PROGRAM OF RESEARCH ON THE MANAGEMENT

OF RESEARCH AND DEVELOPMENT

Department of Industrial Engineering and Management Sciences
The Technological Institute
Northwestern University
Evanston, Illinois

ANNUAL REPORT 1965-1966
and
PROGRAM SUMMARY 1960-1966

SEPTEMBER 1966

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ABSTRACT

The research program described in this report has been supported by grants from the National Aeronautics and Space Administration (NASA Research Grant NSG-495), The National Science Foundation (NSF Grant NSF-G24442), The Office of Naval Research (NR 047-052), The Office of the Deputy Director for Research and Engineering, Department of Defense (N 00014-66-C0020A01), The Public Health Service (LM 00098-01), The McKinsey Foundation, and internal fellowship and research funds. Progress on each of the projects (sub-programs) included in the program during 1965-66 is reported. A list of papers and publications completed since the 1965 Annual Report and a cumulative list for the period 1960-1966 are given by individual project. Personnel associated with the program in the period August 1965-September 1966 are listed.

The project numbers and titles are consistent with the listing in the 1965 Annual Report. One new project has been added. The currently active projects are:

1. Idea Flow in Research and Development
2. Control of Research and Development in Decentralized Organizations
3. Strategies for Organization and Diffusion of Research in Developing Countries
4. R and D Responses to Crises
5. Sources of R and D Achievements in Electronics Since 1945
6. The Acquisition and Development of New Technical Skills in Research and Development
7. Integration and Utilization of Management Science Activities in Organizations
8. Liaison Relations: Transition and Interface Problems between Phases of Research, Development and Application
9. The Information-Seeking Behavior of Researchers
10. Project Selection in R and D
11. Key Researchable Problem Areas in R and D Management
12. Environment and Management Factors Influencing the Performance of Research and Development Groups
13. Other Related Activities, including Studies of Methods of "Research-on Research"

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INTRODUCTION BY THE PRINCIPAL INVESTIGATOR

The Program of Research on the Management of Research and Development is in its seventh year at Northwestern University. It is not formally organized as a separate institute or center, but is an integral part of the teaching and research activities of the Department of Industrial Engineering and Management Sciences. Thus far, all investigators involved in the program have been either teachers or students. In most cases the involved faculty (including the principal investigator) carry full teaching loads during the academic year and devote their research time during that period and their full time during the summer to the program.

In addition, the graduate students involved are generally engaged in full time study and participate in the program either as research assistants or as part of their thesis and dissertation research.

These factors dictate an "academic" time scale for the various projects in the program, rather than an "industrial R & D" time scale. Individual sub-studies may stretch over several years to accommodate a Ph.D. program of one of the investigators. Some projects and ideas lay dormant for several years awaiting an interested student or staff member to design and conduct a relevant study. Some of the projects and the ideas behind them are 10-15 years old, although in some cases, only one or two sub-studies have been performed. Others are relatively new (3-5 years) but a great deal of effort has been expended on them and a large number of sub-studies have been undertaken.

In a number of cases, several individual theses and staff studies have been grouped, for reporting purposes, under one project heading. An example is the project entitled "Liaison Relations." Currently there are four distinct sub-studies under way in this area. Two involve a thesis or dissertation, one is a pre-dissertation study, and one is a staff study. They are designed to generate or test distinct but related models and propositions. As a result of the model-building and proposition-formation in these four studies, and the interaction among the investigators, a more coherent picture is beginning to emerge of the basic nature of the "liaison," "transition," "interface," or "technology transfer" phenomenon in Research and Development.

On the other hand, two of our currently most active projects involve detailed design of large scale "real-time" studies which are expected to continue for several years as staff studies, with theses and dissertations spinning off from them.

Three methodological trends are becoming dominant in our study designs. One is the "real-time" study, where data is collected over a period of years, while the events of interest are occurring. Projects 1, 7, 9, and 10 are examples of such efforts. Another is the attempt to conduct experiments in the field - in operating R & D laboratories. This involves attempting to make experimental changes in the environment of the organizations we are studying, for purposes of studying the effects of change. Projects 9 and 10 involve such attempts. The third is experimenting with "remote" data collection methods. This is discussed further under projects 12 and 13 d.

Albert H. Rubenstein

Professor of Industrial Engineering
and Management Sciences
September, 1966

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CHARACTERISTICS OF NORTHWESTERN'S PROGRAM OF RESEARCH ON THE MANAGEMENT OF RESEARCH AND DEVELOPMENT

1. Focus on R and D Management: Our research program is focused specifically upon increasing our understanding of the R and D management process.

2. Management Science Setting: The ideas, theories, and techniques of many pertinent fields have been brought to bear on this research area at Northwestern through the diverse training and experience of our faculty and advanced graduate students. These fields include most branches of engineering, physics, economics, operations research, sociology, psychology, business administration, and industrial management. The location of this research program in the Department of Industrial Engineering and Management Sciences in the engineering school at Northwestern provides a very important environmental asset. The four major teaching and research areas of the department include these critical sub-fields in Management Science: Operations Research; Information Sciences; Organization Theory; and Systems Analysis. Students and staff members in the research program participate in all of these areas. The program is an integral part of the Organization Theory area of the Department.

3. A Basic and Applied Approach: Our program may be described as basic research in the Management Sciences. However, it is also an applied research program with respect to the specific problems of managing research and development. That is, we have selected the specific projects in our program on the basis of their importance in the practice of research management. We believe that this set of problems represents key issues in R and D management, and that increased understanding of them will contribute to significant improvements in the art of R and D management in all kinds of institutional settings.

4. An Integrated Approach to the Set of Projects: Our method of operation consists of an integrated approach to the whole set of projects by our research staff. Many of the specific projects grew out of other ones in our program and there is continual feedback and cooperation between members of the staff. That is, we do not work in isolation on separate projects. Results on one project are continually made available to people working on the others. The principal investigator is directly involved in all of the studies in the program and each of the other faculty members is directly involved in at least two projects and indirectly in others.

5. Each Project Continuing and Cumulative: Each project in the program is really a sub-program in itself, comprising a number of distinct, but related studies, over a period of years. This has permitted knowledge and research methods to cumulate. Examples are the Idea Flow study which has involved (through September, 1966) seven theses and dissertations, as well as a number of non-thesis staff studies. The Technical Achievements study has produced, since 1958, three distinct published staff studies preliminary to the one now being completed. The Project Selection study has involved five theses and dissertations since 1957 and several staff studies.

PERSONNEL ASSOCIATED WITH PROGRAM - AUGUST 1965-SEPTEMBER 1966

Principal Investigator

Albert H. Rubenstein, Professor of Industrial Engineering and Management Sciences

Other Northwestern University Faculty and Staff

Arthur P. Hurter, Associate Professor of Industrial Engineering and Management Sciences
Michael Radnor, Associate Professor of Business Administration and Research Engineer in Industrial Engineering.
Gustave J. Rath, Associate Professor of Industrial Engineering and Management Sciences
Jack Siegman, Research Sociologist in Industrial Engineering and Lecturer in Sociology
Charles W. N. Thompson, Research Engineer in Industrial Engineering and Management Sciences

Consultants

Robert W. Avery, Associate Professor of Sociology, University of Pittsburgh
Frank Baker, Research Associate in Psychology, Harvard Medical School
Norman R. Baker, Assistant Professor of Industrial Engineering, Purdue University
Dawson E. Brewer, Assistant Professor of Business Administration, University of California, Berkeley
Richard W. Trueswell, Head of Department of Industrial Engineering, University of Massachusetts

Research Assistants

Alden Bean[4]	Daniel L. Kegan[4]	Robert B. Martin[4]
Gary Bryan[1]	John F. Kottas[3]	William C. Moor[3]
Albert A. Denton	Jon A. Larson[4]	Kent Peterson[3]
William L. Etter[4]	Roseclaire Lavery[3]	Senniappe Rathnasamy[1]
Richard C. Hannenberg[3]	Ralph J. Lewis[1]	David J. Werner[3]
Steven R. Kennedy[3]	Dennis McCarthy[1]	Earl C. Young[4]
		Joy H. Zweigler[3]

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1 Summer Assistant only
2 Assistant during Academic Year only
3 Assistant during Summer and Academic Year
4 Assistant during Summer and fellow during Academic Year

Other Associated Graduate Students

William Batchelor (Owens Corning Fiberglass)	Charles F. Douds	Charles Lapp (Southern Railway)
John W. Bonge	James Graham	Robert D. O'Keefe
	John McColly (Esso R & D)	Cliff Young

CODE FOR AVAILABILITY OF PUBLICATIONS, REPORTS, AND WORKING PAPERS

Note: Publications, Reports, and Working Papers for the periods (1) September 1965-September 1966 and (2) 1960-1965 are listed under each project. The number preceding the listing (e.g., 65/4) is our document number. The degree of availability of each item is indicated by the following code:

AP: Available for distribution; supply plentiful
AS: Available for distribution; supply small *
L: Limited distribution *
F: File copy only; available on two-week loan *

* Abstracts of all theses and dissertations are given in the last section of this report.

1. IDEA FLOW IN RESEARCH AND DEVELOPMENT

Objective: These studies grew out of the decentralization project. Their focus was almost entirely within the laboratory itself, in most cases encompassing the company's entire R & D effort. The objectives of these studies were to describe and, hopefully, make useful predictions about the way in which technical ideas for new R & D projects are originated, communicated, and disposed of. The overall design included individual organization studies and comparative studies. Field investigations were conducted in a number of companies which varied in size, industry, and structure. Among the techniques used were several kinds of questionnaires and interviews, examination of internal documents, and, in several sites, direc observation.

The general research questions sought answers to the following: 1) the sources of ideas; 2) the criteria used by various organizational levels and functional groups in evaluating ideas; 3) the effects of individual backgrounds on criteria used and behavior with respect to idea origination and transmission; 4) organizational procedures for handling ideas; and, 5) the decision processes at various stages of transmission or disposi tion of ideas.

Supported by: National Science Foundation and National Aerounautics and Space Administration.

Project Leader: Jack Siegman.

Progress September 1965-September 1966:

1) Further data was collected in a European R and D laboratory for comparison with similar American R and D laboratories with respect to: role orientations of scientists; perceptions of goals and means, the idea submission and acceptance process; control mechanisms.

2) Continuation of Project Selection studies directly stemming from previou research and findings in the Idea Flow studies. Major emphasis here is on those factors affecting the disposition of ideas for projects.

3) Field work continued in five companies on different phases of Idea Flow.

4) One Ph.D. dissertation and two M.S. theses are in progress which will utilize some of the field data collected above.

5) Two invited papers were presented at professional meetings and others are in progress for presentation in the near future.

6) Two papers have been submitted for publication.

Overall Progress 1962-1966: The specific research performed during the period of the project is described below in terms of a number of sub-studi in the project.

1. Idea Disposition, Subjective Evaluations, Urgency, Predictability and Time Horizons: The purpose of this research was to study the ideas produced by three idea generating groups. Two specific purposes were: (1) To relate the disposition of these ideas to the subjective evaluations of "goodness" placed on each idea during each group's time span; and, (2) To study the role of urgency, predictability, and time horizons on the disposition of these ideas. Findings: (1) A significant and positive relationship was found between subjective evaluations and actual idea dispositions. The higher the subjective evaluation rating, the greater the likelihood of an idea being accepted as, or part of, a project in contrast to those ideas which were evaluated lower. (2) It was also found that the urgency of the need which the idea met was significantly related to the chances of it becoming a project. (3) Finally, it was found that favorable subjective evaluation is positively correlated with the urgency, predictability, and shortness of the time horizon of the ideas.

2. Organizational Factors Affecting Idea Flow: See Abstract of Baker's Dissertation (65/4).

3. Control Mechanisms in the Idea Flow Process: The purpose of this study was to isolate those mechanisms which tended to inhibit researchers from generating and submitting ideas. This was accomplished by case history analysis of ideas originated by researchers before they became members of an idea generating group, and submitted during their duration as members of one of the groups. Findings: The three major factors which researchers perceived to inhibit their idea generating activities on their regular job were, in order of importance: (1) Time pressures due to current work; (2) Thinking constraints; and, (3) Interaction constraints. The three major perceived constraints affecting the communication of their ideas to others were, in order of importance: (1) Organizational structural constraints -- e.g., poor communication channels to management; (2) Idea constraints -- e.g., inability to communicate and understand ideas of other specialists; and, (3) Time pressures of current work.

These control mechanisms had inhibited a significant set of ideas which, upon their communication to management and other researchers in an idea generating group, were then given high evaluations as to their "goodness." In turn, these ideas had a higher success ratio of becoming projects than the ideas the same researchers originated during their membership in an idea generating group. The general conclusion is that the above-mentioned control mechanisms tend to depress the communication and submission of ideas which, if they were made known, would be acceptable to the organization.

3. Communication, Evaluation, and the Flow of Ideas in an Industrial Research Laboratory: See abstract of Pound's dissertation (65/12).

4. Enculturation and Accuracy of Perception as It Affects the Idea Flow Process: See abstract of Utterback's Thesis (65/10).

5. Reward Cost Factors Associated with Idea Generation and Submission Behavior in Quasi-Experimental Idea Generating Groups: By studying several IGG's in time sequence, it was possible to collect idea-specific, behavioral data regarding 48 ideas which had been originated by the IGG participants up to three years before the related IGG. These 48 ideas had either not been submitted, or had been submitted but not accepted prior to the IGG. Also, similar data was collected on 31 ideas which were originated during an IGG but which were not submitted. Idea-specific, behavioral data was also collected regarding the generation of over two hundred-fifty ideas which were submitted for review during the IGG's. As a group the 48 ideas orginated before the IGG's were rated by managers and researchers significantly better than the ideas originated during the IGG's.

As expected, support was found for the notion that perceived time pressures due to current work influenced idea origination behavior by constraining thinking to current assigned work and by modifying perceptions of the intrinsic and extrinsic rewards associated with idea generation and submission. These perceived time pressures tended to inhibit ideas not associated with the current work and to increase the perceived costs and/or decrease the perceived rewards which would be associated with taking time and effort from the regular job for idea generation and/or submission. The result was that perceived time pressures due to regular work inhibited the development and communication of ideas. The supporting data comes from case histories of all the "before" ideas.

Apparently the researchers and technicians at the laboratory perceived that ideas relevant to organizational goals, objectives and needs were more likely to be rewarded by the organization than non-relevant ideas. Support was found for the notion that perceptions of organizational goals, objectives and needs tended to stimulate ideas perceived to be relevant to the goals, objectives and needs, and to influence which ideas would be submitted.

6. Evaluative Dimensions of Technical Ideas: See abstract of Goldberg's Thesis (63/26).

7. Relation Between Laboratory Orientation and Range of Criteria Used: The data below is from five R & D laboratories in our sample. The work of these five laboratories can be roughly described allong a continuum of "primarily development" through "primarlly basic." The table indicates the number of criteria which members of these laboratories say must be met by ideas in order to be acceptable. This is based on a list of 36 criteria presented to these laboratory members during the Time Series studies. The average number of criteria per idea decreases with the increasing orientation of the sample laboratories toward more basic research. This, of course, is a small sample of respondents, laboratories, and ideas and the relationship is being studied further.

Company	General Orientation	No. of Respondents	No. of Ideas	Ave. No. of Criteria Used per Idea
1, 2, 3	Essentially Development	14	25	15.2
4	Oriented Toward More Applied Research	9	10	11.3
5	Oriented Toward More Basic Research	7	21	7.0

8. Project Portfolio and Time Horizons: On the basis of a questionnaire classification, the distribution of projects in one laboratory's portfolio was made. From the data, it was found that most of the R and D work by project class is in work supporting current operations: 61% compared to 34% in the classification of "work leading to expansion of present product line" and only 5% devoted to "work not yet connected to any product or process." The company might be described as satisfied with maintaining a position in its current product line and not aggressively seeking new products via R and D.

In addition, data was collected on the estimated time to complete the projects. The results show that for most of the projects there is a short time horizon. Over half of the projects fall into groups that are expected to take 12 months or less to complete. Again, this substantiates the conservative nature of the R and D portfolio and in addition, when the time horizons of projects were studied over a five year period, the time horizons had progressively shortened.

In addition to this data, open ended interviews were held with some of the managers who expressed the opinion that the work the laboratory was doing had been dominated by accounting and financial interests. In another company a study also showed short time horizons and it was found that over 90% of the ideas worked on came from such sources as salesmen and clients. The laboratory closely operated with production and most of the projects fell into the category of work supporting current operations. Both studies suggest a relationship between the closeness of the R and D laboratory to the market and the client, and the time horizons of the lab's project portfolio.

Publications and Papers:

September 1965-September 1966:

65/36 Jack Siegman, Norman R. Baker, and Albert H. Rubenstein, "The Effects of Perceived Needs and Means on the Generation of Ideas for Industrial R & D Projects," Presented at meeting of Operations Research Society of America, Santa Monica, May 1966. AP

1960-1965:

65/22 Jack Siegman, "Relation of Idea Flow Study to Other Research on R & D Organizations: Some Models and Propositions," Department of Industrial Engineering and Management Sciences, Northwestern University, June, 1965. (Includes "References for Idea Flow Study."). AP

65/12 William Pound, "Communication, Evaluation, and the Flow of Ideas in an Industrial Research and Development Laboratory," Ph.D. Dissertation, Department of Industrial Engineering and Management Sciences, August, 1965. AS

65/10 James Utterback, "Accuracy of Perception and Enculturation of Researchers in an Industrial Laboratory," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, August, 1965. AS

65/8 Albert H. Rubenstein, "Applications of Behavioral Theories to Idea Flow in Industrial R & D Laboratories," Presented at the Southwest Chapter, The Institute of Management Sciences, Spring Meeting, New Orleans, April, 1965. L

65/4 Norman R. Baker, "The Influence of Several Organizational Factors on the Idea Generation and Submission Behavior of Industrial Researchers and Technicians," Ph.D. Dissertation, Department of Industrial Engineering and Management Sciences, Northwestern University, January, 1965. AS

64/25 Jack Siegman, Norman R. Baker, and Albert H. Rubenstein, "Control Mechanisms in the Idea Flow Process: Model and Behavioral Study," June, 1966. Based on an invited paper presented at The Institute of Management Sciences, San Francisco, February, 1965. AP

64/17 James Utterback, "Summary of Variables and Propositions Concerning Idea Flow," A working paper, Department of Industrial Engineering and Management Sciences, Northwestern University, June, 1964. L

64/7 Louis C. Goldberg, Frank Baker, and Albert H. Rubenstein, "Local-Cosmopolitan: Undeminsional or Multidimensional," American Journal of Sociology, Vol. LXX, No. 6 (May, 1965), pp. 704-710. AP

63/26 Louis C. Goldberg, "Dimensions in the Evaluation of Technical Ideas in an Industrial Research Laboratory," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, August, 1963. F

63/25 Frank M. Bolen, "A Technique for the Real Time Measurement of the Flow of Ideas in Industrial Laboratories," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, August, 1963. F

63/24 William H. Pound, "Idea Flow--A Sequential Process," A working paper, Department of Industrial Engineering and Management Sciences, Northwestern University, April, 1963. L

63/14 Norman R. Baker, "On Idea Flow," A working paper, Department of Industrial Engineering and Management Sciences, Northwestern University, September, 1963. L

63/2 Albert H. Rubenstein, "Studies of Project Selection in Industry," in Burton V. Dean, ed., Operations Research in Research and Development, (New York: John Wiley and Sons, Inc., 1963). AS

63/1 Albert H. Rubenstein and Richard Hannenberg, "Idea Flow and Project Selectio in Several Industrial Research and Development Laboratories," in Richard A. Tybout ed., Economics of Research and Development, (Columbus: Ohio State University Press 1965), pp. 219-244. AP

2. CONTROL OF RESEARCH AND DEVELOPMENT IN DECENTRALIZED ORGANIZATIONS

Objective: This is a long term study of the characteristics and behavior of decentralized organizations as they affect the inputs to, capabilities of, and output from R and D.

Supported By: National Aeronautics and Space Administration and the McKinsey Foundation.

Project Leader: Michael Radnor.

Progress September 1965-September 1966: Work was continued on the preparation of the volume reporting the findings of the study.

Overall Progress 1956-1966: This ten-year study is now in its final stages. Historical statistics on the trends toward decentralization of large industrial corporations since 1945 have been collected. The organization of R and D in such firms has been traced through this period for almost 200 large companies. Interviews with top executives in a large number of these companies have been carried out over the period of the study. Two M.S. theses and one Ph.D. dissertation have been completed. Twelve articles and research reports have also been completed, and a book summarizing the project is in preparation.

Data Reduction and Analysis: Some 3,500 documents, such as interviews, internal memoranda, annual reports, etc., from the approximately 200 companies have been coded and sorted according to the variables relevant to our study. A form of content analysis was used to obtain data compilations for the following general areas: 1) organizational objectives, environmental conditions, diversification, R and D policy and philosophies, growth route expectations; 2) organizational form of companies, extent of decentralization, changes and frequencies of change, incidence and functions of group executives, division manager attitudes and behaviors, staff services; 3) organization of R and D, incidence of central laboratories, attitudes towards and performance of such laboratories, vice-presidents of R and D, their incidence, functions and changes, internal laboratory organization, R and D capabilities, divisional research directors, liaison between laboratories, minimum effective size, new technical skill development; 4) control and evaluation, funding methods, expenditures on R and D, technical results, economic results, division manager evaluation and compensation; 5) project portfolios, time horizons; 6) idea flow; 7) enculturation; 8) individual case histories.

Survey of Top Managers: A survey was conducted of top managers in 60 of the largest industrial and technically oriented companies in the U.S. Wide-ranging interviews lasting from one and one-half hour to four hours each were conducted with chairmen, presidents, executive vice-presidents, and in a few cases, high level informants. The combined sales of the companies from which these executives were drawn amounted to over 60 billion dollars in 1962.

Publications and Papers:

September 1965-September 1966:

64/23 Michael Radnor, "Control of R & D by Top Managers in 48 Very Large Companies," in J. F. Lawrence, ed., Operations Research in the Social Sciences, (London: Tavistock Publishers, 1966). AS

1960-1965:

64/11 Michael Radnor and Albert H. Rubenstein, "Top Management Control Processes over R & D Activities in Large Decentralized Companies," Department of Industrial Engineering and Management Sciences, Northwestern University, 1964. AP

64/10 Michael Radnor, "The Control of Research and Development by Top Managers of Large Decentralized Companies," A Ph.D. Dissertation, Department of Industrial Engineering and Management Sciences, Northwestern University, August, 1964. F

64/9 Edward C. Murphy, "Some Relationships between R and D Organizational Change and Company Growth Rate," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, October, 1963. AS

64/8 Fred D. Altman, "Performance Evaluation of Division Managers in Large Decentralized Industrial Organizations," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, August, 1963. F

63/12 Albert H. Rubenstein, "Organizational Factors Affecting Research and Development Decision-Making in Large Decentralized Companies," Management Science, Vol. 10, No. 4 (July, 1964) pp. 618-633. AP

63/3 Albert H. Rubenstein and Michael Radnor, "Top Management's Role in Research Planning in Large Decentralized Companies," in Proceedings of the Third International Federation of Operations Research Societies, Oslo, 1963. AP

62/3 Albert H. Rubenstein, "The Constraints of Decentralization," Chemical Engineering Progress, Vol. 58, No. 8 (August, 1962) pp. 11-15. AP

62/1 Albert H. Rubenstein, "Organization and Research and Development Decisio Making Within the Decentralized Firm," The Rate and Direction of Inventive Activity, A Report of the National Bureau of Economic Research, (Princeton: Princeton University Press, 1962). AS

3. STRATEGIES FOR ORGANIZATION AND DIFFUSION OF RESEARCH IN DEVELOPING COUNTRIES

Objective: The objective of the overall study is to describe the means used by developing countries to establish and maintain an R and D capability. A number of alternative strategies that have been used or proposed for this purpose are being analyzed in relation to the stated objectives for R and D in a number of these countries.

Supported by: National Science Foundation and Faculty Research Funds.

Project Leader: Albert H. Rubenstein.

Progress September, 1965-September, 1966: One M.S. thesis was completed, based on a previous large-scale data collection effort (by interview, document examination, and mail surveys) and a field trip to Mexico and Central America. Preliminary work for one Ph.D. dissertation was initiated. Data collection efforts continued.

Overall Progress 1963-1966: Three M.S. theses and two papers have been completed. The primary means of data collection has been through documents, mailed questionnaires, and local interviews. The first on-site field study was conducted in July 1964 in Central America.

In the first report issuing from the study, presented in Paris in June 1963, various strategies and patterns that have been used or proposed to build up the applied research capabilities of developing countries were analyzed and compared. Since that time two sub-studies, completed as Master's theses, have analyzed current facilities for applied research in 21 Latin American countries and 14 countries in Southeast Asia. Another graduate student extended these studies, partially by means of a field study of research institutes in Mexico and Central America.

A preliminary large-scale data collection effort (by mail) has been completed on the organization of and the policies for R and D in the countries of Africa and the Eastern Mediterranean. Returns were analyzed in a number of ways: (1) research engaged in by each; (2) analysis of a sample of replies and institute reports to ascertain previously unclassified R and D objectives and strategies for their development. This analysis has been incorporated in a Master's thesis.

The ultimate objective of the study is to provide a better understanding of a) the alternative means of establishing and maintaining an applied research capability in a country with very limited resources and b) the potential consequences of these alternative means.

The approach is not normative in the sense that an optimal pattern or strategy for organizing applied research in developing countries is prescribed at this point. Indeed, no specific policy or set of strategies is being prescribed or advocated. Rather, an attempt is being made to describe the current situation as accurately as possible, and to understand how it developed and what some of its consequences might be for the future of these developing countries.

The main effort of the study continues to be focused on the analysis of alternative strategies in relation to the stated R and D objectives in these countries. However, further analysis of these R and D objectives, as well as propositions from the literature, indicate recurrent problems or issues which are

being examined. For example, the conflict between experts on whether to establish a solid foundation of basic science or merely to translate existing world literature into applications relevant to the circumstances of the country continues. Some other questions which recur are:

1. How much should science, regardless of the level, be tied to national economic development plans?
2. What are the criteria for project selection in view of the limited funds, facilities, and scientific manpower?
3. How can science and engineering be made sufficiently attractive as a career choice when previous emphasis has been on an education in the humanities and social sciences, and careers in law and administration?
4. Should scientists and engineers be trained at home or abroad?
5. How can the emigration of local scientists be minimized?

These and similar questions are being recast into propositional form as a basis for selecting key aspects of the overall subject for intensive study. Differing perceptions of and attitudes towards these questions between scientists and government administrators form a basis for potential conflict in developing science policy.

Publications and Papers:

September 1965-September 1966:

66/5 Earl C. Young, "An Analysis of Selected Strategies for Organizing R & D in Developing Countries with Reference to Policy and Planning Techniques, International Relations, Manpower and Training & Information Requirements." A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, January, 1966. L

1960-1965:

64/2 Albert H. Rubenstein and Earl Young, "Strategies and Patterns for the Organization of Applied Research in Latin America and South and Southeast Asia," Presented at the Third Regional Meeting of Representatives of National Scientific Research Organizations of South and Southeast Asia Regions, Canberra, Australia, February 17-al, 1964.

63/27 Pakorn Adulbhan, "A Study of the Role of Scientific Research (R and D) in the Industrial Development of Selected South and Southeast Asia Countries," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, December, 1963. F

63/15 Mario D. Pantin, "A Study of the Role of Scientific Research in the Growth and Development of the Latin American Countries," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, October, 1963.

63/6 Albert H. Rubenstein and Earl C. Young, "An Analysis of Alternative Strategies for Organizing the Applied Research Activities of Developing Countries," in The Possibilities of Operational Research in Developing Countries, (Paris: Dunod, 1964). AP

4. R AND D RESPONSES TO CRISES

Objective: Here we are interested in the reactions of the firm, in terms of R and D behavior, to changes in the market place, technology, the economy, and other environmental conditions. A small sample of firms in each of several relatively clearly defined markets is being studied.

Supported By: National Aeronautics and Space Administration and Fellowship Funds.

Project Leader: Albert H. Rubenstein.

Progress September, 1965-September, 1966: During this period two Master's theses were completed. (Abstracts are given in the last section of the report.) One was on the response to introduction of product innovations in a consumer products industry. The other was on the response of railroad management to technological innovations.

Overall Progress 1964-1966: A model of the pattern of responses by the individual firm to crises in its market or in the external environment was adapted from ideas suggested by March and Simon (Organizations, Wiley 1958). Several pieces of this process were selected for study. In addition to the two theses mentioned above, two additional sub-studies were initiated during this period. One encountered data problems on the internal decision-making in the firms of the sample. It may be continued. Continuance of the other sub-study awaits an interested student or staff member who has competence in historical depth interviewing.

Publications and Papers:

September 1965-September 1966:

66/22 Charles J. Lapp, "An Empirical Study of Some Relationships Between Technological Innovations and Organizational Characteristics in Eight Railroads," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, August, 1966. AP

65/38 Dennis McCarthy, "The Response Behavior of Firms Confronted by Market Crises," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, September, 1965. AS

5. SOURCES OF R AND D ACHIEVEMENTS IN ELECTRONICS SINCE 1945

Objective: The objective is to attempt to relate the incidence of R & D achievements in electronics to certain characteristics of the organizations reported to have been responsible for them.

Supported by: National Aeronautics and Space Administration.

Project Leader: Dawson E. Brewer.

Progress, September, 1965-September, 1966: Measures of the incidence of R and D achievements were developed and related to the characteristics of the organizations reported to have been responsible for them. Measures were developed for various degrees of aggregation of the achievements according to technical fields or products areas in electronics. In the development of the measures, consideration was given to the results of a questionnaire that was sent to a panel of specialists who were asked to indicate the significance of individual achievements. Various characteristics of the respondents to the original survey on achievements were analyzed in relation to those of the entire sample.

Overall Progress, 1963-1966: In order to measure the activities and R & D output in electronics of R & D organizations, a mail survey was conducted among individuals who were considered to be knowledgeable in the field of electronics. A geographically stratified sample of senior members of the Institute of Radio Engineers was used as a basis for the survey. On the questionnaire, information was requested as to: 1) the employer, position and fields of technical interest of the respondent; 2) a list of the companies or laboratories doing the most interesting research and development in the respondent's fields of technical interest; and 3) a list of the major technical achievements and companies or laboratories associated with the achievements for the respondent's fields of technical interest.

The study was focused primarily upon information generated by the questions concerning the major technical advances, the companies or laboratories most responsible for the research advance, and the companies that made the innovations.

A two-dimensional measure of the R & D output of organizations was developed, one dimension related to the number of technical fields with which each of the organizations was associated, and the other pertained to the position, or rank, of each of the organizations in relation to other organizations that were associated with a given field of technology. The two dimensions might be described within the context of the source of the data as reflecting the breadth and depth of the R & D output of an organization.

These measures of R & D output were then used for purposes of describing and comparing the output of organizations and classes of organizations based upon what are thought to be relevant measures and categories.

Publications:

1960-1965:

62/5 Albert H. Rubenstein and Dawson E. Brewer, Research and Development in the Chicago Area Electronics Industry, Department of Industrial Engineering and Management Sciences, Northwestern University, 1962. AP

6. THE ACQUISITION AND DEVELOPMENT OF NEW TECHNICAL SKILLS IN RESEARCH AND DEVELOPMENT

Objective: This is an attempt to learn the cost and time necessary for R and D organizations to build new capabilities in technical fields. The concept of "capability" and how it is achieved is the central question under study.

Supported By: National Aeronautics and Space Administration.

Project Leader: Gustave J. Rath.

Progress September 1965-September 1966: The data from the Human Factors and Laser study were coded and entered on punched cards. Several computer programs for data analysis were prepared and executed. One short note was published on the human factors data, and a final report was started. An investigation on the uses of simulation for the project was carried out and published. A set of instruments was prepared for the pre- and post-training testing of engineers who are about to be retrained. An instrument for the study of the sources of personnel for Hindsight groups (see project 12) was developed. This also has relevance to project 10--Project Selection. A real-time computer program has been developed to query a personnel data bank for people with given attributes.

Overall Progress 1963-1966:

Capability and Its Components: "Skills" are required to do R and D. "Skills" are attributes of people. A group of people working together in a technical area constitute a "capability." The focus of the research has been changing, from organization statistics, through the description of people in special fields, to the study of individual skill components.

Human Factor-Laser Study: A series of questionnaires which compare the development of Human Factors and Laser capabilities were mailed and 200 usable questionnaires (40%) have been returned. The data has been posted, the computer program for analysis has been written and the data has been analyzed. A few of the salient results are:

1. A Human Factors capability representing a "supporting" technology is much more apt to be started under customer or management instigation. Laser groups, representing a "prime" technical capability, are often started by the scientists and engineers in the organization under study.

2. Human Factors organizations change their objectives much more often than do Laser groups, reflecting their supporting character.

3. In both Human Factors organizations and Laser groups, original support and later support were either completely internal or completely external (very little cost sharing appeared).

4. Both activities were typically started by the assignment of organization personnel, followed later by hiring. Consultants, if used at all, were called in after a major amount of the staffing occurred.

5. Further evidence has been found for the proposition that attempting to accelerate the start-up of groups frequently results in losing time in achieving a first effective output.

Organizational Growth: In a recently completed Master's thesis, organizational-structural changes were studied during a seven-and-a-half year period in an industrial research and development laboratory. The analysis focused on the differences in growth patterns between "applied research" and "development" units.

Publications and Papers:

September 1965- September 1966:

66/36 T. A. Struve and G. J. Rath, "Planning - Programming - Budgeting in Education: A Systems Approach to Capital Budgeting in School Districts, Educational Technology, Vol. VI, No. 11 (June 15, 1966), pp. 1-14. AP

66/35 Gustave J. Rath and Richard Hannenberg, "Operations Research and Systems Analysis in Education," Data Processing for Education, Vol. 5, No. 4 (April, 1966), pp. 1-5. AS

66/34 Gustave J. Rath and Roger G. Schroeder, "The Roles of Mathematical Models in Educational Research," Psychology in the Schools, October, 1965. AS

66/33 Gustave J. Rath and Roger G. Schroeder, "An Implementation Checklist for PI," National Society For Programmed Instruction Journal, Vol. LV, No. 8 (October, 1965), pp. 6-7. AP

65/15 Robert B. Martin, "Structural Development of An Industrial Research and Development Laboratory," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, February, 1966. F

1960-1965:

65/31 Gustave J. Rath, "The Design and Synthesis of Educational Systems," Presented to the Society for Programmed and Automated Learning, Chicago, April 1, 1965. AS

65/18 Gustave J. Rath, "The Systems Approach in Preparing Auto-Instructional Programs," Teaching Aid News, Saddlebrook, New Jersey, Vol. V, No. 1 (January, 1965), pp. 1-21. AP

65/16 Gustave J. Rath, and William P. Allman, "Computers: Applications to the Quantification of Human Performance," Human Factors, December, 1964. AP

64/14 Gustave J. Rath and Albert H. Rubenstein, "Establishing New R and D Skills," Presented at the Institute of Management Sciences Operations Research Society of America, Minneapolis, October, 1964. L

64/12 Gustave J. Rath, "The Analysis of Behavior for Education and Training," Proceedings of the Conference on the Quantification of Human Performance, Alburquerque, August, 1964. AS

63/21 Robert B. Martin, "New Technical Skill Development," A Summary of Seminar Discussions, Department of Industrial Engineering and Management Sciences, Northwestern University, December, 1963. L

7. INTEGRATION AND UTILIZATION OF MANAGEMENT SCIENCE ACTIVITIES IN ORGANIZATIONS

Objective: The study is concerned with the general process of introduction and adoption of operations research and management science (OR/MS) activities in organizations. The objective is to describe and then, hopefully, to predict the transition of operations research and other management science groups through the various phases in their life cycle, which have been identified. The effects of many internal and external factors are being tested in a series of studies.

Supported By: National Aeronautics and Space Administration.

Project Leader: Michael Radnor.

Progress September 1965-September 1966: Data collection was considerably intensified during this period. Using an expanded and revised instrument, approximately 25 in-depth company studies were completed, involving some 120 separate interviews. A parallel study was initiated in the federal civilian agencies. This phase of the study is now fully under way, and approximately a dozen agencies have already been subjected to study. Preliminary arrangements were made to set up a similar study in England. A pilot study was undertaken there in September 1966. Continuation of this phase of the project will be subject to the availability of new funds to support this British project. A paper was presented at the International Conference of the Institute of Management Sciences, Vienna, September 1965, and another invited paper was given to the Annual Meeting of the British Operational Research Society, Reading, September 1966. A Ph.D. Dissertation in this area is underway. Two other papers were completed in the period.

Overall Progress 1960-1966: This study has proceeded in several phases:

1961-1962: Members of Operations Research groups from some 40 companies were interviewed concerning the history, organization and activities of the groups. Using the membership roster of the Operations Research Society of America (ORSA) and supplementary informant data, statistical data were obtained which give some indication of the births, progress, and in many cases, deaths of OR groups. The concept of "Life Cycle Phases" (pre-birth, introductory, transitional and maturity) was explored. One paper was published and a second working paper was presented to a professional society meeting.

1962-1964: In addition to the continuation of data collection from individual members of OR groups, several in-depth case studies were carried out. Members of management and clients were interviewed. Two Master's theses were completed. One dealt with the concept of "client receptivity" as a key variable, which was measured in terms of the client's willingness to allow the OR group to select projects, collect data, and implement completed projects. A second thesis dealt with an "implementation phase model" in an attempt to relate the various contributing factors in the implementation phase and the success of the projects. An extensive literature search was made to determine the variables that various authors believed were significant in the success or failure of groups like OR/MS groups.

1964-1966: During this period the study was expanded to a more general consideration of the integration of management science activities into organizations. The change in emphasis from an "OR group" focus to that of the

"organization" in which management science activities were appearing, was continued. Some 25 in-depth company studies were carried out, in which members of OR/MS groups, individuals performing OR/MS activities in various existing line and staff functions, members of management, clients and related staff personnel were all interviewed.

There was considerable development of theory and of research instruments. Data that is currently being collected relative to the following variables includes: the history, location and organization of OR/MS activities; the mission performance and projects of the various activities; personnel and leadership; managerial support; client receptivity; reputation and success of OR/MS activities; adequacy of resources available; opposition encountered problems of implementation of projects; and relations with staff groups.

Data files on personnel were brought up to date (from the ORSA listings) and added to (the Institute of Management Sciences rosters, and various confidential personnel-file listings). A punched card and tape system was developed which will facilitate both the tracking of personnel movements between organizations, and the histories of various organizational activities. The study was expanded into federal civilian agencies and a start made to initiate similar studies in educational institutions and in Great Britain.

Three papers were written, one is in progress, and several more are planned. A Ph.D. dissertation, almost completed, is studying the effects of organizational changes and responses generated in Purchasing Departments by the Introduction of management science activities (primarily computer systems).

Publications and Papers:

September 1965-September 1966:

66/24 Michael Radnor and Albert H. Rubenstein, "Integration and Utilization of Management Sciences Activities in Organizations," Presented to the Annual Conference of the British Operational Research Society, Reading, England, September, 1966.

66/19 Gustave J. Rath, "Management Science in University Operation," Paper presented to meeting of The Institute of Management Sciences, Dallas, February, 1966. AP

66/9 Richard C. Hannenberg, "Some Potential Applications of Systems Analysis to a District School System," A working paper, Department of Industrial Engineering and Management Sciences, Northwestern University, September, 1965. AS

1960-1965:

65/26 Albert H. Rubenstein, Michael Radnor, Norman R. Baker, David R. Heiman, and John B. McColly, "Some Organizational Factors Related to the Effectiveness of Management Science Groups in Industry," Presented at the 12th International Meeting of the Institute of Management Sciences, Vienna, September, 1965. AP

64/18 David R. Heiman, "A Procedure for Predicting the Potential Success or Failure of an OR/MS Activity," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, May, 1964. F

63/17 David R. Heiman, "List of Variables in the Birth and Death of Operations Research Groups, A Simmary of Seminar Discussions," Department of Industrial Engineering and Management Sciences, Northwestern University, November, 1963. L

63/8 Norman R. Baker, "Descriptive Model of Several Environmental Factors Affecting Industrial Operations Research - Management Science Activities," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, August, 1963. AS

61/2 Albert H. Rubenstein and John B. McColly, "Phases in the Life Cycle of Industrial Operations Research Groups," Presented at the Joint Institute of Management Sciences - Operations Research Society of America Meeting, San Francisco, November, 1960. AS

60/1 Albert H. Rubenstein, "Integration of Operations Research into the Firm," Journal of Industrial Engineering, Vol. XV, No. 5 (September-October, 1960), pp. 421-427. AS

8. LIAISON RELATIONS: TRANSITION AND INTERFACE PROBLEMS BETWEEN PHASES OF RESEARCH, DEVELOPMENT AND APPLICATION

Objective: This study involves analysis of problems of information exchange between working groups involved in the research and development process. One aspect of the study focusses upon the interface between "systems planning and design" groups and "research and development" groups.

Supported by: RAND Corporation Department of Defence and National Aerounautics and Space Administration.

Project Leader: Albert H. Rubenstein.

Progress September 1965-September 1966: An investigation of the literature directly involving working group interfaces and liaison relations resulted in an internal working paper providing several models of the liaison process and a number of propositions. Two instruments were developed and pilot tested for Project 12. A study-design working paper was published and several interview instruments are being developed for study of the "Systems-R and D" interface.

Overall Progress 1964-1966: This study was originally conceived as focusing upon the vital interface occurring between systems planning and design groups involved in complex military and space systems, and research. It has been expanded to include the interfaces occurring between all types of research and development groups.

Systems-R and D Study: A preliminary historical analysis was made of the materials problems requiring state-of-the-art advances in the development of a major weapon system to determine the extent of semantic barriers as a factor in the Systems-R and D interface. Most of the documents used were classified, and no detailed report on this specific study will be available. A preliminary field-study design was formulated for determining the potential effects of communication problems at the Systems-R and D interface. This design, in conjunction with the study discussed below, is being pursued with the development of instruments and an initial field study in a major government agency.

Liaison Transfer Study: A survey of the limited literature dealing with the interfaces occurring between parallel research and development working groups and groups involved in the transition of a body of work from one stage to the next generated several models of various aspects of the process and a number of hypotheses of potential interest. From this work a questionnaire and an interview instrument were developed and pilot-tested for use in Project 12.

Findings: Results obtained from the pilot study and recent literature point to a predominance of communication being handled through informal liaison roles rather than by formal liaison agents or written media. However, the formal liaison role does appear to be effective in some circumstances. These preliminary results and other questions must be examined rigorously and comprehensively before more definite findings can be reporte

Publications and Papers:

September 1965-September 1966:

66/23 Daniel L. Kegan, "A Technology Transfer Flow Diagram," A working paper, The Department of Industrial Engineering, and Management Sciences, Northwestern University, January, 1966. AP

66/21 Albert H. Rubenstein, "Some Preliminary Notes on a Proposed Study of Selected Communication Problems at the Interface Between Systems Planning and Research and Development," A Working Paper, Department of Industrial Engineering and Management Sciences, Northwestern University, June, 1966. L

66/6 Charles F. Douds and Albert H. Rubenstein, "Some Models of Organizational Interfaces in the R and D Process," A Working Paper, Department of Industrial Engineering and Management Sciences, Northwestern Unviersity, March, 1966. AP

9. THE INFORMATION-SEEKING BEHAVIOR OF RESEARCHERS

Objective: Many different information-seeking behaviors are available to scientists and engineers. The behavior selected by a given individual depends upon his own personal style and the content of his work. His organization may constrain his style or may determine what specific behavior he follows.

This research is concerned, among other things, with determining whether common patterns of information-seeking exist among organizations, as opposed to the existence of a wide variety of behaviors which are constrained by specific sets of organizational resources. It is hypothesized that information-seeking style is a stable behavior pattern, developed slowly over the professional lifetime of an individual. The information-seeking styles prevalent in a group may be one determinant of R and D group effectiveness.

Supported by: National Aeronautics and Space Administration and National Library of Medicine, Public Health Service.

Project Leader: Gustave J. Rath

Progress September 1965-September 1966: A pilot study of medical researchers has been completed, and reported as a Master's thesis. A paper highlighting a specific case of search vs. research was prepared. A study of X-ray crystallographers and a six month post-test have been completed, and the first phase has been reduced, analyzed and reported. The second phase has been analyzed and the draft of the report is being revised. The receipt of a new grant has led to the initiation of an extensive program of site preparation which is still under way. The original instruments and taxonomy of information services are under revision, and new ones are being developed. Further development of the theory of information-seeking behavior is under way. A series of instruments which concern information-seeking behavior have been developed and are undergoing field tests. The instruments are concerned with determining the relationships between services, or media, and specific phases of the R and D process.

Overall Progress 1964-1966: Three studies have been carried out, another has been started, and a working conference was held to discuss current problems--methodology, data collection, and theory--in the field of researchers' needs for information. The studies are:

1. A Study of a Small Medical Research Team. The first study consists of the observation in real time of a group of medical researchers, consisting of three M.D's and one biochemist. The subjects reported on their information-seeking behavior by telephone through our Telephone Data Collection System, by filling out activity cards, and by participating in other method of data collection. An experimental treatment--provision of a medical librarian--was instituted and its effects observed. This research served as the testing ground for the methodology and techniques which are being used in further studies. (Further details are in the abstract of Werner's Thesis 65/35).

2. A Study of X-Ray Crystallographers. A study of X-ray crystallographers in nine organizations--5 in for-profit organizations and 4 in non-profit ones--has been carried out. In each organization, two scientists or engineers, one an experimental subject, and the other a "control," were studie

Data was collected on their current awareness, specific, and exhaustive search activities. An information transient, consisting of a package of specifically developed information which might be useful, was given to the experimental subjects. The package included STAR Abstracts, information on the availability of the National Referral Center (Library of Congress), Argonne National Laboratory and other special services which these scientists and engineers might not know of or might nor have previously used. Their reactions to this new information were observed and recorded. The subjects reported a range of 3 to 15 information-seeking events a day. Some findings were:

a. Researchers in many cases do not use new services which are offered to them, even though they say they desire the services.
b. Researchers in a few cases do not even directly examine the services offered.
c. Researchers often perceive that they do not have time to use new services.

Publications and Papers:

September, 1965-September, 1966:

66/31 Albert H. Rubenstein and Gustave J. Rath, "Some Preliminary Experiments and a Model of Information-Seeking Style of Researchers," Prepared for Presentation to the National Conference on Administration of Research, October, 1966. AP

66/20 Richard W. Trueswell and Albert H. Rubenstein, "Information-Searching Behavior of Physicians," The Department of Industrial Engineering and Managements Sciences, Northwestern University, October, 1966. AS

65/37 Gustave J. Rath, Richard W. Trueswell, and Albert H. Rubenstein, "An Experiment in Measuring Certain Aspects of the Information-Searching Behavior of X-Ray Crystallographers," Technical Report No. 1, Presented at Meeting of The Institute of Management Sciences, Dallas, February, 1966. AP

65/35 David J. Werner, "A Study of the Information-Seeking Behavior of Medical Researchers," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, December, 1965. AS

65/33 David J. Werner, Gustave J. Rath, Albert H. Rubenstein, "A Case of Search vs. Experiment," A working paper, Department of Industrial Engineering and Management Sciences, Northwestern University, December, 1965. AP

1960-1965:

65/5 Gustave J. Rath, "Initial Steps Toward Studies of the Information Behavior of Scientists and Engineers," Information System Sciences, (Washington: Spartan Books, Inc., 1965). AP

64/19 "A Proposal for a Study of Research Personnel in Their Information Environment," The Department of Industrial Engineering and Management Sciences, Northwestern University, August, 1964. AP

62/2 Albert H. Rubenstein, "Timing and Form of Researchers Needs for Technical Information," Journal of Chemical Documentation, Vol. 2, No. 28, (1962), pp. 28-31. AP

61/5 Gustave J. Rath, A. Resnick, and T. R. Savage, "The Formation of Abstracts by the Selection of Sentences," American Documentation, Vol. 12, No. 2, 1961. AS

61/4 Gustave J. Rath, A. Resnick, and T. R. Savage, "Comparisons of Four Types of Lexical Indicators of Content," American Documentation, Vol. 12, No. 2, 1961. AS

10. PROJECT SELECTION IN R AND D

Objective: To describe the currently used R and D project-selection process and to formulate models that might be used to improve it. The long run objective is a "real-time" information and computation system to aid the R and D manager in his project selection and review.

Supported By: National Aeronautics and Space Administration and Office of Naval Research.

Project Leaders: Albert H. Rubenstein and Arthur P. Hurter

Progress September, 1965-September, 1966: Interviews with R and D decision makers are currently being conducted at three large industrial concerns. Their purpose is to trace the decisions made, on the projects now under consideration in each firm, through the appropriate series of decision makers. At each step, we are attempting to obtain the values of the information items and decision criteria employed.

With these data we attempted to: (1) describe in detail the R and D project selection process in each firm; (2) compare, using discriminant analysis, decisions made with the choices indicated by standard decision rules in order to determine whether or not firms behave as if they employed these rules; (3) provide insight for the construction of applicable prescriptive models.

It was thought that item (2) could be investigated by using information recorded by the firms on project decisions made in the past. However, these historical works proved inadequate and the attempt was discontinued.

A draft of a working paper has been completed which reviews the literature on subjective probability with particular emphasis on useful application in R and D project selection models.

Further discussion and planning have taken place relative to the proposed organization and operation of a TIMS College on Research and Development (COLARD) study committee on R and D project-selection criteria. Potential research teams and associated geographical areas have been defined. Some interaction has occurred between the study coordinator and likely participants at the various geographical locations. It is proposed that the research teams gather data from local industrial, university, and government R and D laboratories.

Two field studies were continued and one major field investigation was initiated. Two of the field sites are industrial laboratories; the third is a new government research laboratory.

Empirical Studies: These are underway in the two industrial laboratories. Structured interviews and questionnaires are being utilized in an attempt to identify decision criteria and to measure the relative importance of the identified decision criteria for the project selection decisions. The data base for these studies is the set of proposals considered by management for R & D project status during the 1965-66 fiscal year (approximately 165 proposals over the two laboratories).

Real-time Study: This is scheduled to start with the proposals for the fiscal year 1966-67 as an initial data base. Accordingly, the proposals under consideration for 1966-67 are being documented, and relevant decision information is being collected.

The project-selection models now in the literature have been reviewed and classified according to analytical structure. Three or four general models are being constructed, under which the large number of models now in the literature can be viewed as special cases. These models, and a capital investment model presently being developed, will be evaluated for feasibility and desirability during the real-time study.

Overall Progress 1964-1966: During this period a preliminary design was formulated for a long-term study of the information requirements to support improved project selection in R and D. Preliminary work was initiated on this study in the late spring. It consists of two major (methodological) approaches: (1) a formal one employing the theories and techniques from economic theory and operations research; and, (2) an empirical one employing theories and techniques from the field of organization theory.

Work on the "formal" phase of the project by two investigators was begun in June 1965. Since an important premise on which our research will be based is that risk and uncertainty play dominant roles in R and D project selection, we have begun with a study of subjective probability. The literature on subjective probability, both theoretical and "applied," and the literature on nonparametric statistics is being reviewed with an eye toward their usefulness in project selection models.

It is planned to evaluate several representative project-selection models for feasibility and desirability of implementation. A state-of-the-art paper on R and D selection models was prepared. Working from this paper, it became clear that the existing project-selection models could be classified as "decision theoretic," "economic," or "mathematical programming" in nature. One or at most two general models are being constructed for each category, so that the specific models in each category can be viewed as special cases of the more general models. In addition, a new model is being developed based upon investment-analysis and chance-constrained programming. Thus, approximately five general Rand D project selection models will be generated, all potentially suitable for implementation and empirical evaluation.

Publications and Papers:

September, 1965-September, 1966:

66/28 Albert H. Rubenstein, "A Real-Time Study of Information Requirements for Project Selection in Research and Development," Presented to the members of the International Federation of Operations Research Societies, Boston, August, 1966. AP

66/16 Albert H. Rubenstein, "Economic Evaluation of Research and Development: A Brief Survey of Theory and Paractice," Journal of Industrial Engineering (in Press). AP

66/15 Arthur P. Hurter, "Models We May Be Developing and Preparing To Test in Project Selection Study," A working paper, Department of Industrial Engineering and Management Sciences, Northwestern University, September, 1966. L

66/11 Jon A. Larson, Norman R. Baker, and Jack Siegman, "The Relationship Between Certain Characteristics of Industrial Research Proposals and Their Subsequent Disposition." Paper presented at Dallas meeting of The Institute of Management Sciences, March, 1966. AP

65/39 John F. Kottas, "Quantifying Uncertainty When It Is Necessary to Use Subjective Information," A working paper, Department of Industrial Engineering and Management Sciences, Northwestern University, January, 1966. L

1960-1965:

65/24 Albert H. Rubenstein, "Information Requirements and Criteria for Project Selection Decisions in Research and Development." Department of Industrial Engineering and Management Sciences, Northwestern University, June, 1965. L

65/2 William Pound, "College of Research and Development Memo on the Organization of the Study Committee on R and D Project Selection," Department of Industrial Engineering and Management Sciences, Northwestern University. L

64/27 Michael Radnor, "A Critical Evaluation of the Field of Engineering Economy," Journal of Industrial Engineering, Vol XV, No. 3 (May-June, 1964), pp. 133-141. AP

64/21 Samuel B. McMaster, "Study of Project Selection Techniques in an R & D Organization," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, June, 1964. F

64/15 Norman R. Baker and William H. Pound, "R & D Project Selection: Where We Stand," IEEE Transactions on Engineering Management, Vol. EM-11, No. 4 (December, 1964), pp. 124-134. AP

64/13 William H. Pound, "Research Project Selection: Testing A Model in the Field," IEEE Transactions on Engineering Management, Vol. EM-11, No. 1 (March, 1964), pp. 16-22. AP

62/4 Albert H. Rubenstein, "Hastings Electronics Company: Evaluation of Research and Development," in Dan H. Fenn, Jr. and Linda M. Gernberger, eds., Management of Materials Research, (New York: Interscience Publishers, 1962). AS

60/2 Albert H. Rubenstein and Ira Horowitz, "Project Selection in New Technical Fields," National Electronics Conference Proceedings, Vol. XV, 1959. AS

11. KEY RESEARCHABLE PROBLEM AREAS IN R AND D MANAGEMENT

Objective: The study was designed to explore the feasibility of a series of small, working seminars focused on particular key researchable problem areas in R & D management. This series of seminars was intended to help identify key problem areas and opportunities for research in the R and D management area, and to explore critical issues of theory and methodology.

Supported By: Office of Naval Research and in cooperation with The College on Research and Development of the Institute of Management Sciences.

Project Leader: Albert H. Rubenstein.

Background of the Study: The field of research-on research has grown considerably in the past decade, to the point where several hundred re-engaged in one or more projects related to improving our understanding of and/or practice of R and D management. Many of these investigators are working in parallel or related areas, sometimes in very small groups or alone. They exchange information about their research results through the usual channels of journal articles, books, and papers presented at professional society meetings.

In the past few years, it has become evident that more collaboration and exchange of views before or during their research might be beneficial and might help to alleviate some of the problems of duplication and non-cumulativeness that frequently appear in the published literature. In collaboration with the College on Research and Development (COLRAD) of The Institute of Management Sciences (TIMS), the principal investigator, who is Director of Studies for COLRAD, undertook a series of exploratory small group sessions. The Membership and focus of these sessions varied, but the general theme remained the identification of key researchable problem areas in R & D management. In addition, these sessions were designed to explore critical issues of theory and methodology.

Summary of Activities 1964-1966:

Seven sessions were conducted during the life of the study. In addition, at least one more has been designed, but has not yet taken place. The sessions were:

Date	Loc Location	Subject
1. February, 1964	TIMS Meeting, Pittsburgh	Key Researchable Areas in R & D Management
2. May, 1964 (2 sessions)	Univ. of California at Berkeley (In conjunction with Social Science Seminar of the Space Sciences Laboratory)	The Role of the Research Manager
3. October, 1964 (3 sessions)	Joint TIMS-ORSA meeting, Minneapolis	Project Selection
4. November, 1964 (a two-day seminar)	Northwestern University	Project Selection

	Date	Location	Subject
5.	February, 1965	TIMS-San Francisco	Project Selection
6.	April, 1965 (a two-day seminar)	Northwestern University	The Researcher and His Information Environment
7.	September, 1965	TIMS-Vienna	International Cooperation in Comparative Studies of Research Management
8.	Fall, 1966 (Planned 2-day seminar)	Northwestern University	R & D in Large Decentralized Organizations

The participants in the seven sessions that have been conducted were:

1. Members of COLRAD.
2. Faculty and graduate students engaged in research-on research at Berkeley. (The Principal Investigator participated as a Visiting Professor.)
3. Members of COLRAD and members of COLRAD's Project Selection study committee.
4. Researchers from university and industry.
5. Same as 3.
6. Researchers from industry, university and science publishing.
7. Researchers from six European countries and the U.S.

Results: In several of the seminars (not all) key problem areas were identified which may have been slowing progress. In the "porject selection" area, for example, the following key areas were identified as requiring intensive work:

Nature and use of criteria for selecting projects
Information requirements for project selection
Improved (more realistic and easily computed) models
More work on subjective probability
Real time studies

In the "information needs" area, a number of the findings are presented in "Summary of Principal Points." (65/32)

Findings related to the methodology of conducting such seminars are still tentative since only a limited number of alternative formats was actually tried. Least successful, in terms of substantive results (although their stimulatory effect seems high) were the half-day meetings of "strangers" at professional society meetings. Little could be actually accomplished in view of the recurring need for orienting people not directly or centrally involved in full time research in the problem area (e.g., the interested practicing research manager who was not actually engaged in research-on research himself).

The benefits of such sessions were great in terms of exposing new people to the field, but did not produce much in the way of concrete output.

The most successful sessions were the two-day ones at Northwestern, where attendance was limited by invitation to a dozen or less people from different organizations who were working directly in the field with which the session was concerned. Of the two, more effective results were obtained in the one where a large percentage of the participants had been acquainted previously and have even collaborated in the past. Where most of the participants were unacquainted with the previous work of the others (despite some prior mail-out material), a lot of time was taken in becoming acquainted and "getting definitions straight."

In general, some of the seminars appear to have had a significant effect on the work of individual participants and on the possibility of future collaboration.

Publications and Papers:

September, 1965-September, 1966:

66/3 Office of Naval Research-College of Research and Development Seminar on R & D Project Selection, November 11 & 12, 1964. Department of Industrial Engineering and Management Sciences, Northwestern University, 1964. L

66/1 Albert H. Rubenstein, "Final Report on a Feasibility Study of A Series of Seminars on Research-on-Research Management," for Office of Naval Research, under contract NR 047-052, Department of Industrial Engineering and Management Sciences, Northwestern University, January, 1966. AS

1960-1965:

65/32 David J. Werner, "Summary of Principal Points of the Seminar on the Researcher and His Information Behavior," Department of Industrial Engineering and Management Science, Northwestern University, April, 1965. AP

65/21 "Preliminary List of Research Areas of Mutual Interest to the National Aeronautic and Space Administration and Northwestern's Research Program," Department of Industrial Engineering and Management Science, Northwestern University, May, 1965. L

65/6 Albert H. Rubenstein, "Some Observations on the State of the Art in Research on the Management of Research and Development with Potential Applications and Implications for the National Aeonautics and Space Adminstration," Department of Industrial Engineering and Management Science, Northwestern University, February, 1965. L

61/3 Albert H. Rubenstein, "Opportunities for Research-on-Research," Presented at The Institute of Management Sciences, Brussels, August, 1961. AP

12. ENVIRONMENTAL AND MANAGEMENT FACTORS INFLUENCING THE PERFORMANCE OF RESEARCH AND DEVELOPMENT GROUPS.

Objective: This study provides a means for carrying out a cooperative research program between the Research Management Aspect of Project Hindsight and the program of research on research management at Northwestern. The support of Project Hindsight includes participation and assistance in the design of field research and data analysis. The support of the Northwestern program includes providing data sources.

Supported by: Office of the Deputy Director, Research and Technology, Department of Defense

Project Leader: Albert H. Rubenstein

Progress September 1965-September 1966: Since the start of Northwestern participation in October 1965, members of the Program of Research on the Management of Research and Development have been cooperating with the Office of the Deputy Director, Research and Technology on the Phase II field studies of Project Hindsight. During Phase I, as an in-house program of research by the Department of Defense, information on key "research and exploratory development events" in the life of a number of selected weapons systems was collected to provide a base from which to identify and establish management factors for research and technology programs, and to measure the overall cost-effectiveness of the current generation of systems as compared with their predecessors. The Phase II activity is directed to the identification of management and other environmental factors related to research group performance. The field work is being conducted by in-house investigators in the field sites. For this phase, Northwestern and MIT are working with ten field sites, both industrial and governmental, dividing the sites into two groups of five each, one group working with an assigned university during each of two field-study periods. The accomplishments through September 1966 are presented with respect to five areas:

1. Two week course in field-study methods: With few exceptions, the field researchers who are responsible for the administration of the research instruments on site had no previous experience in this specific type of research. To provide them with a basic orientation, a two-week lecture, laboratory, and demonstration course was conducted in November 1965; this included the design and conduct of a one-week field study under conditions as close as feasible to those that they would encounter.

2. Propositions and Instruments: Through September 1966, fourteen research instruments, and the set of testable propositions upon which they are based, have been developed and pilot tested. Substantive discussion in this area is included within the appropriate other sections of this report. (e.g., projects 1,2,6,8,9 and 10.)

3. Hindsight Field Manual: A critical requirement of the overall study was the necessity of providing a systematic and common basis for: data collection in the field, data transmission, data reduction, and data analysis. With the many different people and organizations involved, it is important to have commonly accepted definitions, common instructions for obtaining and treating data, and common procedures for making changes in various aspects of the program. In order to help accomplish this complex task with a minimum loss or distortion of information, and with as little

burden as possible placed on the field researchers, a Field Manual was developed. It includes all procedures for conducting the field studies, instructions for the handling of data, instructions for the administration of each instrument, and copies of the instruments. The Field Manual in its present form is approximately two hundred pages, but is designed in looseleaf form to allow continuous addition and modification.

4. Field Research: During the first field study period, Northwestern has been working with the five field sites that were originally assigned to it, plus two of the other sites whose staff members were able to administer instruments from both MIT and Northwestern. At these seven sites, thirty-six groups, with an average of ten members each, have been identified, background information has been obtained, and, as of September 1966, administration of the research instruments is in progress.

5. On-Line Field Research: As part of the continuation of the Hindsight program, the field study procedures developed for the retrospective study above are being adapted to allow the gathering of data on a real-time basis, where feasible.

Publications and Papers:

September 1965-September 1966:

66/17 Albert H. Rubenstein, "Research on Proposition Formation and Field Studies in Connection with Project Hindsight," Department of Industrial Engineering and Management Sciences, Northwestern University, July, 1966. First Progress Report.

13. OTHER RELATED ACTIVITIES

A. In addition to the specific research projects in Northwestern's Program of Research on the Management of Research and Development, there are many other activities in the Department of Industrial Engineering and Management Sciences related to the management of R & D. Some of them are:

1. THE TRANSACTIONS ON ENGINEERING MANAGEMENT OF THE INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS. The Principal Investigator of the Program has been editor since 1959, when he came to Northwestern. This is a journal devoted to reporting the results of systematic studies and descriptions of practice in the management of Research and Development and Engineering activities.

A five-year cumulative index was prepared and is available (see below). Affiliate membership in IEEE is available to members of a wide range of other professional societies at a reduced rate.

During the period 1960-1966, the following special issues and sections were published:

"Special Section on Systems Engineering and Management," Vol. EM-8, No. 2 (June, 1961).
"Special Section on Services for R, D, and E," Vol. EM-8, No. 3 (September,, 1961).
"Special Section on Evaluation and Training of R & D Personnel," Vol. EM-8, No. 4 (December, 1961).
"Special Section on Information Retrieval and Journal Readings in R,D, and E," Vol. EM-9, No. 2 (June , 1962).
"Special Issue on Project Management and Control," Vol. EM-9, No. 3, (September, 1962).
"Special Section on Project Selection and Budgeting in Research and Development," Vol. EM-9, No. 4 (December, 1962).
"Special Section on Evaluation of R, D, and E Personnel," Vol. EM-10, No. 1 (March, 1963).
"Special Issue--More on Project Management and Control," Vol. EM-10, No. 3 (September, 1963).
"Special Issue on Research on the Management of Research, Development, and Engineering," Vol. EM-11, No. 3 (September, 1964).

B. THE COLLEGE ON RESEARCH AND DEVELOPMENT (COLRAD) of the Institute of Management Sciences continued to sponsor studies of the R & D process in member organizations. The Principal Investigator has been director of studies of COLRAD since its inception. Members of the Northwestern Program have participated in several of the study committees (see Project 10).

Studies undertaken by the College since 1960 include:

1. Survey and Analysis of Project Resource Expenditures: This project is an evolutionary descendent of the COLRAD SCARDE project (1958-63). Its aim is to develop means for the systematic collection of descriptive quantitative data on R & D project experiences in a way that might be useful to a variety of scholarly research efforts.

2. COLRAD Coop Program: This is an attempt to stimulate more thesis work in the area of R & D management in graduate schools of business, engineering, and liberal arts through providing information on opportunities for such research and facilitating field investigations.

COLRAD is sponsoring the program to bring together R & D management problems currently facing industry with graduate students having both time and motivation to investigate these problems, e.g., as theses.

3. Directory of Research on Research Management: This project is a directory of people currently and recently involved in studies of R & D management and other aspects of the R & D process.

The first issue of the Directory lists over 200 individual projects and more than 350 people who are currently or have recently been engaged in them anywhere in the world where we have been able to obtain information.

4. Project Selection and Review: A survey of project selection criteria in actual use by R & D managers.

C. SHORT COURSES AND SEMINARS were conducted by members of the Northwestern Program on various aspects of the R & D process for several groups. Several members of the program participated. Recent programs included:

September, 1966--Swedish Employers Federation and the Swedish Academy of Engineering Sciences (four days).

June, 1965-- The American Society of Metals and the Metallurgical Society of the A.I.M.E. (three days).

June, 1964--Japan Management Association (two weeks).

In addition, a regular graduate course seminar on the organization and economics of R & D is held each spring for research managers from local industry and graduate students in the Program.

D. METHODOLOGY OF FIELD STUDIES OF ORGANIZATIONAL BEHAVIOR. Due to the heavy emphasis on field research in the Organization Theory area of the Industrial Engineering and Management Sciences Department and in the Program, much attention is paid to field study methods and techniques. Continuous experimentation is underway on questions of study design, setting up and maintaining field sites, collecting and reducing data, and providing for replication and further analysis of the data.

Three main facets of the general methodology problem are receiving major attention:

(1) Real time studies are taking the place of or supplementing retrospective studies in several of the projects, e.g., Projects 7, 9, and 10. Some of the reasons for this trend are given in 66/28, listed under Project 10.

(2) Remote studies are being attempted on a large scale in Project 12. On a smaller scale (one site each in Projects 6 and 10), remote studies are being conducted with Northwestern providing the study design, instruments, and data reduction. The actual data collection is being done by members of the organizations being studied. Major reasons for this trend relate to the large amount of time and travel required for field studies. Other

reasons, perhaps more important theoretically and conceptually, are discussed in 64/4 (referenced below).

(3) Field experiments are the core of the research designs in projects 9 and 10.

E. ADVISORY RELATIONS WITH OTHER RELATED GROUPS. Members of Northwestern's "Research Management" Group have served in advisory capacities recently to the Office of Economic and Manpower Studies, National Science Foundation; the Electronic Industries Association; the Highway Research Board of the National Academy of Sciences; The Natural Sciences Department of UNESCO; The Management Technical Committee of AIAA; The Engineering Management, Human Factors and Reliability Groups of IEEE; and The Society for Programmed and Automated Learning.

Publications and Papers:

September 1965-September 1966:

Albert H. Rubenstein and Chadwick J. Haberstroh, eds., Some Theories of Organization, (Homewood, Ill.: Irwin-Dorsey Press, Second Ed., 1966).

66/37 Robert O'Keefe, "Detecting Autistic Bias through Controlled Empirical Inquiry," A working paper, Department of Industrial Engineering and Management Sciences, Northwestern University, October, 1966. L

66/29 Albert H. Rubenstein, "The Role of Implementation in Several Aspects of the Research and Development Process," Presented at the meeting of The Institute of Management Sciences, Philadelphia, Pa., September, 1966. AP

66/14 Gustave J. Rath, "People, Models and R & D Organizations," Department of Industrial Engineering and Management Sciences, Northwestern University, June, 1966.

66/7 Robert O'Keefe, "Toward Interdisciplinary Understanding: Cognitive Consistency as Autistic Bias in Retrospective Self-Respect Measures," A working paper, Department of Industrial Engineering and Management Sciences, Northwestern University, February, 1966. L

66/8 Richard Hannenberg, "Some Propositions and A Model of the Research and Development Activity in Industry from the Viewpoint of Articles in Research Management," A working paper, Department of Industrial Engineering and Management Sciences, Northwestern University, August, 1965 AS

65/40 Five-Year Index, IEEE Transactions on Engineering Management, Cumulative Index--1960-1964. Vol. EM-11, No. 4 (December, 1964). AP

65/34 Albert H. Rubenstein, "Recent Developments in the Field of Research on Research," Prepared for the "Seminar on the Strategy of Corporate Research," Graduate School of Business Administration, University of California, Los Angeles, sponsored by the McKinsey Foundation for Management Research, Inc., October, 1965 AS

1960-1965:

65/27 Albert H. Rubenstein, "The Need for Replication and Cross-Cultural Comparisons in Studies of the Management of Research and Development," Presented at the 12th International Meeting of the Institute of Management Sciences, Vienna, September, 1965. AP

65/23 Albert H. Rubenstein, "Some Common Concepts and Tentative Findings from a Ten-Project Program of Research on R & D Management," in Gordon and Breech, eds., Research Program Effectiveness (1966). AP

64/6 A Directory of Research-on-Research, College of Research and Development, The Institute of Management Sciences, May, 1964. AS

64/4 Albert H. Rubenstein, "Methodological Aspects of In-House Studies of R & D Management," Presented at the Institute of Management Sciences, Pittsburgh, February, 1964. AP

63/13 Albert H. Rubenstein, "The Study Program of COLRAD," IEEE Transactions on Engineering Management, Vol EM-11, No. 3 (September, 1964), pp. 113-115. AP

63/11 Albert H. Rubenstein, "An Overview of Research on the Research and Development Process," Presented at the American Association for the Advancement of Science, Philadelphia, December, 1962. AP

63/7 Albert H. Rubenstein, "A Program of Research on the Management of Research and Development," IEEE Transactions on Engineering Management, Vol. EM-11, No. 3 (September, 1964), pp. 103-112. AP

62/7 Louis C. Goldberg, "A Selected Annotated Bibliography of Empirical Investigations of Research Personnel," IEEE Transactions on Engineering Management, Vol. EM-10, No. 1 (March, 1963), pp. 31-37. AS

THESES AND DISSERTATIONS

1) ABSTRACTS OF COMPLETED THESES AND DISSERTATIONS

2) TITLES OF THESES AND DISSERTATIONS IN PROGRESS SEPTEMBER, 1966

The following new section in our periodic reports is introduced to facilitate communication about unpublished work in our program. Theses and dissertations are typically bulky (some run into several hundred pages) and available only in small quantities due to the high cost of reproducing them. The abstracts given below (taken from the author's more extended abstract) may enable the reader of this report to decide if certain original documents are of interest. In some cases, enough copies of a thesis have been made to give to people who have specific interest in it. In other cases, only a few are available, but they may be borrowed for a period of two weeks. Part of the value of seeing the original document is that versions of a piece of research published in journals are typically abbreviated and the raw data and other parts--such as detailed descriptions of the methodology employed--are frequently omitted.

In addition to these abstracts of completed theses and dissertations, this section also contains a list, by title, of theses and dissertations in process. This may help people who are engaged in related work to get in touch with graduate students in our program while their work is going on and while they are still in residence here. Some dissertations (and an occasional Master's thesis) take several years to complete and information about them is not likely to be publicly available for some time after they are started. This lag also leads to the danger that the title and/or the focus of the study may change over this period.

63/27 Adulbhan, Pakorn, "A Study of the Role of Scientific Research in the Industrial Development of Selected South and Southeast Asia Countries," A Master's Thesis, December, 1963.

This thesis was undertaken to investigate the role of scientific research in the industrial development of selected South and Southeast Asia countries. A primary study of the relationship of industrialization to the development of the developing countries as a whole was briefly made, and the attitudes of the sample countries towards it were presented. Then an attempt was made to why domestic scientific research is necessary for industrial development along with some evidence on the realization of the sample countries of the need for scientific research. The national scientific research objectives of the sample South and Southeast Asia countries, the strategies being used and proposed for organizing their research capabilities, and the management of research activities in their countries were thereafter presented.

A study of the research process was then made for each of the sample countries for the purpose of finding out some of the factors that appear to influence their scientific research pattern. Based on that study, a simple model was developed to show some of the inter-relationships between the economic development pattern, as represented by the scientific manpower engaged in R & D. The results of the study show that the countries that are more industrialized have a larger number of researchers per million inhabitants. However, it was impossible to test the direction of causation between these two varialbes.

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64/8 Altman, Fred D., "Performance Evaluation of Division Managers in Large Decentralized Industrial Organizations," A Master's Thesis, August, 1963.

This study concerned problems associated with the control and evaluation of division managers of decentralized industrial organizations. In order to ascertain what types of control and evaluation systems are being used in these companies and to determine the nature of the problems encountered when establishing and applying these systems, a literature survey of current practice was conducted. The data revealed that there are a number of widely used systems, all of which have some advantages as well as some important disadvantages. The disadvantages range from "lack of objectivity" to "difficulty in weighing of pertinent criteria." It is apparent that none of the systems described adequately answer all of the requirements for simplicity, objectivity, balance,and relation to organizational goals which generally seem to be considered important.

The Organization Theory literature was then examined to see if it could shed any light on this practical problem. Using David Selznick's simplified model of organizational control, a set of interviews was carried out. The interview data indicated the strong bifurcation of interests which develops in the climate of an evaluation system, and further indicated the resultant concentration on activities directed toward satisfactory evaluations but not necessarily directed toward achievement of overall organizational goals. The model was revised by adding the necessary ingredient of "performance evaluation."

It appears that while the revised model has merit as a guide for analysis of division manager evaluation systems in the decentralized organization, considerably more analysis of the factors involved in the model are required if any attempts are to be made to predict specific consequences of a specific evaluation system. It was concluded (1) that in order to minimize the chance of occurrence of unanticipated consequences, the process of selection of specific evaluation criteria must be carefully determined by selection of those criteria most clearly representative of the organizational objectives which top management wishes transmitted down-the-line; and (2) that companies must be flexible enough to be able to adjust evaluation techniques and criteria to account for special circumstances and changing conditions.

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65/4 Baker, Norman R., "The Influence of Several Organizational Factors on the Idea Generation and Submission Behavior of Industrial Researchers and Technicians," A Ph.D. Dissertation, January, 1965.

The objective of this study was to investigate the idea generation and submission behavior or researchers and technicians in one large industrial research and development laboratory--laboratory Y.

Based on a literature search, several propositions were developed. These propositions hypothesized the influence that researchers' and technicians' perceptions of certain factors--time pressures due to current work, intrinsic and extrinsic rewards and costs associated with idea generation and submission, organization goals, objectives, and needs, and interaction with other laboratory personnel--might have on their idea generation and submission behavior.

Data were collected from seventy-two employees, both managers and research staff members, of laboratory Y. Data were obtained by questionnaire, interview, and non-participant observation. A major portion of the data was collected from participants in three separate "idea generation groups" (IGG's). IGG's were conducted by the laboratory for the purpose of generating ideas with respect to a specified objective.

Support was found for the proposition that perceptions of organizational goals, objectives, and needs tend to stimulate ideas perceived to be relevant to these goals, objectives, and needs, and to influence which ideas would be submitted. The proposition that researchers and technicians formed their perceptions of organizational goals, objectives, and needs partially by interaction with other laboratory personnel was supported by the data and the propositions that these were formed by perception of management's behavior with respect to previously submitted ideas received weak support.

In summary, considerable evidence was found in laboratory Y supporting the case that the influence of perceived time pressures due to current work, intrinsic and extrinsic rewards and costs, organizational goals, objectives, and needs and interaction are critical in explaining, understanding, and predicting some important aspects of the idea generation and submission behavior of industrial researchers and technicians.

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63/8 Baker, Norman R., "An Analysis of Several Environmental Factors Affecting Industrial Operations Research-Management Science Activities," A Master's Thesis, March, 1963.

This report is part of a study being carried on at Northwestern University on the life cycle of industrial operations research and management science (OR/MS) groups--a particular type of management advisory service. For this portion of the overall study, the research concentrated on several aspects of the relationship between the OR/MS activity and its "clients" in the company. The group conducting the broader investigation of the OR/MS groups obtained information from a total of 65 firms, via questionnaires and interviews. From this data, 12 interviews with members of industrial OR/MS activities contained information related to this study, and was used as the preliminary data. An examination of this preliminary data revealed that there were several common factors which were brought to light in connection with the environment within which an industrial OR/MS activity operated and suggested that these factors might be related in some orderly fashion. The researcher developed a propositional ordering and defined the variables.

Two case studies were conducted by the researchers, using two companies that had been included in the preliminary data. A data-gathering process was designed and followed. At this point, the researcher was not testing whether or not the continued existence of the OR/MS activity was a function of receptivity, but was assuming that this was a true statement. He was testing whether or not receptivity was a function of exposure, project results, and/or personal relationships, and what forms these relationships might take if they did in fact hold true. In analyzing the data from the two case studies, several propositions became clear. Two project-ordering processes appeared to be acceptable. The analysis of the data did not refute the predictive model, but it did indicate that some form of a time dimension must be added to make the model complete. Three stages were adopted, which offered an efficient framework within which to discuss the implications of the data. The variables of exposure and personal relationships appeared to make their greatest contributions during the introductory phase, while the group was endeavoring to convince the clients that OR/MS could be of beneficial use. During the transitional phase three variables were important. Favorable results from previous projects were important in order to retain the receptive clients developed during the introductory phase, and also for use in persuading other clients to undertake projects. Moreover, exposure and personal relationships continued to contribute to the process of gaining new clients. Favorable results of implemented projects appeared to be the deciding factor in determining whether or not an OR/MS group moved into the maturity phase. The maturity phase might be identified by the presence of a favorable environment. Apparently it was essential for OR/MS to demonstrate favorable projects results before the environment became stabilized. The importance of exposure and personal relationships was secondary or possibly even nonexistent by this time.

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65/25 Bolen, Frank M., "A Technique for the Real Time Measurement of the Flow of Ideas in Industrial Laboratories," A Master's Thesis, August, 1963.

This is a report of one phase of a three-year study, supported by a National Science Foundation grant, concerning idea flow and project selection in industrial research and development functions. While this particular study concentrated on three aspects of the "Idea Flow" process, the research for this paper particularly concentrated on the "idea originator." The research tried to answer this question: "How can ideasbe identified and how can their development (from the idea originator's view point) be effectively measured in real time in real organizations?" Two instruments were designed and tested in trying to answer this question.

The first tool used was the Idea Inventory (II) questionnaire. Four variations were tested in an effort to ascertain the most form in relation to the type of information sought. The second tool, the Time Series Instrument (TSI) was designed for use after the ideas had been identified by the II. The TSI was designed for use in sampling ideas in real time, subsequently providing data concerning the idea's actual development within the company. Seven different methods of administering the TSI were developed and tested in field work. It was hoped that the TSI would eliminate the serious problems of insufficient recall, encountered in earlier studies, on the part of the respondents. The conclusion was reached that methods a and e are the most acceptable overall administration methods. They are: (a) Face-to-Face, non-interview method, where the administrator is merely present as the respondent completes the TSI; and (e) Independent completion--form delivered and returned by mail--where the administrator is never present.

The researcher has assumed that the results of the pilot administrations of both the II and TSI questionnaire are generalizable to other research and development laboratories. He has accordingly devised a detailed set of instructions for synthesizing the Idea Inventory and the Time Series Instrument questionnaires into a use instrument package for identifying and tracing the development of ideas.

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63/26 Goldberg, Louis C., "Dimensions in the Evaluation of Technical Ideas in an Industrial Research Laboratory," A Master's Thesis, August, 1963.

The chief purpose of this study was the investigation of the kinds of criteria which the personnel of one research and development laboratory emphasized in their evaluation of technical ideas. It was assumed that these criteria were projective indicators of broader role orientations. The general hypothesis that there was both a professional-scientific as well as an organizational factor in the evaluation of a technical idea was examined via the use of a factor analysis. Two orthogonal dimensions were, in fact, delineated as the best solution to the factor problem. It was argued that one dimension was a professional-scientific factor while the other was an organizational factor. The theoretical implications of (1) the orthogonality property, and (2) the high loading on the professional factor of the items concerned with recognition from superiors were discussed.

In examining the relationship between the emphasis placed on professional and organizational criteria and other variables, comparisons were first made across organizational functions, ranks, and technical specialization. The major finding of this analysis was the substantially greater emphasis which the professionals placed on the professional factor than the managers. Moreover, when a discrepancy score was computed by subtracting a person's score on the professional factor from his score on the organizational one, it was found that managers had a quite different modal orientation than professional. While managers showed a very polarized orientation--considering organizational considerations very dominant--professionals tended to have a mixed orientation--giving both professional and organizational criteria equal weight.

Finally, it was noted that managers as a group had been in the organization a considerably longer time than had the professionals. This suggested that a person's work perspective, as characterized by his factor scores, might be related to his organizational age. The correlational analysis which was carried out found that this was the case: (1) the emphasis placed on the professional factor was negatively related to organizational age, while (2) the tendency to consider organizational considerations more important than professional ones is positively related to organizational age.

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64/18 Heiman, David R., "A Procedure for Predicting the Potential Success or Failure of an OR/MS Activity," A Master's Thesis, May, 1964.

This thesis is a continuation of the Life Cycle Study of industrial operations research/management science groups. The importance of the "implementation phase" of an operations research activity is analyzed and a model is proposed for this phase. In addition, criteria for the success of operations research/management science groups are proposed and combined with the "implementation phase model" to form a predictor. The model and the success criteria were then evaluated through brief case studies of eight industrial OR/MS groups and depth studies of two other groups.

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66/22 Lapp, Charles J., "An Empirical Study of Some Relationships Between Technological Innovations and Organizational Characteristics in Eight Railroads," A Master's Thesis, August, 1966.

The author of this paper has attempted to bridge the gap between the environment in which railway organizations operate and characterisitcs of eight railway organizations. This paper consists of two parts: the first is a descriptive study of the development of the principal railroad organizational structure in use in the United States, of problems caused by this type of organizational structure, and of some of the consequences of interactions between railroad organizations and the American economy. Part I concludes with a review of some of the governmental hurdles which must be cleared before a railway may innovate.

Part II is an empirical study of eight railway organizations which investigates relationships between organization factors such as age and education of their members, type of staff groups, and which attempts to relate these to innovation or adoption of new technology by that organization.

Positive correlations were found between average number of years of higher education and innovation or imitation (7.7), and between percent of personnel who graduated from college and innovation or imitation by the organization (8.6). A correlation of .64 exists between age of organization management personnel and innovation or imitation by the organization. It was found that except in traffic research the majority of the eight railroads do not generally engage in research and development in the projects studied. Only one of the railroads maintains a policy of firing personnel; the same carrier was a leader in innovation.

Based upon the eight railroads studied, characteristics of an innovative railroad organzation would include a relatively young, educated management who use consultants, engage in research and development work, and lack an overwhelming feeling of "tenure." The characteristics of a non-innovative railroad organization, on the other hand, would include an older, less educated manager who make little or no use of consultants, maintain no research and development work, and perhaps, value more complete job security.

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65/15 Martin, Robert B. "Structural Development of an Industrial Research and Development Laboratory," A Master's Thesis, August, 1966.

This paper examines 7½ years of change in the formal structure of a large industrial research and development laboratory, relating structural change to the task of the groups involved in the change. The prediction that research groups would tend to be smaller than development groups was strongly supported by one measure of group size but not supported by another measure. The prediction that new development units were more likely to be formed by the transfer of personnel from existing development units than were new research units, was also supported. Other measures of structural change were related in varying degrees to the group task.

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65/38 McCarthy, Dennis J. "The Response Behavior of Firms Confronted by Market Crises," A Master's Thesis, June, 1965.

This study has attempted to investigate the reactions of the firm, in terms of R and D behavior, to changes in the market place. Four firms in a highly competitive oligopolistic industry were chosen as the subjects of this study. A total of 57 product innovations, which were introduced into the products of the Industry during the period 1952-1962, were considered as potential "crisis" events. It was determined which of the product innovations were perceived by the firms as crisis events. The respondents were then asked to describe the behavior of their firm following the introduction of each crisis event. This allowed the author to construct relationships between the product innovations percieved as crisis events and the subsequent reactions of the firms, which consisted of a response event or set of events. Propositions had been previously formulated to reflect the expected pattern of innovative behavior of these firms. The data described above was analyzed to determine whether to accept or reject the propositions, or to consider the results inconclusive. The crisis-response relations were further analyzed, and it was determined that a number of the firms appeared to exhibit regular response behavior patterns, such as the following:

1. None of the subject firms displayed a behavior pattern which was independent of the other firms in the industry. All of the respondents indicated a definite awareness of the innovative behavior of the other firms in the industry.

2. All of the firms in the industry exhibited a response behavior. That is, every firm perceived at least one of the 57 products innovations as a crisis event and introduced a response event. Furthermore, the respondents reported that the response events that were introduced with the primary objective of counteracting or removing the perceived (potential or actual) threat to the market position of their firms.

3. Each product innovation was evaluated by each of the firms. The firms evaluated some variable (or combination of variables) similar to market impact to determine whether a product innovation constituted a crisis event, and based on this evaluation a decision was made whether to introduce a response event.

4. A large percentage of the product innovations introduced by a firm result from the competitive situation. Although the origin of the product innovation was not specifically investigated in this study, the data indicate that most of the firms in the sample will tend to introduce fewer innovations as a natural result of its on-going research that it will in specific response to crisis events.

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64/21 McMaster, Samuel B. "Study of Project Selection Techniques in and R & D Organization," A Master's Thesis, June, 1964.

It was the purpose of this thesis to study the project selection process in a small R & D organization. The first part of the thesis is concerned with (1) a historical reconstruction of the decision-making processes as they existed during the time period covered by the study and (2) the presentation of project case histories. All discussions relate to the end of the period through December, 1961. It is concluded that the decision making process for project selection is not formalized by criteria and formulae but is of a more random nature.

The second portion of the thesis presents abstracts of articles on the subject of project selection techniques which have been accumulated from the available literature. The articles concern various approaches to formalizing the decision making process utilizing mathematical models, such as linear programming, statistical analysis, matrix algebra, and discounted cash flow, as well as simple numerical ranking systems.

Part III is concerned with the detailed application of several project selection models chosen from the literature reviewed in Part II. Several models from the literature reviewed in Part II were selected for detailed application to the Company R & D situation under study. Each model was discussed with emphasis placed on the type of model, the data required, and the accuracy of the data. After establishing a frame of reference for the Company for a given period in the past, the existing projects at that time were tabulated, and finally the data was applied to each model. The R & D programs derived from each model were discussed and compared. The usefulness of each model was reviewed. The numerical rating model was not an economical approach whereas the "product value" model did utilize an economic analysis. The recommendation was made that this latter model be considered as a decision making tool for the Company in its project selection process.

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64/9 Murphy, Edward C. "Some Relationships Between R & D Organizational Change and Company Growth Rate in the Electronics - Aerospace Industry," A Master's Thesis, October, 1963.

This study has attempted to show some of the relationships that exist between R&D Organizational change and company growth rate. Rather than trying to show causal relationships between these factors, the study has taken the approach of trying to show how firms differ with respect to them.

Various constraints on R&D effort and results, such as: the R&D structure within the firm; type of business; financial resources; and others are discussed in the thesis. These different characteristics of the firm were compared with the particular type of R&D changes that the sample companies made. The study shows certain relationships between company characteristics and R&D change quite clearly. It is evident, for example, that the small firms depend on acquisition and merger for development of technical skills much more than the larger firms. Secondly, it is shown that a greater percentage of large firms (both commercial and government oriented) make changes to consolidate their R&D than the smaller firms. Considering these relationships involving acquisition, extent of R&D consolidation and size of business, certain patterns of growth evolved from the data. As soon as a firm finds it expedient either to acquire a company or merge with another firm, the policy of decentraization seems to emerge. When acquisition occurs, the management of most acquired firms remains intact and continues to operate the business as a division or subsidiary. The data shows further that as the companies grow and less acquisitions or mergers occur, there tends to be a greater desire for central research facilities. As acquisition decreases, between the small and large firms, there tends to be an increase in R&D consolidation changes.

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63/15 Pantin, Mario D. "A Study of the Role of Scientific Research in the Growth and Development of the Latin American Countries," A Master's Thesis, October, 1963.

This thesis was undertaken to investigate the role of scientific research in the development and growth of the Latin American countries. A preliminary study of the role of technological changes and of the scientific research process was made. Based on this study, a simple model was developed to show some of the interrelationships between the economic development pattern and the scientific research activities. Some aspects of the model were isolated and working hypotheses were formulated and tested, using the information collected concerning research in most of the Latin American countries.

The results of the study show that the countries that are more industrialized have a larger number of research scientists per million inhabitants. It was not possible to test the direction of causation between these two variables, but some evidence was found to show that the rate of industrialization affects the patterns of scientific research activities.

The results also show that the governments of the less developed countries play a relatively larger role in maintaining a scientific research capability. Finally, it was found that the countries that are more industrialized have a relatively larger number of scientists conducting research in areas not related to agriculture.

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65/12 Pound, William H. "Communications, Evaluations, and the Flow of Ideas in an Industrial Research and Development Laboratory," A Ph.D. Dissertation, June, 1966.

This paper represents an attempt to describe and to explain partially a process called "idea flow." This process, which operates in research and development laboratories, consists of the development, communication, and evaluation of specific, identifiable ideas. The process begins with the origination of a specific idea by a member of a laboratory, and "ends" with the acceptance or rejection of the idea by someone in the laboratory or parent organization with authority to make such disposition decisions.

Idea evaluations are made at all levels in the laboratory, primarily on organizationally oriented criteria, e.g.: "provide a net profit to the company," or "be compatible with current company prodect lines and methods of operation." Personally oriented criteria received little emphasis (items such as, "pertain to my personal interests" or "maintain my professional reputation outside the labroatory"). There was a markedly decreasing pattern of agreement on criteria going down successive levels of the laboratory hierarchy.

The most interesting explanatory results show the following: (1) that an accurate perception of the objectives and evaluation criteria of a laboratory is an important stimulus to the production of ideas; (2) that there is a significantly important relationship between perceived idea relevance and an individual's decision to communicate a particular idea. Communication decisions cannot be entirely explained on this basis, however; (3) that there is strong support, as would be expected, for a relationship between perceived idea relevance and disposition decisions (acceptance, rejection, or no action). No relationship was found between "originator's agreement on criteria with reviewers," and the likelihood of the originator's ideas being accepted or rejected. Finally, (4) that the two results in (3) appear to imply that ideas considered good (or bad) by their originators will also tend to be judged good (or bad) by reviewers, though for somewhat different reasons.

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64/10 Radnor Michael, "The Control of Research and Development by Top Managers of Large Decentralized Companies," A Ph.D Dissertation, August, 1964.

Top Managerial Control of R and D Activities: A theoretical analysis was made of top managerial perceptions of their R and D control situation, the factors leading to such perceptions, and the form of the control responses that might be evoked. In this analysis the R and D area was described as being one which had low visibility for most top managers. It was theorized that the formation of semi-autonomous sub-units would lead to conditions in which many top managers would perceive the existence of goal, attitude and ability differences between themselves and both their division managers and their corporate research directors.

The responses available to the top manager were concerned with the design or redesign and the direct control of the organizational system, the alteration of visibility levels, and goal changes. These were described in a control model. The form of the control response was said to be determined by the following set of conditions as perceived by the top Manager:

CBRS = F (FNC.PACS.PLOV)

where, for the top manager in relation to R and D activities:

CBRS represents the control behavior response system.
PNC represents the perceived need to control the system.
PACS represents the perceived ability to control the system.
PLOV represents the perceived level of visibility of the behavior and performance of the system.

Three modes of control were categorized as being availabe to the top managers. These were direct compliance demands, the structuring of the R and D decision situation and the regulation of the decision premises of the R and D decision makers.

Data was obtained in top managerial attitudes and perceptions concerning R and D control problems and on their control behaviors. The executives also supplied a series of ratings, through a Q-sort procedure, for each division and central laboratory in their companies, relevant to the measurement of the PNC, PACS and PLOV variables as above. Other supporting data were obtained from published and unpublished documents and from previous interviews at the companies. This data was used to investigate the top managerial perceptions concerning the R and D control environment, the forms of their responses, and to provide, at the sub-unit level, a partial test of the control-response theory.

Support was found to validate the description of top managerial perceptions of their R and D control situation. Strong predictive associations were demonstrated between top managerial perceptions of their control situation and the type of control response they made.

Most top managers reported using compliance demands on division managers. Examples were: giving direct instructions, making performance in R and D a part of evaluation criteria, calling for reports on R and D activities, and utilizing corporate research managers to audit divisional R and D. Use of direct compliance demands on corporate research managers was found to be less prevalent.

Examples were noted of attempts to structure R and D decision situations. An example was that of allowing division managers to use corporate funds on favorable terms to finance longer range or larger R and D programs that they would not normally undertake.

Use of "premise regulation" was found to be prevalent at the divisional level. Specifically, most companies had utilized educational programs to change the thinking of their division managers on R and D. Many had added "new blood" to division manager staffs. The use of premise regulation over corporate research managers was also prevalent. In cases where there had been deliberate changes in corporate research managers, there was a tendency to replace them with commerically oriented men.

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65/10 Utterback, James M. "Accuracy of Perception and Enculturation of Researchers in an Industrial Laboratory," A Master's Thesis, August, 1965.

This study involves an attempt to predict the kinds of ideas for research and development projects which will be accepted by an organization. Several questions are of interest in the study: For given ideas, does the "organization" use different criteria of evaluation than do individuals in the organization? If such differences exist, what possible variables might explain them? Finally, what effect could such differences in criteria and other variables have on idea generation and submission behavior in industrial laboratories?

Two variables related to the criteria of judgment used by researchers and by persons influential in the selection of ideas for projects are defined. These are accuracy of perception and enculturation. Relationships are hypothesized between these variables and the number of ideas submitted to the organization by an idea originator, the number of these ideas selected for research projects, and the scope of ideas selected for projects. In addition, the possible influences on the above variables of originators' educational level, career aspirations, organizational age, and position are discussed.

A field study, carried out in a small specialty products company, is reported. This study of the variables mentioned above and possible relationships between them is exploratory in nature. It is subject to a number of limitations, including a small number (20) of respondents, which are discussed in the text. An "index of order association" is used to compute relationships between observations of different variables. No statistically significant support was found for the proposed relationships between accuracy of perception and enculturation and number or scope of ideas selected. Positive and statistically significant (.01 level) relationships are reported between organizational position and organizational age. Accuracy of perception and enculturation are positively and and significantly related to organizational age and position in the specific organization studied. Positive and significant relationships between organizational position and number and scope of ideas selected are discussed. Finally, it is interesting to note that in the organization studied, persons who had a greater number of their ideas selected also had a greater proportion of ideas of broad scope with respect to the number of their ideas selected than did persons having fewer ideas selected. The need for further study of the questions mentioned earlier with larger sample sizes and over a period of time is discusses as a useful extension of this research.

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65/35 Werner, David J. "A Study of the Information-Seeking Behavior of Medical Researchers," A Master's Thesis, December, 1965.

This paper is concerned with one aspect of the interaction of the researcher and his information-environment-- information-seeking behavior. This project consisted of an experimental study of the information-seeking behavior of a small group of medical researchers. The data-gathering technique consisted of a variation of the "diary" method. The participants recorded information-seeking activity by using a telephone-tape recorder system developed for this project. This technique was suppliemented by diary cards which permitted the subject to indicate the path of a search by a series of check marks.

The experimental feature consisted of the introduction of a new information service which previously was not available to the subjects and the attempt to determine the effects of the service upon their information-seeking behavior.

This introduction of a new information service from the real world environment to determine its effect upon the subject's behavior is termed an "operational experiment."

The principal findings of this study are:

1. Most searches appear to be of a limited scope as opposed to a broad "literature search."
2. The type of information needed determines the type of searching behavior.
3. Information needs appear to vary with the phase of the research project.
4. The introduction of a professional information specialist as a personal service for a period of three weeks appears to affect only the searching behavior oriented toward exhaustive searches. That is, the specialist was requested to do "literature searches" rather than to obtain information on a specific problem.

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66/5 Young, Earl "An Analysis of Selected Strategies for Organizing Research and Development in Developing Countries with Reference to Policy and Planning Techniques, International Relations, Manpower and Training, and Information Requirements," A Master's Thesis, February, 1966.

This thesis is an exploration of the set of problems confronting the developing countries in their attempts to build a scientific and technological capability. The analysis is made in terms of a general flow model similar to the one used in the Program of Research on the Management of Research at Northwestern University. The major topics explored include science policy, research planning in relation to economic planning, international scientific relations, manpower and training problems, and the flow of scientific information.

Scientific objectives collected from policy statements have been classified to determine the nature of scientific goals in these countries. Strategies for establishing reserved capabilities at the international, regional, and national level have been identified in order to determine the means used to obtain these goals and to describe selected R and D patterns which appear to be emerging. Finally, several statements that can be operationalized as testable propositions have been collected and classified. Major trends noted and analyzed include: the major role played by the national government in establishing and controlling scientific activities; the growing importance of international relations; the widespread and strong orientation to economic development projects; and the almost universal desire to establish an indigenous scientific capability.

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Subjects of Theses and Dissertations in Progress

September, 1966

Batchelor, William	M.S.	An investigation of the effect of personal esteem, measured by communication patterns, on an individual's perception of specific characteristics of other work group members.
Bean, Alden	M.S.	A study of operations research/management science personnel.
Bonge, John W.	Ph.D.	Organizational response to major change.
Douds, Charles F.	Ph.D.	Study of R & D group interfaces and liason relations.
Graham, James	Ph.D.	Operations research/management science in small business organizations relative to use of computer systems.
Hannenberg, Richard C.	Ph.D.	Structural and interpersonal factors in the project selection and idea flow processes.
Kegan, Daniel L.	M.S.	Researchers uses of technical information.
Larson, Jon A.	M.S.	A behavioral and economic study of R & D management's project selection process.
Martin, Robert B.	Ph.D.	A study of the factors influencing businessmen's decisions on changes to the production process.
McColly, John B.	Ph.D.	Responses to crises in two consumer products industries.
Moor, William C.	Ph.D.	The medical researcher's environment as it pertains to information searching behavior.
Thompson, Charles W.	Ph.D.	A study of selected methodological requisites in field research.
Werner, David J.	Ph.D.	Study of information-seeking behavior of medical researchers.
Young, Clifton	M.S.	The interface between research and marketing.
Young, Earl C.	Ph.D.	A comparative analysis of the development of an R & D capability in selected developing countries.