ADDITIVE MANUFACTURING: WHICH DLA-MANAGED LEGACY PARTS ARE POTENTIAL AM CANDIDATES?

REPORT DL501T1

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Thomas K. Parks

Bruce J. Kaplan

L. Robert Pokorny (XSB, Inc.)

Timothy W. Simpson (Pennsylvania State University)

Christopher B. Williams (Virginia Polytechnic Institute and State University)

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Executive Summary

The Military Services are pursuing additive manufacturing (AM) because of its ability to improve support to the warfighter by providing replacement or innovative parts when and where the warfighter needs them. However, due to the rapid evolution of AM innovations, which technology is most appropriate to produce a part is not always clear, nor is whether legacy parts can or should be made using AM. Addressing these matters is not a trivial or quick exercise.

Currently, the Defense Logistics Agency (DLA) and the Military Services do not have a standard process by which they can quickly and consistently determine whether a legacy part can be made using AM—each individual case must be extensively researched to determine whether AM is a reasonable option. With 4.5 million Class IX legacy parts to consider, DLA and the Military Services have insufficient resources to manually tackle such a task.

DLA recognized the significance of the evolving AM situation and elected to address it by sponsoring a research and development (R&D) project under the auspices of its Weapon System Sustainment Program (WSSP). The purpose of this R&D task was to ascertain the feasibility and, if possible, develop a decision support process for identifying the legacy DLA-managed Class IX parts that could be made using AM by collecting and assessing online data in Department of Defense (DoD), DLA, and commercial databases.

Determining whether a legacy Class IX part is a good AM candidate requires an in-depth understanding of detailed technical attributes (material composition, size, tensile strength, etc.) as well as logistics attributes (production lead time, unit cost, technical data availability, etc.). These attributes have varying degrees of importance, depending on the specific legacy part being considered for production using AM.

Considering today's manufacturing state of the art and currently available AM systems, and assuming no redesign of a legacy part, we chose two technical attributes—dimensional size and material composition—as the primary determinants for assessing part amenability for AM production.

Dimensional size is a primary AM determinant because each AM system has a maximum "build envelope" (length, height, and width) available for making, or printing, parts. Accordingly, to be produced using AM, a legacy part must physically fit within the build envelope of the specific AM system selected for production, or printing.

Material composition also is a primary AM determinant because an AM-produced legacy part must be made from the same material as the current legacy part. We concluded so because DoD has no certified specification, or "table of equivalencies," that stipulates the AM materials (commonly called feedstock) that may be substituted for legacy part materials. Until such a table or specification is created, producing legacy parts using AM likely will be limited to items whose material composition matches available feedstocks or where a specific equivalency analysis and qualification process is performed for an individual part and AM system/feedstock combination.

Dimensional size and material composition are primary AM determinants, and online data are available, but these two attributes are not by themselves sufficient to categorically establish that a legacy part can or should be made using AM. Other technical and logistics attributes must be considered and assessed to account for the many unknowns presently associated with AM (such as the variability of AM processes within and across different systems and manufacturers, microstructure variability of multiple parts produced from the same AM system, lack of DoD material equivalency tables, lack of DoD-approved AM production and testing standards and protocols, and microstructure and porosity differences between materials used for classic or subtractive manufactured items and AM-produced items). Unfortunately, for legacy parts, when DLA has any data at all, most of the technical information required to address these AM variables is contained in two-dimensional, unintelligent, raster drawings, for which no economical, automated means is currently available to extract the data.

The wide range of AM variables and paucity of accessible online technical data precluded developing a generic set of rules or an automated decision support process for categorically determining that a legacy item can or should be made using AM. However, we *were* able to build, demonstrate, and successfully test (using Military Service and DLA personnel) an "AM prescreening" decision support process that can quickly parse the millions of DLA-managed Class IX legacy parts to manageable groups of items "potentially amenable to AM."

The AM prescreening decision support process gathers available online technical and logistics attribute data for each part, assesses the data using a set of filters established by a user, returns a list of parts meeting the filter criteria, and identifies legacy parts that are "potential AM candidates" on the basis of material composition and dimensional size. It also makes the underlying technical and logistics attribute data available to the user for further analysis. The "potential candidates" still require an individual engineering review to determine whether and how they can be produced using AM.

The AM prescreening decision support process can be automated and provided as a web-based application to DoD personnel. We include a set of functional requirements for the prescreening process for DLA review and consideration.

AM capability will continue to evolve and, it will affect DLA operations. DLA needs to determine its enterprise strategy regarding the implementation and use of AM. If DLA chooses to pursue an AM decision support process, it needs to address some critical technical decisions, such as the following:

- whether an AM decision support process should use data from Military Service databases for DLA-managed parts;
- whether an AM decision support process should include Military Service parts (those not managed by DLA);
- whether DLA wants or needs the decision support process to be integrated with or included as a subset of any other Enterprise Business System analysis process or capability and to identify the necessary interfaces; and
- which DLA activity or organization will pay for development, implementation, integration, and maintenance of the decision support capability.

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Chapter 1
Introduction

The Military Services are pursuing additive manufacturing (AM) because of its ability to improve support to the warfighter by providing replacement or innovative parts when and where the warfighter needs them. AM is a transformative technology that offers the capability to build parts at or near the point of need (rather than at conventional manufacturing facilities) and do so with very short production lead time (PLT). In addition, AM has the potential to right-size the Department of Defense (DoD) inventory by sourcing parts directly to the customer in the field.

Although AM is rapidly progressing, the technology is currently most appropriate for producing certain parts. Some parts, such as Critical Safety Items (CSIs), have strict specifications that require a detailed review and approval before AM could be authorized to produce them. Other parts, such as basic tools, that are not CSIs or safety-related, have less stringent requirements and may be good candidates.

Currently, the Defense Logistics Agency (DLA) and the Military Services do not have a standard process by which they can quickly and consistently determine whether a part is a potential candidate for AM—each individual case must be extensively researched to determine whether AM is a reasonable option. With 4.5 million Class IX legacy parts to consider, DLA and the Military Services have insufficient resources to manually tackle such a task.

DLA recognized the significance of the evolving AM situation and elected to address it by sponsoring a research and development (R&D) project under the auspices of its Weapon System Sustainment Program (WSSP). Specifically, DLA commissioned an R&D project jointly with the Military Services to develop a process to determine the applicability of AM technology in manufacturing DLA parts. The process will facilitate Military Service initiatives to test and employ AM technology by identifying DLA parts that are candidates for production using AM. The process will minimize the research time to determine whether AM applies to particular legacy Class IX parts on the basis of product attributes, such as material specifications and criticality, and logistics attributes, such as item cost, backorder, and lead time. In addition, this process could enable the routine use of AM in parts selection and manufacture, creating new efficiencies throughout the Military Services and further speeding support to the warfighter.

This report summarizes our findings about specific part attributes necessary to inform AM decisions and the availability of DLA data for the requisite part attributes (Chapters 2 and 3). It also describes a method (business process) for identifying potential AM candidates on the basis of requisite attributes, including

ground rules and limitations, and results from testing the method using a web-based prototype tool, and a set of functional requirements for DLA review and consideration (Chapter 4). Finally, this report summaries our findings and discusses the need for a DLA enterprise AM strategy (Chapter 5).

Chapter 2
Part Attributes

Part attributes must be considered when evaluating items for AM production. DLA and the Military Services need to examine and understand a variety of technical and logistics factors related to each product to maximize AM benefits. For example, if the average PLT for building a part is 1 year, it strengthens the case for AM because it can drastically reduce the overall PLT and deliver a part much sooner to the end user. On the other hand, if the part is dimensionally larger than the build volume of current AM systems, it argues against the use of AM as a production method.

For this R&D project, we examined only Class IX parts (weapon system replacement parts currently in the DoD/DLA inventory). Also, to constrain the scope of this project, we assumed that legacy parts would not be redesigned to take advantage of AM capabilities.

The following sections describe the various technical and logistics attributes and their relative importance in informing AM decisions regarding legacy Class IX parts. We derived the technical attributes from detailed discussions and inputs from our partners at Pennsylvania State University and Virginia Polytechnic and State University, who are at the forefront of academic research in the use of AM processes and materials. We took the logistics attributes from detailed discussions with our DLA stakeholders in the Aviation, Land and Maritime, and Troop Support supply management organizations, who deal daily with procuring legacy parts, identifying problematic parts, and resolving how best to acquire problematic items, which are considered by DLA management as candidates for AM production.

TECHNICAL ATTRIBUTES

AM creates objects by adding raw material layer by layer and fusing each new layer to the previous one. AM features a variety of processes, each using different methods for adding material and fusing the individual layers. Accordingly, each process creates objects with different material properties. Thus, we need to understand these properties and how they relate to the physical requirements of a legacy part.

In addition, because legacy Class IX parts were designed for production using conventional, or “subtractive,” manufacturing (a piece of material is cut or ground into a desired shape), and we assume no redesigning of the part, we need to understand other technical attributes of the legacy parts (form, fit, and function, for

example) to make informed decisions regarding the potential use of AM. (This restrictive situation likely will change as AM processes mature and knowledge of the similarities and differences between classically manufactured and AM-produced parts are better understood and codified. For the moment, a conservative approach is warranted.)

The following specific technical attributes will influence the decision and ability to use AM to make a legacy part:

- Material/part specifications
  - Tensile strength
  - Elastic modulus
  - Elongation at break
  - Hardness
  - Heat-deflection temperature
  - Melting point
  - Density
  - Fire safety
  - Toxicity
- Overall part size
- Individual feature dimensions
- Profile and dimensional tolerances
- Surface finish specifications
- Datum targets for machined features
- Mating surfaces and interfaces
- Machining allowances
- Internal holes and features

- Criticality (for example, whether the part is a CSI, the failure of which can result in loss of life)
- End item application environment (for example, some polymers are sensitive to light, humidity, and temperature).

Some technical attributes might disqualify the use of AM for part fabrication:

- Thin walls smaller than the minimum beam diameter of the AM system (these parts will fail to build because the beam diameter dimension will vary by AM machine and by build orientation)
- Thick parts (particularly in metals, thick/bulky parts will fail to build)
- Features with very high aspect ratios (will vary by AM machine and build orientation)
- Over-/under-hangs (particularly in metals; may be built depending on orientation and/or use of support structures)
- Mechanical properties (such as fatigue life requirement)
- Material composition (alloys or materials not currently available for additive manufacturing).

Finally, because many (particularly metallic) AM parts are produced as "near-net-shapes," the availability of the secondary, or post-processing, capability will also influence AM decisions. In particular, answers to the following questions will directly affect the practicality—and even the location—for producing a legacy part using AM:

- Will appropriate machining equipment, such as wire electrical discharge machining (EDM), be available for removing parts from a substrate?
- Will appropriate machining equipment or chemical processing capabilities be available for removing "supports?"
- Will appropriate machining equipment (such as milling tools or lathes) be available for smoothing or refining mating surfaces?
- Will appropriate heat treatment options be available for stress relief, solution annealing, aging, etc.?
- Is hot isostatic pressing (HIP) available to reduce the porosity of metals or increase the density of ceramic materials?
- Will the part require any other post-processing (such as surface coatings like phosphate coating or paint) before qualification?

LOGISTICS ATTRIBUTES

In addition to technical attributes, logistics attributes are associated with each legacy part. They must be considered when deciding whether to use AM. The importance and constraints associated with each attribute vary, depending on the part under consideration and the urgency of acquiring it.

The following specific logistics attributes can directly influence the decision to use AM to make a legacy part:

- Item characteristics or special designations
  - CSI
  - Flight Safety Critical Aircraft Part (FSCAP)
  - Nuclear item
  - SUBSAFE item
  - Structural part
  - Commercial off-the-shelf (COTS) item
- End item in which the part is used
- Procurement contract type
  - Fully competitive
  - Indefinite delivery/indefinite quantity (IDIQ) delivery order
  - Long-term contract
- Annual demand over the past 2 years
- Purchase quantities
- Supply or stock status
  - Item not stocked
  - Quantity of items on hand
  - Quantity of items ordered

- Quantity of items on backorder
- Number of days items have been on backorder

- PLT
- Administrative lead time (ALT)
- Unit price
- Unit of issue
- Technical data package existence or availability
- Technical data format
  - Two-dimensional (2D) drawing
  - Three-dimensional (3D) model
- Government data rights (type/class)
- Authorized suppliers for a part
  - Qualified Suppliers List (QSL)
  - Qualified Suppliers List of Manufacturers (QSLM)
- Acceptance, test, and qualification requirements
  - Quality assurance plan (QAP)
  - First article test (FAT)
  - Production lot testing.

PRINCIPLE ATTRIBUTES

To determine whether a legacy Class IX part is a good candidate for production using AM, we need an in-depth understanding of detailed technical attributes as well as logistics attributes. The attributes identified above have varying degrees of importance, depending on the specific legacy part being considered for production using AM.

Considering the current manufacturing state of the art, currently available AM systems, and the project assumption (no redesign of a legacy part), we find that two of the technical attributes, dimensional size and material composition, are the primary physical determinants for assessing part amenability for AM production.

Dimensional size is a primary physical determinant of AM amenability because each AM system has a maximum "build envelope" (length, height, and width) available for making or printing parts. Accordingly, to be produced using AM, a legacy part must physically fit within the build volume of the specific AM system selected for production or printing.

Material composition is also a primary physical determinant of AM amenability. Accordingly, because we stipulated no part redesign, an AM-produced part must be made from the same material as the current legacy part. Currently, a limited set of raw materials is used in commercial AM systems; these raw materials are commonly referred to as feedstock. (Appendix A lists the common metallic and polymeric materials used as feedstock in today's AM systems.)

Although current AM system feedstock materials are numerous, they do not cover the full breadth of materials found in the legacy parts DLA manages. Further, no DoD-certified specification or "table of equivalencies" stipulates which of these feedstocks may be substituted for other materials not currently available in AM systems. Until such a table or specification is created, producing legacy parts using AM likely will be limited to items whose material composition matches available feedstocks or where a specific equivalency analysis and qualification process is performed for an individual part/AM system/feedstock combination.

Although we have identified material composition and dimensional size as primary determinants for assessing amenability for AM production, they are not by themselves sufficient to categorically establish that a legacy part can or should be made using AM. Other technical and logistics attributes must be considered and assessed to account for the many unknown variables currently associated with AM use (such as the variability of current AM processes, lack of DoD material equivalency tables, lack of DoD-approved AM production and testing standards and protocols, and microstructure and porosity differences between materials used for classic, or subtractive manufactured, items and AM-produced items).

Given the diverse set of variables associated with AM fabrication, a qualified engineer—knowledgeable in AM processes and about the use and limitations of the candidate part—needs to assess each candidate legacy part. Specifically, this "engineer-in-the-loop" review must compare the part's technical attributes as described in its technical data package with the AM system's ability to produce those attributes. Concurrent with the engineering review, logistics attributes, which principally address the economic feasibility of using AM, also need to be considered for each item. In short, while we can likely identify legacy parts that are "potentially amenable to AM," we currently cannot develop a generic set of rules for categorically determining that an item can or should be made using AM.

The next chapter describes the location and availability of the information to address the dimensional size, material composition, and other technical and logistics attributes.

Chapter 3
Availability of Data

This chapter identifies the sources and describes the availability and sufficiency of data for the technical and logistics attributes (defined in Chapter 2) required to evaluate DLA-managed Class IX parts as candidates for AM.

To assess online data availability and sufficiency for part attributes, we did the following:

- Identified whether each technical or logistics attribute is available in data that DLA owns or controls.
- Assessed the feasibility of obtaining information from DLA data sources. For attributes not directly available from DLA data, determined whether they can be extracted or inferred from data available in sources such as the Federal Logistics Information System (FLIS), specifications associated with specific parts, or commercial web sources.
- Assessed the sufficiency of all available attribute data and determined whether the data furnish enough information to inform AM decisions.

PART ATTRIBUTE INFORMATION

We identified five data sources for obtaining legacy part attribute information:

1. FLIS database
2. DLA Enterprise Business System (EBS) database
3. DoD Acquisition Streamlining and Standardization Information System (ASSIST) specification database
4. DoD E-MALL Electronic Portal
5. General Services Administration (GSA) Advantage Electronic Portal.

We also identified the SENVOL online Additive Manufacturing Machine Database (http://senvol.com/database/) as a source for obtaining information about current AM systems.

Our study partner, XSB, Inc., evaluated each of these data sources and determined that sufficiently explicit data could be located and mined among them for the requisite technical and logistics attributes.

We obtained some of the requisite attributes and their values for specific parts directly from the identified data sources. Others were extracted or inferred from data available in the data sources. For all extracted or inferred data, we used the XSB Coherent View® tool to perform the extraction and inference processes and store all collected information for each part.

For extracted information, the process involved finding words in narrative text statements/notes that directly mean the extracted value. For example, the phrases Steel Alloy 1020, Steel Comp 1020, and 1020 Steel all mean Low Carbon Steel Alloy 1020. So, if any of these phrases reside in one or more of the data sources for a specific part, we would identify the part material as Low Carbon Steel Alloy 1020.

On the other hand, inferred information for an attribute was produced when a known property of the part implied a second property. For example, if any of the data sources identified that a specific part is subject to Federal Specification QQ-A-601, we would infer or identify that the part is an aluminum sand casting since that is the explicit subject of the specification.

Inferred and extracted attributes for this R&D project were contained in the XSB Coherent View tool. In particular, dimensions for National Stock Numbers (NSNs) and materials used on NSNs were extracted from FLIS Technical Characteristics. If these attributes were not available, we attempted to extract them from commercial part number descriptions in DoD EMALL and GSA Advantage when the commercial part number was also a FLIS reference number for the National Item Identification Number (NIIN). If we could not extract the information, we attempted to infer it from associated specifications titles in ASSIST when the specification was associated to the NIIN through extraction from FLIS or EBS data.

Table 3-1 shows the specific attributes for which we were able to collect data, the method of collecting those data (direct query, extraction, or inference), and the original data source.

Table 3-1. Attribute Data Sources

Attribute	Acquisition method	Data sources
Material	Extract, infer	FLIS, EMALL, GSA, ASSIST
Dimensions	Extract	FLIS
NIIN	Direct query	FLIS, EBS
Federal Supply Class (FSC)	Direct query	FLIS, EBS
DLA Product Class	Infer from FSC	FLIS, EBS
Item Name Code (INC)	Direct query	FLIS, EBS
PLT	Direct query	EBS
ALT	Direct query	EBS
Weapon System Designator Code (WSDC)	Direct query	EBS
Criticality Code	Direct query	FLIS
Acquisition Method Code (AMC)	Direct query	EBS
Acquisition Method Suffix Code (AMSC)	Direct query	EBS
Acquisition Advice Code (AAC)	Direct query	EBS
DLA Supply Chain	Direct query	EBS
DLA Profit Center	Direct query	EBS
Unit Price	Direct query	FLIS
Backorder Status	Direct query	EBS
Annual Demand Quantity	Direct query	EBS

The following sections detail our findings regarding data for the requisite technical and logistics attributes and AM systems data as well as the sufficiency of those data for making decisions regarding the amenability of legacy part production using AM.

TECHNICAL ATTRIBUTE DATA

In Chapter 2, we identify a series of technical attributes that must be considered when assessing legacy parts for production using AM. We also show that of the various technical attributes, material and dimensional size are the primary physical determinants for assessing part amenability for AM production. In examining the above data sources, we found explicit technical attribute data available for a significant number of the 4.5 million legacy Class IX parts that DLA manages.

The next subsection specifically addresses our findings regarding Class IX legacy part material data, while the subsequent subsections address, respectively, findings regarding dimensional data and findings regarding other technical attributes.

Material Data

As described above, we sought material data for the 4.5 million DLA-managed legacy parts from several data sources. To make these data more useful, we mapped, where possible, the material descriptions to one of the common AM feedstock materials (Appendix A). This mapping was based on an exact matching of the part material to its counterpart AM feedstock. For example, a part for which the material description was UNS S31600 would be considered an exact match and mapped to 316 stainless steel alloy (Appendix A). Similarly, a part for which the material description was "nylon" would be considered an exact match and mapped to polyamide.

Conversely, a part for which the material description was simply "steel" would not be considered an exact match to one of the AM materials because it does not stipulate a specific alloy (Steel Alloy UNS S30403, for example). Similarly, a part made from "plastic" would not be considered an exact match because it does not stipulate a specific polymer, such as acrylonitrile butadiene styrene (ABS)/ acrylic or ABS/polybutylene terephthalate (PBT).

Table 3-2 shows a landscape of material data we gathered for the legacy Class IX DLA-managed parts, identified by NSN, mapped to a specific AM feedstock/ material and categorized as a basic AM material type (metal or polymer). The table rows are ordered by a count of the legacy parts (NSN) in descending order.

Table 3-2. Counts of Legacy Parts Made from Current AM Feedstock Materials

NSN count	Material	Material type
59,416	Polyamide (Nylon)	Polymer
18,842	Epoxy	Polymer
15,796	Titanium Alloy UNS R56400	Metal
12,482	Titanium	Metal
7,448	Polycarbonate	Polymer
5,286	Polypropylene	Polymer
4,367	Steel Alloy UNS S30403	Metal
4,142	Plastic Acrylic	Polymer
2,829	Steel Alloy UNS S43100	Metal
2,255	Acrylonitrile Butadiene Styrene	Polymer
2,078	Steel Alloy UNS S30800	Metal
1,915	Steel Alloy UNS S42000	Metal
1,635	Polystyrene	Polymer
769	Polymethyl Methacrylate	Polymer
636	Polyphenylene Sulfide	Polymer
202	Titanium UNS R50550	Metal

Table 3-2. Counts of Legacy Parts Made from Current AM Feedstock Materials

NSN count	Material	Material type
181	Polybutylene Terephthalate	Polymer
129	Polyetheretherketone	Polymer
124	Polyetherimide	Polymer
109	Titanium Alloy UNS R56401	Metal
20	Cobalt Alloy UNS R30006	Metal
18	Cobalt Alloy UNS R30106	Metal
9	Aluminum Alloy UNS A95356	Metal
7	Aluminum Alloy UNS A92319	Metal
3	Aluminum Alloy UNS A94047	Metal
2	Nickel Molybdenum Alloy UNS N10276	Metal
2	Steel Alloy UNS T30106	Metal
2	Steel Alloy UNS T20813	Metal
0	Cobalt Alloy UNS R30012	Metal
0	Steel Alloy UNS S30400	Metal
0	Steel Alloy UNS S30803	Metal
0	Steel Alloy UNS T20812	Metal
0	Acrylonitrile Styrene Acrylate	Polymer

From Table 3-2, approximately 140,000 of the 4.5 million Class IX items managed by DLA are made from a material exactly matching one of the current, common AM feedstocks. Further, our research revealed an additional 1.7 million parts are made from steel or aluminum, where the specific alloy is not identified, and 300,000 parts are made from a polymer where the specific polymer is not identified. Doubtless, for these items, specifics regarding the exact alloy or polymer type are contained in the part technical data, many of which include 2D illustrations.

Unfortunately, there are two exacerbating issues related to technical data for the items noted above:

1. DLA does not have any technical data for many of these parts, and for many parts where DLA does have data, the quality is poor.

2. The majority of DLA/DoD technical data are 2D data often recorded in an unintelligent raster format, and currently no economically feasible means is available to view and extract the information from these 2D drawings.

Accordingly, any decisions regarding amenability of parts for production using AM will require an “engineer-in-the-loop” to initially manually review available

technical data packages (TDPs) and drawings to determine the specific material from which the legacy part is fabricated.

Dimensional Size Data

We also sought, from the FLIS database, dimensional data (length, diameter, height/depth/thickness, and width) for each of the 4.5 million DLA-managed legacy parts. Interestingly, availability of all applicable dimensional data for a part is not consistent. That is, even though multiple dimensions are associated with a part, often data for only the largest dimension are included in FLIS. In other instances, no dimensional information is included, even though it obviously exists due to the reality of the part.

Table 3-3 provides a landscape of dimensional data we gathered for the legacy Class IX DLA-managed parts, identified by NSN and mapped to the existence of data in one or more dimensions. The table rows are ordered by NSN count in descending order.

Table 3-3. Counts of Legacy Parts for Combinations of Dimensions

NSN count	Length	Diameter	Height/depth/thickness	Width
474,799	Yes	No	No	No
457,034	Yes	No	Yes	Yes
343,997	Yes	Yes	No	No
340,917	No	Yes	No	No
200,903	No	No	Yes	Yes
165,103	No	Yes	Yes	No
134,223	Yes	No	No	Yes
103,637	No	No	Yes	No
52,144	No	No	No	Yes
31,718	No	Yes	No	Yes
28,140	Yes	No	Yes	No
8,006	Yes	Yes	Yes	No
3,782	No	Yes	Yes	Yes
3,716	Yes	Yes	Yes	Yes
2,611	Yes	Yes	No	Yes

From Table 3-2, we can identify at least one piece of dimensional information for approximately 2.35 million DLA-managed Class IX parts. Interestingly, we have values for all four dimensions of only about 3,700 parts and values for three dimensions of about 10,000 more parts.

Data for Other Technical Attributes

As noted in Chapter 2, a number of technical attributes may require consideration (secondary attributes) when assessing the amenability of a legacy part for production using AM. These attributes have varying degrees of importance, depending on the specific legacy part. Accordingly, knowing whether or not data are available for these attributes and where those data reside are important. These attributes can be divided into two groups on the basis of data sources.

The first group of attributes are often included in FLIS technical characteristics or they can be inferred from applicable specifications stipulated for a part because it is considered important for performance. These attributes are tensile strength, elastic modulus, ultimate elongation, hardness, surface finish, heat treatment, and surface treatment.

The second group of attributes generally are available only in TDPs that contain drawings or models of the part. (As noted earlier, accessing TDP or drawing information will require a manual review.) These attributes include heat deflection temperature, melting point, density, fire safety, toxicity, feature dimensions and profile, datum target for machined features, mating surfaces, matching allowances, internal holes, application environment, wall thickness, bulkiness, aspect ratios, and overhang features.

Secondary attributes in group one can be used as filters after material and dimensional size when assessing parts for amenability to AM. Subsequently, once potential AM candidates are identified, a detailed examination of the TDP and the group two attributes is necessary to make any final decision regarding whether or not a legacy part can or should be manufactured using AM.

LOGISTICS ATTRIBUTE DATA

Logistics attributes are associated with each legacy part and must be considered when making decisions regarding the use of AM. Logistics attributes are primarily concerned with what the part is, where it is used, how it is obtained, how much it costs, how often it is needed, and how quickly it can be supplied. These attributes do not directly address whether a part can be made using AM. Rather, they address the economic feasibility of using AM to speed delivery or reduce cost.

In general, logistics attributes act as filters when assessing the amenability of an item for production using AM. The importance and necessity for each attribute vary depending on the part under consideration and the urgency for acquiring it.

We identified nine key logistics attributes where current data are available for DLA-managed Class IX parts, as shown in Table 3-1. The attributes and the associated data elements are as follows:

- *Type of item*. Indicated by the FSC and INC.

- *Price*. Obtained from unit price data and from DLA purchase order and long-term contract procurement history.
- *Unit of issue*. Obtained from unit of issue data and from DLA purchase order and long-term contract procurement history.
- *TDP availability*. Indicated by AMC, AMSC, and Document Availability Code (DAC).
- *Data rights*. Indicated by AMC, AMSC, and DAC.
- *Ease or difficulty of sourcing an item*. Determined from data on PLT, ALT, DLA procurement history, and from FLIS Reference Number data.
- *Demand*. Indicated by DLA annual demand quantity, last demand date, stock on hand, and last purchase data.
- *Usage*. Indicates the end item (weapon system platform) where the part or NSN is used and is defined by the WSDC.
- *Item characteristics or special designations*. Indicated by the criticality code, which identifies the criticality or importance of the part or NSN to the safe and proper functioning of the end item in which it is installed.

Data availability and sufficiency are generally good for the logistics attributes identified above, and they are easily accessed as part of the DLA EBS system or FLIS.

AM Systems Data

Any discussion of legacy part amenability to production using AM must necessarily include a dialogue about the current, commercially available AM systems, which might be used to build the parts. Specifically, one needs to know the type of feedstock (material) each system uses and the size of the system's "build envelope" (the dimensional area within the system where a part is actually printed or built).

AM system information was obtained for this project from the SENVOL website (http://senvol.com/). Access to the site is free, and it allows a user to look for AM system information by conducting a "machine search" or a "materials search."

The intent of this study was to identify legacy parts that are potentially amenable to production using AM, so we sought data describing the specific feedstock for each AM system and its build envelope to compare them with legacy part material and size to determine possible matches. We mapped feedstock and build envelope to the appropriate system name and manufacturer to facilitate identifying specific

AM systems that might be used for a specific legacy part. (Appendix B lists the AM systems included in this study.)

To obtain the requisite AM system information originally, we copied the specific data directly from the SENVOL website and imported it into a separate database for use in this project. This is no longer possible. The detailed system data can no longer be copied directly from the website; they are now only available via a paid subscription with SENVOL.

Chapter 4
Identifying AM Candidates

DLA and the Military Services need a standard process by which they can quickly and consistently determine whether a part is a potential candidate for AM. This R&D project identified a set of technical and logistics attributes that can be used to assess the AM amenability of DLA legacy parts (Chapter 2) and identify "potential candidate" items. Further, we identified data sources for these attributes, determined that sufficiently detailed data are available in the data sources, and determined that accessing and extracting that information in an automated fashion is a reasonable possibility (Chapter 3) for building a business process to identify potential AM candidates.

The following sections describe the business process, identify the applicable ground rules and limitations associated with the demonstration prototype business process as it was executed for testing, describe recommendations derived from testing the R&D demonstration prototype (the DLA Legacy Parts AM Prescreening Tool), and identify the functional requirements for DLA use to develop or obtain a capability to automate the business process.

BUSINESS PROCESS

The basic premise for the AM decision support business process was to obtain and use available online data, (DLA/DoD-owned and commercial website information) to describe a legacy part in terms of its technical and logistics attributes. Once the data were harvested from the appropriate source, the business process would compare a subset of the attributes (identified as the principal attributes) with a specified set of attribute values to assess the amenability for manufacturing using AM systems and processes. Items with attributes that meet the minimum criteria are then identified as AM candidates. For these items, the process would summarize all the technical and logistics attribute data collected and make the summary available to the user for additional analysis as desired. In addition, the process was envisioned as identifying AM systems that might be used to produce a legacy part identified as an AM candidate.

In Chapter 2, we identified two principle attributes that define potential amenability of a part for manufacture using AM: material composition and physical size. These attributes form the cornerstone for the AM decision support business process. Nevertheless, although material composition and dimensional size are primary determinants for assessing amenability for AM production, they are not by themselves sufficient to categorically identify that a legacy part can or should be made using AM.

Our research revealed a wide variability in current AM system capabilities, feedstocks, process controls, etc.; noticeable variability in the microstructure of parts (particularly metallic items) built from the same AM system with the same feedstock; lack of DoD-approved material equivalency tables; lack of DoD-approved AM process protocols for build orientation; and lack of DoD-approved testing standards, etc. We also discovered that data or descriptions for many of the part technical attributes reside in 2D drawings, which typically are unintelligent raster formats. Unfortunately, no economical, automated means is currently available to retrieve this information from existing 2D drawings, even when they are available.

Because of the variabilities in the AM processes and systems, lack of DoD standards, and inability to retrieve technical attribute data from 2D drawings, we are unable to define or develop a general set of rules that can be automated and applied to technical attributes for legacy parts to provide an unequivocal assessment regarding the feasibility of a given part for production using AM. However, we can build a decision support process that identifies potential candidate items.

The business process to identify potential candidate items is based on exactly matching part material to a current AM feedstock and ensuring we have dimensional information for determining whether the part will fit inside the build-space of a particular AM system. Items meeting these minimum criteria are then sorted by applying filters that represent various logistics attributes, as identified by individual users on the basis of their particular needs. This realistic approach gives us a means for identifying parts that are candidates for production. The “potential candidate” selection process will significantly benefit DLA and the Military Services by facilitating rapid parsing of millions of legacy parts, collecting key technical and logistics information, and presenting those data in a user-friendly format for subsequent analysis.

We compared available online data for approximately 4.5 million Class IX legacy parts currently managed by DLA with the AM decision support business process principal attributes (material composition and dimensional value). The comparison yielded a group of about 43,000 items that met both criteria, and which were subsequently recorded in a “master database” along with all the associated technical and logistics attributes that we could download from the various data sources (Chapter 3). This group formed the universe of potential AM candidate parts, around which we created an R&D demonstration prototype called the DLA Legacy Parts AM Prescreening Tool, described in the next subsection.

DLA Legacy Parts AM Prescreening Tool

We used the DLA Legacy Parts AM Prescreening Tool to employ and test the AM decision support business process. The tool implemented the business process as a web-based platform, with access controlled by the R&D team. More than 55 DLA and Military Service personnel used this proof-of-concept platform as a hands-on means for testing the AM decision support process, helping identify

legacy parts that were potential AM candidates based on their specific search criteria, and furnishing a means to record lessons learned and provide feedback to the R&D team.

We had 11 different Military Service organizations and four DLA activities, each with their own functional requirements, using and testing the tool, so we gave it a robust set of filters (part attributes) to accommodate a variety of queries.

The main data-input screen gave users the ability to select and adjust filters to facilitate identifying parts on the basis of their needs. Users had the option of using none, one, all, or any combination of available filters. Most filters included drop-down boxes listing available selections from which the user could choose specific inputs. In addition, many filters enabled the user to identify multiple inputs by using a comma to separate individual input items for each filter. The following specific filters were available for user manipulation in the tool:

- *FSC*. Used to group products into logical families for management purposes. The FSC (a four-digit code) and the NIIN form the unique NSN for each part managed by DLA. The tool furnished a drop-down box identifying all available FSCs. Selecting one or more FSCs enables the user to limit the tool searches to a specific part or groups of parts.

- *NIIN*. A nine-digit code or serial number used to identify unique parts. Inserting one or more NIINs enables the user to limit the tool searches to those particular parts. This filter has no drop-down box because the number of available NIINs is too large.

- *WSDC*. A three-digit code used to identify the end item weapon system supported by DLA. WSDCs are associated with DLA legacy parts to provide information regarding the weapon system on which any legacy part might be installed. The tool furnishes a drop-down box identifying all available WSDCs. Selecting one or more enables the user to limit the tool searches to parts associated with those particular weapon systems. Selection of a WSDC automatically populates the System Name and Military Service filter blocks.

- *Long Lead/Overage*. Refers to the total time it normally takes to procure an item, which is represented in the EBS data source as a combination of ALT and PLT. Gives the user a choice of four ranges of days (1–90, 90–180, 180–360, or 360+). Selecting a range enables the user to limit the tool searches to parts that have a combined ALT and PLT in that range and provides a method of identifying long-lead parts.

- *Cost*. The unit cost of an item (NIIN). This filter gives the user a choice of four cost ranges ($1–100, $100–1,000, $1,000–10,000, or $10,000+). Selecting a range enables the user to limit the tool searches to parts that have

a unit cost within that range. The user is limited to entering a single range in this filter for each query.

- *Military Service*. Name of a Military Service (Army, Navy, Air Force, or Marines). Selecting a specific or combination of Military Services enables the user to limit the tool searches to parts used on weapon systems owned or maintained by the selected Military Services.

- *System Name*. Weapon system/subsystem/platform that is the end item for the DLA-managed legacy Class IX parts. Selecting a specific system (for example, Submarine High Pressure Air System, Air Conditioner 6000BTU, AH-64E) or combination of systems enables the user to limit the tool searches to parts used specifically on those systems. Selection of a System Name automatically populates the WSDC and Military Service filter blocks.

- *Criticality*. Identifies any critical features (such as critical safety item, flight safety critical aircraft part, or SUBSAFE) that might be associated with a legacy part. Choosing one or more of the nine possible categories enables the user to limit the tool searches to parts that have the selected critical features. The nine categories are as follows:

  - C—The item has critical features such as tolerance, fit restrictions, or application. Nuclear hardness properties have not been determined (not valid for input).

  - E—The item is an Aviation Critical Safety Item/Flight Safety Critical Aircraft Part (ACSI/FSCAP) and is specially designed to be or selected as being nuclear hard.

  - F—The item is an ACSI/FSCAP.

  - H—The item is specifically designed to be or selected as being nuclear hard (it will continue to perform its designed function in an environment created by a nuclear explosion). The item does not have other critical features.

  - M—The item is specifically designed to be or selected as being nuclear hard. In addition, the item has other critical features such as tolerance, fit restrictions, or application.

  - N—The item does not have a critical feature such as tolerance, fit restrictions, or application. Nuclear hardness properties have not been determined (not valid for input).

  - S—The item is a non-aviation CSI whose failure will result in serious damage to equipment or serious injury or death to personnel.

- X—The item does not have a nuclear hardened feature or any other critical feature such as tolerance, fit restriction, or application.

- Y—The item does not have a nuclear hardened feature but does have other critical features such as tolerance, fit restriction, or application.

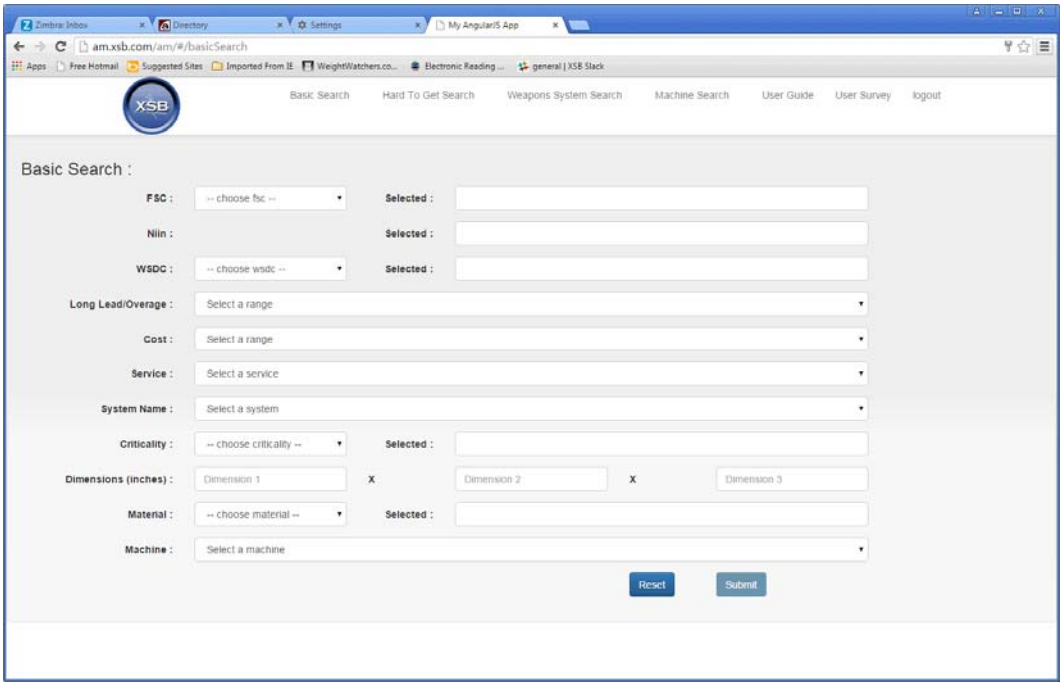
- *Dimensions*. Identifies up to three size measurements for a part. Inserting size measurements (in inches) enables the user to limit the tool searches to parts that are dimensionally no larger than the input sizes; alternatively, inserting dimensional sizes enables the user to identify, for a given parts, specific AM systems that have build-envelopes sufficiently large to accommodate the user-specified dimensions. The user is limited to a single value in each of the dimension fields.

- *Material*. Identifies the specific material, such as Aluminum Alloy UNS A92319, Polyamide (Nylon), from which a legacy part is made. Choosing one or more of the identified materials enables the user to limit the tool searches to parts that are made from the specified materials.

- *AM system/machine*. Identifies the commercial AM systems (by manufacturer and model) that are currently available for purchase or use as identified in the SENVOL database. Choosing one of the identified AM systems enables the user to limit the tool searches to parts made from the exact materials or feedstocks used in that system and dimensionally small enough to fit within the system's build-envelope. The user is limited to a single choice for this filter. Selecting a specific AM system automatically populates the Material and Dimension filters with specific values associated with the selected AM system, which act as the filter criteria during the query.

Figure 4-1 shows the main input screen for the tool.

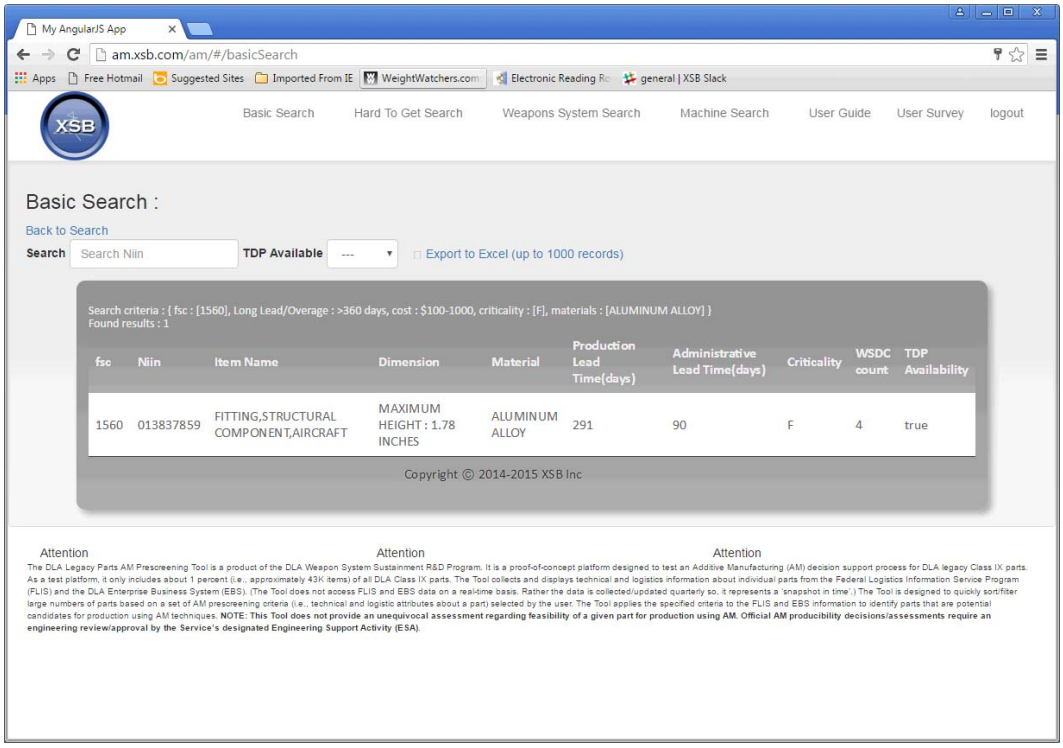
Figure 4-1. Main Input Screen, DLA Legacy Parts AM Prescreening Tool



Once users enter their specific filter inputs, they click the “Submit” button (lower right corner of the screen) to begin a query. The tool then accesses the master database of 43,000 items (DLA Class IX legacy parts that met both of the principal attribute criteria—material composition and dimensional information) and identifies and extracts all the associated information for each item meeting the query requirements.

Upon concluding each query, the tool displays, on-screen, for user review, a complete list of applicable parts, plus a subset of the attribute data for each part. The on-screen display of attribute data was restricted to the following basic attribute items because of space limitations: FSC, NIIN, Item Name, Dimension, Material, PLT, ALT, Criticality, WSDC count (the total number of weapons systems on which the item/NSN is used), TDP availability (a “True” or “False” statement indicating government has technical data). The on-screen display also included a list of the search criteria (as entered by the user), a count of the total number of items found meeting the query constraints, and a filter for parsing the returned items on the basis of the availability or non-availability of a TDP (because any final decision regarding part amenability to production using AM will require an engineering review of the TDP). Figure 4-2 presents a sample on-screen query result display from the tool for search results for FSC 1560 Aircraft Structural Parts made from Aluminum Alloy, Critical Flight/Safety Item, cost between $100 and $1,000, and a combined lead time of over 360 days.

Figure 4-2. Query Results Online Display



In addition to the on-screen display, the tool gives the user the option of exporting an Excel file containing all of the attribute data associated with each part identified by the query. (Because the tool was a prototype built to test the overall screening process, we limited the Excel output report to a maximum of 1,000 parts to ensure the XSB server would not be overloaded during operations.) We selected the Excel format because it gives a user an easy means for additional filtering or analysis outside the tool.

The tool includes three scenario-based search or input screens, which are accessed from the main screen by clicking on the appropriate search screen title in the header bar. These scenario-screens are designed to facilitate specific situational searches we envisioned users might need or want by displaying only the filters relevant to each scenario. As with the main input screen, users had the option of using none, one, all, or any combination of available filters. The scenario-screens were as follows:

- *Hard to procure items*. This search screen was designed to streamline the process of gathering data for parts that DLA or the Military Services are having difficulty acquiring. For this scenario, we assumed the user would likely know the exact NSN for the part or at least know the weapon system platform on which the part is used. Accordingly, the input filters were narrowed to include only FSC, NIIN, WSDC, Long Lead/Overage, and Cost.

- *Weapon system search*. This search screen was designed to streamline the process of gathering data for parts that are associated with a specific weapon system. For this scenario, we assumed the user would know the weapon system and likely know the Military Service using the system. Accordingly, the input filters were narrowed to include only WSDC, Military Service, System Name, and Criticality.

- *Machine search*. This search screen was designed to streamline the process of identifying parts that might be built using a specific AM system or machine. For this scenario, we assumed the user would know the specific AM system or feedstock material. Accordingly, the input filters were narrowed to include only Machine, Material, and Dimensions.

Although we tailored the input filters for the scenario-screens, the tool still returns a summary of all the technical and logistics attribute data collected for applicable parts whenever a query is made using a scenario-screen. Also, similar to the main input screen queries, a subset of information collected for the parts is displayed on-screen for quick reference and there is an option to export an Excel file containing all the data for additional analysis as desired.

Testing the Business Process

As noted, we tested the AM decision support business process by making it available, via a web-based application, to personnel from 11 Military Service activities and 4 DLA activities who partnered with us during this R&D task. We engaged these activities early in the task to gather information on their needs and requirements regarding an AM decision process and to enlist their support in testing the business process.

The web-based application, known as the DLA Legacy Parts AM Prescreening Tool, was developed as a prototype R&D application by our partner XSB, Inc., and was hosted on its server from November 2015 through July 2016 for user testing. The tool is not a deliverable as part of this R&D task, but simply an automated means for testing the business process, identifying lessons learned, identifying desired functionality, and forming a basis for identifying and constructing functional requirements for the decision support process, which is the principal R&D deliverable to DLA.

The DLA R&D team controlled entry to the tool by issuing access credentials (user name and password) to the more than 55 personnel identified by the Military Service and DLA activities as their designated representatives for testing the tool. (Appendix C lists the activities and their principal points of contact for this R&D project.)

We provided a series of optional training sessions (webinars) for attendance by the personnel designated as tool testers. We also gave each tester an electronic copy of the *User Guide* (Appendix D), and we made the guide available online

through a link embedded in all of the data input screens. In addition, we assigned a person from the R&D team as a point of contact (POC) for answering questions regarding the tool; we published his contact information in the *User Guide* and in our e-mail correspondence to the tool testers.

We offered the testers several options for providing feedback regarding the tool, including direct e-mail or phone call to specified contacts on the R&D team or use of a survey form included in our early e-mail correspondence and accessible as an embedded link on all of the data input screens. The following section describes the input we received from the testers.

User Feedback

In general, users found the web-based tool and the embedded decision support process of significant value in identifying potential AM candidates. They were particularly enthusiastic about the automated process because none of them had an available capability for quickly gathering, parsing, and providing specific part information (technical and logistics attributes) relevant to making AM amenability assessments. Nevertheless, they did offer a number of pertinent, useful suggestions regarding additional functionality that could significantly enhance the overall utility and benefit of an automated AM prescreening process for legacy parts:

- *Internet Explorer compatibility.* Virtually every user recommended that the tool be fully compatible with Microsoft Internet Explorer because this web browser is installed on almost every DoD computer. To facilitate rapid development of the prototype tool, XSB used Java script to build the web-based application. Unfortunately, not all versions of Internet Explorer function properly with Java script. Accordingly, some users had to switch to Firefox or Chrome web browsers to access and use the tool. Only one of the users with Internet Explorer compatibility issues was precluded from using the tool; all others were able to obtain access to either the Firefox or Chrome web browsers. (No compatibility issues arose with the Firefox or Chrome web browsers.) Because the tool was a test platform for developing functional requirements, and virtually all users/testers could access the tool, we made a conscious decision not to spend resources on fixing the Internet Explorer compatibility issue.

- *Input data from Military Service databases.* One Military Service user recommended having the decision support process access and incorporate data from (unspecified) Military Service databases used for parts management to supplement and fill voids in information gathered from EBS and FLIS.

- *Inclusion of Military Service-managed parts.* At least one member from each Military Service organization recommended expanding the pool of potential parts available for screening beyond the DLA-managed Class IX

items to include parts managed by the Military Services. They recommended a filter/"flip-switch" to include or exclude parts that are Military Service-managed or DLA-managed.

- *Expanded list of parts that are not exact material matches.* Several users recommended not limiting the pool of parts to those with an exact match to a current AM feedstock. They recommended a filter/"flip-switch" to include or exclude parts that are exact material/AM feedstock matches.

- *Expanded list of parts that do not have dimensional information.* Several users recommended not limiting the pool of potential parts to those with available dimensional information. They recommended a filter/"flip-switch" to include or exclude parts that have dimensional information.

- *Inclusion of supply chain filter.* Several DLA users recommended adding "Supply Chain" filters to parse parts by the responsible DLA Supply Chain and by DLA Cost Center.

- *Inclusion of TDP availability filter.* Several users recommended including the "TDP Availability" filter as one of the primary filters on the main input screen instead of a secondary filter available only after initial search results are displayed. One user further recommended having the "TDP Availability" filter results identify the type of technical data (3D model or 2D drawing) and their location, such as the Joint Engineering Data Management Information and Control System (JEDMICS). One user recommended identifying a technical POC (such as a specific engineering support activity) for each item.

- *Inclusion of technical data rights filter.* Several users recommended including a filter for technical data rights. They didn't specify what the filter should include, but we reason it should offer a choice of one or more of the typical technical data rights categories associated with DLA-managed parts and identified by the AMSC code (for example, "The Government has unlimited rights to the technical data, and the data package is complete," "The government does not have adequate data, lacks rights to data, or both, needed to purchase this part from additional sources," or "The rights to use the data necessary to purchase this part from additional sources are not owned by the Government and cannot be purchased.").

- *Identification of AM systems owned by Military Service/OEM partners.* One Military Service user recommended a filter for identifying AM systems currently in use by the Military Services and their original equipment manufacturer (OEM) partners. The output results from applying the filter should identify the AM system and the Military Service or OEM that owns it.

- *Part demand and backorder status filters.* Several DLA users recommended including additional filters to cover identifying items on the basis of demand, such as annual demand quantity (ADQ), demand frequency (dmd_freq), and backorder issues, such as the sum of backorders (sum_bkord). Information based on EBS data elements for these items and subsequently provided to tool users would need to be refreshed often (daily or weekly) because it is particularly volatile.

- *Scenario-based search/input screen redundancy.* Several Military Service and DLA users commented that the scenario-based search/input screens were redundant and unnecessary because all the user-selectable filters were included on the main input screen and they were easy to find and navigate.

FUNCTIONAL REQUIREMENTS

This section sets forth the functional requirements for a legacy parts AM decision support process. It identifies the decision support process purpose and objective, gives a process overview, and identifies requirements for input data, user interface, and output data.

Process Purpose and Objective

The purpose and objective of the legacy parts AM decision support process is to provide a standard, automated means by which DLA and the Military Services can quickly and consistently determine whether a DLA-managed Class IX legacy part is a potential candidate for fabrication using AM.

The decision support process will minimize the research time to determine AM applicability for legacy parts by gathering part attribute data from current DLA, DoD, and commercial databases, consolidating that information, and making it available for online and offline analysis. The analysis process will be based on a part's technical attributes, such as material composition and size, and business/logistics attributes such as item cost, backorder status, and production lead time.

The process will enable a user to conduct queries by filtering the part attribute data consistent with his or her needs. The query results will be presented as a list of parts in an on-screen display. In addition, the results and all associated attribute data gathered by the process will be made available to the user in a downloadable or exportable Excel file.

Decision Support Process Overview

This decision support process is relatively simple. The user adjusts the available filters (described in the "User Interface Requirements" section) as required to meet his or her requirements, and then executes the query. The process software

accesses the Parts Attributes and AM System Information Database to identify and select parts meeting the query requirements. Results for each query are then provided to the user as output data. Results should be available to the user within 10 seconds.

Input Data Requirements

Input data for DLA Class IX legacy parts technical and logistics attributes are available from one or more of the following five data sources:

- FLIS database
- DLA EBS database
- DoD ASSIST specification database
- DoD E-MALL Electronic Portal
- GSA Advantage Electronic Portal.

Table 4-1 identifies the specific legacy part input data elements (part technical and logistics attributes) and their source. (Chapter 3 details how the R&D team harvested these data elements.)

Table 4-1. Legacy Parts Input Data Elements and Sources

Attribute	Data sources
Material	FLIS, EMALL, GSA, ASSIST
Dimensions	FLIS
NIIN	FLIS, EBS
FSC	FLIS, EBS
DLA product class	FLIS, EBS
INC	FLIS, EBS
PLT	EBS
ALT	EBS
WSDC	EBS
Criticality code	FLIS
AMC	EBS
AMSC	EBS
AAC	EBS
DLA supply chain	EBS
DLA profit center	EBS
Unit price	FLIS
Backorder status	EBS
Annual demand quantity	EBS

Input data for AM systems are available from the SENVOL database that supports their website located at http://senvol.com/. Access and use of the website are free. However, access to the data elements contained in the database requires a paid subscription with SENVOL. Specific AM system input data elements required for each AM system currently included in the SENVOL database are as follows:

- System name
- Manufacturer
- Feedstock (type of metallic, ceramic, or polymeric material used by the AM system)
- Build envelope dimensions (height, width, and length)
- AM process (such as powder bed fusion or direct energy deposition).

The input data for the DLA Class IX parts should be collected from the above sources and then stored in a separate database (Parts Attributes and AM System Information Database) that can be queried by the AM decision support process software to produce an output consistent with a user's query requirements. Parts and part technical attribute data, part logistics attribute data (except annual demand quantity and backorder status data), and AM system data should be updated monthly; as a rule, this information is not particularly volatile. Part annual demand quantity and backorder status data should be updated weekly because it is volatile information.

Part dimensional data measurements collected from FLIS and AM system build-envelope measurements collected from the SENVOL database should be standardized and, where necessary, converted to inches for inclusion in the Parts Attributes and AM System Information Database.

Part material data collected from FLIS/EMALL/GSA/ASSIST should, as necessary, be translated to the appropriate metallic or polymeric material (Appendix A) for inclusion in the Parts Attributes and AM System Information Database. AM System feedstock data collected from the SENVOL database should, as necessary, be translated to the appropriate metallic or polymeric material (Appendix A) for inclusion in the Parts Attributes and AM System Information Database. (Appendix A will likely require revision and addition of new materials by the time this report is delivered because AM system developers are adding new machines and feedstocks almost daily.)

User Interface Requirements

The legacy parts AM decision support process requires an intuitive user interface that can be accessed easily by DLA and Military Service personnel. If DLA

chooses to implement a web-based application, it should be fully compatible with the versions of Microsoft Internet Explorer currently in use across DLA and DoD.

The interface should enable the user to construct queries to identify Class IX DLA-managed parts that are potential candidates for fabrication using AM. To construct the queries, the interface should contain, on a single input page, user-selectable filters (most of which are defined in the DLA Legacy Parts AM Prescreening tool section above) for the following elements:

- FSC (multiple entries should be allowed)
- NIIN (multiple entries should be allowed)
- DLA supply chain (multiple entries should be allowed)
- DLA cost center (multiple entries should be allowed)
- WSDC (multiple entries should be allowed)
- Military Service (multiple entries should be allowed); identified as Army, Navy, Marines, or Air Force; associated with the WSDC
- Weapon system name (multiple entries should be allowed); directly associated with the WSDC
- Criticality code (multiple entries should be allowed)
- PLT (user sets the range with a minimum and maximum number of days)
- Unit price (user sets the range with a minimum and maximum dollar amount)
- Annual demand quantity (user sets the range with a minimum and maximum quantity value)
- Backordered item ("Yes/No," where "Yes" allows selection of a part only when it is currently on backorder and "No" allows selection of parts that are not backordered; default position = "Yes")
- Dimensions; height, width, length, and diameter (in inches)
- Dimensional data available ("Yes/No," where "Yes" allows selection of a part only when dimensional data is available and "No" allows selection of any part regardless of whether or not the Parts Attributes and AM System Information Database contains dimensional data for the part; default position = "Yes")
- Material (multiple entries should be allowed)

- Exact material match to AM feedstock ("Yes/No," where "No" allows selection of any part regardless of whether or not it is made from a material exactly matching one of the common AM metallic/polymeric feedstocks; default position = "Yes")

- AM system (multiple entries should be allowed)

- Technical data rights ("Yes/No," where "Yes" allows selection of a part only when the government has data rights and "No" allows selection of any part regardless of whether or not the government has data rights; default position = "Yes")

- TDP availability ("Yes/No," where "Yes" allows selection of a part only when a TDP is available and "No" allows selection of any part regardless of whether or not a TDP is available; default position = "Yes").

The user-selectable filters should be constructed to enable employment of one or multiple filters, as chosen by the user, to satisfy the user's specific query requirements. The input page should display the specific choices of the user for each filter; for filters the user chooses not to use, the display should remain blank.

All input filters, except NIIN, should include a drop-down box containing all possible entries that can be selected by the user; clicking on a possible entry automatically places it in the filter. For filters where the possible choices exceed those that can be shown on-screen in a drop-down box (FSC, WSDC, System Name, DLA Cost Center, Material, and AM System) a search capability should be available to assist the user to quickly locate appropriate entries.

The user interface should include a means to initiate query execution via a single mouse click, after the user has adjusted the filters to meet his or her requirements. The user interface should contain a means to clear all filters via a single mouse click. Also, the user interface should include a means to return to the main input screen from any other screen via a single mouse click.

The user interface should include easy access to a help/search feature that defines the overall decision support process tool, identifies how to use it, defines each filter and its component parts, and describes the form of the query summary results.

Output Data Requirements

The decision support process should give users two output synopses for each query: an on-screen summary of the query results and a more comprehensive, exportable file of the query results that can be used for offline analyses. The following paragraphs detail the output summaries.

ON-SCREEN QUERY RESULTS SUMMARY

The on-screen summary should be easily viewable by the user and list each filter applied for the query, including the specific filter constraints, and a total count of the number of parts identified as meeting the query requirements. For each part that meets the query constraints, the on-screen summary should include at least the following information:

- FSC
- NIIN
- Item nomenclature
- Material (part material)
- Maximum dimension (identified in inches as “maximum height” plus the actual value, or “maximum width” plus the actual value, or “maximum length” plus the actual value, or “maximum diameter” plus the actual value)
- PLT (days)
- Unit price
- Criticality code (plus definition)
- Weapon system count (count of the number of weapon systems that use the part, calculated from the total number of WSDCs assigned to the part)
- TDP availability (Yes/No)
- Potential AM candidate (Yes/No, where “Yes” means the part material *exactly matches* a common AM material in Appendix A *and* at least one piece of dimensional data is listed for the part)
- AM systems (list of AM systems with feedstock that *exactly matches* the part material *and* for which the build-envelope is large enough to accommodate the part dimensions).

In situations where a query returns more part results than can reasonably be shown on-screen at one time, the system should provide the capability to either page or scroll through the results.

EXPORTABLE QUERY RESULTS SUMMARY

The exportable query results summary should be made available to the user as an Excel file that can be downloaded using a single mouse click, at the user’s option.

The Excel file should contain a list of each filter applied for the query, including the specific filter constraints, a total count of the number of parts identified as meeting the query requirements, the date and time the query was executed, and the definition of specific codes associated with individual data elements included in the file (such as criticality code: a definition should be included for all of the codes that might appear under this data element—C, E, F, H, M, N, S, X, or Y).

For each part identified as meeting the query constraints, the Excel file should include at least the following data elements:

- FSC
- NIIN
- Item nomenclature
- Material (part material)
- Dimensions
  - Height
  - Width
  - Length
  - Diameter
- PLT (days)
- ALT (days)
- Unit price
- Date of last purchase
- Criticality code
- INC
- AMC
- AMSC
- AAC
- DLA supply chain
- DLA profit center

- WSDC
- Weapon system count
- Weapon system names
- TDP availability (Yes/No)
- TDP type (2D or 3D)
- TDP location, such as JEDMICS or the DLA Document Management System (DMS)
- Cognizant engineering support activity (ESA)
- ESA point of contact
  - Phone number
  - E-mail address
- Annual demand quantity
- Backorder status
  - Total number of units on backorder
  - Date of oldest backorder
  - Date of newest backorder
- Potential AM candidate (Yes/No)
- AM systems (a list of AM systems using feedstock that exactly matches the part material and for which the build-envelope is large enough to accommodate the part dimensions)
  - System name
  - System manufacturer.

Chapter 5
Summary

The purpose of this R&D task was to ascertain the feasibility and, if possible, develop a decision support process for identifying the legacy DLA-managed Class IX parts that could be made using AM by collecting and assessing online data. As described in Chapter 4, developing a generic set of rules or a decision support process for categorically making such decisions is not currently possible. However, we *were* able to build, demonstrate, and successfully test an AM prescreening process that can quickly parse the millions of DLA legacy parts to manageable groups of items that are "potentially amenable to AM."

The AM prescreening decision support process can gather available online technical and logistics attribute data for each part, assesses the data using a set of filters established by a user, return a list of parts meeting the filter criteria, and identify legacy parts that are "potential AM candidates" on the basis of material composition and dimensional size. It also can make the underlying technical and logistics attribute data available to the user for further analysis. However, in the end, the "potential candidates" still require an individual engineering review to determine whether and how they can be produced using AM.

AM capability will continue to evolve and, it will affect DLA operations. DLA needs to determine its enterprise strategy regarding the implementation and use of AM. If DLA chooses to pursue an AM decision support process, it needs to address some critical technical decisions, such as the following:

- Determine whether an AM decision support process should use data from Military Service databases for DLA-managed parts. If such data are to be used, identify how that information can and should be collected and define the business rules for its use.

- Determine whether an AM decision support process should include Military Service parts (those not managed by DLA). If such data are to be included, identify where DLA will obtain the logistics information for these parts that is equivalent to EBS data for DLA-managed parts. (Most technical data for non-DLA-managed parts can be obtained from the same sources as for DLA-managed parts.)

- Determine whether or not DLA/DoD should build software to perform the XSB Coherent View® tool functions (used in the R&D tool) or purchase services for those functions or output data.

- Identify how DLA should manage Military Service personnel (non-DLA personnel) access to AM decision support process software if it resides in EBS.

- Determine when DLA wants to have an AM decision support process available for use as part of its daily operations and identify the time and cost required to obtain the capability under various transition options.

- Determine whether DLA wants an AM decision support process to be integrated with or included as a subset of any other EBS analysis process or capability and identify the necessary interfaces.

- Determine the DLA activity or organization that will pay for development, implementation, integration, and maintenance of an AM decision support capability.

Appendix A
Common AM Materials

This appendix identifies the common metallic and polymeric materials, referred to as feedstock, currently used in AM systems. We identified the specific materials on the basis of commercially available AM systems and materials listed in the SENVOL database (http://senvol.com/database/) in November 2015.

Metallic AM Materials

The common metallic AM materials are as follows:

- Titanium alloys
  - Ti64
  - Ti64 ELI
  - Ti6242
  - Commercially pure Ti
- Nickle-based alloys
  - In718
  - In625
  - Waspalloy
- Aluminum alloys
  - AlSi10Mg
  - 4047
- Stainless Steel alloys
  - 17-4
  - 316
  - 15-5
  - 13-8

- 304
- 316
- 410
- 420

- Cobalt-chrome alloys
  - CoCrMo
  - Stellite 21
- Bronze alloy.

Polymeric AM Materials

The common polymeric AM materials are as follows:

- ABS
- ABS/Acrylic
- ABS/PBT
- ABS/PP (polypropylene)
- Acrylic
- ASA (acrylonitrile styrene acrylate)
- Epoxy
- Oxycetane
- PA (polyamide)
- PC (polycarbonate)
- PEEK (polyether ether ketone)
- PEI (polyetherimide)
- PMMA (polymethyl methacrylte)
- PP (polypropylene)
- PPS

- PS (polystyrene)
- Rubber
- Silicone
- TPE (thermoplastic elastomer).

Appendix B
AM Systems Included in Legacy Parts AM Prescreening R&D Tool

This appendix lists the AM systems that were included in the DLA Legacy Parts AM Prescreening R&D Tool.

MANUFACTURER: MODEL

- 3D Systems: ProJet 3510 HD-HD
- 3D Systems: ProJet 3510 HD-UHD
- 3D Systems: ProJet 3510 HDMax-HD
- 3D Systems: ProJet 3510 HDMax-HS
- 3D Systems: ProJet 3510 HDMax-UHD
- 3D Systems: ProJet 3510 HDMax-XHD
- 3D Systems: ProJet 3510 HDPlus-HD
- 3D Systems: ProJet 3510 HDPlus-UHD
- 3D Systems: ProJet 3510 HDPlus-XHD
- 3D Systems: ProJet 3510 SD-HD
- Beijing Tiertime Technology: Inspire A370
- Beijing Tiertime Technology: Inspire A450
- Beijing Tiertime Technology: Inspire D255
- Beijing Tiertime Technology: Inspire D290
- Beijing Tiertime Technology: Inspire S220
- Beijing Tiertime Technology: Inspire S250
- EnvisionTEC: Perfactory 3 DSP
- EnvisionTEC: Perfactory 3 DSP-ERM
- EnvisionTEC: Perfactory 4 DSP
- EnvisionTEC: Perfactory 4 DSP-ERM
- EnvisionTEC: Perfactory 4 DSP XL
- EnvisionTEC: Perfactory 4 DSP XL-ERM
- EnvisionTEC: Perfactory DDSP
- EnvisionTEC: Perfactory Desktop XL
- EnvisionTEC: Perfactory Micro DSP L
- EnvisionTEC: Perfactory Micro DSP M
- EnvisionTEC: Perfactory Micro DSP S
- EnvisionTEC: Perfactory Mini DDSP
- EnvisionTEC: ULTRA 3SP Ortho
- EnvisionTEC: Vector 3SP
- EnvisionTEC: Xede 3SP
- EnvisionTEC: Xtreme 3SP
- Prodways: ProMaker D35
- Prodways: ProMaker L5000
- Prodways: ProMaker L5000 D
- Prodways: ProMaker L6000
- Prodways: ProMaker L6000 D
- Prodways: ProMaker L7000
- Prodways: ProMaker L7000 D
- Prodways: ProMaker L8000
- Prodways: ProMaker V6000
- Stratasys: Dimension 1200es-BST (Breakaway Support Technology)
- Stratasys: Dimension 1200es-SST (Soluble Support Technology)
- Stratasys: Dimension Elite-SST (Soluble Support Technology)
- Stratasys: Fortus 250mc
- Stratasys: Mojo
- Stratasys: uPrint SE
- Stratasys: uPrint SE-Plus
- Unirapid: UNIRAPID III
- Stratasys: Fortus 360mc-Base
- Stratasys: Fortus 360mc-Upgrade
- Stratasys: Fortus 380mc
- Stratasys: Fortus 400mc-Base
- Stratasys: Fortus 400mc-Upgrade
- Stratasys: Fortus 450mc
- Stratasys: Fortus 900mc-Base
- 3D Systems: iPro 8000-RDM 650M
- 3D Systems: iPro 8000-RDM 750SH
- 3D Systems: iPro 8000-RDM 750H
- 3D Systems: iPro 8000-RDM 750F
- 3D Systems: ProJet 6000 HD-HD
- 3D Systems: ProJet 6000 HD-UHD
- 3D Systems: ProJet 6000 HD-XHD
- 3D Systems: ProJet 6000 MP-HD
- 3D Systems: ProJet 6000 MP-UHD
- 3D Systems: ProJet 6000 MP-XHD
- 3D Systems: ProJet 6000 SD-HD
- 3D Systems: ProJet 6000 SD-UHD
- 3D Systems: ProJet 7000 HD-HD
- 3D Systems: ProJet 7000 HD-UHD
- 3D Systems: ProJet 7000 HD-XHD
- 3D Systems: ProJet 7000 MP-HD
- 3D Systems: ProJet 7000 MP-UHD
- 3D Systems: ProJet 7000 MP-XHD
- 3D Systems: ProJet 7000 SD-HD
- 3D Systems: ProJet 7000 SD-UHD
- 3D Systems: ProX 800-Full
- 3D Systems: ProX 800-Half
- 3D Systems: ProX 800-Short
- 3D Systems: ProX 950-RDM 950
- Stratasys: Objet1000-Digital Material (DM)
- Stratasys: Objet1000-High Speed (HS)
- Stratasys: Objet1000-High Quality (HQ)
- Stratasys: Objet1000 Plus-Digital material
- Stratasys: Objet1000 Plus-High quality
- Stratasys: Objet1000 Plus-High speed
- Stratasys: Objet260 Connex
- Stratasys: Objet260 Connex1-Digital material
- Stratasys: Objet260 Connex1-High quality
- Stratasys: Objet260 Connex1-High speed
- Stratasys: Objet260 Connex2-Digital material
- Stratasys: Objet260 Connex2-High quality
- Stratasys: Objet260 Connex2-High speed
- Stratasys: Objet260 Connex3-Digital material
- Stratasys: Objet260 Connex3-High quality
- Stratasys: Objet260 Connex3-High speed

- Stratasys: Objet260 Dental Selection
- Stratasys: Objet30-High speed
- Stratasys: Objet30 Prime
- Stratasys: Objet350 Connex-Digital Material (DM)
- Stratasys: Objet350 Connex-High Speed (HS)
- Stratasys: Objet350 Connex-High Quality (HQ)
- Stratasys: Objet350 Connex1-Digital material
- Stratasys: Objet350 Connex1-High quality
- Stratasys: Objet350 Connex1-High speed
- Stratasys: Objet350 Connex2-Digital material
- Stratasys: Objet350 Connex2-High quality
- Stratasys: Objet350 Connex2-High speed
- Stratasys: Objet350 Connex3-Digital material
- Stratasys: Objet350 Connex3-High quality
- Stratasys: Objet350 Connex3-High speed
- Stratasys: Objet500 Connex-Digital Material (DM)
- Stratasys: Objet500 Connex-High Speed (HS)
- Stratasys: Objet500 Connex-High Quality (HQ)
- Stratasys: Objet500 Connex1-Digital material
- Stratasys: Objet500 Connex1-High quality
- Stratasys: Objet500 Connex1-High speed
- Stratasys: Objet500 Connex2-Digital material
- Stratasys: Objet500 Connex2-High quality
- Stratasys: Objet500 Connex2-High speed
- Stratasys: Objet500 Connex3-Digital material
- Stratasys: Objet500 Connex3-High quality
- Stratasys: Objet500 Connex3-High speed
- EnvisionTEC: 3Dent
- EnvisionTEC: Perfactory 3 DDP-ERM, Lens f = 2.36” (60mm)
- EnvisionTEC: Perfactory 3 DDP-ERM, Lens f = 2.36” (60mm), Increased Productivity
- EnvisionTEC: Perfactory Micro Ortho
- EnvisionTEC: Perfactory Micro XL
- EnvisionTEC: Perfactory Micro EDU
- Mutoh: MR-5000
- Helix 3D: Helix
- 3D Systems: Projet 5500X-HD
- 3D Systems: Projet 5500X-UHD
- 3D Systems: ProJet MJP 3600-HD
- 3D Systems: ProJet MJP 3600-UHD
- 3D Systems: ProJet MJP 3600-XHD
- 3D Systems: ProJet MJP 3600 Max-HD
- 3D Systems: ProJet MJP 3600 Max-UHD
- 3D Systems: ProJet MJP 3600 Max-XHD
- Xery: Vision
- EnvisionTEC: ULTRA 3SP
- EnvisionTEC: ULTRA 3SP High Definition
- Structo: OmniForm
- Structo: OrthoForm
- Structo: RapidForm
- EnvisionTEC: Perfactory 4 Standard
- EnvisionTEC: Perfactory 4 Standard-ERM
- EnvisionTEC: Perfactory 3 Mini Multi Lens with ERM-Lens f=2.36” (60mm)
- EnvisionTEC: Perfactory 3 Mini Multi Lens with ERM-Lens f=2.95” (75mm)
- EnvisionTEC: Perfactory 3 Mini Multi Lens with ERM-Lens f=3.35” (85mm)
- EnvisionTEC: Perfactory 4 Mini-ERM, Lens f = 2.36” (60mm)
- EnvisionTEC: Perfactory 4 Mini-ERM, Lens f = 2.95” (75mm)
- EnvisionTEC: Perfactory 4 Mini XL-ERM, Lens f = 2.36” (60mm)
- EnvisionTEC: Perfactory 4 Mini XL-ERM, Lens f = 2.95” (75mm)
- EnvisionTEC: Perfactory 4 Standard XL
- EnvisionTEC: Perfactory 4 Standard XL-ERM
- EnvisionTEC: Perfactory Micro Advantage
- EnvisionTEC: Perfactory Micro HiRes
- EnvisionTEC: Perfactory Micro Plus Advantage
- EnvisionTEC: Perfactory Micro Plus Hi-Res
- EnvisionTEC: Xede 3SP Ortho
- EnvisionTEC: Xtreme 3SP Ortho
- 3D Systems: sPro 140-HS
- 3D Systems: sPro 140-Base
- 3D Systems: sPro 230-HS
- 3D Systems: sPro 230-Base
- 3D Systems: sPro 60-SD
- 3D Systems: sPro 60-HD Base
- 3D Systems: sPro 60-HD-HS
- Asiga: Freeform Pico
- Asiga: Freeform Pico-Plus 39
- Asiga: Freeform Pico-Plus 33
- Asiga: Freeform Pico-Plus 27
- Asiga: Freeform PRO-50
- Asiga: Freeform PRO-75
- Asiga: Pico 2-39
- Asiga: Pico 2-50
- 3D Systems: ProJet 3510 DP-HD
- 3D Systems: ProJet 3510 DP-UHD
- 3D Systems: ProJet 3510 DPPro-UHD
- 3D Systems: ProJet 3510 DPPro-HDX
- 3D Systems: ProJet 3510 DPPro-HDP
- 3D Systems: ProJet 3510 MP-HDX
- 3D Systems: ProJet 3510 MP-HDP
- 3D Systems: ProJet MJP 3600 Dental-UHD
- 3D Systems: ProJet MJP 3600 Dental-HDX
- 3D Systems: ProJet MJP 3600 Dental-HDP
- Stratasys: Objet24
- Stratasys: Objet30 Pro
- Stratasys: Objet Eden250-High Quality (HQ)
- Stratasys: Objet Eden250-High Speed (HS)
- Stratasys: Objet Eden260V-High Quality (HQ)
- Stratasys: Objet Eden260V-High Speed (HS)
- Stratasys: Objet Eden260VS Dental Advantage
- Stratasys: Objet Eden350V
- Stratasys: Objet Eden500V-High Quality (HQ)
- Stratasys: Objet Eden500V-High Speed (HS)
- Wuhan Huake 3D: HK C250-General type
- Wuhan Huake 3D: HK C250-High precision type
- Concept Laser: M2 cusing
- Concept Laser: M2 cusing
- Concept Laser: M2 cusing Multilaser
- Concept Laser: M2 cusing Multilaser
- EOS: EOS M 290
- EOS: EOSINT M 280
- EOS: EOSINT M 280
- Renishaw: AM 250
- Renishaw: AM 250
- Renishaw: AM 400
- Renishaw: RenAM 500M
- Fabrisonic: SonicLayer 4000
- Fabrisonic: SonicLayer 7200
- Fabrisonic: SonicLayer R200
- Concept Laser: X line 1000R
- Concept Laser: X line 2000R
- Sisma: MY SINT PM-100mm Diameter
- Sisma: MY SINT PM-85mm Diameter
- Sisma: MY SINT PM-63.5mm Diameter

- Sisma: MY SINT PM-50mm Diameter
- Sisma: MY SINT PM-34.5mm Diameter
- Concept Laser: Mlab cusing R
- Sisma: MYSINT 100
- Concept Laser: M1 cusing
- Concept Laser: M3 linear
- Concept Laser: M3 linear
- EOS: EOSINT M 270
- EOS: EOSINT M 270-Standard
- EOS: EOSINT M 270-Dual Mode
- EOS: EOSINT M 270-Xtended
- 3D Systems: ProX 100
- 3D Systems: ProX 100-Dental
- 3D Systems: ProX 200
- 3D Systems: ProX 200-Dental
- 3D Systems: ProX 300
- Concept Laser: Mlab cusing
- Concept Laser: Mlab cusing
- EOS: EOS M 100
- D-MEC: SCS-6000
- D-MEC: SCS-8100
- D-MEC: SCS-8100-D
- D-MEC: SCS-9000
- D-MEC: SCS-1000HD
- CMET: ATOMm-4000
- CMET: ATOMm-8000
- CMET: EQ-1
- CMET: RM-3000
- CMET: RM-6000 II
- EOS: Precious M 080
- 3D Systems: ProJet 160-Monochrome
- 3D Systems: ProJet 260C-Basic CMY
- 3D Systems: ProJet 360-Monochrome
- 3D Systems: ProJet 460Plus-Full CMY
- 3D Systems: ProJet 660Pro-Full CMYK
- 3D Systems: ProJet 860Pro-Full CMYK
- addwii: X1 Full Color 3D Printer
- EnvisionTEC: Perfactory 4 DDP4-ERM
- EnvisionTEC: Perfactory 4 DDP4 M-ERM
- EnvisionTEC: Perfactory 4 DDP4 XL-ERM
- EnvisionTEC: Perfactory DDDP
- EnvisionTEC: Perfactory PixCera
- EnvisionTEC: Perfactory Vida
- EnvisionTEC: Perfactory Vida Hi-Res
- Xery: T10
- 3D Systems: ProX 500-Standard
- EOS: FORMIGA P 100 Dental
- Sinterit: Sinterit Lisa
- Sintratec: Sintratec Kit
- MarkForged: Mark One-Standard
- MarkForged: Mark One-Professional
- MarkForged: Mark Two
- EOS: EOSINT P 380
- EOS: EOSINT P 380i
- EOS: EOSINT P 385
- EOS: EOSINT P 390
- EOS: EOSINT P 395-Basic
- EOS: EOSINT P 395-Surface
- Prodways: ProMaker P2000 HT
- Prodways: ProMaker P2000 SD
- Prodways: ProMaker P4000 HS
- Prodways: ProMaker P4000 SD
- Prodways: ProMaker P4000 X
- EOS: EOSINT P 350
- Hunan Farsoon: FARSOON 251
- Hunan Farsoon: FARSOON 251-HT
- Hunan Farsoon: FARSOON 401
- Hunan Farsoon: FARSOON 402-SS
- Hunan Farsoon: FARSOON 402
- Hunan Farsoon: FARSOON 402-HS
- Aspect: RaFaEl 150
- Aspect: RaFaEl 300
- Aspect: RaFaEl 550
- 3D Systems: ProX 500 Plus
- EOS: EOSINT P 360
- EOS: EOSINT P 700
- EOS: EOSINT P 730
- EOS: EOSINT P 760-Basic
- EOS: EOSINT P 760-Surface
- EOS: FORMIGA P 100 (Rel 2)
- EOS: FORMIGA P 110
- Wuhan Huake 3D: HK P500
- RICOH: RICOH AM S5500P
- MCor Technologies: IRIS
- MCor Technologies: Matrix 300+
- MCor Technologies: MCor Arke
- EOS: EOSINT P 800
- EOS: EOSINT P 800-Standard
- INDMATEC: PEEK PRINTER
- 3DP Platform: 3DP Workbench
- 3DP Platform: 3DP1000
- be3D: DeeRed
- BigRep: BigRep ONE.2
- voxeljet: VX1000-Standard
- voxeljet: VX1000-HP
- voxeljet: VX200-Standard
- voxeljet: VX2000-Standard
- voxeljet: VX2000-HP
- voxeljet: VX4000-HP
- voxeljet: VX500-Standard
- voxeljet: VXC800-Standard
- Kevvox: SP4300
- Kevvox: SP6200
- Wuhan Binhu: HRPS-V
- Wuhan Binhu: HRPS-VI
- Wuhan Binhu: HRPS-VII
- Wuhan Binhu: HRPS-VIII
- Wuhan Binhu: HRPS-II
- Wuhan Binhu: HRPS-IV
- 3Geometry: DSM 1200
- 3Geometry: DSM 1200 HI
- 3Geometry: DSM 350
- 3Geometry: DSM 350 HI
- 3Geometry: DSM 500
- 3Geometry: DSM 500 HI
- 3Geometry: DSM 800
- 3Geometry: DSM 800 HI
- EOS: EOSINT S 750
- Beijing Longyuan: AFS360
- Beijing Longyuan: AFS500
- Beijing Longyuan: AFS5100
- Beijing Longyuan: AFS5300
- Beijing Longyuan: AFS7000
- Wuhan Huake 3D: HK S1000
- Wuhan Huake 3D: HK S1200
- Wuhan Huake 3D: HK S1400-Dual laser
- Wuhan Huake 3D: HK S1400-Four laser
- Wuhan Huake 3D: HK S500
- ExOne: Exerial
- ExOne: S-Max Furan
- ExOne: S-Print Furan
- ExOne: S-Print Phenol

- ExOne: S-Print Silicate
- ExOne: M-Print
- ExOne: X1-Lab
- TRUMPF: TruPrint 1000
- ExOne: Innovent
- ExOne: M-Flex
- 3D Systems: ProX 400
- 3D Systems: ProX 400
- Wuhan Huake 3D: HK M100
- Wuhan Huake 3D: HK M250
- InssTek: MX-3-3 Axis Motion Model, SDM 500
- InssTek: MX-3-3 Axis Motion Model, SDM 800
- InssTek: MX-3-3 Axis Motion Model, SDM 1200
- InssTek: MX-3-5 Axis Motion Model, SDM 500
- InssTek: MX-3-5 Axis Motion Model, SDM 800
- InssTek: MX-3-5 Axis Motion Model, SDM 1200
- InssTek: MX-4-3 Axis Motion Model, SDM 500
- InssTek: MX-4-3 Axis Motion Model, SDM 800
- InssTek: MX-4-3 Axis Motion Model, SDM 1200
- InssTek: MX-4-5 Axis Motion Model, SDM 500
- InssTek: MX-4-5 Axis Motion Model, SDM 800
- InssTek: MX-4-5 Axis Motion Model, SDM 1200
- Mutoh: MA5000-S1
- Realizer: SLM 100
- Realizer: SLM 125
- Realizer: SLM 250
- Realizer: SLM 250
- Realizer: SLM300
- Realizer: SLM300
- Realizer: SLM300
- Realizer: SLM300
- Realizer: SLM 50
- Guangdong Syndaya 3D Technology: DiMetal-100
- Guangdong Syndaya 3D Technology: DiMetal-280
- Guangdong Syndaya 3D Technology: DiMetal-280
- Guangdong Syndaya 3D Technology: DiMetal-400
- Guangdong Syndaya 3D Technology: DiMetal-400
- Guangdong Syndaya 3D Technology: DiMetal-50
- Guangdong Syndaya 3D Technology: DiMetal-50
- SLM Solutions: SLM 125 HL
- SLM Solutions: SLM 125 HL-Extension Z-axis
- SLM Solutions: SLM 125 HL
- SLM Solutions: SLM 125 HL-Extension Z-axis
- SLM Solutions: SLM 125 HL (2015 Release)
- SLM Solutions: SLM 125 HL (2015 Release)-Extension Z-axis
- SLM Solutions: SLM 280 HL
- SLM Solutions: SLM 280 HL
- SLM Solutions: SLM 280 HL (2015 Release)
- SLM Solutions: SLM 280 HL (2015 Release)-Dual lasers
- SLM Solutions: SLM 280 HL (2015 Release)
- Wuhan Binhu: HRPM-II
- Wuhan Binhu: HRPM-II
- InssTek: MPC-5 Axis Motion Model, SDM 800
- Arcam: Arcam A2-Build tank volume 1
- Arcam: Arcam A2-Build tank volume 2
- Arcam: Arcam A2XX
- Arcam: Arcam Q10
- Arcam: Arcam Q20
- Arcam: Arcam A2X
- 3D Systems: ProX 320
- Sciaky: EBAM 110
- Sciaky: EBAM 150
- Sciaky: EBAM 300
- Sciaky: EBAM 68
- Sciaky: EBAM 88
- Xi'an Bright Laser Technologies: BLT-C1000 (LSF-Series)
- Xi'an Bright Laser Technologies: BLT-C1000 (LSF-Series)
- Xi'an Bright Laser Technologies: BLT-C600 (LSF-Series)
- Xi'an Bright Laser Technologies: BLT-C600 (LSF-Series)
- Xi'an Bright Laser Technologies: BLT-S300 (SLM-Series)
- 3D Systems: ProJet 3510 CP-HD
- 3D Systems: ProJet 3510 CP-HDHiQ
- 3D Systems: ProJet 3510 CPX-HD
- 3D Systems: ProJet 3510 CPX-HDHiQ
- 3D Systems: ProJet 3510 CPX-XHD
- 3D Systems: ProJet 3510 CPXMax-HD
- 3D Systems: ProJet 3510 CPXMax-HDHiQ
- 3D Systems: ProJet 3510 CPXMax-UHD
- 3D Systems: ProJet 3510 CPXMax-XHD
- 3D Systems: ProJet 3510 CPXPlus-HD
- 3D Systems: ProJet 3510 CPXPlus-HDHiQ
- 3D Systems: ProJet 3510 CPXPlus-UHD
- 3D Systems: ProJet 3510 CPXPlus-XHD
- DWS Systems: DigitalWax 008J
- DWS Systems: DigitalWax 009D
- DWS Systems: DigitalWax 009J
- DWS Systems: DigitalWax 020D
- DWS Systems: DigitalWax 020X
- DWS Systems: DigitalWax 028D
- DWS Systems: DigitalWax 028J
- DWS Systems: DigitalWax 028J Plus
- DWS Systems: DigitalWax 029D
- DWS Systems: DigitalWax 029J
- DWS Systems: DigitalWax 029J Plus
- DWS Systems: DigitalWax 029X
- DWS Systems: DigitalWax 030D HR
- DWS Systems: DigitalWax 030D SR
- DWS Systems: DigitalWax 030J
- DWS Systems: DigitalWax 030X
- EnvisionTEC: Perfactory Apollo
- EnvisionTEC: Perfactory Aureus
- EnvisionTEC: Perfactory WaxEra
- Solidscape (A Stratasys Company): 3Z Lab
- Solidscape (A Stratasys Company): 3Z Pro
- Solidscape (A Stratasys Company): 3Z Studio
- Solidscape (A Stratasys Company): Max2
- Stratasys: CrownWorx
- Stratasys: FrameWorx
- Lithoz: CeraFab 7500
- 3D Systems: Phenix PXL
- 3D Systems: Phenix PXM
- 3D Systems: Phenix PXS
- 3D Systems: ProJet 1200-Standard
- 3D Systems: ProJet 4500-Standard
- 3DCeram: Ceramaker
- Additive Industries: MetalFAB1
- BeAM: CLAD Unit
- BeAM: MAGIC
- BeAM: Mobile CLAD
- Beijing Longyuan: SLM-250
- Blueprinter: Blueprinter M3
- Carima: DP 110
- Carima: DP 845
- Carima: Master EV
- Cincinnati Incorporated: BAAM 100 ALPHA - Size 1

- Cincinnati Incorporated: BAAM 100 ALPHA - Size 2
- Cosine: AM1
- D-MEC: ACCULAS
- EnvisionTEC: Perfactory Micro DDP
- EnvisionTEC: Perfactory Micro DGP
- EOS: EOS M 400
- EOS: EOS P 396
- EOS: FORMIGA P 100
- Hunan Farsoon: FS271M Series
- Keyence: Agilista-3100
- MASSIVit3D: MASSIVit 1800
- Optomec: LENS 450
- Optomec: LENS 850-R
- Optomec: LENS 850-R
- Optomec: LENS 850-R
- Optomec: LENS 850-R
- Optomec: LENS MR-7
- Optomec: LENS MR-7
- Optomec: LENS MR-7
- PrismLab: Rapid200
- PrismLab: Rapid400
- PrismLab: Rapid600
- Prodways: ProMaker V4000
- Rapid Shape: D30
- Rapid Shape: D40
- Rapid Shape: HA30
- Rapid Shape: HA60 UV
- Rapid Shape: HA90
- Rapid Shape: S30
- Rapid Shape: S30 L
- Rapid Shape: S50 maxi
- Rapid Shape: S50 midi
- Rapid Shape: S50 mini
- Rapid Shape: S60 maxi
- Rapid Shape: S60 midi
- Rapid Shape: S60 mini
- Rapid Shape: S90
- Rapid Shape: S90 L
- Roland: ARM-10
- Shaanxi Hengtong: Digital Light Processing
- Shaanxi Hengtong: SCPS350B
- Shaanxi Hengtong: SPS250E
- Shaanxi Hengtong: SPS250J
- Shaanxi Hengtong: SPS250M
- Shaanxi Hengtong: SPS350B
- Shaanxi Hengtong: SPS450B
- Shaanxi Hengtong: SPS600B
- Shanghai Union Technology: DLP DeX50
- Shanghai Union Technology: DLP DeX60
- Shanghai Union Technology: Lite300
- Shanghai Union Technology: Lite300
- Shanghai Union Technology: RS3500
- Shanghai Union Technology: RS4500
- Shanghai Union Technology: RS6000
- Shanghai Union Technology: RS8000
- Shining 3D: iSLA-450
- Shining 3D: iSLA-650
- SLM Solutions: SLM 500 HL
- SLM Solutions: SLM 500 HL
- SLM Solutions: SLM 500 HL (2015 Release)-Dual lasers
- SLM Solutions: SLM 500 HL (2015 Release)-Quad Lasers
- SLM Solutions: SLM 500 HL (2015 Release)-Quad Lasers
- Stratasys: Objet Eden260V Dental Advantage
- Stratasys: Objet30 OrthoDesk
- Trump Precision Machinery: ELITE 3000
- Trump Precision Machinery: ELITE 3500
- Trump Precision Machinery: ELITE 3600-HD
- Trump Precision Machinery: ELITE 3600
- Trump Precision Machinery: ELITE 5000
- Trump Precision Machinery: ELITE P5500
- Wuhan Binhu: HRPL-II
- Wuhan Binhu: HRPL-III
- Wuhan Huake 3D: HK L350
- Wuhan Huake 3D: HK L600
- Xery: Victory
- Zhuhai CTC Electronic: Riverbase 500
- 3D Systems: ProJet MJP 2500-HD - High Definition
- 3D Systems: ProJet MJP 2500 Plus-HD - High Definition
- 3D Systems: ProJet MJP 3600W-HD
- 3D Systems: ProJet MJP 3600W-UHD
- 3D Systems: ProJet MJP 3600W-XHD
- 3D Systems: ProJet MJP 3600W Max-HD
- 3D Systems: ProJet MJP 3600W Max-UHD
- 3D Systems: ProJet MJP 3600W Max-XHD
- Carbon: Carbon M1-Type B Cassette
- Shaanxi Hengtong: SLS 1200
- Stratasys: J750-High Speed
- Stratasys: J750-High Quality
- Stratasys: J750-High Mix
- Zhuhai CTC Electronic: Walnut 26
- ZRapid Tech: SLA200
- ZRapid Tech: SLA300
- ZRapid Tech: SLA450
- ZRapid Tech: SLA500
- ZRapid Tech: SLA660
- ZRapid Tech: SLM150
- ZRapid Tech: SLM300
- ZRapid Tech: SLM500
- ZRapid Tech: SLM500
- ZRapid Tech: SLS400

Appendix C
Military Service and DLA Supply Chain Points of Contact

Table C-1 lists the principle POCs for each of the Military Service activities and DLA supply chains that participated in this R&D project.

Table C-1. POC List

Name	Military Service/ activity	Phone number	E-mail address
Dr. Jonathan Miller	Air Force/AFRL	937-255-5460	jonathan.miller.22@us.af.mil
Dr. Mary Kinsella	Air Force/AFRL		mary.kinsella@us.af.mil
Mr. Thomas Naguy	Air Force/AFMC		thomas.naguy.1@us.af.mil
Mr. William Veney	Army/CASCOM	804-734-0598	william.t.veney.civ@mail.mil
Mr. Scot Seitz	Army/G4	717-770-4304	scot.s.seitz.civ@mail.mil
Mr. Stephen Luckowski	Army/RDECOM	973-724-3100	stephen.l.luckowski.civ@mail.mil
Maj. Eric Kirchner	Marine Corps/I&L	571-256-7105	eric.kirchner@usmc.mil
Capt. Christopher Wood	Marine Corps/I&L	571-256-2740	christopher.j.wood@usmc.mil
Ms. Yolanda Ward	Marine Corps/I&L	703-432-3099	yolanda.ward@usmc.mil
Maj. Brad Goldvarg	Marine Corps/WL	703-432-1155	brad.goldvarg@usmc.mil
Mr. William Frazier	Navy/NAVAIR		william.d.frazier2@navy.mil
Ms. Elizabeth McMichael	Navy/NAVAIR	301-342-6799	elizabeth.mcmichael@navy.mil
Mr. Glenn Gardner	Navy/NAVSEA		glenn.gardner@navy.mil
Mr. Benjamin Bouffard	Navy/NAVSEA		benjamin.bouffard@navy.mil
Mr. Justin Rettaliata	Navy/NAVSEA 05	202-781-5312	justin.rettaliata@navy.mil
Ms. Natalie Trycieckyj	DLA/TS	215-737-7000	natalie.trycieckyj@dla.mil
Mr. Richard Risbon	DLA/L&M	614-692-1291	Richard.Risbon@dla.mil
Mr. Kyle Hedrick	DLA/AVTN	804-279-4677	kyle.hedrick@dla.mil
Mr. Stephen Rodock	DLA/J344	703-767-5059	stephen.rodock@dla.mil
Mr. Dean Hutchins	DLA/J34 R&D	804-279-5033	dean.hutchins@dla.mil
Mr. Tony Monteleone	DLA/J34 R&D	804-279-5113	Anthony.Monteleone@dla.mil
Mr. Tony Delgado	DLA/J34 R&D	703-767-3669	Luis.Delgado@dla.mil

Note: AFRL = Air Force Research Laboratory, AFMC = Air Force Materiel Command, CASCOM = Combined Arms Support Command, REDCOM = Research, Development and Engineering Command, NAVAIR = Naval Air Systems Command, and NAVSEA = Naval Sea Systems Command.

Appendix D
DLA Legacy Parts AM Prescreening R&D Tool User Guide

This appendix contains a copy of the DLA *Legacy Parts AM Prescreening R&D Tool User Guide*.

Defense Logistics Agency

Legacy Parts Additive Manufacturing
Prescreening Decision Process
Research and Development Tool

USER GUIDE

1. Purpose: to provide the DLA-AM Service Partners with the information needed to access and navigate the XSB-Web based AM decision R&D prototype tool and in return, provide the opportunity for feedback and recommendations.

2. Scope: the development of the Additive Manufacturing (AM) Prescreening Decision Process Research and Development (R&D) Tool is in response to a DLA requirement for Military Services who are actively pursuing additive manufacturing (AM) capabilities, but don't have a process too quickly and consistently determine if a part is a good candidate for AM.

   DLAs requirement for the R&D task, was to develop the business process (technical attributes and business rules) to identify AM-compatible parts only looking at DLA managed Class IX repair parts, defined Business/Logistics, and Part attribute data. Please note the AM candidates can be influenced by the availability of 3D technical data, filter options, and the expansion of search attributes.

   This AM R&D Tool should be viewed as the initial phase of the AM candidate identification process and a Segway into future AM Tool expansion opportunities.

3. Outcomes: the AM prescreening decision process R&D prototype tool will help Services and DLA develop processes to use AM by identifying DLA parts that are candidates for Service AM demonstrations, develop business process to identify AM-compatible parts, test the AM business process within Service-led AM projects, and build a roadmap for deploying AM business processes to Service units utilizing AM technology.

4. AM Prescreening Decision Process R&D Prototype Tool:

   - Login procedures and request for assistance:
     - Go to the following web address: http://am.xsb.com/am
     - Enter user name-provided by XSB
     - Enter Password-provided by XSB
     - Contact Mr. Bob Pokorny for assistance at email: Pokorny@xsb.com, Phone: (631) 371-8115 and Fax: (631) 382-8228

   - Operating design assumptions and source data bases:
     - Defined business/logistics attributes.
     - Defined part attributes data.
     - DLA managed Supply Class IX repair parts only.
     - Some dimensional data must be available.
     - Exact match to common AM material required; no material substitution allowed/considered.
     - Parts universe for AM candidate's selection started at 4.5 M and reduced to 43K as a result of applied attributes to this specific requirement. This R&D AM Tool filters on a pool of 43K AM candidate parts. Note the application of different attributes, expanded availability of 3D technical

data, and filter selection can produce expanded results for the AM candidate pool.
    - Data bases: data for AM systems: SENVOL. Data for part attributes: Federal Logistics Information Service Program (FLIS) and Enterprise Business System (EBS).

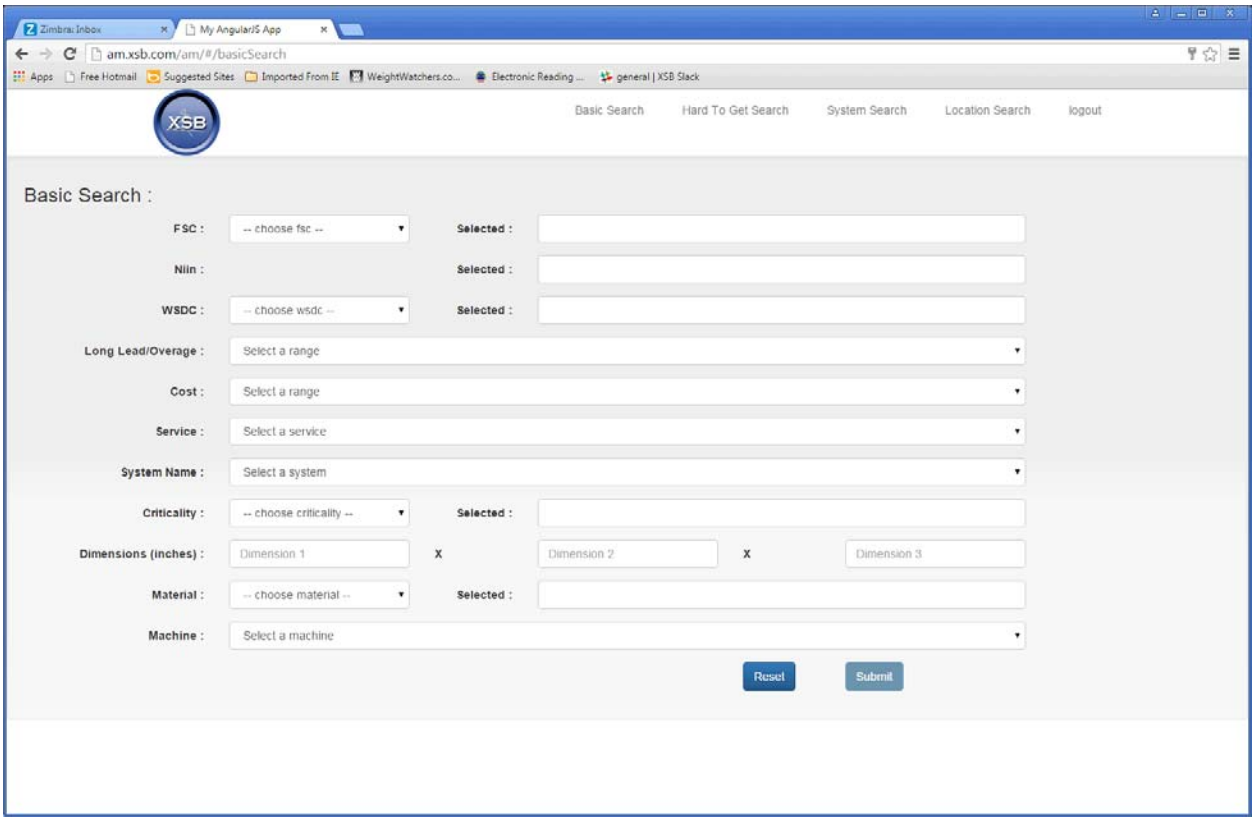
- Query rules/conventions:
    - AM R&D Web based Tool is available 24/7 for a period ending July 31, 2016.
    - Four search screen options and a search results screen are available.
    - Submit and Reset buttons are built in.
    - Search features (selection fields) include drop down button options.
    - Can select multiple items in a single search.
    - Search results range: 1 to a 1,000 maximum responses.
    - Data from search results can be exported to an excel spreadsheet.

- Search Screens and selection field features:
    - "**Basic Search"**

        - Criteria: performing a basic search?
        - FSC: Federal Supply Class-choose FSC
        - NIIN: Type in comma separated list of NIINs
        - WSDC: Weapon System Designator Code-choose WSDC
        - Long Lead/Overage: select a range
        - Cost: select a range
        - Service: select a Service
        - System Name: select a system
        - Criticality: choose critically
        - Dimension (inches): insert dimensions 1, 2, and 3. Note-The logic is designed to expect longest to shortest in that order. So if you have a machine that is 20" long by 15" wide by 25" high you should put in 25 first, 20 second and 15 third.

- Material: choose material
- Machine: select a machine
- Note: selections from a drop down box will appear in the Selected field box

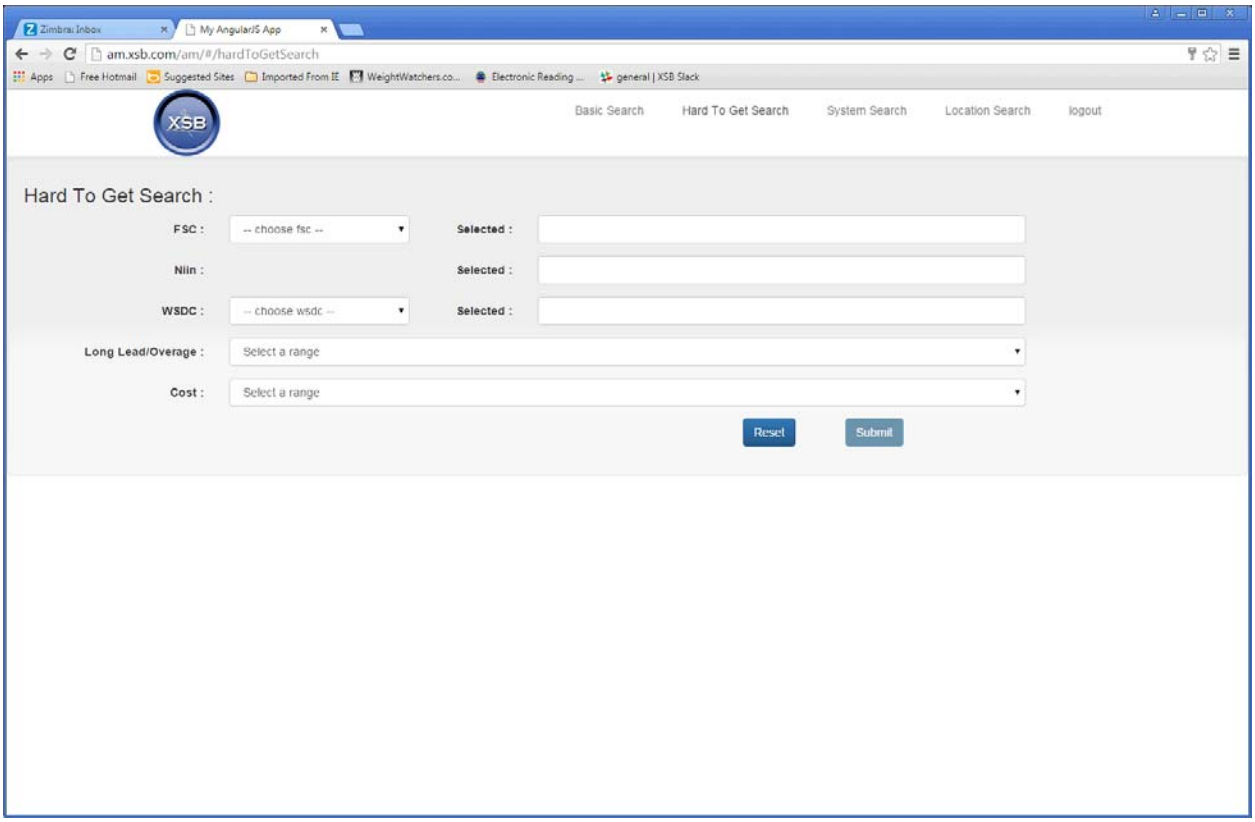
Basic Search Screen



o **Hard to Get Search"**

- Criteria: searching for an item?
- FSC: Federal Supply Class-choose FSC
- NIIN: Type in comma separated list of NIINs
- WSDC: Weapon System Designator Code-choose WSDC
- Long Lead/Overage: select a range
- Cost: select a range
- Note: selections from a drop down box will appear in the Selected field box

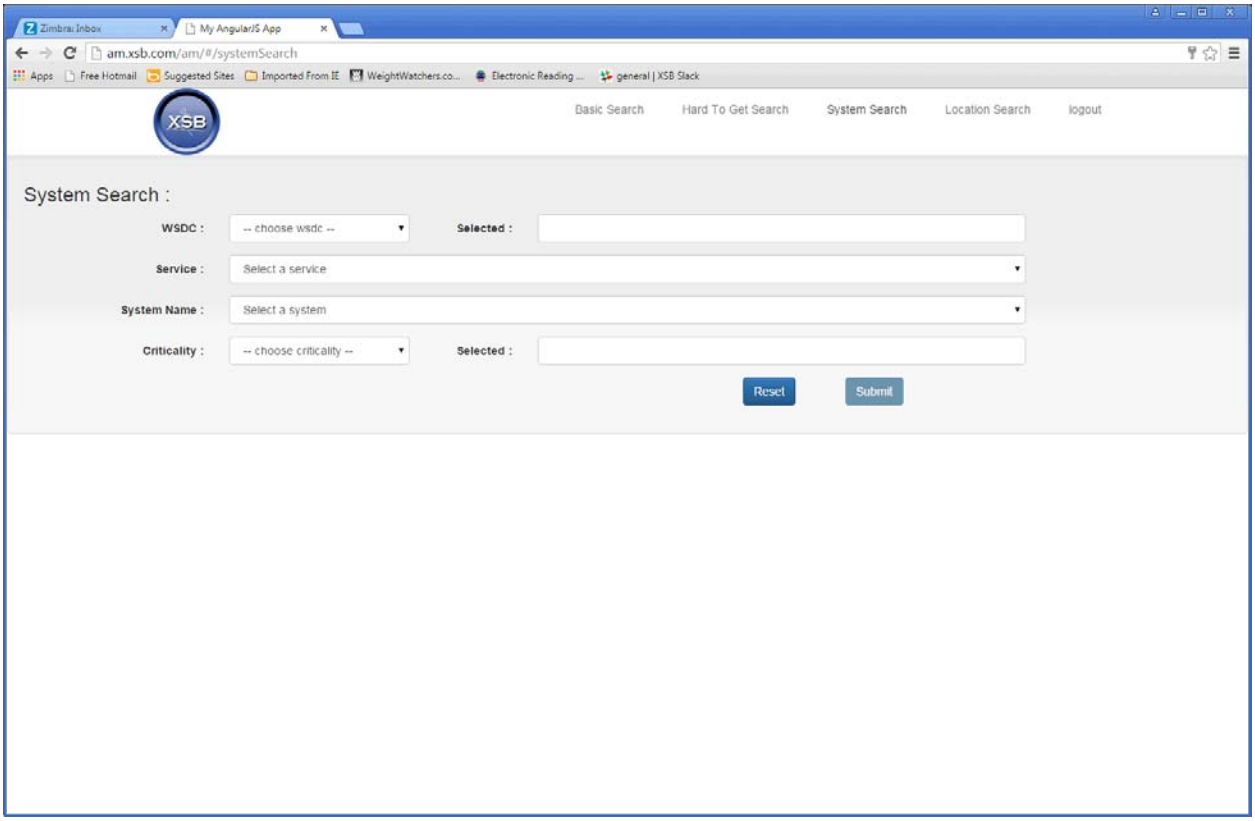
Hard to Get Search Screen



o **Weapon System Search”**

- Criteria: search for parts on a particular weapon system?
- WSDC: Weapon System Designator Code-choose WSDC
- Service: select a Service
- System Name: select a system
- Criticality: choose critically
- Note: selections from a drop down box will appear in the Selected field box

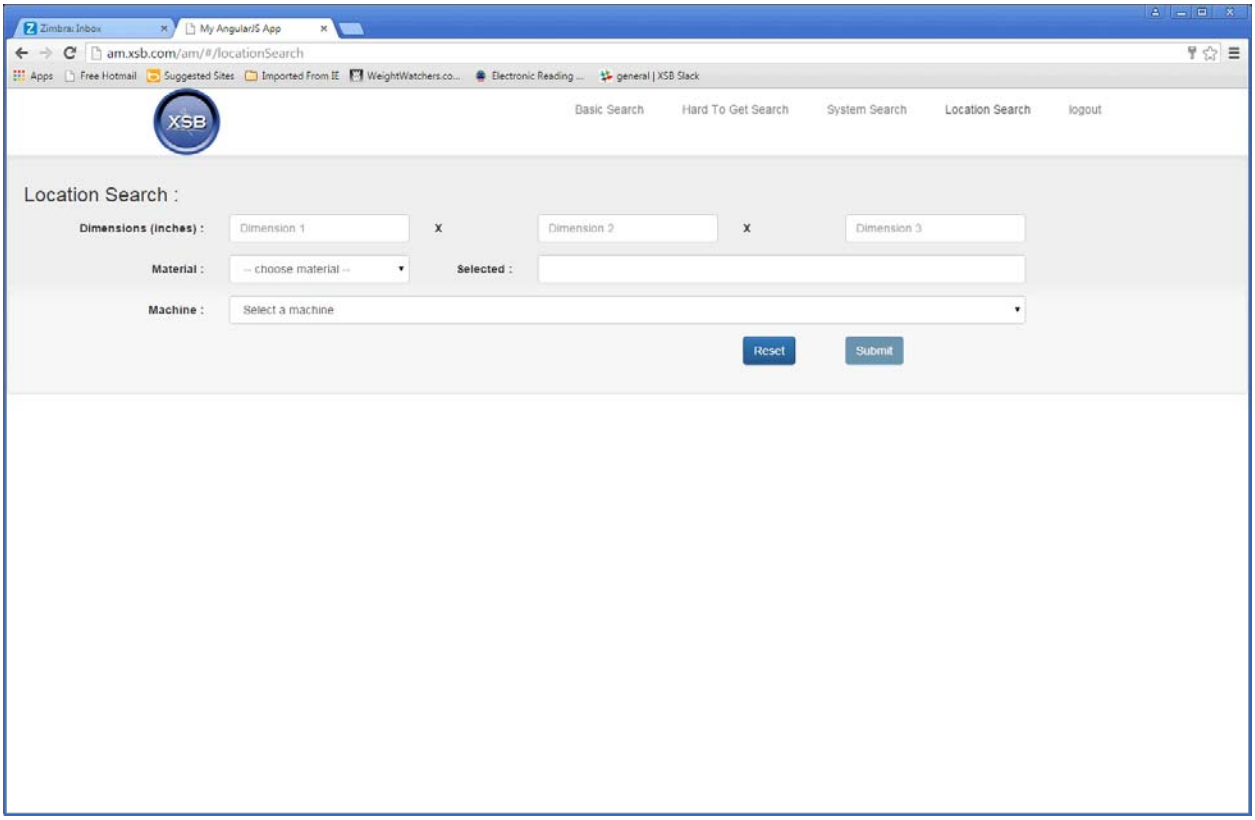
Weapon System Search Screen



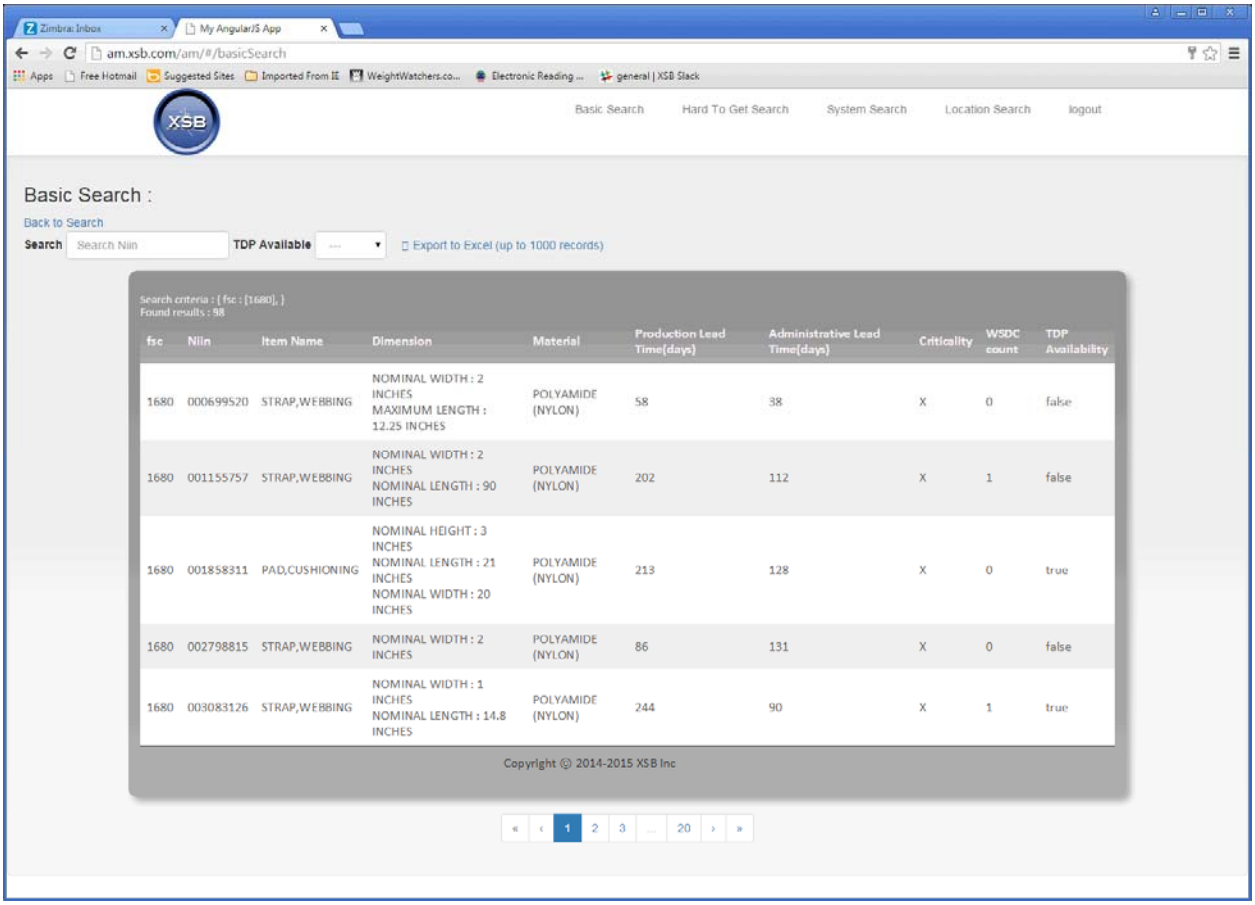
- **“AM Machine Search”**

  - Criteria: looking at a particular AM machine?
  - Dimension (inches): insert dimensions 1, 2, and 3. Note-The logic is designed to expect longest to shortest in that order. So if you have a machine that is 20” long by 15” wide by 25” high you should put in 25 first, 20 second and 15 third.
  - Material: choose material
  - Machine: select a machine
  - Note: selections from a drop down box will appear in the Selected field box

AM Machine Search Screen



Search Results Screen



5. User Survey
    - Submission instructions:
        - Service Partner testers are encouraged to submit surveys, observations, and recommendations to the AM R&D Tool via the hyperlink below. If the hyperlink option is not feasible, please copy and complete the attached survey and submit to: LMI- Mr. Ryan Flanagan, Email: rflanagan@lmi.org. Phone contact is +1 (703) 917-7092.

    - Survey hyperlink: Will be available as link on website shortly

    - Survey word document (attached)

Attachment: Survey included below

Additive Manufacturing (AM) Decision Process Web-Tool Survey

1. Please enter your name_____
2. Please enter you organization_____
3. Did you receive introductory training for using the web-based application? (If you have previously filled out a survey and answered this question, please skip to Question 4; if your answer is No, please skip to Question 6.) Y__ N__
4. Was the introductory training helpful/sufficient to enable your use of the tool? If No, please provide specific comments about what could be improved in the training. (If you have previously filled out a survey and answered this question, please skip to question 6.) Y_ N_ Comments_____
5. Are there any topics/information that should be added to the introductory training? If Yes, please specify and provide rationale. (If you have previously filled out a survey and answered this question, please skip to question 6.) Y_ N_ Comments _____
6. Approximately how many times have you used this tool before this session? ____
7. Did you experience any issues logging in to the website with the XSB-supplied user credentials (i.e., user name and password)? If Yes, please provide specific comments. Y_ N_ Comments_____
8. Did the AM Decision Tool experience any issues (e.g., screen froze, unable to input filter data, etc.) while you were using it? If Yes, please provide specific comments. Y_ N_ Comments_____
9. Was the 'Basic Search' user input screen easy to use/intuitive? If No, please provide specific comments. Y_ N_ Comments_____
10. Were the filters/sort criteria available on the Basic Search understandable/intuitive? If No, please specify what would help clarify them for you (e.g., details described in introductory training, additional explanation in pop-up boxes, etc.) Y_ N_ Comments_____
11. Were the drop-down menus for each filter/sort criteria (e.g., FSC, NIIN, WSDC[1], etc.) on the 'Basic Search' user input screen helpful/intuitive? If No, please provide specific comments. Y_ N_ Comments_____

[1] FSC, Federal Supply Classification

12. Was availability of the three special search scenarios (i.e., Hard-to-Get Item Search, Weapon System Search, and AM Machine Search) useful/convenient? If No, please provide specific comments. Y_ N_ Did not use any of the special searches __ Comments_____

13. Were the user input screens for the three special search scenarios (i.e., Hard-to-Get Item Search, Weapon System Search, and AM Machine Search) easy to navigate/intuitive? If No, please provide specific comments. Y_ N_ Did not use any of the special searches __ Comments_____

14. Are there other special search scenarios you think would be useful to include in an input screen? If yes, please describe the scenario and any filters/sort criteria (i.e., technical or logistics attributes) you believe should be included. Y_ N_ Comments_____

15. Are there additional filters/sort criteria (i.e., technical or logistics attributes) that should be included in the input screens? If Yes, please specify and provide rationale. Y_ N_ Comments _____

16. Were the data elements provided on the 'Results' screen sufficiently comprehensive for your needs? If No, please identify any additional data elements you think would be useful and provide rationale. Y_ N_ Comments_____

17. Are there other databases besides FLIS and (DLA) EBS you feel should be included as data sources for the Tool? If Yes, please provide (to the extent possible) the database name, owning Service, URL/location, and point of contact. Y_ N_ Comments_____

18. Did you have any difficulty in transferring/opening the download file? If Yes, please provide specific comments. Y_ N_ Comments_____

19. Would you prefer the download file be provided in some format other than Excel? If Yes, please specify the format and provide rationale. Y_ N_ Comments_____

20. Were the data element headings included in the download file easy to understand? If No, please provide specific comments. Y_ N_ Comments_____

21. Is there any additional data that should be included in the download file? If Yes, please specify and provide rationale. Y_ N_ Comments_____

22. Is there any feature in the application that you feel is unnecessary? If Yes, please specify and provide rationale. Y_ N_ Comments_____

NIIN, Nation Item Identification Number
WSDC, Weapon System Designator Code

23. Is there any new feature(s) that should be added to the application? If Yes, please specify and provide rationale. Y_ N_ Comments_____

24. Are you aware of any AM machines/technology/feedstock not referenced in this tool? If Yes, please specify. Y_ N_ Comments_____

25. Was the AM Decision Tool useful/sufficient for your needs? If No, please specify what the tool was not able to do/provide for you. Y_ N_ Comments_____ (Please specify the types of searches you ran.)

26. If this tool was available in the future, how do you envision using it on a day-to-day basis? How many users from your organization would require access to the tool? Are there other organizations with whom you collaborate that might use this tool? Comments _____

27. If you have any thoughts or comments that aren't covered by the survey questions, please record them here. _____

Appendix E
Abbreviations

2D	two-dimensional
3D	three-dimensional
AAC	Acquisition Advice Code
ABS	acrylonitrile butadiene styrene
ACSI/FSCAP	Aviation Critical Safety Item/Flight Safety Critical Aircraft Part
ADQ	annual demand quantity
ALT	administrative lead time
AM	additive manufacturing
AMC	Acquisition Method Code
AMSC	Acquisition Method Suffix Code
ASA	acrylonitrile styrene acrylate
ASSIST	Acquisition Streamlining and Standardization Information System
COTS	commercial off-the-shelf
CSI	Critical Safety Items
DAC	Document Availability Code
DLA	Defense Logistics Agency
DMS	Document Management System
DoD	Department of Defense
EBS	Enterprise Business System
EDM	electrical discharge machining
ESA	engineering support activity
FAT	first article test
FLIS	Federal Logistics Information System
FSC	Federal Supply Class
FSCAP	Flight Safety Critical Aircraft Part
GSA	General Services Administration

HIP	hot isostatic pressing
IDIQ	indefinite delivery/indefinite quantity
INC	Item Name Code
JEDMICS	Joint Engineering Data Management Information and Control System
L&M	Land and Maritime
NIIN	National Item Identification Number
NSN	National Stock Number
OEM	original equipment manufacturer
PA	polyamide
PBT	polybutylene terephthalate
PC	polycarbonate
PEEK	polyether ether ketone
PEI	polyetherimide
PLT	production lead time
PMMA	polymethyl methacrylte
POC	point of contact
PP	polycarbonate
PP	polypropylene
PPS	polyphenylene sulfide
PS	polystyrene
QAP	quality assurance plan
QSL	Qualified Suppliers List
QSLM	Qualified Suppliers List of Manufacturers
R&D	research and development
TDP	technical data package
TPE	thermoplastic elastomer
WSDC	Weapon System Designator Code
WSSP	Weapon System Sustainment Program

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Parks, Thomas K.-LMI
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Simpson, Timothy W.-Pennsylvania State University
Williams, Christopher B.-Virginia Polytechnic Institute and State University

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LMI
7940 Jones Branch Drive
Tysons, VA 22102

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Defense Logistics Agency (DLA)
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14. ABSTRACT
LMI and its supporting partners were able to build, demonstrate, and successfully test (using Military Service and DLA personnel) an Additive Manufacturing (AM) Prescreening Decision Support Process that can quickly parse the millions of DLA-managed Class IX legacy spare parts to manageable groups of items ''potentially amenable to AM.'' The process minimizes research time to determine whether AM may be suitable for particular legacy Class IX parts on the basis of part attributes, such as material specifications and criticality, and logistics attributes such as item cost. However, in the end, the ''potential candidates'' still require an individual engineering review to determine whether and how they can be produced using AM. The decision support process allowed service partners an opportunity to evaluate AM technology by identifying DLA parts that are potential candidates for production using AM. This process could enable the routine use of AM in parts selection and manufacture, creating new efficiencies throughout the services, and further speeding support to the warfighter.

15. SUBJECT TERMS
Additive Manufacturing-identification of potential AM candidate parts; Legacy Class IX parts pool; Technical and Logistics attributes

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CONTACT:

ERIC L. GENTSCH
LMI
7940 JONES BRANCH DRIVE
TYSONS
VA 22102

703.917.7226

EGENTSCH@LMI.ORG