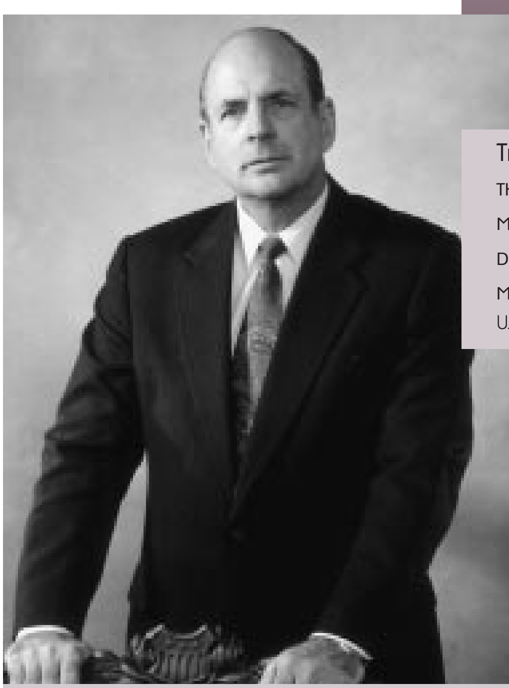
Simulation Based Acquisition

An Effective, Affordable Mechanism for Fielding Complex Technologies

DR. PATRICIA SANDERS

Defense modernization has come a long way technologically, and the United States may have reached a point where it is paying a penalty for past successes. During the Cold War, some argued that the country should not purchase the equipment the nation's industries were producing because it was unlikely to work. Today, not long after the Persian Gulf experience, these same people allege the government should not purchase the equipment that is being produced because it works so well no more is needed.

The Seawolf-class submarine, predecessor of the NSSN, was designed to be the "attack submarine of the 21st Century, "being the fastest, deepest diving, and most heavily armed submarine ever built by the United States."
U.S. Navy photo



Norm Augustine, Chief Executive Officer of Lockheed Martin, pointed out some years ago that the cost of each successive generation of fighter aircraft was increasing geometrically…some time in the middle of the next century, the country would be able to afford only one fearsome, sophisticated aircraft!
Photo by Bachrach

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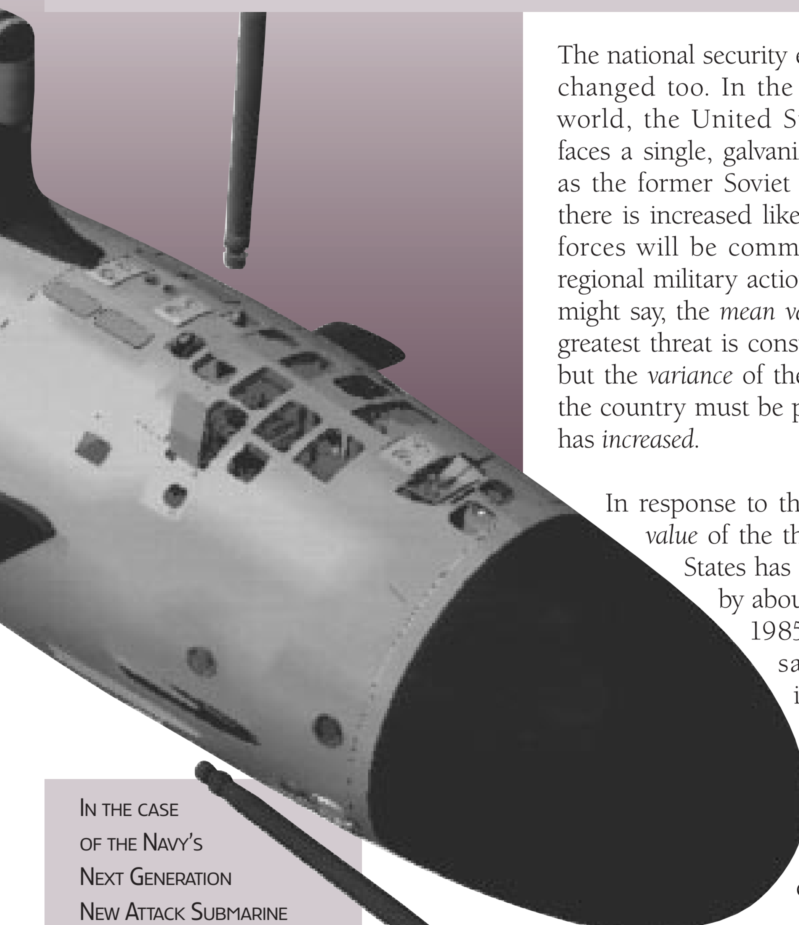
THE NAVY'S NEWEST CLASS OF SHIP, THE LPD 17, IS SCHEDULED TO REPLACE THE MAJORITY OF THE NAVY'S AMPHIBIOUS FLEET. THE LPD-17 PROGRAM SAVED $6 MILLION IN DESIGN COSTS THROUGH THE USE OF NEW MODELING AND SIMULATION TOOLS. AT THE SAME TIME, IT WAS ABLE TO ELIMINATE 100 TONS IN TOPSIDE WEIGHT, A DESIGN CHANGE EXPECTED TO RESULT IN GREATLY IMPROVED PERFORMANCE. THE NAVY ANNOUNCED THE CONTRACT AWARD FOR LPD-17 ON DEC. 17, 1996, TO GENERAL DYNAMICS LAND SYSTEMS, WHICH WILL BUILD THE LPD-17 FOR THE MARINE CORPS.

Photo courtesy General Dynamics Corporation

The national security environment has changed too. In the post-Cold War world, the United States no longer faces a single, galvanizing threat such as the former Soviet Union. Instead, there is increased likelihood that U.S. forces will be committed to limited regional military actions. A statistician might say, the *mean value* of the *single* greatest threat is considerably *reduced*, but the *variance* of the *collective* threat the country must be prepared to meet has *increased*.

In response to the reduced *mean value* of the threat, the United States has cut end strength by about one-third from 1985 levels. At the same time, the increase in *variance* has resulted in a one-third increase in the number of U.S. force deployments.



IN THE CASE OF THE NAVY'S NEXT GENERATION NEW ATTACK SUBMARINE (NSSN), NEW MODELING AND SIMULATION TOOLS HELPED REDUCE THE STANDARDS PARTS LIST TO ABOUT 16,000 ITEMS FROM THE 95,000 ITEMS LISTED FOR THE EARLIER SEAWOLF-CLASS SUBMARINE.

U.S. Navy Digital Representation

Procurement Reductions

The overall U.S. Department of Defense (DoD) budget has been cut by about one-third in real dollars since its peak in the late 1980s. When one considers that the procurement budget changes by two percentage points for every percentage point the overall DoD budget changes (up or down), one realizes that a significant decrease (about two-thirds) in procurement funding has taken place.

Traditionally, procurement has been the most volatile component of a DoD budget drawdown because —

- the acquisition of new equipment for a smaller force structure is viewed as unnecessary; and
- there is an emphasis on near-term readiness and a willingness to gamble on what constitutes acceptable technology.

The effect of such procurement reductions on the ultimate user of the equipment, i.e., the soldier, sailor, airman, or marine, must not be underestimated. If the issue of equipping the military forces is seen as a business proposition, one can readily calculate — by dividing the value of all tangible assets the DoD owns (exclusive of land and buildings) by the annual reinvestment in those same assets — that the average item of military equipment in America's inventory will have to last 54 years! This in a world where technology generally has a half-life of from two to 10 years, and combat casualties are directly related to the quality of technology employed.

Since this approach to the budget defers long-term modernization and is certain to have an adverse effect on future readiness, it must be interpreted as a temporary condition.

Need for Modernization Strategy

In view of the overall federal budget, it is only realistic to assume there will be continued pressure to limit increases in defense investment spending. In such a climate, it is important to think in terms of a *modernization*, rather than *recapitalization*, strategy for equipping U.S. forces. *Recapitalization* suggests a one-for-one replacement of existing platforms with new platforms having similar capabilities. *Modernization* means developing and fielding fewer, more capable systems. The key question is: Can the Defense Department afford a modernization-based investment approach? Technological complexity is certain to increase, dramatically in many instances.

Norm Augustine, Chief Executive Officer of Lockheed Martin, pointed out some years ago that the cost of each successive generation of fighter aircraft was increasing geometrically. As a result, although fighter aircraft were becoming more and more deadly, the United States could afford fewer and fewer of them. Augustine's calculation – an empirical plot of aircraft unit cost as a function of deployment date – was that by some time in the middle of the next century, the country would be able to afford only one fearsome, sophisticated aircraft!

The geometric increase in cost results because complex technologies become more and more interdependent. For example, a radio can interfere with aircraft flight controls or have an impact on electronic warfare equipment. To reduce radar signatures, designers may have to shape an aircraft in a way that forces them to move engines, weapons, and even the pilot. Any of these actions can affect other parts of a system's operation, not to mention its producibility or logistics support.

It is essential to remember that Augustine's prediction is empirical. It is based on past experience and processes for handling the interaction of increasingly complex technologies. Industry and the DoD need to share responsibility for finding an alternative path to fielding affordable, modern systems.

Becoming a "Smart Buyer"

The DoD needs to become a "smart buyer," in terms of both *what* and *how* it buys equipment. The *"what"* is at least as important as the *"how."*

What to Buy?

To determine what it will buy, the DoD is placing considerable emphasis on a "system-of-systems" decision-making approach, or construct. The goal is to select the most cost-effective mix of individual systems for development and fielding. Tradeoffs between onboard and off-board capabilities are being considered, and alternative systems are being evaluated under simulated combat conditions.

Recently, the Heavy Bomber Study looked at the adequacy of the planned bomber force in the context of a two-major-region, contingency scenario. The Strategic Airlift Force Mix Analysis and Tactical Utility Analysis were used to evaluate the cost effectiveness of various mixes of C-17 aircraft and nondevelopmental airlift platforms to perform airlift missions in support of various contingency operations. A similar study is currently in progress to evaluate the mix of accurately guided weapons the Department is procuring.

A hierarchy of models and simulations is being used to support these studies and to help make the what-to-buy decisions. First, at the engagement or system level, the system effectiveness against an adversary system is evaluated. Later, at the mission/battle or force-on-force level, the ability of a multiple platform force package to perform a specific mission is assessed. Finally, in theater- or campaign-level simulations, the conflict outcomes are determined for a total package of Joint and Combined forces.

Extensive use of constructive models for these system-of-systems evaluations is anticipated. Eventually, there will be much greater use of virtual prototypes operated on synthetic battlefields. Without question, the DoD is moving toward greater use of simulation-based system evaluations.

The Department's what-to-buy decisions are also being driven by life-cycle-cost-performance trades where cost is an independent variable. Gone are the days when performance was paramount, and cost took a back seat and was treated as a dependent variable. Life-cycle-cost-performance trades require evaluation of alternative designs and concepts. Computer modeling and simulation, including virtual prototypes, are needed to assess the performance of alternative designs in a simulated combat environment. They are also needed to examine the logistics, manufacturing, and producibility implications of alternative designs, and the cost and schedule impacts of pursuing alternative designs.

How to Buy?

The DoD must also change how it buys. The Department has worked to find the best methods for reengineering its processes. In May 1995 the Secretary of Defense directed a "fundamental change in the way we acquire goods and services" and mandated that the concepts of Integrated Product and Process Development (IPPD) and Integrated Product Teams (IPT) "be applied throughout the acquisition process to the maximum extent possible."

The DoD defines IPPD as "a management process that integrates all activities from product concept through production/field support, using a multifunctional team, to simultaneously optimize the product and its manufacturing and sustainment processes to meet cost and performance objectives." An outgrowth of concurrent engineering practices, the IPPD process reflects a systems engineering approach that has incorporated sound business practices and commonsense decision making. Fundamental to the successful implementation of the IPPD concept will be the willingness of organizations to undertake and experience profound changes in their cultures and past practices.

To reduce the costs associated with the integration of complex systems, it will be essential for the functional members of an IPT (e.g., design engineering, manufacturing, logistics, product support) to understand the concerns of their counterparts and to identify a program's technical challenges as early as possible. Tools available to an IPT include standard, relatively inexpensive computer equipment, virtual prototypes, and simulations. Such resources can aid in the development of a shared vision of the proposed system and provide a means for understanding the complex interactions among the configuration items in the system design.

The real power of a computer-based modeling and simulation system lies in the connection and coordination between the tools and the functional users. In addition to increasing the effectiveness of the design and manufacturing functional specialists, the product support members of the team (e.g., testers, logisticians, and maintainers) will benefit as well.

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Simulation Based Acquisition

The DoD envisions an acquisition process supported by the robust, collaborative use of simulation technology that is integrated across acquisition phases and programs. The objectives of Simulation Based Acquisition (SBA) are to —

- reduce the time, resources, and risk associated with the acquisition process;
- increase the quality, military utility, and supportability of systems developed and fielded; and
- enable IPPD from requirements definition and initial concept development through testing, manufacturing, and fielding.

Substantial evidence has already accumulated regarding the value of a simulation-based approach to acquisition. Both commercial and military programs provide pervasive evidence of tangible results that can be measured in terms of improvements in *cost, schedule, productivity,* and *quality/performance.*

Cost

The LPD-17 program saved $6 million in design costs through the use of new modeling and simulation tools. At the same time, it was able to eliminate 100 tons in topside weight, a design change expected to result in greatly improved performance. In the Joint Strike Fighter program, it is projected that virtual manufacturing techniques may save as much as 3 percent of the program's estimated life-cycle cost, which could be $5 billion.

Schedule

The use of modeling and simulation tools and processes by the "big three" auto manufacturers has reduced the time from concept approval to production from five to three years, and significant further schedule reductions are anticipated. Separately, Electric Boat™ reports it has been able to halve the time required for submarine development, from 14 to seven years.

Productivity

Productivity is also affected by the increased use of modeling and simulation. The required level of effort (person years) is often less, and fewer workers may be needed. Costly intermediate steps (e.g., mockups, redesigns, and engineering changes) can frequently be avoided, there is reduced scrap, and less manufacturing floor space is required when modeling and simulation are used.

It took 38 Sikorsky draftsmen approximately six months to develop working drawings of the CH-53E Super Stallion's outside contours. In contrast, using modeling and simulation one engineer was able to accomplish the same task for the Commanche helicopter in just one month. In another instance, 14 engineers at the Tank and Automotive Research and Development Center designed a new, low-silhouette tank prototype in only 16 months, a task that would have required approximately 55 engineers and three years with more traditional methods.

Quality/Performance

The positive impact of modeling and simulation on quality and performance can be seen in a number of areas, e.g., the proper assembly of products and systems, fewer instances where rework is needed, a reduced parts count, and the opportunity for early design evaluation prior to further design efforts.

For example, Northrop's use of CAD [computer-aided design] systems led to a first-time, error-free, physical mockup of many sections of the B-2 aircraft. In the case of the Navy's Next Generation New Attack Submarine, new modeling and simulation tools helped reduce the standards parts list to about 16,000 items from the 95,000 items listed for the earlier Seawolf-class submarine.

Embracing This Approach — What is Needed?

It is clear that IPPD, backed by a strong commitment to computer-based modeling and simulation tools, provides a dominant and competitive edge in the commercial marketplace and a distinct warfighting advantage on the battlefield. It provides an alternate path for getting to market first, at lower cost. In the process, quality is improved. The underlying technology is widely available, and market forces are driving industry toward SBA. So what is needed to fully embrace this approach?

SBA is comprised of three principal components. The first is an *advanced systems engineering environment* that uses formal methods and automation to support efficient design synthesis, capture, and assessment, as well as other complex life-cycle activities. The SBA engineering environment provides a means for executing a process that can be extended, tailored, and repeated. The process results in the creation of reusable design repositories and products that can be reengineered. The potential gains from the use of such an advanced SBA environment will not be realized until the engineering process, as well as its people and organizations, also evolve.

The second component is a *refined system acquisition process* that takes advantage of the SBA systems engineering environment capabilities. The third component is a culture that has evolved to a point where *enterprise-wide cooperation* is the rule, and individual technical contributions and innovations are encouraged and managed efficiently.

SBA *is not an incremental step* beyond current system engineering methods and tools. Instead, it represents *a major paradigm shift* toward a comprehensive, integrated environment that addresses the entire system development life cycle and the spectrum of engineering and management domains.

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The benefits from the SBA process will be realized not only as time and cost savings within individual programs, but also as cost savings when a program makes use of design repositories and reengineered tools and products from other programs.

Cross-Program Use of Data, Tools, and Techniques

Modeling and simulation tools, as enablers for IPPD development, are already being applied successfully to reduce development time and life-cycle costs in a range of ongoing acquisition programs. The issue is no longer whether extensive use of modeling and simulation tools has merit, but rather how to develop and apply a new acquisition process in a deliberate and coordinated manner that uses these tools to maximum advantage and achieves even more dramatic reductions in cost, schedule, and risk.

The challenge for acquisition reform is to provide the catalyst that will expand the growing successful use of modeling and simulation tools beyond vertical applications within individual programs. If this is accomplished, even more significant benefits will be realized through the shared use of data, tools, and techniques by government and industry. Unambiguous communication is required to achieve full application of the IPPD and IPT processes; such communication can serve as the catalyst that encourages a new acquisition culture to use these powerful new tools and processes.

Partnership

The challenge is clear: The trend toward geometrically escalating costs in successive generations of defense equipment must be reversed. Limiting the sophistication, and therefore the capability, of future systems is not a realistic option. The task is to field increasingly complex technologies at a more affordable cost, in less time.

This will require a team effort by industry and the DoD to field a superior capability, affordably and in less time than potential adversaries. Industry needs to use the latest information technologies to upgrade its integrated product capabilities. The DoD needs to become a smarter buyer. Together, industry and government must ensure that the acquisition management culture evolves to —

- take advantage of IPPD approaches that stress the need for a shared vision and continuous insight to ensure that quality is built into programs from the start;
- emphasize prevention over cures by using virtual prototypes and simulations to identify and resolve problems early; and
- focus on overall program success, not functional area performance.

The appropriate vehicle for meeting this challenge is SBA, a method which combines a new process, new tools, and a new culture to develop a strong collaborative partnership between government and industry.

Dr. Patricia Sanders

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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. These include design, production, manufacturing and quality, acquisition logistics, modeling and simulation, and software engineering, with emphasis on test and evaluation as the feedback loop. 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. The MRTFB comprises more than 50 percent of the DoD land resources, represents a capital investment of more than $25 billion, and employs approximately 47,000 government and contractor personnel. Sanders chairs the Defense Test and Training Steering Group, the Systems Engineering Steering Group, and the Acquisition Council on Modeling and Simulation. She reports directly to the Principal Deputy Under Secretary of Defense for Acquisition and Technology.

Sanders has over 22 years of experience in the Department of Defense with particular emphasis in the areas of test and evaluation, modeling and simulation, resource allocation, and strategic planning. Prior positions within the Office of the Secretary of Defense included serving as the Deputy Director for Test Facilities and Resources, the Director of Land Forces in the Office of the Assistant Secretary of Defense for Program Analysis and Evaluation, and as a Staff Specialist for the Director of Operational Test and Evaluation. Other assignments have included serving as Deputy Director for Analysis, United States Space Command; Science Advisor to the Command, Control, Communications, and Countermeasures Joint Test Force; and Chief of Modeling and Simulation and Technical Advisor to the Electronics Systems Division at the Air Force Operational Test and Evaluation Center. Her government career was preceded by university faculty positions.

Sanders received her doctorate in mathematics in 1972 as a National Science Foundation Fellow at Wayne State University and is a 1992 graduate of the Senior Executive Fellow Program, John F. Kennedy School of Government, Harvard University. She is a member of the Senior Advisory Board and a past President of the International Test and Evaluation Association (ITEA), a Fellow of the American Institute of Aeronautics and Astronautics, and a member of the Board of Directors of the Military Operations Research Society.