NAVSEA 05T Additive Manufacturing Program

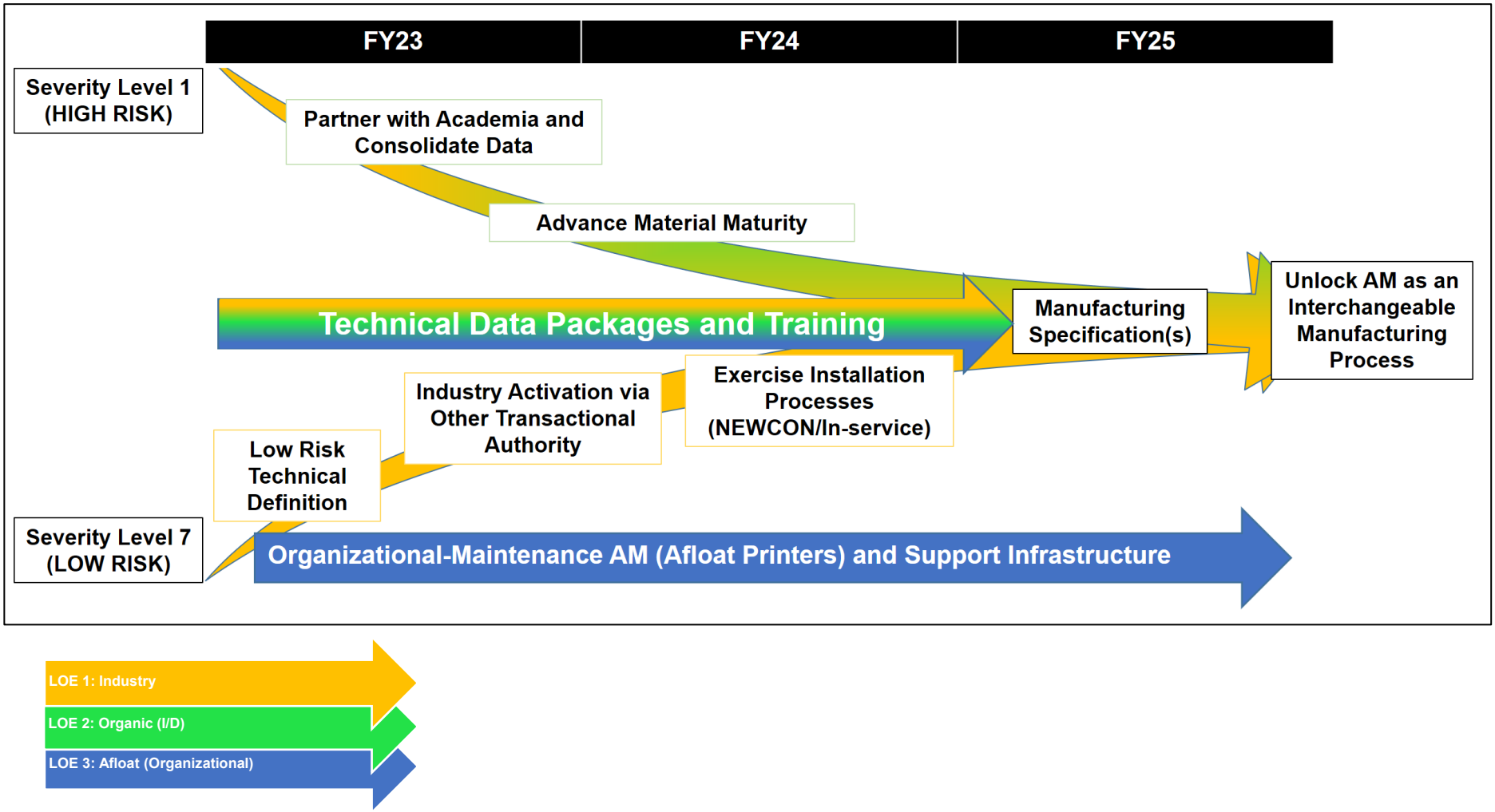
Brief to NRC

24 Oct 2023

Distribution Statement A: Approved for Release. Distribution is unlimited.

Material and Process Strategy

Operationalize Additive Manufacturing as a Routine Manufacturing Process



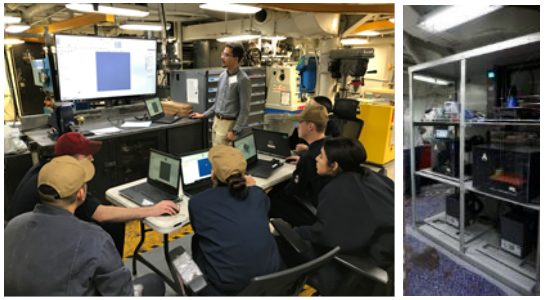
Converging material knowledge, process maturity and operational experience unlocks interchangeability

NAVSEA 05 Additive Manufacturing Overview

- **Process Qualification/Component Certification**
  - Develop Technical publications for repeatable AM processes
  - Explore in-situ monitoring
  - Collaborate closely with industrial base
    - ➢ *To Date: Tech Pubs for metal AM processes; Over 500 approved parts, 300+ polymer TDPs available to fleet*
- **Afloat/Undersea Deployment**
  - Explore how to deploy and integrate advanced / additive manufacturing equipment surface and subsurface
  - Understand environmental / motion impacts on printing process
  - Metal AM capability installed on USS BATAAN in Nov 2022
    - ➢ *Advanced manufacturing equipment installations on 9 ships; 4 submarines deployed with AM; over 4,000 parts printed afloat; 50+ Sailors trained*
- **Digital Integration**
  - Identify file securing / transiting / storage solutions, including parts repository
  - Explore topology optimization and generative design
    - ➢ *Development of digital manufacturing environment to enable networked AM equipment ashore (NNSY in 2022) and afloat (USS BATAAN in 2022)*
- **Logistics/Supply System integration**
  - Incorporate components into logistics databases to enable part provisioning, tracking and 'buy or print' decisions
    - ➢ *146 AM parts have NSNs; initial cost avoidance and lead time metrics generated for afloat components*

TOP LEFT: DSO valve installed on CVN-75. TOP MIDDLE: CAT2 CASREP for satellite IP antenna printed during deployment. TOP RIGHT: AM deck drain installed on USS LABOON. BOTTOM LEFT: Approved metal bilge strainer for SSN. BOTTOM CENTER: Approved cease fire alarm horn installed on DDG. BOTTOM RIGHT: Fuse cover to prolong fuse life, installed several LHDs.

Scaled Propulsor Blade Test Build



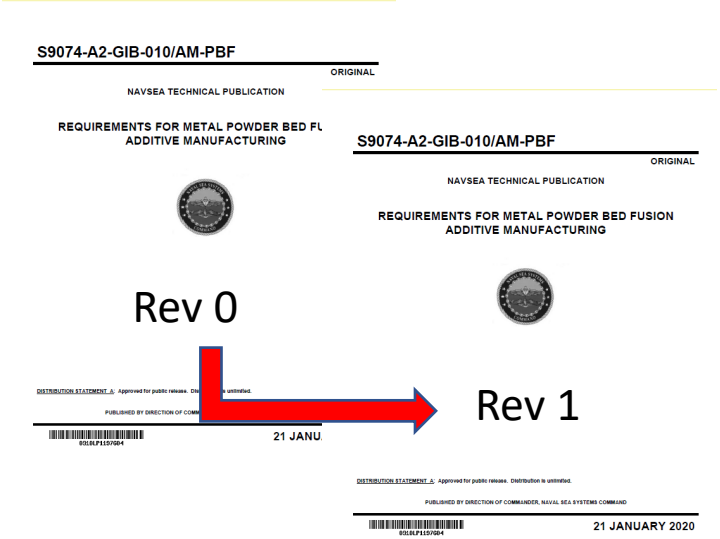
LEFT: AM training on-board CVN-71. RIGHT: 3D printers on CVN-69

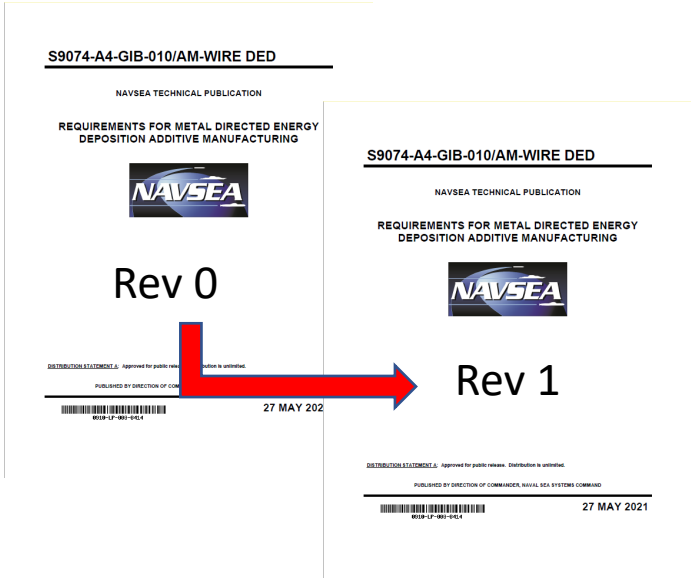
NAVSEA Guidance/Standards

- **Guidance:**
  - Guidance on the Use of Additive Manufacturing (Issued)
  - Guidance on Identification and Installation of Low Risk Additively Manufactured Metal Components (Issued)
  - Guidance on reporting installation of AM components shipboard (under development)
  - Guidance under development for processes and technologies enabling installation of AM components shipboard:
    - Assessment and Use of In-Situ Monitoring
    - Metal Binder Jet Fusion
    - Powder Blown DED
    - Metal Material Extrusion
    - Additive Friction Stir Deposition
- **Standards:**
  - Requirements for Metal Powder Bed Fusion Additive Manufacturing (Issued)
  - Requirements for Metal Directed Energy Deposition Additive Manufacturing (Issued)
  - Requirements for Polymer/Composite Material Extrusion Additive Manufacturing (Under Development)

Process Qualification/Component Certification

- **What have we learned?**
  - Standards are difficult
  - Need for iteration/constant improvement
  - Without guidance, unable to coordinate/collaborate efforts
  - Balance systemic risk to application risk
  - Learn by doing – Need to 'snap chalk line' and start with initial applications/efforts necessary to build knowledge base





Snapping a 'Chalk Line'

- How do we balance systemic vs. component risk
  - No one-size fits all for standards requirements
  - Application specific requirements will drive adoption

- What works best for applications at hand?
  - Accept that 'chalk line' isn't applicable across all applications, but provides opportunities to build knowledge base to translate to future applications
  - Find 'safe zone' for application development that allows tolerable risk acceptance given system requirements

- **<u>As we look at application space for AM, we need to know:</u>**
  - Where we need standards
  - Where we need guidance/best practices
  - Where we identify applications to begin learning

Afloat AM Update

Legacy AM Equipment Installations:

- As of Aug 2022, NAVSEA R&D program installed polymer AM on 8 surface ships as R&D prototypes (3 CVNs, 4 amphibs, 1 DDG)
  - AM assets installed via nonpermanent Ship Change Document
  - Polymer AM capability deployed on three submarines (fleet funded equipment/NAVSEA supported)
- Nov 2021: Polymer printer installed via DFS on USS KEARSARGE (fleet funded equipment/NAVSEA supported)
- July 2022: Polymer printer deployed on submarine
  - Submarine deployed with a desktop 3D printer (Lulzbot Mini 2) in 2020-2021 and shared lessons learned with SEA05T
  - SEA05T, SUBLANT, submarine and PMS394 coordinated to install and evaluate improved polymer printer on FY22 NHP deployment
  - Developing updates to submarine AM guidance document to reflect addition of improved printer

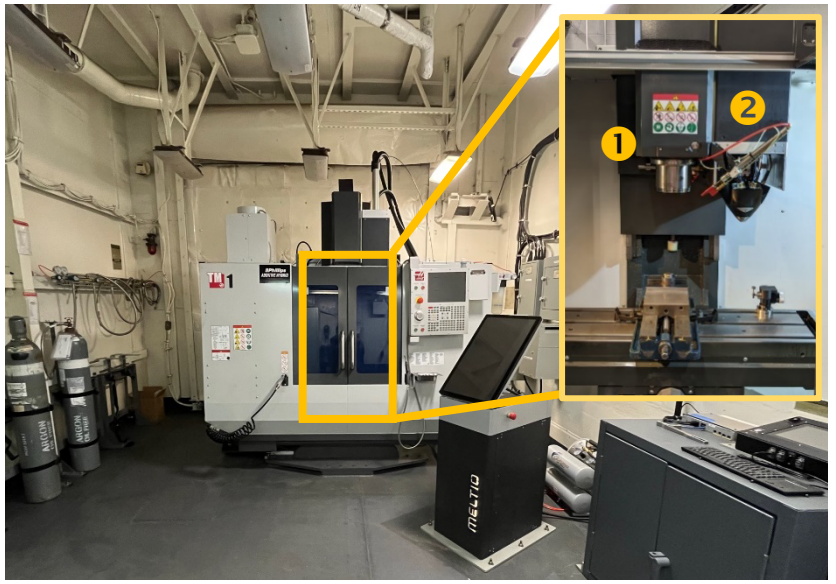
Recent AM Equipment Installations:

- Metal and polymer capability on USS BATAAN (LHD-5) – **COMPLETED NOV 2022**
  - Installation of Hybrid metal additive and CNC capability (Phillips Additive Hybrid)
  - Installation of polymer system (Markforged X7)
  - Additional planned install of Hybrid Metal and polymer AM equipment on USS WASP – Summer 2023
  - Conversion of Balloon Inflation Room to Additive Manufacturing Shop, planned as common location across WASP-Class
  - SEA05T supporting deployment by conducting shore-based R&D and providing afloat support to BATAAN

Afloat Additive Manufacturing Hybrid Metal System

- **Shipboard Metal AM**
  - Phillips Additive Hybrid Laser Metal Wire Deposition (LMWD) Hybrid AM technology
    - ❑ Wire-fed laser DED AM system (Meltio Engine)
    - ❑ CNC milling machine (Haas TM-1)
  - Combines additive and subtractive processes
- **Installed on USS BATAAN Oct-Nov 2022**
  - 5 Sailors trained (1 MR, 2 HT, 2 DC) on CNC operation, Hybrid LWMD operation, Polymer AM equipment operation (+3 KSG sailors), MasterCAM (Hybrid AM software), and SolidWorks (3D modeling) [5 weeks total]
  - MOA established between BATAAN, NAVSEA and CNSL to facilitate RDTE sample printing, data acquisition, print logging, and reach-back support

R&D-Related Partners:
Johns Hopkins University-Applied Physics Lab (JHU-APL), Advanced Technology & Research Corp. (ATR), Building Momentum



Phillips Additive Hybrid Aboard USS Bataan – November 2022
Laser Metal Wire Deposition System
Inset: 1) CNC Tool Spindle, 2) Deposition Head

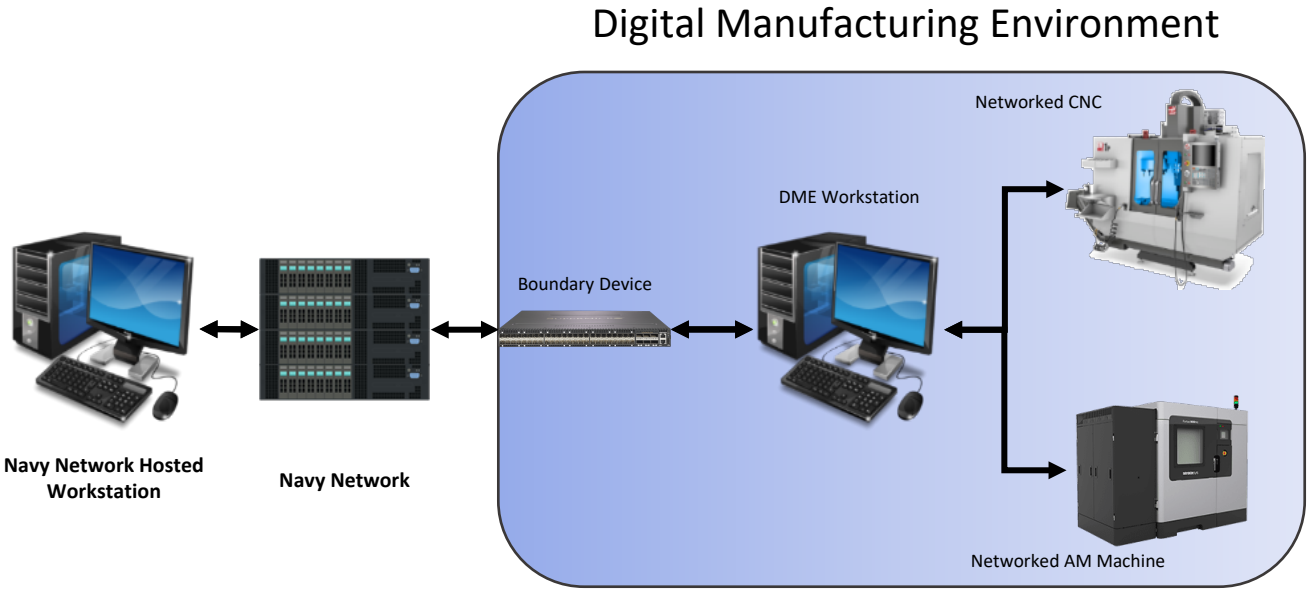
Dimensions *(L×W×H)*	168"×134"×110"
Build Envelope *(L×W×H)*	~20" × ~10" × ~12"
Machining Envelope *(L×W×H)*	~30" × ~12" × ~16"
Materials	316L Stainless Steel *(welding wire)*
Features	• 3-axis CNC milling operations • Parts designed using SolidWorks CAD software • Additive and subtractive operations controlled using MasterCAM APlus

AM Logistics Integration

- NAVSEA 05T and NAVSEALOGCEN partnered to initiate an AM Logistics Integration Team in FY19 with participation from:
  - NAVSEA 05T, 05R, 03R
  - NSWC Philadelphia
  - NUWC Keyport
  - NAVAIR
  - NSLC Mechanicsburg
  - NSLC Portsmouth
  - NAVSUP HQ & WSS
  - DLA Cataloging
- Establish toolsets to facilitate AM logistics information tracking/part identification IAW AM TWH policies and requirements
- Integrate and sustain AM parts into supply; develop vendor source approval infrastructure
- Define the process for traceability of AM parts in the supply chain
  - DRAFT guidance for leveraging the maintenance action reporting process (2K/AWN) developed
- Establish the metrics for reporting the impact of implementing AM solutions
- DLA Joint Additive Manufacturing Acceptability (JAMA) Project
- AM Acquisition procedures for logistics support/Future LOG IT Infrastructure Inclusion

Digital Infrastructure

- NAVSEA is prototyping the Digital Manufacturing Environment (DME) to address the need for advanced manufacturing cybersecurity and streamlined communication between ashore and afloat activities
- The DME provides a scalable, proof-of-concept secure network boundary that separates manufacturing equipment and workstations from the host network
- Two DME pilots to demonstrate secure connections and communication between digital manufacturing equipment and navy networks
  - Ashore DME pilot with NNSY July 2022
    - ❑ Finalized Updates 1 Sep 2022
  - Afloat DME pilot with USS BATAAN installed concurrently with AM equipment Oct-Nov 2022



Questions