PROGRAM OF RESEARCH ON THE MANAGEMENT

OF RESEARCH AND DEVELOPMENT

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The Technological Institute
Northwestern University
Evanston, Illinois

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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-G 24442), The Office of Naval Research (NR 047-052), The Department of Defense (N00014-66-C0020-A01), The Public Health Service (LM 00098-01), The Ford Foundation (through Northwestern's Council on Intersocietal Studies), and internal fellowship and research funds. Papers and publications completed since the September 1966 Annual Report are given by individual project, and personnel associated with the program since September 1966 are listed.

The project titles are consistent with the listing in the 1966 Annual Report, except for items 13-15. 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. ENVIRONMENTAL AND MANAGEMENT FACTORS INFLUENCING THE PERFORMANCE OF RESEARCH AND DEVELOPMENT GROUPS
13. METHODOLOGY OF RESEARCH ON RESEARCH
14. OTHER RELATED ACTIVITIES
15. THESES AND DISSERTATIONS

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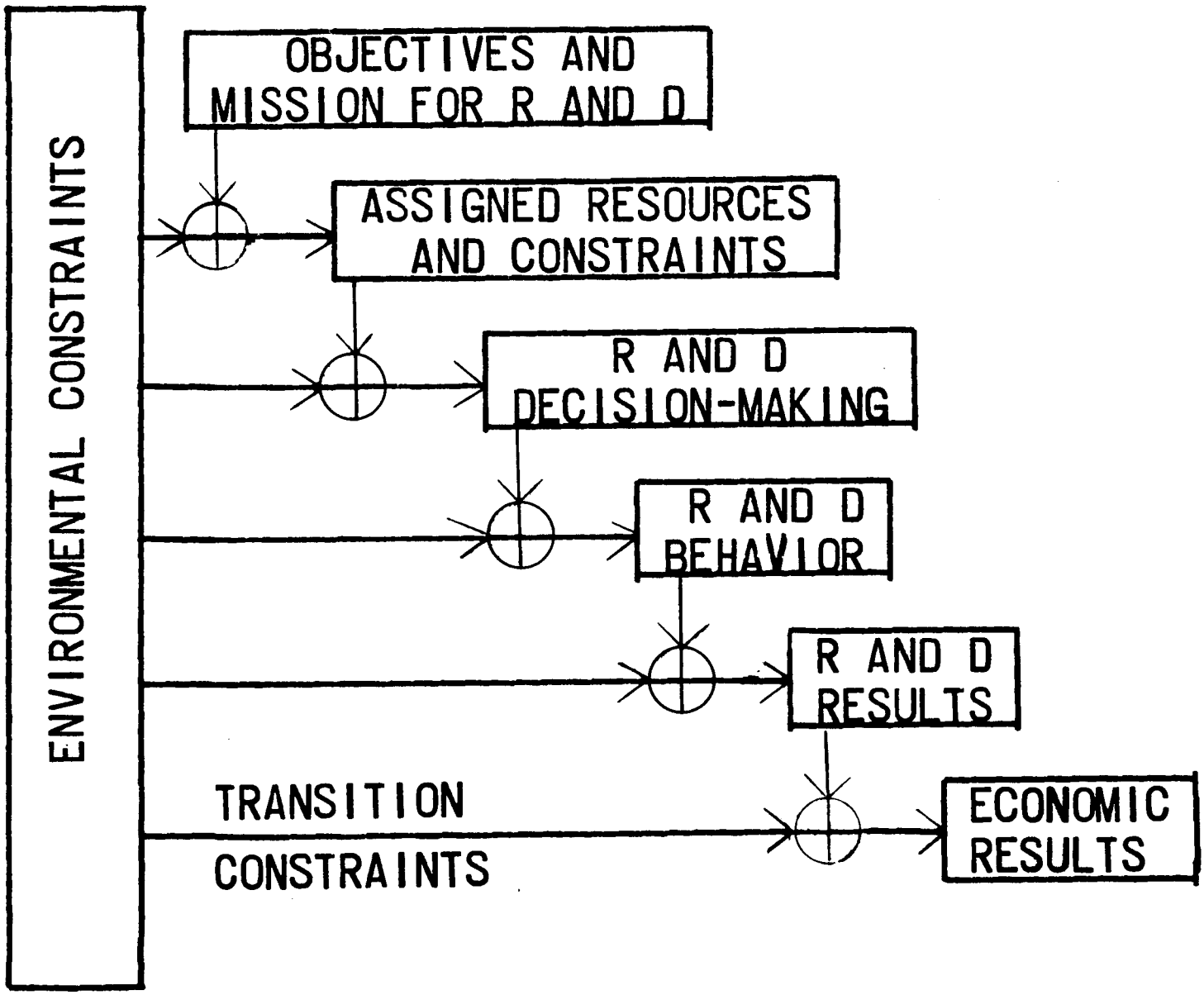
Note: Publications and Working Papers for the period September 1966-September 1967 are listed under each project. The number preceding the listing (e.g. 65/4) is our document number. The degree of availability of each item is indicated by the following code:

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 theses and dissertations completed in 1966-67 are given in the last section of this report.

A SCHEMATIC DIAGRAM OF THE R AND D PROCESS IN THE FIRM



INTRODUCTION BY THE PRINCIPAL INVESTIGATOR

The Program of Research on the Management of Research and Development enters its eighth year at Northwestern with the largest number of faculty and graduate students in its history. This includes the period 1955-1959 at M.I.T. and 1950-1953 at Columbia University. Although it is still based in the Organization Theory area of the Department of Industrial Engineering and Management Sciences, participation by people from other areas in the department and other departments in the university has increased and continues to do so.

As indicated in the description of our program on the next page, the projects and people in the program are highly integrated. The academic base of the program involves a high degree of individual choice among the various projects or sub-programs. Hence, some projects were heavily manned during the past year, while others waited for interested graduate students or faculty members to pursue them.

The most active projects during the past year, in terms of number of people involved and amount of field research activity were: OR/MS (No. 7), Liaison (No. 8), Info Search (No. 9), and Project Selection (No. 10). Field work has been terminated and the major activities have been data analysis and write-up on: Idea Flow (No. 1), Decentralization (No. 2), Achievements (No. 5), Skills (No. 6), and HINDSIGHT (No. 12). A modest level of effort was carried on in Developing Countries (No. 3) and Crisis (No. 4). Key Problems (No. 11) is cooking on the back burner and springs to life occasionally, even though a "final" report has been issued on it. Finally, a new project area has been separated out for increased attention, under the heading of Methodology of Research on Research (No. 13).

Several new sources of financial support in the past two years have enabled us to increase the size of the total group involved in the Program. All members (excluding secretaries) are primarily students or teachers (all faculty members in the program carry full teaching loads). The number of full-time graduate students associated with the Program increased from 10 in academic year 1965-6 to 13 in 1966-7, and 23 in 1967-8. In addition, a number of other graduate students (some not in residence) were associated with the program for summers or through dissertations being completed on a part-time basis.

Albert H. Rubenstein

Professor of Industrial Engineering
and Management Sciences

September 1967

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 the 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, law, psychology, political science, anthropology, 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 are: 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, 1967) seven theses and dissertations, as well as a number of non-thesis staff studies; the Technical Achievements study which has produced, since 1958, three distinct published staff studies preliminary to the one now being completed; and the Project Selection study which has involved five theses and dissertations since 1957 and several staff studies.

PERSONNEL ASSOCIATED WITH THE PROGRAM - SEPTEMBER 1966-SEPTEMBER 1967

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
Charles W. N. Thompson, Research Engineer in Industrial Engineering and Management Sciences and Lecturer in Business Administration

Consultants

Robert W. Avery, Associate Professor of Sociology, University of Pittsburgh
Norman R. Baker, Assistant Professor of Industrial Engineering, Purdue University
Dawson E. Brewer, Assistant Professor of Business Administration, University of California, Berkeley (at Northwestern for 1967-68).
Richard C. Hannenberg, Assistant Professor of Business Administration, University of Wisconsin (Milwaukee).
Jack Siegman, Associate Professor of Sociology, University of Nebraska
Richard W. Trueswell, Associate Professor of Industrial Engineering, University of Massachusetts

Research Assistants

Alden Bean[4]
Kevin Croke[1]
Daniel Kegan[3]
Steven Kennedy[3]
Kenneth Kosnik[3]
Jon A. Larson[3]
Robert B. Martin[4]
William C. Moor[3]
Kent Peterson[2]
David Tansik[1]
David J. Werner[3]
Michael White[1]
Earl C. Young[4]

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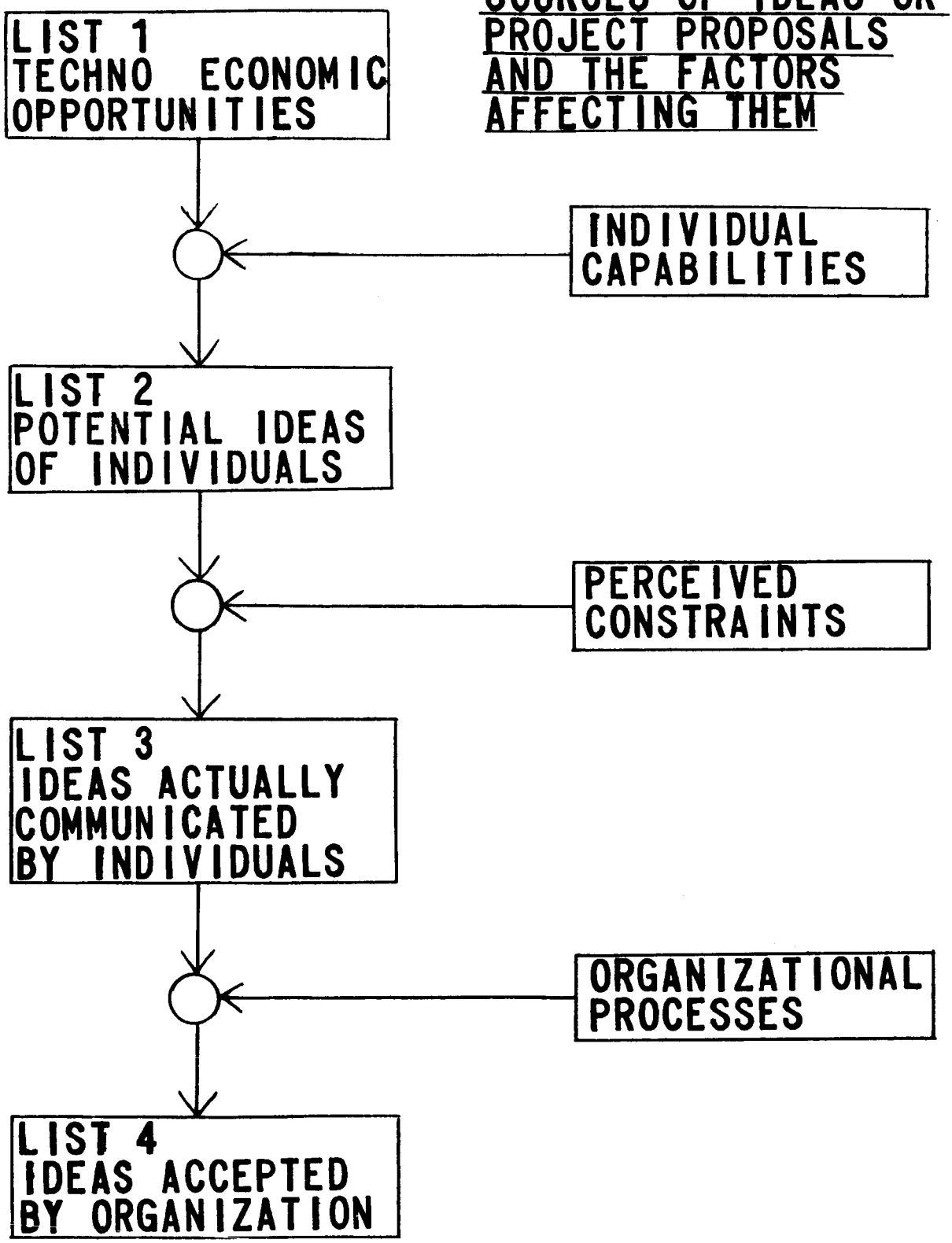
1. Summer Assistant only
2. Assistant during Academic Year only
3. Assistant during Summer and Academic Year
4. Assistant during Summer and fellow during Academic Year

Other Associated Graduate Students

William Batchelor (Owens Corning Fiberglass)
John W. Bonge (Michigan State)
Charles F. Douds
Ralph J. Lewis (University of California, Irvine)
John McColly (Esso R & D)
Robert Mills
Robert O'Keefe
Clifton C. Young

A FLOW MODEL OF THE SOURCES OF IDEAS OR PROJECT PROPOSALS AND THE FACTORS AFFECTING THEM



1. IDEA FLOW IN RESEARCH AND DEVELOPMENT

Objective: These studies grew out of the decentralization project (No. 2). Their focus was almost entirely within the laboratory itself, in some cases encompassing the company's entire R and D effort. The objective of these studies was to describe and, hopefully, make useful predictions about the way in which technical ideas for new R and 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, direct observation.

The general research questions focused on 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 disposition of ideas.

Supported By: National Science Foundation and National Aeronautics and Space Administration.

Project Leader: Jack Siegman

Progress September 1966-September 1967: 1) Continuation of Project Selection studies (No. 10) directly stemming from research and findings in the Idea Flow studies. Major emphasis here is on those factors affecting the disposition of ideas for projects. 2) Field work continued in two major sites. 3) One Ph.D. dissertation and two M. S. theses in progress which will utilize some of the field data collected over the past 4-5 years. 4) Two papers submitted for publication. 5) Continuation of writing research reports and articles for professional publications based on data collected in idea flow studies. These include work tentatively entitled: 1) "Communication, Interaction and the Formation of Status Hierarchies in Groups of Scientists;" 2) "Use of Criteria in the Submission and Evaluation of Ideas by Researchers and Managers in R and D Laboratories;" 3) "The Enculturation of Scientists in a Small R and D Laboratory" and, 4) "Idea Disposition, Subjective Evaluation, Urgency, Predictability and Time Horizons."

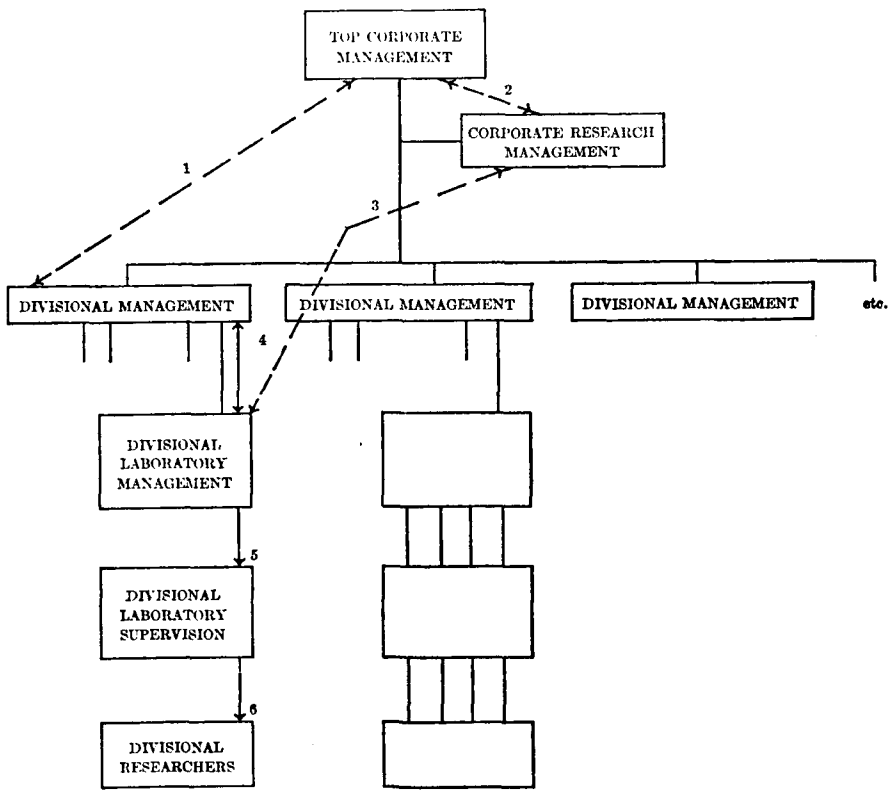
2. CONTROL OF RESEARCH AND DEVELOPMENT IN DECENTRALIZED ORGANIZATIONS

Objective: This is a long-term study of the characteristics and behavior of decentralized organizations as they affect the input 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 1966-September 1967: Work is continuing on the preparation of the final research report of the findings of this study. This will include theoretical material as well as selected case studies, illustrating the theoretical background.



Critical junction points for influencing R & D decision-making in the decentralized company, where R & D is deployed in a decentralized or combination pattern.

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: Ford Foundation, through The Council on Intersocietal Studies at Northwestern University.

Project Leader: Albert H. Rubenstein

Progress September 1966-September 1967: Theory development and proposition construction were the main focus of activity during the year, preparing the ground for renewed efforts in data collection by mail and field study. A second field visit to Mexico was initiated during the summer of 1967, as well as an initial, brief series of interviews in Peru, with people in industrial and government R and D organizations. A new grant was received from Northwestern's Council for Intersocietal Studies for the support of several graduate research assistants for the coming year. As of September 1967, five new graduate students interested in this project were in residence. Earl Young, associated with the project for several years, was in the field collecting data for completion of his dissertation on the sources of new technology for the industrial sector in newly developing countries. Plans for the coming year include greatly intensified collection of data on the size, composition, growth rate, missions, portfolios, sources of support and various other factors describing the actual R and D institutes or laboratories in the sample countries (over 60 in Asia, Latin America, Africa, and the Mediterranean).

Publications and Papers September 1966-September 1967:

67/60 Albert H. Rubenstein and Earl C. Young, "Strategies for Organization and Diffusion of Research in Developing Countries." Presented at the International Meeting of The Institute of Management Sciences, Mexico City, August 1967.

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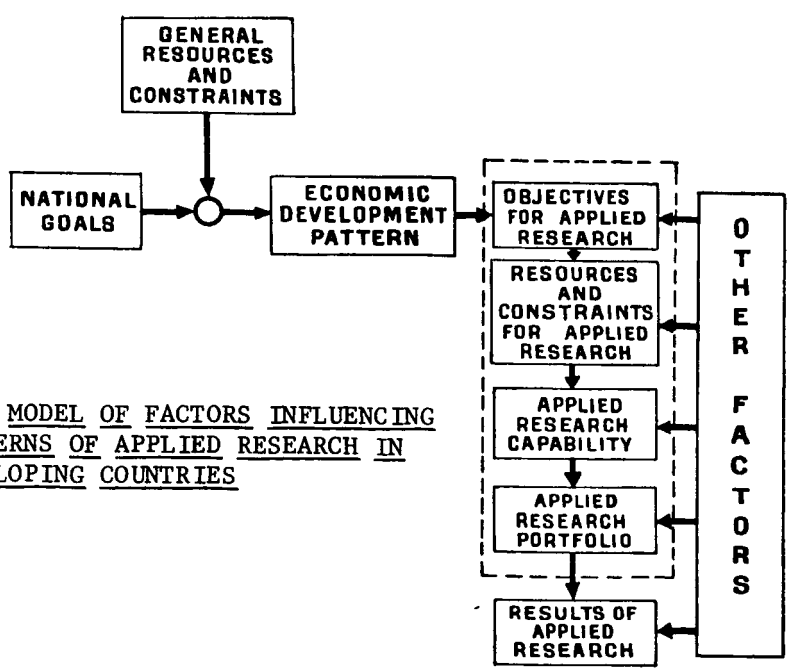


FLOW MODEL OF FACTORS INFLUENCING PATTERNS OF APPLIED RESEARCH IN DEVELOPING COUNTRIES

4. R AND D RESPONSES TO CRISES

Objective: We are interested in the reactions of the firm, in terms of R and D behavior, to changes in the marketplace, 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 1966-September 1967: The "crisis" project is an example of an area in the program which has not been highly organized or staffed or programmed. The original idea for this series of related, but independent studies arose directly from some theoretical notions in the organization theory literature about how organizations respond to threats or crises in their market environment. Since our primary focus has been on the R and D function in the firm, the three studies so far in this series (McCarthy 66/38, Lapp 66/22 and McColly 67/15), have concentrated on those events in the marketplace which concerned new or improved products or other events with direct implications for R and D. McColly's results (see the abstract of his dissertation in the last section of this report) suggest the need for deeper probes into the blow-by-blow details of the decision process involved in responding to crisis events. This, in turn, strongly suggests the need for conducting such studies in real organizational time, while the events are occurring. This need has been encountered in several of our projects or sub-programs where perceptions, attitudes, and decisions are difficult to reconstruct in retrospective studies. His thesis employed a relatively new statistical approach - discriminant analysis - in attempting to conduct a multi-variate analysis of his results. This contrasts with the two-variable propositional approach which has been characteristic of many of our studies-- e.g., Idea Flow, Decentralization, and Liaison-Interface. The use of this technique in McColly's and Martin's dissertation (67/29 -- Project No. 8) was promising enough to suggest increased use of it in future studies, as an aid in developing and testing models and theory-segments of organizational behavior.

Publications and Papers, September 1966-September 1967:

67/15 John B. McColly, "An Investigation of Factors Affecting the Perceived Impact of Marketplace Events upon Decision Makers," A Ph.D. dissertation, Department of Industrial Engineering and Management Sciences, Northwestern University, June 1967.

AS

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

Objective: The objective is to attempt to relate the incidence of R and 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 1966-September 1967: Data reduction and analysis continued at a slow pace during the year, awaiting resolution of some problems of evaluation and weighting of the "achievement" events which constitute the raw data of the study. A final report is anticipated during the coming year.

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.

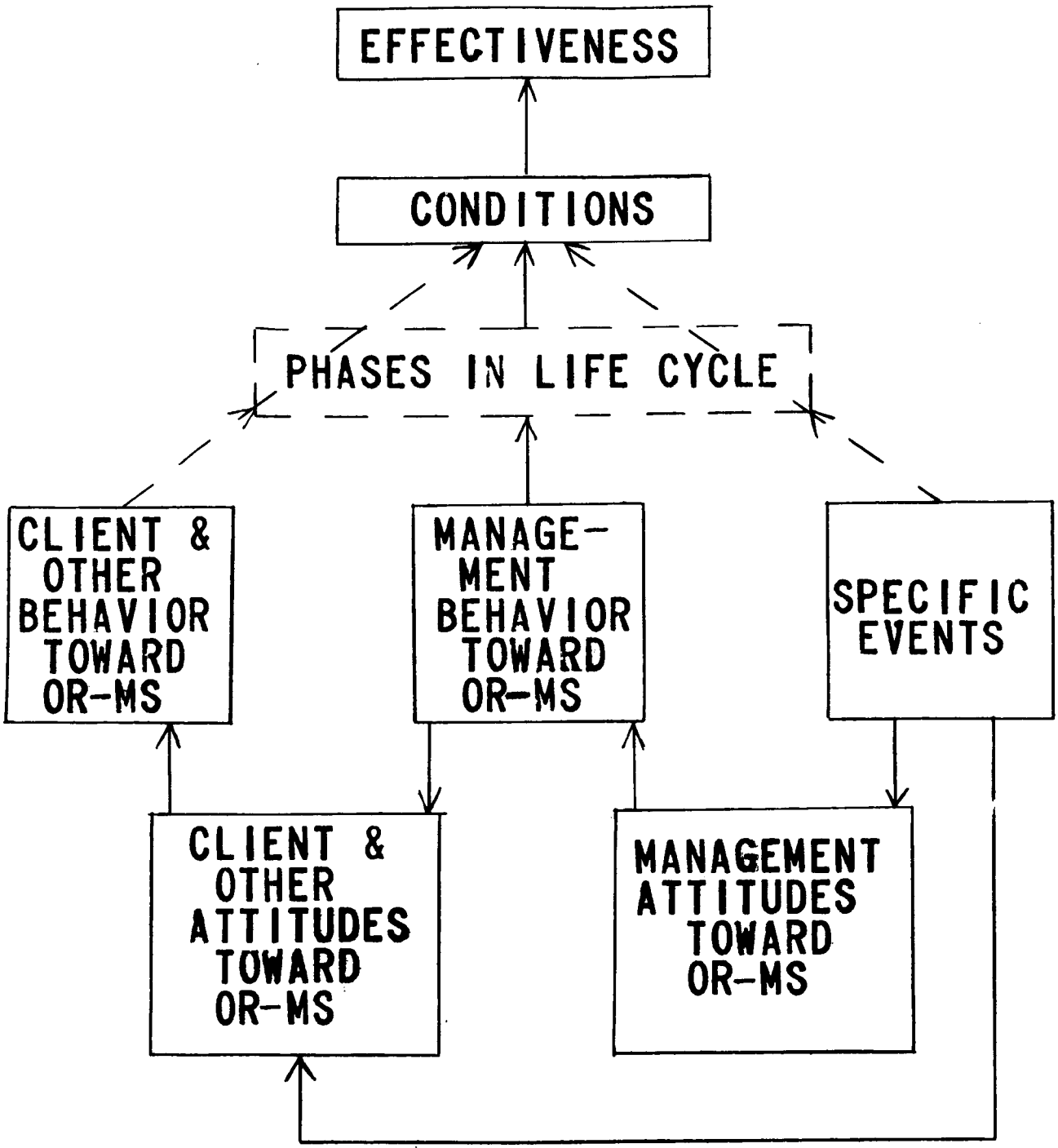
Project Leader: Gustave J. Rath.

Progress September 1966-September 1967: During the current year, the project remained inactive except for the coding and analysis of data on the source of personnel skills (Group Composition Questionnaire, HINDSIGHT Instrument 3.5-see project No. 12).

A preliminary report was prepared on the human factors data. Coding and analysis of all the human factors and laser data is completed.

Publications and Papers, September 1966-September 1967:

66/51 Gustave J. Rath, "Some Characteristics of the Development of Human Factors Engineering Groups," IEEE Human Factors in Electronics Group Newsletter, Vol. IX, NO. 4, October 1966. AP



A GENERAL MODEL RELATING THE EVENTS THAT OCCUR IN THE HISTORY OF AN OR/MS ACTIVITY, THE CONDITIONS UNDER WHICH IT FUNCTIONS, AND EFFECTIVENESS

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. The effects of many internal and external factors are being tested in a series of studies.

Supported By: National Aeronautics and Space Administration and the Ford Foundation through Northwestern's Council on Inter-Societal Studies.

Project Leader: Michael Radnor

Progress September 1966-September 1967: The survey phase of the study of OR/MS in business organizations was completed and a research report for publication has been produced. This report describes the findings obtained from 66 large U. S. companies and involved approximately 250 interviews. A number of very significant trends in the changes in personnel performing OR/MS, their organization, portfolio mix, support from management, and client and staff relations were identified. Further in-depth studies on the relation between group development and acceptance in the organization, and on OR/MS personnel and client relations are in progress. Several research instruments have been developed to measure attitudes towards change. A Ph.D. dissertation is underway in this area.

The first phase of a survey of 35 Federal Civilian Agencies involving approximately 150 interviews has been completed and the research report is in preparation. Two Ph.D. dissertations on in-depth aspects of this study are in progress.

A number of papers have been presented on these studies to business, government and professional groups.

An international phase of this study has been set up in cooperation with several overseas universities. The study is being coordinated by Northwestern and has been funded by a grant from the Inter-Societal Studies Council of the University.

Publications and Papers, September 1966-September 1967:

66/50 Rubenstein, Albert H., "Some Comments on the Role of The Management Sciences in the Industrial Organization," Department of Industrial Engineering and Management Sciences, Northwestern University, February 1966. AP

66/39 Rubenstein, Albert H., "List of potentially 'researchable' or 'studyable' questions that arose during the TIMS Symposium on the Future of Management Sciences," Department of Industrial Engineering and Management Sciences, Northwestern University, October 1966. AP

66/29 Rubenstein, Albert H., "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

67/26 Albert H. Rubenstein, "Summary Comments: Symposium on the Future of the Management Sciences," Presented to The Institute of Management Sciences, Boston, April 1967. AP

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 focuses upon the interface between "systems planning and design" groups and "research and development" groups.

Supported By: RAND Corporation, Department of Defense, and National Aeronautics and Space Administration.

Project Leader: Albert H. Rubenstein.

Progress September 1966-September 1967: This project area is one that moved, during the year, from the status of a series of related, but independent studies, toward a more coherent sub-program of cumulative studies of the relationships between organizations engaged in the various stages of the laboratory-to-market (or use) process.

Students and staff directly involved in this area increased during the year from two to half-a-dozen. Two of them received their degrees and left the program (see abstracts of Mills 67/33 and Martin 67/29 in the last section of this report). It is anticipated, however, that additional people will move into this area during the coming year.

Intensification of activity in this area has been motivated by two glaring needs, one theoretical and one practical. The theoretical need is for more understanding of the process of communication between organizational units, such as "research and marketing," "development and production," "systems planning and R and D." Although transfer of information is, ultimately, a process involving individual behavior and perceptions, there is much to be learned about this process at the aggregate level of communication between groups that may be linked or separated by many design features of the organization.

The practical need is evident in the increased interest by many segments of the society in the essential process known variously as technology transfer, technology utilization, diffusion of innovation, and spin-off. Our studies in this area have tended to focus on the characteristics and behavior of the potential or actual "user" of the information--his perceived needs, his decision and selection processes, his knowledge of sources and evaluation of them, and his actual use of technical information.

Since questions of communication of technical information and transfer of technology arise in most of our projects or sub-programs, from Idea Flow to Project Selection, aspects of this subject are treated throughout the program. The two needs discussed above, however, have led to intensified concentration on development and testing of models and propositions specifically focused on the liaision - interface - technology transfer phenomenon. While we are far from a complete theory of this phenomenon, possible pieces of such a theory are beginning to emerge.

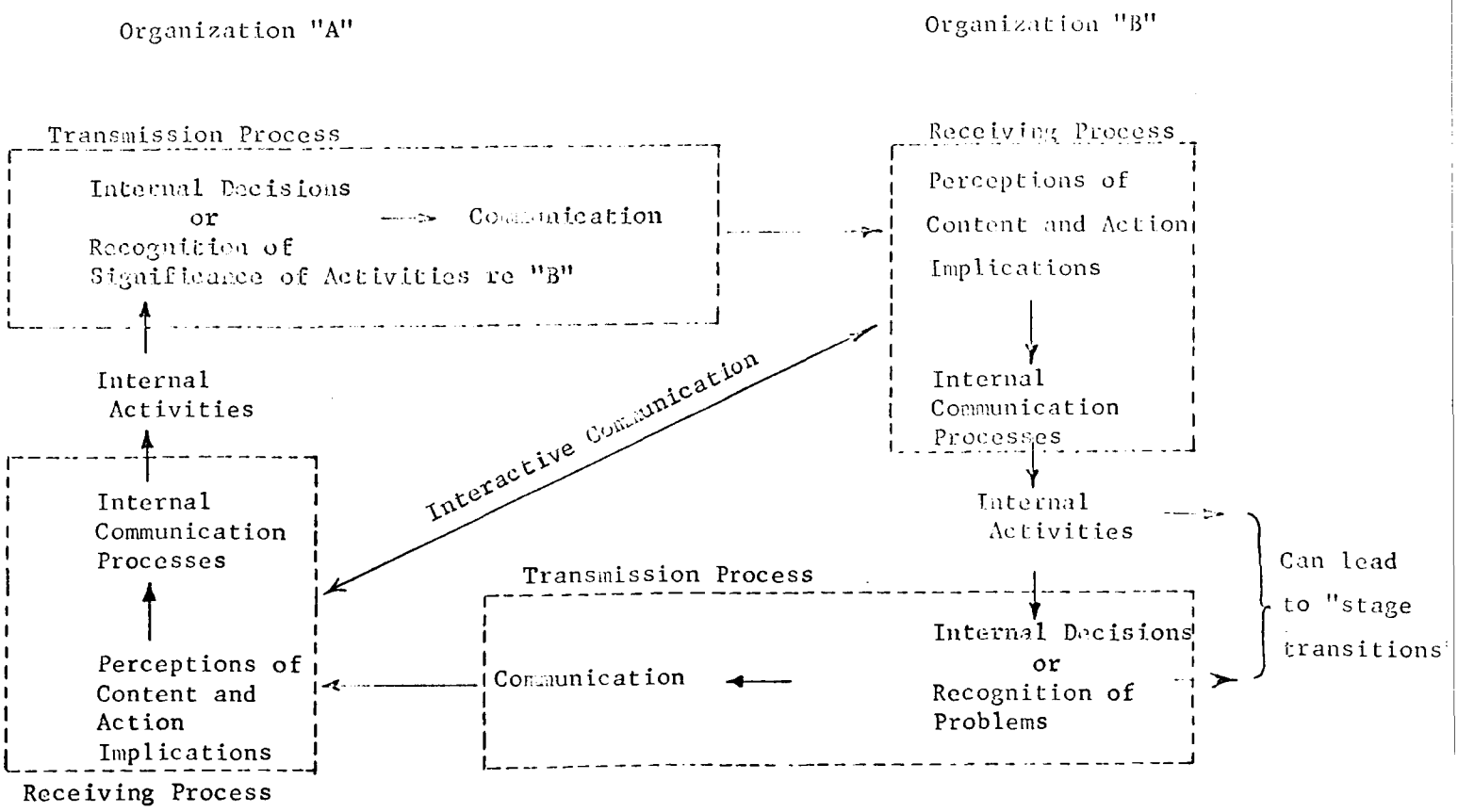
Publications and Papers, September 1966-September 1967:

67/19 Albert H. Rubenstein, "Research Note on a Possible Investigation of the Organization of Project Teams," Department of Industrial Engineering and Management Sciences, Northwestern University, May 1967. AP

67/17 Charles F. Douds and Ralph J. Lewis, "An Exploratory Study of Interface Models and Hypotheses," Department of Industrial Engineering and Management Sciences, Northwestern University, 1967. L

67/29 Robert B. Martin, "Some Factors Associated with the Evaluation of Ideas for Production Changes in Small Companies," A Ph.D. dissertation, Department of Industrial Engineering and Management Sciences, Northwestern University, 1967. AS

67/32 Charles F. Douds, "An Approach to A Theory of Organizational Interfaces," Department of Industrial Engineering and Management Sciences, Northwestern University, 1967. AP



General Interface Model

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 1966-September 1967: During the past year a major experiment was started. All major research hospitals and medical schools in the Chicago area were contacted. After several meetings, six hospitals which had both a cardiology and an oncology group were chosen. From the twelve groups, 106 persons completed a forty-five minute questionnaire and were briefed on the real-time experiment. The sample included 48% M.D.s and 10% Ph.D.s. Half of the groups were given an experimental information system on April 10 and became control groups on August 21. The other half of the groups were control groups first. After a pilot run,using the Northwestern University Medical School Library and three physicians in a nearby hospital, a facsimile system was chosen. Two facsimile transmitters and a copier were installed in the John Crerar Library,connected by leased telephone lines to six facsimile receivers in the hospitals. Each group (4-30 people) was given budgets between $355-$1,175,with a mean of $550 for a 4-week period. The cost of services was $12/hour for staff time. If the "exact" reference was known, a $1.00 retrieval fee and 30¢/page copy fee were charged. The service operated continuously, using tape recorders to receive information requests and data outside of normal working hours. The original copy was sent by mail, in addition to the facsimile transmission.

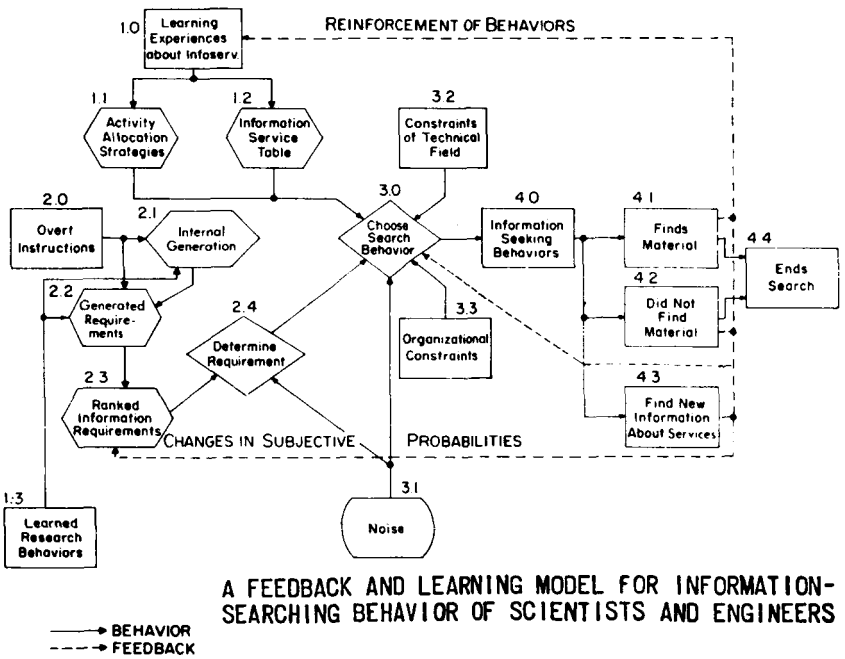
Efforts to define information-seeking style have been made since the beginning of this project. Current efforts have been started to develop a test which may be used for identifying and classifying different types of information seekers. Comparative information-seeking style data have been collected from the HINDSIGHT sites (see Project 12) on the sources of information used for research. Approximately 1500 copies of Instrument 3.6 have been filled out. Results have been coded and analysis programs written.

Publications and Papers, September 1966-September 1967:

67/1 David J. Werner, "Real-Time Data Collection of Information-Seeking Behavior: Two Methods and Some Results," Northwestern University, Department of Industrial Engineering, January 1967. AP

67/35 Gustave J. Rath and David J. Werner, "Infosearch: Studying the Remote Use of Libraries by Medical Researchers," The Proceedings of ADI 1967 (American Documentation Institute National Meeting 1967). AP

67/46 Albert H. Rubenstein, "Some Comments on Criteria for the Use of Scientific Information." Presented to the Council on Intersocietal Studies, Northwestern University, 1967. AS



A FEEDBACK AND LEARNING MODEL FOR INFORMATION-SEARCHING BEHAVIOR OF SCIENTISTS AND ENGINEERS

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

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

Progress September 1966-September 1967: Interviewing and data collecting at two large industrial concerns has continued with mixed success. Quarterly data for six quarters and Mottley-Newton type scoring data for one quarter have been obtained from one company while fragmentary data have been collected from the other. The data from the first firm yields rather complete cost information and less complete revenue information.

The scoring model was applied to projects for a single quarter. Projects were graded from one to five (poor to excellent) according to six attributes: sales, technical success, financial payoff/project cost, manufacturing capabilities, project life and novelty. The projects were rated by eight people. An independent observation of whether the project was open or closed was available. Tests showed that: (i) the eight people were consistent in their rankings, (ii) frequency distribution of project scores for closed and open projects showed considerable overlap,indicating that the Mottley-Newton project score (the product of its score on each of the five attributes) is not a good prediction of the "closed" or "open" decisions, and (iii) discriminant analysis indicates that sales and product life are far more important than the other four attributes in predicting the "closed" or "open" decision. Using numerical data from the quarterly reports, product life and future cost to end of project phase were most important in predicting the open and closed decision when life of product, sunk cost to date, future cost to end of project phase, total future cost to development, and probability of success,were the independent variables in a discriminant analysis. Revenue and profit data were not available.

A paper providing some of the theoretical structure needed to develop and compare project selection models has been prepared and is now in working paper form: "Notes on Investment Analysis" by A. Hurter. An extension of this development, focusing on scoring models, has also been prepared: "Scoring Models, Preference Functions and R and D Project Selection: Part I" by A. Hurter. Part II of this paper will incorporate the empirical work with scoring models. A draft of a working paper is underway supplementing the previous review of project selection models and their classification according to analytical structure. For each model class, this paper: a) details the underlying analytical approach, b) describes the rationale for computing project value or payoff, c) identifies the input data required d) makes explicit the project selection rules which can be utilized, e) discusses the relative advantages and disadvantages,and f) suggests possible utilization procedures by the study team. Based on a draft of this paper, 21 input data parameters were selected which will permit utilization of nearly all proposed models. The data collection and interviewing phase of the study has been constructed to reflect this, where possible.

Publications and Papers, September 1966-September 1967:

67/23 Arthur P. Hurter, Jr., "Notes on Investment Analysis," a working paper, Department of Industrial Engineering and Management Sciences, Northwestern University, May 1967. AP

67/2 Daniel Kegan, "Project Selection Field Study Instruction," Department of Industrial Engineering and Management Sciences, Northwestern University, November 1966. AS

67/34 B. John Holtel, "A Working Paper on a Computer-Aided Management Information and Decision System for Project Selection and Review in Research and Development," Department of Industrial Engineering and Management Sciences, Northwestern University, July 1967. AP

67/45 Arthur P. Hurter, Jr., "Scoring Models, Preference Functions and R and D Project Selection, Part I," Department of Industrial Engineering and Management Sciences, Northwestern University, July 1967. AP

GENERAL PHASES IN THE PROJECT SELECTION PROCESS FOR A GIVEN PROPOSAL (NOT ALL STEPS OCCUR FOR ALL PROPOSALS, AND NOT ALL STEPS OCCUR IN THE SAME SEQUENCE).

IDEA GENERATED
↘
PRELIMINARY DISCUSSION
↘
REVISION, IF NEEDED
↘
FORMAL PROPOSAL
↘
INITIAL FORMAL SCREENING
↘
ECONOMIC EVALUATION
↘
OTHER EVALUATIONS
↘
DECISION TO PUT IN PORTFOLIO
↘
DECISION TO FUND
↘
ASSIGNMENT OF PEOPLE
↘
IN-PROCESS REVIEWS
↘
PERIODIC REVIEWS
↘
FINAL REVIEW

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 & 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

Progress September 1966-September 1967: No additional specific seminars were held beyond the ones reported in last year's Annual Report.

However, a number of the meetings described in other sections of this report (Nos. 12 and 14) provided the opportunity to discuss promising key researchable problems in R & D management. Members of the program are continually reexamining the projects in our portfolio for promising new project areas and connections between projects that relate to important aspects of R & D management.

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

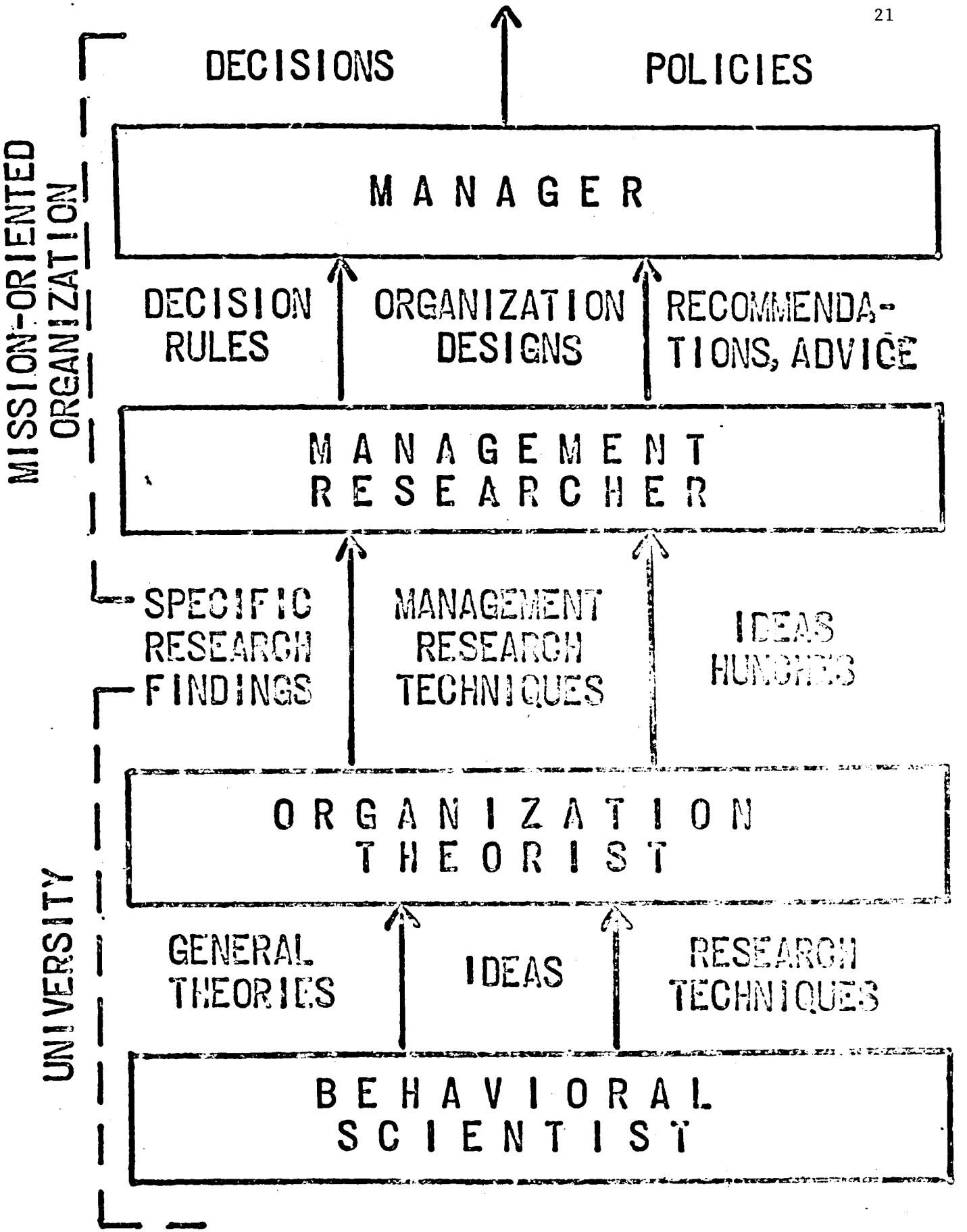
Objective: This study provides a means for carrying out a cooperative research program between the research management aspect of Project HINDSIGHT and the Program of Research on the Management of R & D at Northwestern. The support of Project HINDSIGHT includes participation and assistance in the design 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 Engineering, Department of Defense.

Project Leader: Charles W. N. Thompson

Progress September 1966-September 1967: In the previous period, from the start of work on this project in October 1965 through August 1966, the Phase II activity, directed to the identification of management and other environmental factors related to research group performance, resulted in the training of the in-house field researchers, the design of research--including propositions and instruments, publishing the HINDSIGHT Field Manual, and the initiation of field research. During the period from September 1966-September 1967, the field research part - the collection of data required by the instruments - was completed, and the analysis has been partially completed. Salient points include the following:

1. Reunion of field researchers: On October 19-20, 1966, field researchers from the nine active sites met at Northwestern University with university research personnel to review progress and problems, and to discuss means and methods of handling data collection.


DECISIONS
POLICIES
MISSION-ORIENTED ORGANIZATION
MANAGER
DECISION RULES
ORGANIZATION DESIGNS
RECOMMENDATIONS, ADVICE
MANAGEMENT RESEARCHER
SPECIFIC RESEARCH FINDINGS
MANAGEMENT RESEARCH TECHNIQUES
IDEAS HUNCHES
UNIVERSITY
ORGANIZATION THEORIST
GENERAL THEORIES
IDEAS
RESEARCH TECHNIQUES
BEHAVIORAL SCIENTIST

2. Workshop on In-House Research: Three field researchers and eight university staff members participated with eighteen other government personnel in a workshop on in-house research on December 12, 1966, drawing upon the experience obtained during the course of the research, and developing methods useful in the collection of field data by in-house researchers.

3. In-House Management Research Course: From July 5-July 14, 1967, members of the university staff conducted a course for government personnel based, in part, on the techniques and methods developed on this project.

4. Status of data collection: Significant amounts of data have been collected from the five field sites which have completed the field phase. These data are from thirty-five groups,with approximately 670 individuals, and include approximately 4650 separate instruments.

5. Status of data analysis: With two exceptions, all of the instruments were designed to be punched into cards to facilitate handling and preliminary analysis. All of the data from seven instruments has been punched, and preliminary analysis has been accomplished for four instruments. One report has been prepared (see Mills, below) and others are in preparation.

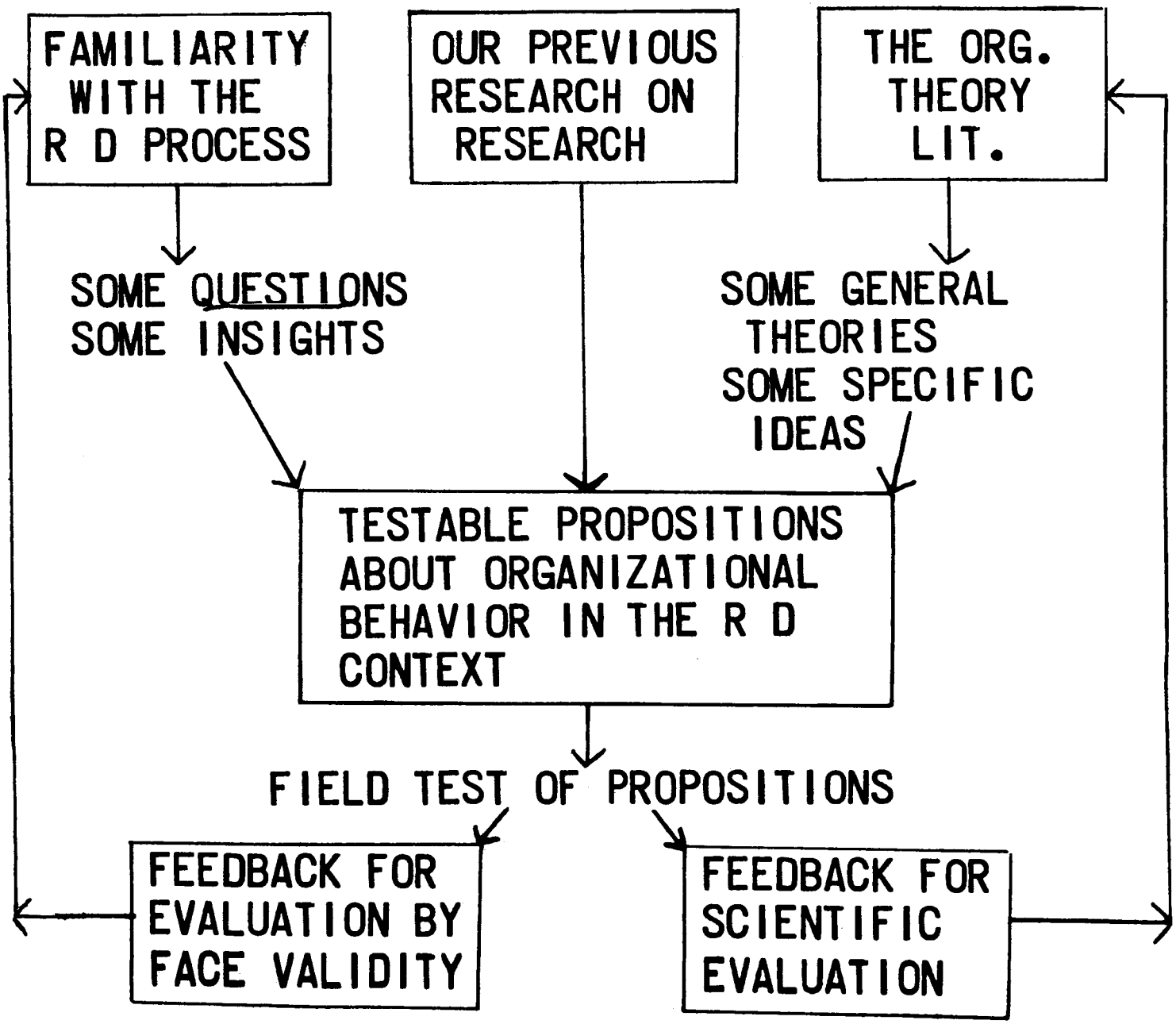
Publications and Papers, September 1966-September 1967:

67/21 Albert H. Rubenstein and Charles W. N. Thompson, "List of Potential Variables for DOD Information Experiments," Department of Industrial Engineering and Management Sciences, Northwestern University, May 1967. AP

67/4 Albert H. Rubenstein, and Charles W. N. Thompson, "Some Potential Experiments on Information-Seeking Behavior of Scientists and Engineers," Department of Industrial Engineering and Management Sciences, Northwestern University, January 1967. AP

67/33 Robert Mills, "Liaison Activities at Research and Development Interfaces: A Model, Some Empirical Results, and Design Considerations for Further Study," A Master's Thesis, Department of Industrial Engineering and Management Sciences, Northwestern University, June 1967. AP

THE USE OF MULTIPLE SOURCES FOR PROPOSITIONS ABOUT ORGANIZATIONAL BEHAVIOR



13. METHODOLOGY OF RESEARCH ON RESEARCH

Objective: To continually examine and attempt to improve our current methods of field research and to develop new ones for specific and general use in our overall program.

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

Project Leaders: Albert H. Rubenstein and Charles W. N. Thompson.

Progress September 1966-September 1967: Since field research in operating organizations constitutes the major means of data-gathering by members of the Program, continuing attention to improvement of field study methods is a core concern. Last year's report (66/32) indicated a number of methodological trends in our research towards 1) real-time studies, 2) remote studies, and 3) field experimentation. General approaches and specific techniques in all three areas continued under development during the year. Several new studies (involving projects 9 and 10) were placed on a real-time basis, in which data are being collected as events occur, over longer periods of time than the usual thesis or dissertation will allow.

Designs for remote field experiments and field studies were developed in several areas, particularly in connection with a new series of studies in the "Infosearch" area (see projects 9 and 12). Both remote studies, using in-house field researchers in the organizations being studied (e.g. project 12) and quasi-experimental studies, using Northwestern personnel as data collectors, require improved research methodology. A significant part of the Organization Theory area, in which the Program is located at Northwestern, is devoted to training graduate students (and selected undergraduates)in field research methodology and to developing new general approaches and specific techniques for field research.

Experience in a number of areas (notably project 12) has reaffirmed our belief that useful studies of organizational behavior in R and D generally require "real-time" study as compared to retrospective study. By "real time" we mean: while the events of interest are occurring. This is not always possible, of course, such as in cases of completed projects or events that became of research interest after they occurred. However, the loss of data in retrospective studies of R and D management has always been a source of distress to students of the R and D process. For example, the lack of recorded or readily reconstructable accounts of decision and communication events has been a continuing source of difficulty in studies of idea flow (project 1), project selection (project 10), and others. In addition, there is the difficulty of recapturing relevant perceptions, attitudes, and motives at the time of such events.

On the other hand, the difficulties of access, the need to avoid affecting the events being observed, and the costs of real-time studies combine to make them difficult and less tempting than the retrospective study. Despite this, we are attempting to increase the ratio of our real-time to retrospective studies.

Publications and Papers, September 1966-September 1967:

67/18 Charles W. N. Thompson, "On Finding Squirrels: Less Obvious Sources of Information in Formal Organizations," Department of Industrial Engineering and Management Sciences, Northwestern University, November 1966. AP

67/7 William L. Williams and Michael Radnor, "In-House Research on the Management of R and D in Government Agencies," presented at the COLRAD session of the International Meeting of The Institute of Management Sciences, Mexico City, August 1967. L

67/8 Albert H. Rubenstein, and Charles W. N. Thompson, "Remote Studies of R and D Management Using In-House Field Researchers," Department of Industrial Engineering and Management Sciences, Northwestern University, August 1967. AP

14. OTHER RELATED ACTIVITIES

A. THE TRANSACTIONS ON ENGINEERING MANAGEMENT OF THE INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS: Edited by the principal investigator, continued as the only professional society journal devoted exclusively to the management of Research, Development, and Engineering (R, D, and E). Articles were published on aspects of R, D, and E management from creativity and supervision to project selection and program scheduling. A special issue--March 1967--included selected papers from the Working Group on Research Management, of the Military Operations Research Symposium (MORS).

B. THE COLLEGE ON RESEARCH AND DEVELOPMENT (COLRAD): Data Collection was initiated during the year for a second edition of the Directory of Research-on Research, co-sponsored by the College on Research and Development (COLRAD) of The Institute of Management Sciences (TIMS). Publication is anticipated in mid-1968. It will continue to focus on current (rather than completed) research and on the management aspects of the total R and D process, since several other directories are available on completed research and the macroeconomic aspects.

C. SHORT COURSES AND SEMINARS: Our Spring Quarter Seminar in the Organization of Research and Development continued to attract research administrators from local industry and graduate students involved in our research program.

One major short course in Field Research Methods (see Project No. 12) was conducted for in-house management researchers.

D. ADVISORY RELATIONS WITH OTHER RELATED GROUPS: Members of the Program contined to serve in various advisory and consulting capacities in the R and D community. These activities,during 1966-7, included: National Science Foundation, National Aeronautics and Space Administration, National Bureau of Standards, National Academy of Sciences, American Dental Association, and several industrial corporations and not-for-profit organizations.

Numerous talks, papers, and lectures were given by members of the Program during the year. In many cases, formal papers are not available from them, since they were presented as "slide talks."

Publications and Papers, September 1966-September 1967:

67/10 Albert H. Rubenstein, "Some Views on the Function of an Undergraduate Engineering Magazine," Department of Industrial Engineering and Management Sciences, Northwestern University, February 1967. AP

67/12 "Proposed NASA-Northwestern Collaboration in Center Development Program," Department of Industrial Engineering and Management Sciences, Northwestern University, March 1967. L

A) ABSTRACTS OF THESES AND DISSERTATIONS COMPLETED IN 1966-67.

67/29 Martin, Robert B., "Some Factors Associated with the Evaluation of Ideas for Production Changes in Small Companies," A Ph.D. dissertation, Department of Industrial Engineering and Management Sciences, Northwestern University, 1967.

This paper reports research into some of the factors which influence the rate of technological change in industry. The gap between the availability of new knowledge and technology and the application of that knowledge and technology to the process of producing goods and services is generally considered to be substantial. The research reported herein is an attempt to explore the relevance of certain organizational and individual factors to the acceptance of ideas for changes in the firm's production process. This exploration was carried out by measuring the evaluation of actual ideas in the organizational setting and relating the number of ideas evaluated and the number accepted,to the organizational and individual factors hypothesized to be relevant.

Data for the study was gathered by the author from 86 cooperating managers and engineers in 34 firms engaged in electronics manufacturing. Each manager and engineer, hereafter called an evaluator, was asked to keep a record of all ideas for changes in the firm's production process which he evaluated. The author collected these records once a week from each evaluator for six weeks. At the end of the six-week period each evaluator filled out a questionnaire which served to measure certain organizational and individual variables of interest. Data was gathered on a total of 391 idea evaluations, and was analyzed by computer using a binary multiple regression model.

For the set of all idea evaluators, the following variables were found to be correlated, at a significance level of .90, with the number of ideas evaluated: the number of employees in the company, the amount of dissatisfaction with costs expressed by the evaluator, the number of professional, trade, and business publications read by the evaluator per month, and the number of trade shows attended per year by the evaluator. The first three correlations above were positive and the last was negative. The four variables together accounted for 26% of the variation in the number of ideas evaluated.

Again,working with the group of all evaluators, the following variables were correlated at the .90 level with the number of ideas accepted: the number of employees in the company, the number of professional, trade, and business publications read by the evaluator per month, and the amount of dissatisfaction with sales levels expressed by the evaluator. The first two correlations above were positive and the last was negative. Together they accounted for 13% of the variation in the number of ideas accepted by each evaluator. It is apparent that the number of ideas evaluated is not influenced by the same variables as is the number of ideas accepted, for only two of the influential independent variables are common to both sets above.

The set of company presidents yielded three correlations with the number of ideas evaluated which were significant at the .90 level. These were dissatisfaction with costs, the amount of business travel performed, and the number of professional meetings attended. Together, these three variables accounted for 45% of the variation in the number of ideas evaluated. Those variables which are most influential in explaining the number of ideas evaluated among presidents are not the same as those which are most influential in explaining the number of ideas evaluated among production managers. As will be shown below, the same is true of the variables which are most influential in explaining the number of ideas accepted.

Again working with the set of company presidents, three correlations with the number of ideas accepted were significant at the .90 level. They were the amount of business travel, the number of professional, trade, and business publications read, and the company's freedom to alter its products. The first correlation above was positive and the last two were negative. Together, these three variables accounted for 22% of the variation in the number of ideas accepted.

Including correlations which carried significance levels lower than .90, the first stage models accounted for a larger portion of the variation in the dependent variables than is indicated above. For example, the last two model tests given for company presidents accounted respectively for 57% and 47% of the variation in the dependent variables.

Independent variables investigated which failed to show correlation significant at the .90 level included the age, educational level, and risk propensity of the idea evaluator.

The second stage of the model dealt with the factors influencing the outcome of individual idea evaluations. The following attributes were correlated at the .90 level with the acceptance of an idea: the fact that the idea was perceived to have 1 chance in 10 of failure (or less),the fact that the idea was a potential solution to a problem perceived as "very urgent," the fact that obtaining the money required to implement the idea presented no problem, and the fact that obtaining the people necessary to implement the idea was a problem of moderate magnitude. The latter attribute was negatively correlated with idea acceptance. The evaluator's evaluation of the source of the idea, the potential dollar value of the idea to the company, and the amount of search associated with the problem to which the idea was a potential solution were not significantly correlated with the acceptance of the idea.

67/15 McColly, John B., "An Investigation of the Factors Affecting the Perceived Impact of Marketplace Events Upon Decision Makers, A Ph.D. dissertation, Department of Industrial Engineering and Management Sciences, Northwestern University, 1967.

The market structure of several industries may be characterized by few sellers, significant product differentiation,and many buyers. As a result of this structure, decision makers in firms in these industries are confronted with a high frequency of marketplace events. The oligopolistic nature of these industries implies that these decision makers will want to respond to these events should they be interpreted as a present or potential threat to the market position of their respective firms. This research investigates a portion of the response behavior of the decision makers--the identification and relative importance of factors which affect the perceived impact of marketplace events upon decision makers.

A conceptual model for analyzing response behavior of an individual decision maker is developed. This model details the perception of a marketplace event, the interpretation of the event and the decision process which determines whether or not the decision maker feels a need to respond to the event. A decision maker may interpret a marketplace event as posing a degree of threat to the market position of his firm. This degree of threat associated with an event is termed the "impact" of the event upon a decision maker.

Five factors are postulated to contribute to the level of impact perceived from an event by a decision maker, and propositions relate these factors to the perceived impact. The impact a decision maker perceives from an event is hypothesized to be directly proportional to:

A) the perceived degree of competition with the firm responsible for the event,
B) the perceived degree of penetration to which the event reaches in the product line of the decision maker's firm,
C) the perceived degree of customer appeal associated with the event,
D) the perceived degree to which the event affects a market segment in which the decision maker's firm is engaged
and E) the perceived cost-saving potential associated with the event.

Data on response behavior were collected by interview from a sample of fifteen executives identified as "decision makers" from four firms in a highly technical, consumer-product industry. Data on response behavior for a total of 178 perceived events were subjected to statistical analyses to test the propositions and investigate the existence of behavior patterns for decision makers A) aggregated by firm, B) aggregated by organizational function, and C) in response to selected groups of marketplace events.

Strong support was found for the propositions relating to competition and customer appeal. The data indicated that the perceived impact of an event is directly proportional to the degree to which the decision maker views his firm as competing with the firm responsible for the event. The data also suggested that perceived impact varies directly with the degree of customer appeal associated with the event by the decision maker. The data weakly supported the propositions on "penetration" and "market segment" relationship. Based upon the data collected for this study, no statistically significant conclusions could be drawn regarding the importance of "cost-saving potential" as a contributing factor.

In summary, the data indicated that the perceived degree of competition with the firm responsible for an event and the perceived degree of customer appeal associated with the event were found to be major contributing factors to the perceived impact of the event upon a decision maker.

67/33 Mills, Robert C., "Liaison Activities at Research and Development Interfaces: A Model, Some Empirical Results, and Design Considerations for Further Study," A Master's Thesis, Department of Industrial Engineering and Management Sciences Northwestern University, June 1967.

The thesis presents a basic interface model that identifies major sets of variables which influence liaison activities at research and development interfaces. Some research questions and propositions are extracted from the model. Further richness can be added to the model as literature from related substantive areas is more thoroughly surveyed. The model is intended to be a foundation to which further research can contribute.

Analyses of two empirical studies on liaison relationships are described. Although the settings vary, one proposition was common to both studies. It was found that there was marginally significant support for the proposition that liaison agents who were perceived as group members are also perceived as effective. An inverse relationship between distance and certain aspects of interface communication was supported. It was not possible to draw any firm conclusions about the behavior of liaison agents during project crises because of insufficient data.

A discussion of methodological problems is included. Certain aspects of research design for field experimentation on interface activity are elaborated, and a potential experimental design for the study of liaison agent effectiveness is presented. Some possible data collection procedures and important elements of analysis of the potential design are included.

Subjects of Theses and Dissertations in Process

September 1967

Bean, Alden	M.S., Ph.D.	The effects of group composition on the acceptance of OR/MS groups in industry.
Bonge, John W.	Ph.D.	Organizational response to major change.
Douds, Charles F.	Ph.D.	Study of R & D group interfaces and liaison relations.
Hannenberg, Richard C.	Ph.D.	Some structural and interpersonal factors in the project selection and idea flow processes in an industrial research laboratory.
Holtel, B. John	Ph.D.	Basic constructs of information processing structure for computer-aided management systems.
Kegan, Daniel L.	M.S.	Researchers' uses of technical information.
Larson, Jon A.	M.S., Ph.D.	A behavioral and economic study of R & D management's project selection process.
Moor, William C.	Ph.D.	The medical researcher's environment as it pertains to information searching behavior.
Tansik, David A.	Ph.D.	Some factors influencing the integration and utilization of management science activities in the federal civilian agencies.
Thompson, Charles W. N.	Ph.D.	A study of selected methodological requisites in field research.
Werner, David J.	Ph.D.	Study of information-seeking behavior of medical researchers.
White, Michael J.	Ph.D.	Determinants of conflict behavior in the integration of management science activities in the federal civilian agencies.
Young, Clifton C.	M.S., Ph.D.	The interface between research and marketing.
Young, Earl C.	Ph.D.	Sources of technical information for firms and the development of R and D capability in selected developing countries.