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Background / Purpose

This AM Business Model Workshop was a follow up to the Business Model Wargame II held on 16 – 17 May, 2017.

The purpose of this workshop was to address five business model aspects of AM for sustainment and production in parallel with ongoing AM technology community efforts.

Participants were assigned to one of the following work groups:

• Develop an AM Contracting Guide for Navy / DoD
• Information Assurance on 3D Technical Data Packages and Blockchain
• Pathfinder Scenario Study of AM Repair Part
• 3D Model Exchange
• Intellectual Property Repository / Cadre of IP SMEs Working Group
Participant Demographics

- **170 people** from DoD, other government agencies, Industry, and Academia registered, and were assigned to groups ranging from 20-30 members.

- Participant Disciplines Included:
  - Logistics
  - Acquisition
  - Engineering
  - Legal
  - Contracting
  - Program Management
  - Information Technology & Networking
AM Business Model Work Groups

Develop an AM Contracting Guide for Navy / DoD

Abstract: This group is working on a contracting guide that lays out the various business models and methods of acquisition for AM-related products and services, so that DoD is able to maximize the value of AM investments, and ensure interoperability of this game-changing technology.

*Working Group Co-Leads: CAPT Armen Kurdian (USN) & James Willcox (Lockheed Martin); IT Facilitator: Kelly Kyes (Boeing); Scribe: Maggie Gutierrez (Lockheed Martin)*

Information Assurance on 3D Technical Data Packages and Blockchain

Abstract: This working group will identify secure data transmissions such as technical data package (TDP) sharing and data transfer amongst AM machines within the digital infrastructure and explore cybersecurity solutions, including Blockchain technology and its capabilities to verify and record digital transactions.

*Working Group Co-Leads: COL Howard Marototto (USMC) and Dana Ellis (NCMS); IT Facilitator: Teresa Clement (Raytheon); Scribe: Lori Hartung (NCMS)*
AM Business Model Work Streams

Pathfinder Scenario Study of AM Repair Parts

Abstract: This working group will conduct an End-to-End "Pathfinder" study that looks at the DoD AM repair part process from requirement determination, through contracting, design and manufacturing, certification and qualification, and delivery.

*Working Group Co-Leads: Liz McMichael (NAVAIR) & Mark Shaw (GE Aviation); IT Facilitator: Gug Sresty (AST2); Scribe: Fred Herman (Sherpa)*

3D Model Exchange

Abstract: This working group will examine the development of a 3D-Model/Print Exchange that provides 3D-models for 3D-Printers to assist sustainment professionals in maintaining and sustaining their equipment.

*Working Group Co-Leads: Alex Viana (NAVFAC) & Bob Persely (United Global Group); IT Facilitator: Ashley Mitchell (LMI); Scribe: Ray Langlais (LMI)*

AM Intellectual Property Management

Abstract: This working group will examine the requirements and processes involved with establishing a central repository for IP associated with AM.

*Working Group Co-Leads: Tony Delgado (DLA) & Michael Minter (Lockheed Martin); IT Facilitator: Joe Schibi (Deloitte); Scribe: Vikram Rajan (Deloitte)*
AM Contracting Strategy

Additive Manufacturing Business Model Workshop Outbrief
Objectives:

- Engineering Services PWS/SOO
  - Every type of AM service conceivable
- IP Escrow / Licensing Agreement
  - Guaranteed source of supply
- Crowd-Manufacturing Business Model
  - Extremely rapid, high quantity AM production
AM Contracting Strategy
Engineering Services PWS

Objectives:
• Develop AM-specific PWS guide
• Consider revenue scheme / business model

Steps to Achieve Objectives
• Team members drafted inputs in the following areas:
  1. TDP/Design Engineering
  2. Workforce Development
  3. Design/Build AM Lab
  4. Material Analysis
  5. Post-Processing & Repair
  6. AM Candidate Assessment
• Developed consolidated draft AM specific PWS guide
• Developed draft Engineering Services input for NAMTI AM Business Model
• Discussed revenue model – similarities with existing models
Challenges / Gaps Identified:
• Revenue stream related to OEM IP
• Use of incentive fees / what could be incentivized to increase use of AM

Key Takeaways:
• It is important to communicate what’s unique about AM to the acquisition community so that contracts are enablers to AM
Post-AM Workshop Effort: Next Steps

- Have other experts review documents developed (incorporate Legal’s comments)
- Explore additional AM services
AM Contracting Strategy
IP Escrow

Objectives
Continue brainstorming of roadblocks and solutions
• Initiate drafting of Contract Guidebook language

Steps to Achieve Objectives
• Analyzed lifecycle and risk management considerations
AM Contracting Strategy
IP Escrow

Challenges / Gaps Identified:

• Lifecycle considerations
• Contracting limitations
• Time
AM Contracting Strategy
IP Escrow

Key Takeaways:

• Escrow should not be a default solution. Alternative solutions should be identified and explored (e.g., negotiation of prices for the delivery of data and associated rights, reverse engineering of non-complex parts, etc…).

• Escrow is not appropriate early in the acquisition lifecycle.

• Analysis needs to be performed to identify limited set of parts for which escrow may be considered.
AM Contracting Strategy
IP Escrow

Post-AM Workshop Effort:

• Continue drafting guidebook language and example solicitation and contract language for:
  • Third party escrow arrangements
  • OEM escrow (in-house)
Objectives:
• Create business model

Steps to Achieve Objectives:
• Describe requirement
• Determine contracting options
Challenges / Gaps Identified:

- Pre-conditions
  - Available, qualified vendors
  - Workable Tech Data Packages (TDPs)
  - No IP issues
Key Takeaways:

• Speedy contracting can happen…if all the preconditions are met.

• Contracting for AM as a service…not a supply
AM Contracting Strategy
Crowd-Manufacturing

Post-AM Workshop Effort: Next Steps

• IDIQ establishment
• DoD strategic sourcing vehicles
• AM specific NAICS Codes
AM Contracting Strategy

Deliverables

- **Engineering Services PWS/SOO**
  - Draft AM specific PWS guide
  - Draft Engineering Services input for NAMTI

- **IP Escrow / Licensing Agreement**
  - Draft AM Contracting Guide language for IP and escrow

- **Crowd-Manufacturing Business Model**
  - Draft Crowd-Manufacturing input for NAMTI
Information Assurance in the Additive Manufacturing (AM) Thread

Additive Manufacturing Business Model Workshop Outbrief
Information Assurance in the AM Thread

How it works / When to use it

- Sharing data between parties via transactions
- Intermediary between the parties
- Recording the transactions
- Fundamental transactions
Information Assurance in the AM Thread

Considerations for Blockchain for AM

- Auditability
- High cost
- High precision
- Low volume
- Long life
- Source-recipient trust
- Time sensitive
Barriers

The technology itself is not the barrier… but business cases and ROI in AM are still being defined.

Barriers identified:
- Integration / Adaptation
- Governance for DoD applications
- Interoperability across DoD, OEM, global allies and partners
- Cultural
- Workforce Development / Training
- Define capability needs specific to AM
- Standard TDP workflows through supply base
Information Assurance in the AM Thread

It is all about CODIFYING TRUST in the supply chain… there has to be a common trust vector backing up the data or all the advantages of Additive Manufacturing go away

Understanding when Blockchain makes sense (or similar technologies, ex Graph database)

• Trusting ANYONE around to fab anything all around the world
• Trusted Data Transfer (up and down the supply chain)

USE CASES:

• Classified AM Components
• AM Ordinance Scenario
• AM Design Process Lifecycle - Auditability, IP & Sustainability
1. Process from CAD design (.prt file) to physical part involves multiple intermediate formats
2. Process spreads across multiple networks, organizations, 100s of printers, air gaps, etc
3. A change upstream (.prt for example) invalidates all derived files (.stl, .gcode)
4. Three sub-use cases
   1. Parent file changes (.PRT), ensure derived files are not used to print
   2. New make/model of printer added. Ensure previous .gcode file not used on new printer
   3. Mishap with system involving part. Ensure full auditability back to original design
Information Assurance in the AM Thread

Use Case #2:

**Today:** 2 vendors fabricating large ordinances in metal AM, each at capacity and only producing a small quantity

**Surge:** 50 vendors to fabricate, both DoD and DoD commercial suppliers

AM Large Metal Ordnance

Surge capability enabled by AM

TDP delivered from government to many vendors to meet a surge need in a validated and expanded industrial base. Also expands the potential for a reliable source of supply enabled by AM as an alternative source of manufacturing.

- Part 1 – Assessment for Blockchain Opportunities
  - Phase 1 – Validate the Data through the TDP Workflow
    - Verify the Data is correctly received (send a valid file from an invalid sender)
  - Phase 2 – Validate the Data through Part Fabrication

Part 2 – Print the parts at scale with multiple data sources

Stressing the System: Configuration Management, Red-cell & White-hat testing

Identify phases of workflow to support TDP-to-print to validate transactions

Determine all transactions where blockchain should be applied
Information Assurance in the AM Thread

Post-AM Workshop Effort: Next Steps

Demonstrate these use cases collaborate with the other existing efforts

- NATO project
- CTMA project
PATHFINDER

Additive Manufacturing Business Model Workshop Outbrief
Pathfinder

Vision 2020: The Path to Improve Readiness

Proactive
Manage Known Risk

Reactive
Act on known issues

Way Forward
- End-to-End Supply Tool
- Vector
- Technical data rights
- Budget Harmonization
- Additive Manufacturing

Navair
- Acquisition of Systems
- Sustainment of Systems

Predictive
Anticipate and preclude risks

- Dynamic Scheduling Tool
- Condition Based Maintenance (CBM)
- Readiness Forecasting Model (RCM)
- Predictive Analytics Model (PAM)
- Aviation Logistics Model (ALE)
- Digital Thread

Readiness
Pathfinder

Engineering Triage Process

**Legend:**
- **YELLOW**
  - RECEIVED AND TRIAGE IN WORK
  - GREEN BOX ITEMS DISPOSITIONED AS NO AIRWORTHINESS IMPACT – Released for Fleet AM
  - BLUE BOX ITEMS REQUIRE A TDP TO ACHIEVE AIRWORTHINESS – PMA Coord Required
  - RED BOX ITEMS REQUIRE AM TECHNOLOGY DEVELOPMENT/AIRWORTHINESS CERTIFICATION
- **GREEN**
  - BLUE/RED Items require prioritization and funding through PMA’s for completion
- **BLUE**
- **RED**
Pathfinder
Pathfinder

Engineering Process (include all users)

• System Level Design
  – Exhaust Logistics options, look at conventional approaches
  – Services Engineering (PMA / PEO) provide historical data
  – Go back to prime (Drawings, Design Notebooks, Test reports, etc)
  – Determine Loads and Environmental Conditions (Conditional)
  – Engineering Assessment – Model and Test (Engineering Review)
    • Evaluate for materials impact
    • Special conditions for Additive Manufacturing
    • Evaluate for conventional alternatives
    • Air Worthiness (Ground / Flight test)

Engineering Process has Not Changed
Manufacturing & Quality

– Manufacturing process development (Engineering Review)
  • Proof of manufacturing
– Verification & Validation
  • Approval of the manufacturing process
  • Material qualification / specification
  • Quality Plan / Acceptance
  • AM process control (machine calibration, training, prevent maintenance) – lock down
  • Machine Qualification / Reliability / Repeatability
  • Process control on dimensions (4 sigma)

Manufacturing & Quality Processes Unchanged
Pathfinder

Supply Chain Management

• Appropriately catalog
• Seek concurrence if multiple users
• Standard Procurement Activity
  – Digital data - Digital definition (1D, 2D and 3D digital)
    • Design, Modeling & Sim, Production
  – Licensing options
• Manufacturing Schedule
• Delivery

Supply Chain Management is Unchanged
Pathfinder

Key Takeaways: (Blue Box)

• Working AM technology with the current processes in place
  • Same engineering processes
  • Similar procurement
  • Similar qualification and testing
Pathfinder

GAPS

• Material Allowable / Material Specifications
• Allocation of IP concerns
• Digital thread definition with minimal data schema
  – Data repository
  – Cybersecurity
• Communicating need to industry
• Standardizing the AM process
  – Industry standards
• Distributed AM printing network
  – Lack of government equipment, skills and knowledge
  – Industrial equipment
• Funding for NRE / part cost
3D Model Exchange
Additive Manufacturing Business Model Workshop Outbrief
3D Model Exchange

Initial Risk Assessment:

1. Funding constraints
2. Barriers - lack of cooperation, funding, bureaucracy
3. Validation of data, metadata terms avoids Garbage In Garbage Out (GIGO), provides Quality Assurance (QA)
4. Cybersecurity Concerns
5. Sufficient Funding required by Joint Offices
6. Senior leadership buy-in from multiple disciplines (technical, support, CIO, maintenance, etc.)
7. Policy and Legal Barriers to data/IP/etc.
8. Establishing and enforcing standards.
9. Lack of leadership engagement
10. Lack of standardization/integration from existing builds
Initial Risk Assessment Cloud:

- 3D Model Exchange
- Lack of technical support
- Funding
- Data joint tool
- Models
- Leadership
- Workforce working
3D Model Exchange

Key Components Desired:

1. Simple front-end: leverages Services existing PLMs and data storage/transfer infrastructure.
2. System with ability to pull data from multiple sources, but to users, data appears to come from a single source.
3. User friendly front-end that links to the technical data systems of each Service.
4. Ability to deploy for accessibility in austere/low bandwidth environments.
5. Data and metadata hosted in a cloud environment, accessible by front-end system.
6. Joint, common tool or interface accessible to diverse data sources.
7. Access Site/ Front-End from various systems. i.e. DoD/Army/Marines field CPUs.
8. Enable metrics and analytics.
9. Common standard protocols for posting of technical data, which would be agreed upon data schema.
3D Model Exchange

Key Outcomes Desired:

1. 1. User feedback if models/files printed well; rating system
2. 2. good search capability
3. 3. Info need for what file/model, what material should be use, and what systems it can be used with
4. 4. Front End / GUI (Graphic User Interface) that easy to user by Warfighters at Point of Need
5. 5. Content should be "FAIR" - findable, accessible, interoperable, and reusable
6. 6. Joint common "color" system for part risk/use for maintenance and Battle Damage & Repair (BDAR)
7. 7. Needs to be FAIR: Findable, accessible, interoperable, reusable
8. 8. Accurate and complete data
9. 9. User-submitted training videos like in RAPTOR, with voting functionality to indicate most useful videos
10. 10. Accessible and shareable database that contains accurate data and descriptions of 3D printable objects.
Model Exchange (Day 1)

Joint Federated Architecture (Day 2)
3D Model Exchange

Post-AM Workshop Effort:

• Proposed DLA ownership of front-end Joint Federated Architecture
• AM-focused policy needed from OSD
  • Service-level policy, cybersecurity, implementation methods, tracking AM-related items
• Governance needs to be established
  • Subgroup of JAMWG – right personnel
  • Service-level Leadership
• Draft RFP via America Makes
  • Leverage Navy blueprint/roadmap
  • Follow-on engagement with NIH and NPS
AM Intellectual Property Management

Additive Manufacturing Business Model Workshop Outbrief
AM Intellectual Property Management

Objectives

1. Review Methods
   Cover sample licensing processes and IP valuation methods available

2. Conduct Case Study
   Walk through a mock negotiation, employing best practices and methods discussed during the session

3. Prioritize Focus Areas
   Reflect on lessons learned to prioritize future DoD-industry IP management initiatives
AM Intellectual Property Management
Steps to Achieve Objectives

1. **Review Methods**
   - **Methods:**
     - Cover IP Licensing and Valuation Methods
     - Practice Methods via Activity

2. **Conduct Case Study**
   - **Methods:**
     - Complete Negotiations Prep
     - Conduct Facilitated Negotiation

3. **Prioritize Focus Areas**
   - **Methods:**
     - Reflect on Lessons Learned
     - Revisit Barriers to Prioritize Future Focus Areas
AM IP Management

Mock Negotiation Conducted

**Background:** The Government has a low volume (40/year) and low value ($35/part) part that is failing in the field and causes a vehicle to be inoperable. The part is protected by a utility patent for the next 5 years and a version of the part is used commercially. Time considerations make traditional manufacturing a poor option. AM is identified as an opportunity to deliver the part faster.

**Result**
- Negotiated for the Government and OEM to jointly develop the AM TDP for an optimized design of the failing part.
- OEM would own the AM IP created; OEM would be free to use IP in their future AM efforts commercially. Government would have GPR.

**Lessons Learned from Negotiation Consider**…..
- Thinking out of the box on benefits to/needs of both parties.
- Trading dollars for time (i.e. higher upfront costs).
- Pursuing non-traditional agreements (e.g. Other Transaction Authority – OTA).
- Having the Government co-develop AM IP and accept GPR. OEM contributes data and may commercialize.
AM IP Management

Capability Maturity Assessment from Day One

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<td>High</td>
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<td>Adequacy of IP for AM and QA requires highly manual and skilled review</td>
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<td>Governance structure and availability of resources to support valuation</td>
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<td>Organizational unit with licensing experience, but no standardized processes</td>
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<td>Use of technical data digitally traceable and auditable</td>
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<td>Access granted per group and security systems built on top of digital infrastructure</td>
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<td>Medium</td>
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<td>Systematic method of ensuring IP necessary for AM and QA is present</td>
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<td>Analytics tools and resources to provide tailored valuations</td>
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<td>Organization-wide understanding of licensing processes and access to resources</td>
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<td>DRM tool enforces IP licensing terms on technical data use</td>
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<td>Low</td>
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<td>Review of IP completeness done on ad-hoc basis, if at all</td>
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<td>Few guiding principles and available resources</td>
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<td>Handful of practitioners with licensing experience</td>
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<tr>
<td>Oversight of technical data use managed manually</td>
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<td>Digital infrastructure highly networked with minimal hardening or access limits</td>
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Identified Focus Areas from Day One

1. Creating Central Database for AM IP Management
2. Rethinking AM IP Knowledge Management and Training
3. Enacting Policy Changes (e.g. Lifecycle Milestones, Reverse Engineering)
4. Creating New Business Model Templates for AM IP Scenarios
Money was allocated towards focus areas with barriers that are considered the greatest roadblocks to effective AM IP management.
AM IP Management

Focus Areas Approach: Difficulty Analysis

Actions that address Focus Area 1

Considered what risks and issues exist that might add complexity to addressing the barriers in each focus area (i.e. difficulty)
AM IP Management
Focus Areas Prioritized

Legend

- G.1 – Creating Central Database for AM TD and IP Rights
- G.2 – Rethinking AM IP Knowledge Management and Training
- G.3 – Enacting Policy Changes
- G.4 – Creating New Business Model Templates for AM IP Scenarios
# AM IP Management

## Post-AM Workshop Effort: Next Steps

<table>
<thead>
<tr>
<th>5 DAYS</th>
<th>5 WEEKS</th>
<th>5 MONTHS</th>
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<tbody>
<tr>
<td>1. Identify active working groups to agree to common lang. (e.g. MOSA)</td>
<td>2. Identify common scenarios and workforce considerations</td>
<td>Publish business model templates</td>
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<td>2. Document desired outcomes and roles</td>
<td>3. Draft whitepaper on DoD AM IP rights strategy – AMMO</td>
<td>Agree to final content of whitepaper</td>
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<td>4. Consolidate findings from other AMMO sessions (e.g. contracting)</td>
<td>Integrate IP findings into AM contracting guide</td>
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AM Workshop Final Thoughts

- Governance needs to be established – a Joint body of Service-level Leadership - subgroup of the Joint Additive Manufacturing Working Group (JAMWG).

- Implement AM-focused policy for AM to begin in the acquisition and contract phase.

- AM Contracting Strategy should contract for AM as a service…not a supply

- Create a Central Database for AM Tech Data, 3D Model Exchange, and IP rights.

- The Services are working AM technology with the current processes in place, Same engineering processes, Similar procurement, Similar qualification and testing.

- Blockchain technology itself is not a barrier but business cases and ROI in AM are still being defined to determine when blockchain makes sense.
What’s Next for the AM Community?

• AM Workshop for 2019 Possible Work Groups:
  
  – AM Contracting Guide

  – AM IP Management

  – Evolution of central databases for AM Tech Data, 3D Model Exchange, and IP rights

  – Information Assurance - Demonstrate how Blockchain use cases collaborate with other existing efforts