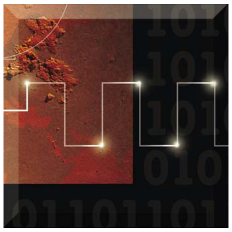

Communications Systems Development at APL: Guest Editor's Introduction

Joseph J. Suter

Many programs at APL involve communications systems development. These efforts are under way in ultralow-power transmitters, terahertz frequency sources, next-generation Doppler positioning systems, future space-based optical two-way communications systems, miniaturized receivers and transmitters, and low-probability-of-detection radios. Robert L. Holland, in a previous issue of the *Technical Digest*, reported on the development of communications and distributed systems at APL.[1] A new, more capable generation of communications systems is under development that integrates miniaturized transmitters and receivers, GPS receivers, and secure communications into novel communications networks. Future Laboratory contributions in this field will include the development of software radios, highly secure communication technologies, self-forming networks, and low-probability-of-intercept communications devices.

For more than 60 years, scientists and engineers at APL have been engaged in the development of communications systems.[2] Given the large number of communications-related programs in several of the Laboratory's business areas, the focus of the following articles is on recent developments (from a technology point of view) in space and military communications systems and emerging systems that explore the use of terahertz and optical frequencies. In addition, initial technical advances in local area networks have demonstrated their effectiveness in self-forming networks to telemeter sensor data over relatively large areas. The Laboratory's work in military communications as part of the Global Information Grid (GIG) has seen substantial growth as well.

Obviously, APL's contributions in the field of communications systems cover many different aspects. Hence, the challenge was to select a representative set of articles. The DoD emphasis on the research and development of low-probability-of-intercept communications systems, RF spectrum management, self-forming networks, and high-bandwidth satellite communications drove the selection presented here.[3] Furthermore, because of increasing interest within civilian and military space programs in developing high-bandwidth communications data links for spacecraft, several articles are devoted to

APL's accomplishments in space-based RF communications systems and developmental efforts in optical links.[4,5]

Spacecraft and military communications systems have historically been areas of major innovation at the Laboratory. Efforts to develop a next-generation space-based communications system have resulted in novel approaches to the noncoherent Doppler tracking of spacecraft as well as Ka-band communications systems that enable high-data-rate transmissions to and from deep space satellites. In his article, Bokulic describes how APL staff engineered solutions over the past decade to problems in three key areas of spacecraft communications: science return, transceiver systems, and emergency-mode communications. He reports on the space mission to Pluto and how a novel low-power digital receiver, combined with a medium-gain antenna, is used for routine ranging operations out to Pluto and beyond. In collaboration with Morgan State University, Wallis et al. developed a state-of-the-art X-band power amplifier that is currently being flown on the MESSENGER spacecraft. The article by Boone and colleagues describes a proposed free-space optical communications system for spacecraft-to-ground and deep space applications. Their vision is to develop the critical components of an optical communications terminal in which the spacecraft's mass is kept to a minimum and its data rate falls within the range required to give a significant gain over an RF system, thereby allowing higher bandwidths for spacecraft communications on deep space missions.

In the next series of articles, the focus is on advances made in the development of military communications systems—a historically strong area at APL. In 1994, APL was tasked to design and develop prototype software to bridge the interface gap and provide, over a series of version releases, increasing capabilities for the exchange, management, and correlation of data; situational awareness; and ultimately, decision support for the Army's wideband SATCOM systems. Hostetter and his team report on the development of the next generation of large-scale software systems integration capabilities for satellite communications.

Given that DoD is moving toward "net-centric operations," significant efforts have been under way at the Laboratory to address several technical challenges. Hammons and his team report on propagation studies to characterize radio transmissions in military RF bands, studies regarding the best military use of COTS technologies, the increased efficiency of wireless links, and studies of adaptive spectrum use and cross-layer design to optimize the radio to prevailing conditions.

In the area of emerging communications systems, a practical two-way wireless network that enables seamless data acquisition for multiple, simultaneous test activities and data sources is presented by D'Amico and Lauss. This is part of a joint effort between APL and Yuma Proving Ground to implement a network to test high-speed munitions. Initial results of this technology have led to a thrust in the development of self-forming *ad hoc* networks. Complementary to this endeavor, Darrin, Carkhuff, and Mehoke report on trends in the miniaturization of wireless device applications. Wireless networks represent a sharp change from the current wireless solutions of replacing what would be traditional hardwired components with their corresponding wireless counterparts. The next generation of wireless technology will incorporate MEMS, optical, and nanotechnologies as miniaturized electronic building blocks for self-contained modules in wireless networks. Distributed wireless sensors are expected to find numerous military and space applications (e.g., robotic explorers).[3,5]

APL's strongest contributions in communications systems are in the conventional frequency bands (UHF, L, S, X, K, and Ka), but scientists are exploring the use of terahertz signals as well. Appropriately, the last article of this *Digest* issue discusses the development of potential communications systems operating at terahertz frequencies (10^{12}–10^{14} Hz), also known as the very long wavelength IR region. Considered as an extension of microwave and millimeter wave, the terahertz radiation band offers greater communications bandwidth than is available at microwave frequencies. Fitch and Osiander report on the development of early prototype terahertz frequency sources and detectors that may find application in future intersatellite communications systems.

The Laboratory's technical contributions to systems developments have been critically acclaimed as enablers for major DoD and NASA communications systems. Transit, the Teleport Program, the Defense Satellite Communication Systems, spacecraft X- and Ka-band communications systems, noncoherent Doppler navigation techniques, and Army wideband military SATCOM are just a few examples of demonstrable APL contributions. Given the demand for future survivable and assured communications, self-forming networks, TTL (tagging, tracking, and locating), and low-probability-of-detection and interception communications, many new opportunities are emerging in which the Laboratory can continue to make significant technical contributions.

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