Simulation Based Acquisition: The Revolution Is Coming!

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Feb 16, 1999

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The American Revolution was complete October 17, 1781, when British General Lord Charles Cornwallis surrendered his Army at Yorktown. So began the new republic breaking from traditions of the past. The rebellious colonials achieved victory against a military force superior in training, equipment and manpower. Most historians credit the American victory to a combination of innovative tactics, will power and the aid of outside interests. The enduring revolutionary form of government of the United States of America is a unique and unqualified success.

Revolutionary change in our defense acquisition process is essential. Our systems continue to cost too much, take too long to develop, and, once fielded, often require immediate upgrading of obsolescent technology. But, revolutions take time, effort and money. And, a successful revolution requires dedication and commitment at the individual level – as well as innovation, will power and dedication at the organizational level. Making precisely that point while addressing the Army's Simulation & Modeling for Acquisition, Requirements and Training (SMART) conference on January 28, 1999, Brigadier General Joseph Yakovac said: "To make a revolution a reality requires an entrepreneurial spirit." So it is for Simulation Based Acquisition (SBA). Like the will power driving the American Revolution, SBA can succeed in revolutionizing acquisition only if we have the desire and perseverance to make it happen.

We have a constant vision driving SBA. The vision was carefully crafted and approved in September 1997, by the DoD Executive Committee on Modeling and Simulation (EXCIMS) Acquisition Council with input from an Industry Steering Group operating under the National Defense Industrial Association.

The SBA Vision

An acquisition process in which DoD and industry are enabled by robust, collaborative use of simulation technology that is integrated across acquisition phases and programs.

This vision is a deliberate response to two facts:

1. We have a defense acquisition process costing TOO MUCH and taking TOO LONG. Average system development time is on the order of 8-10 years; total time to fielding is 15-20 years. Recall Norm Augustine's often cited projection – an extrapolation of aircraft unit cost history as a function of deployment date. He projected that by the middle of the next century the United States will only be able to afford one fearsomely sophisticated aircraft. While his analysis was intended in a humorous vein, cost trends are a real problem. System requirements and design decisions are made too early resulting in approximately 70% of the total cost of ownership of a system being locked in by milestone I of a program's life. Operation and support

costs continue to dominate the total life cycle costs without benefit of full understanding of what they are when the system is designed.

2. Clear and convincing evidence shows that modeling & simulation technology offers substantial benefits in time, cost and productivity. A 1996 study of modeling and simulation (M&S) effectiveness in acquisition (found at http://www.acq.osd.mil/te/pubdocs/acqstudy.htm) leaves no doubt that M&S adds value to defense acquisition programs. For example, with the use of simulation technology the Army Tank and Automotive Research Development and Engineering Center was able to design a new, low silhouette tank prototype using 14 engineers for 16 months, whereas it previously took 55 engineers 36 months. However, while such valuable, but typically stove-piped, application of M&S is clearly beneficial, it will not solve the cost and schedule problems of acquisition. Revolutionary change is necessary.

The goals addressed via the SBA vision correspond to those two above facts. SBA is a strategy for change deliberately intended to satisfy these three goals:

SBA Goals

1. Substantially reduce time, resources, and risk associated with the entire acquisition process.
2. Increase quality, military worth, and supportability of fielded systems while reducing their operating and sustaining costs throughout the total life cycle.
3. Enable Integrated Product and Process Development (IPPD) across the entire acquisition lifecycle.

The first two goals will result from the achievement of the third. IPPD evolved in industry, as an outgrowth of efforts such as Concurrent Engineering, to improve customer satisfaction and competitiveness in a global economy. But DoD has not achieved the full benefits of IPPD because we do not have the tools to allow respective users to "touch and feel" the item until a physical prototype is built. SBA enables IPPD by providing a collaborative, virtual context for system development. The underlying key technology is the computer that provides a dimension described by the Honorable Paige Hoeper (Assistant Secretary of the Army for Research, Development and Acquisition) as "electronic agility."

The cornerstone of SBA is the concept of continuous evaluation of programs throughout their development. This continuous evaluation process is facilitated by:

- Collaboration of all the functional areas, through the IPPD process, as a system matures from concept to design, manufacturing, fielding, employment, and finally disposal.
- A continuous comparative assessment activity. It begins early in the requirements generation process as operational needs are assessed in light of the materiel solutions trade space.

- Simulation and computer visualization technology which permit the user to see graphical views of operational performance and total cost resulting from early system representations of the user's requirements.
- As early designs take shape, concurrent consideration by the different functional areas to analyze the design in terms of training, force lethality, deployment, maintenance, man-machine interface, manufacturing processes, materials, environment, etc.
- Rapid iteration. Because of the capabilities of simulation and computer technology, iterations of design trades can occur quickly and extensive evaluation of the trade space can occur before decisions are made. This is the power of electronic agility.
- Robust assessment. The design trades include operational performance across a wide spectrum of scenarios, human interfaces, system to system interfaces, lifecycle sustainment, production materials, manufacturing processes, cost, etc.
- Synthetic environment testing. The system is virtually wrung-out in the computer before time and money are spent on physical prototypes. Mr. Hoeper has suggested: "whenever possible, we must reduce the need for costly, repetitive live testing."

The result: when physical prototypes are built, SBA will provide better form, fit, and function the first time – without expensive rework. As Dr. Jacques Gansler, Under Secretary of Defense (Acquisition and Technology), has said of SBA: "it gives you the ability to make lots of tradeoffs in cost and performance, early-on."[1] Increased use of M&S by the US commercial automotive industry, by the aerospace industry, and by defense programs has produced dramatic results.

M&S has provided substantial benefit measured in time, cost, productivity, system quality and performance. The evidence is consistent and pervasive, across both DoD and industry. It follows that M&S integrated across all the phases of a program will generate greater reuse and help to eliminate redundancy, saving even more time and money. Savings can continue to climb if M&S can be compatible across programs – much greater reuse and interoperability. An initial business case study of return on SBA investment considered all the factors – the evolution away from the traditional process, the challenges for future acquisitions, and the examples of successful M&S technological applications – and concluded sufficient information is available to warrant further investment in the SBA initiative.

Over the past year, DoD has developed a Roadmap for SBA – a set of recommendations for policy, education, technology development, and architecture designs for establishing SBA. The task force drafting the document was Joint, representing the military departments and defense agencies. In addition, an Industry Steering Group participated to identify the top priorities for SBA planning. The Roadmap is undergoing extensive coordination within government and industry. Currently, a draft strawman implementation plan assigns responsibility and priority for the activities to establish SBA. The Roadmap and the draft strawman Implementation

[1] Defense News, February 1, 1999, page 6, SBA Remains Pentagon Priority

Plan do not contain all the answers. The precise templates and standards to implement SBA are evolving. We plan to have a series of immediate and then deliberate SBA experiments to "Build-a-little, test-a-little" to arrive at a common set of designs for SBA to be used across industry and DoD.

The essence of SBA is not just the technical environment; it is three things:

1. The technical engineering environment exploiting the power of computer and simulation technology.
2. A reborn acquisition culture of new policy and regulation, direction, education, priority, and funding to take advantage of SBA.
3. A new process bringing together the separate system development functional areas of government and industry into a seamless, smoothly linked, and rapidly operating team.

The technical architecture in the Roadmap identifies basic features of SBA: Collaborative Environments, Distributed Product Descriptions, a DoD/Industry Resource Repository, and Standards.

Collaborative Environment

A Collaborative Environment (CE) is an enduring collection of resources, people, processes, and tools assembled to attack a given problem. Basically, a CE exploits information technology to permit people to work together and share common information, models, simulations, and data in real time.

The idea of collaborative environments is to create groupings of tools, people, and processes to foster reuse and interoperability. The intent is to be able to work across functional areas, across acquisition phases, and across programs.

There are many different types of collaborative environments that could be formed. Collaborative environments could be created within industry at the sub-system level, focusing on commonality between sub-systems of a system. Collaborative environments could be built at the traditional product level, seeking reuse and interoperability within the context of a common product like aircraft, ships, or tanks. Others propose building collaborative environments at the mission level, (e.g., strike warfare, integrated air defense) leveraging the commonality that exists between programs of the same mission area.

As a notional Collaborative Environment example consider tank, armored personnel carrier, and tracked artillery development centers working together to share common terrain, logistics, and vehicle design and performance data (in a "product line" Collaborative Environment).

Distributed Product Description (DPD)

The simple definition is a 3-dimensional representation of a system, combining data and other characteristics associated with a given product together with the inherent inter-relationships of the product with its environment. It includes associated process data (e.g., system function, requirements, manufacturing processes, cost data) with features such as user selectable views, etc.

The DPD is the responsibility of the Project/Program Manager (PM). It is the authoritative collection of program information. Users could consider the DPD as a one-stop shopping center for any information about a product. The DPD will include one or more system representations for others to use as they "play" the system in their simulations.

Interconnected via web technology, the DPD elements appear (to the user) to be a single, logically unified product representation. As a product develops during initial stages, the DPD associated with the product matures in parallel. The acquisition process acquires both the product and the associated representations of the product at the same time. It is these product representations within the DPD that will enable IPPD and IPTs. When provided the appropriate automated support tools and schema, all the IPT members will have access to and work with the same information resident in the DPD.

DoD/Industry Resource Repository (DIRR)

The DIRR is intended to be a collection of pointers in a web technology based distributed repository of DPDs, tools, information, and generic infrastructure components for use within and reuse across programs – the union of capabilities provided by all CEs. The DIRR can be likened to a card catalog. This virtual repository will be built on the existing M&S Resource Repository developed by the Defense M&S Office.

Standards

Certain formats are essential for interchange of information and interoperability. The Roadmap recognizes the need to establish an essential set of standards as necessary for M&S interoperability & reuse. The M&S community will need to develop a set of appropriate Data Interchange Formats (DIFs) that will support the interchange and flow of product information.

The relationship of the key SBA architectural components is illustrated in Figure 1, SBA Reference Systems Architecture.

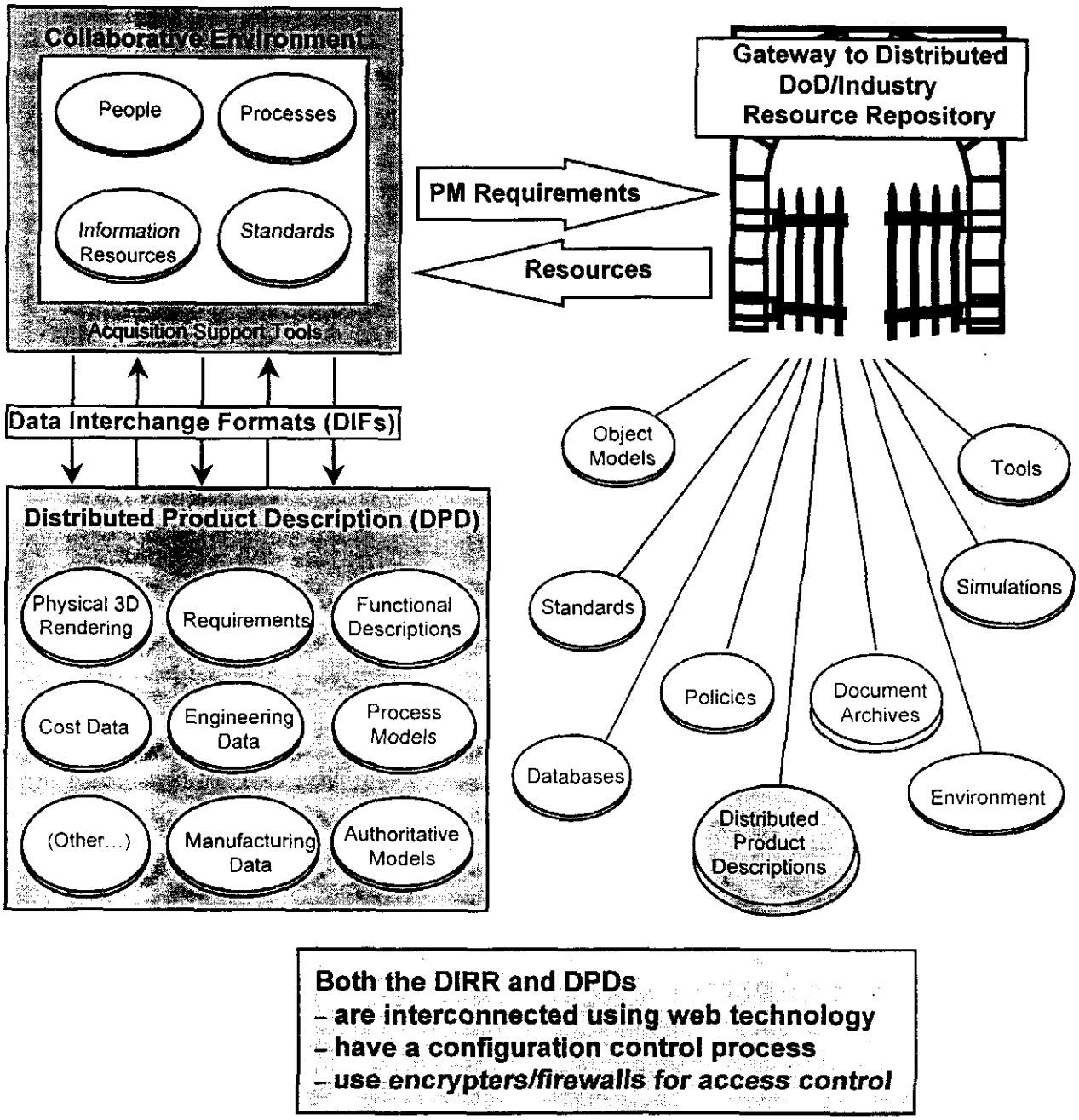

Figure 1. SBA Reference Systems Architecture.

In addition to the technical architecture, SBA requires change to existing culture and processes. Training the acquisition workforce in the use of the new concepts is critical to achieving the SBA vision. A working group has identified a comprehensive core body of knowledge for the Acquisition Council. The body of knowledge is the proposed M&S content for Defense Acquisition University curriculum.

DoD policy is sharpening its focus on the use of M&S in acquisition. In particular, DoD Directive 5000.1, DoD 5000.2R, and the DoD M&S Master Plan (DoD5000.59-P) agree that M&S must become an integral part of the entire acquisition process and system life cycle. As SBA parameters are better defined, the policy and doctrine will be updated.

The Roadmap and the implementation plan both prescribe a series of near term experiments to develop the technical environment by trial and error. The intent of the experimentation is beginning to define essential templates, interface mechanisms, and standards by a diversified and coordinated series of "Build-a-little, test-a-little" projects. Those participating have been described appropriately as the "Federation of the Willing." Emphasis will be on improving understanding of CEs, DPDs, and reuse and interoperability.

Service initiatives are underway and will contribute significantly to improved processes and understanding. Specifically, the Army has identified four "Flagship" programs for special attention and SMART application. They are the Crusader, Apache upgrade, Future Scout Cavalry System, and the Close Combat Tactical Trainer. Another example is the Fort Knox Mounted Maneuver Battle Lab work to establish a Collaborative Environment bringing together Manprint, vehicle technologies, tactics, and the joint/combined synthetic battlefield for an integrated approach to development. The Navy has a solicitation inviting industry ideas to develop a distributed "Collaborative Engineering Environment" for Navy systems aggregated at Battle Group/Force level. The acquisition strategy for the new destroyer program, DD21, calls for the two ship-builder prime contractors to each develop a Smart Product Model (SPM). The SPM will be one of the selection criteria used in selecting the winning development contractor. The Air Force is linking requirements M&S tools/data (used by C4ISR operators) with system design & build tools/data (used by C4ISR developers).

While there is a lot of activity, much is needed to move ahead with SBA. These actions are required but not necessarily listed in priority order:

Commitment by Defense leadership.	• *Direction and resources to move ahead.* • To execute the desired SBA Implementation Plan under the leadership of the Acquisition Council. • Priority for developing Distributed Product Descriptions (DPDs) vice simply physical hardware prototypes.
Planning & investment by programs.	• Encourage Programs to develop a comprehensive M&S plan focused on reuse across the acquisition cycle. • Adequate funding to implement the M&S plan.
Support of Congress for non-traditional funding profiles.	• Funding for Distributed Product Description and Collaborative Environment (DPD/CE) development. • Adequate investment in M&S early in the program.
New way of working with Industry – access to Distributed Product Descriptions (DPDs) and sharing models simulations and associated data. Several SBA experimental efforts are being considered now to examine different approaches.	• Consideration for property rights. • Configuration management. • Access control.
Programs working together, sharing system models, employment doctrine, interfaces across the battlefield, and performance data in Collaborative Environments.	
Technology development.	• First Principle or Physics Based models necessary for credible M&S. • Better models for reliability prediction of new systems. • Linking logistics & operational sustainment models to system design & performance modeling.
Development of standards will be *necessary for interoperability and* exchange of data in Distributed Product Descriptions, and to permit M&S reuse.	• We do not yet know exactly what standards *are appropriate.* • We hope to learn the correct approach as we "build-a-little, test-a-little." • *Models that will realistically represent total* cost of ownership.

The expectations for SBA are significant. The Defense leadership expects this approach to contribute substantially to a 50% reduction in acquisition cycle time and to achieve significant reductions in total cost of ownership. Clearly, much is left to do. But, M&S has proven to be an effective way to improve system acquisition.

SBA is still only a concept. It is a strategy for how DoD, as an enterprise, can conduct the future business of acquiring defense systems. It is a strategy that exploits recent advances in M&S technologies to change traditional paradigms and traverse current barriers in defense acquisition. SBA is using M&S to capture and share the state of product knowledge between functions, phases and programs. Much research remains to be done. One of the leading areas is in the development of appropriate reference architecture and standards that will permit the creation of collaborative environments and DPDs.

These are some of the necessary steps for a PM to move toward SBA and establish an environment for continuous weapon systems assessment using M&S:

- Start early, plan and resource robust M&S use - and reuse - across the system life-cycle, from pre-Milestone 1 through Disposal.
  - Use M&S in a program based upon a strategy and a detailed plan. The cost to implement the M&S plan must be funded.
  - Include industry in the M&S strategy and plan.
- Use M&S in a collaborative environment, with visualization technology, as a means to integrate functional areas for continuous evaluation of requirements, design, performance, sustainment, etc.
- Leverage other programs – reuse other credible M&S (threat, environment, etc) instead of building M&S again that already exists. Apply the philosophy of build once – reuse many times.
- Leverage HLA and other simulation and data standards that accommodate interoperability & reuse.
- Exploit M&S investment to evaluate the system continuously; use the power of M&S to rapidly iterate design trades.

I would like to close with a challenge – questions to assess use of SBA principles in programs:

1. Does your M&S plan address the full system Life Cycle, with reuse across phases?
2. Does the M&S funding profile support the M&S strategy?
3. Does the acquisition strategy call for a Distributed Product Description (DPD)?
4. Does the Acquisition Strategy place the DPD in the MSRR (DIRR)?
5. Is the program a part of any collaborative environments?
6. What M&S is leveraged from other programs?
7. Does the program leverage HLA and other standards?
8. Is interoperability outside the program a priority?
9. Is T&E integrated with your M&S strategy?
10. Has the program formed government/industry IPTs, including one for M&S? Are the IPT members empowered to make decisions to take advantage of SBA technology?
11. Are incentives identified for industry to assist in, or develop, necessary products & services to support SBA implementation?
12. Does the Acquisition Strategy call for sharing M&S with industry (ala IPPD) beginning as early as source selection and continuing over the program life?

So we have the constant SBA vision, the architectural concept announced in the Roadmap, the developing implementation plan, and an emerging set of experiments to refine the concepts. We are preparing the appropriate educational and regulatory changes. The military services are beginning to move ahead in their programs. We have identified several necessary actions, ranging from leadership commitment to technology development. We have assembled a set of questions to assess progress toward SBA. Have we covered all the bases? Remember BG Yakovac's basic requirement for a revolution? Entrepreneurial spirit is essential. I challenge you to look for opportunities for SBA, communicate your interest, devise new methods, bring in outside interests, and strive to break from traditions of the past. The SBA Revolution is coming. Are you ready to be one of the revolutionaries?

BIOGRAPHICAL SKETCH:

Dr. Patricia Sanders is the Director, Test, Systems Engineering and Evaluation (DTSE&E) for the Department of Defense (DoD) where she is responsible for ensuring the effective integration of all engineering disciplines into the system acquisition process. She is also responsible for oversight of the Department of Defense's Major Range and Test Facility Base (MRTFB) and the development of test resources such as instrumentation, targets, and other threat simulators. Dr. Sanders chairs the Defense Test and Training Steering Group, the Systems Engineering Steering Group, and the Acquisition Council on Modeling & Simulation.

Dr. Sanders has over twenty-four years of experience in the Department of Defense with particular emphasis in the areas of test & evaluation, modeling & simulation, resource allocation, and strategic planning.

She is a Fellow of the American Institute of Aeronautics and Astronautics (AIAA) and was awarded the 1998 AIAA deFlorez Award for Modeling and Simulation in recognition of inspiration and relentless advocacy in implementing the disciplined use of modeling and simulation in the DoD weapons systems acquisition process.