Introduction to Programs

The role of the Air Defense Systems Department (ADSD) is to help the U.S. Navy defend against air targets. The mission is typically broken into three constituent components: detect, control, and engage. Initially, the target is detected, usually with radar. Then the target is tracked, its position updated, and its future position predicted in the control phase. In the control context, the fusing of data and the creation of a single, integrated air picture will continue to be important future capabilities. Finally, a missile is launched to engage the target. During engagement, both midcourse and terminal phase course corrections are essential.

In the past, the threatening targets were airplanes, followed by air-breathing missiles and, most recently, by ballistic missiles. Ballistic Missile Defense presents a number of important challenges to the system designer. For example, the incoming target must be detected at longer ranges than previous targets. In addition, the target is smaller in terms of radar cross-section, is faster, and flies a more difficult trajectory than formerly encountered. These problems may be solved by building larger radars or by putting infrared (IR) detectors on satellites in space and communicating the data to the defending ships.

The most difficult problem appears to be that of determining which object in a threat cluster is really the target. A ballistic missile may separate into several principal components, such as a reentry vehicle (RV), a booster, and an attitude control module (ACM). Additional debris may be present, generated during booster separation in the form of hot fuel fragments. The threat complex may also be accompanied by decoys, chaff, and jamming. It would not be feasible to launch a defensive missile at each of these objects. Instead, the difficult job of discrimination must be performed in order to reach a high degree of confidence that the defensive missile is aimed at the warhead.

In addition to its sponsored efforts, ADSD has provided initial funding for some novel discrimination techniques through its Independent Research and Development Program, and the Department's sponsors have subsequently provided additional funding to further explore these techniques. ADSD has also been funding a program on the fundamental properties of materials to determine the viability of radomes to protect the seeker.

All of these topics fall under the heading of the engagement mission phase and are discussed in this issue of the *Digest*. Detect and control functions will be discussed in the next issue.

In the first article of this section, K. V. Kitzman presents a technique for discriminating the hot fuel debris from the principal threat within the complex of objects. Using information gathered in the 7.0–7.7- and 9.3–10-μm bands, Kitzman demonstrates that a Bayesian hypothesis testing approach can provide a high degree of confidence in discriminating hot fuel from an RV, ACM, or booster. His derived probabilities of discrimination are above 96%.

In the next article, I. N. Bankman, E. W. Rogala, and R. E. Pavek discuss the potential advantages provided by the higher frequencies of laser radar or ladar for purposes of discrimination. Ladar allows measurements with significantly higher angle and velocity resolution compared to radar and is essentially insensitive to jamming. In comparison to passive IR detection, ladar has higher angular resolution, provides range and Doppler information, and does not respond to IR flares. In the terminal guidance phase of the interception, ladar also provides three-dimensional images at ranges substantially longer than the two-dimensional images of passive IR detection.

D. D. Duncan et al. address the very critical problem of assessing the performance of optical windows for endo-atmospheric interceptors in the last article. This assessment is of the complete thermo-mechanical behavior, as well as the bottom-line impact on the image quality of the sensor that looks through the window. A window was nonuniformly heated using a high-energy carbon dioxide laser beam. This heating pattern, which was representative of that experienced in flight, was imaged with a long-wave IR pyrometer. Simultaneously, assessment was made of the mid-IR wavefront transmitted through the dome. The end result of these measurements was twofold: (1) the quantification of boresight error under conditions representative of flight and (2) validation of numerical predictions of the same. These efforts are aimed at the creation of a parametric boresight error model suitable for incorporation into a six-degree-of-freedom engagement model. The article emphasizes the crucial role of fundamental research in understanding the behavior of optical window materials under the extreme environments encountered by today's missiles. The tools and techniques used by the authors are presented in the context of characterizing the imaging quality of a sapphire dome under expected aerothermal environments.

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