevent injury to personnel
Performing Activities:
- Performing Activity: iMAST, ARL Penn State, CIMP–3D
- Program Office: PMA-257
- Implementing Organization: FRC-E

Technical Achievements:
- Repairs for seal ring successfully applied and tested
- Qualification Test Plan submitted to FRC-East
- Initial testing completed by accelerated deadline, supporting:
  - FRC-E approval of ~$1M in capital expenditures
  - FRC-E cost-savings of ~$1M on expected capital costs
- FAA-approved 3rd party has produced repairs as potential vendor

Implementation:
- System: AV-8B - F402 Engine
- Site: FRC-East
- Schedule:
  - 2.1 Qual Plan: (SEPT 16)
  - 2.2 Exec Plan: (SEPT 16)
  - 2.3 Tech Data Pkg: (SEPT 17)
  - 2.4 Final Report: (SEPT 17)
- Status: Active
- Payoff:
  - Project motivation stems from unknown value of grounded assets due to unavailable replacement parts or repair options.
  - FRC investment in additive repair technology, supported by initial project testing, shows interest to advance technology.
## Metals: Cold Spray Technology for Shipboard Components

### Project Details

**Project Number:** S2580  
**Title:** Cold Spray Technology for Shipboard Components  
**Performing Activity:** iMAST/ARL Penn State  
**Objective:** Develop and implement cold spray repair processes to repair NAVSEA shipboard components.  
**Start / End Dates:** JUN 2014 - Sep 2016  
**Project Cost:**  
- MANTECH Investment: $600K  
- Cost Share: $600K – hardware and support  
**Weapon Systems:** Submarines

### Technical Achievements:

- **1st Component:** Al-6061 Hydraulic Actuator. TD-63 and TD-16 have been repaired and approved for use and are in service. Repair of Al-6061 Hydraulic Actuator with Al 5056 completed.  
- **2nd Component:** #1 Main Circulation Water Pump repair was approved and component is in service.  
- **3rd Component:** Steel Motor End Bell housings – Repair approved on mockups. Qualification Testing continues.  
- **4th Component:** A nickel coating on a mockup of the 70/30 CuNi swing check valve approved. Qualification testing continues.

### Implementation:

- **Systems:** Submarines  
- **Site:** PSNS & IMF  
- **Schedule:** FY2015  
- **Status:** 1st and 2nd article have been approved for use. 3rd and 4th articles are undergoing validation testing.

### Payoff:

- Components that don’t have approved repairs and/or replace current repair process with improved repair processes.  
- Help maintain inventories / reduce down time.  
- Technology can be implemented on several platforms.  
- Reduced LCC for long lead time components (previously condemned), increased readiness.  
- Five year cost savings is >$5M - ROI of 8.3:1.

---

**Performing Activities:**

- iMAST ARL Penn State – project lead  
- Puget Sound Naval Shipyard (PSNS) and Intermediate Maintenance Facility (IMF) – technical assistant and implementing organization  
- Cold Spray Equipment Manufacturers– commercialization

---

Main Circulating Water Pump Casing repaired by Cold Spray
### Metals: VLS-LCRS Updates

**Laser Clad Repair System (LCRS) for corrosion damage to VLS missile tubes**

<table>
<thead>
<tr>
<th>Project Number:</th>
<th>S2545</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title:</td>
<td>VLS-LCRS Updates for Production Readiness</td>
</tr>
<tr>
<td>Performing Activity:</td>
<td>iMAST/ARL Penn State, NUWC-Division Keyport</td>
</tr>
<tr>
<td>Objective:</td>
<td>To equip the Laser Clad Repair System for full-scale use, addressing risk to minimize expected downtime</td>
</tr>
<tr>
<td>Weapon System:</td>
<td>Submarines</td>
</tr>
<tr>
<td>Current status:</td>
<td>Project completed and implemented</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performing Activities:</th>
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</thead>
<tbody>
<tr>
<td>Performing Activity/COE:</td>
</tr>
<tr>
<td>Program Office:</td>
</tr>
<tr>
<td>Implementing Organization:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technical Achievements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completed system evaluation and identification of necessary engineering upgrades to laser-based system as well as design of LCRS back-up (GTA) system</td>
</tr>
<tr>
<td>System upgrades and training for Pearl welders complete</td>
</tr>
<tr>
<td>System application on USS Asheville complete (Dec 14) and successfully demonstrated on one tube.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Implementation:</th>
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</thead>
<tbody>
<tr>
<td>System:</td>
</tr>
<tr>
<td>Site:</td>
</tr>
<tr>
<td>Schedule:</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Pay Off (10 yr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Avoidance:</td>
</tr>
<tr>
<td>ROI:</td>
</tr>
</tbody>
</table>
**AME: Shipyard Capacity Planning**

### Development of Integrated Capacity Planning System at Bath Iron Works

**Configuration Tools**
- User Editor
- Facility Editor
- Hull Editor
- Product Editor
- Product Type Editor
- Scenario Editor
- Workcenter Editor

**Central Data System**
- Planning Data
- Shipyard Data
- User Management
- Baseline Capacity Plan

**Spatial Scheduling Tool**

**Long-Range Capacity Planning Tool**

**Project Number:** S2600  
**Title:** Shipyard Capacity Planning at BIW  
**Performing Activity:** iMAST, Bath Iron Works (BIW)  
**Objective:** Develop a shipyard-wide capacity planning system that results in more robust and achievable plans/schedules while meeting ship delivery requirements  
**Start/End Dates:** JUL 2014 – JAN 2017  
**Project Costs:** $730K  
**Cost Share:** $500K (BIW, estimated)  
**Weapon System:** DDG-51, DDG-1000

### Performing Activities:
- iMAST  - Project Lead
- BIW  - Facility Technical Support, implementing org.

### iMAST Technical Achievements
- ARL/iMAST continued to support the structural unit planning user group at BIW by fixing software bugs
- ARL/iMAST enhanced the SLCPT scenario management capability based on initial testing and feedback obtained from the BIW user group.
- ARL/iMAST began development of the software test plan which is essentially a combination of detailed software instructions for SST and LRCPT as well as procedures for configuring the tools to communicate with the Central Data System and deploying updated software releases provided by ARL/iMAST.

### Implementation
- **System:** DDG-51, DDG-1000
- **Site:** Bath Iron Works (Bath, ME)
- **Schedule:** JUL 2014–JAN 2017
- **Status:** In-Process (Phase 2 started on 7/15/15)

### Payoff:
- 7% reduction in overtime for DDG-51 contracted hulls – $2.92M
- Reduction in planning labor hours with implementation of capacity planning software tools - $1.725M (through contracted DDG-51 hulls)
  - TOTAL PROJECT SAVINGS (6-year) = **$4.645M**
  - ROI (6-year) = 6.36:1
Thanks!
Electronics Manufacturing Productivity Facility

Michael Czajkowski
Specific Functions:

- Serve as corporate residences of expertise in particular technological areas
- Collaborate with the Program Executive Offices and industry to identify and resolve manufacturing issues
- Develop and demonstrate manufacturing technology solutions for identified Navy manufacturing requirements
- Provide consulting services to Naval industrial activities and industry
- Facilitate the transfer of developed manufacturing technologies
A Critical Resource for the U.S. Navy

- Agent for manufacturing and process engineering support
- Risk reduction in the transition of transformational electronics technologies
- Extracts and consolidates Navy manufacturing requirements
- Helps leverage industry assets to support Navy requirements
- Influences commercial specifications for Navy DOD benefit
- Rapidly resolves manufacturing and reliability issues
Capabilities of the Navy COE

National Center Functions:

– World class competency in manufacturing
– Science and engineering capability in manufacturing technology
– Acute understanding of Navy weapon system requirements
– Ability to transition manufacturing know-how and technology effectively
– Performance enhancements affordability
– Operational and business structure to rapidly apply resources
– Ability to forecast technology shifts
Industrial Involvement & Investment

Significant ROI for Both Government & Industry
Applied Research and Development

- **Electronics Packaging**
  - Ruggedization and reliability of electronic assemblies and packages
  - Packaging solutions for microelectronics
  - COTS component integration

- **Materials**
  - Material qualification and integration
  - Validation of environmentally safe materials
  - Analysis of RF materials

- **Power Electronics/Power Semiconductors**
  - Develop low/medium power control systems
  - Develop affordable Manufacturing processes

- **Program Management**
Specific Functions:
- Advanced RF devices and systems
- High power and energy storage batteries and systems
- High power solid state devices
- Advanced micro-mechanical systems
- Advanced 3-D die packaging
- High-g electronics for smart munitions
- Software defined radio technologies
- Environmentally safe materials
Product Support

- Materials analysis
  - Cleanliness testing and contamination analysis
  - Solderability testing analysis and restoration
- Reliability and failure analysis
- Process development analysis and demonstration
- X-ray inspection
- Rework and repair services
- Technology commercialization support
Manufacturing & Production Support

- Manufacturing and process engineering
- Rapid prototyping and pre-competitive manufacturing
- Equipment, material and process specification, analysis and selection support
- Transition to advanced packaging technology
- Production planning
- Build package support
Training Center Capabilities

- **Certification Training**
  - IPC-A-610 Acceptability of Electronic Assemblies
  - J-STD-001 Process Control for Electronic Manufacturing
  - IPC-7711 / 7721 Rework & Repair of Electronic Assemblies
  - WHMA-A-620 Wire Harness Manufacturing

- **Engineering Level Training**
  - Electronics Manufacturing Boot Camp
  - Characteristic Properties of Materials
  - Design for Manufacturability and Test
  - Failure Analysis and Reliability Testing

- **Electronics Manufacturing Skills Training**
  - BGA Manufacturing
  - Chip Scale Manufacturing
  - SMT Manufacturing
  - Lead Free Manufacturing

- **Customized Curriculum Development**
  - Boeing
  - Lockheed Martin
  - Harris
  - Motorola
  - Northrop Grumman
  - NASA
Current ManTech Investments

• Current Investments:
  – Common Modular Power Supply (FY18)
  – Manufacturing Cost Reduction of EW Downconverters (FY18)
  – Solid State Continuous Wave Illuminator Transmitter (FY19)
  – Optimization of Azimuth and Inertial MEMS (FY17)
  – Ice Detector System (FY18)
  – Low Cost Radar Element (FY18)
Navy Metalworking Center
Dr. Daniel Winterscheidt
This presentation was prepared by the Navy Metalworking Center, operated by Concurrent Technologies Corporation, under Contract No. N00014-10-D-0062 to the Office of Naval Research as part of the Navy ManTech Program. Approved for public release; distribution is unlimited.
NMC Overview

To support the Navy’s mission to reduce total ownership cost, NMC works with government and industry to develop and optimize metalworking and manufacturing processes and to implement the solutions in the U.S. industrial base.

NMC is operated by Concurrent Technologies Corporation, an independent, nonprofit applied scientific research and development professional services organization, based in Johnstown, Pa.
Technology Areas

- Metalworking Technologies
- Joining Technologies
- Shipyard Processes
- Design for Manufacturability
- Advanced Metrology & Inspection Technologies
- Coatings Applications & Removal

Platforms

- Submarine: 34%
- Carrier: 12%
- Surface: 32%
- Aircraft: 14%
- Other: 8%
### Project Recognition

- During the past decade, numerous projects have been candidates for **DoD ManTech Achievement Awards**
  - Nominations – 10 projects
  - Finalists – 6 projects
  - Winners – 3 projects
- In 2016, NMC’s *Tow Cable Maintenance Winch* project won the **ONR Technology Transition Achievement Award**

### Implementation Achievement

On the current NMC contract, 45% of the projects have implemented results, and 31% of the projects are on track to implement results.
Weld Sequence Planning for Major Assemblies

To address a major manufacturing challenge, an NMC project team is developing a user-friendly weld sequence planning tool to provide timely analytical data to guide weld sequencing of major ship assemblies.

Benefits

- $3.9M five-year cost savings for VCS
- $580K per CCS hull through reduced trial-and-error weld sequencing, mitigation of weld-induced distortion in the final product, and improved throughput
Efficient Identification of Plate Defects

An NMC project team evaluated and down-selected 3-D inspection technologies capable of reliably and repeatedly identifying surface defects on ship surfaces before painting. The team is modifying a prototype automated visual inspection system and demonstrating its use in an industrial environment.

Benefits

• $3.5M inspection cost savings over five years at NNS for CVN 78 class
• $650K cost savings over five years at Ingalls on DDG 51 and LHA
Automated Manufacturing Cell for Repetitive Assemblies

A manufacturing work cell that automates and/or mechanizes various processes will reduce costs, improve ergonomics and quality, and increase throughput on multiple naval platforms. There are several process focus areas; mechanized stud welding has already been implemented.

Benefits

- $1.5M per year savings across all platforms constructed at Ingalls (DDG 51, LHA, LPD, and National Security Cutter [NSC])
Automated Hanger Manufacturing

An NMC project team is streamlining the production of the several thousand hangers used to install and route pipe, ventilation, and cable on submarines. The team is developing an automated work cell to efficiently produce several hanger types and sizes. Flexible fit and weld fixtures developed on the project are being used in production. Complete implementation is expected at EB on VCS and CCS platforms beginning in FY18.

**Benefits**

- $10.3M potential five-year savings for the VCS and CCS programs through a reduction in rework / material handling and an increase in throughput
Self-Locating/Self-Fixtured Structure

NMC and GDEB developed the manufacturing process for a new concept of fitting and joining the deck structures for CCS and the Virginia Payload Module (VPM). The self-locating, self-fixtured method will enable construction with notched beams that interlock and are continuous in both directions. Implementation is expected on CCS and VPM in FY19 at EB’s Quonset Point facility.

Benefits
• Expected five-year $12.1M savings for CCS hulls and VPM sections
Pipe Cutting Machine Technology

Improved equipment and tooling for onboard pipe cutting / beveling processes will enable reduced labor requirements and safer working conditions. Implementation is expected on VCS and CVN new construction and CVN Refueling and Complex Overhaul at NNS, and on DDG 51, LHA, LPD, and NSC new construction at Ingalls in 1Q FY18.

Benefits
• $3.5M projected five-year savings as a result of reduced labor for all hulls affected at NNS and Ingalls
Mechanized Cable Pulling

NMC developed portable, power-assisted tools to help workers pull an entire cable evenly, pull portions of cable through immediate distances, and reduce the amount of effort required to pull cable through bends. Ingalls began implementation in 1Q FY16, BIW started using the tools in 3Q FY16, and NNS plans to purchase the tools for evaluation in 2017.

Benefits
• 20% labor savings to install Class III and Class IV cables on LHA, LPD, DDG, and NSC class ships
• $1.5M savings using the cable-pulling tools on a single hull of each of the programs under construction at Ingalls
For more information, contact:

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Dan Winterscheidt  
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winter@ctc.com
Electro-Optics Center

David Ditto
Electro-Optics Manufacturing Technology Center Overview

March 8, 2017

Presented to: National Shipbuilding Research Program All Panel Meeting
Presented by: David H. Ditto, EO ManTech Director, Penn State Electro-Optics Center

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The Penn State Electro-Optics Center has been the Navy’s ManTech Center of Excellence in Electro-Optics since 1999.

- Located in Freeport Pennsylvania.
- Other Services leveraged (SOCOM, MDA, Army, AF, USMC, etc.)

We utilize the best available to arrive at solution—internal, subcontracted, or a combination of both.
Electro-Optics Alliance

“An Alliance of 450+ Companies, Academic, Government, and Non-Profit Institutions Committed to Providing the Best Capabilities to Our Warfighters”

Defense Contractors

Manufacturing

Academic Researchers

Government Labs

Office of Naval Research
Science & Technology

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Shipbuilding Related ManTech Projects at EOC

Completed Projects:
• Fiber Optic Measurement and Shape Sensing (FOMSS)

Current Projects:
• Test Adapter Efficiency Improvement
• Augmented Visualization for Manual Welding
Fiber Optic Measurement and Shape Sensing (FOMSS)

Confined Space Measurement Tool

**Issue Description:** 3D Measurement in confined spaces is difficult, time consuming and prone to error

**Project Objective:** Develop a ruggedized, portable coordinate measurement system that can be used in confined spaces

**Outcomes & Benefits:**
- Enable finer tolerances in cramped/confined spaces, non-line of sight dimensional control applications in significantly less time and with fewer personnel required.
- Achieved Accuracy 0.125” (2σ) (0.0625” RMS)
- Repeatability issue currently limits some applications
- Manufacturer to introduce FOMSS as a product and is working to improve repeatability and accuracy

DISTRIBUTION STATEMENT A: Approved for public release: distribution unlimited.
Test Adapter Efficiency Improvement

E-O tool for automating quality testing and record keeping

Issue Description: Cable testing is expensive, time consuming, and prone to errors.

Project Objective: Improve a previously developed portable system to automatically test and record results for electrical, RF, and fiber optic links. Reduce the number of required test adapters.

Expected Outcomes and Benefits:
• 25% decrease in cable test time
• Central database for records management
• Reduction of transcription errors
• Manufacturer introducing product line around this system
Augmented Visualization for Welding and Non-Eyesafe Environments

Increased Welder Productivity

Issue Description: Providing adequate visibility of the welding process has been a difficult problem for decades. The high levels of UV radiation and extremely bright light prevent direct viewing.

Project Objective: Develop indirect viewing system for use in welding, beta test system, and commercialize for use in the shipbuilding industry

Expected Outcome & Benefits:

- Provides affordable 3D viewing in a variety of environments
- Improves welder arc-time productivity from 12% to 14%
- Faster transition from novice welder to expert
- Develop and retain trained welders
Future Projects at EOC

Continuing Thrust:

Electro-Optic Based Tools for Use in Shipbuilding—Putting light to work building ships.
Automated Preheat Temperature Monitoring

Reduce the amount of time spent manually monitoring weld preheat areas during vertical access joining.

Utilize Distributed Fiber Optic Temperature Sensors to Accurately Monitor Preheat—Temperature and Position

Close the Loop Around the Sensors to Control Preheat
Drone Inspection at Assembly

Current State: Boom lift platforms for inspection are slow and cumbersome.

- Target State: Major assembly fit, surface inspection can be performed with drones:
  - Camera or scanning payload
  - Tethered for longer TOF
  - Ground-based reference
  - Autonomous obstacle detection

Impact: Improved inspection, rapid access to data
Drone Logistics and Quality

Current State: Handheld reading of barcodes and RFID tags is labor-intensive.

- Target State: Miniaturization of many technologies make them “dronable:”
  - RFID or QRcode reader for logistics
  - X-Ray Fluorescence Analyzers for positive material identification

Impact: Improved inspection, rapid access to data

RFID-Reading Drone Tracks Structural Steel Products in Storage Yard

Dubai-based Age Steel is using an airborne RFID reader to inventory and locate tagged bundles of pipes, plates and other items stored in its yard.
EOC Contacts

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ATI Navy ManTech COE
Overview
Marty Ryan
ATI ManTech Overview

Marty Ryan
Executive Director, CMTC, CNM NSAM

NSRP All Panel Meeting
Charleston, SC
8 March 2017

Document prepared under ONR contracts N00014-17-D-4003, N00014-16-D-4001, N00014-14-D-0377
Distribution Statement A—Publically Releasable; Unlimited Distribution

Document Control Number (DCN #): 43-2489-17; Approved 24 Feb 2017
Who We Are

Headquartered in Summerville, SC

16 years of Operation
Contract renewed 2017

163

13 years of Operation
Contract renewed 2014

New award in 2016

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We also...

19 years of Operation

Headquartered in Summerville, SC
Project Development Process

- Industry generates ideas
- COE evaluates and screens ideas
- Navy and ONR review project ideas

- Project Planning Document (PPD) is developed by COE with input from the Navy and industry
- ONR Program Officer issues PDR

- COE develops and issues RFP’s
- Industry submits proposals
- COE and ONR evaluate proposals for compliance, cost and feasibility
- Recommended project plans presented to ONR

- ONR approves project
- COE develops and issues contracts
- Task orders are issued to Project Teams
- Project Team executes work
Project Types

• ManTech
  • Traditional Projects (12-30 months, $750K-$2M)
  • Mega Rapid Response (6-9 months, $500K)
  • Rapid Response (<6 months, $150K)

• Non-ManTech
  • Industry Design/Build
  • DoD Studies
  • Other DoD initiatives

• Special
  • Benchmarking
  • Build Strategies
  • Technology Roadmaps

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Metrics

- ManTech Cost Savings: $1.25B to date; growing
- Transition and Implementation Rates: 80%
- Projects:
  - Completed: 200 projects
  - Active: 30+ projects
  - In development: 40+ projects
- ROI: > 10:1
Center for Naval Metalworking
Dale Orren
Center for Naval Metalworking

Dale Orren
NSRP All Panel Meeting
8 March 2017

www.navalmetalworking.org

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.
• Overview
• Organizational Structure
• Capabilities
• Projects
Overview

• **Mission**: Identify, develop, and deploy metalworking and related manufacturing technologies to reduce the cost and time to build and repair key naval platforms and other relevant industries. Focus is shipbuilding and shipyard improvements to support Navy ManTech Investment Strategy.

• **Hybrid COE Model**: Deliver the best value to the Navy by:
  – employing proven successful virtual center model, augmented by available technical resources
  – teaming with industry experts and the best technology providers, generating the best technology teams
  – implementing results to address the requirements of Navy weapon systems.
Focus Areas

* metals and advance metallic materials
* metal-based composites & ceramics
* metallic materials-based systems
* metal/non-metals interfaces issues
* primary metal materials manufacturing processes (e.g. additive manufacturing)
* joining techniques
* surface and heat treatments
* metalworking systems engineering activities
* material characterizations and testing
* process design control
* product design and structural performance
* environmental issues and recycling
* information and data handling and transfer
* manufacturing technology/industrial base infrastructure
* inspection technologies
Organizational Structure

Business Manager
Kathy Zolman

Director
Marty Ryan

Technical Director
Paul Blomquist

Technology Solution Network
- Industry Partners
- Navy ManTech Centers of Excellence
- EWI Advisory Board
- NSRP Review Panel
- FDMC
- AMC
- The Composite Consortium
- The Southeastern Institute of Manufacturing & Technology
- University Partners

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Dale Orren

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- Mr. Jon Tirpak
- Mr. Thonton White
- Mr. D. Tim Wallace
- Mr. Jon Osborn

Project Manager
Nancy Porter

Project Manager
Warren Southerland

Project Manager
Chris Bergner

Project Manager
TBN

Program Administrator
Elizabeth Barton

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Partnership

- Colorado: Process and quality measurement
- Ohio: Joining, forming, metal additive manufacturing, testing
- New York: flexible automation, additive manufacturing, advanced metrology

- Materials selection
- Manufacturability
- Formability
- Joining constraints
- Joint designs
- Process selection
- Design optimization
- DFx
- Analytical modeling
- Inspectability / NDE
- Process validation
- Automated systems development
- Process monitoring and controls
- Tooling development
- Onsite training and support
- Weldability analysis
- Process feasibility
- Joining trials
- Technology demonstration
- Property characterization
- Process optimization
- Rapid prototyping
- Testing and analysis
- Equipment specification
- Onsite troubleshooting
- Continuous improvement
- Failure analysis
- Service life inspection

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.
## Projects

<table>
<thead>
<tr>
<th>CNM Project Candidates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automate Line Heating</td>
</tr>
<tr>
<td>Shaped Plated Verification and Accuracy</td>
</tr>
<tr>
<td>High Speed Rotating Welding Arc Process</td>
</tr>
<tr>
<td>Portable Robotic Welding Cell</td>
</tr>
<tr>
<td>Automated Welding of Hull Frames</td>
</tr>
<tr>
<td>Alternate Leak Detection Methods</td>
</tr>
<tr>
<td>Digital Casting Production for Large Thin-Walled Rotocraft Castings</td>
</tr>
</tbody>
</table>
Contact

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Naval Shipbuilding & Advanced Manufacturing Center
Kevin Carpentier
Naval Shipbuilding & Advanced Manufacturing Center
Kevin Carpentier, Technical Director

NSRP All Panel Meeting
8 March 2017
Background

- **Mission**: Identify, develop and deploy advanced manufacturing technologies that will reduce the cost and time to build and repair Navy platforms.

- **NSAM’s Virtual COE Model**: Deliver the best value to the Navy by:
  - *Teaming with industry experts and the best technology providers*
  - *Creating project development, review and execution teams as needed*
Stakeholders, Partners & Results

NSAM/CNST Results

• Transition Rate of >85% (over 13+ years)
• Return on Investment > 11:1
• Over $500M in Navy Cost Savings ($1.5B potential when all fully implemented)
• 20 Active Projects (13 more in development)
Dynamic Change Awareness

Objective
Develop a real time process for seamless communication between engineering, planning, supply chain management, and production control organizations.

Approach
- Phase 1: Develop As-Is process map; identify authoritative sources of data, relations between enterprise data end-users; identify process and capability gaps and map out the desired, future process.
- Phase 2: Develop dashboard requirements; define measures of success; pilot real-time process with dashboards, demonstrate & prepare for implementation.

<table>
<thead>
<tr>
<th>PEO</th>
<th>Shipyard Lead</th>
<th>Project Status</th>
<th>Cost Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ships</td>
<td>HII-Ingalls</td>
<td>Completing Apr 2017</td>
<td>$3.3M/DDG (est.)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>$2.3M/LHA (est.)</td>
</tr>
</tbody>
</table>

PEO
Shipyard Lead
Project Status
Cost Savings

PEO Shipyard Lead Project Status Cost Savings
Ships HII-Ingalls Completing Apr 2017 $3.3M/DDG (est.) $2.3M/LHA (est.)

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.
Synchronized Material Logistics

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Carriers</td>
<td>HII-Newport News</td>
<td>Complete &amp; Implemented</td>
<td>$3.1M/CVN</td>
</tr>
</tbody>
</table>

**Objective**

Develop a simulation-based material logistics planning tool to create a library-based, re-usable application that optimizes material logistics and improves CVN construction efficiency.

**Approach**

- Phase 1: Developed tool requirements; determined how data would be collected and formatted.
- Phase 2: Developed data input and reporting processes and adaptive optimization process for Final Assembly & Drydock 12 material laydown areas. Finalized coded algorithms to support the Adaptive Material Logistics Tool.

**DISTRIBUTION STATEMENT A.** Approved for public release; distribution is unlimited.
Objective
Develop dimension locating/metrology tools that:
1. Can be used by GDEB’s trades personnel to determine location within a grid system on curved and planar surfaces, and are
2. More cost-effective than traditional methods

Approach
• Phase 1: Develop system requirements; identify existing metrology technologies that satisfy those requirements, select a system for further development and create a test plan.
• Phase 2: Prototype the selected system and test it on various structural fabrications in a production environment using EB trades-people as system operators.

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.
Advanced Ultrasonic Testing of Butt Welds

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</thead>
<tbody>
<tr>
<td>Subs</td>
<td>GD Electric Boat</td>
<td>Complete &amp; Implementation u/w</td>
<td>$317K/VIRGINA</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>$476K/COLUMBIA</td>
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</table>

**Objective**
Develop techniques for implementing Phased Array Ultrasonic and Time of Flight Diffraction (PAUT/ToFD) technologies to replace radiographic and conventional ultrasonic testing.

**Approach**

- Phase 1 includes a feasibility determination for two joint types (equal thickness and a tapered joint) and a modeling & simulation effort to assess flaw detection ability in both joint designs. Mockup joints with implanted flaws were designed/fabricated to calibrate, develop, and validate the procedures.
- Phase 2 conducted tests to compare effectiveness of conventional UT to PAUT/ToFD inspections on as-welded hull butts and coordinated the Navy approval process.

**DISTRIBUTION STATEMENT A.** Approved for public release; distribution is unlimited.
Machine Readable Material Transactions

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<tbody>
<tr>
<td>Ships</td>
<td>HII-Ingalls</td>
<td>Complete &amp; Implemented</td>
<td>$2.9M/DDG</td>
</tr>
</tbody>
</table>

**Objective**
Develop tools and processes that reduce the cycle time for material transactions. Employ mobile devices and COTS software to enable machine-readable material transactions that improve traceability/accountability from Receipt Inspection through ship installation, checkout, and delivery to the end user.

**Approach**
- Phase 1: Develop unique alpha-numeric identifiers for all materials and processes for receipt inspection & QA verification.
- Phase 2: Develop warehouse inventory, preventative maintenance and material consumption processes.
Retractable Bow Planes

<table>
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<th>Cost Savings</th>
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<tbody>
<tr>
<td>Subs</td>
<td>GD Electric Boat</td>
<td>Complete &amp; Implemented</td>
<td>$9.5M/VIRGINIA</td>
</tr>
</tbody>
</table>

**Objectives**

1. Develop a plasma-sprayed, ceramic coating for VCS Retractable Bow Plane (RBP) cylinder rods to electrically isolate the piston rod and prevent calcareous deposits from forming.
2. Achieve maintenance-free operation of the RBP extend/retract cylinders for 96 months.

**Approach**

- Pre-ManTech effort to determine cause (iMAST)
- Phase 1: Optimize application process for an alumina-titania coating, then validate the effectiveness of the optimized coating system.
- Phase 2: Transition the process to industry; including destructive examination of full-scale test rod and vendor/procedure/operator qualification.
Future Project Candidates

• Internal Traffic Control Plan (VCS/CCS)
• Digital Thread Outside the Shipyard Gate (CVN)
• Autonomous Inspection Cell (CVN)
• Laser Scanning for Problem Solving (CVN)
• CNC Forming (VCS/CCS)
• Energy Conservation (VCS/CCS)
• Electron Beam Welding - Submarine Components (CCS)
• Portable Power Feed Drill Unit (F-35)

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.
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CMTC Update

Jon Osborn, Deputy Director
NSRP All Panel Meeting
8 March 2017

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.
Background

- **Mission**: Identify, develop and deploy advanced manufacturing technologies that will reduce the cost and time to build and repair Navy platforms.

- **CMTC’s Virtual COE Model**: Deliver the best value to the Navy by:
  - *Teaming with industry experts and the best technology providers*
  - *Driving state of the art material solutions from the best available sources to implementation on target platforms*
Stakeholders, Partners & Results

CMTC Results

- Transition Rate of >75% (over 16+ years)
- Return on Investment > 9:1
- Over $750M in Navy Cost Savings ($1.75B potential when all fully implemented)
- 13 Active Projects (20+ more in development)

Stakeholders

Industry Partners

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.
Research Focus Areas

- Fiber-reinforced polymeric (organic) resin composites
- Ceramic-matrix, metal-matrix, and carbon-carbon composites
- Chemical technology and environmentally-safe practices for composite materials and manufacturing processes
- Graphite, glass, and polymeric fibers as well as alternate reinforcements
- Composite “internal” stiffening core materials such as foam, ceramic, balsa wood, polymeric or metallic honeycomb, or other
- Composite “external” stiffening concepts such as hat and blade stiffeners and methodologies to manufacture them
- Composite manufacturing and similar processes and related equipment, including best practices, maintenance, set-up, and environmentally safe disposition. Composites manufacturing processes include but are not limited to wet hand lay-up, prepreg hand lay-up, automated fiber placement and tape laying, resin transfer molding and related infusion technologies, pultrusion, etc. Curing technologies include autoclave curing, out of autoclave/oven curing, press curing, etc.
- Engineering plastics and similar materials and related processes (thermoforming, sanding/polishing, etc.)
- Signature reducing materials and treatments
- Materials for radomes and other electrical applications
- Pourable filling, shaping, and fairing materials
- Adhesives, adhesive bonding, and related technologies (i.e., surface preparation techniques), as well as mechanical fastening, and other methodologies for joining composites to other composites or metals, and similar assembly technologies
- Sealant, coating, and filling materials technologies, including mixing, application, and removal
- Robotic or automated processing of the above materials (i.e., drilling, machining, etc.)
- Mechanical, physical, chemical, thermal, and/or electrical testing for characterization of composite or other nonmetallic materials
- Quality assurance/advanced non-destructive evaluation covering all aspects of composites manufacturing from incoming raw material control through in-service inspection
- Modeling and simulation, (i.e., cure modeling, finite element analysis, etc.)
- Process analytics
- Polymeric additive manufacturing technologies
- Repair technologies
## Extended Life Propulsion Shaft Surface Treatment

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<tbody>
<tr>
<td>Carriers</td>
<td>HII – Newport News</td>
<td>Complete &amp; Implemented</td>
<td>$170M/14 years</td>
</tr>
</tbody>
</table>

### Objective
Identify failure mechanism of current covering and defeat that failure mechanism to allow for a 15 year corrosion prevention system.

### Approach
- Worked with Penn State ARL and NSWCCD to determine the failure mechanism of the current covering.
- Developed additional processing step and introduced a decoupling material.
- Implemented on CVN as a demonstration.
- Process and approach has been included in MIL-STD-2199A for coverings for main propulsion shafting for ships and submarines.

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**Composite EHF Antenna Platform**

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</thead>
<tbody>
<tr>
<td>Carriers</td>
<td>HII– Newport News</td>
<td>Complete &amp; Pending Implemented</td>
<td>~$100M</td>
</tr>
</tbody>
</table>

**Objective**
Utilize specialized materials and construction to improve the frequency response of cantilevered platforms to prevent failures of attached machinery.

**Approach**
- Worked with HII- NNS, Penn State ARL and HI-TEST laboratories to develop frequency mitigation approach.
- Unable to properly mitigate the frequency response with steel construction, as stiffness is added, so is weight, requiring additional stiffness.
- Developed subscale demonstration articles of hybrid construction.
- Weld ready beam termination.
Submarine Sail Support Program

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<tbody>
<tr>
<td>Sub</td>
<td>GD Electric Boat</td>
<td>Complete &amp; Implemented</td>
<td>&gt;$150M</td>
</tr>
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</table>

**Objective**
The submarine environment offers a unique challenge where doubly curved steel sections are difficult and expensive to fabricate and all steel components require frequent maintenance due to corrosion in the harsh underwater environment. Composite materials offer the perfect combination of corrosion resistance, strength of materials, and acquisition cost savings over doubly curved or hard to maintain steel components.

**Approach**
- Team with NAVSEA Sail Cost Reduction Program
- Flood Ports, Slack Racks, Cableways, Covers, Doors, Access Panels, Sail Cusps, Trailing Edge

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.
**Objective**
Develop robust Fire, Smoke, & Toxicity (FST) safe materials for internal applications. Targeting the most restrictive FS&T requirements.

**Approach**
- Improve the processing of phenolic resins
  - Able to process 1-2% void content FST phenolic panels
- Survey cutting edge materials and additives to improve performance
- Downselect to 1-3 viable materials systems, using off the shelf materials.
- Project briefed at NSRP All Panel
Enabling Technologies – MS&T

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<th>Cost Savings</th>
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<tbody>
<tr>
<td>Sub</td>
<td>GD Electric Boat/Materials Science Corp.</td>
<td>Complete &amp; Pending Implemented</td>
<td>~$25M</td>
</tr>
</tbody>
</table>

**Objective**
Demonstrate a combination of advanced materials/technologies/manufacturing methods to enable application of composites to a broader set of submarine applications.

**Approach**
- Determine highest yield technology areas to mature.
- Break the myth that carbon or specialty composites are too expensive.
- Develop examples of highly integrated, hybridized composites
- Main goal was to integrate as many cross functional materials and processes as possible to eliminate additional work required by the yards.
- Goal: Life of ship and ease of installation.
Composites Projects Focus

• High On the Ship/Too Heavy for Personnel Lift
• Below Waterline
• Curved or Doubly Curved
• High Amounts of Touch Labor (automation)
• Failing Due to Vibration or Corrosion (Internal or External)
• Integrated Weapons Systems – Multi Platform Support
• Use of exotic metals
Contact

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Questions?
Adjourn General Session

LUNCH & EXPO