National Security Space: Guest Editor's Introduction

Joseph J. Suter

Since its inception in the 1940s, APL has designed, developed, and launched 63 spacecraft and more than 150 instruments in partnership with NASA and DoD. During that time, space has increasingly become a critical part of the nation's strategic posture; thus, APL continues to develop effective space-based solutions for the nation's challenges, including weather, reconnaissance, surveillance, space control, missile defense, and homeland security, while also providing enhanced space support for combat forces in navigation, communications, and targeting. Significant experience in both civilian and national security space programs allows APL to leverage capabilities and accomplishments from NASA programs to address national security space requirements—and vice versa. APL has chosen to take on these demanding technical and scientific challenges with the goal of enhancing national security through the application of space science and technology. This issue of the Technical Digest *highlights some of APL's space-related accomplishments as well as new mission and technology concepts under development at APL for national security space programs.*

INTRODUCTION

In the early days of the space race, APL established a space science and engineering capability even before Sputnik was launched. The Laboratory has now contributed to space programs for six decades.[1] More than 50 years ago, APL's invention of satellite navigation (Transit)[2,3] enabled the U.S. Navy to obtain the precise navigational references necessary for targeting its Polaris missiles. Since the early days of Transit, APL has designed, developed, and operated more than 63 spacecraft and 150 scientific instruments flown on demanding missions for DoD and NASA. A unique synergy exists at APL as advances in the civilian space arena can be used directly for national security purposes—and vice versa—as has been often demonstrated in spacecraft systems, sensors, and technology transfer.[4] This issue of the *Technical Digest* highlights some of APL's space-related accomplishments as well as new mission and technology concepts under development at APL for national security space programs. In addition, on the APL website there is an informative video describing past and current national security space endeavors; the video serves as a nice complement to this issue of the *Digest*.[5]

Beginning with Transit in the late 1950s and extending into the 1960s and 1970s, APL satellites built for the Transit system became the foundation for future satellite developments. For instance, passive gravity attitude control was one of the many pioneering APL technologies flown on early missions such as DODGE (DoD Gravity Experiment).[6] The first satellite with an orbit free of drag and radiation pressure was APL's TRIAD (TRansit Improved And Disturbance compensation system)[7, 8] satellite.

In the 1980s, APL developed and implemented GEOSAT (GEOdetic SATellite),[9] a low-cost classified mission for the Navy to improve its knowledge of Earth's shape and gravity field. The APL-built radar altimeter on GEOSAT spent an unprecedented 36 months collecting the first continuous set of ocean altimeter data, producing a comprehensive and accurate satellite altimetry dataset for use in both geodesy and oceanography.

The Defense Nuclear Agency and the DoD Space Test Program funded HILAT (HIgh LATitude satellite)[10] to learn more about radio frequency propagation in the high-latitude ionosphere when little was known about this phenomenon. Then Polar BEAR (Polar Beacon Experiment and Auroral Research)[11] studied the polar regions for the U.S. Air Force to determine the causes of space communications interference from solar flares and increased auroral activity. SATRACK, the first committed user of GPS, played a critical role in the operational success and improvements of the Trident weapon system.

APL developed and executed the first flight experiments, the innovative Delta 180, 181, and 183 experiments, for the Strategic Defense Initiative Organization. These flight experiments demonstrated the technical feasibility of space-based missile intercepts, collected data on various defense-related phenomena in space, and provided multispectral data on launch vehicles viewed from space. Later, in the 1990s, APL built MSX (Midcourse Space Experiment)[12, 13] for the Ballistic Missile Defense Organization. MSX provided the first demonstration of a space system's ability to identify and track ballistic missiles during midcourse flight.

As described in the preceding paragraphs, throughout its history,[1, 14] APL has maintained its role in national security space with innovative solutions to critical problems of the day. What follows is a brief overview of the articles in this issue of the *Technical Digest*. The articles provide a sampling of the broad range of APL's current national security space activities.

THE ARTICLES

The first article, by Henderson, Devereux, and Thompson, presents a historical perspective spanning 50 years of APL's critical contributions in the field of satellite navigation and Doppler position fixing. The article covers the science and engineering of global and theater navigation systems and highlights some exciting new technologies and capabilities being developed today.

As discussed in the next article, by Norkus, Baker, and Erlandson, MSX was the largest and most complex spacecraft ever built by APL. On board was the first hyperspectral sensor in space. MSX provided the first real-time tracking of satellites from space and the first space-based sensor integrated into the National Space Surveillance Network. During its 12 years of active data collection for the national security and civilian space communities, MSX contributed key elements of space situational awareness and helped guide future DoD space missions. The article by Norkus et al. describes the decommissioning of MSX after the spacecraft had exceeded its design lifetime by 7 years.

Next, Cancro describes the development of a new set of autonomous software systems that will meet the critical challenges of our next generation of spacecraft. The development of this new set of autonomy systems will draw on lessons learned from the past, new technologies being developed today, and a four-pronged vision of what future APL autonomy systems require.

The challenge to develop complex operational systems across various organizational entities is described by Stadter, Reed, and Finnegan. The Integrated Systems Engineering Team (ISET) concept is detailed as a pragmatic approach to integrate government, industry, and laboratory/academic organizations. The ISET allocates organizational capability to manage risk during program development and acquisition, allowing technical interactions among participants without conflicts of interest to ensure the efficacy of a future competition for development of operational space, weapon system, or intelligence systems.

In the next article, Cook discusses how strong, flexible space program management plays a critical role in delivering proven and reliable capability to systematically define and solve critical challenges for defense, civil, and intelligence objectives.

Yan, Potter, and McGovern's article on commanding service architecture describes a prototype capability that explores a fundamentally new way to access, task, and receive information from tactical spacecraft assets. The Tactical Spacecraft Commanding Service Architecture (TSCSA) is based on the notion of a distributed, semi-automated planning and scheduling framework built using a service-oriented architecture (SOA) and current Web-service standards.

Flight software for future tactical satellites needs to satisfy the Operationally Responsive Space (ORS) vision.

Cancro et al. describe APL's development of a new ORS flight software concept architecture that enables rapid assembly of a system from existing component parts. It incorporates flexibility to add new capabilities without compromising existing features and covers the entire life cycle of an on-orbit asset.

A space group consists of multiple clusters of satellites in geosynchronous orbit in a constellation architecture. Orndorff and Zink compare monolithic and distributed space group architectures and discuss the benefits of distributing critical resources for surveillance, reconnaissance, weather, and communications among the satellites.

Then, Rogers and Summers present a concept in direct response to the need for smaller, reliable spacecraft to more effectively utilize access to space. APL invented a flexible and modular Multi-Mission Nanosatellite spacecraft architecture for low-cost execution of critical missions. It utilizes a three-unit (3U) CubeSat that stows in a containerized deployer.

In the final article, Erlandson et al. describe a two-pronged approach to the development of optical kill assessment technology in support of ballistic missile defense applications. One aspect is modeling and predicting the signatures resulting from intercept events. The other aspect is developing and deploying imaging, spectrographic, and polarimetric sensors to collect signatures of intercept events. This approach has provided the technical foundation for developing space-based kill assessment sensors.

As APL moves toward a new era of national security space initiatives, it will continue to provide nationally recognized capabilities: space weather, remote sensing from UV to near IR, and small, capable (CubeSat) spacecraft. In short, APL's national security space programs will apply technological innovation to solve complex critical problems for the military and intelligence communities.

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