



Guest Editor's Introduction

Dale K. Pace

Warfare analysis has numerous applications across many disciplines. With the aid of warfare analysis, defense leaders can determine which military forces will best serve the national interests, and military leaders can evaluate their strategy and tactics. It helps military planners determine the number of ships, aircraft, tanks, and other forces needed to counter threats, enhances the ability of weapon system designers and developers to determine the most appropriate characteristics for a particular weapon, and increases the warfighter's understanding of force employment.

This is the second of two *Technical Digest* issues focused on warfare analysis. The first appeared concurrently with the move of the Joint Warfare Analysis Department (JWAD) to new facilities in APL's recently completed Building 26 in May 2000. These facilities have substantially enhanced the Department's capability for collaborative analysis through a new version of the Warfare Analysis Laboratory called WAL 2000. Consequently, seven articles in "Warfare Analysis Part I" addressed the WAL and WAL exercises (WALEXs). They provided a historical review of WAL applications and accomplishments over the past two decades as well as descriptions of specific WAL applications, WAL 2000, and the WALEX process.

These WAL-related articles were preceded by three articles that offered perspective about warfare analysis. One traced the evolution of warfare analysis at APL from the 1940s to the present, examining its characteristics and identifying some of the Laboratory's special contributions to this art. The second article described the distinctive characteristics of Joint warfare analysis, and the third described the important role that Design Reference Missions (DRMs) play in the development of effective warfare systems.

The issue concluded with four articles that illustrated different applications of warfare analysis, including missile defense, undersea warfare, mine countermeasures, and logistics. These analyses used a variety of techniques and computer simulations. Taken as a whole, the articles demonstrated some of the breadth encountered in warfare analysis. (For reader convenience, we have included all warfare analysis articles for both issues in the tables of contents—Part I and II.)

This second issue of the *Technical Digest* devoted to warfare analysis focuses more on methodology and technology rather than applications. How is an increased comprehension of a complex topic such as “Network-Centric Warfare” (NCW) obtained through use of a war room (or study room)? How can cornerstones be used as a stabilizing focus in the analysis and development of capabilities in a particular warfare arena? How should cost and affordability issues be addressed? These are among the methodology issues considered here. Other topics include the development of simulation conceptual models; the use of the High Level Architecture (HLA) to increase distributed simulation capabilities; simulation verification, validation, and accreditation (VV&A) issues; and the development of a road map for simulation based acquisition (SBA). We also consider ways to incorporate C⁴ISR (command, control, communications, computers, intelligence, surveillance, reconnaissance, and targeting) in DRMs, analytical processes for ship defense, and “sufficiency analysis” for surface combatant force structure studies.

These articles provide an indication of the current state of warfare analysis methodology and technology as well as ways that Laboratory personnel are contributing to their advancement. These methods help APL and its sponsors to better understand the dynamic and evolving environment in which we all live, identifying areas in which the Laboratory can apply its capabilities to enhance the security and well-being of our nation.

Most of the authors are members of JWAD, and as one might expect, the focus of this issue, like that of the first, is on warfare analysis performed at APL, especially within JWAD. The remainder of this introduction provides a guide to the content of the articles presented here.

THE ARTICLES

The articles are organized into three general groupings. The first group contains an article by guest author Dr. Patricia Sanders, the Associate Director of the Ballistic Missile Defense Organization for Testing, Simulation, and Evaluation. She addresses the attributes of warfare analysis that make it most useful—relevance, reliability, and timeliness—from her perspective as a government leader who must use the results of warfare analyses. Her responsibilities range from the development and application of models and simulations to system testing and the evaluation of both current and potential concepts and capabilities. This gives her perspective both depth and breadth, making her article most appropriate as a source of ideas against which warfare analyses should be measured.

The second group contains 10 articles. In the first, Heidepriem describes how JWAD helps the Laboratory

and its sponsors better understand our dynamic and evolving environment through general background studies and assessments that provide both perspective and a foundation for more focused endeavors. The author details JWAD’s role in a number of areas during the past decade including Desert Shield/Desert Storm and operations in Kosovo, Joint warfighting requirements, counterterrorism efforts, the Infosphere, NCW, and an assessment of trends for the Laboratory’s strategic planning. A significant aspect of the multistep, iterative process illustrated in this article is its potential to create coherence among the multiple perspectives that are brought to bear on a complex issue. These perspectives must address not only the different levels at which a problem is viewed (ranging from the microscopic to the macroscopic), but also the orthogonal aspects of policy, social and legal considerations, and military practices. Coherence in addressing such complex issues means that the impact of one factor on another is considered and that assumptions related to each factor are compatible with assumptions for other factors. The iterative review, reassessment, and refocusing that is the heart of the process is key to the development of such coherence in perspective.

Next, Pace addresses the development of a simulation conceptual model for both unitary and distributed simulations. The conceptual model addresses the relevant application domain context for the simulation, how the simulation will satisfy its requirements, and how entities and processes will be represented within the simulation. It establishes simulation appropriateness for intended applications. Pace focuses on three approaches that enhance simulation conceptual model completeness and correctness: (1) conceptual model definition processes, which are closely associated with the subject of requirements engineering; (2) conceptual model decomposition, which concerns the level of detail or aggregation appropriate for simulation elements; and (3) “real-world” abstraction to provide representation in the simulation.

The DoD HLA was established to promote and facilitate interoperability across a wide range of military simulation systems. The purpose of the HLA Object Model Template (OMT) is twofold: to provide a standardized mechanism for HLA federations (i.e., distributed simulations) to formally specify the exchange of runtime data, and to provide a standard format for specifying the public interfaces of individual HLA federates. In the third article of this group, Lutz reports on recent efforts to transition the current DoD version of OMT (V1.3) to a recognized commercial standard.

In 1997 the Acquisition Council of the DoD Executive Council for Modeling and Simulation (EXCIMS) adopted a vision for SBA: “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." Subsequently, a Joint Task Force was chartered to develop a SBA road map. Keane et al. describe how the Laboratory, as part of the Task Force, developed the architecture concepts covering the operational, systems, and technical views that would promote the interoperability and reuse of models and simulations.

Amazing advances in software, computer, and network technology have occurred in the last 10 years. These advances have contributed significantly to the increasing impact of models and simulations on scientific investigation, system acquisition and development, operational decision aids, planning, analysis, medical diagnosis, and many other areas. There is growing emphasis on processes that will ensure that computer models and simulations are performing correctly and that appropriate confidence can be placed in their results. This has been accompanied by an increased use of models and simulations. VV&A is one way to establish the required correctness and credibility of simulations. The article by Youngblood et al. addresses APL's VV&A activities and describes the Laboratory's contribution to advances in VV&A methodology.

Also during the last decade, the commercial world has demonstrated that significant gains are possible through network-centric computing, i.e., linking together computers over networks to speed transactions, monitor sales and inventories, and identify shifts in customer trends. The Navy realizes that this same network-centric approach can provide significant military gains and uses Network-Centric Warfare as a label for such an approach. NCW is a fundamental shift from platform-centric warfare and may prove to be one of the most important changes the Navy has undergone. When the NCW concept first appeared, very little was known about its potential capabilities, possible vulnerabilities, or requirements for implementation. As a consequence, JWAD set up an NCW War Room to develop a better understanding of the approach and identify its implications and opportunities for APL. Sinex et al. describe the NCW War Room to illustrate how this approach can contribute to the comprehension of a complex topic. A particularly interesting innovation adopted in this NCW War Room was the use of a parallel electronic war room to preserve a record of the process.

The article by Salamacha et al. describes the ways in which C⁴ISRT is characterized as a function of mission context. Navy-sponsored DRMs provide contexts for the Area Air Defense Commander function in Theater Air Defense and platform-specific contexts for the next-generation aircraft carrier CVNX and future land-attack destroyer DD 21. All of these DRMs view C⁴ISRT as an enabler for warfighting missions and characterize it in terms of the combat activities it supports. The DRMs, however, have fundamentally different operational

perspectives and objectives, with resulting differences in C⁴ISRT emphasis and implications as to how C⁴ISRT should be characterized.

Next, Foard addresses Theater Air Defense (TAD) Cornerstones and how they were developed. Any large-scale military system, or in the TAD case, a "system-of-systems," benefits from a disciplined, systems engineering-based development process. This discipline concerns itself first with mission needs statements, operational requirements, and concepts of operation from which architectural designs and trade-offs can be derived. The Navy, drawing upon past systems development experience with the Aegis Weapon System, undertook an effort in late 1997 to develop a set of guiding principles for future systems development. These principles, known as Cornerstones, were developed to solidify and emphasize the most important attributes that lead to performance success for TAD systems and shape their engineering development. The Cornerstones are enduring and simple expressions of key technical factors that are measurable and stable.

The article by Farris and Stuckey describes an adaptable, efficient, and cost-effective process that has been developed to analyze ship self-defense systems in support of Program Executive Office (PEO) Theater Surface Combatants and PEO Expeditionary Warfare. A broad range of ship defense anti-air weapon systems and threats were modeled and evaluated. The analysis process relies on, and in turn expands, an extensive database of Navy weapon systems and threats. The article discusses the need for ship self-defense combat system analysis and presents three examples that illustrate the process.

The final article in this group examines studies conducted to assess the surface combatant force structure needed from 2005 to 2025. Although the studies were performed in a Joint context, only certain classes of combatants were considered. Morris describes an approach that blended results from many different analysis tools, including wargaming, computer simulations, and simple analytical models. This approach allowed key factors to be clearly appreciated, resulting in a means to determine the capability of possible surface combatant forces to satisfy specified requirements. This article illustrates how flexibility in using analytical tools and approaches can reduce the amount of resources required to develop useful insights for decision makers.

The final group of articles deals with ways to treat cost and affordability issues in warfare analysis. First, Luman shows how cost/performance models of systems can be integrated to facilitate requirements allocations for complex systems. The engineering of complex systems as well as systems of systems has become increasingly problematic in recent years. Although

characteristics and systems engineering challenges associated with complex systems are well understood, effective “architecting” approaches that enable cost/performance trades are still immature.

A systematic approach to the allocation of top-level system requirements to component systems using cost as independent variable (CAIV) has been demonstrated on a naval mine countermeasures system-of-systems representation of sufficient complexity to demonstrate its feasibility. By integrating traditional performance models and innovative performance-based cost models, the “best” system requirements allocation can be determined as a function of total system cost. A series of point designs would be generated, expressed in terms of key performance parameters that have been optimized by considering all component systems simultaneously, not just one at a time. Since the process can apply nonlinear constrained optimization techniques as necessary to capture system complexity, the cost models can also be nonlinear, thereby accommodating full life-cycle cost models. This integrated cost and performance analysis then produces (1) system effectiveness as function of cost (CAIV), (2) corresponding subsystem requirements allocations, and (3) a corresponding force structure or inputs to an overarching force-level cost/performance analysis. Furthermore, parametric analysis on the integrated model can provide insights into threat, mission, and system architecture assumptions as well as total system sensitivities necessary to focus an effective technology investment strategy.

The second article in this group concerns the evaluation of “affordability initiatives.” In today’s defense acquisition climate, the affordability of weapons system development is an important consideration. One way that defense leaders are approaching affordability is by introducing affordability initiatives into their program development plans. Myers et al. describe how the Laboratory worked with the Joint Strike Fighter Program

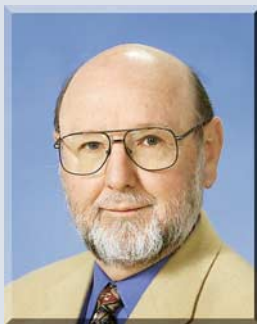
Office’s Advanced Cost Estimating Integrated Product Team to develop a method to evaluate these initiatives. The process focused on assessing the risks of each initiative, with the results providing inputs to government cost estimating models.

In the final article, Kroshl and Pandolfini address affordability analysis for Defense Advanced Research Projects Agency (DARPA) programs. In recent years, affordability analysis has become important for understanding investments and payoffs of all types of projects. Competing claims on a shrinking defense budget means that not every idea, no matter how technically sound, can be developed. DARPA projects are high-risk, high-payoff endeavors that involve advanced technologies. There are special challenges in conducting an affordability analysis for such advanced concepts; the traditional methods of cost and benefit estimation may not be applicable or may need modification to fit the needs of the analysis. The Laboratory conducted three affordability analyses for DARPA projects: affordable rapid response missiles, flexible fabrication of titanium, and gun-launched satellite systems. The methods described in the article include a blend of interval cost estimation and life-cycle cost/benefit analysis.

SUMMARY

Taken together, these articles show some of APL’s contributions to contemporary warfare analysis methodology and technology. They also reveal something of the background of experience and analytical capability that APL brings to warfare analysis. This is one reason why the Laboratory’s past warfare analyses have been so useful to the defense community. The future use of these skills by APL analysts will help the Laboratory continue to deal constructively with complex problems of national significance, especially those whose difficulty requires creative and innovative approaches.

THE GUEST EDITOR



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