

TELECOMMUNICATIONS: AN INTERDISCIPLINARY SURVEY



Edited by
L. Lewin

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**TELECOMMUNICATIONS:
AN
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BIOGRAPHIES OF CONTRIBUTORS

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G. Gail Crofts is a communications policy analyst in the Office of Plans and Policy at the Federal Communications Commission. She obtained her B.A. from Baylor University. She received her M.S. in journalism in 1969 and her Ph.D. in communications in 1974 from the University of Illinois, Urbana-Champaign. Her thesis was on the public information function of the FCC. She joined the agency in 1974, and helped to establish the Consumer Assistance Office in 1976. In 1977 she joined the Office of Plans and Policy.

A. Terrence Easton is Director of the Graduate School's Department of Telecommunications Management at Golden Gate University in San Francisco, and President of International Communications Management Inc., a San Francisco based telecommunications consultancy firm. He obtained his undergraduate degree in Electrical Engineering from the Johns Hopkins University and received a dual-major Masters Degree in Computer Systems and International Business from the American University (Washington D.C.) in 1972. He joined the graduate faculty of the Center for Technology of Administration at the American University in 1972, and was elected to the faculty of Golden Gate University in 1976. Prior to joining the American University, Mr. Easton held positions with NASA's Apollo Project, Bendix Radio Corporation, GE's Information Services Division and Strayer College. Mr. Easton is Professor of Telecommunications and director of the MBA Program at Golden Gate University. He has published numerous monographs and articles and two books on the subject of international communications.

Warren L. Flock is a Professor of electrical engineering at the University of Colorado. He received a B.S. in electrical engineering from the University of Washington, and from 1942 to 1945 he was a Staff Member of the Radiation Laboratory of M.I.T. He received an M.S. in E.E. from the University of California, Berkeley and a Ph.D. in Engineering from the University of California, Los Angeles in 1960. From 1960 to 1964, he was with the Geophysical Institute, University of Alaska, and he then accepted his present position. His interests include telecommunications, remote sensing, radar systems, and solar energy.

Dale N. Hatfield is a Program Policy Specialist with the National Telecommunications and Information Administration, U.S. Department of Commerce. He received a B.S. in electrical engineering from Case Institute of Technology in 1960 and an M.S. in Industrial Management from Purdue University in 1961. He has held telecommunications policy research positions with various government agencies and was formerly the Chief of the Office of Plans and Policy, Federal Communications Commission.

Howard Higman is Professor of Sociology at the University of Colorado where he served as Chairman of the Department of Sociology. He is Chairman of the University of Colorado Conference on World Affairs and Director of the Center for Action Research. His primary field of inquiry is in cross-cultural communication and in the impact of changing technology on social organizations.

Harold E. Hill is Professor and Chairman, Department of Communication, University of Colorado-Boulder. He has B.S. and M.S. degrees from the University of Illinois-Urbana, and his experience includes: several years (at all levels from announcer to program director) in both commercial and public broadcasting; service as a Communication Officer (terminated as Major) during World War II; Executive Vice President of the National Association of Educational Broadcasters in Washington, D.C. for 13 years; has written some 50 articles and made over 100 presentations on communication, particularly media; served as consultant for many broadcasting projects, e.g., helped design the educational television system in American Samoa; 18 years teaching experience at the Universities of Illinois and Colorado; recently received the Distinguished Service Award from the National Association for Educational Communication and Technology.

Baylen Kaskey is head of the Billing systems Department at Bell Telephone Laboratories in Columbus, Ohio. He attended the University of Pennsylvania, where he obtained his bachelor's degree in Mechanical Engineering in 1950, and he did his graduate work at Kansas State College where he was

a faculty member from 1950 to 1951. Kaskey joined the technical staff of Bell Laboratories in 1951, where he designed military electronic equipment. He served in U.S. Army Ordnance from 1954 to 1956, working on design of solid propellant rockets. In 1962 he joined Bellcomm, Inc., in Washington D.C., where he headed the Mission Assignments Department. He returned in 1967 to Bell Laboratories to head the Physical Design and Computer Applications Department. On March 1, 1978 he assumed his present responsibilities as head of the Billing Systems Department.

Irving J. Kerner is an attorney in Boulder, Colorado, engaged in the private practice of law. Mr. Kerner's practice is limited to communications matters, primarily involving electronic communications. He obtained his law degree from the University of Colorado in 1966. During the past four years he taught mass communication law at the University of Colorado.

Leonard Lewin is a professor of Electrical Engineering at the University of Colorado at Boulder, where he is Coordinator of the M.S. Interdisciplinary Program in Telecommunications. He was formerly head of the Microwave Department, and later Assistant Manager of the Telecommunications Research Division of Standard Telecommunication Laboratories in the United Kingdom. Earlier, he had worked on radar at the British Admiralty during World War II. His research has focused on antennas, waveguides and propagation, and he was awarded the 1963 International Microwave Prize and also the IEEE W. G. Baker award for a research paper on waveguides. He joined the Boulder faculty in 1966 and was awarded an honorary D.Sc. the following year. Lewin is interested in many aspects of the educational process and in the development of meaningful teaching techniques at all grade levels.

S. W. Maley is Professor of Electrical Engineering at the University of Colorado where he has been teaching telecommunications since 1962. He also conducts research in waveguiding systems and in electromagnetic propagation. He organized and taught courses for the Bell Telephone System Regional Communication Engineering School at the University of Colorado between 1962 and 1970.

Lawrence M. Mead received his B.A. in political science from Amherst College in 1966 and his Ph.D. in government from Harvard University in 1973. He served as a policy analyst in the Department of Health, Education, and Welfare and as a speechwriter for Secretary Kissinger at the Department of State. In 1975, he joined a new research group at the Urban Institute studying implementation problems in Federal social programs. There he participated in a study comparing the decision processes

of the FCC and the Environmental Protection Agency for the National Science Foundation. He has published several studies on implementation, bureaucratic reform, and health policy. He recently became Deputy Director of Research for the Republican National Committee.

Robert J. Williams is professor of engineering design and economic evaluation. He attended Michigan State University where he received his bachelors and masters degrees in mechanical engineering. He has taught engineering economy courses in the regular curriculum and to a variety of special groups including the Regional Communications Engineering School at CU and the Telecommunications Masters Degree program also at CU. During 1961-63 he was a full-time consultant to the Government of India on industrial productivity. He served as senior industrial engineer at the Boeing Company in Seattle from 1951-1954. Williams was the Chairman of the mechanical engineering department at the University of Colorado from 1956-1961.

Wesley J. Yordon is professor of economics at the University of Colorado where he teaches courses in microeconomic theory and industrial organization. He attended Wesleyan University from 1949-51, served in the U.S. Army, then received his B.A. from the University of Colorado in 1956. His Ph.D. is from Harvard in 1960, and he has been a Fulbright lecturer in Argentina and Mexico. His research interests have ranged from the mechanics of inflation to the problems of cost analysis in the regulated industries.

PREFACE

The main purpose of this volume is to make generally available the basic material constituting the MS interdisciplinary program in telecommunications that has been offered at the University of Colorado at Boulder since 1971. Initially all of the courses had to be put together for the program and until now have existed only in note form. With the publication of this book, both the essential courses and some valuable ancillary material are made available in collected form for the first time. It is, of course, not possible in a single volume to cover in an adequate way the entire field of telecommunications; neither is it possible to teach it in a 12 month university program. What has been attempted is to provide a balanced survey with representative material selected to provide a wide and reasonable coverage. About the only essential course not explicitly covered here is the one on telephone traffic theory, since this had already received prior publication and is currently readily available.* This apart, it is felt that the present work is complete and self-contained and can be usefully recommended as a basis for an interdisciplinary study of the large and growing field of telecommunications.

Leonard Lewin
May 1978

* Beckmann, Petr, *Elementary Queueing Theory and Telephone Traffic* (Geneva, Illinois: Lee's abc of the Telephone; Traffic Series, 1977.)

INTRODUCTION

THE UNIVERSITIES AND TELECOMMUNICATIONS

L. Lewin, University of Colorado

1. THE INTERDISCIPLINARY NATURE OF TELECOMMUNICATIONS

It would be a great mistake to see telecommunications too narrowly as only the technical aspect of the design and operation of the communication network. Features concerned with government regulation at the international, national and local level, the economics, the management, the legal and social impact; these are but a few of the important aspects that determine the shape and growth of the industry. A good example is CATV which started as a local community development for TV signal acquisition. The long incubation and subsequent form of the FCC regulations have determined in large measure the current structure of this branch of the industry. Copyright laws and federal taxation policy have affected its programming and finance; current development in optical fiber technology will no doubt determine its future growth and social impact.

Although many of the features of the telecommunications industry are covered in one or another discipline in the various departments of universities, the approach is necessarily that of the discipline concerned. Thus, the electrical engineering department of a university or college will be concerned with many things electrical. Some aspects of the light current courses will bear on signal processing. There may even be courses that are specifically designated as telecommunications oriented. But there will be virtually no collaboration with, say, the Political Science department, where a discussion of regulation of public utilities is covered.

The initiation and development of an integrated *interdisciplinary* program in telecommunications is something quite recent to the American university. The earliest of these, and the one I am most familiar with, was undertaken at the University of Colorado at Boulder at the beginning of the seventies, and an account of it forms a substantial part of this introduction. Several other programs, each somewhat different from the others, will also be briefly discussed. There are, of course, many high quality courses in telecommunications offered by various universities, but these are not part of integrated interdisciplinary programs.

2. TEXAS A AND M

With one exception, these programs have all been developed at the Master's level. The exception is at Texas A and M. Initiated in 1975 with encouragement and also financial assistance from the ICA, this program is set at the Bachelor's level, and leads to a B.S. in Engineering Technology with a specialty in Telecommunications. The Telecommunications Technology Specialty is intended to develop the applied scientific knowledge and basic technical skills necessary for a graduate to effectively communicate with employees and apply this knowledge and skill in the telecommunication industry. Emphasis is placed on preparation of the student for understanding of the manufacturing, construction, operation, and design of telecommunications systems, as well as providing the leadership expected of the Telecommunications Technologist. The curriculum comprises a number of courses in various disciplines, including several courses in electrical engineering specifically tailored to the program. A total of 134 semester hours is required for graduation. The emphasis in the curriculum appears to be mainly technical, but, as it evolves, other features may become evident. It is probably too soon to say much at this time about graduates of this program, and precisely what kinds of jobs or further training may be involved for them.

3. GEORGE WASHINGTON UNIVERSITY

An off-campus program in Telecommunications Operations is offered by the Graduate School of Arts and Sciences of George Washington University. It is an interdisciplinary program oriented to operation and management of telecommunications systems.

The degree requires 36 credit hours of coursework taken from the disciplines of Economics, Electrical Engineering, Management, Political Science, Psychology, Sociology, and a Telecommunications Seminar on policy and regulation. Through the School of Engineering and Applied Science and the Continuing Education Program, George Washington University also offers a sequence of five-day symposia on a number of germane subjects such as Telecommunications Policy, Digital Communications, Microprocessors, etc. Although mainly domestic, many features deal with international aspects, including satellites, international telephone, CCITT standards, international Radio Conferences, and much else. The university is greatly aided in this endeavor by its proximity to the U.S. capital, and the availability of government and other experts. Donald Jansky, Assistant Director at NTIA, together with Bud Paul, is largely responsible for much of this program, and he also teaches as an adjunct assistant professor of telecommunications at the University of Pennsylvania. A recent summer session at George Washington University included a course dealing with international and domestic telecommunications institutions, and international policy issues which arise from the interaction between scientific and technological development and activity. Something of the flavor of the program can be gleaned from this very brief description.

4. SOUTHERN METHODIST UNIVERSITY

An interdisciplinary program of a somewhat different character is offered at Southern Methodist University at Dallas-Fort Worth. Their program draws together courses from different schools, enabling the student to concentrate on telecommunications while earning a Master's degree in any of the disciplines of Electrical Engineering, Computer Science, or Operations Research. Degree requirements are 30 hours at the Master's level. Courses on satellites, packet switching, etc., and on policy and regulation cover international features. This program also provides scope for pursuing work beyond the Master's level, working in the respective department. In 1977 they had two Ph.D. students working in this way. One was doing his dissertation in Europe studying the engineering use of broad-band networks with interest on the

parameters and issues affecting policy decisions, including legal, social and economic matters. The other was studying the social, economic, political and management issues in international information systems, from the point of view of the user company or institution. The study dealt with developing countries, including Latin America.

This departmental approach, which at the doctoral level is also followed on the Boulder campus, appears to be the only method, at the time of this writing, whereby a doctor's degree in Telecommunications can be awarded in universities in the U.S.

5. GOLDEN GATE UNIVERSITY

The Telecommunications Management Program at Golden Gate University offers professional training in the cost-effective design, utilization and management of currently available telecommunications capabilities (including voice and data communications) in relation to the needs of business and governmental organizations. Developed with the assistance of an Advisory Committee of professionals in the field of Telecommunications, the program was the first of its kind on the West Coast.

The program is in two parts. Students who satisfactorily complete a concentrated 18-unit curriculum of six specified graduate seminars are awarded the Certificate in Telecommunications Management. Designed primarily for the practicing telecommunications professional, the Certificate Program is for those who by the nature of their professional functions may not need the highly specialized management topics covered by the complete M.B.A. curriculum. It is also developed for the specialist whose formal education does not include a baccalaureate degree and who feels that certification of completion of graduate-level studies in his or her field would help to further career objectives.

The Certificate Program curriculum consists of the following 3-unit seminars:

- Organizational Behavior & Management Principles
- Statistical Analysis for Managers
- Introduction to Telecommunications Management

- Managing Corporate Telecommunications
- Introduction to Data Communications Systems
- Design & Management of International Corporate Communications

For the M.B.A. degree in General Management, students must complete both a Foundation Program and an Advanced Program. The former consists of eight 3-unit courses which serve as the necessary background for advanced, graduate-level studies in management. The 30-unit Advanced Program requirement consists of two specified General Management seminars, one seminar selected from each of five specified subject areas (Economics, Finance, Human Resources Management, Marketing, and Quantitative Analysis), and three of the four Telecommunications Management seminars. The Golden Gate program is directed by Professor Easton, who currently heads U.S. operations of International Communications Limited. The courses are offered off-campus, mainly for evening enrollment, and serve to provide training in currently available telecommunication capabilities.

6. SYRACUSE UNIVERSITY

The most recent, at the time of this writing, of the interdisciplinary programs to come to my attention is the Master of Science degree program in Telecommunications (engineering) sponsored by the Department of Electrical and Computer Engineering at Syracuse University. The program is designed to meet the need for professional personnel in the telecommunication field who will be working on problems related to the generation, storage, transmission, retrieval and display of information. The program is interdisciplinary in nature, as it includes a number of integrated courses which cover technical and non-technical aspects, such as historical development, economics, political considerations, and social impact. These integrated courses, which constitute one of the novel features of the program, are primarily technical courses in which the evolution of the discipline, as affected by historical, economic and other forces, is built into the description of the material under study. A minimum of 30 credits is required for graduation.

The program, which accepted students in the fall of 1977, is currently under development as the form the courses will take continues to evolve. There were initially some 50 students enrolled, both on campus and at three off-campus sites. Many of the students come from local companies with telecommunications concerns, so that the program, in fact, acts to supplement and reinforce on-the-job training of graduates in the area.

7. NEW YORK UNIVERSITY

Under the auspices of Dr. Elton of the Alternate Media Center of the New York University School of the Arts, a new interdisciplinary program is being planned, to come into full operation in the fall of 1979. It will involve teaching how to set up new telecommunications applications, with special interest in such areas as local community services, telemedicine, teleconferencing, and legal, business and educational uses. At the time of this writing, the program is planned for a two year, 60 unit syllabus consisting of required courses, elective courses, field experience, seminar participation and a thesis.

The core courses will be required of all students and, as currently planned, are a) Communications Laboratory, b) Interpersonal Communications, c) Organizational Systems, d) Communications and Information Technology, e) The Structure and Regulation of the Telecommunications Establishment, and f) Introduction to Applied Research. There will be one required course each semester in which themes of importance in the program will be explored in a series of seminars. Considerable attention is to be devoted to student advisement, with a segment of the program in the second year devoted to a course of study tailored to the student's interests, and including elective courses selected from other schools of the university. It will be interesting to see how this distinctive program develops over the years.

8. UNIVERSITY OF COLORADO AT BOULDER

The Telecommunications Master's Degree at the University of Colorado is an interdisciplinary program, started in 1971 after more than a year of preparation. The initial idea of developing a Master's Program that was neither an engineering program nor

a social science program but helped to bridge the gap between the technology and the social structure in which it is governed and operated, resulted from conversations between some members of the U.S. Department of Commerce and representatives from the university's departments of Political Science and Electrical Engineering.

The original objectives of the program included providing a curriculum in which students without necessarily any formal technical background but with an interest in communications could learn some of the vocabulary and concepts which underlie the technology of telecommunications systems while also providing detailed information on the economics and political structures which govern the industry. At the same time, we wanted to develop a program in which engineers could learn about the social and economic structures while improving their knowledge of the technology. We also hoped that by placing these two groups of students in many of the same classes and by having them work together in teams of two's and three's on projects, that both groups would obtain a better understanding of the complex social, political, economic and technical problems which govern the field.

We saw potential needs for manpower with this broad communications background in government policy and regulating bodies — both at the national and local levels. There also appeared to be a need for broadly trained operating personnel by major users of communications services. For example, it appeared that Cable TV was going to require significant numbers of trained people to write franchises for local governments and regulate the operations of the cable companies.

As the program evolved, some of these original ideas were modified along with the program itself. First, the military surprised us by being extremely interested in the program and sending us many able students. Secondly, the market for graduates from the program appeared to be shifting away from local government and regulatory agencies towards companies who were heavy users of communications equipment, and to interconnect suppliers.

The program at Colorado is now in its seventh full year, and it is possible to see in perspective how some of the various forces have molded it to its present shape. Currently it involves the areas covered by the departments of Electrical Engineering, Political Science, Sociology, Law, Engineering Economy, Business, and Communication. This breadth has been found to be necessary to provide the coverage needed for an adequately trained telecommunications manager, a type of person increasingly in demand in the rapidly expanding field of telecommunications in the modern world. Although the present program administration has been coordinated from the department of electrical engineering, the very broad coverage ensures its fully interdisciplinary nature; administratively it reports directly to the Graduate School of the University.

9. PROGRAM EVOLUTION AT BOULDER

Program Structure.

The program was initially designed around a twelve-month enrollment and the earning of a minimum of 30 credit hours. It commenced with a core structure consisting of two courses from the Engineering Department, one from Political Science, one from Business and one from Sociology. Although not obligatory, most students were expected to take the core courses, together with a number of electives.

The courses earned 12 credit hours each semester. In addition there was the telecommunication seminar, of which more later, and the summer term project or thesis, which earned 6 credit hours for a total of 30 credit hours for the full program. This was normally completed in one full year.

The electives were chosen by the students themselves from a wide variety of graduate programs from the several departments, and more will be said on this subject later. Meanwhile it will be noted that, at the beginning, the engineering core courses constituted only a modest contribution to the total, being only one course in each semester.