Separating **Hype** from **Reality**

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Additive manufacturing (AM) technology is changing and improving rapidly. For years, AM has been used for rapid prototyping, but as computing power and software, input materials, machine speed and performance have improved, AM has morphed into a method for end-use production with great potential for Department of Defense (DoD) use. Imagine a future battlefield where U.S. forces fully leverage AM capabilities to support their materiel needs—producing critical, but otherwise unavailable, parts on demand in the optimum location in the DoD supply chain. You can see why AM has captured the imagination of military planners.

By prepositioning three-dimensional (3D) printing machines, feedstock, and post-processing equipment at choice locations, only the technical data, or "recipe," would need to be sent forward, instead of the part itself. Oner-

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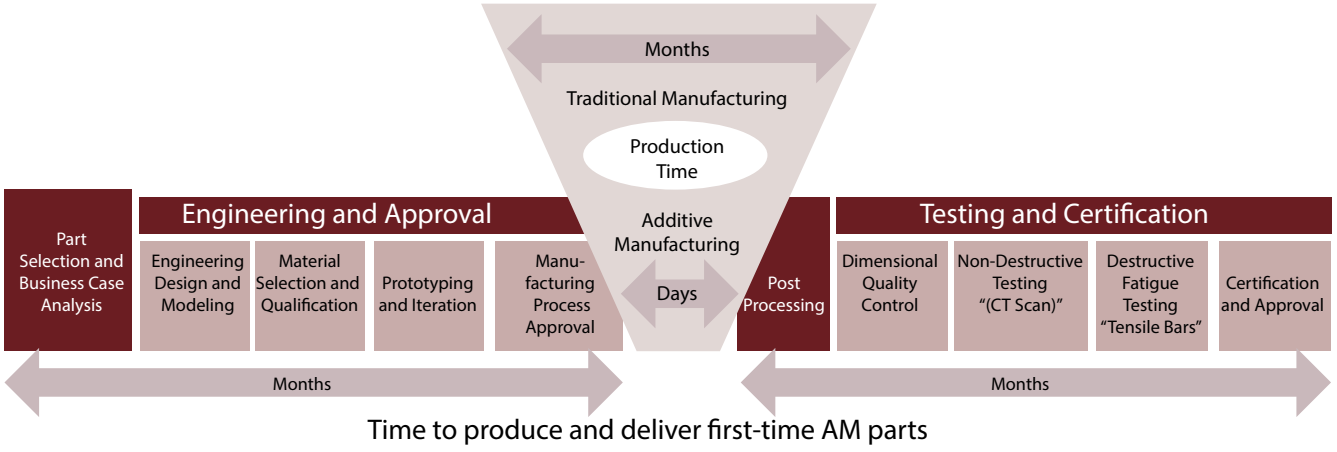
Figure 1. A Realistic View of Additive Manufacturing



ous supply wait times, large inventory levels, and dangerous transportation requirements could all decrease, resulting in higher materiel availability and equipment readiness rates, and a streamlined, less costly supply chain. If the DoD develops, fields and monitors AM capabilities thoughtfully and deliberately, this scenario could become reality.

Although a fully leveraged AM future for the DoD is appealing to contemplate, we should not let the "hype" of this vision blind us to the real requirements to achieve implementation. AM is complicated, and the DoD must acknowledge and understand the key challenges to integrating it into the DoD maintenance and supply chain overall:

- Current limitations of the AM process
- AM technical data requirements
- Intellectual property (IP) rights
- Liability and warranties
- AM workforce development

For each of these, we examine the associated issues unique to AM, separating the hype from the reality. We then offer insight into how the DoD and industry can address these challenges and conclude by discussing both the promise and the hard work required to realize AM's full potential to support DoD sustainment.

DoD's AM Challenges

Current Process Limitations: AM often is discussed as if it were push-button technology. The reality is much more complex. The extensive work that occurs before and after the printing process is not always visible.

In Figure 1, the central triangle illustrates the current "hype" of AM—the notion that production through AM is significantly faster than production using traditional manufacturing methods. The actual printing of a part can be accomplished in hours or days, but that is only a small piece of a larger process. For example, identifying the parts that can and should be manufactured with AM, along with prior engineering and approval, can take months. On the back end, post-processing and testing and certification can take a similar amount of time. The reality of using AM for end-use part production is complicated and involves significant analysis, planning, testing and specialized skill sets.

In addition, AM is a maturing and rapidly changing technology, and so does not have recognized certifications to standardize output. The machines vary enough that each is in effect its own "foundry," producing slight variations in its end products. The "hype" is that all parts can be made to the same standard as conventional manufacturing; the reality is that they will vary slightly from machine to machine without extensive calibration.

AM Technical Data Requirements: Every AM part requires a 3D model, but for decades most DoD engineering efforts have relied on blueprints—that is, two-dimensional (2D) schematics. Transitioning from 2D to 3D is neither simple nor inexpensive.

Table 1 shows key roadblocks facing the DoD. Many new weapon systems are being designed in 3D. But to utilize AM for production of legacy weapon system parts, the vast majority of parts in the DoD inventory will have to be converted to a 3D format. In addition, many of the 3D data packages available are in a proprietary format that requires expensive software even to read. The DoD could buy, license or re-engineer the technical data packages (TDPs) needed to produce parts using AM, but none of these options is easy, quick or cheap. Finally, the DoD lacks central direction on standards for 3D model content and metadata to guide further development among the several military Services.

TDPs contain many elements other than 3D model data (Table 2). Standard TDPs are needed to move AM forward.

Table 1. Roadblocks: The Hype Vs. the DoD's AM Reality

Hype		Reality
DoD has access to Technical Data Packages (TDPs) in a consistent and complete format	→	Approximately 75% of parts the Defense Logistsics Agency manages do not have TDPs; of the remaining 23%, most are in 2D format not optimized for AM
The current acquisition system allows the DoD to purchase TDPs in an efficient and cost-effective manner	→	The DoD acquisition system makes procuring government purpose rights to TDPs challenging and prohibitively expensive
3D model formats are universal	→	There are over 50 different 3D file formats, many of which are proprietary

Graphics courtesy of LMI

Table 2. Elements in the Technical Data Package

- 3D Model Data
- Engineering Drawings
- Specifications
- Standards
- Performance Requirements
- Quality Assurance
- Reliability Data
- Packing Details

LMI has led efforts to standardize model formats DoD-wide. For example, LMI has designed a test procurement for the Defense Logistics Agency (DLA) that will use legacy procurement systems. DLA is testing the use of neutral file formats for procuring weapon system parts. The agency is engaging with the military Service engineering activities to provide validated 3D Portable Data File (PDF) and Standard for the Exchange of Product Model Data (STEP) files that meet all of the procurement legal requirements for fair and open competition.

In addition, in partnership with DLA, LMI is leading the next step: testing a real world government commercial acquisition to validate the feasibility of using these model formats in open competition. Currently, DLA is seeking bids to manufacture selected legacy parts using a TDP containing only 3D PDF and STEP files. (No 2D drawing data are included in the bid packages.) After the parts are delivered, DLA and the military Services will validate that the parts were made correctly and of the expected quality through using only the provided 3D data. By early 2017, the project will have results and lessons learned it can share. This type of project will lay the groundwork for a standardized process to acquire, rent access, or create and approve TDPs. This may involve a royalty system to distribute the upfront costs associated with procuring government purpose data rights.

Intellectual Property (IP) Rights: The original equipment manufacturer (OEM) owns the IP rights to the TDP. At initial acquisition or later, the government can acquire those rights, but it does not purchase the IP rights to the vast majority of parts. Because the TDP is needed to produce a part with AM, a streamlined process is required for the DoD to rapidly gain access to the TDP.

The "hype" is that DoD can just purchase the IP rights from the OEM and start producing the parts with organic AM assets.

The LMI Research Institute studied the feasibility of creating a rapidly executable protocol for the temporary exchange of IP/technical data between the OEM and the DoD to produce urgently needed nonstocked parts with 3D printers. LMI's objective was to help DoD and the OEMs resolve questions concerning limited use and assured disposition of technical data once they have been used to additively manufacture a needed part temporarily in a "remote" location. The focus is on a specific legal exchange of IP from OEM to DoD (Figure 2).

LMI's goal is to create a rapidly executable protocol for the DoD and the OEMs to follow when exchanging technical data for unavailable AM-producible parts. In an emergency, the DoD needs to be able to additively manufacture an unavailable component or part without having to work out IP issues with the OEMs. This effort proactively addressed the issue of IP access, security and storage; certification and qualification repeatability; and legal agreements between the DoD and the OEMs.

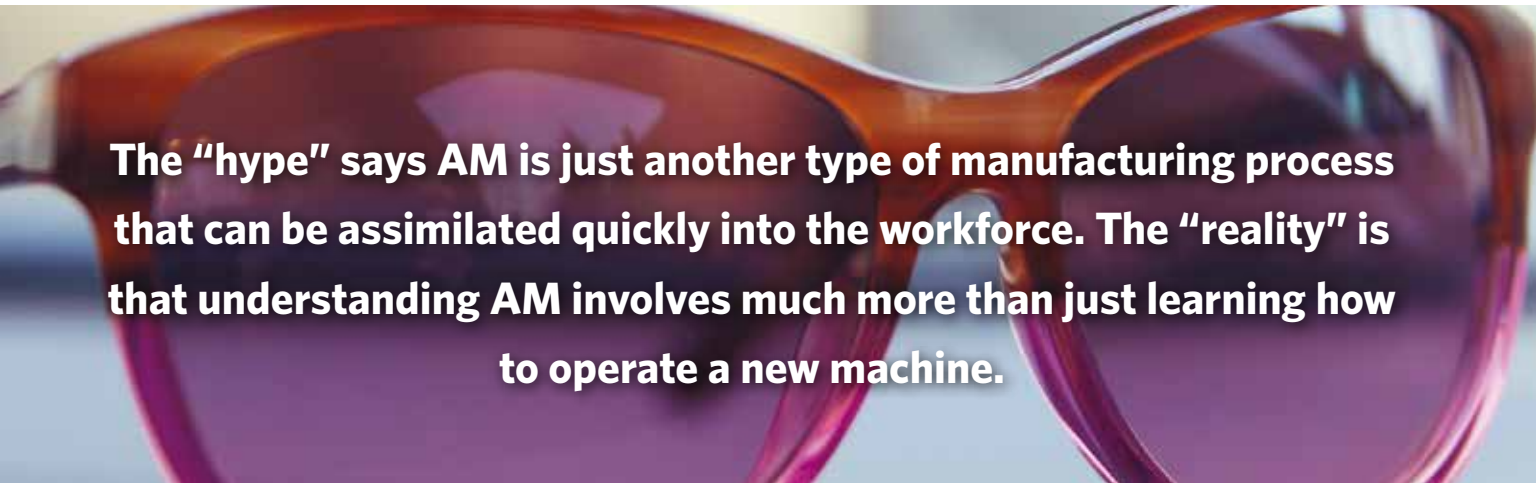
In a May 2016 AM business process wargame sponsored by America Makes, IP access and security were cited as the top issues among industry participants during a simulation of a scenario involving IP/TDP exchange between the OEM and the DoD. The "reality" is that allowing DoD access to IP creates serious industry concerns in the areas of security, quality, reliability and liability. For example, security of the data as well as access to the machines will need to be tightly controlled.

Figure 2. The Legal Exchange of Intellectual Property

This includes user identification and proper safeguarding and storage of the data across wireless networks. Any transfer of IP to the government, even temporarily, will require negotiating terms covering these concerns, as well as compensation.

Liability and Warranties: In the wargame scenario, two questions arose. Who is liable if the part fails? Does the OEM's warranty still apply? Normally, the manufacturer is liable, but in this case, the customer is the manufacturer, using OEM-provided build instructions. Does liability shift to the DoD? A strict certification and qualification process, possibly using a field Service representative, may ensure the manufactured part complies, but the OEM's brand reputation also is an issue. Once these questions and IP issues are resolved, they must be incorporated into the Federal Acquisition Regulation (FAR).

and a partial solution. Many of the OEMs have long since gone out of business, so obtaining parts from traditional sources can prove problematic. The DoD is working to find ways to identify parts amenable to AM and prototyping the process to get them approved for use after manufacturing. LMI has helped the DoD develop a method to evaluate millions of DLA legacy parts to determine those that can be supported by AM. This method looks at not only whether AM production is possible but whether it makes fiscal and operational sense to manufacture with AM. Once the part is identified, it must be made and certified ready for use, an area in which the Navy is taking the lead. Naval Air Systems Command spent the last 18 months developing and testing the first flight-critical part, a link and fitting assembly for the MV-22 Osprey.



AM Workforce Development: The "hype" says AM is just another type of manufacturing process that can be assimilated quickly into the workforce. The "reality" is that understanding AM involves much more than just learning how to operate a new machine. To fully understand AM, the workforce must think differently about design. Also, the AM workforce needs multiple skills, including knowledge of AM design, manufacture and material properties. Due to the variations in AM feedstock, material types, part orientation during manufacture, post-processing, and even the output of the machines themselves, AM requires more of an "artisan" skill set—featuring extended hands-on experience—than traditional manufacturing. The difficulty of training the workforce in AM is exacerbated by the lack of standards in the field. The DoD needs better defined, improved standards to properly develop the workforce.

Answering the Challenges

The challenges facing the DoD and AM integration appear daunting, but numerous efforts are aimed at establishing a solid foundation to enable integration into the acquisition and maintenance processes. Here are a few:

Defining AM's role in DoD: AM cannot solve all of the DoD's legacy part acquisition problems, but it can be a useful tool

America Makes—the National Additive Manufacturing Innovation Institute—is the nation's leading collaborator in AM technology research, discovery, creation and innovation. It has established working groups to examine AM challenges, including the following:

- The Additive Manufacturing Sustainment Business Model Working Group, (AMMO WG) addresses the business model aspects of AM sustainment, focusing on the use of AM for maintenance and sustainment of commercial and defense equipment. The group provides a forum for addressing issues discovered during the May 2016 AM Business Model Wargame.
- The AM Legal Working Group focuses on the legal issues associated with adopting AM technologies. Its goal is foster a collaborative effort between government and industry to identify, examine and propose solutions for these legal issues.

AMMO WG seeks an integrated DoD strategic vision and facilitates collaborative implementation of AM technology in support of DoD maintenance. The AMMO WG promotes the development and adoption of AM capabilities through collaborative efforts between the DoD, other government agencies and industry.

Future AM Wargames: The May 2016 wargame brought together sustainment executives and managers from the DoD and industry to simulate a specific scenario and identify issues, form potential courses of action and propose solutions. America Makes plans to continue with future collaborative AM wargames to expand the areas of interest and better understand the issues and solutions available to government and industry.

Conclusion

Compared with other manufacturing capabilities, AM holds incredible promise to dramatically reduce warfighter wait times for materiel. Progress must be deliberate, however, and the sustainment community must now work hard to deliver on this promise by contemplating a different and likely smaller supply chain that can be responsive and reliable to serve this dynamic AM environment.

The DoD sustainment community must balance the excitement about the novelty and expediency of current and emerging AM capabilities with appropriate consideration of accountability and predictability.

If the DoD approaches business rule development through partnerships with industry, it can ensure it "walks before it runs." For example, the DoD can begin to imagine echelons or levels of AM capability akin to its organizational, intermediate, and depot maintenance levels—all operating in a supportive and lean business framework. This kind of progress will contribute directly to delivering required availability at best cost.

As DoD sustainment and maintenance professionals move forward and integrate AM into operations, leaders and policymakers need to do the following:

- Take the lead in creating standards, updating policy and the FAR, and simplifying certification processes to take advantage of the full potential of this technology.
- Continue the DoD-wide education on AM, emphasizing that the full scope of the business processes involved in implementing AM need to be understood before deployment.
- Realize that achieving AM benefits will take time and investment in developing essential business processes as well as the AM technology itself.
- Focus on where AM can add value now and build on successes to further advance business process maturity.

In the DoD's emerging AM environment, our key task is to continue to foster innovation and experimentation while forming an emerging policy framework that progresses with AM business rules.

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Holguin Receives Contracting Excellence Award

This year's recipient of the Elmer B. Staats Contracting Professional Award is Luis Albert Holguin, certified federal contracts manager (CFCM) of the U.S. Air Force at Hanscom Air Force Base in Massachusetts. Holguin leads a five-member team in the contract execution of a $2.8 billion development portfolio that is directly sponsored by the Under Secretary of Defense for Acquisition, Technology, and Logistics.

Runners up included Raymond McCollum, a certified professional contracts manager (CPCM) with the General Services Administration (GSA) Information Technology Schedule 70 Program; Kristina Parmenter, a CFCM with the Missile Defense Agency; Jennifer Mattessino, a CFCM with the Army Contracting Command; and Brittney Davis, a CFCM with the Naval Air Systems Command.

The award is issued by the Procurement Round Table (PRT) to recognize a federal acquisition professional with extraordinary business leadership or team participation in the design, development or execution of an acquisition program or project that furthers an agency's mission.

The PRT is a nonprofit organization chartered in 1984 by former federal acquisition officials concerned about the economy, efficiency and effectiveness of the federal acquisition system. Its directors and officers are private citizens who serve pro bono with the objective of advising and assisting the government in making improvements in federal acquisition.