



The Technical Management and Systems Engineering Programs

Samuel J. Seymour and Alexander Kossiakoff

The Master's of Science programs in Technical Management and Systems Engineering have several unique features and high relevance to government and industry that have led to significant growth, the creation of partnerships, and leadership in these academic fields. We discuss those topics as well as the history of the programs, the curricula, admissions requirements, and the faculty.

INTRODUCTION

The Technical Management (TM) and Systems Engineering (SE) programs are intended for professional scientists and engineers who wish to apply their technical knowledge and experience to the management of technical organizations or engineering programs. Typically, neither the students' professional education nor their work as technical professionals has prepared them for dealing with the complex and often frustrating problems involved in planning, organizing, and directing the efforts of diverse groups of people according to a strict technical objective, budget, and schedule. A major goal of the TM and SE programs is to provide students an opportunity to learn what practical problems they are likely to face as managers and systems engineers and how such problems may be resolved successfully. For students with prior experience, the programs offer a framework of methodology, a broadening of outlook, and an opportunity to apply their skills to a wide variety of situations and problems.

Clearly, these traditional programs are quite different from academic programs in engineering disciplines with

their basis in established knowledge and quantitative methods. Fortunately, since the early 1980s, a number of highly experienced technical managers and systems engineers at APL have had a strong interest in teaching their accumulated knowledge to students who have chosen a career in technical management or systems engineering. Another impetus for the development of a curriculum came from then President of The Johns Hopkins University, Dr. Steven Muller, and the Westinghouse Electric Company (now Northrop Grumman Electronic Systems), who saw the need to establish such programs to benefit area industry.

The TM and SE curricula were developed in 1981 and 1991, respectively, and have been in strong demand ever since. The early history and program development are described in Refs. 1 and 2. This article focuses on more recent developments.

PARTNERSHIPS

From the beginning of the programs in the 1980s, special relationships have existed with some of the

larger employers in the area. After its initial support in 1981, Westinghouse created a competitive scholarship program in 1986 that eventually included both systems engineering and technical management students.

In 1999, BAE Systems Corporation (previously Lockheed-Sanders), a large defense electronics company in Nashua, New Hampshire, asked APL to provide graduate systems engineering education to their senior personnel. BAE senior management actively supports the program through the nomination of students, provision of facilities, and nomination of highly qualified co-instructors from among the company's engineering managers. Also in 1999, at the request of the Naval Sea Systems Command, the SE Program was initiated in Crystal City, Virginia, for naval personnel and local DoD contractors.

The offering of courses at the Southern Maryland Higher Education Center (SMHEC), starting in 1999, was a direct response to expressed needs by the Naval Air Weapons Center (NAWC) at Patuxent River Naval Air Station. A special partnership with the Naval Test Pilot School provides a curriculum tailored to the schedules and demands of this student population. In addition, the leadership at NAWC asked APL to provide systems engineering courses for their Class Desk staff members that are now offered in a weekly format twice a year on the naval base.

In 2002, the MITRE Corporation conducted a national search for a quality graduate program in systems engineering and selected the APL program for senior employees in Bedford, Massachusetts. The SE Program was expanded in 2003 for MITRE's McLean, Virginia, location. These special initiatives were established in recognition of the growing need for systems engineering in the development and application of complex military and commercial systems.

PROGRAM DEVELOPMENT

Like other Engineering Programs for Professionals (EPP), the TM and SE programs are offered at the APL Education Center in Laurel, the Dorsey Center in Howard County, and the Montgomery County Campus in Rockville, Maryland. However, unlike the EPP, the TM/SE programs are also offered to the public at the SMHEC in St. Mary's County and at "partnership" sites restricted to students from particular organizations.

The increase in management demands and the complexity of systems development have led both civilian and military employers and employees to participate in the TM

and SE programs in order to gain fundamental comprehension and skills as well as an understanding of best practices. As shown in Fig. 1, the number of students has grown steadily since the TE Program was initiated by Dr. Alexander Kossiakoff in 1981. More than 800 students are enrolled today, making the APL offerings one of the largest part-time TM/SE programs in the country.

Through public offerings and partnerships, current program students represent more than 150 employers (Table 1). About 30% are employed by the DoD, 30% work for defense contractors, and the remaining students are from commercial industry or non-DoD government agencies. Student enrollment from APL is usually around 10% but has been increasing in recent years. Because of the experience of the faculty members, student application needs, and the similarity between the work of partnership organizations and APL, the programs are strongly focused on military and government topics and practices.

THE CURRICULA

The courses in both the TM and SE programs have evolved over many years. Instructors continually update and modify the course content to maintain currency, relevancy, and interest. Advances in management have required increased emphasis on software, modeling and simulation, quality, and risk management. In systems engineering, significant changes are occurring in expanding the understanding of systems of systems, systems architecting, and systems enterprise engineering.

The management and systems engineering processes in the academic programs are defined in the top-level flow of a project life cycle that we define as the systems engineering method (Fig. 2). This systematic way of producing complex products requires specific activities and uses procedures and tools that vary with each step

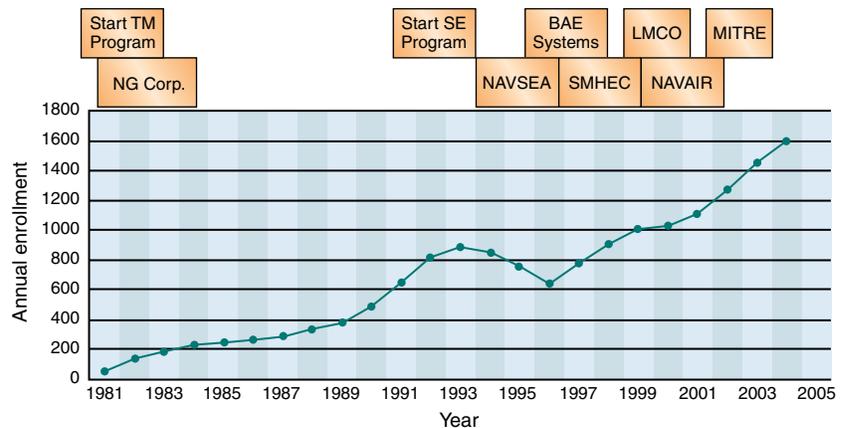


Figure 1. Annual enrollment in the TM/SE programs and key milestones. (LMCO = Lockheed Martin Corp., NAVAIR = Naval Air Systems Command, NAVSEA = Naval Sea Systems Command, NG = Northrop Grumman, and SMHEC = Southern Maryland Higher Education Center.)

Table 1. Leading employer source of students in the TM/SE programs and number of active students per employer.

U.S. Navy	140
Lockheed Martin	73
JHU/APL	65
MITRE	62
BAE	61
Northrop Grumman	56
Other DoD	16
SAIC	15
Boeing	13
Booz Allen & Hamilton	12
Raytheon	8
Total	521

Note: Total number of active students = 675.

in the method. The solutions to the problems faced in each phase can best be resolved through broad experience and knowledge of effective best practices.

Unlike most programs in the field, the APL programs are a cohesive, integrated set of courses that build on each other within the systems engineering method. For instance, the systems engineering courses (after an overview course) follow a project life cycle from conceptual design through final test and evaluation and deployment. Each course relies heavily on team collaboration

and group projects to give students hands-on experience in managing or developing complex projects.

Table 2 lists the current courses for the programs. The introductory courses are prerequisites for later advanced courses. To graduate, students must complete 10 courses and, depending on their choice of concentration, may take up to three electives in addition to the required courses.

The fundamental systems engineering text used in the introductory courses was written by Dr. Kossiakoff³ and is widely used throughout the world in systems engineering education. In recognition of his achievements, the International Council on Systems Engineering (INCOSE) named Dr. Kossiakoff an Honorary Fellow in 2004.

ADMISSIONS

Another special feature of these programs is the requirement for several years of job experience (not counting graduate education). To gain full value from the programs, students must be sufficiently experienced and professionally mature to fully appreciate the types of people and program problems that confront managers and systems engineers. It is also stressed throughout the program that technical managers must have a broad understanding of the technical content of the work they manage. Consequently, admission is also limited to those who have a bachelor's degree in science, engineering, or mathematics and who meet the scholastic requirements of the JHU Whiting School of Engineering. Because of the highly interactive nature of the courses, class size is limited to 20 students.

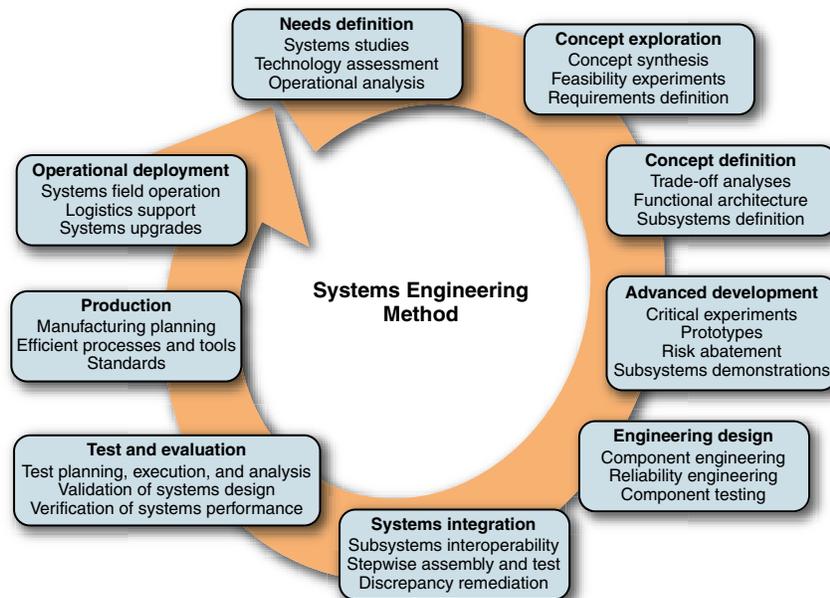


Figure 2. The phases of the project life cycle serve as the basis for the systems engineering method used throughout the curricula.

FACULTY

Unlike normal academic practice, courses in the TM and SE programs are team taught by two instructors who are expert practitioners in the field. This is done to give students a broader viewpoint of the largely experiential knowledge base required by successful technical managers and systems engineers. The effectiveness of this arrangement is further amplified by having an average of three or four guest lecturers on specialized topics of current interest. Secondary reasons to have co-instructors are to promote a high level of class interaction and to handle the large amount of homework that must be evaluated. It also provides senior staff in highly responsible positions sufficient flexibility to be able

Table 2. Courses for M.S. degrees in Technical Management and Systems Engineering (R = required, E = elective).

Courses	Concentrations		
	Project Mgt.	Organizational Mgt.	Project/Org. Mgt.
Technical Management			
Introduction to Project Management	R	R	R
Technical Group Management	R	R	R
Introduction to Systems Engineering	R	E	R
Project Planning and Control	R	R	R
Communications in Technical Organizations	R	R	R
Finance and Contract Management	R	R	R
Software Engineering Management	R	E	R
Technical Personnel Management	E	R	R
Management of Technical Organizations	E	R	R
Advanced Technology	E	E	E
Quality Management	E	E	E
Systems Conceptual Design	E	E	E
Systems Design and Integration	E	—	—
Systems Test and Evaluation	E	—	—
Systems Engineering			
	Systems Engineering		Project Mgt.
Introduction to Systems Engineering	R		R
Introduction to Project Management	R		R
Project Planning and Control	R		R
Software Engineering Management	R		R
Systems Conceptual Design	R		R
Systems Design and Integration	R		R
Systems Test and Evaluation	R		R
Systems Engineering Project	R		R
Technical Group Management	E		R
Communications in Technical Organizations	E		R
Approved electives (2)	E		—

to serve as faculty members. The team-teaching format facilitates the development of new faculty by having the more experienced co-instructor serve as mentor. It also makes for continuity of course subject matter during changes of instructors.

About two-thirds of the faculty are members of the APL Principal Professional Staff, a rank equivalent to tenured faculty. The non-APL faculty are drawn from the management ranks of nearby industry and government, such as Northrop Grumman, Lockheed Martin, and the Navy.

APL staff members have been a particularly rich source of faculty because of the Laboratory's diverse activities in developing missile, space, and other complex systems for the Navy, NASA, and other government agencies, as well as its broad range of research, analysis, and evaluation programs. The staff traditionally work closely with both industry and major government laboratories and understand their organizations, methods of operation,

and special abilities. Through APL's service in many programs as a technical agent for the government, the staff have acquired experience in all phases of major system acquisition and operational evaluation. Several have also had prior senior management responsibilities in industry or government.

PROGRAM OVERSIGHT

Academic governance of the TM and SE programs is carried out by a single committee because of the considerable overlap in course content and singularity in approach as described above. The functions of the program committee are similar to those of the other major EPP committees and are directed to the preservation and improvement of the academic quality of the programs. The committee has also been involved in recent initiatives in special programs and partnerships.

Because of the nontraditional nature of the TM/SE programs, the use of co-instructors and guest lecturers, and extension of the program offerings to remote locations, far more time has had to be devoted to managing these programs than is necessary for the more conventional EPP. Activities include the recruitment of experienced faculty, new course and program develop-

ment, planning and executing the course scheduling at the various locations, reviewing and maintaining a database of student records and plans, reviewing student applications to determine whether students meet the special criteria for admission (education and experience), updating the catalogue and course schedule, and reviewing and approving systems engineering capstone project course submittals.

FUTURE PLANS

The TM/SE programs continue to explore opportunities and requests for new partnerships. A successful relationship has the strong management/leadership commitment of the partner, a well-defined need matching our curricula that will make a difference, conditions that will add value to APL and the JHU School of Engineering, and a long-term expectation of qualified student enrollments. We are currently exploring

potential partnerships with the U.S. Strategic Command (STRATCOM) in Omaha, Nebraska, and the Naval Post Graduate School. We are also expanding our successful partnership with BAE Systems in other locations while continuing to enhance our relationships with Northrop Grumman and Lockheed Martin.

The development of new partnerships, especially those at a distance, requires additional faculty, increased coordination, and improved use of instructional technology. We also recognize that curriculum content needs to address the current needs of our student base and the increasing complexity of the disciplines.

Academically, we are developing a new systems engineering concentration in software systems engineering and new advanced systems engineering courses in enterprise systems engineering, systems-of-systems engineering, and systems architecting. These courses have become the core for a post-master's certificate program in systems engineering.

SUMMARY

The welcome challenges of the TM/SE programs are to balance growth to meet demand while

maintaining the high quality and relevance of the curricula. The unique academic approach honed over two decades, the development of tailored programs for partners, and leadership in developing advanced management and systems concepts and courses are key features in making a difference in thousands of students' careers and in numerous successful organizations.

ACKNOWLEDGMENT: This article is dedicated to the memory of Dr. Alexander Kossiakoff, who passed away on 6 August 2005. His vision and devotion have made these graduate academic programs possible.

REFERENCES

- ¹Kossiakoff, A., "The History of the Master's Degree Program in Technical Management," *Johns Hopkins APL Tech. Dig.* 10(2), 154–161 (1989).
- ²Thompson, R. J., and Kossiakoff, A., "The Master's Degree Program in Technical Management," *Johns Hopkins APL Tech. Dig.* 10(2), 162–173 (1989).
- ³Kossiakoff, A., and Sweet, W. N., *Systems Engineering Principles and Practice*, Wiley and Sons, Inc., Hoboken, NJ (2003).

THE AUTHORS

Samuel J. Seymour received a B.S. in chemistry from the Rochester Institute of Technology in 1968 and a Ph.D. in physical chemistry from the University of Illinois. Since joining APL in 1973, Dr. Seymour has conducted research and managed programs in the Submarine Technology and Strategic Systems departments. He became the Laboratory Business Coordinator in 1991 and also serves as the Business Area Executive for Emerging Business, Deputy Chief Quality Officer, and facilitator for the Business Review Committee. Dr. Seymour has taught management and systems engineering courses in the JHU Engineering Programs for Professionals for more than 20 years and serves as the student programs advisor and coordinator of the partnership programs. He was appointed Vice Chair of the Technical Management and Systems Engineering programs in 1998.



Samuel J. Seymour



Alexander Kossiakoff

Alexander Kossiakoff received a B.S. in chemistry from the California Institute of Technology in 1936 and a Ph.D. from JHU in 1938. He taught at the Catholic University of America, served with the wartime Office of Scientific Research and Development, and was Deputy Director at the Allegany Ballistics Laboratory, Cumberland, Maryland, from 1944 to 1946. Dr. Kossiakoff joined APL in 1946 and served as Head of the Bumblebee Launching Group until 1948, when he was appointed Assistant Director. He became Associate Director in 1961 and Director in July 1969. In 1980, he stepped down as Director and was appointed Chief Scientist. He also became the Program Chair of the Technical Management and Systems Engineering programs, positions he held until his death on 6 August 2005. In recognition of his work on national defense, Dr. Kossiakoff was awarded the Presidential Certificate of Merit, the Navy's Distinguished Public Service Award, the DoD Medal of Distinguished Public Service, and the prestigious Johns Hopkins University President's Medal in 2005. He was also named an Honorary Fellow of the International Council on Systems Engineering. For further information about these programs, contact Dr. Seymour. His e-mail address is samuel.seymour@jhuapl.edu.