NAVSEA Additive Manufacturing

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1. Standards / Technical Data Package / Material Science Database:
   – Accelerate standards development (i.e. metal, polymer, tooling, digital)
   – Establish DON Technical Data Package
   – Enable rapid approval process for certain AM components

2. Prototype Digital Manufacturing Ecosystem:
   – Streamline AM part ID by connecting user, logistics and manufacturing communities
   – Publish product production requirements and align AM capacity
   – Network select printers
   – Field initial 3D Print Exchange Server

3. Define AM afloat infrastructure:
   – Increase experimentation afloat to inform operational utility
   – Define ship integration requirements

4. Define workforce development requirements:
   – Warfighter, Artisan, DAU/acquisition

5. AM Business Practices, Cost Modeling, and Supply Chain Policy:
   – Examining Business Case Analysis
• Develop & align engineering and acquisition competency and expertise to:
  o Build AM ship and weapon system components
  o Leverage AM as a(nother) manufacturing technique ‘in the tool box’
    – Grow AM knowledge base through investment and collaboration
    – Push AM capabilities and authorities to waterfront (depots and shipyards), afloat, etc.
  o Employ AM in maintenance & repair shoreside
  o Expand the use of AM for rapid design development, prototyping & tooling
  o Identify long-term investment to ensure AM capabilities for the NAVSEA enterprise
  o Connect with AM, digital backbone, and cybersecurity

• Identify areas for application that improve capability and/or reduce cost

• Establish processes, specification and standards for use of AM in design, acquisition, maintenance, and operations

• Coordinate & collaborate with other SYSCOMs, industry and academia
  o OEMs awareness of DON AM requirements

Operationalize AM in support of the Fleet where it makes sense
Approval Process and Spec/Standard Development

- NAVSEA AM Guidance released August 2018
  - Guidelines for use of polymeric materials aboard ship (fire, smoke, and toxicity requirements)
- Powder Bed Fusion Specification (Sept FY19)
- Directed Energy Deposition Specification (Draft end of FY19)
- Requirements for the use of AM in indirect applications
- Engage Standard Development Organizations with industry for AM processes
• NAVSEA AM Guidance (Ser 05T/2018-024):
  o Decision/Approval Process
  o Definitions
  o AM Process
  o AM Materials (including Fire/Smoke/Toxicity limitations for polymer)
  o Technical Data Package Requirements

• Does:
  o Requirements for shipboard components
  o Submittal/approval process for AM components installed shipboard
  o Applicable for all vessels
    - EXCEPTION: No AM Polymer material is permitted on a submarine w/o NAVSEA approval (off gassing of material need further investigation)
  o Fire/Smoke/Toxicity compliant polymer materials
  o Requirements for incorporation of polymer materials shipboard
  o Metallic material requirements/considerations

• Does NOT:
  o Apply to Naval Nuclear Propulsion plant systems, equipment and facilities under cognizance of Naval Reactors (SEA08)
  o Apply to Strategic Weapons Systems and Attach Weapons Systems under cognizance of Strategic Systems Programs
  o Provide guidance for AM equipment installation shipboard
• Engage fleet and leverage logistics databases to ID priority components
• Interim process established for digitally sharing files
• Scalability is key for NAVSEA-wide implementation

<table>
<thead>
<tr>
<th>Submitted For Approval</th>
<th>Approved Low Risk Applications</th>
<th>Received Tech Authority Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applications have been submitted for assessment.</td>
<td>Delegated to local technical authority (Chief Engineers - Waterfront or Ship).</td>
<td>Approved TDP which specifies materials and printers</td>
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<tr>
<td># of Parts: <strong>584</strong></td>
<td># of Parts: <strong>85</strong></td>
<td># of Parts: <strong>3</strong></td>
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Afloat/Expeditionary AM

• Afloat R&D
  o Outfit a limited number of platforms/hulls with AM Equipment
  o Establish networking requirements and means to transfer digital files securely
  o Identify ship modifications
  o Assess performance of equipment and materials in non-static, non-laboratory environments

• Equipment Installation Challenges:
  o Networking of equipment/alternative IT approvals to allow stand alone
  o Electrical requirements for industrial equipment
  o Space configuration and shock mounting

• Other Metrics and Outcomes:
  o Identify the ‘use case’ for the equipment
  o Define workforce development and training requirements
  o Establish requirement for equipment, and ID/prioritize platforms/hulls

• Future Equipment Installation
  o Current: AM equipment installed shipboard via a Ship Change Document (SCD)
  o Establish “green box” for AM equipment, identifying requirements for desktop printers (power, etc.), installation requirements (mounting, etc.) and IT and Infrastructure requirements (computers, networking, etc.)
  o Determine means to establish afloat AM within NAVSEA structure (Program of Record, Outfitting Allowances, etc)
Advanced Manufacturing Lab Capabilities

**Small Industrial Printer**
Polymer Printer with open source materials capabilities

**Prosumer Printer**
Polymer Printer with open source material capabilities

**Laser Cutter**
Ability to cut and engrave multiple materials at a determined size scale

**3D Scanner**
Large and small scale part capabilities

**CNC Mill**
Multi-axis mill to support high hardness materials

**Digital Infrastructure**
Part design and library hosting capabilities
• **Prototype hanger door bolt**
  - USS CHUNG-HOON, part of CSG – 3; requested replacement bolt for hanger bay door assembly
  - USS JOHN C. STENNIS sailors modeled and printed part for form-fit, responded to necessary changes and used the model to machine the final metal bolt allowing for material replacement
  - Each bolt would take up to 6 hours to machine; saving time and money

• **Replacement AIMD calibration equipment knobs**
  - Resulted in operational availability of $5300 machine that would otherwise have to be replaced

• **Other:**
  - Various knobs (kitchen oven, other)
  - Electrical knockout plugs
  - Sound Power Phone Cap
  - Electrical Contact Pin Spacer
Future Afloat Work

• Expansion to additional motion profiles, including high frequency vibration
  o Rapid screening for geometric variance
  o Recording of ship motion data
  o Shipboard integration requirements and representative mounting to establish a framework for rapid qualification of AM systems

• Establishing relationships with industry and academia to develop printers and materials that are tailored to at-sea application

• Minimize integration impacts (power requirements; installation and mounting)

• Ruggedization

• FST compliant materials

• Qualify and Certify higher risk and higher criticality applications

• Metal capability
Logistics Integration

• Motivation: Growing application space for AM across the Naval Enterprise requires supply chain Integration

• Goal: Data-driven AM part identification using automated logistics, supply and maintenance data

• Approach: Leverage existing databases and policies to integrate AM into the supply chain to promote improved agility, lower response times minimize brittleness

• Current Roadmap:
  • Establish cataloging and provisioning guidelines for AM parts
  • Logistics database and search for evaluating AM mission impact and readiness
  • Establish procedures for traceability of shipboard AM components at all levels; risk assessment and management
Notable Challenges

• AM Data management
  o High ‘variability’ with respect to manufacturing parameters
  o DoN early adopter: determining “what matters” from a technical perspective
  o Standards are immature
  o Lack of engineering data and requirements

• AM “economic models” evolving
  o Digital file sharing and publishing sporadic
  o File transfer/translation challenged by unique processes and configurations
  o Cyber security and configuration management
  o Monetizing AM (production and/or component data)
Discussion/Questions