The Science and Technology of Detect, Control, and Engage

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In the "detect" part of air defense, APL has been engaged in phased arrays since the mid-1960s when it developed a proof-of-principle array, which evolved to the Aegis phased array antenna. The first article in this section, "Active Phased Array Antenna Development for Modern Shipboard Radar Systems," discusses the recent move of phased array radars from high-powered microwave tubes to solid-state, low-powered modules. The phased array is essential because modern radars are required to look in thousands of angular directions and detect and track multiple targets in widely separated positions. This requires a change in beam direction in microseconds, which cannot be accomplished by a conventional rotating array. Recent performance requirements for phased arrays have increased by orders of magnitude since the original Aegis design.

The change in technology is the advent of solid-state transmit/receive modules. Using this technology, the transmit and receive functions are performed very close to the radiating element, and losses can be reduced dramatically. Compared to a conventional phased array, the required power may be reduced by a factor of 10 to achieve the same sensitivity. The conventional phased array suffers from losses in the phase shifters and the beamforming networks.

APL is now involved in a wide variety of solid-state phased array programs, and this first article discusses the pertinent issues. In particular, the solid-state transmit/receive module is of great concern because thousands or even tens of thousands of transmit/receive modules may be used in a single system. Most solid-state arrays use GaAs as the semiconductor; this is addressed in some detail, including a discussion of cost, wafer size, and packaging.

"The Interacting Multiple Model Algorithm for Accurate State Estimation of Maneuvering Targets" focuses on the "control" part of the problem. Here, algorithms are developed to improve the tracking ability of the radar for maneuvering targets. This is accomplished by using combinations of multiple filter models to best match the trajectory of targets with changing dynamics. The interacting multiple model algorithm provides a structure to efficiently manage the multiple filter models.

Simulation results are provided for five filter models on 10 target trajectory segments. The complexity of the filter models increases from a single constant-velocity model to a three-model interacting multiple model filter. The component filter models include constant velocity, constant acceleration, and a three-dimensional turn filter. Results show that the overall performance of the stated estimates for most trajectory segments improves as the complexity of the filter models increases. The performance of the interacting multiple model has been shown to be similar to the filter best matched to the target.

"Approaches to Multisensor Data Fusion" describes a program funded by the Office of Naval Research that includes the development of a sensor data fusion test-bed. This program, which is shared with the Naval Research Laboratory and General Dynamics Electronics Systems, is designed to integrate IFF (identification, friend or foe), electronic support measures, and radar data into a single composite combat identification analysis test-bed. The goal is to provide target classification and identification.

APL is examining Bayesian and evidential reasoning concepts to provide the data fusion algorithms. Evidential reasoning concepts apply belief and plausibility to measure theory. The techniques of measure theory, well described here, are applied to multiple simultaneous targets to assist in the resolution and correct identification of each of the targets while using sensors located on differently placed platforms.

"A Low Cost Gun Launched Seeker Concept Design for Naval Fire Support" is an example of the "engage" part of air defense. The article describes an effort to provide the surface Navy with precision-guided munitions to attack track-fixed, mobile, and sea targets with low circular error probabilities. The work concentrates on the design of an infrared seeker with target detection, classification, and selection algorithms. Although the APL effort and this article are mainly concerned with algorithm development, the system design and requirements have been addressed in some detail.

The low cost gun launched seeker program was originally intended as an enhancement to the ERGM (Extended-Range Guided Munitions). It will be applicable to a large number of precision-guided weapons. At the heart of the system is an uncooled, longwave infrared focal plane array that is the key to a lightweight, low-cost design. The seeker is provided with initial targeting information from a forward observer, an air controller, or an airborne asset. It then navigates to the target using GPS-aided inertial navigation.

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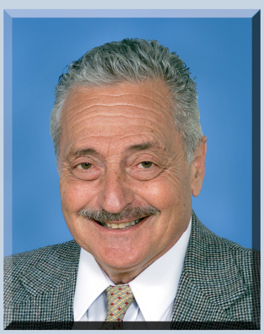

JOE FRANK received a B.S. in engineering physics from the University of Colorado and an M.S. and Ph.D. in electrical engineering from the University of Maryland. Dr. Frank originally joined APL in 1962 and was engaged in microwave, antenna, and radar efforts. One of his responsibilities during this time was the development of the Advanced Multi-function Array Radar, which led to the Aegis phased array. Dr. Frank is Chief Scientist of the Air Defense Systems Department and a member of the Principal Professional Staff. Dr. Frank is a fellow of IEEE and co-author of the chapter on phased arrays in the *Radar Handbook*. His e-mail address is joe.frank@jhuapl.edu.