Guest Editor's Introduction

Robert T. Lundy

This is the second of three *Johns Hopkins APL Technical Digest* issues featuring the Air Defense Systems Department (ADSD). In the first issue R. W. Constantine outlined the Department's programs in area defense, self-defense, and battle force. Two articles then described ADSD's systems engineering and technical approach to solving air defense and other technical problems. These were followed by articles relating primarily to surface-to-air missilery and to the science, technology, engineering, and operational requirements that drove the development of the Standard Missile variants (Fig. 1). The third *Technical Digest* issue in this Air and Missile Defense series will be devoted to battle force engineering. All three issues are in consonance with APL's roles as the Navy's Technical Direction Agent, Technical Advisor, and Trusted Agent for Air and Missile Defense

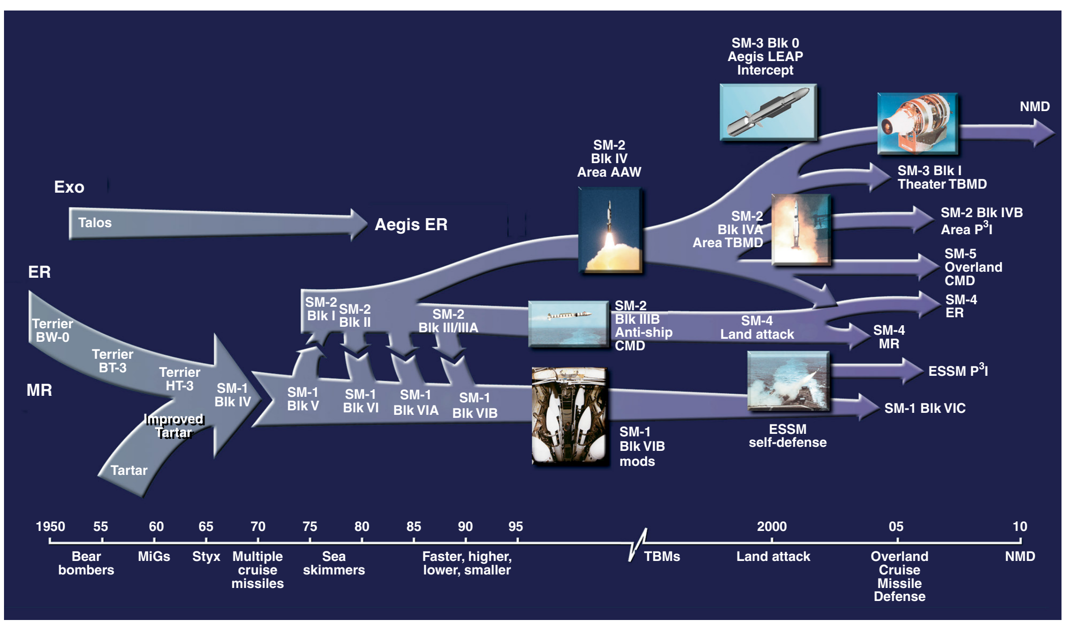

Figure 1. Evolution of the Standard Missile family.

matters. Each issue describes the engineering we do to provide defense against the spectrum of hard-to-hit, long-range, high-altitude ballistic missiles to close-in self-defense seaskimming cruise missiles.

Introducing this issue is a letter from RADM K. K. Paige, the former Deputy Program Executive Officer, Theater Surface Combatants, PEO(TSC). She notes APL's past contribution to Air and Missile Defense and voices the expectation that the Laboratory's future contributions will be equally valuable. This is followed by the first of a two-part series by the "Father of Aegis," RADM W. E. Meyer, USN (Ret.). His article, "A Beginning or Just a Change in Course," notes five epochs in the last half of the 20th century. The first began with the V-2 rocket experiment fired from the flight deck of the carrier USS *Midway* (CVB 41). His follow-on article in the *Digest* devoted to battle force engineering will feature his observations on the future of Aegis.

This second issue continues with articles on combat systems in Aegis cruisers and destroyers, aircraft carriers, and amphibious ships (LSDs, LPDs, and LHDs). Each combat system group uses similar but distinct architectures based on its particular mission, combat system elements, and technologies unique to the time in which the architectures were developed (Fig. 2).

APL's contributions to Aegis have evolved over a 40-year period during which our studies, critical experiments, and demonstrations helped define requirements necessary to attain and maintain air superiority. The Laboratory's early involvement began when the requirements and specifications for the then-unnamed advanced surface missile system were being established. Our inputs were based on the experience of Terrier, Tartar, Talos, and Typhon; on our radar automation work, basically conducted under the Terrier Program; and on studies and critical experiments conducted under the Advanced Surface Missile System task. These experiments essentially set forth the critical requirements in the proposal data package submitted to industry for competition. RCA (now Lockheed Martin) won the competitive award in December 1969.

Since then, APL, a designated Technical Advisor for the Aegis Program, has monitored performance, recommended technical changes, conducted risk assessments, modeled the effects of change, and conducted studies and critical experiments for future upgrades. Several of these are described in later technical articles. All are aligned with the Aegis mission: to detect, track, identify, and engage hostile air targets, individually or cooperatively with other forces; control fighter combat air patrols; and conduct electronic warfare against air targets to attain and retain air dominance. Figure 2a outlines seven baseline evolutionary improvements to the basic Aegis Combat System, all aimed at keeping Aegis preeminent in Air Defense.

J. G. Wilkinson Jr. provides an overview of key Aegis Combat System developments in "APL's Contributions to Aegis Programs: An Overview." Each combat system baseline gets more complex as the spectrum of the threat and technology continue to change.

D. M. Sunday and C. J. Duhon describe APL's major and seminal work in software engineering. The display software developed by APL for the Cooperative Engagement Capability (CEC) has become the kernel for combat systems in all Aegis ships and the basis for display software in carriers, major amphibious ships, and E-2C aircraft. These programs have now been transitioned to industry design agents for production, installation, and maintenance. The special three-dimensional displays developed for the Area Air Defense Commander will be covered in the third issue of this *Digest* series.

M. A. Landis presents an analysis of the Navy Theater Wide fire control "loop," which is really not one but a series of loops, the number depending on the target and the various time states of the engagements. An understanding of these loops is fundamental and essential to the engineering design change process used in the various baseline upgrades. Our systems engineering approach to this upgrade process was described in the first *Digest* issue.

J. R. Rottier et al. present a history of environmental assessment work performed in support of U.S. Navy surface ship defense programs. APL has developed a unique capability to measure and characterize critical aspects of the ocean environment—particularly those aspects that impact shipboard combat systems through their effects on microwave and infrared propagation. The Laboratory produces analysis techniques, instrumentation, models, simulations, and tactical decision aids (TDAs) that support a surface ship's defense against seaskimming missiles. The conclusion here is that the combat system must be adjusted to the local environment to optimize its performance.

Some of the successes of APL's environmental assessment programs are highlighted in companion articles by M. H. Newkirk et al. and J. J. Sylvester et al. The former describe advances in calculating electromagnetic field propagation near the Earth's surface. This article summarizes the recent progress in propagation modeling aimed at improving the ability to model propagation and clutter effects in littoral regions. The article by Sylvester et al. discusses shipboard TDAs, in particular, the successes of the Shipboard Environmental Assessment Weapons System Performance (SEAWASP) radar performance TDA and the Shipboard Meteorological and Oceanographic Observation System (Replacement) marine meteorological system known as SMOOS(R), which has been selected by the Navy as standard equipment for surface ships. Also presented is the Meteorological and Oceanographic Center (METOC) equipment developed to measure the air–water interaction and

Figure 2. Evolution and planning of (a) Aegis and (b) the Ship Self-Defense System.

the impact of the environment on radar and missile performance. Sylvester et al. note that the combat system must be adjusted to the local environment to optimize missile performance. The equipment and computer programs developed by APL and how they function as part of the combat system are also briefly discussed.

M. E. Schmid and D. G. Crowe examine distributed computer architecture developments over the last several years that have enabled several improvements in the Aegis Combat System baselines. Their article is followed by a discussion of the Java Enhanced Distributed System Instrumentation (JEDSI) authored by B. A. Shapter and D. G. Crowe. JEDSI makes it possible to capture performance and diagnostic data from a distributed software system, analyze the data, and display the results while the software system is running. The system has been designed to have minimal impact on the instrumented system, to be flexible in its application, to be extensible for new analyses, and to yield a variety of customizable diagnostic displays. JEDSI provides a way to instrument an application so as to observe its performance in real time at any stage in the software life cycle.

The article by A. F. Pollack and A. K. Chrysostomou describes an APL-developed high-fidelity end-to-end Navy Theater Ballistic Missile Defense simulation known as ARTEMIS. ARTEMIS uses the high-level architecture distributed simulation protocol to integrate existing high-fidelity component simulations to capture the effects of critical closed loop system interactions. It provides a systems engineering tool for functions including performance assessment, design verification, and flight analysis.

The next series of articles deals with ship self-defense systems. Self-defense has always been the most basic requirement for the Navy, as ship survival is essential to carry out offensive missions. Since the mid-1960s, the Anti-Ship Cruise Missile (ASCM) has been recognized as a major threat to ship survival, and thus largely stand-alone self-defense systems have been developed in response to the growing ASCM threat. Three programs are discussed: the Ship Self-Defense System (SSDS), Evolved Seasparrow Missile (ESSM), and Rolling Airframe Missile (RAM). The goal of these systems is to provide a quick-reaction, automated, multitarget engagement response against low-altitude, high-velocity, and maneuvering hostile targets.

APL made its greatest contribution to Navy ship self-defense in the 1980s and 1990s. In the mid- to late-1980s, the Laboratory and the Naval Surface Weapons Center (NSWC), Dahlgren Division, led a six-nation "NATO AAW" team to develop requirements for future ship self-defense systems. This effort spanned several allied programs for ship defense and initiated the formal SSDS Program in the United States. Based on the NATO AAW experience, the APL and NSWC team built the first SSDS prototype and tested it at sea in 1993. APL continued for 5 more years as the Sensor and Communications Infrastructure Design Agent as well as Technical Direction Agent for the SSDS until it successfully passed developmental, operational, and follow-on testing and was approved for service use in 1997.

APL transferred all Design Agent roles to an industry team in 1998–1999 after providing an advanced communications infrastructure and Common Display Kernel to the team to begin the second-generation SSDS (i.e., Mk 2). That system has completed initial land-based and shipborne testing and is scheduled for installation in aircraft carrier classes and major amphibious classes. An important aspect of APL's role in the SSDS is the coordination of SSDS and CEC technology. Both systems share the APL-developed communications infrastructure with common APL-developed software in track identification and sensor processing areas. This commonality contributes significantly to the ability to integrate SSDS and CEC systems in key Navy ship classes.

J. E. Whitely's article places these programs in context and introduces the related articles in this section by R. J. Prengaman et al., L. S. Norcutt, J. W. Thomas et al., R. K. Frazer et al., E. C. Elko et al., R. C. Kochanski and B. A. Bredland, and R. R. York and K. L. Bateman.

The last part of this *Digest* issue looks at specialty science and technology investigations for the "detect, control, engage" sequence of events that are not yet planned for implementation in future upgrades. J. Frank introduces and summarizes these articles by A. K. Agrawal et al., A. F. Genovese, J. S. J. Peri, and D. E. Maurer et al. The articles in this section are only representative of the vast amount of ongoing Air and Missile Defense developments by the Laboratory that have kept the Navy in the forefront for almost a half century.

THE AUTHOR

ROBERT T. LUNDY is the Chief of Staff for Air Defense Programs in the Air Defense Systems Department and is a member of APL's Principal Professional Staff. He has extensive experience in anti-air warfare with 25 years as both a project and program manager. He received a B.S. in chemistry from Northwestern University and has done graduate work in communication engineering and operations research. Mr. Lundy served 29 years in the Navy as a surface line officer, commanding two surface combatants and two naval research and development laboratories. He retired as Captain in 1972. He spent the next 5 years with ITT Electro Physics Laboratory developing an over-the-horizon radar. He joined APL in 1977 as Project Manager of the Taskforce AAW Coordination Program developing incremental capabilities in air defense that resulted in the Cooperative Engagement Capability Program. He was Program Manager for the CEC Program from its inception in 1987 to its initial operational capability in 1996. He has been in his current position since that time. His e-mail address is robert.lundy@juhapl.edu.