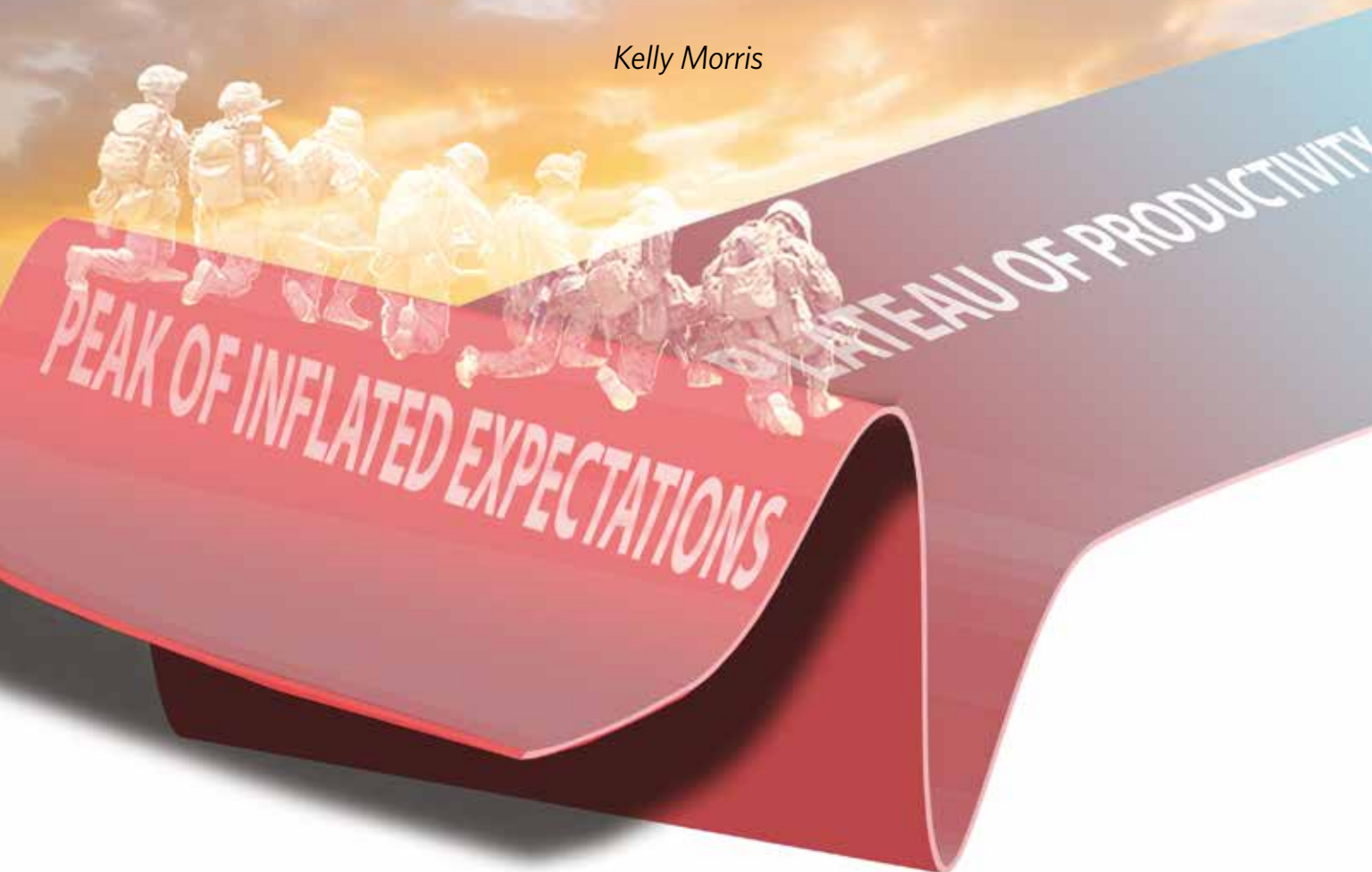


Driving **Innovation** to Support the Warfighter

Additive Manufacturing Initiatives Within the Defense Logistics Agency

Kelly Morris

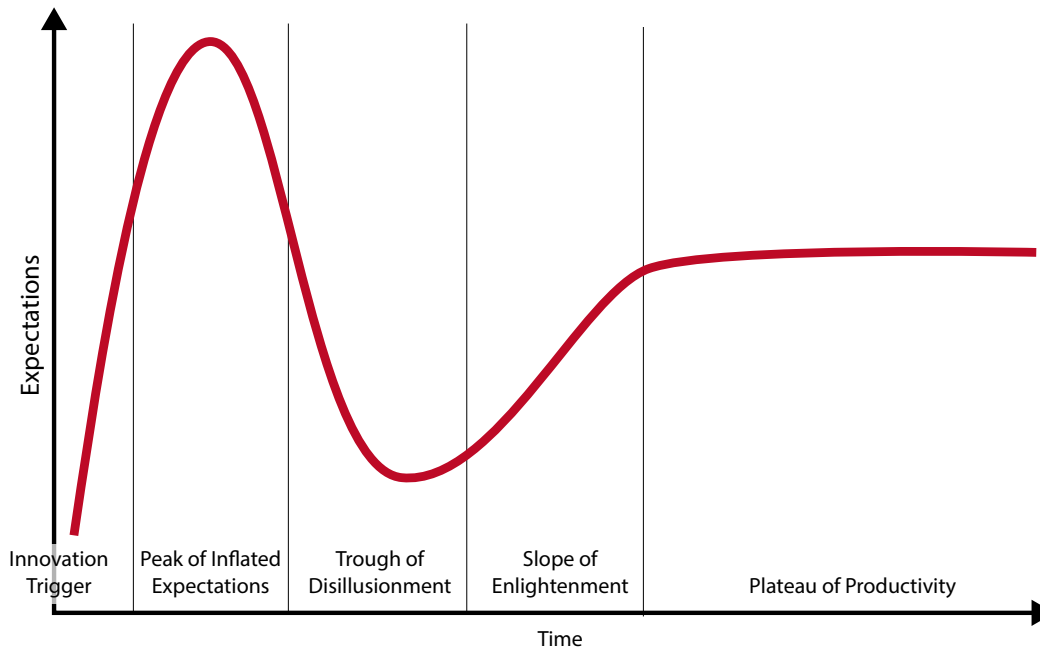


The spotlight is on for additive manufacturing (AM) in the commercial sector, but it is also intense for the Defense Logistics Agency (DLA), which hopes to capitalize on the promise of innovation to improve readiness and support to the military. As it tracks AM through the Gartner Hype Cycle, which depicts phases that innovations move through from the initial “Innovation Trigger” through the “Plateau of Productivity,” is DLA headed down the “trough of disillusionment” or up the “slope of enlightenment” to a “productive plateau” for AM investments? (See Figure 1.) The productive plateau is where mainstream adoption starts to take off. Criteria for assessing provider viability are more clearly defined and the technology’s broad market applicability and relevance are clearly paying off.

Morris is chief of research and development for the Defense Logistics Agency at Fort Belvoir, Virginia. She has a Master’s Degree in National Resource Strategy from the Industrial College of the Armed Forces in Washington, D.C.

Figure 1. Gartner's Hype Cycle

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to bulk petroleum, the DLA provides items and logistics support in peacetime and wartime. The mission to provide Class IX spare parts for aviation, maritime and land combat systems is perhaps, the most challenging, especially when weapon systems have been called to serve much longer than originally planned. Spare parts often are hard to procure, have long lead times, are frequently back ordered, and finally become obsolete and nonprocurable. Regardless, the items are still needed to keep the weapons systems in combat mode.

One of the DLA's roles is to provide Class IX spare parts to maintain Department of Defense (DoD) weapons systems. However, this is not as easy as it might seem. Parts may become hard to source because they become obsolete or have long lead times. They may also be back ordered because of diminishing sources or because contractors do not bid on producing them. The Research and Development (R&D) team in DLA Logistics Operations has worked with industry to build a prototypical tool that filters on critical logistics and technical parameters to identify target problem parts for AM. The DLA has also partnered with the Navy and industry to further identify hard-to-source parts and build the respective three-dimensional (3D) technical data packages (TDPs) and AM plans. The DLA is tackling the tough issues to move AM into the realm of the possible. The agency is investigating storage and protection of 3D model diagrams, qualification and certification of AM-produced parts, supplier qualifications and integration of the AM procurable parts into the supply chain to support the military. The DLA's integrative role in the supply chain allows it to leverage its procurement and distribution capabilities to capitalize on the potential new efficiencies of AM.

Background

The DLA is a combat support agency within the DoD. In 2015, the DLA had \$38 billion in sales to military and federal civilian customers; the agency supports 24 distributions centers worldwide and operates in almost all 50 states. Its mission is expansive. The DLA supports every aspect of the supply chain, including distribution and disposition. It is responsible for nine different supply chains covering six classes of supply to support the warfighter. From troop support items such as uniforms, rations, medical supplies and special equipment

Research Efforts and Reality Check

AM or 3D printing may well be the solution to the hard-to-source parts issue. The DLA first started a partnership with Naval Air Systems Command (NAVAIR) and Naval Sea Systems Command (NAVSEA). Both organizations have parts that are hard to source and are looking to AM as a solution. In December 2014, the DLA and NAVAIR conducted their first demonstration to identify and make two parts in 4 weeks. The two parts, a bracket and an insulator plate, were both made of polymers. Working with DLA Aviation, NAVAIR reverse engineered the parts, developed the TDP for the parts using an AM methodology, then built, qualified and tested the repeatability of the process using its warfare centers.

With the process in place, the next step was to really buckle down and identify parts that were in the hard-to-source category. Another effort, this time through a contract with LMI Research Institute, was established to develop a prototype tool to aid in identifying those parts. LMI developed a database-like tool that would sort through the hundreds of thousands of DLA-managed national stock numbers. From these, LMI filtered on physical attributes (materials and dimensions) and logistics attributes (availability of TDPs, days on back order, production lead times, demand, criticality, etc.). The logistics and physical attributes of the parts were then compared to technical attributes such as AM machines and materials that were obtained through a commercial open source available from Senvol. The resulting list of parts would be candidates for AM usage, with an emphasis on hard-to-source parts. The list included not only polymeric parts, but also metallic and flight critical parts.

Another R&D contract was awarded to Alion Science to capture the state of the art in the manufacturing industry and gather lessons learned for DLA. Industry feedback from an Alion survey indicated that AM still was an immature manufacturing method. Few standards in the industry exist—cost and time to manufacture vary from machine to machine; machines use stereolithography (STL) files, but companies prefer native computer-aided design (CAD) files or Standard for the Exchange of Product Data (STEP) files to share 3D models between users with different CAD systems. Companies generally are performing visual inspections and not materials testing. While these issues may not be problematic for tooling or quick fixes in industry, they are huge when it comes to making spare parts for a DoD weapon system, especially critical safety items.

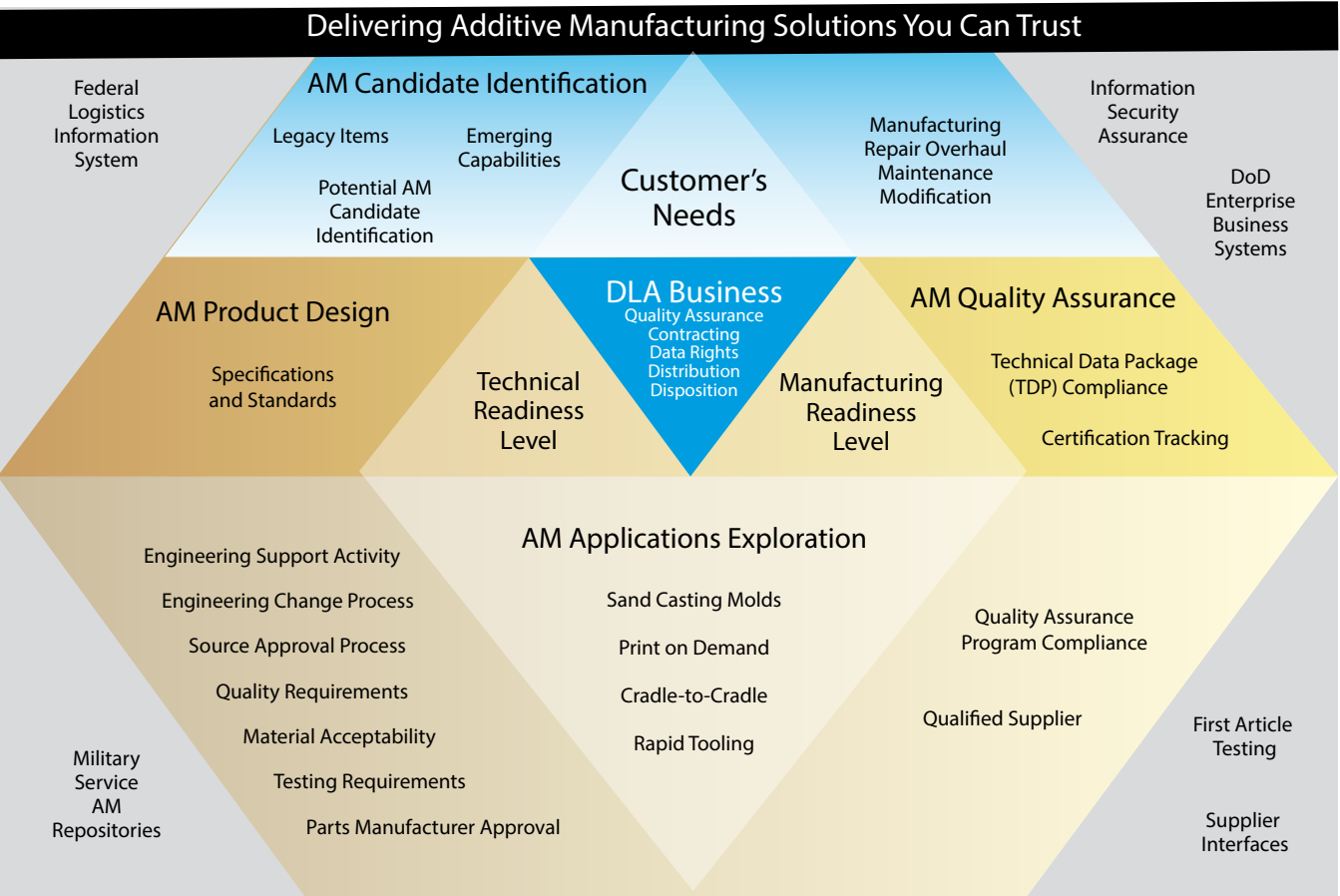
Alion was asked to collect manufacturing capabilities and survey the industry to determine market forces and establish a vendor list that the DLA could rely on for hard-to-source spare parts made by using AM. Alion also tested if the Navy’s process could be replicated. Using the 3D models and TDPs built by the Navy for the bracket and insulator clip, Alion sourced the requirements to industry to test the repeatability of the process to build the parts via AM. Many vendors declined to participate. Those vendors who did participate were not fa-

miliar with the Acrobat 3D Portable Data File (PDF) provided by the Navy. They preferred STEP files and drawings. For both parts, thickness and open porosity varied from the specification. None of the openings were in tolerance for the insulator plate, and the dielectric strength was significantly lower than specified. The results seemed to show that AM was sliding down the “trough of disillusionment.”

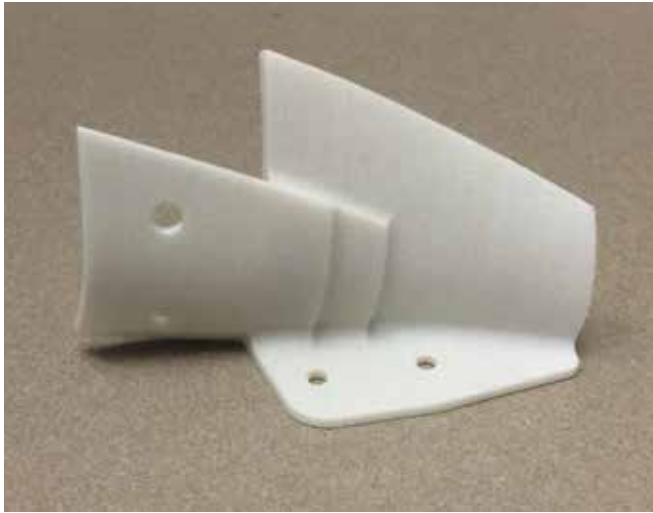
Subsequently, DLA contracted 2Is Inc., a small business out of Boston, to work on the AM production of hard-to-source parts. The people at 2Is Inc. used their own data to identify six hard-to-source parts, included one metal part as well as a critical safety item that would be manufactured by AM. One part on the list was the Navy’s Leading Edge Root Extension (LERX) for the Harrier AV-8B. This part is really hard to source or repair for the Navy. Contractor 2Is Inc. developed the TDP for AM and built this part through 3D Systems (see photo left, next page). NAVAIR also built the part through Stratasys Ltd. The LERX part will now go through NAVAIR’s Engineering Support Activity (ESA) approval process.

The firm 2Is Inc. also designed a 3D model for a ball fitting (see photo at right, next page) for the CH-53E helicopter, a metallic critical safety item that has been hard to source. This is a particular case where AM shows more flexibility in fabri-

Figure 2. The DLA View of AM



Source: The Defense Logistics Agency.



Left: LERX or Leading Root Extension. Right: 3D model for a ball fitting
Photos Courtesy of 2Is Inc.

cation, since the original part had numerous welds. Designing it for AM production would make one stronger, single piece. The part was delivered in April by 2Is Inc., which is working to get the ball fitting qualified and certified through the Navy Engineering Support Activity before the end of 2016.

A Vision for Moving Forward

The results of the preliminary R&D efforts helped the DLA craft its vision—“A secure digital network that contains all the technical qualifications, logistics and supplier base data needed to certify AM as an option to procure hard-to-source parts, reduce production lead time and meet the warfighter’s needs” (see Figure 2).

In order to “deliver additively manufactured solutions you can trust” (see Figure 2) in the DoD supply chain, the DLA is working to:

- Establish an Additive Part Candidate Identification Tool. Identify the parts for an AM investment that make sense and support the customer in the maintenance depot or the warfighter at the tip of the spear.
- Turn AM-produced part candidates into 3D models using a repeatable process that qualified suppliers can replicate. The DLA must also establish and ensure qualified sources. The agency’s vendors are critical for the success of AM as a new paradigm of manufacturing support to the warfighter. Because of the variability in machines, materials, costs and capabilities, the DLA wants to make sure it contracts with qualified suppliers for AM-produced parts, ensuring compliance with TDPs and source approval authority quality assurance parameters for the parts.
- Get models into a data repository using an AM-defined format. The DLA wants to store the data, not the parts.
- Establish a secure digital information framework and repository of data that contains all the standards, qualifications and certifications by Service engineering support activi-

ties, and logistics and supplier base data needed to enable delivery of certified AM-produced items where and when needed. The DLA supports the military Services and industry in efforts to improve the technological readiness level of the product design, materials and equipment to be used for AM, and then provide a secure environment for the data.

- Establish a repeatable process with military Services’ engineer support activities for qualification of TDPs and AM-produced parts. This includes a vendor qualification plan, first article testing and other quality measures that can be included in policy and acquisition guidelines.

Expanded Partnerships

The DLA is expanding military Service partnerships with NAVSEA, the Army Research, Development and Engineering Command, and the Air Force Life Cycle Management Center to further identify hard-to-source parts that can be produced through AM. An agreement was signed with NAVSEA to work on hard-to-source parts as well as demonstrate AM capabilities to build sand casting molds, an important capability for producing hard-to-source parts. The DLA will further outline opportunities for AM research with other federal agencies, as appropriate. All the R&D efforts in this area will help push AM up the “slope of enlightenment” to the “plateau of productivity.” At the strategic level, the DLA worked with America Makes, the National Additive Manufacturing Innovation Institute and Deloitte to refine its vision and roadmap for AM. The R&D team also worked with America Makes and representatives from the Army, Navy, Air Force and Marines to build a DoD-level strategic roadmap for AM. Both the DLA and DoD roadmaps are near completion.

The Realm of the Possible

The DLA’s near-term priorities for its R&D on AM are to move its prototypical tool for identifying hard-to-source parts into a production environment, standardizing the process and incorporating the tool into everyday use. The agency also will

Figure 3. Delivering Always and On Time Through AM

Near Term			Far Term		
R&D Focus		AM Parts Flow		Supply Chain	
Identify process to deliver AM hard-to-source and long-lead-time parts		Align AM TDPs with AM demand and vendor manufacturing capacity		Opportunities to reduce DLA storage footprint	
Technical Digital Data Interface			Leverage In-Theatre Capability		
Receive, protect and direct TDP			Print-on-Demand Capability		

Source: The Defense Logistics Agency

establish a data repository solution with the military Services, and ensure vendor quality of AM-produced parts. However, this is just the beginning. The DLA wants to integrate parts and solutions into the supply chain that use AM. Print-on-demand is a viable opportunity to get parts to the military faster. The DLA would like to explore with military Service partners the capability to send a TDP anywhere in the world, in a cyber-safe manner so that a spare part can be printed on demand, either by military Service qualified personnel or a qualified vendor. There are opportunities to reduce links and nodes in the supply chain and expedite delivery of critical parts where needed. The DLA also has an opportunity to store the data and not necessarily the parts. Inventory space would no longer be needed for obsolete or hard-to-source parts. Finally, the DLA has an opportunity to extend the operational reach of the military by supplying TDPs in theater to be made by advanced manufacturing labs of the Army or fabrication labs on ships in the Navy, or by vendors. Combined with other advanced technologies, parts might even be delivered in theater by drones. See Figure 3.

nable for AM production. Working with the Navy to establish the standards and process for certification of the parts through the Engineering Support Activity has also been an imperative. Ultimately, the DLA also must have vendors to supply spare parts needed in the repair and maintenance of weapon systems. The DLA is working to establish a viable contractor base, experienced in AM and able to meet quality standards for AM-produced parts. This will provide the DLA a valuable solution set for hard-to-source parts. Integration of these capabilities into the supply chain is yet to come.

Although the hype for AM is intense, the DLA is diligent in its approach, and its R&D shop is working to push this technology into the “plateau of productivity” in DoD logistics. &

The author can be contacted at kelly.morris@dla.mil. Luis Antonio (Tony) Delgado, research-and-development program manager at the Defense Logistics Agency, also contributed to this article.

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