Open Systems

Additive Manufacturing (or 3D Printing)

Enhancing Interoperability Through Open Systems Architecture

DoD as a Model-Based Enterprise

Journal

Defense Standardization Program

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Director's Forum

The Link Between Open Systems and Consensus Standards

There has been a lot of emphasis recently in the Department of Defense on the use of open systems architecture. Identified as a key tenet of better buying power, open systems architecture can help promote effective competition because it enhances system interoperability and the ability to integrate new capabilities without the re-design of entire systems or large portions of the enterprise. In asking the question "What makes an open system truly open?", the answer—believe it or not—is with consensus standards.

When we think of open systems architectures, it's important to realize that there is a direct correlation between consensus standards and open systems architectures. Modular design is based primarily on widely supported—consensus-based—standards for their key interfaces. These key interfaces are an important element of making systems interoperable, so future modernization efforts can be made without having to scrap or completely redesign the legacy system. Because open system architectures employ widely accepted standards that have been validated by the market, these standard interfaces make integration and interoperability possible. Not only can this save time with development, maintenance, and sustainment activities, but it also helps save precious program dollars.

So how can we as a department ensure that our voice is being heard when these consensus standards are being developed? The answer is simple, participate! By participating with standards-developing organizations, we ensure that our voice is heard and may have an impact over some of the open system architectures we employ. And while we can't direct the conversation, we can at a minimum help craft a standard that can work for all concerned parties. I am often asked under what authority can DoD participate with standards-developing organizations? To that question, I answer there are two issuances in particular that give authority to participate in the standards development process. The first is the National Technology Transfer and Advancement Act of 1995. This act directs federal agencies with respect to their use of and participation in the development of voluntary consensus standards. The act's objective

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is for federal agencies to adopt voluntary consensus standards, wherever possible, in lieu of creating government-unique standards. The other document—which provides more in-depth information in the mechanics of participating in the development of voluntary consensus standards—is OMB Circular A-119, "Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities." The circular—which was just recently revised—not only gives those of us in government the authority to sit at the table, but also clarifies many of the roles and responsibilities we as government employees can play in the development process.

Given that the circular was just released, I would like to provide several highlights as to the content of some of the revisions. While the spirit of the circular didn't change, more emphasis has been placed on providing clarity for those of us in government in how we participate. The circular provides additional guidance for agency participation in standards-development activities. The revised circular also strengthens the role of agency standards executives. While this was done to encourage better internal coordination and training on standards, this also helps to elevate the role of standardization within an agency. The circular provides guidance to agencies on how they should implement provisions of the circular in their rulemaking and guidance documents, as well as what factors to consider when incorporating standards by reference in regulation. But the most important take-away from this revision is that the circular maintains the government's strong preference for using voluntary consensus standards over government-unique standards in federal regulation and procurement.

All that said, this issue of the *Defense Standardization Program Journal* focuses on the development and use of open systems. As you read through these articles, keep a keen eye on how the application of open systems architectures and consensus standards align. Perhaps you will be able to draw conclusions through your own experience of where the use of open system architectures may affect your program or what voluntary consensus standards can be used in lieu of government-unique standards. For more information on OMB Circular A-119, please go to https://www.whitehouse.gov/sites/default/files/omb/inforeg/revised_circular_a-119_as_of_1_22.pdf.
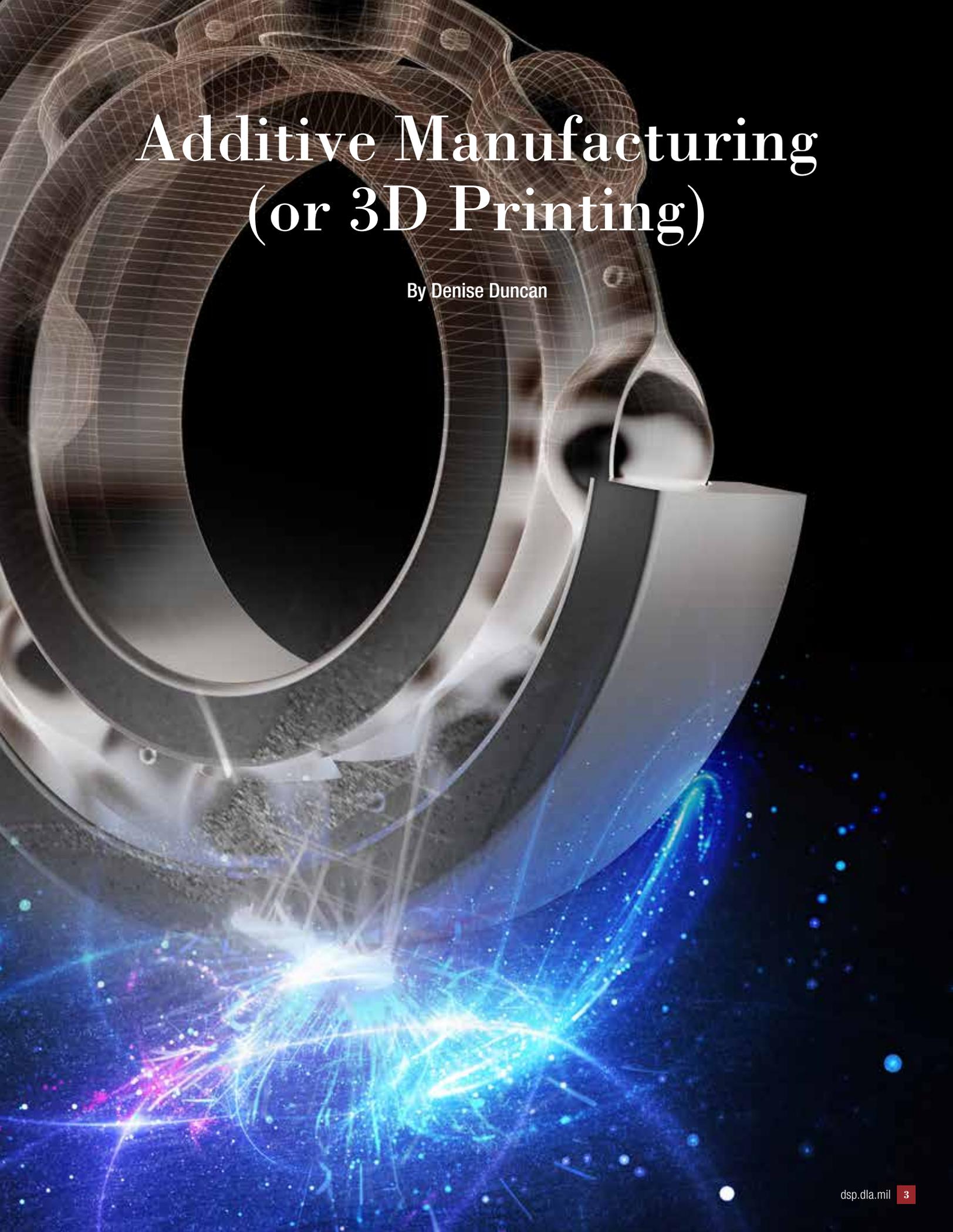
Additive Manufacturing (or 3D Printing)

By Denise Duncan
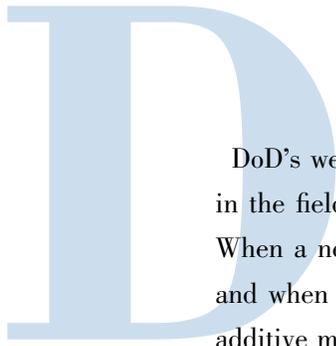
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DoD's weapon and other systems keep soldiers, sailors, and airmen safe and effective in the field; and it takes over a billion parts per year to keep those systems running. When a new technology or process affects the logistics of providing those parts where and when needed, DoD pays attention; and so it is with the manufacturing process of additive manufacturing (AM), sometimes called "3D printing." AM has the potential to be a transformative technology, completely changing the way we think about designing, manufacturing, and delivering parts and goods. In 2012 *The Economist* called additive manufacturing "a third industrial revolution,"[1] and since then it has published eight additional articles on its growth in manufacturing. AM has achieved a foothold in the defense industrial base and will grow in use for certain types of parts.

Additive manufacturing is the process of building an object by depositing layers of material, one layer at a time. Contrast that approach with our current "subtractive" processes where we cut away or subtract (by milling, grinding, drilling, etc.) material from a block of metal or other material. To imagine one AM approach, picture a laser printer that, instead of ink cartridges, has cartridges filled with very fine powdered metal or plastic. A 0.1-millimeter-thick layer of powder is laid down, and a laser sinters the powder only in those places where a cross-section of the final object will be solid. The build platform drops a tenth of a millimeter, and the process is repeated. Videos of AM abound on the Internet, and viewing one or two of those will make the process more intuitive for the reader.[2]

Characterizing AM by Processes Used

In general, the AM process starts with a three-dimensional (3D) model of the object to be built. This is usually created by computer-aided design (CAD) software, or from a 3D scan of an existing object. 3D scans can be especially useful in the case of repair or rebuild tasks, because the scan will capture changes to the article due to use—which is useful feedback for designers of the article. Examples of both a wireframe and a solid model are shown in Figure 1.

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[1] *The Economist*, April 21, 2012, http://www.economist.com/node/21553017.

[2] http://www.ted.com/talks/lang/en/lisa_harouni_a_primer_on_3d_printing.html.

Figure 1. Example of Step 1 in Additive Manufacturing—a Wireframe (on the left) and a Solid Model (on the right)
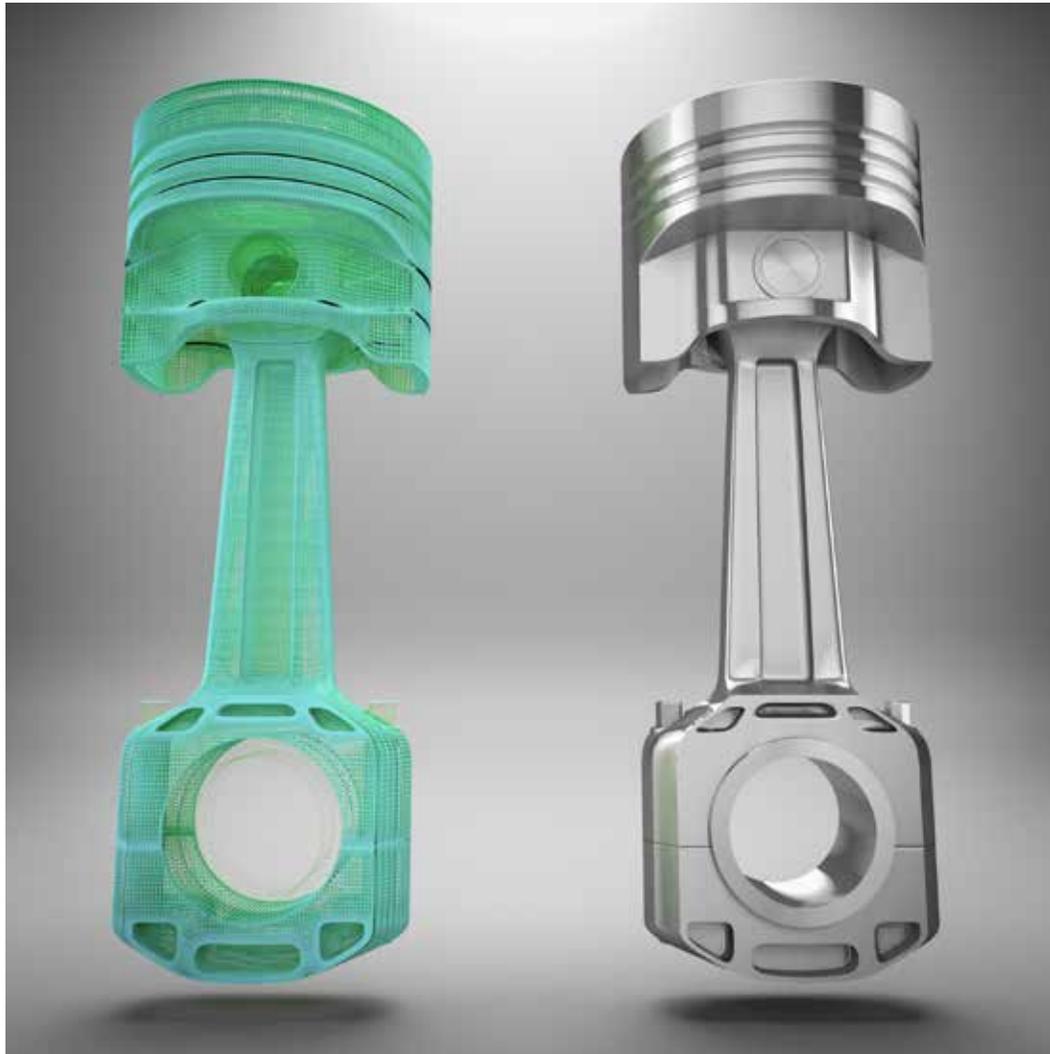
The next step in almost all cases is converting the file containing the 3D model (generally in a format used by CAD software) into a standard file format, such as .STL.[3] The resulting file is then sent to "slicing" software, which creates the layers for the AM process. After these three steps, the actual AM process takes place.

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[3] For more information, see ISO/ASTM52915–13, "Standard Specification for Additive Manufacturing File Format."

Many different AM processes exist; Table 1 provides a sampling of some common processes.

Table 1. Characteristics of AM Types

Type of AM	Process name	Materials	Process
Deposition of molten material	Fused deposition modeling	Metal or plastic wire	Material is melted and extruded in layers to build up the object.
Binding of granular materials	Electron beam melting	Titanium alloys, including gamma titanium aluminide	The electron beam melts metal powder in thin layers in a vacuum.
	Selective laser sintering (SLS) and direct metal laser sintering (DMLS)	For SLS, metal or polymer powder For DMLS, powdered stainless steels, mar-aging steel, cobalt chromium, inconel, and titanium Ti6Alv4	Lasers are used to sinter metal or plastic powders. Sintering is the process of heating material (below its melting point), causing atomic diffusion of the particles in the powder.
	Binder jetting	Plaster or resin	Thin layers of material powder are spread across the build platform, and a binder is sprayed through the inkjets to set the powder for the solid area on each layer.
Photopolymerization	Stereolithography	Polymers	Lasers are directed into a vat of polymer.
	Digital light processing	Polymers	Safelight is used with masks to expose a vat of polymer to digital light.
	Inkjet printer	Polymers	Each layer is cured by ultraviolet light upon deposition.
	Photolithography	Synthetic resin	Light-emitting diodes are focused on a block or vat of resin on a block or vat of resin.

Advantages of AM

One of the early uses of AM was for rapid prototyping. Studies have shown that the use of 3D modeling software, combined with rapid prototyping, results in significant savings of both time and money.[4] Businesses that used both approaches typically got products to market earlier and saved significantly on product development costs. When a business uses AM to build prototypes, it can save 50 percent of the time normally required to produce the prototype. Sending an article out for fabrication, it will typically take 2 to 3 weeks until the prototype is in hand. When using in-house AM, the time can be cut to 2 to 3 days. Using AM to build a wireframe physical model (versus a solid model of the prototype) can cut this time even further.

Another advantage of AM is its flexibility, which gives businesses the ability to make modifications to prototypes or customize products for different customers. Finally, the processes employed in AM allow freedom of geometry, and that changes the rules of design. The "design for manufacturability" step can be greatly simplified, and items can be produced with significantly fewer process steps. That, in turn, makes it possible to produce highly complex geometries economically.

Labor savings also are significant, because once the design files are loaded to the AM process, little labor is involved, except for a finishing process for some products. AM also allows far more freedom in design. For example, GE Research invested $50 million in a 3D printing facility in Auburn, Alabama, to produce fuel nozzles for the new LEAP jet engine. To start, it will print 1,000 nozzles a year, but eventually the number may reach 40,000. The fuel nozzle in a jet engine is a complex part that has to withstand high temperature and pressure. Normally it is made from 20 different components. GE instead prints the part in a single AM process, using a laser to fuse layers of a powdered alloy made up of cobalt, chrome, and molybdenum. The resulting nozzle is 25 percent lighter and 5 times more durable than the traditionally manufactured one.

Finally, AM has positive logistical impacts. By building items close to where they will be used, much of the transportation of the finished object can be eliminated. For example, the National Aeronautics and Space Administration (NASA) has tested 3D printing in zero-gravity flight; its aim is to develop AM for the International Space Station to reduce the number of spare parts required to be transported to, and stored on, the station. NASA also recently awarded three teams a total of $40,000 in the first stage of the 3-D Printed Habitat Challenge Design Competition, to produce architectural concepts for a habitat on Mars using AM and materials found on Mars.

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[4] Aberdeen Group, *The Transition from 2D Drafting to 3D Modeling Benchmark Report*, September 2006.

Disadvantages of AM

AM has a few limitations. In particular, the size of the build platform is limited. Typically, objects are smaller than a cubic yard, although with electronic beam melting, the build platform can be up to about 5 feet long, 3 feet wide, and 5 feet high. Further, some larger build platforms—several meters in all three dimensions—are used for "printing" buildings in sandstone or concrete. The availability of materials in the proper form for AM is another limitation. Table 2 shows some of the materials available now, and new materials are being added continually.

Table 2. Types of Materials Used in Additive Manufacturing Processes

Process	Materials used
Material extrusion	Thermoplastic; may require support structures.
Material jetting	Photopolymers/thermoset plastic or wax-like materials for investment casting patterns.
Binder jetting	Plaster powder with water as binding agent. Metal powder or sand, with glue-like binding agents: finished by sintering in a furnace. Acrylic polymer, with a monomeric liquid binder.
Sheet lamination	Paper, with adhesives. Metal tapes and foils, with ultrasonic welding.
Vat photopolymerization (also known as stereolithography)	Liquid photopolymer, including ceramic-filled photopolymer. Cured with light (usually lasers). Digital light processing uses micromirrors to project an image of the layer onto the vat, curing an entire layer at once.
Powder bed fusion (also known as laser sintering, selective laser melting, direct metal laser sintering, and electron beam melting)	Polymer and metal powders, and more rarely, sand. Uses thermal fusion, usually from a laser or an electron beam.
Directed energy deposition	Metal powders and focused thermal energy.

Finally, AM is not the optimal process for high-volume manufacturing, unless some customization is required. For example, AM is used to mass produce the clear plastic "aligners" used to straighten teeth. These are built from a model of a client's teeth, and then the model is changed very slightly over many iterations, to gradually align the teeth to the desired "bite." But typical assembly-line methods are more suited for mass-producing products that are identical for every customer.

Current Applications of AM

Rapid prototyping is an example of AM integrated with traditional manufacturing processes. Even when mass production is needed, AM can shorten cycle times for engineering reviews by providing a physical prototype in much less time than getting prototypes developed by an outside firm. Reverse engineering is used to (for example) reproduce items if the design documentation has been lost. When technology is used to create a 3D model of the item (whether by laser scanning, x-ray, or magnetic resonance imaging), the 3D model can be used as input to the AM process.

Medical and dental device applications are plentiful, due to AM's customization capabilities. For example, AM is used to develop surgical guides, customized prostheses, and engineered tissue scaffolds. In addition, AM is used in some applications to create geometries not possible with traditional manufacturing techniques, resulting in new designs with higher strength and lower weight. AM also supports manufacturing of electronic items, by printing the electronics embedded into the final product.

DoD Applications of AM

Additive manufacturing is already in use by DoD and its supply chain. Original equipment manufacturers routinely use AM for rapid prototyping of new products, for molds and casting patterns, and for direct part production. The Joint Strike Fighter contains many parts manufactured using laser sintering and other AM techniques. DoD is using AM in medical applications as well, for example, to plan surgeries and to visualize reconstructive surgery, surgical implants, and prosthetics.

The Army's Rapid Equipping Force has deployed mobile laboratories to the war zone in Afghanistan. Each mobile lab—a roughly $2.5 million investment—is a 20-foot container and can be transported by truck or helicopter to any location. These labs speed up the design and production processes; the warfighter can provide feedback to the designer and, with rapid iterations, can proceed to a design for a complete solution. Engineers can work together inside each mobile lab to create needed items or repair parts made of plastic, steel, and aluminum. If the end item is going to be mass produced, the design can be transmitted back to the United States for procurement and production.

About the Author

Denise Duncan is a senior fellow at LMI with more than 30 years of information systems management experience. She has managed a wide variety of projects, from assisting senior leaders with portfolio management to strategic planning for chief information officers. For the past 12 years, Ms. Duncan has worked extensively on the application of data management principles to engineering and scientific data. She has authored standards, handbooks, and training materials in enterprise-level data management and information management. Ms. Duncan has been honored as a technical fellow of TechAmerica and is the vice president for programs in the local chapter of Data Management Association–International.

Enhancing Interoperability through Open Systems Architecture

By Joseph Norton
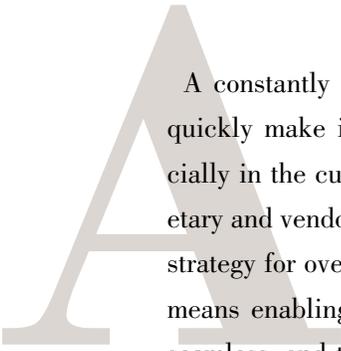
A constantly changing technology landscape and expectations to adapt and innovate quickly make it challenging to acquire, integrate, and upgrade fielded systems, especially in the current economic environment. Highly integrated systems are often proprietary and vendor locked, expensive, and difficult to upgrade with emerging technology. A strategy for overcoming these challenges is to design highly interoperable systems. This means enabling systems or components to exchange services and information through seamless, end-to-end connectivity. This article describes how open systems architecture (OSA) leverages reusable components, well-defined interfaces, and standard interface specifications to enhance system interoperability. This article also discusses design principles for implementing OSA to enhance interoperability.

Open Systems Architecture—An Overview

OSA is an integrated business and technical approach to acquire and assemble interoperablecomponents using modular systems design. The business strategy is to drive down costs, enable systems to easily adapt to changing business needs, and increase the number of available vendors to create competition-driven product lines. The technical approach decomposes systems into components that interact through key interfaces according to formal specifications.

OSA aims to enhance interoperability by realizing the following benefits:

- Increased flexibility in vendor selection fostered by competitive marketplaces
- Interchangeable components to simplify maintenance, upgrades, and technology insertion
- Greater accessibility to innovative technology
- Shortened design times and streamlined development processes
- Improved information sharing and data quality
- Reduced total cost of ownership.

OSA applies to all types of systems. Although some of its most familiar uses are in computers, software, and electronics, this approach applies to other areas, such as communications, electricity production and use, and the design of weapons, vehicles, and artillery for armed forces. Computer networks are tightly integrated systems that employ standard hardware, such as cables, routers, and servers. This hardware uses standard protocol to enable devices and machines to communicate and exchange information. With constantly changing operational needs for new weapons and armor, the armed forces use a similar approach to enhance interoperability in military vehicles. By developing standard electronic platforms and mounting systems, military vehicles can quickly access electronic and information assets and introduce new weapon and sensor capabilities.

Components, Interfaces, and Standards

OSA abstracts systems into three key elements: components, interfaces, and standards. Figure 1 describes these elements and their characteristics. These are generic to any system and span several dimensions of interoperability, including technical, informational, and organizational. This involves the physical connections and communications between components, their information flows, and relationships between people and organizations.

Figure 1. Elements of Open Systems Architecture

Component
- Modular and interchangeable
- Distinct functionality
- Self-contained

Interface
- Key boundary between components
- Change and configuration managed

Standard
- Widely supported
- Maintained by consensus organization
- Specifies operational and performance requirements
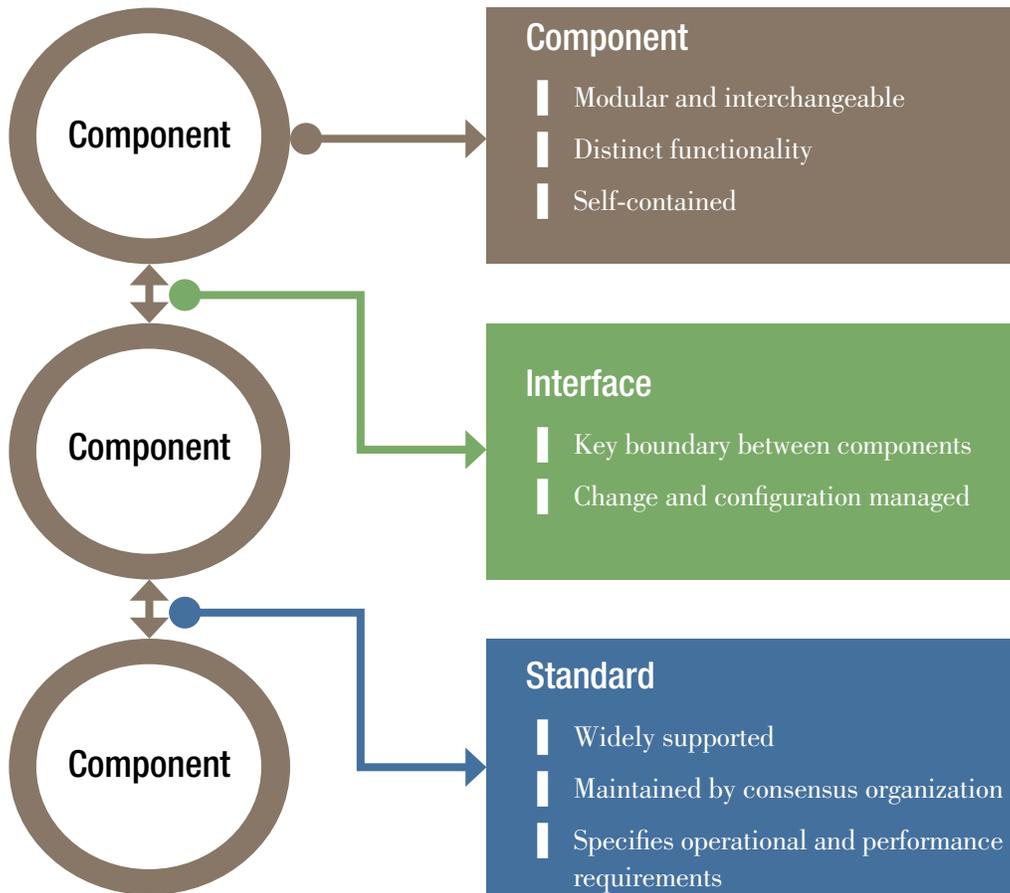
Components are the physical modules of a system. Each component has distinct functionality and operates independently and with limited impact on the rest of the system. This decouples the components from each other and makes it possible to interchange units provided by alternate vendors. The desired functionality and inner workings of components may also vary across vendors.

Interfaces define the key boundaries between components and how they interact. The types of interfaces depend on the physical connections, information, or services the components need to exchange. Interfaces should be standardized, change and configuration managed, and publicly available.

Standards define the specifications for how components interact through defined interfaces. These include operational and performance requirements, such as security, reliability, and maintainability, that describe how an interface should perform. Standards should be managed by consensus groups and widely accepted to ensure they meet the requirements across all systems.

Design Principles to Ensure Interoperability

OSA considers interoperability through the entire life cycle of a system. A program must design its systems to be interoperable from the time it acquires and defines its components, interfaces, and standards through the time when those systems become operational and eventually are decommissioned. Several critical success factors contribute to successfully implementing OSA principles:

▌ Firm commitments and well-defined governance
▌ Available, reliable, and economical components
▌ Controlled interfaces
▌ Mature standards.

Firm Commitments and Well-Defined Governance

Interoperability requires cooperation. The programs and involved systems should be dedicated to an enterprise-wide strategy to implement and realize the benefits of OSA. This includes developing a strategic sourcing approach for acquiring system components, contributing to the ongoing development of open standards to meet business and system requirements, and providing guidance and oversight to align systems to OSA principles. Political and financial support from program offices, project managers, and senior managers who understand the long-term benefits of OSA are crucial to its successful implementation.

A program implementing an OSA system should establish enterprise governance through policy, guidance, and enterprise planning to develop and maintain its systems. Interdisciplinary practices, such as systems engineering and enterprise architecture, enable organizations to manage system complexity and align resources with an OSA strategy.

Organizations should establish governing bodies supported by communities of interest and working groups or committees to oversee design and implementation, champion enterprise-wide adoption, and assess benefits realization. Governing bodies should make funding and approval decisions for systems to proceed through key life-cycle milestones.

Available, Reliable, and Economical Components

OSA focuses on decomposing systems into modular components. In order for these components to be interoperable, easily upgraded, and maintained, there must be a broad range of components that meet the functional and performance requirements of a system. The specifications for components must be formal and publicly available to encourage broad commercial support. This will allow a number of vendors to produce the same or similar components with standardized functionality. This will also promote competition between vendors to produce usable, reliable, and economical components and to incentivize productivity and innovation.

Controlled Interfaces

Controlled and consistent interfaces enhance the interoperability of components. Interfaces should be controlled, monitored, and published to clearly and fully define all inputs and outputs of a component. Interfaces separate the functionality of each component and define the requirements that interface standards need to support. By monitoring the number of interfaces within a system, their rate of change, and their conformance with standards, a program will be able to assess the openness, interoperability, and affordability of a system over time.

Mature Standards

To mitigate the risks associated with enhancing interoperability, systems should use standards that are well-developed and stable and that have achieved widespread adoption by industry. This will ensure that interfaces meet current industry-wide operational and performance requirements, adapt to changes due to emerging technology or innovation, and are published. Programs should participate in standards development to ensure that their adopted standards continue to meet their business and technical requirements.

Standards organizations often manage the overall production and evolution of mature standards among a wide base of adopters. These organizations benefit from collaborative participation from industry, universities, and government to develop robust and comprehensive interface specifications. Well-known standards organizations such as the ISO, International Electrotechnical Commission, and International Telecommunication Union have developed standards for all types of interfaces, including physical, data, network, and applications. These standards support various OSA-based approaches, such as the Open Systems Interconnection (OSI) model and service-oriented architectures. Consistent with an OSA approach, OSI decomposes communications systems into functional layers where components within each layer interact through well-defined protocols. Similarly, service-oriented archi-

tectures separate software systems into loosely coupled pieces of software that communicate using standard web-based services and that can be published and discovered. In both cases, mature standards enable interoperable machine-to-machine interaction over a network.

Summary

OSA decomposes systems into components, interfaces, and standards to enhance interoperability. As long as the interfaces are fully defined and there are mature standards to govern them, system owners can interchange components with the same or similar ones. OSA overcomes the challenges of highly integrated, proprietary systems by using a modular architecture that allows commercial companies to build systems or subsystems to common industry specifications. This enables organizations to directly impact the interoperability, supportability, and affordability of their systems.

About the Author

Joseph Norton is an enterprise architect with LMI. He manages systems engineering and information technology projects, with a focus on facilitating enterprise architecture development and adoption within the federal government.

DoD as a
Model-Based Enterprise

By Denise Duncan

DoD is one of the largest buyers of complex systems and the parts to maintain them; it spends billions annually on weapons systems, spares, parts, and related supplies. These systems are in active use for decades and must be ready for use at any time. Over the entire life cycle of a given system, sustainment is the largest cost, surpassing even the original purchase price. Sustainment costs can be as much as 60 to 80 percent of the total life-cycle costs of a weapons system.

Costs during the sustainment phase can be driven by a number of factors, but technical data—for example, design and engineering models, manufacturing processes, and maintenance instructions—are key. DoD has traditionally used two-dimensional (2D) technical data, such as engineering drawings. Two-dimensional technical data were the state of the art when many of the legacy systems were designed, and DoD's policies, infrastructure, and staffing for technical data still reflect that 2D environment. For example, many DoD programs required technical data to be delivered in 2D drawings, even though contractors typically use three-dimensional (3D) models. To satisfy DoD's deliverable requirement, contractors converted their 3D models to 2D drawings.

Cycle times, errors, and costs can be reduced by the use of 3D models throughout the product life cycle—from the start of system design through the disposal of the system. The use of 3D models throughout the product life cycle is often identified as a model-based enterprise (MBE) approach.

What Is MBE?

MBE uses the 3D models initially created in the conceptual design phase and evolves the models throughout the rest of the product life cycle (see Table 1). The MBE concept evolved because, over the past several decades, major manufacturers have adopted 3D models in computer-aided design (CAD), computer-aided engineering, computer-aided manufacturing, and numerically controlled machines. Those who have implemented MBE and some lean manufacturing techniques have seen a significant return on that investment.

Fully implementing MBE means creating electronic models of early designs (in the conceptual design phase) and using those models to facilitate collaboration on those designs. Electronically shared 3D models enable collaboration on preliminary design, detailed/engineering design, virtual prototyping, manufacturing process design, and maintenance process design and documentation. During the sustainment phase, 3D models provide a consistent representation of the product line for various operations and sustainment processes. The models contain all of the information needed to define the product in a form that allows the data to be automatically extracted for other uses, from virtual prototyping to Interactive Electronic Technical Manuals. This is how MBE shortens schedules, reduces errors and miscommunication, and saves money.

Table 1. MBE Improvements to Some Life-Cycle Activities

	Solutions analysis	Technology development	Engineering and production	Support
DoD	Faster and more thorough trade-space evaluation Improved cost modeling Virtual manufacturing feasibility assessment	Early assessment of producibility, maintainability sustainability, and affordability	Thorough assessment of producibility, maintainability sustainability, and affordability	Faster and less error-prone part sourcing/organic manufacturing Potential for more competition in bidding
OEM	Fast and more thorough trade-space evaluation Improved cost modeling Virtual manufacturing feasibility assessment Virtual design review	Faster and more thorough risk identification and mitigation Virtual manufacturing processes evaluation	Reduction in the amount of nonrecurring engineering Virtual prototyping Fewer defects/ less rework Faster time to market	Reduction in the amount of non-recurring engineering
Supplier		More thorough understanding of design intent in less time	Faster setup of manufacturing processes	Faster and less error-prone production
All	Collaboration among stakeholders and data exchange Real-time configuration management			

Why MBE in DoD?

The production of DoD weapons systems has been plagued by schedule and cost overruns for decades. There have been numerous studies and reports of DOD acquisition program cost overruns and estimates that two-thirds of active DOD programs will exceed their projected costs.[1] There have also been studies of manufacturing organizations that show that those using an MBE approach can significantly reduce both nonrecurring costs and time-to-market.

[1] Government Accountability Office, *Defense Acquisitions: Assessments of Selected Weapon Programs*, GAO-09-326SP, March 2009.

Although specific industry return-on-investment analyses are held proprietarily, best-in-class companies are using 3D models to achieve efficiencies. In a 2006 study,[2] the Aberdeen Group classified companies' use of 3D technology and data as "best in class," "average," or "laggards" for five parameters: (1) product revenue targets, (2) product cost targets, (3) development cost targets, (4) launch dates, and (5) quality expectations.

According to the study, the group of companies that adopted 3D modeling early and integrated it with all parts of the manufacturing process regularly hit revenue, cost, launch date, and quality targets for at least 84 percent of their products.[3]

If DoD adopts MBE, we can expect the following gains across the acquisition life cycle:

▎ *Faster and more thorough trade-space evaluation*. DoD and OEMs can identify and evaluate alternative parts, approaches, and designs more quickly.

▎ *Improved cost modeling*. Cost modelers can use the PLM to instantly identify current designs and extract bills of material for costing.

▎ *Virtual manufacturing feasibility assessment*. The ability to "virtually assemble" multiple 3D models can uncover potential problems with clearance/tolerances, incompatibility of materials, order of assembly, and so on.

▎ *Virtual design review*. The manipulation of 3D models allows design review by many different "customer" types (logistics, financial, maintenance, etc.).

▎ *Faster and more thorough risk identification and mitigation*. The combination of intelligent and navigable 3D model views with process data helps with the identification of risk and development of effective inspection and maintenance strategies.

▎ *Virtual manufacturing processes evaluation*. 3D models can help assess production line performance without incurring the cost of a physical production line demonstration.

▎ *Reduction in the amount of nonrecurring engineering*. Design engineers can retrieve similar parts' models for partial reuse to "jumpstart" the design process.

▎ *Virtual prototyping*. The assembly of 3D models into a prototype is faster and less costly than physical prototyping.

▎ *Fewer defects, less rework*. 3D models and PLM enable frequent and thorough reviews so that many defects (and the need to scrap or rework parts) are eliminated prior to low-rate initial production.

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[2] Aberdeen Group, *The Transition from 2D Drafting to 3D Modeling Benchmark Report*, September 2006.

[3] Aberdeen Group, *Complementary Digital and Physical Prototyping Strategies: Avoiding the Product Development Crunch*, February 2008.

- *Faster time to market*. The accumulation of shorter cycle times across many processes (design, review, prototyping, etc.) thanks to 3D models and PLM culminates in faster time to market.

- *Faster and less error-prone part sourcing/organic manufacturing, and faster and less error-prone order production*. When suppliers must interpret 2D technical data, it takes longer to prepare a bid, the data are more prone to misinterpretation and may require revised bids, and it adds to cost.

- *Potential for more competition in bidding*. Providing a validated 3D CAD model increases the likelihood of bidding by suppliers; more competition likely leads to lower costs.

- *Collaboration among stakeholders and data exchange*. The ability to exchange models and technical data electronically and visualize products in a 3D format inherently increases the occurrence for and quality of collaboration between supply chain partners.

- *Real-time configuration management*. In the MBE, a configuration control board will review a proposed change to a 3D model. Once approved, that model will be stored as part of the current configuration in the PLM, thus eliminating one or more manual processes for the storage of 2D drawings.[4]

In 2008, a community of interest—with members from the uniformed services, the Coast Guard, DoD, and their partners in industry—was formed to share information, processes and tools, and the results of experiments using 3D models. Some of the studies shared by this group have shown the following results from using 3D models as the authoritative technical data in individual projects:

- BAE Systems' SimTeam used an MBE approach to design, collaborate with the customer, and deliver mine-resistant, ambush-protected egress trainers to the Army in about one-fifth the time of a traditional engineering approach (less than 4,000 hours vs. 23,000 hours proposed with the traditional approach).

- The Army Armament Research, Development and Engineering Center and DSN Innovations completed a network-centric manufacturing business case to show that 3D data will yield better sourcing results when compared to traditional sourcing methods that use 2D drawings. The project results noted supplier time savings of 412 hours and customer time savings of 23 hours during the purchase order process.

[4] LMI Report NG403T1.

■ MBE data were used to create an immersive training environment for Army Stryker maintenance personnel, which allowed personnel to train in a virtual environment. This business case estimates a 25 percent reduction in field maintenance and repair time and a yearly return on investment of $25 million if MBE data are reused in interactive 3D models embedded in animated training files.

■ PDES Inc. and ITI led an Air Force–sponsored project looking at technical data exchange between suppliers and customers, specifically, the challenges and inefficiencies even in a model-based environment. The project team identified automation opportunities and workflow enhancements that are estimated to save large programs $27 million in nonrecurring engineering and more than $20 million in recurring engineering.

Most recently, the Defense Wide Manufacturing Science and Technology Program recently funded three projects that focus on data exchange processes, from the perspectives of both government-to-government and government-to-industry or supplier.

■ The first focused on 3D technical data for electrical systems, specifically electrical wiring harnesses. It measured the cost of converting legacy technical data to standard 3D formats. It showed that the cost to develop translation software dropped steeply after the first translator, so that a translator for a third legacy format cost about a half a man-year in labor. The utility of using the PLCS format as the neutral-format "Rosetta Stone" for further translations was also proven to be both effective and efficient.

■ The second investigated the validation and verification (V&V) of technical data packages delivered to the government. This project focused on the ability to perform V&V on data exchanges, whether between different PLM formats, PMI within models, or data from 2D formats remastered into 3D formats. This project showed that a PMO with access rights to a supplier's PLM could save more than $20 million over 5 years by using its own PLM versus simply downloading the data to its LAN for sustainment actions. Transferring entire models from the supplier's PLM to the PMO's PLM ensured that configuration management was maintained during engineering changes.

▎ The third project focused on MBE transfer capabilities (industry to industry)— demonstration of data exchange and validation by an OEM and its suppliers. This study found a time savings of about 12 percent by passing models up and down the supply chain (from prime to supplier, and from supplier back to the prime along with the manufactured item).

All of these studies and experiments taken together show that MBE offers a great deal to DoD. It has been tested—this approach has been used in the DoD industrial base for more than a decade—and it can be implemented using existing, commercially available tools. MBE can potentially generate large returns on investment, and it can help meet aggressive schedules for both initial production and sustainment. Various DoD organizations have been using 3D models on select acquisitions, and some have documented the benefits. The time is right for programs to consider the use of MBE for the full life cycle and for DoD to investigate the most efficient and effective ways to implement MBE.

About the Author

Denise Duncan has worked extensively on the application of data management principles to engineering and scientific data. She has authored standards, handbooks, and training materials in enterprise-level data management and knowledge management. Ms. Duncan is a senior fellow at LMI with more than 30 years of information systems management experience managing a wide variety of projects—from assisting senior leaders with portfolio management to strategic planning for chief information officers. She is the vice chair of the Enterprise Information Management and Interoperability Committee of SAE's Aerospace Council; she is also the industry-data management section chair of NDIA's Technical Information Division and serves on the board of the local chapter of Data Management Association–International.

Program News

Topical Information on Standardization Programs

Don't Miss the Standardization in NATO Course

If you are interested in NATO standardization and want to gain familiarity with this fascinating but complex subject, the introductory "Standardization in NATO" course is offered twice a year. The 25th edition of the course will take place in Warsaw in spring 2016. The Polish Military University of Technology, in collaboration with the Polish Ministry of Defence and the NATO Standardization Office (NSO), offers this comprehensive course, accredited by NATO's Allied Command for Transformation.

The course analyzes standardization as a key element to achieve and maintain the compatibility, interchangeability, or commonality necessary to attain the required level of alliance interoperability, and to optimize the use of resources, in the fields of operations, materiel, and administration. It provides students with a clear knowledge of the NATO standardization structure, its processes and products, as well as the interdependencies with European and national systems.

The course is aimed primarily at beginning practitioners who are relatively new to NATO standardization. Nevertheless, it can be useful for those already working in both NATO and standardization for several months. The course prepares practitioners for national standardization positions such as custodian of a NATO standard or national representative to a NATO working group or NATO standardization tasking authority. It also prepares practitioners for international roles within NATO or the European Union, such as standardization working group chairperson or a NATO staff position with some responsibilities in the area of standardization.

The course includes specific lectures on several key areas. One explains NATO's standardization documents development process, including consensus-based decision making. Lectures on partners' involvement and NATO's use of civil standards demonstrate some of the bridges between NATO and the rest of the standardization world. Practical hands-on work with the NSO-protected website and the NATO Standardization Document Database ensure that course members receive a firm grounding in these important tools. This approach is based on the well-received hands-on workshop on the NATO Terminology Programme, also provided by NSO personnel.

Experts from national standardization organizations present in-depth information on European and national systems. An interactive visit to the Polish to Military Center for Standardization, Quality Assurance and Codification offers first-hand information on the Polish standardization system and its current activities. Throughout, the course reflects the most recent policy developments and takes into account evolving interoperability requirements.

Participants include personnel from NATO and partner nations. They, together with personnel and experts from the NATO Standardization Office and national standardization organizations, provide the course with a strong international character. Participants are encouraged to compare challenges and share information and best practices. As with most professional courses, this opportunity provides good practical insight and directly useful solutions to common challenges.

A well-organized social program offer many opportunities to build personal and professional contacts in numerous NATO and partner countries. These currently include tours of the cities of Warsaw and Krakow as well as hosted lunches and a cookout.

Application forms for the 25th edition of "Standardization in NATO" and additional information will be found on the NSO website (https://nso.nato.int/nso/SOSite/WEBUpdate/NSOEvents.html).

NATO Standardization Office Drafting Team Seeks Input

The North Atlantic Treaty Organization (NATO) Standardization Office has established a drafting team to manage the update for AAP-03J, "Production, Maintenance and Management of NATO Standardization Documents."

While the United States is well represented in the drafting sessions with both the U.S. Military Delegation and the Defense Standardization Program Office, additional input by defense activities that support NATO standardization is welcomed. Your input is invaluable to our continued effort to work with allies and partners to ensure interoperability through standardization. Your review and comments will provide the input needed to ensure that AAP-03K makes it easier to conduct standardization business within NATO.

If you are interested in participating, please contact Latasha R. Beckman via e-mail at latasha.beckman@dla.mil, or by phone at 703-767-6872. As action officer, Ms. Beckman will ensure that you are included in efforts to coordinate AAP-03K within the United States, as appropriate.

Events

Upcoming Events and Information

April 26–28, 2016, Tysons, VA
PSMC Spring 2016 Meeting

The Parts Standardization and Management Committee (PSMC) will hold its spring 2016 meeting at the new LMI building, Rooms 1 South A and B, 7940 Jones Branch Drive, Tysons, VA 22102. Primary topic areas to be addressed include parts management contracts, procedures, and guidance; counterfeit parts and risk mitigation; and parts management tools and data. Participation is open only to PSMC participants. If you are interested in becoming a PSMC participant, please contact Donna McMurry at Donna.McMurry@dla.mil or 703-767-6874.

May 3–5, 2016, Mountain View, CA
NASA Ames Research Center

The next GIDEP New User Training Clinic is being planned for May 3–5 at the NASA Ames Research Center in Mountain View, CA. This event is specially geared toward new representatives and users who have been in the program for 3 years or less. Avoid "reinventing the wheel" and learn what's necessary to do the job right the first time. You will learn about representative responsibilities, policies, products, services, all five data areas, utilization reporting, and special sessions on DMSMS tools and counterfeit. Hands-on computer training also will be offered throughout the clinic. For more information, go to http://www.gidep.org/events/clinic/clinic.htm.

June 14–15, 2016, Knoxville, TN
SAE 2016 Additive Manufacturing Symposium

Get the latest information on innovations, technical advances, products, applications, and market issues. This conference is a great opportunity for technical and/or engineering professionals, business developers, quality or manufacturing experts, or leaders concerned with the design, production, development, and implementation of "3D printing" and associated technologies. For more information, go to http://www.sae.org/events/ams.

August 8–11, 2016, Denver, CO
65th Annual Standards Engineering Society Conference

The Standards Engineering Society (SES) will be holding its 65th Annual Conference on August 8–11 at the Grand Hyatt Hotel in Denver, CO. This year's conference theme is "New Frontiers in Standards and Conformity Assessment." The Keynote will be delivered by Keith Williams, president and CEO of Underwriters Laboratories Inc. For more information on this event, go to the SES website at http://www.ses-standards.org and click "annual conference."

Events

Upcoming Events and Information

October 24–28, 2016, Washington, DC
World Standards Week

Save the date—World Standards Week will take place the week of October 24, 2016. While many of the details are still being worked out, please "save the date" for what promises to be a comprehensive week of both meetings and events. A must attend for all standards professionals. For more information and event updates, go to http://www.ansi.org/wsweek.

December 5–8, 2016, Albuquerque, NM
2016 DoD Maintenance Symposium

The mission of the 2016 DoD Maintenance Symposium is to create an environment that enables attendees to share relevant information, identify critical issues, discuss key topics, and increase their awareness of Department of Defense maintenance initiatives. Join military, government, and industry leaders and maintainers from all levels at this distinctive, first-class event—the maintenance community's primary venue for networking and content sharing. For more information or registration details, go to http://www.sae.org/events/dod.

People

People in the Standardization Community

Farewell

Alex Melnikow retired on February 3, 2016, after more than 40 years of federal service. He began his career with the Tennessee Valley Authority (TVA), which he joined in 1975. After 7 years at TVA, he went on to hold various positions at the Naval Air Test Center and Defense Logistics Agency before coming to the Defense Standardization Program Office (DSPO) in 2007. While at DSPO, Mr. Melnikow was responsible for establishing policy, guidance, and training for the Diminishing Manufacturing Sources and Material Shortages (DMSMS) program and led efforts to invigorate proactive obsolescence management through enhanced engineering practices. We congratulate Alex on his retirement and wish him well in his future endeavors.

Charles Zegers retired after more than 30 years with the American National Standards Institute (ANSI). In his most recent position, he served as senior director for international policy and general secretary for the U.S. National Committee to the International Electrotechnical Commission. During his tenure at ANSI, Mr. Zegers served in various other positions, including director with staff responsibility for the Board of Standards Review and the Audit Accreditation Board and senior program administrator within various technical areas for the institute. Prior to joining ANSI, he also held positions with the American Society of Heating, Refrigeration and Air-Conditioning and the Edison Electric Institute. We wish him well in retirement.

Upcoming Issues
Call for Contributors

We are always seeking articles that relate to our themes or other standardization topics. We invite anyone involved in standardization—government employees, military personnel, industry leaders, members of academia, and others—to submit proposed articles for use in the *DSP Journal*. Please let us know if you would like to contribute.

Following are our themes for upcoming issues:

Issue	Theme
January/March 2016	Standardization Stars
April/June 2016	Interoperability
July/September 2016	Standards Policy
October/December 2016	Agency Standardization

If you have ideas for articles or want more information, contact Tim Koczanski, Editor, *DSP Journal*, Defense Standardization Program Office, 8725 John J. Kingman Road, STOP 5100, Fort Belvoir, VA 22060-6220 or e-mail DSP-Editor@dla.mil.

Our office reserves the right to modify or reject any submission as deemed appropriate. We will be glad to send out our editorial guidelines and work with any author to get his or her material shaped into an article.