

Additive Manufacturing (AM) Business Model Workshops 2018

30-31 May 2018

Final Report

Lockheed Martin Global Vision Center

2121 Crystal Drive

Arlington, VA 22202

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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 Marotto (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

AM CONTRACTING GUIDE

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

AM Contracting Strategy Engineering Services PWS



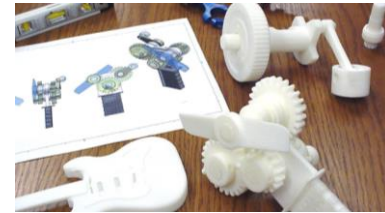
Challenges / Gaps Identified:

- 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

AM Contracting Strategy Engineering Services PWS



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)

AM Contracting Strategy Crowd-Manufacturing



Objectives:

- Create business model

Steps to Achieve Objectives:

- Describe requirement
- Determine contracting options

AM Contracting Strategy Crowd-Manufacturing



Challenges / Gaps Identified:

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

AM Contracting Strategy Crowd-Manufacturing



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



AM Eng Svc for
PWS



Eng Svc for
NAMTI



IP Escrow



Crowd Mfg

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

Is blockchain the solution for you?

- Are multiple parties sharing data?
- Will multiple parties be updating data?
- Is there is a requirement for verification?
- Are intermediaries adding cost and complexity?
- Are interactions time sensitive?
- Will transactions by different participants depend on each other?

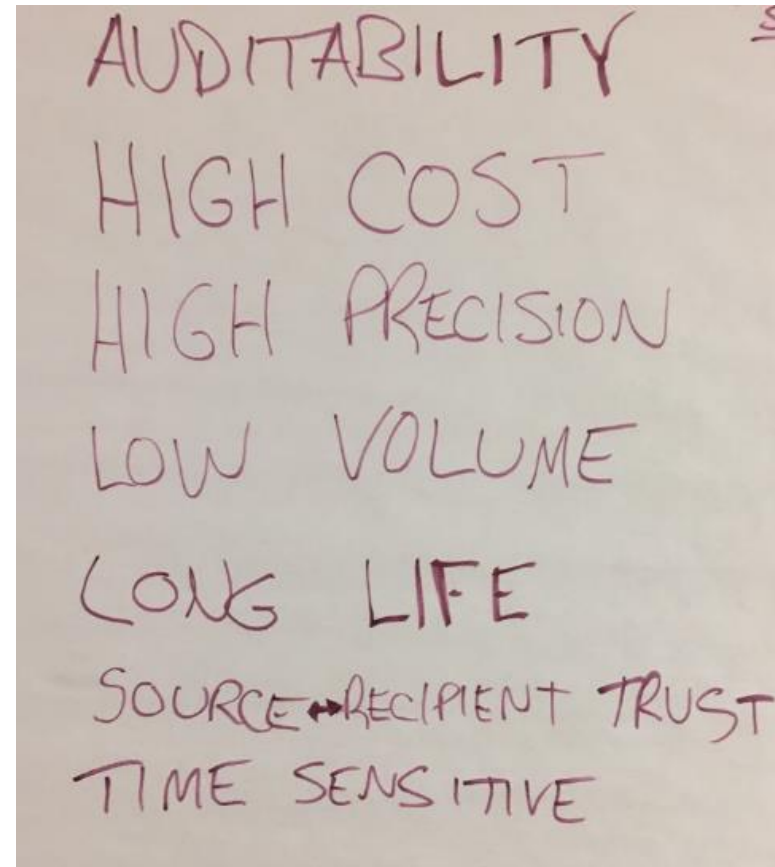
If you can't tick at least four of these conditions, ask "why blockchain?"



 pwc

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

Information Assurance in the AM Thread

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)

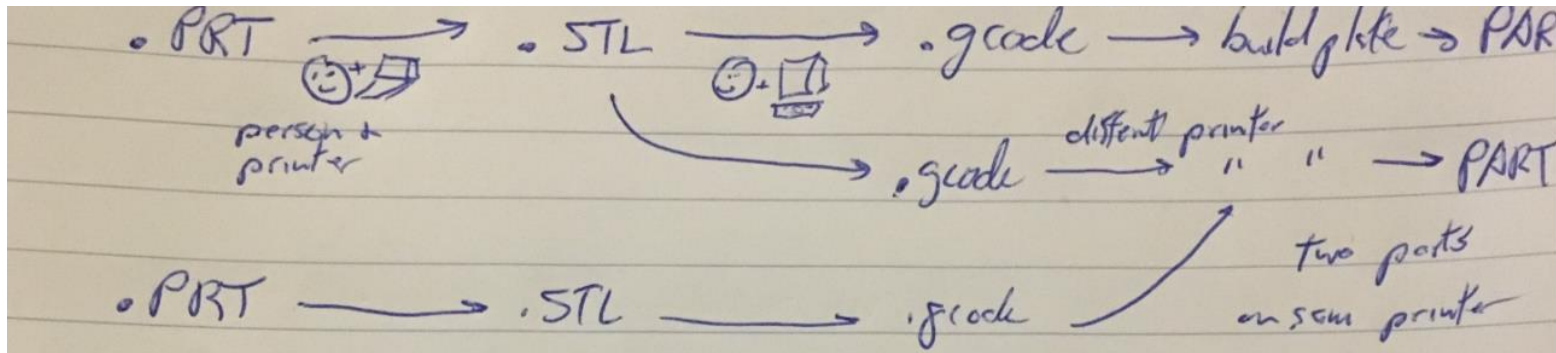
- Trusting ANYONE around to fab anything all around the world
- Trusted Data Transfer (up and down the supply chain)

USE CASES:

- Classified AM Components
- AM Ordinance Scenario
- AM Design Process Lifecycle - Auditability, IP & Sustainability

Information Assurance in the AM Thread

Executive Summary: Use Case #1



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

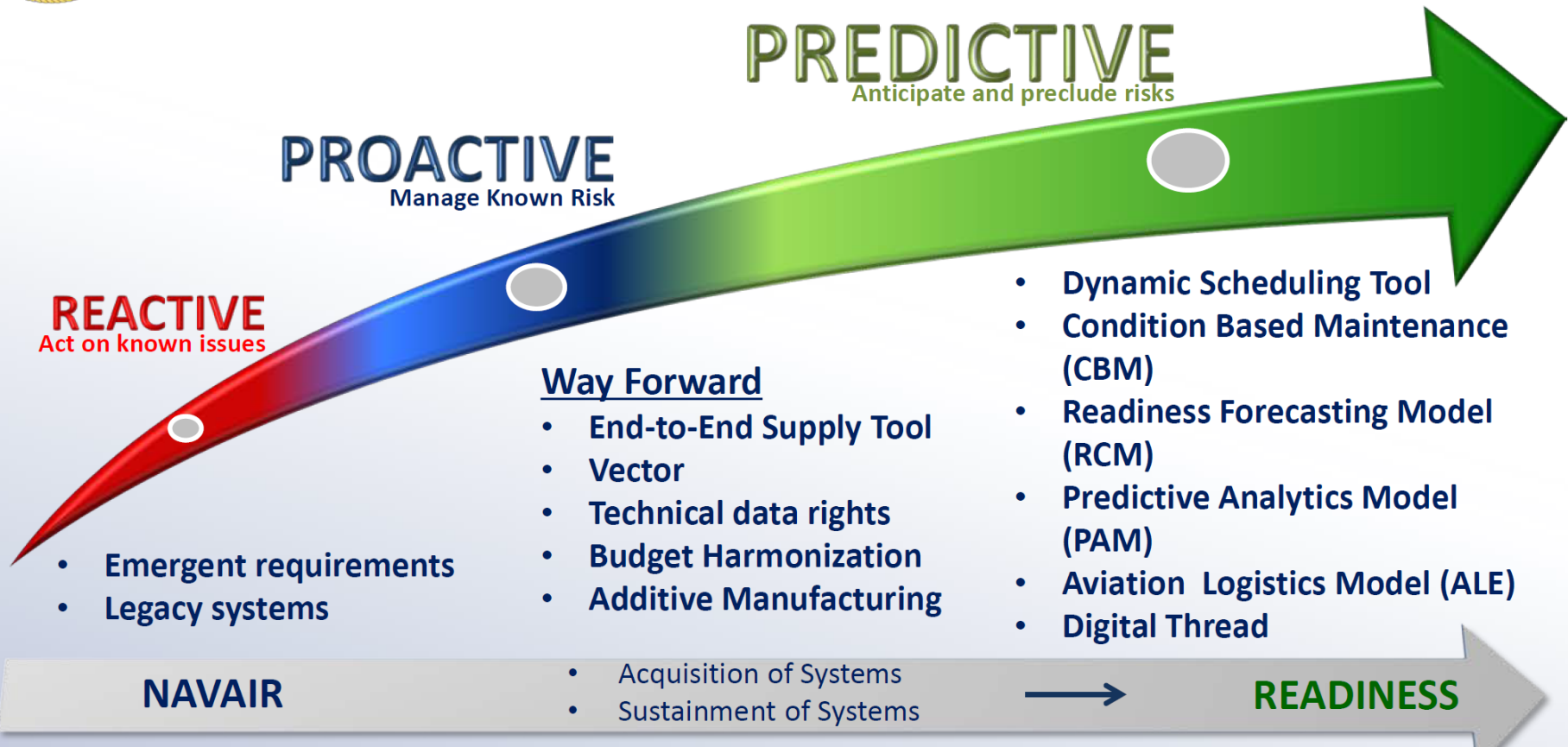
- NATO project
- CTMA project

PATHFINDER

Additive Manufacturing Business Model Workshop Outbrief

Pathfinder

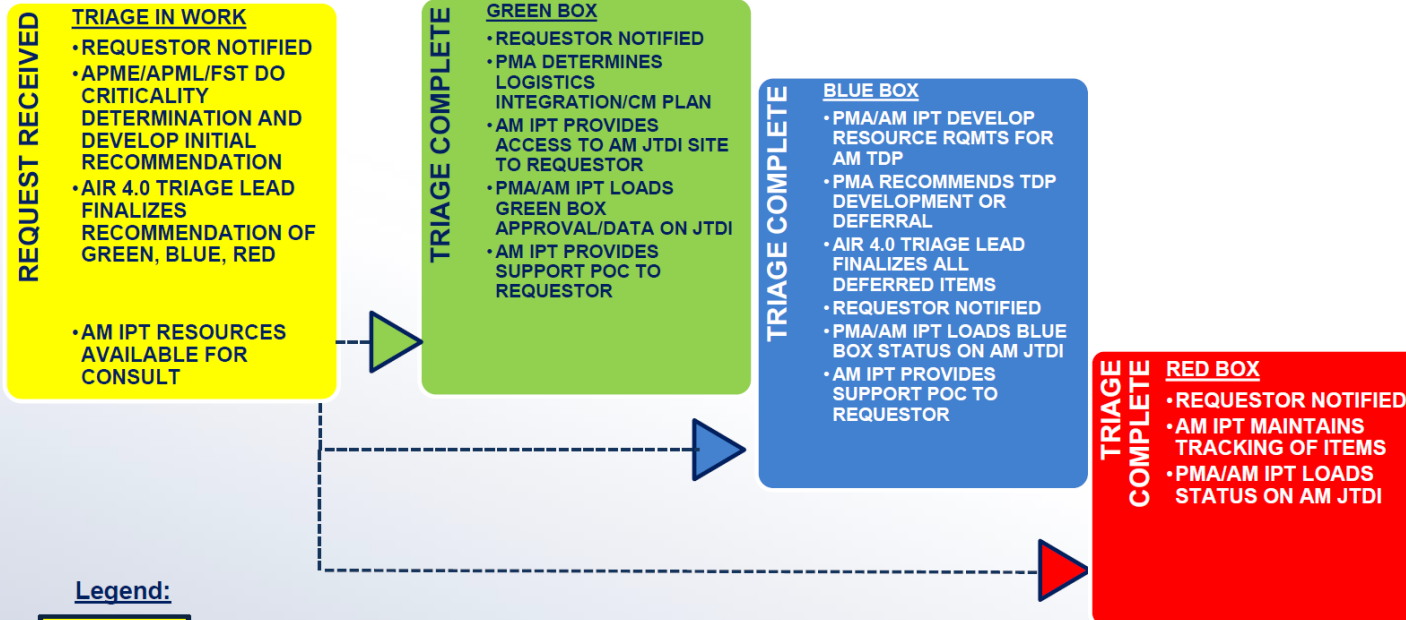
Vision 2020: The Path to Improve Readiness



Pathfinder



Engineering Triage Process



Legend:

YELLOW
GREEN
BLUE
RED

RECEIVED AND TRIAGE IN WORK

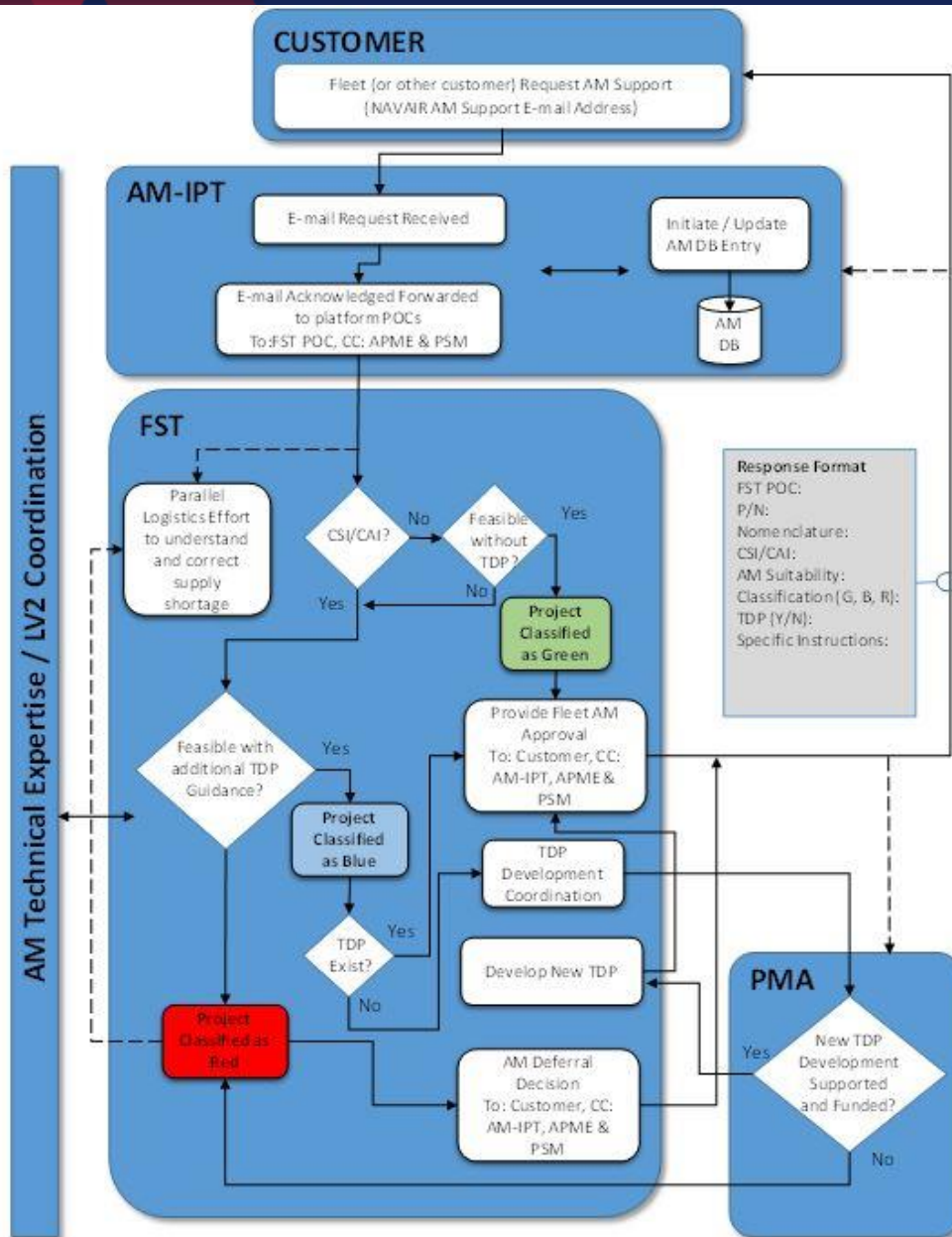
GREEN BOX ITEMS DISPOSITIONED AS NO AIRWORTHINESS IMPACT – Released for Fleet AM

BLUE BOX ITEMS REQUIRE A TDP TO ACHIEVE AIRWORTHINESS – PMA Coord Required

RED BOX ITEMS REQUIRE AM TECHNOLOGY DEVELOPMENT/AIRWORTHINESS CERTIFICATION

BLUE/RED Items require prioritization and funding through PMA's for completion

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

Pathfinder

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

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.
10. Required Security and Access Controls.

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.

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

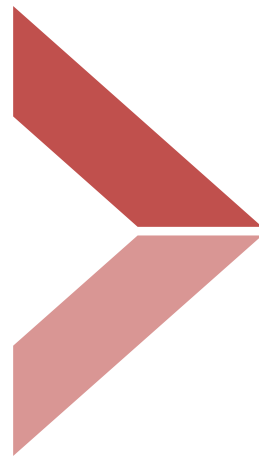


1

**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.

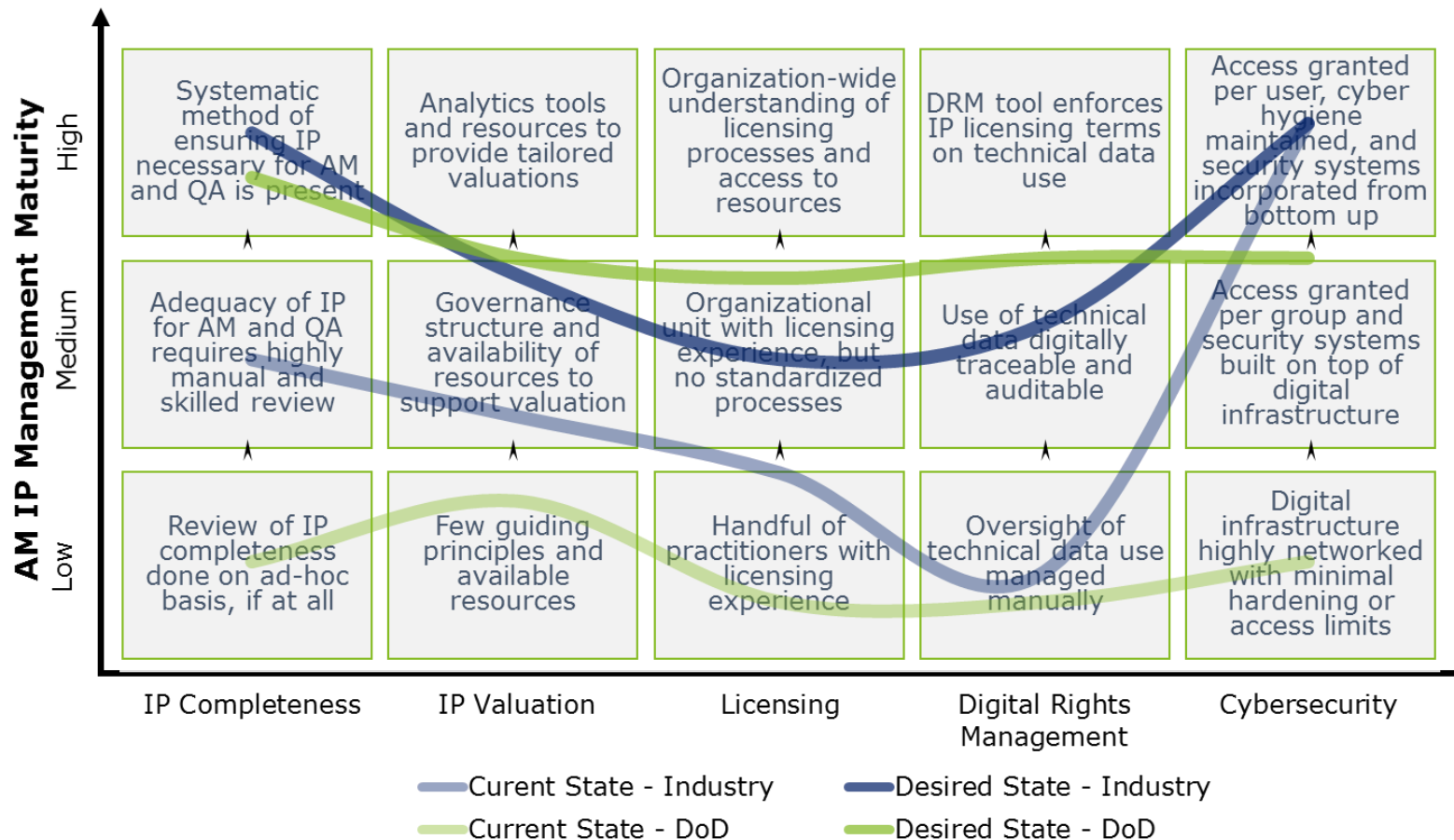
Lessons Learned from Negotiation

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



AM IP Management

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

AM IP Management

Focus Areas Approach: Impact Analysis

Actions that address
Central IP Database

Actions that address
IP Knowledge Management



4x



1x



Actions that address
Policy Changes

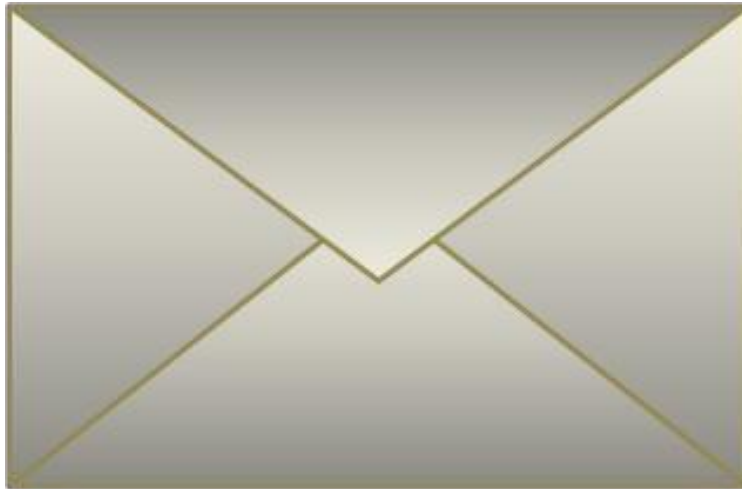
Actions that address
Business Model Templates

Money was allocated towards focus areas with barriers that are considered the greatest roadblocks to effective AM IP management

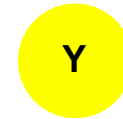
AM IP Management

Focus Areas Approach: Difficulty Analysis

Actions that address
Focus Area 1



Simple



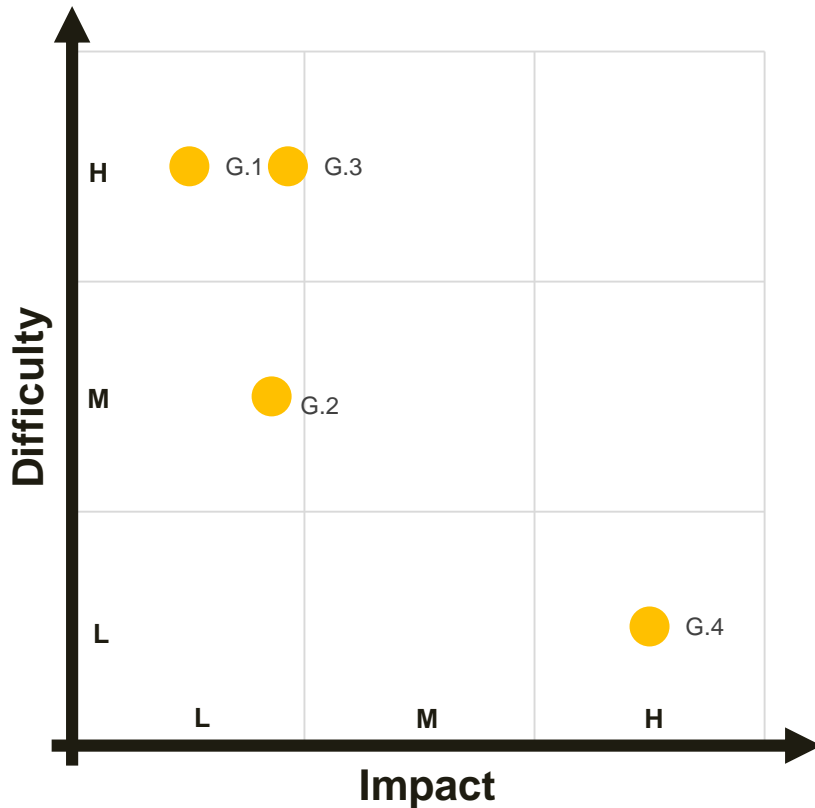
Moderate



Complex

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

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

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