Raytheon
An RTX Business

Localized Additive Manufacturing Capability to Support Contested Environments

Authors:
Dan Hoffman, Principal Engineer, Raytheon
Bijan Hamidi, Senior Engineer, Raytheon

Aug 7-9 2024

ETI Emerging Technologies Institute
NDIA

2024 EMERGING TECHNOLOGIES FOR DEFENSE CONFERENCE & EXHIBITION

eTCPR ID: RMD-22431
Approval for Release: Jul 25, 2024

BLUF

Observation:

- Researching into leveraging localized AM capability in the field, yielded the observation that there is no formalized or reliable process at the edge.

Opportunity:

- Our team sought to develop an AM capability focused on the maintenance processes that may support AM processes in a contested environment.
- Through fault association, connection with program Interactive Electronic Technical Manuals (IETM), and direct connection to 3D Printer interfaces, we have begun to structure a process to field AM.

Benefits & Outcome:

- These connections enable the software to identify required parts for maintenance, the associated remove & replace procedures, and provide access to appropriate AM-Ready Build Files.
- Capability to tie AM parts to maintenance alerts allows the warfighter to leverage AM equipment to provide an alternate pathway to conventional supply chains and an opportunity to “fix differently,” and stay in the fight.
- A maintenance alert workflow is utilized to track the usage of the AM Parts that may be in service, so they can be properly replaced at a more opportune time (temp part), or properly maintained in a future maintenance cycle (perm part).

3D Printing in Contested Environments

Self-Sufficiency and Agility Enable Deployed Systems to Sustain Operations Longer in the Presence of Contested Environments

- **Technical Solutions**
  - High Reliability/ Commonality
  - Pre-Deployed Material / Resources
  - Forward-based Additive Manufacturing for Critical Devices
- **Benefits**
  - Increases System Ao
  - Reduced Dependency in Logistic Supply
  - Increased Mobility
- **Approach for 3D Printing = Fix Differently:**
  - Restore Functionality given available resources
  - Repair differently than OEM prescribed.
  - Increases self-sufficiency through resiliency, and agility

Additive Manufacturing: Transforming Contested Logistics in the DoD

*"Additive manufacturing, with its array of benefits, stands poised to **play a crucial role** in reshaping how the DoD approaches and masters the c**hallenges of contested logistics.**"*

*"By integrating AM into its operations, the DoD not only **enhances its logistical agility** but also **fortifies its supply chains** against the myriad of threats in the contested logistics landscape."*

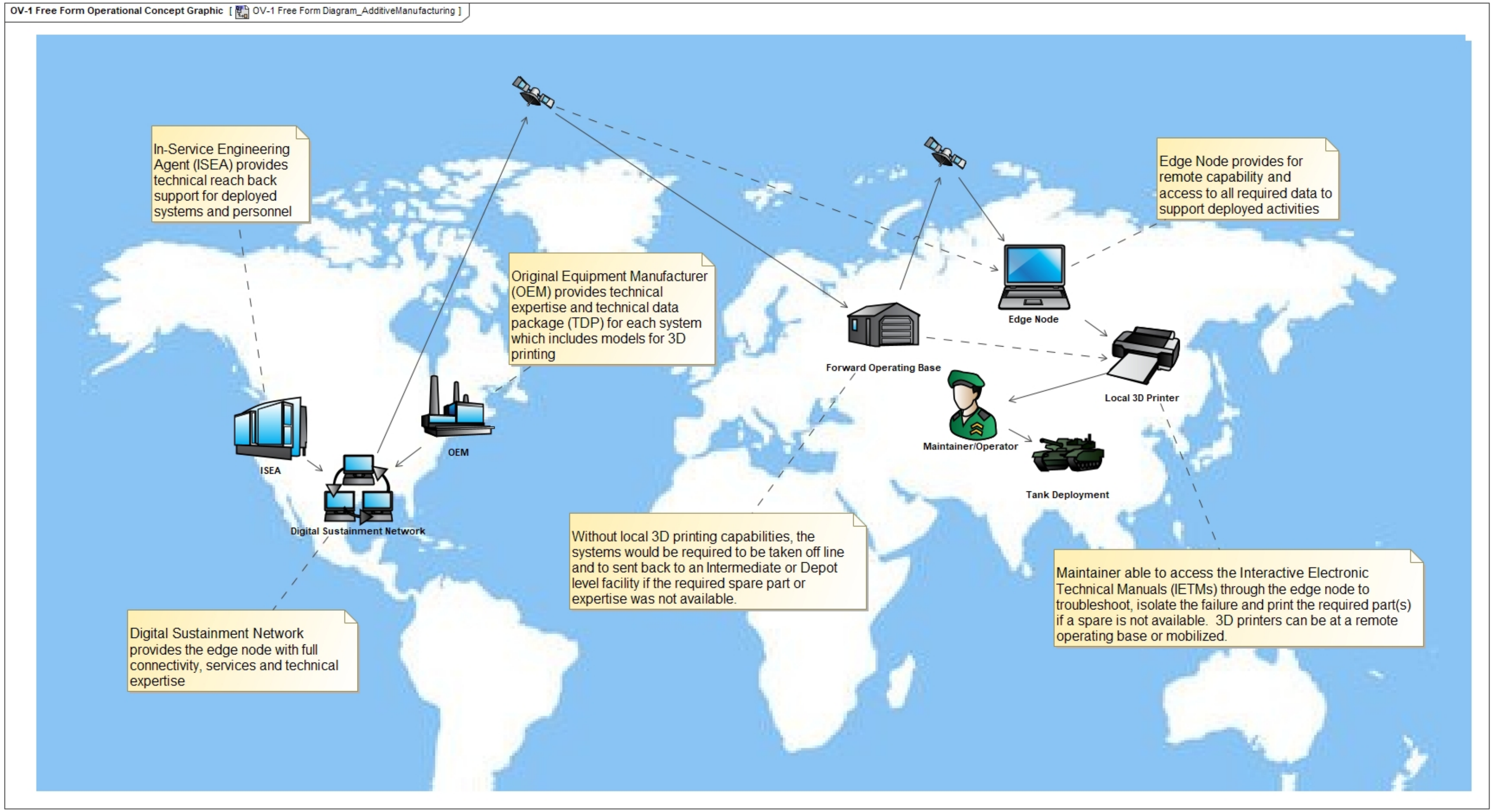
Source: Additive Manufacturing: Transforming Contested Logistics inthe DoD | IC3DPrinters

Fielded 3D Printing Capability provides an alternative supply source to meet demands on the battlefield

OV-1 Concept

Overview:

- A “Fix Differently” approach allows for systems to be repaired in the field without requiring a large logistics footprint, which is especially challenging in a contested logistics environment
- Through the Digital Sustainment Network, we are able to provide the maintainer at the edge node with full access to system data and technical expertise
- In the event of a failure the maintainer would use the edge node to:
    - Access Interactive Electronic Technical Manual (IETM) to troubleshoot and Isolate the failure down to the LRU level
    - If the spare part is not available, the IETM work package identifies if the part(s) can be 3D printed and if the sliced 3D models are available
    - Maintainer prints required parts using an available local 3D printer to complete required repair



Capabilities & Features

Capabilities:

- These connections enable the software to identify required parts for maintenance, remove and replace procedures and provide access to appropriate build files.
  - Fault >> Work Package >> Tools/Parts >> AM-Ready Build File
  - Display printable parts in relation to operator workflow
  - Track the usage of temporary parts that may be in service, so they can be properly addressed in a future maintenance cycle

Features:

A. Applicable Training Aid Display & Section Access

B. 3D Printer Selection Menu, Capability to Access Printer Interface (if applicable), and Direct Print Access (if available)

C. Connected Printer Information (if available)

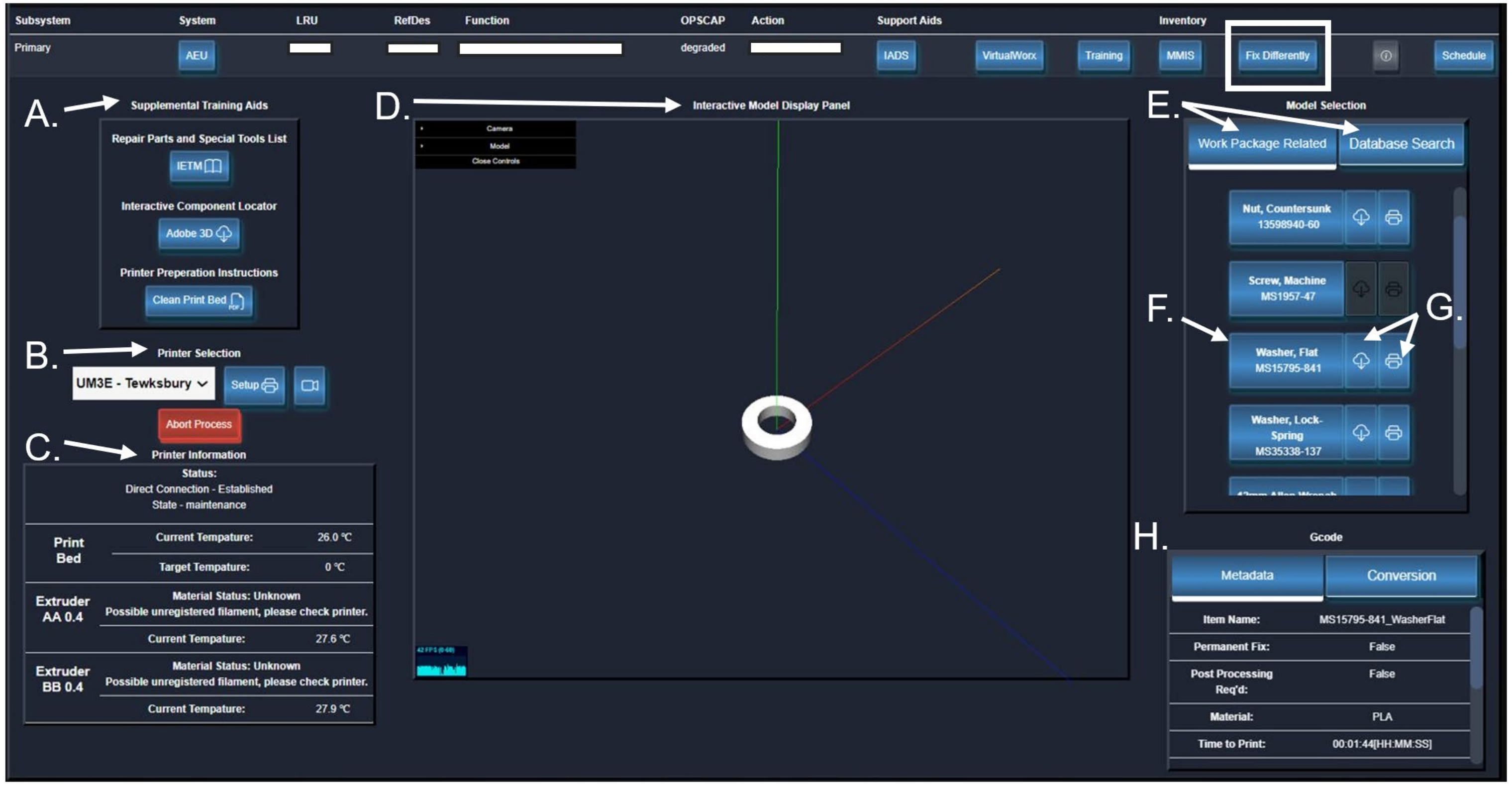
D. Interactive AM File Display Panel

E. Component Selection Display Window Offering Maint. Related AM Files & Ability for Advanced Searching

F. Component Selection Button for Display within Interactive Display Panel

G. File Download Selection Button (file provided in appropriate syntax per Printer Selection)

H. Component File High Level Metadata Display



Repair is needed however; parts are not available in inventory. What we do have available are the build files of required parts, so the recommended course of action would be to fix differently with fielded additive manufacturing technology.

Technologies / Technical Solutions – Limitations / Challenges for this Tech

Challenges

- Current adoption of AM is typically limited to prototyping and secondary/tertiary components
  - Some AM components requiring additional qualification prior to being installed onto a fielded asset
- Legal Concerns
  - IP protected data over external system connectivity
  - Components produced by external suppliers
  - Components that may be proprietary in nature and are protected
- AM Equipment and Materials Availability

Big Picture Vision

- Focus on *Expedient Method* Practices for near-term support and adoption of "fix differently" concept in contested environments
  - Investment into permanent/qualified replacement processes and procedures is a longer-term initiative
- Creation of unique support protocols enabling the use of non-qualified/unapproved components in a temporary nature
- Unique supplier agreements to provide protected files for temporary reproduction
- AM Equipment and Material selection would vary dependent on situation/location within the Military Operations Theater
  - Front Area of Operations: Small Polymer Machines for Front Line, Medium Polymer/Metal Machines for Small Operational Bases
  - Rear Area of Operations: Larger-Scale Polymer/Metal Machines for Operational Bases, Depot/Logistical Locations
  - Remote Locations of Operation: Largest-Scale Polymer/Metal Machines for OEM Locations, Headquarters

Next Steps in Concept Evolution

What's Next?

- Continued internal development and expansion of capabilities, such as:
  - Allow for adaptation and connectivity to external inventory platforms
  - Allow for connectivity to external build file database platforms
  - Increase in reach back support and AM expertise support
  - Increase printer connectivity/functionality
  - Expansion into additional materials
  - Collect more in-depth understanding of qualification requirements for permanent AM replacement parts
  - Protection methods for components with intellectual property
  - Increase printing "robustness" agnostic to printer type/model
- Seek integration into PoR and begin fielded testing
  - Generate baseline requirements and development of thin spec
- Expansion of intellectual property of implemented technologies

Final Summary

AM for Contested Logistics Environments Supports Self-Sufficiency and Agility of Deployed Systems

- Based on current maturity of AM we have begun to structure a formalized process for utilizing AM technologies across all echelons for the warfighter.
- By leveraging existing maintenance processes and through fault association, connection with program Interactive Electronic Technical Manuals (IETM), and direct connection to 3D Printer interfaces, we can begin to apply technology to both legacy and future problems.
- This structure enables pathways to provide continued advancement and application of AM technologies.

AM Technology Used on Fix Differently Concept Enables Higher Operational Availability

Author Bios

Dan Hoffman

- Principal Engineer and Technology Portfolio Execution Manager for Cross-Cutting Capabilities, within Technology Engineering Organization at Raytheon
- Hold several degrees, including an Associates in Engineering Science with a focus in Mechanical Engineering, a Bachelors in Project Management, and a Masters in Engineering Management
- Over 20 years of professional engineering experience in mechanical engineering, manufacturing engineering and operation, additive manufacturing technologies, and project management

Bijan Hamidi

- Senior Software Engineer within the Software Products Engineering Organization at Raytheon
- Holds MS & BS Degrees in Computer Science
- 3 years with Raytheon and spent the prior 4 years as an Adjunct Professor of Computer Science at California State University Fullerton.
- Expertise and experienced in multiple forms of software languages for full stack software development and execution

Questions?

Thank You!!