

Science and Technology for Precision Engagement—Part II: Guest Editor's Introduction

Susan B. Kennedy

This issue of the Johns Hopkins APL Technical Digest is the second in a two-part series on science and technology for precision engagement. The purpose of this series is to reaffirm the benefit of science and technology and to showcase the science and technology achievements of the Precision Engagement Business Area. The first issue introduced the APL challenge of providing the war-fighter with capabilities that span all aspects of precision engagement, from detecting, tracking, and characterizing targets of interest; through employing the appropriate weapon or effect that satisfies the warfighting requirement; to controlling the execution of the entire engagement. This second issue of the precision engagement science and technology series focuses on detecting, tracking, and characterizing targets of interest, key functions in the suite of military activities that are often referred to as intelligence, surveillance, and reconnaissance (ISR).

INTRODUCTION

Intelligence, surveillance, and reconnaissance (ISR) has been and continues to be one of the most significant challenges the DoD faces. In April 2012, the House Permanent Select Committee on Intelligence conducted a performance audit of the DoD ISR. This report states that, “DoD has spent about \$67 billion on ISR since 9/11 but has failed to strategically plan for how this investment relates to future requirements.”¹ It goes on to say, “DoD has invested

roughly \$44 billion in acquiring new and enhanced ISR capabilities since 9/11 without a strategy for how these systems fit into its future ISR architecture.” Lastly it makes the point that, “Operator training for DoD’s current inventory of Unmanned Aircraft Systems (UAS) is unsustainable due to cost and airspace constraints.” It is for these very challenges that the Precision Engagement Business Area is attempting to provide technological solutions.

THE ARTICLES

APL proposes a concept we call closed-loop collaborative ISR resource management as an important piece of the future ISR architecture. We also have identified and developed several key technologies that enable the closed-loop collaborative ISR resource management concept. As the number and diversity of ISR assets continues to expand, it will become more and more difficult for humans to manage, control, and exploit the ISR ensemble. A truly dynamic environment, in which it is essential to be able to act quickly, will only further add to the burden on human operators. Automation in the processing of the massive amounts of sensor data and in the control of the sensor assets will be absolutely essential. The article by Newman and DeSena describes an approach that applies the principles of feedback control to ISR operations, “closing the loop” from the sensor collections through automated processing to ISR asset control. Their closed-loop ISR process monitors the quality of information that a tactical commander receives and continually steers and reprograms the platforms and sensors to respond to the changing conditions and to provide a relative optimization of the use of the ISR assets. In short, closed-loop collaborative ISR resource management provides a future architecture that has the potential to dramatically improve the employment and exploitation of the DoD’s \$67 billion investment in ISR. It may also significantly reduce the training burden for employing the large number of UAS assets in DoD’s inventory.

The closed-loop collaborative ISR resource management concept requires four fundamental capabilities: fusion of sensor data, coordinated control, dynamic tasking, and feedback control. Newman and Mitzel’s article addresses the first of these fundamental capability needs: fusion of sensor data. The authors present the history, a technical overview, and several applications of upstream data fusion (UDF). APL has been the pioneer of UDF techniques since the early 2000s. APL’s algorithms combine “upstream” (partially processed, pre-detection) measurement data from different sensors and sensor modalities to find targets that a single sensor would not find. By far the most mature application of this technology is the Air Force Dynamic Time Critical Warfighting Capability (DTCWC) program, which fuses a variety of sensor inputs to find time-sensitive ground targets. This UDF technique has also been successfully applied to the space situational awareness (SSA) problem. During 2008–2012, on two Air Force projects, UDF was applied to the problem of detecting, tracking, and characterizing space objects in Earth orbit. In one project, APL used a field-collected data set from a geographically distributed set of optical space surveillance sensors to demonstrate improved space object tracking and discrimination. In the other project, APL applied UDF

within a closed-loop collaborative ISR resource management architecture in a series of simulation experiments to demonstrate, assess, and quantify improved SSA in an environment of dynamically changing priorities and information needs.

ISR data exist in many forms. One key form is an image such as that taken by an electro-optical (EO) camera or generated by a synthetic aperture radar (SAR). High-resolution panchromatic EO and SAR images are two of the most important ISR resources. SAR is especially important because of its ability to work in all weather conditions and during day or night and because of the precise location information that it can produce. With the increasing numbers and sizes of images to consider, a critical challenge is to develop an automated capability to detect target-like objects rapidly in the images. Murphy et al. present a 3-D target detection and recognition algorithm based on the biologically inspired map-seeking circuit (MSC). This algorithm was originally designed and has been proven to work with panchromatic EO images. The authors show that it also can be successfully applied to SAR data. They have also been able to modify the algorithm to increase its speed and efficiency.

Another key form of ISR data is a set of measurements of an object’s RF emissions, often taken remotely from airborne receivers. Such measurements can show the presence, identity, and direction of the emitter without revealing the presence of the sensor platform, as would be especially important in an anti-access area denial (A2AD) environment. Grabbe and Hamschin develop a mathematical description of the problem of estimating a stationary object’s geodetic position by using measurements of the direction to a moving receiver.

The last article of this issue moves us to a yet deeper level of the ISR challenge, that of fine-grained characterization of targets. Dumm et al. focus on accurately characterizing the antenna patterns of threat radars. High-fidelity pattern estimation of large radar antennas is critical for many precision engagement analyses, especially in the areas of electronic attack and suppression of enemy air defenses. Whether or not a specific radar jamming technique will be effective is highly dependent on the detailed understanding of the threat radar’s antenna pattern. As the authors state, “Accurate pattern prediction in the sidelobe and backlobe regions is challenging because of the sensitivity to radar antenna structure complexities, reflector surface errors, and the scattering environment local to the radar.” The article demonstrates significantly improved antenna pattern modeling accuracy through the combined use of lidar as a measurement device and sophisticated computational software algorithms. Their work will allow much more accurate prediction of radar-detection receiver, anti-radiation homing missile seeker, and jamming

technique performance. It will give our operational commanders the best information available in planning precision engagements.

SUMMARY

The articles in this issue of the *Digest* provide just a glimpse into the many science and technology initiatives underway in the Precision Engagement Business Area. There remain many operational problems in need of technological solutions, and most of them will benefit broadly, if not specifically, from contributions across the

APL enterprise. Our challenges are inherently cross-domain; our sponsors recognize that this is a joint fight. I hope that focusing on the science and technologies of this business area will generate discussion, collaboration, and further innovation for all of us. We now return to the challenge proffered in the October 2012 issue of the *Digest*: "what do you see?"

REFERENCE

¹House Permanent Select Committee on Intelligence, *Performance Audit of Department of Defense Intelligence, Surveillance, and Reconnaissance*, Washington, DC (Apr 2012).

The Author

Susan B. Kennedy is the Deputy Business Area Executive and Chief of Staff for the Precision Engagement Business Area at APL. Susan's expertise in the areas of systems engineering and analysis ranges from the development of survivability and effectiveness models to the technical evaluation of potential missile system improvements. She has also been very involved in the development of operational concepts for employment for today's weapon systems in tomorrow's environment. Susan's deep technical experience with Navy cruise missiles includes extensive engineering contributions to the Tomahawk weapons system program office. She has served as a special assistant for the Strategic Advisory Group (SAG) Panel for Command, Control, Integration, and Synchronization serving the Commander, U.S. Strategic Command (USSTRATCOM). Her e-mail address is susan.kennedy@jhuapl.edu.

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