Critical Contributions to Critical Challenges

Alexander Kossiakoff

Since its establishment during the Second World War to develop a radio proximity fuze to defend the U.S. Fleet from enemy air attacks, the foremost mission of APL has been the application of advanced technology to Fleet air defense. Today, the Navy boasts a fleet of destroyers and cruisers armed with Aegis systems and Standard Missile batteries, as well as carriers and auxiliaries equipped with an array of self-defense weapons—owing in large measure to the Laboratory's contributions.

Technical Digest Vol. 22, nos. 3 and 4, described developments in current and advanced Standard Missile technology programs, combat systems, and ship self-defense systems. This issue focuses on two major breakthroughs in the command and control aspects of air defense: air defense coordination of a battle group and command decision support of an entire theater of operations. It also looks into the future of Navy air and missile defense and to the new challenges that will need to be overcome.

To put these developments into perspective, and to help visualize what APL's future endeavors might be, it is worth noting that the history of the Laboratory's air defense contributions has followed a distinct pattern characterized by a number of key attributes: an operational focus, end-to-end development, a systems engineering approach, pioneering technical solutions, and defying obstacles to important objectives. While no single attribute is unique, their effective combination is indeed rare.

Operational focus. The Laboratory's original wartime mission to develop a radio proximity fuze was directed to solving an acute operational problem of blunting the deadly air attacks on the U.S. Fleet in the Pacific. While new technology had to be developed, it was only the first step in achieving the operational objective of a major increase in the effectiveness of anti-aircraft gunnery. To serve its operational objective, the fuze had to also be producible, reliable, and safe. Every subsequent APL development has been directed to meet these operational imperatives.

End-to-end development. To impact the war effort, proximity fuzes also needed to be produced by the hundreds of thousands and more, and within months—not years—of their development. The Laboratory teamed with a group of U.S. electronics companies to transition the experimental product into a production article. Finally, to speed the operational use of the fuzes, key APL staff donned Navy uniforms and accompanied the first shipments of production fuzes to the Fleet to help train sailors in their use. The result was to make the proximity fuze a vital factor in the victory in the Pacific. This process of at-sea training to introduce new capabilities continues to this day, but with nonuniformed APL personnel.

Systems engineering approach. In pursuing development goals, APL has always viewed the ultimate aim to be the achievement of the overall operational objective, not the development of a particular system element. Thus, the successful development of guided missiles exposed the limitations of the detection and control elements of the total defense systems. The Laboratory played the key technical role in the 3T (Terrier, Tartar, Talos) Improvement program, which successfully integrated all the system elements of the guided missile cruisers and destroyers of the 1960s and 1970s into effective fighting units. This systems engineering approach continues to this day as evidenced, for example, by the integration of automatic gridlock and multifrequency Link-11 into ship combat systems.

Pioneering technical solutions. When the successful achievement of an essential operational objective has gone beyond existing technology, APL has often conceived an innovative technical approach that has solved the problem. A prime example was a multifunction phased array radar for rapidly responding to surprise low-altitude attacks by formations of enemy aircraft, screened by countermeasures. The concept, demonstrated in the Typhon radar, laid the technical foundation for today's Aegis system. The APL invention of an automatic detection and tracking system for conventional Navy radars also solved a long-standing system problem that had defied solution.

Defying obstacles. Many of the above examples involved assuming unconventional roles, challenging traditions, or tackling problems that others had failed to solve. The whole history of APL's contributions, especially in air defense, has exemplified the same characteristic. In the 50th APL anniversary issue of the *Technical Digest* (Vol. 13, No. 1), I referred to this attribute as "Expanding the Limits."

In reviewing the Laboratory's evolving contributions to the Navy's air defense mission, another pattern emerges, that is, the progressive expansion of the scope of APL's development efforts to successively overcome a series of limitations of traditional Fleet air defense systems. The development of guided missiles was a giant step beyond the proximity fuze. The automation of means to detect and track enemy attackers extended the system to the ship sensors and performed the time-critical functions of radar operators. The concept of battle group anti-air coordination expanded the scope of Fleet air defense to the entire force—a concept that greatly magnified the total capability of the battle force.

The developments of the Cooperative Engagement Capability (CEC) and the Area Air Defense Commander (AADC) operational prototype represent the latest examples of this pattern of "expanding the limits." Both are directed to major improvements in combat information and decisions. CEC provides high data-rate precision target data, derived from fusing the optimal data from all sensors in a battle group, and distributes the integrated data via a highly secure network. The AADC uses an extraordinary array of situation displays, symbology, and other advanced command support tools to create a high-fidelity, theater-wide air picture; perform sophisticated scenario simulations; and enable rapid planning and replanning—capabilities never before available to operational commanders and planners. This information greatly increases the effectiveness and timeliness of defending the friendly assets in an entire theater of operations.

Both of these developments exemplify APL's focus on solving important operational problems through the application of advanced technology. They are based on fundamental systems engineering principles, seek to satisfy real needs by innovative yet practical solutions, and have been demonstrated at sea and welcomed by the users. CEC has not only passed its Operational Evaluation but has been approved for production and deployment. AADC operational prototypes have been proven at-sea and are installed in an Aegis cruiser and two command ships. Today, under the direction of the Navy, APL is transitioning the AADC prototype to General Dynamics for production. CEC and AADC will change the way the Navy and Joint forces operate in the future and satisfy the Laboratory's goal of making "Critical Contributions to Critical Challenges."

THE AUTHOR

ALEXANDER KOSSIAKOFF is Chief Scientist of APL and a member of the Science and Technology Council. He is also Program Chair of the Master of Science programs in both systems engineering and technical management for the G. W. C. Whiting School of Engineering. He graduated from Cal Tech and received a Ph.D. from JHU. Dr. Kossiakoff joined APL in 1946 after wartime service in the Office of Scientific Research and Development and as Deputy Director of Research, Allegany Ballistics Laboratory, MD. In recognition of his work on national defense, he was awarded the Presidential Certificate of Merit, the Navy's Distinguished Public Service Award, and the DoD Medal for Distinguished Public Service. He became Assistant Director of APL in 1948, and served as Director from 1969 to 1980. Dr. Kossiakoff's technical work includes the systems engineering of guided missiles, automation of radar surveillance systems, and software engineering technology. He co-authored a textbook on systems engineering. His e-mail address is alexander.kossiakoff@jhuapl.edu.