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GUEST EDITOR'S INTRODUCTION

When he was Director of APL, Alexander Kossiakoff was fond of explaining to visitors that The Johns Hopkins University Applied Physics Laboratory is "neither a research laboratory nor a development laboratory but, rather, a problem-solving laboratory." That description represents the style of thinking that has pervaded APL since its inception almost a half-century ago. In the course of problem-solving, there is also the need to initiate new developments. In many cases, a problem could be solved only because of the scientific research base that has existed since the Laboratory's founding. For example, research in atmospheric electromagnetic propagation phenomena led to the invention of the Transit satellite system, a solution to the problem of providing extremely accurate navigation for ballistic missile submarines.

The success of any technical organization depends on anticipating—and being ready to apply—new technologies. Two years ago, Alvin R. Eaton, Chairman of the APL Program Review Board, established the Advanced Technology Subcommittee, under my chairmanship. The primary purpose of that subcommittee is to perform a continuing review of new scientific concepts and technological areas that might be essential to meet the needs of APL sponsors over the next decade. Over the last two years, we have considered ongoing work and recommendations made by both members of the APL staff and many outside individuals. In some cases, the subcommittee, as part of its long-range planning function, has provided support for initiating or expanding some particular phase of new technology.

The concept for this issue of the *Technical Digest* arose from the Advanced Technology Subcommittee's program. Unlike most other issues of the *Technical Digest*, which publish reports on completed research and development or on a completed major phase of a program, the intent here is to try to give our readers some background in critical areas of technology that will, we believe, affect naval and aerospace technology during the next decade. In general, these are areas where some level of effort has already been initiated at APL. In determining which topics should be covered, we realized it would have been easy to double—or even triple—the 14 topics discussed here. Perhaps at some future date another set can be presented. Certainly, many equally significant topics have been discussed in previous *Technical Digest* articles, and many more will be described in forthcoming issues.

We have tried to arrange these topics in some logical order, but it was not easy. Most of the advanced technology programs are interdisciplinary, with little correspondence to the classical disciplines by which we still categorize definitions of employment or the departments of academia (such as physics, chemistry, electrical engineering, mechanical engineering); also, the backgrounds of the individuals are not necessarily discipline-related to the work. Further, a topic in one article (e.g., superconductivity or neural networks) may reappear in a later article (e.g., missile guidance or magnetoencephalography). It is noteworthy that 13 of the 14 topics presented here derived all or part of their support from the Laboratory's Independent Research and Development Program, four of these also were supported in part from Program Review Board funds, five also derived some support from ongoing program funds, and only one was totally supported by a funded task.

No recent development in materials has created more excitement than high-temperature superconductivity. The article by Kishin Moorjani and his associates discusses some significant innovations at APL, including production of high-T_c superconducting thin films by laser ablation and a unique measurement method, using microwave absorption, to determine the presence and characteristics of superconductivity. The same article also discusses some of the potential applications related to new instrumentation. Exciting developments are also under way in organic molecular materials with nonlinear optical properties. Applications include optical bistable devices, a harmonic generator, and optical storage devices. They are discussed by Richard S. Potember and his co-workers. The combination of new materials and advances in computer-aided design has produced a quantum jump in the development of microwave systems and completely new concepts of using microwaves. The area of microwave/millimeter-wave monolithic integrated circuits (MIMIC) is discussed by Joseph L. Abita, who describes how those new techniques are being introduced into APL programs.

Continuing improvement in precision time and frequency standards is necessary for many existing and proposed military and space systems. Joseph J. Suter discusses developments in quartz-crystal oscillators, hydrogen masers, and superconducting frequency standards, and the material properties necessary for the achievement of current goals. Innovation is required, not only in the materials themselves, but also in the techniques for nondestructive characterization of complex structures involving layered materials and multiple interfaces. John C. Murphy and his associates discuss several variants of thermoacoustic and thermoelastic methods developed at APL for observing the internal characteristics of such materials.

Since the early days of the electronic computer, computer scientists and technologists have gazed with envy and wonder at the massive ability of the human brain to process information—far beyond that of electronic and mechanical devices. Although attempts were made to emulate the neuron over several decades, in recent years it became apparent that the real key lies not in the specific characteristics of the neural cell but, rather, in the architecture of the brain. That realization led to the concept of the neural network. Robert E. Jenkins discusses the fundamental principles of neurocomputing as well as current research in the neural-network process, and some specific applications that are under way as a collaborative effort between APL and the Homewood Campus of The Johns Hopkins University. In a companion article, Michael W. Roth reviews the recent history of neural-network technology and describes a number of ongoing programs for applying neural networks to practical military problems that require the extraction of useful information from complex or uncertain data.

The original source of the neural-network concept, the human brain, is examined in an article by Harvey W. Ko and his co-workers. Multiaxis magnetic gradiometers are being used to study the neuronal activity in the brain by localizing and tracking its magnetic signals. That type of sensor will become practical when high-temperature superconductors can be incorporated. Magnetoencephalography is one example of a sophisticated signal-processing problem. Most of the military areas in which APL is involved are critically sensitive to advances in signal processing. William G. Bath discusses signal-processing theory as it evolves toward discrete, nonrecursive models and solutions, and toward real-time adaptation with programmable hardware. Future missiles must use image-based signal processing. Some advanced concepts under investigation at APL are reported by Bradley G. Boone and Richard A. Steinberg, including the use of neural networks and image-processing concepts derived from the logic inherent in human vision.

Software engineering is the most pervasive single problem area in modern defense systems, present and future, and in many information and control systems in our daily lives. Bruce I. Blum and Thomas P. Sleight present an overview of software engineering, examining how the software and hardware developments differ and using an extrapolation of present trends to look toward future software developments. Innovative developments in both software and hardware over the next decade will lead to flexible electronic display systems for the tactical commander. F. Jennings Willey discusses the realizable possibilities for advanced tactical displays for shipboard systems.

APL has played a leading role, since the beginning of the space age, in the development of small, relatively low-cost satellites. Eric J. Hoffman discusses possible future trends in lightsats (sometimes called cheapsats). Low-cost satellites lead to new concepts of survivability in military systems and provide the opportunity for many scientific missions at minimal cost. Not only is increased interest in low-cost space systems anticipated, but, even more important, new methods must be found for lowering the cost of inserting mass into orbit.

This leads full circle to the cover of this issue, which shows a Victorian artist's concept of Jules Verne's moonship. Following through with Verne's original concept of a ballistic launcher, Harold E. Gilreath, Robert M. Fristrom, and Sannu Molder discuss how the application of internal ballistics and aerodynamics techniques may lead to lower-cost access to space by the technique of distributed-injection ballistic launching, as opposed to the use of rockets that have to lift both their payload and their fuel. It may be a 125-year-old idea whose time will come during the next decade.