The IEEE Systems, Man, and Cybernetics Society: Past, Present, and Future

James D. Palmer, *Fellow, IEEE*, Andrew P. Sage, *Fellow, IEEE*, Thomas B. Sheridan, *Fellow, IEEE*, James M. Tien, *Fellow, IEEE*

***Abstract*—In the evolution of any professional organization, it is informative and desirable to take stock of what has occurred, and to use this assessment to consider and plan for the future. In this paper, we—a group of four current and former IEEE Systems, Man, and Cybernetics (SMC) Society presidents—consider the past, present, and future of the IEEE SMC Society; we are also doing this to commemorate the Society's 20th anniversary. In particular, we address our auspicious beginning; our transition from an incubatee to an incubator society; the breadth of our TRANSACTIONS; the international character of our membership; the appropriateness of our name; the move toward a systems-oriented umbrella organization; the evolving array of research areas; and the challenges and opportunities we face in the future.**

I. Introduction

In this paper, we consider the past, present and future of the IEEE Systems, Man, and Cybernetics (SMC) Society. Our consideration must, by necessity, be nonexhaustive. Indeed, we are but four out of a total of 12 current and former SMC presidents; our backgrounds, work experiences and research endeavors do not completely encompass the broad range of SMC concerns; and our ability to look into the future is limited. Additionally, because of space limitation, we cannot comment on a number of other important issues. One such issue — and despite the fact that we the authors are all academics by profession — is the impact that the SMC Society has had or should have on systems engineering education.

We begin with a brief discussion of the scope of SMC interests. The principal thrust of activities within the SMC is the development and use of the methods of systems engineering, together with the strongest of emphasis on human–system interaction concerns, for the design of knowledge-based cybernetic systems and processes that support human activities in planning, design, decision making, and associated resource allocation. It is through this thrust that we define the purpose of systems engineering as working with clients to assist them in the organization of knowledge, which in turn requires methods for knowledge acquisition and representation, as well as utilization. Thus systems engineering activities—and the activities of the SMC—vary from requirements definition or specification, to the conceptual and functional design and development of systems; they are much concerned with architectural definition and performance evaluation. These activities are needed to obtain functional integration, maintainability, reliability and, perhaps most importantly, the appropriate interfaces that will insure system design for successful human interaction—which may involve human supervisory control of physical processes, such as the robots that are used in automated manufacturing. It may involve typically cognitive tasks at the operational levels of fault diagnosis, detection, and correction; or at the level of strategic planning.

Thus, contemporary and future research efforts in systems engineering and the SMC Society place major emphasis on behavioral factor concerns associated with systems engineering. This includes a variety of human–machine interaction issues and a number of cybernetics areas related to communications, and command and control in humans and machines. All of these are, and will be, especially concerned with the use of computers in decentralized, interactive, information repositories; they also concern the development of analytic, computational, and behavioral constructs that support the design of knowledge bases, model bases, and dialogue generation and management systems that, in turn, support information technology-based systems and processes for efficient and effective planning, design, and decision support.

II. An Auspicious Beginning

In trying to understand our past, we have found the 1987 article by Joseph G. Wohl [10] both interesting and informative. Joe was an extraordinary volunteer who was not only instrumental in the founding of our Society but who worked tirelessly for the Society's well-being. In fact, when Joe died unexpectedly in 1989, he was again serving as the General Chair for our annual conference that year. In recounting the beginning period of our Society, we have borrowed liberally from Joe's article—in fact, we hope that this brief account will interest many readers to actually peruse the entire article.

Our Society was formally born in late 1970 by the merger of two groups in the IEEE—the Man–Machine Systems Group (chaired by Joe Wohl) and the Systems Science and Cybernetics Group (chaired by Donald B. Brick). From the beginning, these two groups were oriented toward modeling over a broad spectrum of fields, ranging from modeling of biological functions to modeling of large-scale socioeconomic systems, with man–machine systems of all kinds in between.

Manuscript received August 27, 1991; revised December 17, 1991 and December 25, 1991. A draft version of this paper was presented at the 1991 SMC Conference in Charlottesville, VA.

J. D. Palmer and A. P. Sage are with the School of Information Technology and Engineering, George Mason University, Fairfax, VA 22030-4444.

T. B. Sheridan is with the Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, MA 02139.

J. M. Tien is with the Department of Decision Science and Engineering Systems, Rennsalear Polytechnic Institute, Troy, NY 12181.

IEEE Log Number 9106985.

0018-9472/92$03.00 © 1992 IEEE

The members were largely researchers, in academe or in industrial research laboratories or in consulting firms.

The Man–Machine Systems Group had its beginning in 1954. Frank V. Taylor, who had just organized Division 21 (now the Society of Engineering Psychologists) of the American Psychological Association and who had helped establish the Human Factors Society, and his colleague, Henry P. Birmingham, published an article on "Design Philosophy for Man–Machine Systems," in the *Proceedings of the Institute of Radio Engineers* (IRE, a predecessor to IEEE). Realizing that a closer link to engineers must be established in order for work on human factors to have an effect on hardware design, Hank Birmingham took the initiative in 1955 (against the advice of his colleagues in the Human Factors Society) to establish a professional group on human factors in electronics in the IRE. It became the 28th group in the IRE. Hank was chair of the group for the first year. Curt Jansky chaired it the second year. Bernie Mannheimer, John Senders and Frank Taylor were early members. The first issue of the IRE TRANSACTIONS ON HUMAN FACTORS IN ELECTRONICS came out in March 1960; it was initially published aperiodically—that is, when enough good articles had been received and refereed.

In 1968, the Professional Group on Human Factors in Electronics changed its name to the Professional Group on Man–Machine Systems in order to reflect the increasing interactions of humans in systems. By this time, the IRE had merged with the American Institute of Electrical Engineers to form the present IEEE. The first issue of the IEEE TRANSACTIONS ON MAN–MACHINE SYSTEMS was dated March 1968. It was edited by Tom Sheridan, who also served as the first Chair of the Man–Machine Systems Group until the following year when Joe Wohl took over.

The Professional Group on Systems, Science, and Cybernetics was organized in the early 1960s. The first issue of its TRANSACTIONS was published in November 1965, with Arthur D. Hall as its first editor. Early issues of the TRANSACTIONS included important contributions by Hall as well as R. L. Ackoff, D. B. Brick, R. A. Howard, I. de Sola Pool, and L. Stark. Following the merger of the two IEEE groups, the first issue of the renamed IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS was published in January 1971 under the joint Editorship of Russ Ferrell and John Warfield. About a year later, Andy Sage became the Editor of the TRANSACTIONS.

III. FROM AN INCUBATEE TO AN INCUBATOR SOCIETY

The IEEE SMC Society was incubated through the merger of two IEEE groups—Man–Machine Systems and Systems Science and Cybernetics. In turn, these two groups were born during the late 1950s and early 1960s because a significant body of intellectual ferment was brewing throughout the IRE, the AIEE, and subsequently, the IEEE. The essence of this concern centered on the fact that there was no place to air the efforts of engineers and engineering psychologists working at the intersection of technology and human functioning. Existing IEEE groups at the time generally eschewed publication of research papers on these topics in favor of "mainstream technological advances" such as more mathematical treatises on the nuances and fine points of control theory. While these efforts were laudable in every way, they did not encompass the whole world of engineering interests.

Given the manner in which the SMC Society was established, it is little wonder that it has become an incubator for related technological thrusts. We have only to examine an early list of SMC's Technical Committees to come to this conclusion. If we go back to the initial 1971 list of Technical Committees, we find the following:

- *Systems Science Committee*
  CADAR Representative
  IEEE Applications of Electrotechnology to Social Problems
  IEEE Environmental Quality Committee Representative
  IEEE Transportation Committee Representative
  National Priorities
  National Goals: Health Care
  Nonquantifiable Elements in Decision Making
  Optimization and Decision Analysis
  Problem Definition, Modeling and Simulation

- *Cybernetics Committee*
  Adaptive and Learning Systems
  Biocybernetics
  Foundation of Cybernetics
  Pattern Recognition

- *Man–Machine Systems Committee*

This relatively short list of technical interests of the membership of the newly formed IEEE Group on Systems, Man, and Cybernetics already showed sure signs of becoming an incubator organization. Of course, the hindsight afforded by several decades of seeing these things happen helps this visionary process. For example, we can track activities in health care, transportation, pattern recognition, and decision making and decision analysis. Pattern recognition has gone on to become PAMI and has a life of its own as an IEEE technical interest activity complete with its own TRANSACTIONS on pattern analysis. Yet another example is in simulation. For the technical interest area embodying simulation, SMC joined several other non-IEEE Societies to form the Winter Simulation Conference that publishes its own Proceedings, perhaps the most influential publication in the area of simulation. Unlike PAMI, the Winter Simulation Conference remains an integral part of SMC and SMC remains as one of the founding member societies of the Conference's Board of Directors. So we may say that from the very beginning of this newly formed SMC Group, itself the result of having been within an incubator environment of sorts, has itself become a recognized incubator for new technologies at the cutting edge of engineering.

By the year 1983, we saw SMC Technical Committees in areas such as energy systems, knowledge-based systems, artificial intelligence, control and decision, adaptive and learning systems, technology forecasting, and technology resources and environment, in addition to many of the same Technical Committees that were first listed in 1971. Within these technical interest areas, we again saw the seeds of incubation that led to entities beyond SMC. Knowledge-based systems and artificial intelligence led to the development of an interest group in neural networks. Special interest groups in decision and control led naturally into an interest in robotics. First robotics and automation and then neural networks have gone on to become separate IEEE entities, although supported by SMC as a sponsoring society. Today, there are the IEEE Robotics and Automation Society and the IEEE Neural Networks Council. A new Transactions on Fuzzy on Fuzzy Systems will soon be born.

By 1990, the SMC Technical Committees had continued to evolve to reflect both the traditional and continuing interests of SMC members and a number of emerging and evolving technologies. We presently have an interest in international stability (this for the past five years—and how could we have a more pertinent topic, given the rapid changes in the international political scene), manual control, optimization, pattern recognition, image processing, computer vision, cognitive systems science and engineering, human decision making, human–computer interaction, information and decision systems, and integrated manufacturing. Which of these is a candidate for the next incubated spin-off? Only time will tell. Certainly, several of these areas look promising. For example, it would appear that the human–computer interaction is an area that is receiving an unusual level of international interest by both technical and non-technical individuals and groups. Computer vision seems to be of interest to an increasing number of technical groups both within and without the IEEE. Information and decision systems continues to surge in national importance as much of the U.S. and the world economy becomes more and more dependent on the products of the information revolution. Any one or several of these are truly candidates for the next great surge of interest in areas pioneered by the SMC Society.

IV. The Breadth of Our Transactions

Since its inception in 1971, the IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS has published articles in a broad range of areas, including biocybernetics, biomedical systems, artificial intelligence, robotics, adaptive systems, large-scale socioeconomic systems, man–machine systems and systems science—all of which are based on Norbert Wiener's interdisciplinary cybernetics concepts that, to a large measure, originated in the development and planning of large hardware systems. Many SMC articles have been modeling oriented. In general, systems are modeled as consisting of components, the salient governing equations of which could be identified. The components are then aggregated into subsystems and systems with various disturbance and goal inputs. There is little concern for describing the physics of the systems; the primary concern is system performance with respect to minimizing or maximizing certain objective functions. Many model forms are found; these include stochastic, deterministic, decision-making, communication, control, pattern recognition, queuing, linear and dynamic programming, and economic models. Readers are expected to be mathematically sophisticated. However, the TRANSACTIONS has never been interested

TABLE I
PRIMARY WORD USAGE IN TITLES OF SMC PAPERS

Agents (6)	Generalization (11)	Optimal (15)
Algorithms (9)	Graph (6)	
Applications (9)		Pattern (9)
Approach (16)	Human (7)	Planning (15)
Architecture (6)		Problem (8)
Automatic (13)	Image (9)	Process (11)
	Information (13)	
Based (24)	Integration (11)	Reasoning (9)
	Intelligent (13)	Recognition (8)
Complexity (6)		Robot (27)
Computational (7)	Knowledge (17)	
Coordination (8)		Search (6)
	Learning (6)	Signal (6)
Decision (16)		Simulation (7)
Detection (9)	Manipulator (7)	Space (8)
Diagnosis (6)	Manufacturing (7)	Structural (7)
Distributed (23)	Method (13)	Support (11)
Dynamic (15)	Model (11)	Systems (60)
	Modeling (8)	
Experimental (7)	Models (11)	Theory (9)
	Motion (16)	
Fault (6)	Multiagent (11)	Using (10)
Flexible (7)		
Functions (8)	Navigation (9)	Visual (12)
Fuzzy (7)	Network (24)	
	Neural (10)	

TABLE II
SUBJECT AREA CATEGORIZATION OF SMC PAPERS

Mathematical Modeling and Simulation (68)
Vision, Image Analysis, and Robotics (47)
Knowledge Representation, Artificial Intelligence, and Expert Systems (28)
Inference, Uncertainty and Data Fusion (23)
Neural Networks and Fuzzy Systems (22)
Human Functioning in Systems (14)
Decision Support Systems (13)
Systems Management (10)
Manufacturing Systems Engineering (8)
System Architecture (4)

in publishing purely mathematical papers. There has always been an implied requirement that models be focused on some real application, even if experimental data were not offered.

In order to better understand the current scope of papers in our TRANSACTIONS, we have undertaken an analysis of actual papers published, or scheduled for publication, in the TRANSACTIONS over a 28-month period, from January 1990 through April 1992. Only regular full length papers have been considered in the analysis. Table I lists those words—and their frequency of use—that appeared more than five times in the titles of the 237 papers published in the indicated 28-month period. There are indeed some surprises in this listing. As might well be expected, the word system is surely the most important word in our vocabulary. But, the words "man" and "cybernetics" are not even on the list—cybernetic was used only a single time, as was man. The more generic term "human" was used seven times. The words automated, based, decision, distributed, motion, network, robot and planning are the next most important—as determined by frequency of usage—vocabulary. Somewhat frivolously, we might suggest that the most generic title for an SMC paper is *Distributed Dynamic Decision and Planning Systems for Robot Motion.* Actually, this title may well not be so frivolous!

TABLE III
HISTORY OF SMC CONFERENCES

Year	Location	Chairman	Society President
1971	Disneyland	Gary Hollander	William H. von Alven
1972	Washington	K. S. Narendra	John Warfield
1973	Boston	Ahmed Meer	Kan Chen
1974	Dallas	Andrew P. Sage	Thomas B. Sheridan
1975	San Francisco	L. Stephen Coles	Thomas B. Sheridan
1976	Washington	William H. von Alven	Edward A. Patrick
1977	Washington	William H. von Alven	Edward A. Patrick
1978	Tokyo/Kyoto	Michael S. Watanabe	James D. Palmer
1979	Denver	James D. Palmer	James D. Palmer
1980	Boston	Richard F. Vidale	S. Basheer Ahmed
1981	Atlanta	Robert P. Zimmer	S. Basheer Ahmed
1982	Seattle	James A. Wise	William B. Rouse
1983	Bombay/Delhi	Faqir C. Kohli	William B. Rouse
1984	Halifax, NS	Mohammed El Hawari	Andrew P. Sage
1985	Tucson	William R. Ferrell	Andrew P. Sage
1986	Atlanta	William B. Rouse	G. V. S. Raju
1987	Alexandria	Andrew P. Sage	G. V. S. Raju
1988	Beijing/Shenyang	Jiang Xinsong/ A. Terry Bahill	Arye R. Ephrath
1989	Boston	Sheldon Baron	Arye R. Ephrath
1990	Los Angeles	Amos Freedy	James M. Tien
1991	Charlottesville, VA	Chelsea C. White III	James M. Tien

It is also of interest to examine the general subject areas of papers that appeared during this 28-month period. It would, we believe, be reasonable to assign weights to a paper to reflect the extent to which its coverage emphasizes a given subject area. Rather than do this, however, we have taken the simpler approach of assigning a paper to one and only one interest area category. Table II illustrates the several principal subject areas chosen and our categorization of each full length paper. While Table II does not reflect the range of subject areas covered by a single paper, it does indicate the importance of modeling and other areas to SMC.

V. THE INTERNATIONAL CHARACTER OF OUR MEMBERSHIP

While the IEEE itself is an international organization, with some 22.2% of its 287 557 members (as of May 1990) being located outside of the U.S., we note with pride that the comparable figure for the SMC Society (which has a total membership of 4819) is 40.6%. More specifically, and in terms of the four non-U.S., IEEE regions, the 40.6% is distributed as follows: 4.6% in Region 7 (i.e., Canada), 17.5% in Region 8 (i.e., Europe, Africa and Russia), 2.6% in Region 9 (i.e., South America), and 15.9% in Region 10 (i.e., Pacific Rim). Of the 35 IEEE Societies, our Society ranks third in terms of the proportion of non-U.S. members, behind the Industrial Electronics Society (with a figure of 43.2%) and the Power Electronics Society (with a figure of 41.3%). Moreover, the proportion of our membership who are non-U.S. is growing.

Clearly, we must recognize the fact that we are an international Society; indeed, we should welcome this situation. Along with this recognition, we must accept the responsibility we have to our non-U.S. members. For example, as indicated in Table III, we have only held four of our 20 annual conferences outside of the U.S. (i.e., in Japan, India, Nova Scotia, Canada, and China)—resulting in a one-in-five or 20% ratio. Obviously, we should, at the very least increase that frequency to one-in-four. An *ad hoc* committee was recently established to identify key groups of non-U.S. members who might be interested in hosting future SMC conferences. As another example, we might want to assure a governance structure that is reflective of our international character, including electing non-U.S. members as AdCom members and officers of our Society. A third area where we should be sensitive to our international character is in member services. At a recent meeting in June 1990, the IEEE Technical Activities Board (TAB) voted to establish its first non-U.S. office in Brussels, Belgium. SMC supported this action, with the expectation that our Region 8 members will soon experience enhanced member services.

VI. THE APPROPRIATENESS OF OUR NAME

Systems, man, and cybernetics are the three primary fields of interest of the IEEE SMC Society. Even these three words represent a sort of shorthand for lengthy terms. The word systems is used as shorthand for systems engineering. Sage [5], [6] relates systems engineering to the methods and tools of systems engineering, the systems and design and development methodologies that can be employed to produce a system of large scale and scope, and the systems management processes needed to insure that an overall systems engineering effort is trustworthy in terms of both process and product. The word man is used to imply system design for human interaction. That is to say, systems engineering that is human oriented. This requires that humans participate in setting forth design requirements and that systems designs are such that humans can effectively interact with them. The term cybernetics relates to command, control, and communication among humans and machines such that the ultimate human–machine combination is well suited to its intended purpose.

Clearly, systems, man, and cybernetics are terms that have served us well during the past two decades; they have appropriately described our broad range of interest areas. But, do these terms appropriately characterize our efforts today and beyond, as we approach the 21st Century? As noted earlier in our analysis of SMC paper titles, the term systems is indeed very much used while the terms man and cybernetics are used quite infrequently. Moreover, as we become more sensitive to "politically correct" terms, should we not consider substituting the more generic term human for man? In regard to substituting for cybernetics, there are other terms that might better describe our Society's current and future interests. Information technology, decision sciences, and human–computer interaction are but a few possible terms.

On the other hand, why substitute term for term? Why not consider an entire new name for our Society? For example, "Knowledge, Decision and Human Systems" might be considered. Or " Systems Engineering and Human Productivity" might be considered. At any rate, we as a Society should engage in such a discussion, perhaps after we have next reviewed and updated our field of interest — as we must do, as a requirement of our Constitution.

VII. Toward a Systems-Oriented Umbrella Organization

As systems-oriented professionals, we each belong to several professional societies, including, of course, the IEEE Systems, Man and Cybernetics Society (SMC), the Human Factors Society (HFS), The Institute of Management Sciences (TIMS), the Operations Research Society of America (ORSA), and the Institute of Industrial Engineers (IIE). We belong to these and other professional organizations because they underpin our systems-related research and education interests. Yet, there is obviously a strong degree of commonality or overlap among these organizations. Should they not all belong to a systems-oriented umbrella organization?

We are certainly not the first individuals to have had such thoughts. In an editorial in the April 1990 issue of OR/MS Today, the then President of ORSA, Don Gross, called for an "ORMSSADSIE" (which stands for operations research, management science, systems analysis, decision science, industrial engineering) umbrella for all those organizations which deal with the analysis, modeling, design and control of complex systems made up of people, hardware and information. Interestingly, Don suggested that one approach for organizing ORMSSADSIE is to employ an IEEE-like model in which each member society would retain its own identity with its own list of officers, dues structure and publications.

An embryonic version of ORMSSADSIE is already in existence. In a joint editorial in the June 1990 issue of OR/MS Today, Don Gross and the then President of TIMS, William King, announced that ORSA and TIMS now have a Combined Council that meet to consider and act on issues related to the 50% of each society's activities that are joint. Perhaps, the fact that ORSA and TIMS are now organizationally closer together is not surprising, since they have had many years of cooperation, including holding two joint national meetings per year and having crossovers occur among their Council and officer positions (e.g., the second President of ORSA later became a President of TIMS). The inclusion of other societies within an expanded ORSA/TIMS partnership will undoubtedly be fraught with difficulties.

One such difficulty will be the choice of a name. In his April 1990 editorial, Don Gross has already indicated that it should "certainly not [be] ORMSSADSIE!" At Rensselaer Polytechnic Institute, for example, a similar problem was faced in 1987 when the evolving need for a new endeavor in decision sciences led to a formation of a unique interschool department with faculty drawn from Rensselaer's Schools of Engineering, Management and Science. The question remained as to what to call this interschool department of 22 faculty, representing the disciplines of operations research, management science, systems engineering, industrial engineering, statistics and information systems. After much thought and deliberation, they settled on the name Decision Sciences and Engineering Systems (DSES). We are sure that the faculty in DSES would welcome an umbrella organization with the same name. Should there be an umbrella ORMSSADSIE or DSES organization? Like Don Gross, we are for it—for many of the same reasons that Rensselaer took the pioneering step to establish a multidisciplinary department in decision sciences and engineering systems. The growing need to approach problems in an integrated or interdisciplinary manner augur for the creation of new units or organizations that combine many of our traditional disciplines. For example, the International Institute for Applied Systems Analysis (IIASA) was founded in 1972 to bring to bear on world class problems the joint efforts of East–West scientists; they have attacked the problems from both an interdisciplinary and a system analytic perspective. Indeed, the international systems community seems to be better coordinated. In July, 1989, a "Systems Summit" meeting was held in Budapest, Hungary. After a two-day discussion among 21 attendees, representing 11 systems societies (including the SMC Society) and institutions (including IIASA), the Worldwide International Systems Institutions Network (WISINET) [9] was established. WISINET has become an initiative for worldwide cooperation among systems organizations and publications.

Finally, it should be clearly understood that we are not advocating that SMC migrate from IEEE to an ORMSSADSIE or DSES. Instead, while being primarily an IEEE society, SMC should also be in a position to become formally affiliated with a systems-oriented umbrella organization, in much the same manner as it has already done so—in its loose association with WISINET.

VIII. An Evolving Array of Research Areas

The techniques and concepts that underpin the field of systems, man, and cybernetics are evolving, especially as technologies evolve. Many of the SMC-related research efforts involve information technology. An objective that supports all of these efforts is the continued development of systems engineering as an information-science and information systems-based discipline. Much of traditional engineering activity within the IEEE has been concerned with the physical and materials sciences. Today is clearly the age of large systems and information. Systems engineering and information systems engineering compliment and enhance traditional engineering activities through their emphasis on the information basis for engineering. Systems engineering efforts allow the integration of the information basis for engineering with the traditional physical basis for engineering so as to enable the design of technological systems and processes that provide effective, efficient, and explicable support to humans in strategic planning and management control of operations and tasks.

In systems engineering, and within the SMC Society, we are especially concerned with aiding clients in the organization of knowledge for such purposes as design, and we realize that initiative and creativity are best enhanced when the user of an information system is able to self direct the system towards skill-based, rule-based, or formal reasoning-based assistance rather than having to respond to the dictates of behaviorally insensitive and inflexible software. We must provide for user-directed assistance and varying levels of imprecision and uncertainty associated with knowledge in the design of change receptive software. We must not allow the specific nature of the images produced by a computer to create an "illusion of concreteness" that does not correspond to the realities of existing situations. Thus the systems design for human interaction that is systems engineering encourages users to integrate an understanding of what is known with the capacity for self learning concerning that which is unknown to them. The integrating element that enables this is an appreciation for human physiological and cognitive factors, and the requirements that these impose for the enhancement of human skills and intelligence. Complexity is a central, even if unmentioned, notion in these efforts.

The technical activities within the SMC Society are especially concerned with complexity. This complexity is brought about because of the multitude of relations and competing perspectives that surround almost all contemporary issues. Generally, knowledge is imprecise and incomplete. This complexity often requires that many people, with varying experiential familiarity with a particular task, be involved in issue resolution efforts. This brings about yet another complexity that requires aggregation of group efforts, including forecasts. Continued developments in information technology give much promise for large scale integrated information systems that can potentially aid human cognition and associated control action through the provision of effective, efficient, and explicable support for a variety of operational and strategic tasks. A top level goal for many within the society is to provide educational and research leadership that will enable people to better cope with complexity, especially as this relates to information technology-based support systems that ameliorate the effect of human error, which will always be with us.

We do not underestimate the importance of the traditional disciplines and their role in systems engineering efforts. We are well aware, for example, that there is much to gain from a large number of new mathematical discoveries of the last three decades—especially in applied mathematics, statistics, and the mathematics of operations research. The challenge, in this regard, is to exploit this knowledge in the development of new computer simulation models that can be used by humans in ways that allow them to increase their intelligence through an increase in their skills of intuitive affect and reasoning by analogy, their heuristic rules used on familiar tasks, and their formal reasoning abilities in unstructured situations. Doubtlessly, it is for this reason that modeling has become such an important part of SMC efforts.

The preceding discussion has suggested a number of contemporary research areas. These concern systems engineering as an information science-based management technology that can do much, from a short and long range perspective, to resolve issues in organizations in general and in industry and engineering in particular. Among these are:

- systems integration;
- systems configuration management;
- system simulation and modeling;
- system maintainability and reliability;
- system architecture; systems acquisition and procurement;
- strategic and tactical planning;
- operations level quality assurance;
- strategic level quality assurance;
- stochastic optimization and control;
- software systems engineering;
- robotics and intelligent machines;
- risk-benefit analysis of proposed technological innovations;
- queues and networks;
- pattern recognition;
- multicriterion decision analysis;
- modeling and analysis under risk uncertainty and imprecision;
- management of research and development;
- knowledge acquisition;
- intelligent programming and decision support generators;
- information technology for systems control (vision and image analysis);
- information environments of organizations;
- information economics;
- imperfect information processing;
- human–computer interaction;
- expert systems;
- evaluation of systems and processes;
- economic systems analysis, time series, and forecasting;
- design of intelligent data bases;
- decision support systems;
- computer-assisted engineering design and management; communication, command, and control;
- cognitive ergonomics;
- broadband telecommunication systems management;
- behavioral and human factors in systems design; and
- artificial intelligence and cognitive science.

Obviously, these subject areas are interrelated. And, there are numerous specific research endeavors within each subject area. Each endeavor, however, is related by the common need to acquire, represent, and utilize knowledge in the resolution of issues. It is this provision of information-based assistance in the organization of knowledge and the communication of this knowledge for command and control purposes, such as to support diverse human activities that is a goal and central focus for the membership of the IEEE SMC Society. We are indeed fortunate to live and practice our profession in these exciting times.

IX. A Future of Challenges and Opportunities

Over the years, SMC has retained its broad perspective and its role as an incubator society; we have stoutly resisted becoming narrowly focused on any one application (as is true of many of the other IEEE societies) or on any single modeling approach. This has probably cost SMC some membership, particularly among those engineers and scientists who are not clear on what we stand for or what is our specific focus. A broad interest in systems modeling, particularly those with human components in some form, can be rather ominous for many engineers who have been trained in a less abstract approach to thinking and problem solving and professional activities in general. At the same time, we are a haven for modelers and systems professionals who are interested in systems modeling and systems management for technogical advancement.

Our opinion is that SMC should hold the course, that it has unique and valuable contributions to make in its present form, and that there is no purpose to be served in forcing it to change its nature. Fashions will come and go. New fields will evolve, and in some cases break off part of our own membership and carry it along into a new society. That could happen, for example, with fuzzy logic and neural networks — if it is not already happening. However, SMC should vigorously pursue the activities that interest its members, so as to continue to be the premier IEEE Society for those technical areas. While not interfering with the formation of new societies, we should not be shy about "claiming the turf" in those areas in which we are strong. This should include, as examples, decision support, human–computer interactions, systems management, and large scale socioeconomic modeling.

There is no dearth of challenges and opportunities facing SMC. The U.S. and the world are confronted with many serious problems. All of these have components that can be modeled in one way or another. Therefore policy alternatives can be explored. As examples, the following problems are among those confronting the U.S. and other industrialized nations.

- *Environment:* We in the developed nations are addicted to use of energy and chemicals that pollute our air and water and consume nonrenewable resources. Developing nations are emulating us, cutting down the rain forests, and generally exacerbating the situation. Greenhouse gases seem to be raising the temperature of the planet, posing long-term threats of unknown nature and magnitude.
- *Automation, Productivity, and Industrial Infrastructure:* In the U.S. not only basic industries but also our high-tech industries are moving overseas. Yet we are not willing to make long-term investments in automation, robotics and industrial infrastructure to improve our productive capacity. Instead of long-term investment in the future, and sacrifice and hard work in the present, we try to protect our jobs and our current standard of living.
- *Education:* Standards of basic education for the masses of people in the U.S. continue to decline relative to other industrialized nations, particularly in science and math. Yet taxpayers seem unwilling to pay for education. As a result, young people at the bottom tiers of U.S. society are ill-matched to an ever demanding employment need, and eventually they become clients of the state.
- *Health:* Health costs in the U.S. continue to rise relative to other costs, in part because as new technology is developed everyone feels that they have a right to it at whatever the cost. Meanwhile, we continue to tolerate alcohol on the highway, accept and sometimes even subsidize tobacco and junk food, and do our best to use technology to take all the physical exercise out of daily living (e.g., walking to work, doing manual labor). Terminally ill individuals who themselves want to die are being kept alive by heroic technical measures at great cost to society, while ghetto children are being denied health care. Paperwork in the U.S. health care system continues to cost about 25% of the total, twice that in other industrialized nations with just as good a health record.
- *Criminal and Civil Justice:* An ever increasing number of people in the U.S. are incarcerated in prisons, at a cost to the state of many times that of a private college education. Firearms are freely sold and freely used. In our major cities, theft and threats to persons are common. It is not clear whether we should be still tougher on drug users and dealers, or take the completely opposite strategy and legalize drugs. What is clear is that the present strategy does not work well. Litigation has become the accepted means to settle differences rather than mediation or arbitration, and the benefits seem to go more to the lawyers than to the disputants.
- *Air and Ground Transportation:* Capacities of airports serving metropolitan areas have reached their limits. Rush hour congestion has made urban highway systems into parking lots. Electronic technology is now being applied to both these transport modes to squeeze more traffic through by reduced headways and tighter, and to some degree automatic, controls. Especially on the highways, we know that the right of drivers to drive anywhere at any time with any size vehicle may have to be limited.
- *Economics and Gratification:* It is often repeated that within a decade the U.S. changed from being the world's largest creditor to its largest debtor nation. Yet most citizens regard this fact as an abstraction with little real impact on themselves or their children. At the same time, having been conditioned to an era of credit-card consumption, the prospect of rejoining the world competition by return to a life-style of saving and hard work is unthinkable.
- *Discrepancies between the Rich and the Poor:* On a worldwide basis perhaps the greatest threat of all is the growing discrepancy between the rich and the poor

nations, both because of economic forces and because of differential population growths. The latter naturally want what the former have, and whether it comes in the form of illegal immigration, isolated terrorism, or growing nuclear capability, the poor will demand better treatment. Old fashioned military strength is no longer sufficient to maintain the security of the rich nations, especially since alliances and arms sales can change the delicate balance so rapidly.

- *Critical Technologies:* Recently in the U.S., the National Critical Technologies Panel [7] identified 22 technologies that it considered essential to the nation's long-term security and economic prosperity. They included technologies in materials (i.e., materials synthesis and processing, electronic and photonic materials, ceramics, composites, and high-performance metals and alloys), manufacturing (i.e., flexible computer integrated manufacturing, intelligent processing equipment, micro- and nanofabrication, and systems management technologies), information and communications (i.e., software, microelectronics and optoelectronics, high-performance computing and networking, high-definition imaging and displays, sensors and signal processing, data storage and peripherals, and computer simulation and modeling), biotechnology and life sciences (i.e., applied molecular biology and medical technology), aeronautics and surface transportation (i.e., aeronautics and surface transportation technologies), and energy and environment (i.e., energy technologies and pollution minimization, remediation, and waste management).

These are but a few of the problems we all face for the future. They are complex dynamic problems, surely amenable to modeling, computer simulation, prediction and policy decision—the special capabilities of SMC members. In this sense, SMC faces a future of challenges and opportunities. We, along with our colleagues in related fields [1], [2], [4], [8], welcome these challenges and opportunities. Today, because of the efforts of such visionaries as Joe, Frank, Hank and Don, the SMC Society remains a strong and vital organization. As we look toward the future, we can do no better than to go back to the beginning and emulate our founders. So long as we remain true to our earliest objectives of being a "scientific, literary, and educational" society [3] and maintain our lively interest in emerging and cutting-edge technologies, SMC will continue to provide the invaluable service that it has given to its profession and to mankind.

REFERENCES

[1] Committee On the Next Decade in Operations Research (CONDOR), "Operations research: The next decade," *Operations Res.*, vol. 36, no. 4, pp. 619–637, 1988.

[2] D. Gross and M. U. Thomas, "IE/OR Research: Present status and future directions," in *1990 Int. Industrial Eng. Conf. Proc.*, pp. 360–365.

[3] A. D. Hall, "Systems engineering from an engineering viewpoint," *IEEE Trans. Syst., Sci., Cybern.*, vol. SMC-1, pp. 1–4, 1965.

[4] J. D. C. Little, "Operations research in industry: New opportunities in a changing world," *Operations Res.*, vol. 39, no. 4, pp. 531–542, 1991.

[5] A. P. Sage, *Decision Support Systems Engineering.* New York: Wiley, 1991.

[6] ——, *Systems Engineering.* New York: Wiley, 1992.

[7] The National Critical Technologies Panel, Report of the National Critical Technologies Panel, Washington, DC, Mar. 1991.

[8] J. A. White, "An existence theorem for OR/MS," *Operations Res.*, vol. 39, no. 2, 1991, pp. 183–193.

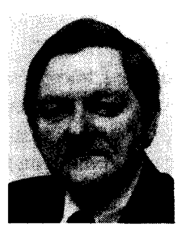
[9] Worldwide International Systems Institutions Network (WISINET), "Systems Directory," Budapest, Hungary, 1991.

[10] J. G. Wohl, "On the evolution of man in systems, man and cybernetics," *IEEE Trans. Syst., Man, Cybern.*, vol. SMC-17, pp. 117–119, 1987.

James D. Palmer (M'56–SM'65–F'82) received the B.S. and M.S. degrees, respectively, from the University of California, Berkeley, and the Ph.D. degree in 1963 from the University of Oklahoma, Norman, OK. He received the Doctor of Public Service (*honoris causa*) in 1978 by Regis College, Denver, CO.

He served on the Faculty of the University of Oklahoma, Union College, Metropolitan State College, and University of Colorado. He has also served in senior executive positions in government and industry. He was the first Administrator of Research and Special Programs for the U.S. Department of Transportation, where he was responsible for advanced research programs for the Department of Transportation, interaction with other Administrators, and for the Transportation Systems Center. He is active as a consultant for industry and university in information systems engineering and design and software systems engineering. He has served as Executive Vice President of the J. J. Henry Company, Inc. (1982–1985);Vice President and General Manger of the Research and Development Division of Mechanical Technology Inc. (1979–1982) and Administrator of the Research and Special Programs Administration of the U.S. Department of Transportation (1978–1979). In these positions he was responsible for major research, development, and design programs carried on for industry, the Department of Transportation, the Department of Defense, the Department of Energy, the EPRI, and the GRI. From 1971 to 1978, he served as a President of Metropolitan State College, Denver, CO, where he was also a Professor of Computer and Management Science. He has been a Professor of Electrical, Engineering at the University of Colorado (1971–1978): Dean of Science and Engineering and Professor of Electrical Engineering at Union College (1966–1971); Director of the School of Electrical Engineering and the Systems Research Center at the University of Oklahoma (1957–1966). He joined the Faculty of the School of Information Technology in 1985 as BDM International Professor of Information Technology.

Dr. Palmer is a Fellow of the IEEE. Among the awards he has received are the U.S. Coast Guard Medal for Outstanding Public Service for his service as a member and Chairman of the USCG Academy Advisory Committee, the Outstanding Contributions award by the Systems, Man, and Cybernetics Society, the IEEE Technical Activities Board Contribution award, and the Case Institute Centennial Medal. He is listed in many bibliographical references including *Who's Who in America*, *Who's Who in the World*, *Who's Who in Engineering*, *American Men and Women of Science*, *Leaders in Technology*, and *Community Leaders in America*. He was President of the SMC Society, a member of the Computer Society, the Communication Society, the Industrial Electronics Society of the IEEE, and the American Society for Engineering Education. He is a Registered Professional Engineer in Oklahoma, New York, Colorado, and Wisconsin.



Andrew P. Sage (S'56–M'57–SM'65–F'76) received the B.S.E.E. degree from the Citadel, Charleston, SC, the S.M.E.E. degree from the Massachusetts Institute of Technology, Cambridge, and the Ph.D. degree in 1960 from Purdue University, West Lafayette, IN. He received the Doctor of Engineering *Honoris Causa* degree in 1987 from the University of Waterloo, Waterloo, ON.

He has been with George Mason University, Fairfax, VA, since July 1984, as the First American Bank Professor of Information Technology and Engineering. In July 1985, he was appointed to his current position as the first Dean of the George Mason University School of Information Technology and Engineering. He previously held faculty positions at the University of Arizona, the University of Florida, and Southern Methodist University. From 1974 to 1984, he was the Lawrence R. Quarles Professor of Engineering Science and Systems

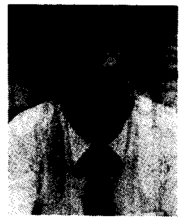
Engineering at the University of Virginia, Charlottesville. During portions of that time, he was Acting Chairman of the Chemical Engineering Department, Associate Dean for Graduate Studies, and Chairman of the Department of Systems Engineering. His initial research concerned optimization, estimation, system modeling and identification, and associated computational algorithms for communications and control systems design. His current interests include decision support systems engineering, command and control, information system design and evaluation, and the software systems engineering, as well as application of these information technologies in defense and industry.

Dr. Sage is a Fellow of the IEEE and of the American Association for the Advancement of Science (AAAS). Among the awards that he has received are the Frederick Emmonds Terman Awards from the American Society for Engineering Education (ASEE), an Outstanding Service Award from the International Federation of Automatic Control (IFAC). He has received the Norbert Weiner Award and an Outstanding Contribution Award from the IEEE SMC Society. In October 1991, he received the first Joseph G. Wohl Outstanding Career Award from the SMC Society. He is the editor of the IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS, *AUTOMATICA*, *Large Scale Systems*, and the John Wiley textbook series on Systems Engineering. He is on the editorial board of several journals, including *Computers and Electrical Engineering*, *Control: Theory and Advanced Technology*, *Future Generation Computer Systems*, *IEEE Expert*, *The International Journal of Expert Systems: Research and Applications*, and the *Journal of Intelligent Systems*. He is a member of a number of professional societies, including the American Institute for Artificial Intelligence, the Operations Research Society of America, the AAAS, the ASEE, and the Institute for Management Sciences. He was Chairman of the IEEE SMC annual conference in 1974 and in 1987. He was President of the IEEE SMC Society for the two-year period 1984–1985. Centennial Medals were awarded by the Case Western Reserve University in 1981 and by the IEEE in 1984. He was the Chair of Section M of the AAAS for the calendar year 1990.

Thomas B. Sheridan (M'60–SM'82–F'83) was born in Cincinnati, OH. He received the B.S. degree in 1951 from Purdue University, West Lafayette, IN, the M.S. degree in 1954 from the University of California at Los Angeles, and the Sc.D. degree in 1959 from the Massachusetts Institute of Technology, Cambridge, MA.

He was Professor of Mechanical Engineering and is now Professor of Engineering and Applied Psychology and the Director of the Man–Machine Systems Laboratory at MIT. His research and teaching activities include: design, control, modeling, and human factors experimentation of telerobotics systems for space and undersea, operation of nuclear power plant and commercial aircraft, individual and group decision processes, and social effects of automation.

Dr. Sheridan served as President of the IEEE Systems, Man, and Cybernetics Society, Editor of the IEEE TRANSACTIONS ON MAN–MACHINE SYSTEMS, and is an IEEE Fellow and Centennial Medalist. He is also a Fellow and current President of the Human Factors Society.



James M. Tien (S'66–M'67–S'69–M'78–SM'82–F'91) received the B.E.E. degree in 1966 from Rensselaer Polytechnic Institute, Troy, NY, and the S.M., E.E., and Ph.D. degrees in systems engineering and operations research in 1967, 1970, and 1972, respectively, from the Massachusetts Institute of Technology, Cambridge.

He joined the Department of Electrical, Computer and Systems Engineering at Rensselaer Polytechnic Institute in 1977, and since 1988 has been Professor and Chairman of a recently constituted interschool Department of Decision Sciences and Engineering Systems. Previously, he has been a Member of the Technical Staff at Bell Telephone Laboratories, Holmdel, NJ (1966–1969), a Project Director at the Rand Corporation, New York, NY (1970–1973), an Area Research Director at Urban Systems Research and Engineering, Cambridge, MA (1973–1975), the Executive Vice President at Public Systems Evaluation, Inc., Cambridge, MA (1975–1977), and Vice President of Queues Enforth Development, Cambridge, MA (1977–present). His areas of research include the development and application of computer and systems analysis techniques to public information and decision systems. He has published extensively, with more than 70 refereed publications to his credit. He has presented invited papers and lectures at numerous conferences and workshops. In the past few years, he has averaged about ten presentations per year.

Dr. Tien is a Fellow of the IEEE. He is listed in several *Who's Who* publications and is an Associate Editor of both the IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS and the *Journal of Information and Decision Technologies*. He has served the IEEE and the SMC Society in several capacities since 1980. Presently, he is a member of the IEEE Technical Activities Board, the President of the SMC Society, the Chair of the IEEE Society Presidents' Forum, and the Chair of the IEEE Research Initiation Grants Review Committee.