

## COLOSSUS ON THE DUCK POND: THE JHU/APL EDUCATION CENTER

The primary mission of The Johns Hopkins University Applied Physics Laboratory Education Center is to meet the ever-increasing demand for maintaining the technical currency of the practicing engineer and scientist. The G. W. C. Whiting School of Engineering Continuing Professional Programs leading to the master's degree is the country's largest part-time graduate engineering program, with the APL Center as its major component. The development of the APL programs and physical facilities is summarized. The current APL Education Center philosophy, operations, and the composition of its student body are discussed. In addition to the programs leading to the master's degree, several innovative non-degree programs are described.

### ORIGINS

In common with many other large technical organizations, APL has always had a limited number of courses available for training its staff members in various specialties or for helping them achieve higher professional status within the organization. In 1958, numerous people in the Personnel Department and in various technical departments thought it might be a good idea, because of the remoteness of APL's site relative to universities in Washington and Baltimore, to provide the staff with courses at the graduate level that would eventually carry credit toward a master's degree in engineering. Courses were established first in electrical engineering, physics, and mathematics, in addition to an agreement with the McCoy (later the Evening) College at the Homewood campus of Johns Hopkins that these could carry some sort of graduate degree credit. In 1964, arrangements were made to designate the APL operation as a center of the Evening College open to the public and to offer the master of science degree in electrical engineering. In the 25 years that followed, the program at APL (since 1983, associated with the G. W. C. Whiting School of Engineering), together with the Whiting School's other part-time programs at Homewood and, most recently, at the new Montgomery County Center of The Johns Hopkins University, has become the largest part-time graduate engineering program in the nation.<sup>1</sup>

Paul Edwards, the first director of the JHU/APL Education Center, in an article reviewing the history of the APL Education Center pointed out that<sup>2</sup>

The graduate educational needs of employed scientists and engineers differ in several important aspects from the needs of full-time graduate students in science or engineering departments of universities. Full-time students usually are heading for an advanced degree and are intensely interested in one area of specialization without any real knowledge yet of its application to real time problems. Employed students usually desire more knowledge of tools and techniques with which to attack the problems facing them daily.

The emphasis on the applied rather than the abstract—the focus of the program under the Whiting School's Continuing Professional Program on the needs of the practicing engineer or applied scientist—has certainly been a major factor in the popularity and consequent rapid growth of the program. Another, more significant phenomenon is visibly becoming a major factor in the growth and diversification of the program. As Kenneth C. Rogers, President of The Stevens Institute of Technology, succinctly pointed out,<sup>3</sup>

The greatest challenge to engineering education is the problem of continuing education. In many areas, rapidly developing technologies are rendering engineers' educations obsolete in less time than they spent studying as undergraduates.

The attitude of the scientists and engineers, representing many disciplines and different organizational structures, who compose the APL Education Center can best be summarized by a statement made by Steven Muller, President of The Johns Hopkins University:<sup>4</sup>

We are, whether fully conscious of it or not, already in an environment for higher education that represents the most drastic change since the founding of the Universities of Paris and Bologna and the other great universities some eight or nine centuries ago . . . We are going to serve a substantially altered clientele; we are going to deliver our services in new ways; the content of our services is going to be different; and the style in which we operate is going to change . . . The state of knowledge now dates itself so rapidly that it is inconceivable that someone who emerges with the latest learning in any field is going to stay in command of that latest learning for more than a decade. And if that person is going to be engaged professionally for longer than ten years, that person is going to seek relearning.

### PHYSICAL PLANT

When the R. E. Gibson Library was built, it included a basement that was planned as an area for reserve stacks



and document files. Since this space was not being used extensively, the APL Evening College borrowed some of the library basement space and divided it into appropriate classroom facilities. Initially, four classrooms were set up; later, the basement was expanded to add two more rooms. Because the Evening College lacked its own computing resources, one room was designated as a terminal room where computer terminals transmit over telephone lines to computers at Homewood; the numerous computer facilities within APL, dedicated to Department of Defense programs, were unsuitable for student use.

The courses, which had been open to students from local government and industrial firms as well as APL staff members, were beginning to fill the basement, and, in 1981, planning began for what was to become the Kossiakoff Conference and Education Center. A large auditorium was badly needed at APL, and it seemed appropriate to incorporate an area that would contain some classrooms so that the library basement could be given back to its rightful owner.

When the plans for the Kossiakoff Center were finalized, two wings, sometimes called "silos," were connected by a reception and dining area. A large, 500-seat auditorium filled one wing; the second wing consisted of two floors that could be used for classrooms. The building planners did not see the need for more than one classroom floor with eight generously sized rooms. Construction proceeded under the assumption that the second floor would not be finished until some time in the distant future. As construction continued, President Muller and Dean VandeLinde felt it would be useful to have a TV link between the Homewood campus and APL, requiring at least one and preferably two dedicated classrooms, as well as space for the system operators and the monitoring equipment. It seemed reasonable to finish the second floor, provide these two classrooms and a small computer laboratory or two, and allow a substantial amount of floor space for the APL Exhibit Center, which had recently been dispossessed from its former long-time home. Within a year after completion of the building, however, the Exhibit Center once again had to move to make way for extensive computer laboratories that now share the upper floor with the TV classroom.

The problem of how much space was needed closely interacted with the strategy of what time of day courses should be offered. If offered too early in the day, employers objected to the amount of time their employees would be absent. If offered too late in the day, the possibility existed that only a single session could be scheduled during the evening. The strategy adopted by the Education Center was to have classes meet once a week at one of two evening sessions, from 4:30 to 7:10 and from 7:15 to 10:00, with occasional classes on Saturday morning. Obviously, both students and instructors preferred the earlier evening session, with a general distaste for both Friday evening and Saturday morning sessions. The sad news, however, is that in the fall of 1988 all classrooms in the Kossiakoff Center were scheduled for both sessions every night and for Saturday morning. The

even sadder news is that all space in the Gibson Library basement is fully occupied by classrooms, laboratories, and offices of the Education and Training Group. The overflow from multiple sessions in some courses meets at the Whiting School's Parkway Center a few miles away. As might be expected, a frequent topic of conversation is how a wing could be enlarged or added to the Kossiakoff Center without impairing its award-winning architectural design.

The Kossiakoff Center today is the principal facility of the APL Education Center (Figs. 1 and 2). In addition to its large auditorium (Fig. 3) and dining facilities, the education wing contains eight large classrooms, one large and four smaller computer laboratories, a TV classroom flanked by a control center (Fig. 4), and the Education Center office. The basement of the Gibson Library still houses three classrooms (Fig. 5), two laboratory rooms, and offices for the Education and Training Group.

A recent innovation has been the establishment of laboratories for electrical engineering and applied physics, where equipment is being developed for instruction in microwave circuit techniques, microwave/millimeter-wave monolithic-integrated circuits, electro-optics, and solid-state physics. In recent years it has been recognized that all engineering programs, not just computer sciences, require laboratories to enable students to develop a full grasp of the subject. The use of computers has in fact minimized the hands-on relationship of engineers and applied scientists to the equipment they design or synthesize into systems. Over the next few years, we hope we can establish the physics and electrical engineering



Figure 1—The entrance to the reception area of the Kossiakoff Center.





**Figure 2**—The award-winning architecture of James Goldstein is carried into the interior of the Kossiakoff Center. A section of the dining and reception areas is shown.

laboratories sufficiently in variety and quality to require the student to perform precise measurements as part of the requirement for an advanced degree.

The mainframe room in the computer center is now in its second generation. Initially through the generosity of AT&T, a 3B20 computer was installed, together with

about 40 terminals. In addition, Dr. Paul Pan, then Chief Scientist at Westinghouse, had donated a DEC VAX 11-780. The 3B20 has now been replaced with a DEC VAX 8810; the 11-780 has been modified to drive a QUEN computer given to JHU, as part of the royalty agreement, by Interstate Electronics Corporation, which manufactures this super computer that was designed by APL's Quentin Dolecek.<sup>5</sup> In addition, about 30 stand-alone computers, consisting of IBM XTs and ATs, Compaqs, Apollos, and DEC 2000s, provide additional facilities for the students. In turn, the mainframe computers at the APL Center are linked by 56-kilobaud lines to the JHU Computer Center at Homewood and to computer terminals and printers at the Montgomery County Center and the Parkway Center. This link allows access of a DEC VAX 8600 computer at Homewood from each location. The computers can also be accessed by the students through telephone modems.

The TV classrooms at APL (Fig. 3) are linked to TV classrooms at both Homewood and the Medical Institutions in East Baltimore. Two TV channels are beamed by microwave, via the roof of the U.S. Fiduciary Guaranty Trust building on the Baltimore waterfront, to an antenna on Building 6 at APL. A fiber-optic link then carries the signals to the Kossiakoff Center. One channel goes directly to Homewood and the other goes to the Medical School, both of which are interconnected, making it possible to use two channels between Homewood or the Medical School and APL. In recent years, these TV links have been active almost every night of the week with classes at either APL or Homewood; in some cases, courses have been taught with instructors at both ends of the TV links. In the near future, the TV network will be linked to both the School for Advanced International Studies in Washington, D.C., and the Montgomery County Center.

The R. E. Gibson Library (Fig. 6) is a most important adjunct to the educational facility. Containing a large

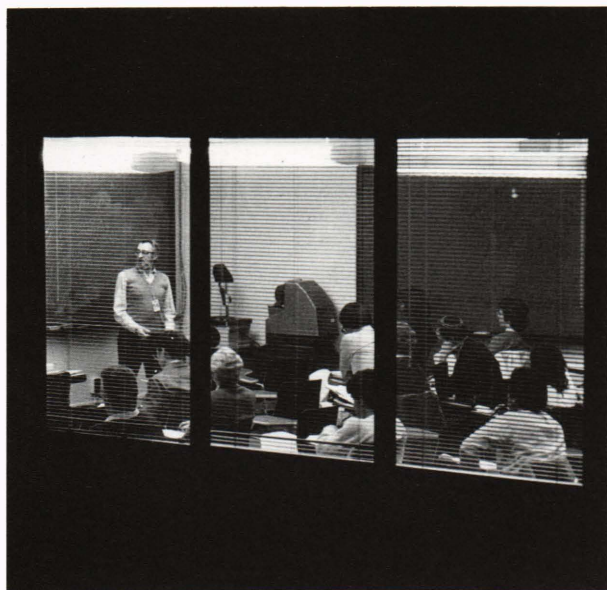


**Figure 3**—The 500-seat Kossiakoff Center auditorium has satisfied a long-required need for large internal meetings. It has also been used extensively by professional organizations and government agencies for technical symposia.





**Figure 4**—The control room operator of the intercampus Instructional TV microwave link can control and monitor transmissions to other locations and to the students' desk monitors while operating the three video cameras available in the classroom.



**Figure 5**—A Computer Science class in one of the spacious classrooms in the basement of the Gibson Library.

(40,000 volume), up-to-date collection of technical books and more than 800 periodicals and journals, and electronic access to other library catalogs and specialized databases, it is primarily intended to supply the needs of the 3000 staff members at APL. The library contains no classified material and is available to students and faculty during the day and evening.

For many years, the APL Education Center has been the major Johns Hopkins location for part-time graduate students to pursue degrees in technical disciplines. Several programs have also been offered at Homewood in different technical disciplines but, in general, with smaller enrollments. In 1986, the University made a commitment



**Figure 6**—The Gibson Library's extensive collections of technical periodicals and books, together with electronic access to other libraries and specialized databases, are available to Education Center students.

to establish an Education Center in Montgomery County. This resource was very strongly desired by the county business community to support the increasingly varied industrial and governmental technical complex developing along the Route 270 corridor. Montgomery County very generously supplied both a major tract of land and funds for the construction of a modern building containing classrooms, offices, an auditorium, and a library for the use of all divisions of JHU. Three APL-based degree programs are now being offered there: Computer Science, Electrical Engineering, and Technical Management. In addition, courses are being offered in Applied Mathematics and Applied Physics. At the present time, completion of the degrees in these latter subjects will require some attendance at APL. Although the APL Center has no direct responsibility for this venture, the APL Program Committees and their Chairs have the academic responsibility for the courses derived from the APL programs. APL faculty members and student advisors are making significant contributions to ensure the success of this effort.

## GOVERNANCE

In 1980 the Ranum Committee was formed to review the progress and prognosis of the APL Education Center's activities and to define its role within a restructured



university community. Although engineering education at Hopkins was started in 1913, the original School of Engineering was dissolved in 1966 and the residual engineering courses were incorporated within the School of Arts and Sciences. The Evening College, which had been the division of Johns Hopkins granting degrees for APL programs, was renamed the School of Continuing Studies in 1984. Another major development, through the generosity of the estate of G. W. C. Whiting, was the establishment of a new School of Engineering in 1979. The Ranum Committee suggested that it would be valuable to relate all engineering educational activities, including the APL Center, directly to the new G. W. C. Whiting School of Engineering while retaining the APL Center's unique identity and initiative.

Paul Edwards, a member of APL's Personnel and Education Department, had been the driving force in both establishing and managing the APL Center (see his reminiscences elsewhere in this issue). When Edwards retired after 18 years of service, a logical choice for his successor was Theodore Poehler, who held an appointment as a faculty member in the new Department of Electrical Engineering and Computer Science; Poehler was also a member of APL's Principal Professional Staff and was an active supervisor and investigator in its Research Center. Thus, he was in a position both to represent APL at Homewood and to act as a conduit of academic direction to the Center.

When the programs transferred from the Evening College to the G. W. C. Whiting School of Engineering in 1983, it was an appropriate time to establish the position of Director of Part-Time Programs at the Whiting School. Poehler was appointed to this position and assumed responsibility for programs at all locations, including APL. With Poehler's appointment as Director of the APL Research Center later that year, Roger Westgate, Professor of Electrical Engineering, was named to the Whiting School post and later designated the Associate Dean for Part-Time Programs. A new APL Director of the Education Center, Samuel Koslov, was named for APL oversight of the activities. All of these changes, fortunately, did not interfere with James Teesdale, Assistant Director of the Center, and his operations staff in the Education and Training Group, who continued to do most of the hard work, as they have done since Edwards' tenure.

The Ranum Committee also recommended an innovative approach for the academic management of the part-time engineering programs: the institution of faculty committees, now known as Program Committees, *in locum parentis*, in lieu of academic departments. The five current Program Committees consist of members from the roster of the APL teaching faculties, some full-time faculty members from Homewood, and, on occasion, a part-time teaching faculty member from another institution. These Committees, each with a Chair, provide the academic governance normally carried out by an academic department: decisions related to faculty selection, course content, teaching quality, degree requirements and their satisfaction, and selection of students.

After Westgate's appointment as Chair of the Electrical Engineering Department in 1986, Theodore Glickman was named Associate Dean for the newly named (more appropriately) Continuing Professional Programs. When Glickman decided to return to research and consulting at the end of 1987, Vincent Sigillito served as Interim Associate Dean until October 1988. Then, in recognition of the academic stature and the significance of these programs to the Whiting School, the governing structure was modified so that the Program Chairs would report directly to the Dean of the Engineering School, as do the Chairs of the departments at Homewood. In addition, other responsibilities were transferred to the Associate Dean for Academic Affairs and to a newly created position of Director of Operations, thus obviating the need for an Associate Dean of the Continuing Professional Programs. Further, the size of the Graduate Committee, a subcommittee of the JHU Homewood Academic Council responsible for overseeing all master's degree programs in engineering, was expanded to include two of the Program Chairs.

Although APL is not a degree-granting division of the University, its dedication to education, both as a necessity for its advanced research and development activities and as a service to the industrial and governmental community of which it is a part, is demonstrated by its giving birth and sustenance to one of the largest graduate programs in the country. Education as a role for APL was recognized on 11 April 1988 by The Johns Hopkins University Board of Trustees when the mission statement for APL was changed to include, specifically, the educational mission and now reads:

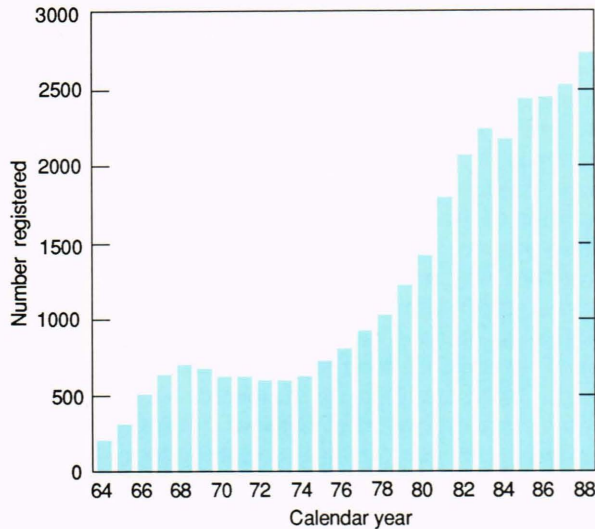
The general purpose of The Johns Hopkins University can be stated as public service through education, research and the application of knowledge to human affairs. As part of the University, the Applied Physics Laboratory shares this purpose through the application of advanced science and technology to the enhancement of the security of the United States of America and through basic research and participation in the educational programs of the academic divisions of the University to which its staff and facilities can make an especially favorable contribution.

## FACULTY AND STUDENTS

The faculty members of the APL Education Center are carefully selected and possess outstanding credentials and professional experience in the areas in which they teach. They also demonstrate an understanding of the particular abilities and needs of employed scientists or engineers who continue their education on a part-time basis. APL staff members constitute 67% of the instructional staff. Faculty are also provided by other University divisions and by the staff of about 20 other governmental, university, and private organizations.

The APL Center's Fall 1988 class registration total was 2713 (Fig. 7); by means of the Instructional TV System, an additional 61 registrants at Homewood attended courses at APL. Registrations are remaining steady despite the graduation of 447 APL Center students with





**Figure 7**—The APL Center's Fall 1988 class registration total was 2713, including 263 registrations at the Parkway Center. By means of the Instructional TV System, an additional 61 registrants at Homewood attended courses at the APL Center.

master's degrees in May 1988 in the five APL-based programs.

For the past few years, a conscious effort to reduce class sizes has resulted in a decrease from 28 to 20 students per class between 1984 and 1988. Reducing class sizes while maintaining high enrollment has been made possible by the dedicated efforts of the Program Committees. The number of courses has been increased by recruiting new faculty members. Fifty-seven more class sections were offered in the fall of 1988 than in the fall of 1984. Currently, 2076 students are enrolled (118 APL staff members, 1958 others), which is 207 more than the 1869 enrolled in Fall 1987 and represents an enrollment increase of 11.1% compared with 1987.

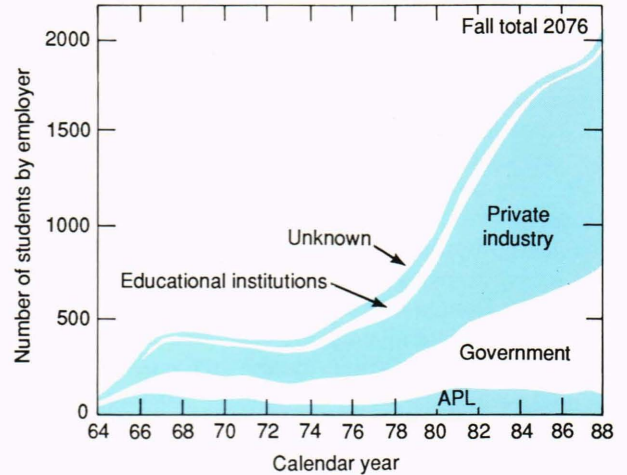
Some students take more than one course per term, so the number of students is always smaller than the sum of the various class registrations. The growth trend is similar, but a very definite change in the composition of the student body has taken place over the years (Fig. 8). In 1964 and 1965, APL staff members constituted 65% and 61%, respectively, of the student body. That ratio changed markedly in 1966, however, and APL staff members have been a minority ever since. In 1988, they make up only 5.7% of the total.

Definite trends in program enrollment can be seen (Fig. 9).

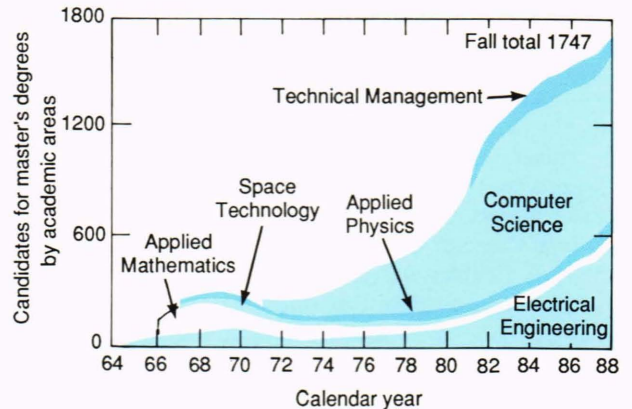
1. *Electrical Engineering*—This program is continuing to grow. Since 1984, the number of degree candidates has more than doubled. After filling the APL classes, students were directed to those at Homewood (Instructional TV System) and the Montgomery County Center.

2. *Applied Mathematics*—After several years of declining enrollments, this program is now attracting a growing number of degree candidates (Fall 1986: 39; Fall 1987: 49; Fall 1988: 61).

3. *Space Technology*—Lack of sustained student in-



**Figure 8**—In the present student body, the number of individuals enrolled is 2076 (118 APL staff members, 1958 others). This total is 207 more than the 1869 enrolled in Fall 1987 and represents an increase of 11.1% in individuals enrolled compared with 1987.



**Figure 9**—Trends in program enrollment. The Electrical Engineering program is continuing to grow. Since 1984, the number of degree candidates has more than doubled. Computer Science continues to be the largest program. Lack of sustained student interest resulted in the deletion of the Space Technology program.

terest resulted in the deletion of this program; the final degree was awarded in 1985.

4. *Applied Physics*—After experiencing significant growth for the past several years as a result of major enhancements to the program, the number of candidates has stabilized between 65 and 70.

5. *Computer Science*—This program continues to be the largest (50.5% of all degree candidates), although its dynamic growth has leveled off.

6. *Technical Management*—Enrollments in this program are remaining at capacity.

At the May 1988 commencement ceremonies, 447 master of science degrees were awarded to students completing their studies in the APL-based programs. Master's degrees in six academic areas have been available



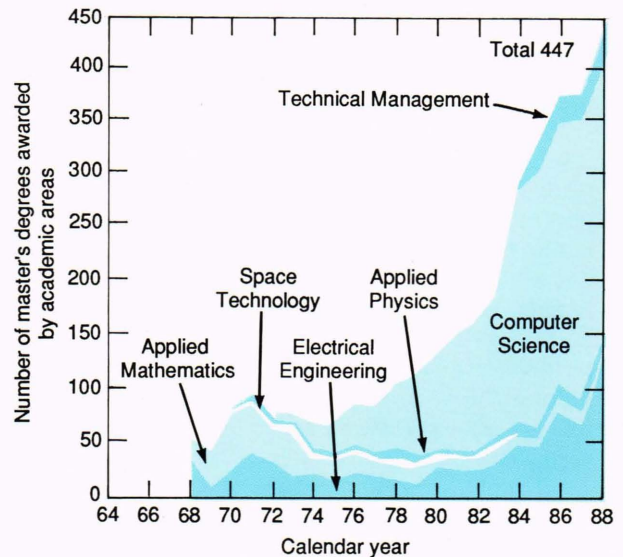
through the APL Center, and 3408 have been awarded (420 to APL staff members and 2988 to others) (Fig. 10). Computer Science has awarded 1928, followed by Electrical Engineering, 808; Applied Mathematics, 389; Applied Physics, 125; Technical Management, 107; and Space Technology, 51.

## VENTURES AND VISTAS

The APL Education Center, while primarily functioning as a major component for providing master's degree-level courses within the G. W. C. Whiting School of Engineering, is constantly monitoring the constantly changing educational needs of the technical community the Laboratory serves. In today's ever-expanding world of technology, the programs must necessarily provide a large and continually changing menu of technical subjects in the courses carrying credit for the degree, as well as ensure adequate correlation between these courses to provide areas of concentration.

Many areas of military technology encompass entire disciplines of sciences and engineering that, by their nature, require classified course work, which is implicitly contrary to the normal academic philosophy of open discussion. As a major national laboratory dedicated to the country's security, APL has the ability and the opportunity for providing appropriate educational resources in a classified format. In 1985, the Association of Old Crows, a major professional society whose members are concerned with the technology of electronic warfare, requested that APL develop secret-level short courses in the scientific and engineering aspects of electronic warfare and its operational concepts that would be presented in various regions of the country to appropriately authorized students. Subjects covered include radar equations, radar detection formulas, jamming modulations and techniques, principles of electronic countermeasures-resistant design, missile guidance fundamentals, communications electronic countermeasures/electronic counter-countermeasures, and air/land/sea electronic warfare scenarios. Under the sponsorship of the Education Center, Robert F. Gehrke and his associates have now given three-day short courses on these subjects at ten locations throughout the United States and Canada to about 1300 students.

During a symposium, "The Future of Naval Multi-warfare Coordination," held at the Kossiakoff Center in 1983, several flag officers expressed concern over the lack of technical knowledge among naval personnel of the abilities of space systems for naval warfare. As a result, Koslov suggested to Rear Admiral Ramsey, then Commander of the Naval Space Command, that it might be appropriate for APL to provide a one-semester course on the basic principles of spaceflight and satellite systems as they might relate to military requirements to the upperclassmen at the U. S. Naval Academy. Admiral Ramsey approved of the concept and suggested it be broached to the Superintendent of the Naval Academy. Vincent Pisacane, head of the Space Department at APL, and Koslov quickly prepared a proposed syllabus as a basis for discussion. After a long period of correspondence,



**Figure 10**—At the May 1988 commencement ceremonies, 447 master of science degrees were awarded to students completing their studies in the APL-based programs. Master's degrees in six academic areas have been available through the APL Center, and 3408 have been awarded (420 to APL staff members and 2988 to others).

APL was asked to come to Annapolis and talk to a group of faculty from the Aeronautics Department. We were, admittedly, quite concerned that our one-semester-course idea would be greeted by an N.I.H. (not invented here) approach; after three hours of continuous wrangling and shouting, however, we were asked to provide three courses rather than just one. These included space environment combined with an existing orbital dynamics course, spacecraft systems, and spacecraft design. The concept was that if APL would provide the needed faculty for a short time, the Naval Academy would eventually develop its own internal resources.

The first time this option was offered to the second-year class (junior year), more than half the students in the department expressed a desire for the space technology option. The APL Education Center has continued to support this program with ever-decreasing manpower as the Naval Academy has increased its own internal faculty. The Naval Space Command has provided a Chair in Space Engineering, which has been filled for several years by a member of the APL staff. The structure of the aeronautical engineering curriculum has been rearranged to provide a better background for the students who elect this option, and the program has been hailed as one of the best in the country.

We are all familiar with the multifaceted competition among the United States, the Soviet Union, Japan, and Western Europe for technological supremacy. One classical parameter for measuring the rate of progress has been the educational output of new graduates in the engineering disciplines. In recent years, many observers have recognized that this particular parameter has a more complex etiology than simply nose-counting.



A landmark study of this problem was *The Report of The Centennial Study Committee at MIT*.<sup>6</sup> To quote some aspects of the committee's concern,

The present rapid rate of scientific and technical innovation invalidates one of the basic assumptions underlying the traditional structure of engineering education: that a few years of formal education can provide an adequate foundation for a lifetime of professional engineering work . . . The demand for highly creative, up-to-date engineers has intensified during the last decade as a result of the rapid growth of the knowledge-intensive industry and of the increasing competition for national and international markets . . . This demand cannot be met by replacing "obsolescent" engineers with new graduates (and the human costs of such a replacement policy would be unacceptable even if it were feasible) . . . The only apparent alternative is better utilization of the presently available engineering workforce through continuing education at the workplace, with the active encouragement and support of employers.

Preventive maintenance, like insurance, is generally accepted as a proper or even essential budget item. It provides protection against the disruption caused by unpredictable equipment failures and the high cost of emergency repairs. . . . If engineers are valuable assets, why do we pay relatively little attention to extending their useful life through the education equivalent of preventive maintenance and modernization?

Edward Lumsdaine, speaking at a conference on manufacturing engineering education, pointed out that<sup>7</sup>

The majority of engineers still follow a typical engineering career pattern: they enter the profession at 25, achieve peak technical productivity by age 35, and then move into a managerial or administrative position by age 40, where they manage to hang on until retirement. Up against this traditional pattern we are now facing some new realities: half of what our new engineers know (especially in electrical engineering and computer engineering) will be obsolete within five years. Thus, we must now address the large and pressing problem of updating large numbers of older engineers so that they can keep functioning at a technically competent level.

Simply stated by Thomas J. Allen,<sup>8</sup>

The publications of the professional engineering societies in all of these diverse fields are little used by their intended audience . . . The principal reason for the reluctance of engineers to use their professional society journals is very simple: they cannot understand the material published in them.

The APL Education Center has now had many years of experience in observing the pattern of students who seek advanced knowledge essential to keep up with their fields and to improve their performance in jobs at the forefront of modern technology. One aspect of these observations is that many in the engineering professions, proficient in their initial assignments, tend to be kept

in a narrow domain until there is no longer a significant need for their particular specialty. At this point, they are many years removed from the discipline and work habits of their undergraduate or early graduate days. These "older" engineers may have left academe anywhere from 10 to 30 years before and are highly intelligent and energetic professionals, but are intimidated by the concept of going back to graduate programs to compete with students fresh from undergraduate programs or who are only a few years removed from them. In many cases, practicing engineers, with responsibilities now of family and finance and living in an established life-style, do not really want to commit themselves to an advanced degree as such but, rather, want to obtain the knowledge necessary to become current and work at the forefront of their fields. In many cases, their backgrounds may not qualify them for admission to a highly competitive graduate program, such as those offered at the APL Education Center. Although a plethora of short courses is available as well as specialized multiweek programs, the former rarely provide the tools needed for continuing into the advanced courses, and an intensive specialty course can rarely be successfully absorbed by the student who has forgotten, or never received, the tools needed in his educational background.

During the past year, the APL Education Center has initiated an experimental program of "Career Enhancement Courses" to provide a bridge between the previous training and work experience of the practicing engineer and entry into modern graduate programs. Now on a pilot-program basis internal to APL, courses have been or are being developed, using small classes and highly interactive tutorial methods, in Applied Mathematics, Modern Electronics, Modern Physics and Materials, and Computer Applications. The Center hopes that these will be available in the near future to the broader community of which it is a part.

It may be appropriate to close with another quotation by President Muller of Johns Hopkins:<sup>9</sup>

Clear recognition that universities exist to teach and that the contemporary university must do research in order to teach—not do research for its own sake—provides the best guidance for future courses of action . . . The future of innovation in the American economy does indeed depend on the American university . . . The university's role in the development of human talent transcends by far the university's role in discovery . . . The future of both national security and national prosperity depends significantly on a continued investment in university science and technology, supported by both government and industry, with the primary emphasis on the development of human talent.

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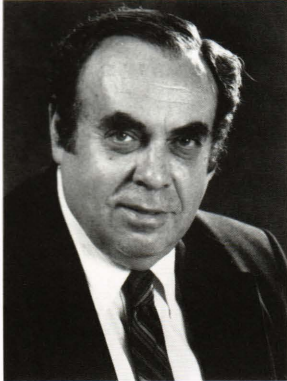
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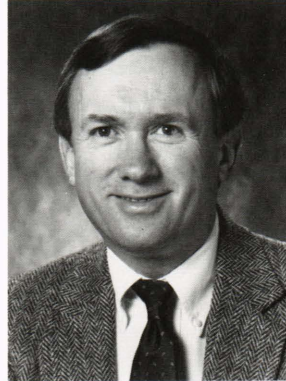
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## THE AUTHORS



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