



Guest Editor's Introduction

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America's defense leaders face many challenges. They have to cope with a world that is very different from the World War II and Cold War eras, during which the adversary was clearly known and methods of conflict well understood. Missile technology and weapons of mass destruction, especially chemical and biological, have proliferated, not only among nations but also terrorist groups. The whole arena of information operations and attitudes about U.S. casualties compound the challenges faced by defense leaders as they seek to determine how to equip and use America's military. Warfare analysis helps our leaders cope with these challenges.

Warfare analysis applies scientific methods to the study of warfare and related topics. As such, warfare analysis seeks to collect, organize, and manipulate information so as to reach conclusions that are logically compelling and conceptually robust. Usually emphasis is placed on quantitative, repeatable, and functionally clear methods. This makes warfare analysis what the first textbook on operations research called "polemology," from the Greek word for warfare, *polemos*.¹ The breadth of warfare analysis encompasses not only the weapon systems used in warfare, but also the technologies upon which they depend and the political and social contexts within which they are exercised. Warfare analysis considers military tactics and strategies, but also addresses analytical methods used to assess military operations and concepts. It even extends to the economic, personnel, and organizational structures in which weapon systems and military forces exist. This perspective on warfare analysis reveals its murkiness; so many factors interact in the real world that it sometimes can be difficult to ensure that an analysis has accounted properly for all the significant aspects of warfare under consideration.

This is the first of two issues of the *Johns Hopkins APL Technical Digest* focused on warfare analysis. Most of the authors are members of the Laboratory's Joint Warfare Analysis Department (JWAD), and as one might expect, these two issues focus on warfare analysis performed at APL, especially within JWAD. Although the historical roots of an organization within the Laboratory devoted to warfare analysis extend back to the 1940s, the *Joint* emphasis in APL's warfare analysis is relatively recent. For most

of the 1980s and 1990s, the Naval Warfare Analysis Department (NWAD) was the element of the Laboratory devoted to warfare analysis, and the name reflected its emphasis, even though its analyses addressed air, space, and land warfare as well as naval warfare. In 1996, under the leadership of Robert F. Gehrke, then Department Head of NWAD, JWAD was created to reflect the growing emphasis on the multiservice aspects of warfare analysis. The articles in these two issues reflect this emphasis.



Robert F. Gehrke, NWAD Department Head, 1992–1996; JWAD Department Head, 1996–1997.

This first issue appears concurrently with JWAD's move into new facilities in APL's latest building (opened in May 2000). These facilities substantially enhance the Department's capability for collaborative analysis through the new version of the Warfare Analysis Laboratory called WAL 2000. Consequently, significant attention is given in this issue to our approach to collaborative analysis. Seven of the articles address the WAL and WAL exercises (WALEXs). These articles provide a historical review of WAL applications and accomplishments over the past two decades as well as descriptions of specific WAL applications, the new WAL 2000 facility, and the WALEX process. The WAL-related articles are preceded by three articles that offer perspectives about warfare analysis. The first traces the evolution of warfare analysis at APL from the 1940s to the present, examining its characteristics and identifying some of APL's special contributions to this art. The second article describes the distinctive characteristics of Joint warfare analysis, and the third highlights the important role that Design Reference Missions (DRMs) play in the development of effective warfare systems. The

issue concludes with four articles that illustrate various applications of warfare analysis.

The second issue of the *Technical Digest* devoted to warfare analysis (to appear next quarter) focuses mainly on the methodologies, modeling and simulation techniques, and technologies supporting warfare analysis. Together these two issues provide indications of the wide variety of problems which have been addressed by Laboratory analysts and our warfare analysis capabilities in resolving them. For reader convenience, the table of contents in each issue lists all warfare analysis articles for both issues. The remainder of this introduction serves as a guide to the content of the current issue.

THE ARTICLES

The articles presented here are organized into three general groupings. The first group gives a perspective on warfare analysis. Since the 1940s, APL has used its warfare analysis capabilities to analyze future military needs, evolve appropriate requirements to meet those needs, and evaluate alternative solutions to meet those requirements. The opening article by Pace and Gingras describes the origins and evolution of warfare analysis at APL and shows how it has been applied to a wide range of problems. Information developed from APL warfare analysis efforts has contributed to important decisions shaping our military forces. Our efforts also contributed to the development of analytical tools and collaborative analysis techniques which have been widely shared and adapted within the defense community.

In the second article, Biemer and O'Brien describe an approach to Joint warfare analysis that provides decision makers with information needed to evaluate alternative approaches to meeting future Joint war-fighting needs. "Jointness" is not a new concept in military operations, but the past 15 years have seen a dramatic increase in its importance. Historically, the Army, Navy, Air Force, and Marine Corps have worked toward common goals to enhance overall military capability to meet expected national security challenges. Today, a primary goal of jointness is to leverage individual service capabilities and unique strengths to reduce requirements for multiple, possibly redundant, military acquisition programs. The article identifies the distinguishing characteristics of Joint warfare analysis.

The last article of the group addresses DRMs. Skolnick and Wilkins discuss the need for and the role of DRMs in the Navy systems engineering process, introduce DRM objectives, and trace the recent evolution of the DRM concept. The end of the Cold War forced the Navy to develop new cost-effective systems that must be flexible and sufficiently robust to successfully conduct a host of worldwide missions. These missions increasingly require operations in littoral

regions, a complex arena characterized by a multitude and variety of potential threats, reduced maneuver areas and reaction times, and stressing physical environments. A DRM defines the projected threat and operating environment baseline for a rigorous systems engineering process to help ensure that future Navy systems can meet 21st century challenges and uncertainties. The DRM defines the problem, not the solution, via families of specific operationally representative situations and supporting characterizations of the threat and physical environment.

The second grouping of articles focuses on APL's WAL and WALEXs. Gingras describes the evolution of the WAL, the associated analysis process, examples of significant WAL applications, and the analytical and programmatic contributions of the WAL process to assessments of both defense and nondefense problems. The WAL is a dynamic, interactive systems analysis facility designed for requirements development, concept evaluation, planning, and simulation. It also has shown its usefulness in evaluating technology's benefits for operational systems in the real world.² People and organizations are brought together and led through a well-defined, yet adaptable, seminar process by experienced facilitators and staff. The WAL allows participants to examine and prioritize requirements for meeting future needs and to assess capabilities and limitations of current, planned, and proposed systems and concepts. Blending visualization, simulation, and information technologies with a structured analysis process provides an environment for effective collaborative analysis of complex systems engineering and planning problems.

In the second article, Nolen details the collaborative analysis process used in WALEXs. The methodology developed for conducting open seminar war games in the WAL to analyze problems of naval and Joint warfare has proven to be a highly adaptive and flexible approach for addressing many kinds of complex issues collaboratively. These issues include some outside the defense arena such as transportation and management, as well as the full spectrum of military operations ranging from medical and logistics support for the services through system design to combat. Nolen describes the underlying WALEX concept, its basic features, and its development using the WALEX process.

The design of WAL 2000 reflects lessons learned from our earlier analysis laboratories and the evolution of our analysis processes. Its analytical tools and physical arrangement have been combined to create a unique collaborative environment. Technological advances have extended the reach of this environment and improved the interactivity and fidelity of its tools. The article by Dean describes the key design elements of WAL 2000 and discusses important features of the facility, the capabilities they provide, and the rationale

for their inclusion. These features include an expansion of its physical capacity to handle larger numbers of participants, the extension and development of WAL telecommunications and data networks that add a geographically distributed dimension to the facility, and the modernization and improvement of its analysis tools.

The next four articles address WAL applications. They show how a varied set of sponsors have used WALEXs in very different areas of warfare analysis. The Ballistic Missile Defense Organization (BMDO) successfully employed WALEXs to improve the understanding of missile defense issues for both the United States and the international community. Kohri and Amann describe a collaborative examination of missile defense requirements. Extensive knowledge was gained by WALEX participants, at significant savings in cost and time to the sponsor, when compared to the amount of time and effort that would have been expended in trying to achieve the same outcome through ordinary meetings, seminars, or war games.

From June 1995 through September 1998, a series of WALEXs supported a request by the Naval Air Systems Command to examine a concept for Navy Overland Cruise Missile Defense, previously called the Air-Directed Surface-to-Air Missile (ADSAM) System concept. Kauderer's article describes how a team of analysts and engineers was assembled from APL and elsewhere to develop a high-fidelity, physics-based engineering modeling process suitable for understanding and assessing the performance of both individual systems and the "system of systems" related to this idea.

A "Collaborative Tools Workshop" was conducted for the Air Force Command and Control Battlelab (C²B) in May 1998 to explore the potential use of such tools in the preparation of an Air Tasking Order (ATO) in a geographically and temporally distributed environment. Keane et al. use this workshop as an example of Air Force WALEX applications. The exercise was designed to "walk" participants through several vignettes to identify issues related to the use of collaborative tools and to develop or examine alternative means to resolve them. APL and C²B staff developed a model encompassing both the ATO development cycle and the Joint Air Operations Center Division structure which were used to focus discussion during the workshop. Comments from subject-matter experts were gathered using the WAL's Electronic Seminar Support System. Insights gained for the use of collaborative tools were incorporated in the C²B Concept of Operations which was exercised in Expeditionary Force Experiment '98.

The equipment, systems, and operational procedures used by warfighters and operators in the field must continually evolve to cope with today's ever-changing operational environment. Such changes can result from evolving doctrine or policy as well as different types and numbers of threats. In the final article of the WALEX

grouping, Kohri describes how interactive seminars helped warfighters and developers determine the best use of technology to protect troops against biological warfare, specifically the early detection of biological warfare agents, for the Joint Biological Remote Early Warning System Advanced Concept Technology Demonstration.

The final group of articles highlights the specific application of warfare analysis in four areas. These articles address a variety of situations including missile defense, undersea warfare, mine countermeasures, and logistics. The analyses reported employed a range of analytic techniques and computer simulations. Taken as a whole, the articles demonstrate some of the breadth encountered in warfare analysis. However, they do not provide exhaustive coverage of warfare analysis and its methodology at APL. In some cases, national security classification restrictions, current locations in the acquisition decision process of a particular program, and/or technology transfer restrictions prevent meaningful descriptions of our high-quality, sophisticated warfare analysis and analytical techniques in an open public forum such as the *Technical Digest*.

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Theater Ballistic Missiles (TBMs) are a growing threat to American forces and interests. DoD is funding the development of Army, Navy, and Air Force systems to defend against TBMs. The performance of these systems as a part of a Joint Theater Ballistic Missile Defense (TBMD) Architecture in operationally realistic situations is being analyzed as part of every phase of system development. The article by Pavalko et al. describes the analysis of Navy and Joint TBMD systems from the past several years. Results of these analyses have added to our understanding of operational requirements and the performance of such emerging systems.

The article by Benedict explains why it will become increasingly difficult to counter future undersea threats. Significant undersea warfare technology—including modern/stealthy submarines and minisubmarines, air-independent propulsion, and advanced submarine combat systems plus associated weaponry (torpedoes, mines, submerged-launch missiles)—is being transferred among the nations of the world. Conventional approaches to Anti-Submarine Warfare (ASW) and Mine

Countermeasures (MCM) will not provide adequate situational awareness, tactical control, or force protection to achieve stated Joint warfighting objectives in future contingencies. Advanced technology solutions and new operational approaches are needed in four broad capability areas: (1) distributed, deployable/offboard ASW sensor networks, (2) organic MCM developments for the Fleet, (3) advanced offboard vehicle concepts (both unmanned and minimally manned undersea systems), and (4) advanced warship self-protection measures against undersea threats. Technology and operational initiatives in these areas would form the cornerstone of a future undersea warfighting vision as described in this article.

Navy MCM ships and helicopters were designed for Cold War applications, which emphasized clearance of our own ports and relegated amphibious assault to a low priority. Today's naval mission requires regional contingency operations where friendly forces must be capable of projecting power ashore. To fight effectively in the littorals, naval forces must develop a capability to insert Marines and materiel from sea to shore where the shallow water and beaches are defended. Pollitt's article examines alternatives for conducting future amphibious operations and discusses some of the more promising MCM techniques.

The final article in this group focuses on logistics and how to link logistics and warfighting simulations. In the past, warfighting and logistics models have not been closely linked. The models used by the warfighting and logistics communities were designed for different purposes, required very different data, and did not stress model interoperability. Consequently, no integrated model exists for developing and testing an integrated warfighting and logistics plan, making it difficult to evaluate new logistics concepts and systems on their ability to support the warfighter under all contingencies. The Warfighting Logistics Technology and Assessment Environment (WLTAE) Project showed that existing warfighting and logistics models can be linked in a High Level Architecture (HLA) simulation to address such issues. Sinex et al. describe the WLTAE development effort to date and possible extensions to new applications.

SUMMARY

Taken as a whole, the articles in this issue illustrate the breadth and many complexities of warfare analysis. They also show something of the background of experience and analytical capability that APL brings to warfare analysis. This is one reason why APL's past warfare analysis efforts have been so useful to the Navy and other parts of the defense community. The future application of these skills by our analysts will help

APL continue to deal constructively with problems of national significance.

It is helpful at times to stop and take a panoramic view of warfare analysis—one, like this, that reaches back half a century and spans many problem domains. This not only brings insights about new applications of techniques used in particular areas, but also helps to clarify the capabilities and limitations of our analysis

techniques so that the crucial role of knowledgeable and competent analysts is correctly perceived and understood.

REFERENCES

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²Morford, P. W. D., and Miller, J., "How To Evaluate Technology in the Real World," *Naval Inst. Proc.* 126(1), 74–77 (Jan 2000).

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