NAVSEA Additive Manufacturing

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NAVSEA 05T

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Naval Lines of Effort

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

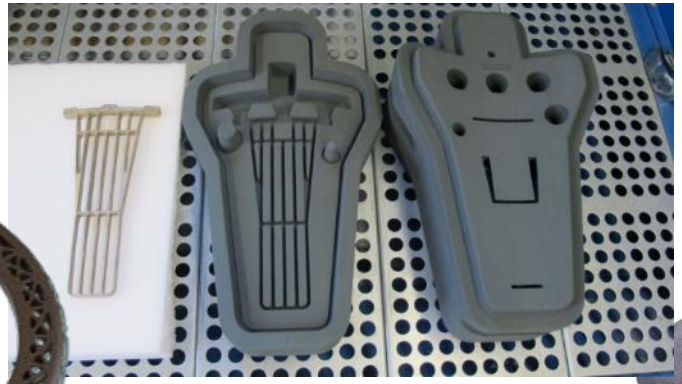
NAVSEA Additive Manufacturing Strategy

- Develop & align engineering and acquisition competency and expertise to:
  - Build AM ship and weapon system components
  - 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.
  - Employ AM in maintenance & repair shoreside
  - Expand the use of AM for rapid design development, prototyping & tooling
  - Identify long-term investment to ensure AM capabilities for the NAVSEA enterprise
  - 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
  - OEMs awareness of DON AM requirements

Operationalize AM in support of the Fleet where it makes sense

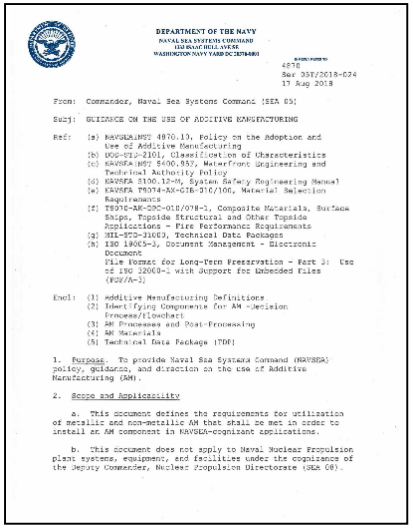
Approval Process and Spec/Standard Development

- 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



Approval/Guidance

- NAVSEA AM Guidance (Ser 05T/2018-024):
  - Decision/Approval Process
  - Definitions
  - AM Process
  - AM Materials (including Fire/Smoke/Toxicity limitations for polymer)
  - Technical Data Package Requirements
- Does:
  - Requirements for shipboard components
  - Submittal/approval process for AM components installed shipboard
  - 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)
  - Fire/Smoke/Toxicity compliant polymer materials
  - Requirements for incorporation of polymer materials shipboard
  - Metallic material requirements/considerations
- Does NOT:
  - Apply to Naval Nuclear Propulsion plant systems, equipment and facilities under cognizance of Naval Reactors (SEA08)
  - Apply to Strategic Weapons Systems and Attach Weapons Systems under cognizance of Strategic Systems Programs
  - Provide guidance for AM equipment installation shipboard



DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
1333 ISAAC HULL AVENUE
WASHINGTON NAVY YARD DC 20376-5001

4870
Ser 05T/2018-024
17 Aug 2018

From: Commander, Naval Sea Systems Command (SEA 05)

Subj: GUIDANCE ON THE USE OF ADDITIVE MANUFACTURING

Ref: (a) NAVSEAINST 4870.13, Policy on the Adoption and Use of Additive Manufacturing
(b) MIL-STD-2101, Classification of Characteristics
(c) NAVSEAINST 5400.95, Waterfront Engineering and Technical Authority Policy
(d) NAVSEA S9300.12-AA, System Safety Engineering Manual
(e) NAVSEA T9074-AX-GTB-010/100, Material Selection Requirements
(f) T9310-AM-SPC-010/078-1, Composite Materials, Surface Ships, Topside Structural and Other Topside Applications - Fire Performance Requirements
(g) MIL-STD-31000, Technical Data Packages
(h) ISO 19005-3, Document Management - Electronic Document File Format for Long-Term Preservation - Part 3: Use of ISO 32000-1 with Support for Embedded Files (PDF/A-3)

Encl: (1) Additive Manufacturing Definitions
(2) Identifying Components for AM - Decision Process/Flowchart
(3) AM Processes and Post-Processing
(4) AM Materials
(5) Technical Data Package (TDP)

1. Purpose. To provide Naval Sea Systems Command (NAVSEA) policy, guidance, and direction on the use of Additive Manufacturing (AM).

2. Scope and Applicability

a. This document defines the requirements for utilization of metallic and non-metallic AM that shall be met in order to install an AM component in NAVSEA-cognizant applications.

b. This document does not apply to Naval Nuclear Propulsion plant systems, equipment, and facilities under the cognizance of the Deputy Commander, Nuclear Propulsion Directorate (SEA 08).

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Approval Status

- Engage fleet and leverage logistics databases to ID priority components
- Interim process established for digitally sharing files
- Scalability is key for NAVSEA-wide implementation

Submitted For Approval
Applications have been submitted for assessment.

# of Parts: **584**

Approved Low Risk Applications
Delegated to local technical authority (Chief Engineers - Waterfront or Ship).

# of Parts: **85**

Received Tech Authority Approval
Approved TDP which specifies materials and printers

# of Parts: **3**

Afloat/Expeditionary AM

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

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

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

- Future Equipment Installation
  - Current: AM equipment installed shipboard via a Ship Change Document (SCD)
  - 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.)
  - 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

USS STENNIS Advanced Manufacturing Lab

- *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

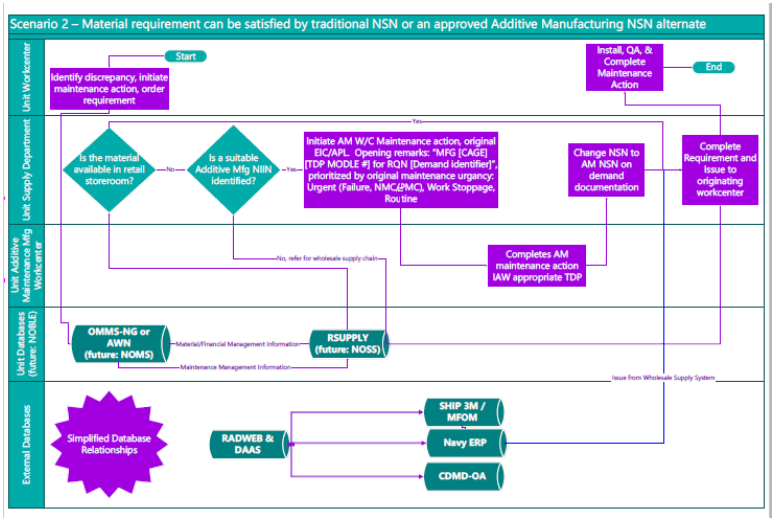
Future Afloat Work

- Expansion to additional motion profiles, including high frequency vibration
  - Rapid screening for geometric variance
  - Recording of ship motion data
  - 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
  - High ‘variability’ with respect to manufacturing parameters
  - DoN early adopter: determining “what matters” from a technical perspective
  - Standards are immature
  - Lack of engineering data and requirements

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

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Discussion/Questions