Getting AM Up to Speed

Across the Army Life Cycle

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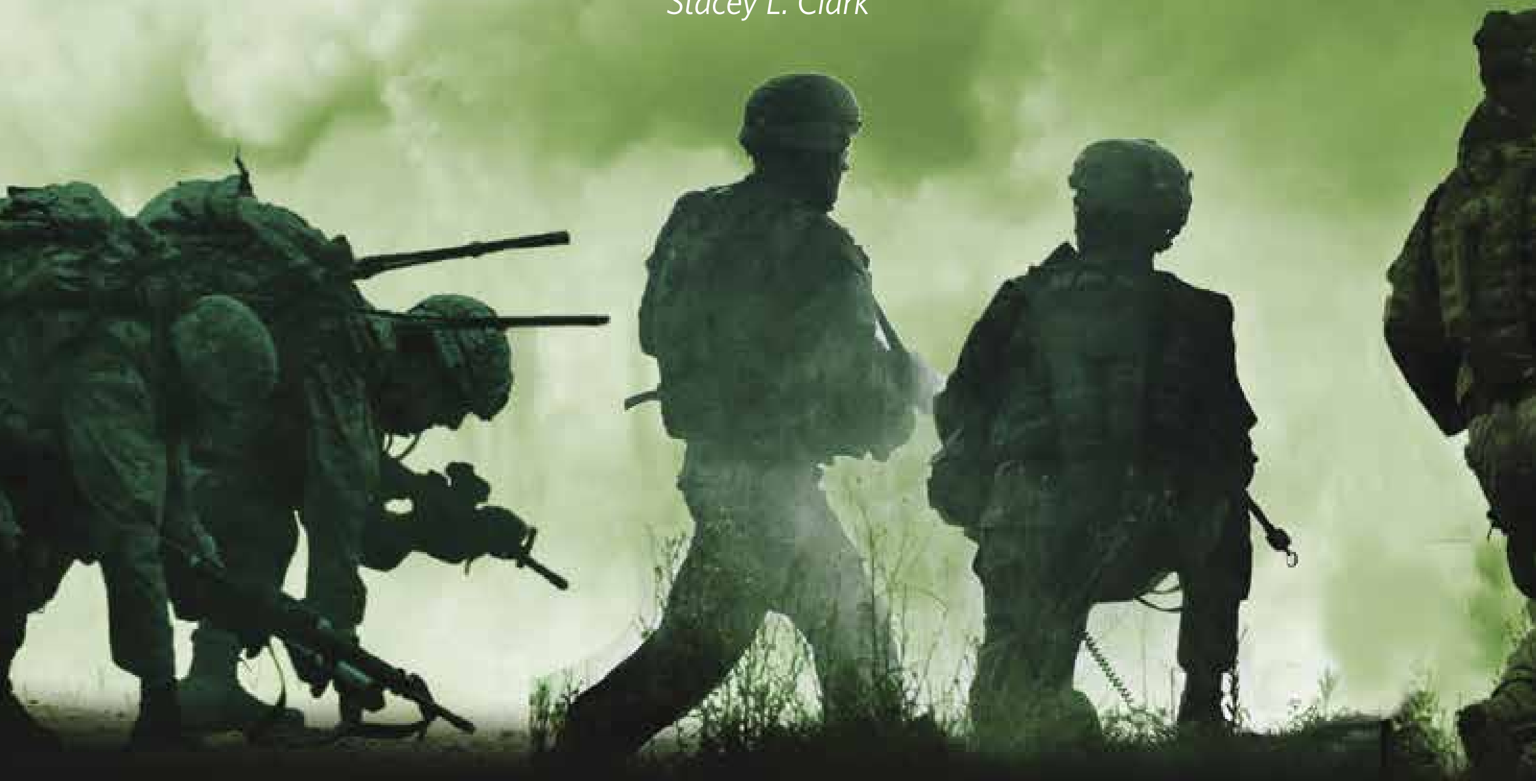

The U.S. Army, along with the Defense Logistics Agency (DLA), manages thousands of unique items, called materiel, in order to support its land force mission. This materiel can be broken into several portfolios: platforms, payloads and equipment. Platforms, such as helicopters and tactical vehicles, are weapon systems that can transport payloads and equipment. Payloads, such as missiles and armaments, deliver lethality to a target. Equipment includes communications systems, tools, body armor or other ancillary gear that a soldier may have to carry.

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For every piece of materiel that the Army acquires, it must also look at how to maintain and sustain that materiel through an extensive logistics chain. It is across these two domains, acquisition and logistics, in which the Army seeks to improve its materiel through the strategic use of additive manufacturing (AM). The Army Additive Manufacturing Strategic Roadmap, developed earlier this year in conjunction with America Makes and Deloitte, will be used to define what specific actions the Army needs to take.

In general, the Army is interested in the promise of AM for the following reasons:

- Point-of-use manufacturing—the ability to produce spare parts, in the field, for immediate repair to support a mission. (Additive Manufacturing Cost-Benefit Analysis, U.S. Army Logistics Innovation Agency, HQDA G-4, October 2015.)
- Weight reduction—reducing the weight of platforms can save on fuel costs and reducing the weight of equipment can reduce the load a soldier must carry.
- Reduce internal volume of payloads—using new AM technologies, such as flexible printed electronics, can reduce the internal volume of payloads that currently are taken up by printed circuit boards and increase lethality.
- Multi-use materials—structural materials used for external packaging on equipment can be designed to incorporate materials used to harvest electricity, as an example.
- Repair—larger items that may take too long to be cast or forged through the typical acquisition process may be repaired using laser cladding or cold spray.

Table 1: Acquisition vs. Logistics Domain Challenges

Acquisition Domain	Logistics Domain
Cost is often a driver	Time is often a driver
All parts must meet inspection and acceptance criteria	Not all parts are "critical"
Manufacturing processes must be reproducible	"Onesies" and "twosies" are OK

Source: The author

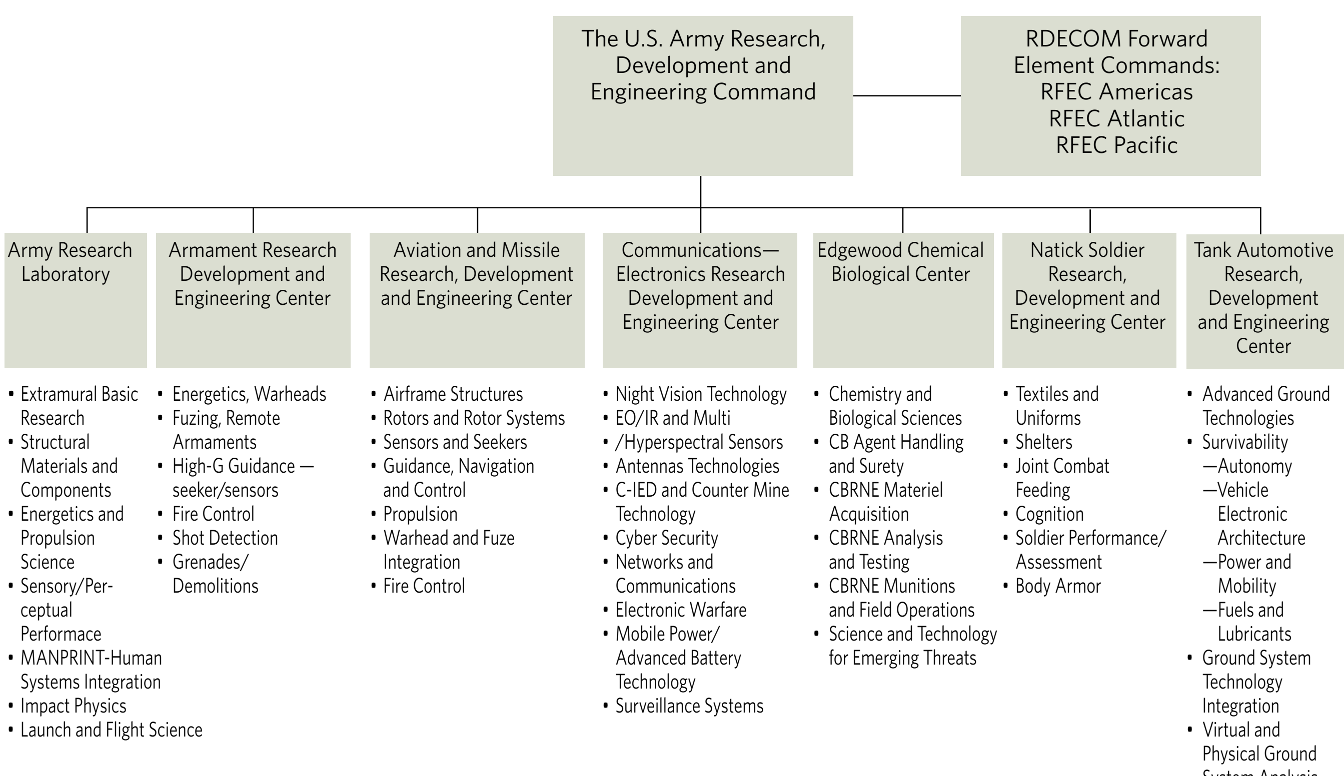
Implementing AM in the Army depends greatly upon which domain, acquisition or logistics, deploys this technology. For example, Table 1 below shows the pros and cons of using AM for each domain. In acquisition, producing a number of parts in a consistent manner is critical for part acceptance. However, in logistics, producing only a few parts quickly that are "good enough" may be more critical to meet mission needs.

Regardless of which domain is used to obtain an AM part, the use of three-dimensional (3D), fully annotated models is essential in order to specify part geometry, manufacturing data and inspection criteria. Some minimal standards, such as Military Standard 31000A, exist to guide the use of 3D models— however, the Army still does not consider these to be official data. Therefore, in the acquisition domain, more engineering work is needed to better define what standards should be used in Data Item Descriptions (DID) and Contract Data Requirements Lists (CDRL) in order to acquire a 3D model. Just as important is the Army's ability to verify and validate the accuracy of the 3D model delivered for acceptance. The Army ManTech Office has established a pilot program called the Net-Centric Model Based Enterprise (MBE) to examine the state of the art to manufacture items from 3D fully annotated models, which is essential for AM.

To support wider adoption of 3D models and digital engineering information, the Army is initiating a project called Life-cycle Product Data Management (LPDM). LPDM will provide an integrated capability to manage Army weapon systems and end item data throughout the life cycle and provide an End-to-End solution. It will increase collaboration, especially between the acquisition and logistics domains, by using common data formats and workflow processes. By providing authoritative Bills of Materials (BOMs), LPDM will reduce cost and risk across the Army life cycle through the use of sharing and reusing both engineering and operational data.

As of yet, there are no additively manufactured items in the Army inventory that have achieved full materiel release. To date, AM has been used successfully only by the Rapid Equipping Force and depots for spares, repairs and tooling. Whether

Table 2. U.S. Army Research, Development and Engineering Command



Source: U.S. Army

a platform, payload or equipment, various AM techniques have been demonstrated successfully for repair purposes.

Cold spray is an AM coating deposition technology that hypersonically drives solid powders to impact and adhere to a substrate. One payload, the UH-60 helicopter, experiences corrosion issues in the transmission and gearbox housings. These housings typically are made of cast magnesium which are expensive and take a long time to procure. However, as demonstrated by the Army Research Lab (ARL), cold spray can be used to repair these housings quickly and cheaply when compared to traditional parts replacement using procurement.

While cold spray AM technology does not necessarily require the use of 3D models, to fully implement it for widespread use on Army systems, it will require the development and adoption of standards to guide the specifications for the powders, process and final inspections.

To aid in the development of standards and specifications for AM, the U.S. Army is making targeted investments in engineering development. This past spring 2016, the Army ManTech Office, part of the Research, Development and Engineering Command (RDECOM), worked with America Makes and Deloitte to produce the U.S. Army Additive Manufacturing Technology Roadmap. The roadmap is broken up into five activity areas: Design, Material, Process, Value Chain and AM Genome. Each of these five activities can be used to support both the acquisition and logistics domains of the Army. For example, investments in the Process activity might be used to produce a new platform, payload or equipment in the acquisition domain or produce a new repair technique in the logistics domain.

Since AM is still a developing technology, it often is necessary to determine which platform, payload or equipment would derive the most benefit from an engineering project even if it is not clear which domain would be the greater beneficiary. Thus, RDECOM is broken out into seven Research, Development and Engineering Centers (RDECs) and the ARL that have the task of inserting AM technology according to what is within their respective portfolios (see Table 2). The portfolios are broken out into platforms (aviation; tank and automotive; soldier), payloads (armaments; missile) and equipment (communications and electronics; chemical and biological) with the ARL supporting each portfolio with applied research. RDECOM also has chartered an Army Additive Manufacturing Community of Practice to further harmonize efforts to leverage equipment and training investments.

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To fully implement the Army AM Technology Roadmap, efforts need to be synchronized across the Army to include all activities across the life cycle. Looking again at the five activity areas in the roadmap—Design, Material, Process, Value Chain, and AM Genome—it is apparent that implementing AM is not solely an engineering challenge. While Design, Material, Process and AM Genome are more likely to be engineering efforts, Value Chain requires more engagement from other organizations across the Army that are involved with soldier training, generating operational requirements, developing policy and usage guidance for use of AM in weapons systems and for crafting language involving the use of intellectual property (IP) for acquisition. Value Chain tasks include the "AM acquisition process," "robust supply chain" and "develop continuous learning model," which fall just outside the traditional engineering efforts yet need to be synchronized.

The Army seeks to develop and exploit the advantages that AM can bring to the soldier: point-of-use manufacturing; weight reduction; increased lethality; multiuse materials; and quicker, cheaper repair processes. Currently, most of the work in AM is performed by the engineering organizations to better understand the state of the art and guide implementation into platforms, payloads and equipment. However, as AM technology matures, along with the digital engineering information it requires, the Army will need to synchronize efforts across the entire life cycle from operational doctrine and training to the acquisition and logistics domains in order to implement the U.S. Army Additive Manufacturing Technology Roadmap.

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