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ORGANIZATION RESEARCH PROGRAM

RESEARCH AND DEVELOPMENT

Report of Activities  
March 1, 1963

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This report was prepared and revised by the entire staff of the Organization Research Program, and was coordinated and produced by Marie Kechejian. The introductory pages were drafted by D. G. Marquis.

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ORGANIZATION RESEARCH PROGRAM

RESEARCH AND DEVELOPMENT

School of Industrial Management, MIT

March 1, 1963

In the spring of 1962 MIT's School of Industrial Management, with the support of a grant from the National Aeronautics and Space Administration,<sup>1</sup> undertook to develop a program of research and education on the problems of organizing and managing large-scale technology-based enterprises. The studies under way and planned for the future are focused on the broad problem of understanding and improving the effectiveness of R & D activities relative to their goals. Before describing the specific projects currently in progress, a brief statement of the underlying concept of research<sup>2</sup> which guides the program will help place these studies in perspective.

BASIC RESEARCH ON THE R & D PROCESS

In general, the Organization Research Program associates think in terms of quantitative open-system concepts: inputs, flows, complex interdependencies, outputs, and feedback loops. The fundamental processes of R & D are problem-solving and decision-making. Our area of interest excludes highly programed or routine repetitive activities except as they contribute to problem-solving (e.g., memorizing).

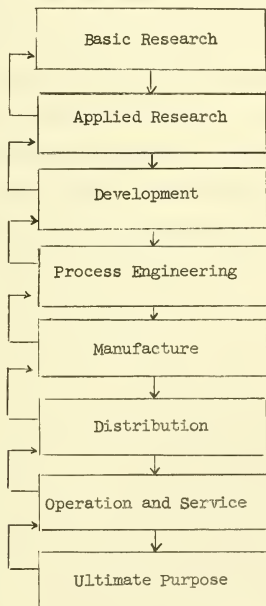
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<sup>1</sup> Research grant #NsG 235-62

<sup>2</sup>The words research and R & D will be used in this report as synonyms denoting the entire range of activities from basic science to process improvement, whether performed by an individual, an organization, or a government. Adjectival modifiers (e.g., applied research) will be used to denote subclasses of research activity.



We think of R & D activity as a sequence of subactivities, each of which is essential to the ultimate accomplishment of a useful goal. They may in some cases be carried out completely by one person or they may be carried out by many different people in different places. The concept of R & D as a planned, organized approach by technically trained people to the solving of certain sorts of problems is a development of the two decades since the Manhattan Project, but the essence of the research process is as old as Archimedes. The sequential steps in R & D may be labeled as follows:





From each activity there are feedback loops--a strong one to the immediately preceding activity and less operative ones to all of the preceding activities. Some loops such as the one from Development to Applied Research are critically essential; others such as from Applied Research to Basic Research are often dysfunctional, and barriers to communication in this loop must be deliberately planned<sup>3</sup> (e.g., separate buildings). At the core of each stage of the R & D process is a problem-solving process. Understanding the R & D process thus requires knowledge of problem-solving itself, as well as of the interconnections among the various problem-solving processes as they occur in each of the activities listed above.

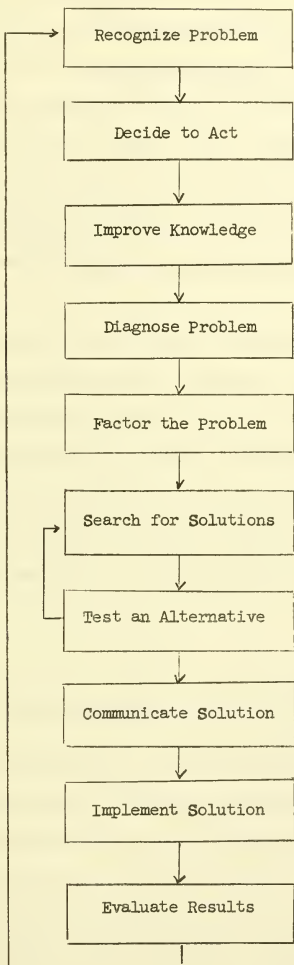
The problem-solving process consists of a series of imperfectly sequential activities with feedback loops. The inputs to a researcher are problems, information, and expected rewards. A problem is defined as a discrepancy between a present state of affairs and a desired state. The outputs are problem solutions of some degree of utility.

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<sup>3</sup>This way of formulating the old adage that "applied research tends to drive out basic research" was presented in a talk to the Sloan Fellows at the School of Industrial Management by Dr. Jack Morton, Vice-President of the Bell Telephone Laboratories, and is known as Morton's Law.



The steps in problem-solving are as follows:





Probably the busiest feedback loop is from Test Alternative to Search for Solutions. It is well known that successful performance is a function of the number of alternative solutions considered (Allen and Marquis, 15).<sup>4</sup> Another important loop is from Evaluate Results to Recognize Problem, since the discrepancy between measured output performance and required performance sets a new problem calling for rework. What is called creativity or originality is heavily involved in the innovative steps (Recognize Problem, Diagnose Problem, Search for Solutions), but much less often in the evaluating or decision-making steps (Decide to Act, Test an Alternative, and Evaluate Results).

Basic research on multiple goals in problem-solving, information requirements for problem-solving, and the nature of competence in problem-solving and decision-making is being carried out in several projects (Soelberg, 2; Bowman and Pounds, 3; Stedry, 4; and Marquis, 7). These studies are thus directed both to understanding the problem-solving process as it takes place at each stage of the R & D sequence of activities and to understanding the necessary interconnections, informational and motivational, among the various stages.

#### APPLIED RESEARCH ON THE R & D PROCESS

When research is performed, as it typically is, through the joint efforts of two or more people, additional considerations of organization and management arise from the need for planning, staffing, scheduling, directing, coordinating, monitoring, and so forth.

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<sup>4</sup>Names followed by a number designate a specific project, described later, which is directed at the question under discussion. In this instance, Project 15, directed by T. J. Allen and D. G. Marquis is studying factors in the successful solution of problems arising in the course of proposal preparation.



There are many levels of complexity in organizational systems performing research, and we are concentrating on five:

Individual researchers

Functional groups

Projects

Laboratories and research centers

Corporations and government agencies

Work is also focused on that most important interface between government agencies and laboratories:

Contracting procedures

The five systems, taken in reverse order, are seen to be systems and sub-systems. Corporations and government agencies are subsystems of a national and international socio-politico-economic system. The outputs of the sub-systems are inputs to the supersystem, and this interface defines the vital questions of the impact of research in general, or of a particular research agency, on the society, the economy, and the polity of our nation. The reverse, or feedback loop, raises questions of the adequacy of information flow in the loop, and of the sensitivity of the agency to its impact on society. Analysis of flows in both directions are crucial in the definition of the goals of the agency. We have so far not initiated any work in this area because it is receiving substantial attention from other researchers (e.g., American Academy of Arts and Sciences, Indiana University, National Planning Association,<sup>5</sup> the Civilian Industrial Technology Program of the U. S. Department of Commerce, the National Science Foundation, the Midwest Research Institute, the Panel on Civilian Technology of the President's Office of Science and Technology, and the NASA Industrial Applications Program).

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<sup>5</sup> See Solo, Robert A., Gearing military R & D to economic growth. Harvard Business Review, 1962, November- December, 49-60.



Similarly, Laboratory and research centers are subsystems of Corporations or government agencies; Projects are subsystems of Laboratories and research centers; Functional groups are also subsystems of the Laboratories, with critical interfaces with Projects (Evan, 16; Thomas, Th);<sup>6</sup> and Individual researchers are subsystems of both Functional groups (the supervisor-subordinate interface) and Projects (the director-directed interface).

It is not possible to do useful scientific research on R & D at any of the levels of organizational complexity unless research performance can be evaluated. This is the \$64 question, and the most serious deficiency in previous studies. It is, therefore, the problem to which we are directing major attention and most urgent effort.

Research performance is necessarily evaluated with respect to the purposes or goals of the research. Goals must be clearly formulated by someone before any next step can be meaningful (Wood, 13; Voss, Th). Special effort is being directed to the theoretical and empirical analysis of performance by projects and by laboratories (Roberts 1, 9; Maffei and Marquis, 6; Maffei, 8; Allen and Marquis, 15). Little effort is being devoted to the performance criteria for individual researchers because this question has received most attention in previous studies by others, albeit with little success. We hope eventually to be able to design improved measures of individual research performance on the basis of the still unpredictable results of basic research on the nature of the problem-solving process in research (Soelberg, 2).

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<sup>6</sup>Th means thesis; a list of theses currently in progress is included as Appendix C.



No one knows which are the most critical factors in research performance. For this reason, as Burton Klein might advise,<sup>7</sup> the Organization Research Program is undertaking parallel effort in a number of small exploratory studies with a variety of directions; "fishing expeditions" they are sometimes called.

Principal attention, however, is being directed, at all levels of organizational complexity, to the following:

Motivational factors, because of the ubiquitous effects of incentives on every kind of performance.

Information communication factors, since 60% of research time in a typical industrial development laboratory was found to be devoted to communication of one kind or another.

Competence factors, for obvious reasons.

Interpersonal factors, because effective coordination is the crux of organized research.

Different factors can be expected to exert more or less influence on research performance at the different organizational levels, and studies are currently in progress at all levels.

The Individual researcher is the subject of study with respect to his allocation of effort among multiple goals (Stedry, 4; Rubin, Th), and his long-term career development (Schein, 5; Joyce, Th).

The Functional group is the hierarchically organized set of scientists and engineers, usually in the same field. The process under study is supervision, or the superior-subordinate relationship, in all aspects except the direction of technical work, which is considered below. Particular attention is given to studies of the long-range career development (growth, fluctuation, decline) as a function of organizational policy and procedure (Schein, 5; Coleal, Th; Doty, Th; Levine, Th).

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<sup>7</sup>National Bureau of Economic Research. The Rate and Direction of Inventive Activity, Princeton: Princeton University Press, 1962, 635 pp.



The Project is the organization for the management of technical work, and may range in size from three part-time engineers writing a proposal (Allen and Marquis, 15), to the manned lunar landing. We are focusing on middle-range projects; large enough (\$1M) to involve organization and management, and small enough (\$20M) so that there will be enough of them to permit statistical analysis (Maffei and Marquis, 6). Smaller scale studies are in progress on the perception by researchers of their technical job role (Stedry, 4; Rubin, Th), and on sources of bias and inaccuracy in estimating research jobs (Marquis, 7; Hersh, Th; Jacob, Th; Miller, Th; Pope, Th).

The Laboratory or research center is the next larger unit, comprising both functional and project organization in varying proportion and with varying degrees of conflict (Evan, 16; Thomas, Th). Major effort is directed to the collection of ten-year histories of large laboratories whose work is principally government contract R & D (Maffei, 8; Mead, Th; Piselli, Th). This field research is in continuous interaction with other research which is developing mathematical models of the R & D firm (Roberts, 9; Holman, Th; Kane, Th; Wachold, Th; Welles, Th). Related special studies are directed to the effect of communications on work effectiveness (Muller-Thym and Eberhard, 11), computerized management of information (Emery, 10; Thorpe, Th), the design of research space (Eberhard, 12), and criteria for project selection (Cramer, Th).

The Corporation and government agency are difficult subjects for scientific research because they are one-of-a-kind organizations, and comparative studies are impossible or of dubious validity. We are undertaking in collaboration with members of the MIT Political Science Department to study in depth a series of major decisions at the top of NASA (Wood, 13).



The Contracting process<sup>8</sup> is at the moment the target of many commissions, boards, interagency groups, and Congressional investigations. We are keeping up with the current news and conducting some field studies to build up our competence (Roberts, 14; Allen and Marquis, 15; Maffei, 8; Richard, Th), and when the dust has settled a little we will try to determine the unfilled needs in this area and design some long-range research studies.

#### ADMINISTRATION OF THE PROGRAM

The management of the Organization Research Program is vested in a Steering Committee of seven members (Appendix D), and in a research director and an administrative director, who are also members of the Committee.

The direction is typical of academic settings, with "colleague authority" based on persuasion and wheedling. Each of the research associates (listed in Appendix D) has joined the Program because he found it more interesting and challenging than other alternatives open to him. It is easier, however, to recruit research assistants because graduate students are usually hungry, and because they welcome a chance to join an active on-going research program.

The research associates come from a motley collection of disciplines: mathematics, sociology, operations research, psychology, statistics, economics, engineering, political science, architecture, and philosophy. But they had already learned to live and work together before this Program was conceived, and conflict other than intellectual argument is rare.

Coordination is achieved by two seminars which are described in the next section, by many small informal ad hoc groups, and by numerous luncheon appointments.

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<sup>8</sup>See Peck, M. J. and Scherer, F. M. The Weapons Acquisition Process, Boston: Harvard University Graduate School of Business Administration, 1962, 736 pp.



Each new major project (except theses) is reviewed by the Steering Committee. Half a dozen or more have been rejected and two have already been terminated. Several have been guided into more promising directions, and there is a general atmosphere of fluidity and growth.

#### EDUCATIONAL ACTIVITIES

An important feature of the Program is a weekly seminar throughout the academic year which is regularly attended by all the research staff and a number of interested guests from other MIT schools, from industry, and from NASA. This fall the seminars have served as a forum for progress reports from the individual projects, leading to discussion and debate on the research design, methods, and in some cases, utility. On several occasions we have asked an outside guest to meet with us and present a paper growing out of operating experience or relevant research. The list of topics is presented in Appendix A.

The graduate seminar in research management which has been offered by Professor Marquis for the past two years has been changed this spring to a series of lecture discussions, each led by a different member of the Program staff. In addition to School of Industrial Management students, the course is attended by some graduate students from engineering departments and from Harvard School of Business Administration. The topics and speakers for the sessions are listed in Appendix B.

The School of Industrial Management has collaborated with the School of Engineering in designing a new course for the spring term which provides actual experience in conducting a R & D project. Sixty-five students are



enrolled from electrical, mechanical, aeronautical, chemical and civil engineering, meteorology, and industrial management. The five graduate students from the School of Industrial Management belong to the project management team. The specific task this year is to design an equatorial earth-orbiting weather satellite; a sorely needed component in the U. S. meteorological program. The technical and cost requirements, along with engineering guidance, are provided by faculty from the several departments and by invited outside speakers. The students must organize themselves for the conduct of the project. Professor Marquis conducted the first session of the course on the topic of Project Management, including PERT-time. The academic term fixes the scheduled delivery date as May 21, 1963 and, who knows, the class may be awarded the follow-on development contract!

A bibliography of carefully selected articles, books, and reports in the field has been in preparation during the past three years and will be ready for distribution in May 1963. Plans are being formulated now for other educational activities specially designed for industrial and governmental research managers and ranging in scope from two-day seminars on restricted topics to longer programs on the broad subject of the organization and management of research.

#### KNOWLEDGE AND ACTION

The objective of a research program such as this is knowledge. But we must continually ask, with Robert Lynd, "Knowledge for what?" It is clear to us that we are seeking knowledge of R & D that will lead to increased effectiveness, teachability, predictability, and control. Recognizing that



behavioral research is often not carried through to the point of developing policies, procedures, teaching materials, etc. for practical application, we explicitly acknowledge our responsibility and intentions in this respect. Some of the usable outputs will be developed in one year, others in three, five, or ten years.

In applying to proposed projects the criterion of usable end product, we have in mind as users those governmental, university and industrial research organizations which contribute to the mission of NASA. Systematic study of the organization and operation of NASA has been carried out by interviews with key executives at NASA headquarters, at Langley, Goddard, Lewis, and Huntsville Centers, and in a number of industrial contractors. With the valuable help of members of the Office of Administration we have formulated a set of long-range problems and opportunities in NASA toward which our efforts are directed.

#### SPECIFIC RESEARCH PROJECTS

In the following pages each of the research projects is described in terms of its current activities and work plans for the immediate future.



1. The Dynamics of R & D

E. B. Roberts

This project is a continuation of research done as part of a doctoral thesis. The initial phases of the project developed a general theory of research and development project behavior, created an Industrial Dynamics<sup>9</sup> model of that theory, performed a large number of computer simulation studies of the model, and derived tentative conclusions on government and industry policy for R & D management. This research is described in Roberts's book, The Dynamics of Research and Development, which will be published later this year.

Current efforts on this project are twofold: (1) broadened documentation of the study and its implications for R & D policy;<sup>10</sup> and (2) development of more simplified representations of important parts of the general project model, aimed at enhancing the use of the model as a teaching device.

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<sup>9</sup> Forrester, J. W. Industrial Dynamics. Cambridge: M.I.T. Press, 1961.

<sup>10</sup> Roberts, E. B. The Design of Research and Development Policy. MIT, SIM, Working Paper No. 8, January 1963.



2. Individual Problem-SolvingO. P. Soelberg  
R. E. Good

Study of unprogramed problem-solving behavior has already contributed centrally to the understanding of creative research processes. One strategy for learning more about thinking and problem-solving is to observe behavior of human subjects under carefully controlled laboratory conditions. The objectives of this project are three-fold:

1. Design of an experimental problem-solving environment which is:  
(a) sufficiently complex and flexible to warrant long-term commitment to it as an opportunity for systematic investigations of both orthodox and hitherto unexplored areas of human thinking and decision-making; (b) sufficiently well specified to permit application of rigorous experimental controls; and (c) sufficiently quantifiable to allow explicit measurement of behavioral observations as well as direct comparison of alternative schemes for positive and normative decision theory analysis.

2. Laboratory tests of certain specified hypotheses of human cognitive rationality, symbolic information processing, and goal resolution in the general problem-solving environment defined above.

3. Initiation of a research seminar which, utilizing experimental data and information processing language simulation techniques, will explore theoretical and practical pitfalls (and potentialities) of alternative methods of decision-process data analysis.

Parametric forms of a general experimental environment have already been designed and programed for two alternatives: real time and time sharing computer systems. A number of pilot studies have been initiated to clarify (1) operational questions of variables and measures of the general conceptual model;



(2) phenotypic problems of relevant variables and parameters; (3) the inferred validity of environmental simulation and treatment manipulations; (4) the adequacy of proposed experimental controls; (5) problems of the information load on the experimenter; (6) man-machine laboratory communication requirements; and (7) estimated manpower and equipment needs, together with projected cost and time schedules, for completing proposed research runs. These exploratory studies are also expected to help reduce the experimental Type II errors, eliminating the expense of controlling large numbers of variables of minor operational consequence to particular treatments. Several major modifications of experimental procedure have already been suggested by the exploratory results.

Plans for the spring and summer of 1963 call for continuation of pilot investigations leading to a series of formal experimental treatments during the following year. Studies will first investigate potential interactions between (1) problem complexity levels, (2) subjective information structures, and (3) experimental protocol data collection procedures, with respect to a selected subset of behavioral process and outcome measures. Half the problem solvers will work alone as individual subjects, and the others will constitute two-person research groups in comparable problem environments working under partial conflict of goals and information.



3. The Process of Managerial Decision-Making

E. H. Bowman

W. F. Pounds

The purpose of this research is to gain greater understanding of the management decision-making process. Search of the literature on management decision-making has defined the present state of theory and research results, a firm with about 3,000 employees engaged in the business of making small mechanical and electrical controls has been selected for initial study.

Interviews with a number of managers (approximately 50) in the firm have been completed. During these interviews data were gathered on the history of the various parts of the firm, and some insight was gained into long-range plans. A number of staff meetings dealing with budgets and the planning of various projects were observed. Attention was then focused on several decision cases which were investigated in some detail. On several of these cases observations are still in progress.

At the present time effort is directed to the development of a programmatic theory which will describe an underlying process with sufficient detail and completeness to explain much, though probably not all, of the empirical evidence which has been collected.



4. Researchers' Goals and Effort Allocation

A. C. Stedry  
I. M. Rubin  
R. D. Willits  
E. Yaffa  
D. R. Zibbell

Theoretical studies already carried out<sup>11</sup> have investigated the kinds of effort or resource allocations that would represent rational behavior in response to a set of goals in several activities competing for scarce resources.

Work is now progressing in generalization of the model to broader classes of distribution functions. An attempt is also being made to incorporate earlier work on single-goal models to determine the effect of some composite of the goals on total effort to be allocated as well as on allocation of effort.

Field research has obtained data on effort allocation and personal goals from engineers in four levels of supervision at the Waltham and Needham laboratories of Sylvania Electronic Systems Division. Thirty engineers and 108 engineering supervisors were asked to estimate their time allocation to five substantive activity areas, and to rank these five areas in the order of importance to them. They were also asked how they would like to, how they thought they should, how their supervisors wanted them to, and how they wanted their subordinates to, allocate their time. To obtain a measure of personal goals they were asked to estimate on a four-point scale the extent of the personal satisfaction they obtained from engaging in each of twenty listed activities.

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<sup>11</sup>Stedry, A. and Charnes, A. Some models of organization response to budgeted multiple goals. MIT, SIM, Working Paper No. 1, September 1962.

Charnes, A. and Stedry, A. Further explorations in the theory of multiple budgeted goals. MIT, SIM, Working Paper No. 12, February 1963



Data analyses indicate that personal goals appear to have some effect on effort allocation despite job similarities. Great disparity was found between what allocation the subordinate thought his supervisor actually did desire. The translation of personal goals into effort allocation seems to be most direct, however, in the expression of the difference between what the individual would like to do and what he estimates he is doing, suitably adjusted for a limitation on the possible additional allocation. Thus, we have apparently found a measure, in terms of estimated and desired effort allocation, of personal goals.

A further study has been designed to test the accuracy of measuring devices for time allocation and to determine correlations between evaluation of performance and time allocation (including the relationship between actual allocation and supervisors' desires).



5. Career Development of Researchers

E. H. Schein  
S. D. Levy  
W. W. McKelvey  
D. R. Peters

The purpose of this project is to develop basic information about the career patterns of scientists, engineers and administrators in NASA with a focus on those factors which enable them to maintain effectiveness, creativity and growth. The ultimate end-product would be the design of organizational policies and procedures to increase the competence and the contribution of researchers over their entire career.

An exploratory study using open-ended interviews supplemented by a brief questionnaire, was undertaken during the summer of 1962. Nearly 100 interviews ranging in length from 1 - 2 1/2 hours were conducted at Langley and Lewis Centers. At the end of the interview the questionnaire dealing with different areas of individual growth and development was left for each man to fill out and mail to the research team.

Interview data are now being coded and scored and summary tables constructed. The growth questionnaire was analyzed by determining the frequency with which different growth areas were mentioned, and by computing an average importance rank for each area. The respondents also indicated what they attributed their growth to.

The growth areas were selected to reflect a number of different basic dimensions or orientations:

1. Technical--desire to become better technically and to receive recognition for it;
2. Managerial--desire to become a better manager and to obtain recognition for it;



3. Institutional--desire to do job well; fulfill organizational goals;
4. Personal--desire to develop personal and interpersonal areas.

An individual's ratings of areas in which he expects to grow in the future can be used as an index of his type of career orientation, while ratings of past growth can be used to infer the kinds of growth possibilities which existed in the person's environment.

The next step in the study is to revise the growth area questionnaire and to combine it with a questionnaire based on the interview results to obtain more systematic information from a large sample of NASA respondents.



6. Project Management and Performance

R. B. Maffei  
D. G. Marquis  
A. J. Hansen  
K. R. Hootnick  
J. E. Mahoney  
R. L. Pearson  
J. J. Richard

Comparative study of factors affecting the research and development function is difficult because no two research tasks are the same and performance cannot be directly compared. Previous work in this area has been limited to comparisons of cost and schedule overruns or to case studies of a few large projects. Although the difficulties are great, it seems worthwhile to try to devise methods of obtaining commensurate data on a large number of projects in order to carry out statistical analyses of the effect of important variables on performance of R & D.

A preliminary formulation of important variables was first prepared on the basis of published literature and interviews with experienced research managers. During the summer of 1962 the feasibility of obtaining various types of data was explored at three NASA centers: Langley, Huntsville, and Lewis. Attention was first directed to large projects involving substantial in-house effort, e.g., ECHO II, MECA, and AEROBEE. This exploration made it clear that there are very few large projects which are carried out predominantly in-house, and effort is now being directed to projects in industrial and university laboratories which are (1) conducted under contract with a government agency (or a prime), (2) between \$1 million and \$20 million in size, and (3) completed or nearly completed. Data are collected both in the laboratories and in the related government contracting agencies, such as Air Force Systems Command and NASA centers.



Project performance will be measured in several ways: (1) objective records of cost, time, and technical accomplishment will be compared with the estimates and requirements in the contract; (2) judgments of performance will be obtained from the project manager, the laboratory director, and the government technical representative; (3) an account of the critical problems, slippages, and failures in the course of the project, together with the steps taken in response, will be obtained from the project manager and the technical monitors.

Information on critical factors in the history of the project will be obtained from laboratory records, from government contracting offices, and from interviews with project managers, and will be analyzed in relation to project performance.

The possibility has been investigated of obtaining from central depositories aggregated information on completed contracts. Valuable computer analyses could be performed if data were available on contract identification, task specifications, expenditure, and interim and final evaluations. Visits have been made to the Office of the President, Bureau of the Budget, General Accounting Office, General Services Administration, Departments of Defense - Army, Navy and Air Force, Renegotiation Board, and National Science Foundation. There seems to be general agreement that such a data source would be invaluable and that it does not exist. The principal shortcomings of the sources which have been examined are that (1) evaluation data do not exist for all contracts; (2) when they do exist, their validity is open to question; and (3) significant financial data for many contracts are not readily available. It is probable, however, that partial collections of project data can be assembled, and arrangements are currently underway to obtain such collections.



7. Risk and Uncertainty in Research DecisionsD. G. Marquis  
J. H. Hubbard

Preliminary experimental work has indicated that in decisions involving both risk and uncertainty people will accept less risk than in comparable decisions involving pure risk without uncertainty.

In the process of research and development there is a succession of decisions involving various degrees of uncertainty. How do research managers in fact handle decisions involving estimates of feasibility, cost, and schedule? In collaboration with Karl Miller (S.M. thesis) we designed a situation to obtain time estimates of a number of subactivities by 40 managers who were being given instruction in PERT. Sources of bias and of inaccuracy are obtained by comparing engineers with different amounts or kinds of experience, and by comparing engineers with finance managers.

Because decisions made by groups have been found<sup>12</sup> to be more risky than those made by individuals alone, we are comparing PERT time estimates made by groups of managers with estimates made individually by the same managers before the group discussion.

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<sup>12</sup> Marquis, D. G. Individual responsibility and group decisions involving risk. Industrial Management Review, 1962, 3, 8-23



8. Laboratory Management and Effectiveness

R. B. Maffei  
A. J. Hansen  
K. R. Hootnick  
J. E. Mahoney  
R. L. Pearson  
J. J. Richard  
I. M. Rubin

This project was initiated a few months ago to parallel Project No. 6 which deals with project management, and the same team of research assistants are working on it. The purpose is to obtain ten-year histories of a number of industrial, government, and university laboratories performing contract R & D for government agencies. If data can be obtained on relevant features of proposal success, project performance, personnel competence, etc., it may be possible to identify critical factors which could be incorporated in improved source selection, and which would increase our knowledge of laboratory effectiveness.

Data collection procedures and questionnaires for these purposes are ready for field pretesting, and negotiations with several industrial laboratories are under way.



9. A General Model of R & D Organization EffectivenessE. B. Roberts  
L. P. Kane  
G. Welles

This project seeks to develop a general model of R & D organization effectiveness which may then be used to study the problems of laboratory policy design with regard to organizational structure and resource allocation of engineers and management. The model will initially be based on information derived from a study of the M.I.T. Instrumentation Laboratory and on several models of R & D organizations which have been developed over the past few years.

To date there have been developed: (1) a conceptual framework for the organization model; (2) detailed descriptions of the phenomena included in the initial version of the model; (3) a flow diagram of the model; and (4) the first formulations of the model equations. Initial computer simulation studies have been aimed at testing the model's structural validity and at determining the need for data collection in the Instrumentation Laboratory. The data collection program was started early in February and involves both analysis of records and personal interviews with laboratory engineers and managers.

Since both research assistants plan to base their S.M. theses on this investigation, the study is aimed at tentative completion by early April. This should allow adequate time for additional analysis of the empirical data and the model results, and produce thorough documentation of the study by the end of the academic year.



10. The Role of the Information System in  
Managing an Organization

J. C. Emery

This project is studying the role of the information system in managing a large hierarchical organization having multidimensional goals. The project has been in abeyance between November 1962 and March 1963 while Emery was lecturing on this subject at the Indian Institute of Management, Calcutta.

Planning is the first step in the management cycle. This requires the factoring of the organization's goals into subgoals, which are in turn further factored into lower-level subgoals in hierarchical fashion. The problems of suboptimization introduced by this process will be examined and the information system will be viewed as a means of mitigating some of these problems. Consideration will also be given to the static and dynamic effects of a decision in one unit on other units within the organization.

Control is the second step in the management cycle. Control involves comparison of actual results with the plan, and determination and reporting of significant deviations. The use of control information in an adaptive feedback system will be studied. Heuristic programming techniques will be applied to the problem of adjusting the decision parameters at each level in the hierarchy in order to elicit the desired responses throughout the organization.

A computer model will be used during the course of the project to simulate the behavior of the organization. The goal is to develop a prototype model which could be used in the actual planning and control activities of a large organization.



11. Space and Work in R & D

B. J. Muller-Thym  
J. P. Eberhard  
H. P. Baya  
J. M. Kaufman  
R. W. Puffer

This project is concerned with the relationship between space and the work which is done in it; more specifically, the physical communication patterns in a R & D organization as they influence the work structure of the engineer, scientist, or administrator.

Field work has been carried out at the Goddard Space Flight Center. Detailed floor plans and plot plans indicating physical location of all Goddard personnel were constructed. Interviews were held with members of several projects, such as OGO, Tiros, Nimbus and Syncom--not only with those who had direct project responsibility but also with those in staff or support capacities. Other people not directly involved with the projects were also interviewed in order to provide a broader perspective of the Goddard organization. The interviews ranged in length from two to four hours and dealt with the role of the individual in the action-communication network of the project and center (Whom do you see in the course of your work and why?), and with the individual's judgment of the emphasis of any of the physical factors in his environment (crowding, noise, lighting, etc.) and the performance of his work.

As a supplement to the interviews, several hundred Goddard personnel were asked to complete activity logs designed for the recording of an individual's contacts in person, by telephone, or by mail. These logs indicate the flow of information between individuals and between groups.

Coding of the interviews has been completed and the items of information from them are being built into a reconstruction of the project



history and the information and action flow within the project as these are related to the physical travel pattern. The logs are currently being used to supplement the interview material, although they will later be used to construct a system of coding for potential computer analysis.

This study, therefore, looks to the answers to two questions:

1. What are the characteristics of the work structure, and the action-communication network in which the work of a project gets done and what differences in work structure can be related to the relative success of a project?

2. What are the characteristics of the physical communication structure which is the analog of the primary work structure?

This is a "generator" project which aims at identifying the variables which are significant in the relationship between work and space, at constructing a model or set of models, and of developing methods which can then be applied with greater assurance and elegance in subsequent studies. One such study is described in Project 12, and two laboratories have expressed interest in working with the project team as they proceed with the expansion of their present physical facilities. It is expected that the project will also develop enough of a methodology for studying information flow and the way that various sciences and technologies are mobilized in research work to provide a base for more detailed studies of this sort.



12. Research Laboratory Design

J. P. Eberhard

The formation of a task force in NASA headquarters for the advance planning of the site and concept of the proposed Electronics Research Center in the Greater Boston area suggested the extension of the work of Project No. 11 to include some preliminary applications to the problem of space planning. Accordingly, the cooperation and interest of the MIT School of Architecture has been solicited.

Plans have been made for two areas of participation by graduate students in Architecture under the direction of Professor Eduardo F. Catalano. The first will be undertaken by four graduate students and will involve library research, interviews, and a questionnaire survey designed to identify the criteria being used by architects and their clients in planning research buildings; i.e., those criteria derived from the nature of research work. Among such criteria would be those used in determining the distribution of laboratory spaces versus office spaces versus utility spaces; or the criteria used in determining the physical size of various work spaces; or the criteria used to determine the amount of flexibility required, etc.

The second area of participation will incorporate the graduate architectural theses projects of a number of students who will explore in drawings and models the architectural solutions possible within the limits of our present building technology, to the design of "dynamic" research buildings, in the sense of adapting the building to the work to be done, rather than adapting the work to a building composed of static spaces with limited flexibility.







These studies, though complete in themselves, are regarded as preliminary to the more general characterization of the particular properties of "space politics." They serve as a backdrop for more systematic investigations, possibly involving computer simulations of the policy process, including the development of communication influence networks. An attempt will be made to establish the relationship with general processes of policy making within the American government and to identify the significant proponents of expanded space activity, their resources of influence and their strategies. The result of this work should be an analysis comparable to those which now exist in the fields of resource development, military strategy-making and labor-management relations. From the viewpoint of NASA, a more explicit understanding of the political environment in which it exists should be forthcoming. From the perspective of scholarship, the empirical analysis of an important national political subsystem should provide a framework for further investigations of the increasing interactions between science and government.



14. Government-Industry Contracting SystemE. B. Roberts  
R. A. Levine

The project is divided into three phases: (1) determination of the decision process used for government award of research and development contracts; (2) study of the beliefs of industrial organizations as to the government award process, and investigation of corporate proposal strategies; and (3) development of a system model for simulation analysis of the contracting system, using results of the phase one and two studies as inputs, and aiming at design of a more effective government contracting system. Only phase one has yet been initiated.

Work on the project to date has focused on interviews and records at NASA's Goddard Space Flight Center. Project records have been studied and several competitive cost-plus research and development contracts, each over one million dollars in initial magnitude, have been selected for detailed investigation. Interviews have been conducted with members of the source evaluation boards, project managers, negotiating officers, and others related to a few of these contracts. In addition, data pertinent to the source evaluation phase of the contracts was extracted from NASA records. This information is not yet complete, but study of all relevant Goddard contracts should be finished before the end of the current academic year.



15. Problem-Solving in Proposal PreparationT. J. Allen  
D. G. Marquis

Preliminary research<sup>13</sup> has demonstrated that the proposal competition provides an excellent opportunity for the study of factors influencing success in problem-solving. It is one of the rare situations in real life in which a number of different firms work on the same task and can therefore be compared. Technical evaluations are obtained from the government agency, and interviews in each firm provide information on relevant characteristics of the firm and of the proposal effort.

Results on a few competitions suggest that technical competence, as evidenced by the use of company specialists, and size of the technical work force, far outweigh other factors such as company size and the level of effort expended on the proposal, in influencing the technical quality of proposals. There is also definite indication that proposal teams are prone to repeat an approach which they have previously used. This results in successful or unsuccessful solutions depending upon the appropriateness of the experience to the problem at hand. Unsuccessful solutions based on inappropriate experience are less probable if a larger number of alternative approaches are considered in preparing the proposal.

Plans for future research include the replication of the preliminary work with larger samples and more complete information. Other situations involving duplicated effort (feasibility studies, parallel contracts, etc.) will be located and studied in similar manner.

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<sup>13</sup>Allen, T. J. Problem-solving by research groups: A study of factors influencing the technical quality in the preparation of proposals for government contract. S.M. Thesis, 1963, MIT School of Industrial Management.



16. Four Types of Conflict in R & D PerformanceW. M. Evan  
M. J. Newman

A common structural feature of R & D laboratories, particularly those engaged in applied research and development, is the organization of personnel according to projects or tasks rather than or in addition to departments or disciplines. To achieve the objectives of a project, members of more than one discipline must interrelate and coordinate their activities.

In the course of such project research at least four types of conflict may arise:

- a) Task conflict among peers--disagreement among project members as to how to achieve the objectives of the project.
- b) Task conflict between one or more project members and the project director.
- c) Interpersonal conflict among peers--personal dislikes or mutual distrust among project members.
- d) Interpersonal conflict between one or more project members and the project director.

Are all four types of conflict equally dysfunctional for the attainment of the objectives of a project? A common management assumption is that all kinds of organizational conflicts are disruptive and should be minimized. The general hypothesis of this study is that task conflict, in the absence of interpersonal conflicts (especially among peers) is functional for the accomplishment of project objectives.

Work on this study was initiated in February of this year. A questionnaire is being designed to measure the degree to which the four types of conflict are prevalent in a project group. When completed, the questionnaire will be



administered to the members and supervisors of a sample of project groups in one of the NASA centers. A measure of research performance will be obtained by asking the first- and second-level supervisors of the project groups to rate the performance of the group as a whole on a scale of effectiveness. An attempt will also be made to use data from organizational records to assess the level of project performance.

The field study will probably suggest the need and value of investigating the same problem under experimentally controlled conditions in a laboratory, in order to test causal hypotheses on the relation between types of conflict and level of performance.



APPENDIX A

ORGANIZATION RESEARCH PROGRAM SEMINARS

- September 12, 1962 Reports on NASA research in progress
- September 21, 1962 Research at Sylvania on engineers allocation of effort  
Dr. Andrew Stedry
- September 28, 1962 Information programing system for the Department of  
Defense  
Dr. James Emery
- October 5, 1962 Research plans for studies of laboratory effectiveness  
and project performance  
Drs. D. Marquis and E. Roberts
- November 9, 1962 The policy process in space activities  
Dr. Robert Wood
- November 16, 1962 Career patterns of scientists and engineers within NASA  
Dr. Edgar Schein  
Mr. John Thomas  
Mr. David Peters
- November 30, 1962 Impact of space research on the economy  
Dean Howard Johnson
- December 6, 1962 Research on the diffusion of innovation  
Dr. Edwin Mansfield  
Carnegie Institute of Technology
- December 7, 1962 Research program of the American Academy of Arts and  
Sciences on the socioeconomic impact of NASA  
Professor Raymond Bauer  
Harvard School of Business Administration
- December 14, 1962 Analysis of relationships between spatial factors, commu-  
nications, and work  
Dr. Bernard Muller-Thym
- December 21, 1962 Report of research at Goddard on spatial factors and work  
Mr. John Eberhard  
Mr. Robert Puffer  
Mr. Jerome Kaufman



January 11, 1963

Factors in the technical evaluation of R&D proposals;  
research at AFSC Bedford  
Mr. Thomas Allen

January 18, 1963

Technological innovation in the digital computer  
industry  
Mr. Kenneth Knight  
Carnegie Institute of Technology

February 8, 1963

General discussion of methods and measures applicable  
to several projects  
Dr. D. G. Marquis

February 15, 1963

Incentive factors in R&D contracting  
Dr. Frederick M. Scherer  
Harvard School of Business Administration

March 1, 1963

Source evaluation studies  
Mr. Henry Norwood  
Harbridge House



ORGANIZATION AND MANAGEMENT OF RESEARCH AND DEVELOPMENT

A Series of Lecture Discussions  
Open to Anyone Interested

Thursdays, 1-3 p.m., Room 52-432

Donald G. Marquis, Moderator

February 7, 1963

Professor Bernard J. Muller-Thym

The over-all nature of R&D: a general view of  
problems in organization and management

February 14, 1963

Professor Donald G. Marquis

The R&D process: problem solving

Professor Leo B. Moore

Creativity in research, invention

February 21, 1963

Professor William M. Evan

R&D manpower: the profession of research, education,  
recruitment, selection, evaluation

February 28, 1963

Professor Andrew Stedry

Characteristics of the R&D professional: motivations,  
rewards, and values in relation to role requirements

March 7, 1963

Professor Herbert D. Saltzstein

Effectiveness of R&D groups: composition of teams,  
group problem solving, communication, interaction,  
space layout

March 14, 1963

Professor Edgar Schein

Supervisory management of R&D: autonomy, authority,  
leadership

March 21, 1963

Professor William Pounds

Project organization and management: planning, scheduling,  
control, evaluation

April 4, 1963

Professor John D. Little

Project selection and evaluation: for commercial products,  
research grants, etc.

April 11, 1963

Professor Richard B. Maffei

Contract research: interaction of firm and government  
in proposal preparation, evaluation, and contract moni-  
toring



April 18, 1963

Professor Edward B. Roberts  
The research laboratory: management, source evaluation

April 25, 1963

Professor James C. Emery  
Management of information: corporate programs, defense  
and space programs

May 2, 1963

Professor Zenon Zannetos  
Impact of R&D on national economic growth: industry  
differences, rate of invention, diffusion of innovation

May 9, 1963

Professor Jay W. Forrester  
Corporate organization and integration of R&D: relations  
to marketing, production, engineering; decentralization

May 16, 1963

Professor Robert C. Wood  
National policy and organization: political bases of  
research support, agency organization

Dean Arthur L. Singer, Jr.  
National policy: education, government-university  
relations



APPENDIX C

GRADUATE THESES CURRENTLY IN PROGRESS

RELATING TO R&D

- Allen, Thomas J., Jr.  
 Problem solving under conditions of competition and reward: a study  
 in factors influencing technical quality in the preparation of propo-  
 sals for government contracts  
 D. Marquis\* B. Muller-Thym
- Hersh, Marvin  
 Investigation of the nature of parameter estimation in the newly developed  
 program planning techniques  
 R. Maffei B. Smith
- Jacob, Itzhak  
 Network planning for time, cost, and performance in R&D projects  
 D. Carroll G. Kaufman
- Joyce, Charles C., Jr.  
 Factors affecting the maintenance of technical competence in engineering  
 organization  
 D. Marquis E. Schein
- Kane, Leo P.  
 A model oriented approach to studying the structure and performance of  
 a R&D organization  
 E. Roberts D. Marquis
- Levine, Richard A.  
 The organizational problems associated with engineers  
 L. Moore A. Siegel
- Miller, Karl A.  
 An assessment of certain influences on the temporal activity estimates  
 in a network model describing uncertainty  
 D. Marquis L. Lombardi
- Pope, Kenneth R.  
 Identifying and estimating the engineering effort involved in manned  
 military aircraft development programs  
 Z. Zannetos E. Bowman
- Richard, J. Jean-Paul  
 Technical monitoring of weapons systems contracts  
 D. Marquis R. Maffei
- Rubin, Irwin M.  
 Measuring allocation of effort: a study of methodology  
 A. Stedry P. Soelberg

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\*The first named is chairman of the thesis committee.



- Thomas, John (Ph.D.)  
Overlay of project and functional organization in R&D laboratories  
D. Marquis
- Thorpe, Thomas J.V.  
Management information systems in procurement of electronic defense  
systems  
D. Carroll
- Welles, Gillett III  
An analysis of the dynamic behavior of R&D organizations  
E. Roberts D. Marquis

SLOANS

- Coleal, Ernest  
A study of the internal staffing system of Air Force laboratories  
T. Alfred
- Cramer, Robert H.  
An application of decision theory to the selection of research projects  
B. Smith W. Pounds
- Doty, William E.N.  
Status congruency and research performance  
W. Evan T. Alfred
- Holman, Frank S.  
A dynamic analysis of a large system development  
E. Roberts D. Marquis
- Mead, Merrill H.  
Organizational problems of a dual-role NASA field center  
D. Marquis B. Muller-Thym
- Piselli, Joseph R.  
Some factors relating to engineering organization of a R&D company  
B. Muller-Thym E. Roberts
- Voss, Robert G.  
The effect of NASA spending on the Gulf Coast economy  
R. Evans R. Wood
- Wachold, George R.  
An investigation of the technical effectiveness of an organization  
E. Roberts A. Stedry



APPENDIX D

PERSONNEL, ORGANIZATION RESEARCH PROGRAM (NASA)

September 1962 - March 1963

(Brief biographies on following pages)

STEERING COMMITTEE

Donald G. Marquis (Chairman), Professor of Industrial Management  
Howard W. Johnson, Dean, School of Industrial Management  
John M. Wynne, Associate Dean, School of Industrial Management  
Max F. Millikan, Professor of Economics, and Director, Center for  
International Studies  
James McCormack, Vice President, Massachusetts Institute of Technology  
Jay W. Forrester, Professor of Industrial Management  
Bernard J. Muller-Thym, Professor of Industrial Management  
Arthur L. Singer, Jr., Assistant Dean, School of Industrial Management

ADMINISTRATIVE STAFF

Donald G. Marquis, Research director  
Arthur L. Singer, Jr., Administrative director  
Marie Kechejian, Administrative secretary  
Susan Rogers, Clerk-typist

RESEARCH ASSOCIATES

Thomas J. Allen, Jr.	Bernard J. Muller-Thym
Edward H. Bowman	William F. Pounds
John P. Eberhard	Edward B. Roberts
James C. Emery	Edgar H. Schein
William M. Evan	Peer O. Soelberg
Richard B. Maffei	Andrew C. Stedry
Donald G. Marquis	Robert C. Wood

RESEARCH ASSISTANTS

Harry P. Baya	William W. McKelvey
Enid Bok	Joseph B. Mobius
Miltiades Chacholiades	Michael J. Newman
Craig K. Comstock	David A. Nichols
Robert E. Good	Robert L. Pearson
Ravendra Gupta	David R. Peters
Adolph J. Hansen	Robert W. Puffer, III
John F. Harkness	J. Jean-Paul Richard
Kenneth R. Hootnick	Irwin M. Rubin
John H. Hubbard	Gillette Welles, III
Leo P. Kane	Robin D. Willits
Jerome M. Kaufman	Earle Yaffa
Richard A. Levine	David R. Zibbell
Steven D. Levy	
James E. Mahoney	



Thomas J. Allen, Jr.

Research Associate

Born: August 20, 1931  
Degrees: B.S., Upsala College, 1954  
S.M., M.I.T., 1963  
Field: Electrical Engineering and Industrial Management  
First Appointed: 1963

Professional Experience

1956-57	Tung-Sol Electric Company, Bloomfield, N.J.
1957-59	The Boeing Company, Seattle, Washington
1959-	The Boeing Company, Boston Engineering Office
1963-	Research Associate, School of Industrial Management, M.I.T.

Publications

"Competence, Effort and Experience in Successful Rand D Proposals:  
A Study of Factors in Problem Solving  
S.M. Thesis, 1963, M.I.T. School of Industrial Management



Born: September 30, 1925

Degrees: S.B., M.I.T., 1947  
M.B.A., University of Pennsylvania, 1949  
Ph.D., Ohio State University, 1954

Field: Industrial Management

First Appointed: 1952

#### Professional Experience

1947-48 Corning Glass Works  
1949-52 Faculty, Ohio State University  
1952 Instructor, M.I.T.  
1956 Consultant: RAND Corp and Industrial Companies  
1956 Assistant Professor, M.I.T.  
Lecturer, U. S. Air Force School of Logistics  
1959 Lecturer and Research at: University of Manchester;  
University of Birmingham, England; The Stockholm  
School of Economics, Sweden; Research Institute for  
Management Science, Delft, The Netherlands  
1959 Member of the Faculty at the Summer Seminar for European  
Management, Consultant OEEC  
1959- Associate Professor of Industrial Management, M.I.T.

#### Honorary and Professional Societies

Institute of Management Sciences  
Operations Research Society of America  
Econometric Society

#### Publications

"The Schedule Sequencing Problem"  
Operations Research, 1959

Analyses of Industrial Operations (with R. D. Fetter)  
Richard D. Irwin, Inc., 1959

"Assembly Line Balancing by Linear Programming"  
Operations Research, 1960

"Management Decision Making: Some Research"  
Industrial Management Review, 1961

Analysis for Production Management (with R. D. Fetter)  
Richard D. Irwin, Inc., rev. ed. 1961

"Consistency and Optimality in Managerial Decision Making"  
Management Science, 1963



John P. Eberhard

Lecturer

Born: January 29, 1927

Degrees: B.S., University of Illinois, 1952  
 M.S., M.I.T., 1959

Field: Architecture and Industrial Management

First Appointed: 1959

Professional Experience

- 1953-59 President, Creative Buildings, Inc.
- 1955-59 Partner, Architectural Firm of Eberhard and Murphy
- 1959- Director of Research, Sheraton Corp. of America
- 1959- Lecturer, School of Industrial Management, M.I.T.
- 1959- Consulting Architect to Various Clients

Honorary and Professional Societies

Society of Sloan Fellows

Publications

- "Architecture and Creativity"  
Response, 1960
- "Architecture and the Church"  
Protestant Church Administration, 1960



James C. Emery

Assistant Professor of  
Industrial Management

Born: October 12, 1929  
Degrees: B.S., Arkansas, 1952  
S.M., M.I.T., 1954  
Field: Management Information Systems  
First Appointed: 1959

Professional Experience

1955-56 Department Manager, Procter and Gamble  
1956-59 Manufacturing Controls Department, Westinghouse Electric  
Corp.  
1959- Assistant Professor of Industrial Management, M.I.T.  
1961-62 On Leave, Staff Analyst, U. S. Department of Defense,  
Office of the Assistant Secretary of Defense  
(Comptroller)

Honorary and Professional Societies

Phi Beta Kappa  
Institute of Management Sciences  
Association for Computing Machinery

Publications

"Control of Finished Goods Inventory"  
Proceedings of 6th International TIMS Meeting in Paris, 1959  
  
"Production and Inventory Control" (one chapter)  
American Management Association, 1960  
  
"An Approach to Job Shop Scheduling Using a Large-Scale Computer"  
Industrial Management Review Association, 1961  
  
"Modular Data Processing Written in COBOL"  
Communications of the A.C.M., Vol. 5, No. 5, May 1962



Associate Professor of  
Sociology and Industrial  
Management

Born: December 17, 1922

Degrees: A.B., University of Pennsylvania, 1946  
A.M., University of Nebraska, 1949  
Ph.D., Cornell University, 1954

Field: Sociology

First Appointment: 1962

#### Professional Experience

1946-47 Research Assistant, College of Law, University of Nebraska  
1950-51 Research and Teaching Assistant in Sociology and Anthropology,  
Cornell University  
1954-56 Instructor in Sociology, Princeton University  
1956-59 Assistant Professor, Graduate Department of Sociology,  
Columbia University  
1959-62 Research Sociologist, Social Science Research Department,  
Bell Telephone Laboratories  
1962- Associate Professor of Sociology and Industrial Management,  
M.I.T.

#### Honorary and Professional Societies

American Sociological Association  
Eastern Sociological Society  
American Association for the Advancement of Science  
Phi Kappa Phi

#### Publications

"Due Process of Law in Military and Industrial Organizations",  
Administrative Science Quarterly, Vol. 7, September 1962

Editor, Law and Sociology: Exploratory Essays  
Free Press, New York, 1962

"Role Strains and the Norm of Reciprocity in Research Organizations"  
American Journal of Sociology, Vol. 47, November 1962

"Simulated Bureaucracies: A Methodological Analysis" (with M. Zelditch, Jr.)  
in Harold Guetzkow, ed., Simulation in Social Science: Readings  
Prentice-Hall, Englewood Cliffs, New Jersey, 1962



Richard B. Maffei

Lecturer

Born: June 12, 1923

Degrees: S.B., M.I.T., 1945  
M.B.A., Wharton School, 1948  
Ph.D., University of Pennsylvania, 1956

Field: Economics, Statistics

First Appointed: 1955

#### Professional Experience

Instructor, Wharton School of the University of Pennsylvania  
Instructor, Moore School of Electrical Engineering,  
University of Pennsylvania  
1954 Visiting Assistant Professor, University of Washington  
Statistician and Research Economist, Institute of  
Cooperative Research, University of Pennsylvania  
Consultant, Logistics Research Group, George Washington  
University  
1955-62 Assistant Professor of Industrial Management, M.I.T.  
1957 Participated in Ford Foundation, Harvard Business School  
Case Study Seminars  
1957-62 Senior Consultant, H. N. Shycon Company  
1958-61 Visiting Lecturer, Air Force School of Logistics  
1960- Consultant, O.E.G., U. S. Navy  
1962- Lecturer, School of Industrial Management, M.I.T.

#### Honorary and Professional Societies

Kappa Mu Epsilon  
Sigma Xi

#### Publications

"Simulation, Sensitivity, and Management Decision Rules"  
Journal of Business, 1955-58

"Brand Preferences and Simple Markov Processes"  
Operations Research, March-April 1960

"Simulation-Tool for Better Distribution" (with Harvey N. Shycon)  
Harvard Business Review, November-December 1960

"Advertising Effectiveness, Brand Switching and Market Dynamics"  
The Journal of Industrial Economics, April 1961



Donald G. Marquis

Professor of  
Industrial Management

Born: June 22, 1908

Degrees: A.B., Stanford University, 1928  
Ph.D., Yale University, 1932

Field: Psychology

First Appointed: 1959

Professional Experience

1942-45 Chairman, Department of Psychology, Yale University

1945-57 Chairman, Department of Psychology, University of Michigan

1947-50 Chairman, Committee on Human Resources, Research and Development Board, Department of Defense

1953-57 President, American Board of Examiners in Professional Psychology

1954-60 U. S. National Commission for UNESCO; U. S. Delegation to Ninth General Conference, New Delhi, 1956

1956-60 Member, National Advisory Committee on Mental Health, NIMH

1957-59 Staff Member, Social Science Research Council, New York Consulting: Ford Foundation, National Science Foundation, Veterans' Administration, National Aeronautics and Space Administration, International Business Machines Corporation, General Electric Company

1959- Professor of Industrial Management, M.I.T.

Honorary and Professional Societies

American Psychological Association (President, 1947-48)

Phi Beta Kappa

Sigma Xi

Publications

Conditioning and Learning (with E. R. Hilgard)  
Appleton-Century-Crofts, Inc., New York, 1940

Psychology (with R. S. Woodworth)  
Henry Holt & Company, New York, 5th ed., 1947

"Research Planning at the Frontiers of Science"  
The American Psychologist, Vol. 3, No. 10, October 1948

"Individual Responsibility and Group Decisions Involving Risk"  
Industrial Management Review, 1962



Bernard J. Muller-Thym

Visiting Professor of  
Industrial Management

Born: October 7, 1909

Degrees: A.B., Rockhurst College, 1930  
A.M., St. Louis University, 1932  
Ph.D., University of Toronto, 1938  
Lic.Stud.Med., Pontifical Institute of Mediaeval Studies, 1940  
LL.D., Rockhurst College, 1942

Field: Administrative Policy

First Appointed: 1955

#### Professional Experience

1938 Instructor, St. Louis University  
1939-42 Assistant Professor of Philosophy, St. Louis University  
Director of Research, Edward G. Doody & Company  
1946-55 Management Consultant, McKinsey & Company  
1953-58 Lecturer on Human Factors in Administration, Columbia  
University Graduate School of Business  
1955- Management Consultant, Independent Practice  
Visiting Professor of Industrial Management, M.I.T.

#### Honorary and Professional Societies

American Association for the Advancement of Science  
American Association of University Professors  
Catholic Commission on Intellectual and Cultural Affairs  
Listed: Who's Who in the East, Who's Who in Commerce and Industry

#### Publications

(For earlier publication in logic and history of philosophy see listing  
in Who's Who in Philosophy)

"New Directions for Organizational Practice"  
Fifty Years Progress in Management  
ASME, 1960

"The Technical and Social Aspects of Automation"  
Proceedings of 1961 Meeting Council of the International  
Chamber of Commerce, 1962

"The End of the Neolithic Age"  
Papers on Economic and Social Changes  
Columbia University Press, 1962



William F. Pounds

Assistant Professor of  
Industrial Management

Born: April 9, 1928

Degrees: B.S., Carnegie Institute of Technology, 1950  
M.S., Carnegie Institute of Technology, 1959

Field: Production Management

First Appointed: 1961

Professional Experience

1950-51 Industrial Engineer, Eastman Kodak Company  
and  
1955-57  
1958-59 Consultant, Westinghouse Electric Corp.  
1960-61 Assistant to Director of a Division of Pittsburgh Plate  
Glass Company  
1961- Assistant Professor of Industrial Management, M.I.T.

Publications

"Statistical Scheduling of a Highly Mechanized Production Facility"  
(with E. P. Kraai)  
Journal of Industrial Engineering, 1959

The Scheduling Environment  
Prentice-Hall, Inc., 1962



Edward B. Roberts

Assistant Professor of  
Industrial Management

Born: November 18, 1935

Degrees: S.B., M.I.T., 1958  
S.M., M.I.T., 1958  
S.M., M.I.T., 1960  
Ph.D., M.I.T., 1962

Field: Industrial Dynamics, Research and Development  
Management

First Appointed: 1958

Professional Experience

1957-60 Director of Forensics, Brandeis University  
1958- Industrial Dynamics Research Group, M.I.T.  
1958-61 Associate, Data Processing Company  
1961 Consultant, National Aeronautics and Space Administration  
1961- Assistant Professor of Industrial Management, M.I.T.

Honorary and Professional Societies

American Economic Association  
Eta Kappa Nu  
Institute of Management Sciences  
Institute of Radio Engineers  
Sigma Xi  
Tau Beta Pi  
Tau Kappa Alpha

Publications

"Simulation Techniques for Understanding R&D Management"  
IRE Convention Record, 1959

"Toward a New Theory of Research and Development"  
Industrial Management Review, Fall 1962

The Dynamics of Research and Development  
(in preparation for publication)



Edgar H. Schein

Associate Professor of  
Industrial Management

Born: March 5, 1928

Degrees: Ph.B., University of Chicago, 1946  
B.A., Stanford University, 1948  
M.A., Stanford University, 1949  
Ph.D., Harvard University, 1952

Field: Social Psychology

First Appointed: 1956

Professional Experience

1947-49 Taught Statistics, Stanford University  
1949-52 Taught Social Psychology, Harvard University  
1952-56 Research Psychologist, Neuropsychiatry Division,  
Walter Reed Army Institute of Research (Chief  
of Social Psychology Section)  
1956-60 Assistant Professor of Industrial Management, M.I.T.  
1960- Associate Professor of Industrial Management, M.I.T.

Honorary and Professional Societies

American Psychological Association  
American Sociological Society  
Phi Beta Kappa  
Sigma Xi

Publications

"The Chinese Indoctrination Program for Prisoners of War: A Study  
of Attempted Brainwashing"  
Psychiatry, 1956

Coercive Persuasion (with I. Schneider and C. H. Barker)  
W. W. Norton & Company, Inc., 1961

"Management Development as a Process of Influence"  
Industrial Management Review, 1961

"Expressed Attitudes Toward the Legitimacy of Organizational  
Influence" (with J. S. Ott)  
American Journal of Sociology, 1962



Peer Olav Soelberg

Assistant Professor of  
Industrial Management

Born: July 20, 1934

Degrees: B.S., Carnegie Institute of Technology, 1956  
M.S., Carnegie Institute of Technology, 1957

Field: Industrial Management

First Appointed: 1962

#### Professional Experience

1957 Norwegian Delegate, United Nations Interne Programme,  
New York

1957-58 Consultant, International Business Machines, Inc.

1958-62 Doctoral Research, Carnegie Institute of Technology

1959-61 Lecturer, Carnegie Institute of Technology  
Research Associate, Computer Simulation of Models of  
Behavioral Theory of the Firm, Carnegie Institute  
of Technology

1961 Visiting Assistant Professor of Public Administration,  
University of Pittsburgh

1962- Assistant Professor of Industrial Management, M.I.T.

#### Honorary and Professional Societies

The Institute of Management Sciences

#### Publications

"A Positive Model of Price and Output Determination" (with R. M. Cyert  
and J. G. March)  
Econometric Society Annual Meeting, December 1960

"Adaptive Multiple Regression Analysis"  
BTOF, W.P. #35, 1961

Behavioral Theory of the Firm (Contributions) (with R. M. Cyert and  
J. G. March)  
Prentice-Hall, Inc., 1963



Andrew C. Stedry

Assistant Professor of  
Industrial Management

Born: April 14, 1936

Degrees: B.S., Carnegie Institute of Technology, 1956  
M.S., Carnegie Institute of Technology, 1957  
Ph.D., Carnegie Institute of Technology, 1959

Field: Economics and Industrial Management

First Appointed: 1961

Professional Experience

	Instructor (Part-Time), Carnegie Institute of Technology
1960-61	Associate Lecturer, George Washington University
1961-	Assistant Professor of Industrial Management, M.I.T.

Honorary and Professional Societies

American Accounting Association  
 American Economic Association  
 The Institute of Management Sciences

Publications

"A Note on Interest Rates and the Demand for Money"  
Review of Economics and Statistics, Vol. XLI, No. 3, August 1959

Budget Control and Cost Behavior  
 Prentice-Hall, Inc., 1960

"Exploratory Models in the Theory of Budget Control" (with A. Charnes)  
Proceedings of the Conference on Organization Research  
 Wiley (Forthcoming)

"Aspiration Levels, Attitudes, and Performance in a Goal-Oriented  
 Situation"  
Industrial Management Review, Vol. 3, No. 2, 1962

"Some Models of Organization Response to Budgeted Multiple Goals"  
 (with A. Charnes)  
 M.I.T. Organization Research Program, 1962



Robert C. Wood

Professor of  
Political Science

Born: September 16, 1923

Degrees: A.B., Princeton University, 1946  
M.P.A., Harvard University, 1947  
Ph.D., Harvard University, 1949

Field: Political Science

First Appointed: 1957

Professional Experience

1949-51 Associate Director, Legislative Reference Bureau of  
the State of Florida

1951-54 Office of Management and Organization of the Bureau  
of the Budget

1954-57 Lecturer, Harvard University  
Assistant Professor of Government, Harvard University  
Director of the Summer School, Harvard University

1957 Director, M.I.T. Field Study Program for Political  
Education  
Professor of Political Science, M.I.T.

Honorary and Professional Societies

Associate, M.I.T.-Harvard Joint Center for Urban Studies  
Member, Technical Advisory Committee of the Greater Boston  
Economic Study Committee  
Member, Committee on Urban Plans and Development of the  
Inter-University Case Program  
American Society for Public Administration

Publications

"Metropolis Against Itself"  
Committee for Economic Development

Area and Power (essays in)  
Edited by Arthur Maass

The Suburban Community  
Edited by Wilburn Dobriner

Suburbia: Its People and Their Politics

1400 Governments  
1961



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S.B., Industrial Management, 1961, Massachusetts Institute of Technology  
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Past employment in office work in construction company

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B.A., Modern European History, 1960, Radcliffe College  
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Past employment as trainee, Chicago and Northwestern Railroad; as  
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Past employment in Burmah-Shell Refineries, Bombay; Tata Oil Mills,  
Bombay; DCM Chemical Works, New Delhi

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S.B., Chemical Engineering, 1956, Massachusetts Institute of Technology  
Candidate for S.M. in Industrial Management, Massachusetts Institute  
of Technology  
Past employment as project engineer, Texas Instruments (M&C Nuclear,  
Inc.); staff engineer, Kaiser Aluminum, Chalmette, Louisiana

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Past employment in M.I.T. Instrumentation Laboratory - plastic molding

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Candidate for S.M. in Industrial Management, Massachusetts Institute  
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Past employment in Navy as antisubmarine warfare officer; torpedo and  
missile officer on guided missile submarine



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Candidate for S.M. in Industrial Management, Massachusetts Institute  
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Past employment in Production Engineering Department of Leeds  
Northrup Company; supervisor in maintenance and testing  
special weapons NWS, Yorktown, Virginia; engineering officer  
in destroyer operation in Navy

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Candidate for S.M. in Industrial Management, Massachusetts Institute  
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Past employment as physics laboratory instructor, Tufts University;  
standards and specifications writer, Minneapolis-Honeywell

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Candidate for S.M. in Industrial Management, Massachusetts Institute  
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Past employment in housing project as assistant field superintendent  
(dealing with subcontractors, etc.)

Mahoney, James E.

B.S., General Business, 1958, Florida State University  
M.S., Industrial Management, 1961, Florida State University  
Candidate for Ph.D. in Industrial Management, Massachusetts Institute  
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Past employment as assistant to Director of Oceanographic Institute,  
Florida State University (Business Manager of Institute);  
assistant to Director of Research, Florida State University  
(administration of University research)



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B.F.A., Theater Arts, Boston University  
M.S., Communications, Boston University  
Candidate for Ph.D. in Political Science, Massachusetts Institute of  
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Past employment as a social worker and as Resident Counselor at the  
University of Wisconsin

Newman, Michael J.

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Candidate for S.M. in Industrial Management, Massachusetts Institute  
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Past employment as representative for Eastman Dillon, Union Securities  
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A.M., Social Sciences, 1962, University of Chicago  
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M.I.A., Industrial Administration, 1961, Yale University  
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Past employment as production development engineer, Reliance Electrical  
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B.S., Electrical Engineering, 1962, Massachusetts Institute of Technology  
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Past employment in Raytheon Klystron Laboratory; Raytheon special microwave devices operation; Raytheon microwave ferrites and ruby laser

Richard, J. Jean-Paul

B.S., Chemistry, 1959, Northeastern University  
Candidate for S.M. in Industrial Management, Massachusetts Institute of Technology  
Past employment as development chemist, Armstrong Rubber Company

Rubin, Irwin M.

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Past employment as engineering aide, New York Port Authority; production line in a television tube factory; assistant instructor in Physics Department, Tufts University

Welles, Gillette, III

B.E., Electrical Engineering, 1961, Yale University  
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Willets, Robin D.

A.B., Physics, 1947, Middlebury College  
B.S., Business and Engineering Administration, 1948, Massachusetts Institute of Technology  
Candidate for Ph.D. in Industrial Management, Massachusetts Institute of Technology  
Past employment as manager of Systems and Procedures, Airborne Manufacturing, Raytheon Company; as staff assistant to production manager, Raytheon Company; operations manager, General Control Company, Boston; senior industrial engineer Eastman Kodak; and instructor, Division of Continuing Education, Boston University



Yaffa, Earle

B.S., Mechanical Engineering, 1961, Tufts University  
Candidate for S.M. in Industrial Management, Massachusetts Institute  
of Technology  
Past employment in mechanical design, New England Electric System

Zibbell, David R.

B.E.E., Electrical Engineering, 1961, Rensselaer Polytechnic Institute  
Candidate for S.M. in Industrial Management, Massachusetts Institute  
of Technology  
Past employment in coop educational program with IBM (redesigned a  
multivibrator and built printed circuit core card tester,  
devised reliability tests for optical reading machine)









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