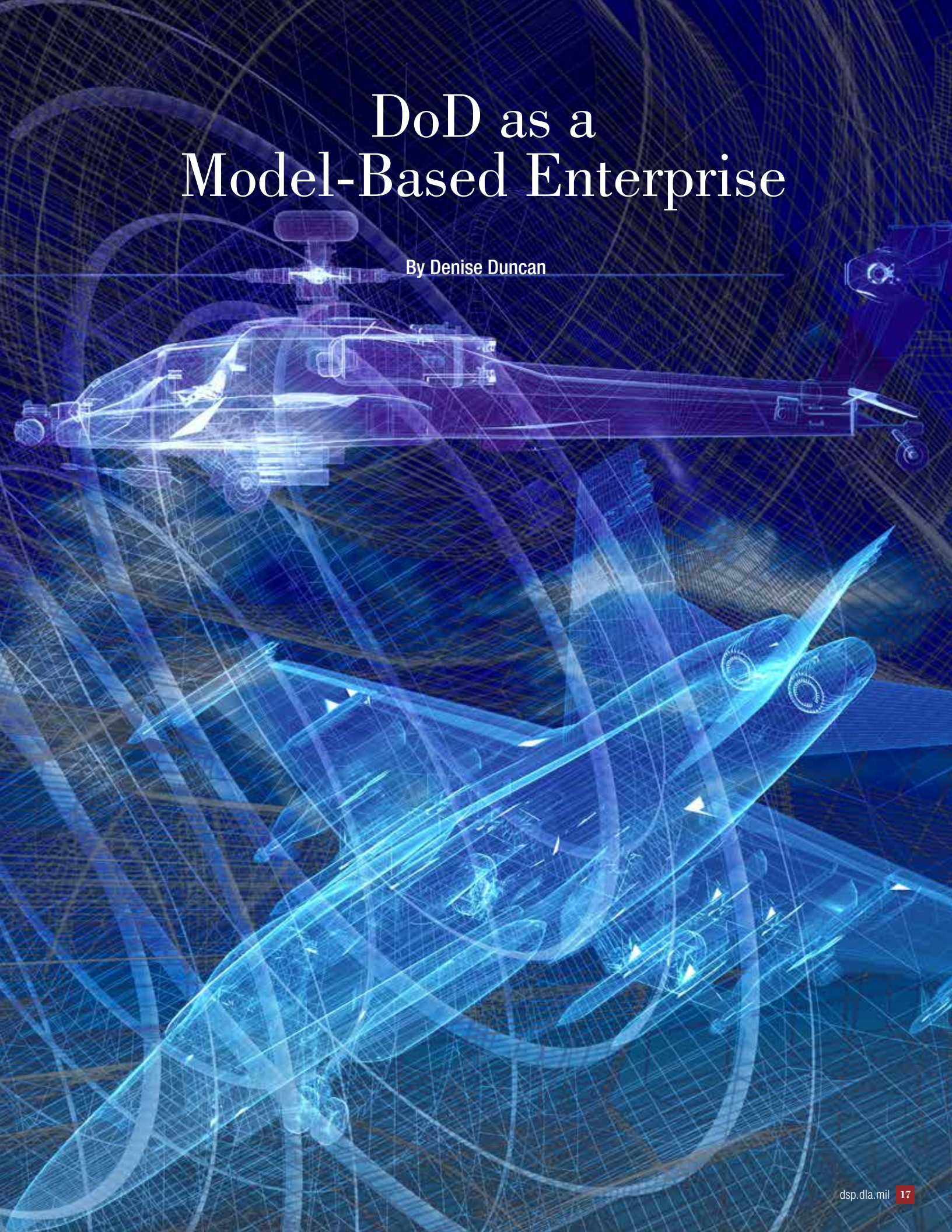
DoD as a Model-Based Enterprise

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.