Why Systems Science and Cybernetics?

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THIS ISSUE of these TRANSACTIONS represents the first publication of a new IEEE group, Systems Science and Cybernetics (G-SSC). The areas of systems science and cybernetics are difficult to describe since descriptors mean different things to different people. The present terms were chosen because they come closer to the connotation of the things that members of the group are working on than many other new, coined words. New terms were not chosen as they would only tend to confuse an already diffuse area.

The scope of the G-SSC encompasses the treatment of the science that is common to all large collections of interacting functional units that together achieve a defined purpose. This includes analysis, simulation, synthesis, implementation, evaluation, and the consideration of the uncertainties of system parameters. Also included are matters pertaining to the theory and design of communication and control in natural and synthetic systems, including biological and behaviorial systems. Areas of interest include such interdisciplinary subjects as bionics, artificial intelligence, and self-organizing systems, and such aspects as modeling, optimization, and general theory.

Within the group the two areas of Systems Science and Cybernetics have considerable overlap, but can separately be defined as follows:

Systems Science: The scientific theory and methodology that is common to all large collections of interacting functional units that together achieve a defined purpose. It includes the application of common methods in analysis, simulation, synthesis, implementation, evaluation, and parameter interaction. The field is concerned with large technological systems as opposed to specific control systems or components. It includes the economics, operation, logistics, and utilization as well as the engineering design of systems. Transportation systems, traffic control systems, and complete factories are examples of large systems where common methods are applicable.

Cybernetics: The scientific theory and methodology that is common to all interdisciplinary systems.[1] Since these systems encompass control and communication, the original Wiener definition is contained. Interdisciplinary areas, such as artificial intelligence and biological system models are included, but the application of the methods of technological systems to the biological, behavioral, sociological, political, legal, and economic systems are the primary emphasis.

The difference between Systems Science and Cybernetics arms of the Group is one primarily of approach to the solution of the same types of problems based upon background, experience, and history of development rather than a fundamental difference in goals. In general, the Systems Science participants approach problems from an optimization point of view, i.e., the system is described analytically by a set of cause and effect relationships whose parameters can be varied to optimize a particular measure of effectiveness. Cybernetics participants approach the same problems in terms of models (real or postulated) of natural systems, systems whose variables are not readily describable in analytic terms. Examples of such systems are biological, sociological, behavioral, etc., systems. Because it is observed that their behavior causes a desirable result with a high degree of efficiency, their functioning is studied, analyzed, evaluated, and modeled with the goal of providing a basis for understanding and operation for the purpose of providing models to be used in the design of analogous systems.

In the Systems Science area the growth of complex communication, transportation, automatic control, electrical transmission, and large weapon systems has occurred at a tremendous rate since World War II. As systems grew, the complexity of systems with large numbers of interacting parameters became too unwieldy to be treated by trial and error methods. A systematic and scientific approach to problems of systems methodology through techniques, such as simulation on analog and digital computers and network analyzers, and modeling with operational research, control theory, and optimization methods resulted. Although the field is in its infancy, a large body of work already exists. The system scientist now looks ahead to application of these and new methods to even larger more complex systems.

Cybernetics has existed since 1948 with the publishing of Wiener's book. However, progress has not been rapid in this area until the last few years. A new tool has now made significant progress possible to the extent that the scientific society as a whole with its many disciplines has become more aware of the theory of systems and its possibilities. Prior to 1960, anyone programming a computer had to have a fairly extensive knowledge of the hardware organization and operation of the computer for which he was writing a program. Programmers were specialists in transforming problems into machine language. About this time, the use of compilers of various types became widespread. Suddenly, the computer became a tool available to anyone with a minimal amount of training. Workers in a wide variety of disciplines, who had never even heard of a flip-flop, suddenly had a new and powerful tool available to them for analyzing, modeling, simulation, and synthesizing a wide variety of complex systems. The very complexity of these problems had

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[1] Concern is with information utilization among interdisciplinary systems in the sense of communications and control.

made them unapproachable up to this time. Clever people with a new tool found new and clever ways of attacking the problems. (The advent of time-sharing indicates even wider usage in the future by a more diverse group of users.) With extreme rapidity the whole atmosphere surrounding complex systems changed. No longer was it a question of whether a system, even biological and intelligent systems, could be synthesized, but only a question of how much time and how much money. Anybody with access to a computer or console can now get into the game.

Within IEEE, recognition of this turn of events came early. Prior to merger of the IRE and AIEE, two committees were formed within the old AIEE Science and Electronics Division: Systems Science and Cybernetics. Counterpart interest in IRE appeared in the Computer and Automatic Controls group, but no definite organizational steps were taken. After merger and much discussion, the Systems Science and Cybernetics Committees joined in a petition for Group Status. This turned out to be more than a marriage of convenience. The only difference in objectives of the two committees was that of emphasis as just described.

Acceptance of Group Status of the G-SSC represented a new problem in the IEEE. Here was a group whose range of interest cut across that of many existing groups, but whose interest was too large to be covered by a single group. However, in reacting to the G-SSC application, IEEE made a major step forward. IEEE acknowledged the fact that scopes cannot be written in these times without overlap, but that the overlap can be managed. A Systems Council, reporting to the Technical Activities Board (TAB) has been set up, consisting of G-SSC, Computer, Biomedical Engineering, Information Theory, Automatic Control, and Circuit Theory groups. The object is to voluntarily resolve overlap problems and coordinate efforts. These groups all have system theory interests which have grown more general in the past ten years.

Since electrical engineers have provided some of the methods for understanding the theory of technological systems, IEEE also has some of the responsibility for showing the other disciplines how to apply these methods in new areas; conversely, the electrical engineering profession must become aware of the tremendous progress being made in other fields. For example, the use of coding theory, developed by communication engineers, can be useful in understanding the amino acid sequences in the DNA molecule, helping to break the genetic code. The breaking of this code may very well be the most significant breakthrough of the century. Examples such as this amplify the need of IEEE to work industriously in the Systems Science and Cybernetics area to provide the leadership and interest its large membership of professionals can provide.

The G-SSC is now underway and under full steam. This issue of the TRANSACTIONS represents the first of what is expected to be a semiannual publication. It is aimed at serving both the generalist who likes to see specific proof and documentation of real work and the specialist who wants a technical forum and some view of the overall picture. A difficult aim? Certainly, but less is not acceptable. The objective of these TRANSACTIONS is to provide its varied audience with readable papers of such high quality that even the uninitiated may find the paper valuable and informative, while the initiated will find sufficient backup documentation to make the papers valuable, permanent references. This implies the development of new formats which will undoubtedly be some time in developing. Both the Administrative Committee of the Group and the Editorial Staff are committed to it.

Membership is now being earnestly solicited inside and outside the IEEE. The interdisciplinary nature of this field implies that many of our members will not be engineers, but professionals in a wide variety of subjects. The affiliate plan of IEEE makes participation by these people possible without their joining IEEE as a full member; they only join the group as an IEEE Affiliate. However, it is urged that they do apply for IEEE membership since members of Adcom and officers must be IEEE members. We seek these nonengineers as full partners and want their total participation.

We are poised here, taking our first step in a new and vital area of interdisciplinary endeavor. The path may be long and difficult but none of us ought to miss the passage.