ADDITIONAL

PAPERS PRESENTED AT

CONFERENCE ON UNIVERSITY RESEARCH MANAGEMENT

JUNE 6 and 7, 1977

NEW YORK UNIVERSITY

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The contents of this document complete the collection of papers submitted by the speakers. It also contains a list of all persons attending the conference. As before, no attempt has been made to edit the papers.

For the entire proceedings, please refer also to the earlier (blue) document.

Conference

University Research Management

June 6-7, 1977

Schedule

Monday, June 6, 1977 — Meyer Hall, Room 121

8:00-9:00a.m. — Registration and Check-in

9:15-9:30a.m. — Opening Statement: Dr. L. Jay Oliva
Vice President for Academic Affairs
New York University

9:30-10:00a.m. — Address: Honorable James H. Scheuer (D-N.Y.)
Member of Congress; Chairman, DISPAC

10:15-12:30p.m.

Panel I on: "Joint University-Industry Research Management"

Chaired by: Sidney G. Roth
Associate for University Relations
ERDA

Dr. Ralph L. Ely, Jr.
Director, University Relations
Research Triangle Institute
— "The Role of a Not-For-Profit Research Organization"

Dr. Robert K. Soberman
University City-Science Center
Philadelphia, PA
— "A University-Industry Interface"

Dr. John R. Ragazzini
Dean Emeritus, School of Engineering and Science
New York University
— "A Merged University-Industry Laboratory Facility"

Dr. Maurice J. Sinnott
Associate Dean, College of Engineering
The University of Michigan
— "Analysis of University-Industry Programs Sponsored by the Department of Defense"

Dr. John B. Bush, Jr.
Manager, Advanced Energy Programs
General Electric Company
Research Operations
Corporate Research and Development
— "Management of Joint Programs for Energy R, D & D" (Research, Development & Demonstration)

2:00-4:00p.m.

Panel II on: "Management of the Products of Research:

Chaired by: Victor Medina,
Assistant Director
Office of Sponsored Programs
New York University

Robert Goldsmith
Research Corporation
— "Patent Awareness Programs"

A.S. Alpert, Esq.
Vice-President, Operations and Secretary
University Patents, Inc.
— "University Patents, Inc.-Its Relationships with Universities"

Joseph J. Keeley Associate Director, Division of Research Development and Administration The University of Michigan	"Copyrights-Recognition, Rewards and Problems"
Lawrence Gilbert, Esq. Patent Administrator Boston University Community Technology Foundation	"How to Surface University Developed Inventions"
Norman J. Latker Patent Counsel DHEW	"Current Trends in Government Patent Policy"

4:30-7:00p.m. Reception (Bobst Library)
John Ben Snow Room
Coffee
Greetings by:
Dr. John C. Sawhill, President
New York University

Address:
Dr. Eric H. Willis
Assistant Administrator for Institutional Relations
ERDA

Refreshments

Tuesday, June 7, 1977 Meyer Hall, Room 121

8:30-9:00a.m. Late Check-in

9:00-11:00a.m.

Panel III on: "Management Tools"

Chaired by: Dr. John K. Wolfe, Manager
University Relations
General Electric Company

Dr. Charles C. Congdon Assistant Director, Memorial Research Center The University of Tennessee	"Management and the Achievement of Research Goals"
Dr. Winford E. Holland Associate Professor, Organizational Behavior University of Houston	"The Application of Management Tools in the University Research Environment"
Dr. Burton V. Dean Professor, Department of Operations Research Case Western Reserve University	"On University Research Information Systems"
Dr. H. Dudley Dewhirst Associate Professor, Industrial Management The University of Tennessee	"Management-by-Objectives for Research-A Contingency Approach"

11:00a.m.-12 Noon Summary Discussion

Remarks of the Honorable James H. Scheuer

before the

Conference on University Research Management

New York University

June 6, 1977

To begin, I want to thank you for inviting me to participate in this conference on the management of university research. I always welcome the opportunity to meet and talk to those people who are actually carrying out the research programs we, in the Congress, propose or authorize. In the three years that I have served on the Committee on Science and Technology, I've come to realize that we are all struggling with many of the same fundamental issues whether we are managing a research program in an university or industrial laboratory, monitoring supported research in a federal agency, or formulating and authorizing national research and development policies and priorities. This morning I want to discuss some of these issues of mutual concern and explain how the subcommittee on Domestic, International, Scientific, Planning, Analysis and Cooperation (DISPAC) is attempting to address them in its current work.

Before I do so, I think it would be beneficial to describe the scope of the DISPAC subcommittee's responsibility. We are charged with the special oversight and evaluation of single agency, non-military research, development programs. Intergovernmental mechanisms for research, development and technology transfer and all interanational cooperation in science and technology including the transfer of technology fall within our jurisdiction. In carrying out this oversight function, we work closely with the other six subcommittees of the Committee on Science and Technology, as well as with the other

Congressional Committees who have legislative responsibility for the mission agencies.

Perhaps the most critical issue to decide is the apportionment of public funds for our varied research priorities. We must assess how much money to allocate at the various points along the continuum from basic knowledge-building enterprises all the way to short-run, solution-oriented research and subsequent technological development. Similar judgements must be made with regard to the spectrum of disciplines within the broad domains of the physical, social, behavioral, and, if you will, the policy sciences. We must not only attempt to judge what we need to know now, but also what will most likely be necessary to know at various points in the foreseeable future.

Almost as important as the quest for this optimal mix is the search for ways to encourage creativity and thus ensure the continuing emergence of first class ideas, innovations and inventions to meet present and future societal needs.

We must also be aware that the fruits of science and technology, both the beneficial as well as the detrimental, have come under increasing public scrutiny. We live in an age where the authority of leadership, whether it be political or scientific, is being seriously questioned. A natural and healthy outgrowth of this questioning is the demand for accountability of tax supported research programs; accountability to the public they are purportedly designed to serve. However, concern for accountability has produced a number of effects, not all of which were anticipated and some of which appear to have retarded rather than fostered the growth of science and technology. Many scientists I've spoken with believe that it is possible to continuously search for knowledge and solutions while also adhering to the ethic of accountability; that good and creative science is not only possible, but perhaps only possible, in the context of addressing the great problems of human society.

The management of research has thus evolved into an high art-requiring the ability to identify talent and then to create the climate for bringing out the best that the human imagination and intellectual discipline can achieve. Research management must see to it that the canons of scientific excellence are satisfied in conjunction with the observance of accountability criteria.

This is no easy task. We, in the Congress, are fully aware that quality research can not simply be legislated. You, in the forefront of research management, know that you cannot coerce or exhort the invention of theory, the perfection of method or the refinement of practice. Scientists, regardless of what stage they have reached in their careers, must be given the freedom to try themselves and to risk a break with traditional styles and habits of thought. We have all learned to recognize that the ultimate potential in ideas whose practical utility may not yet be readily apparent is sometimes very great. Such explorations must be undertaken cautiously but not conservatively. However, speculative investments of this nature are becoming harder to justify in the context that "accountability" is currently defined. The National Science Foundation has just released its study on "The State of Academic Science" in which it has drawn some disquieting conclusions on what is happening to university research. It appears that many research managers are playing it safe and not taking what might be remotely termed as "magnificent" chances on long-shot investigations. Support for basic theory or method building is drying up and reporting requirements of the funding sources may be unnecessarily encumbering if not constraining scientific inquiry.

I suspect that much of this can be attributed to an over-emphasis on the engineering of solutions for the short run- a proper concern which may have reached exaggerated proportions. The unintended and perhaps unforeseen result may be that we are now seriously diverting scientific talent away from the longhaul objective of broadening our knowledge base in many fields.

For example, we think that this might very well be the cause of problems with federally sponsored research into crime and the criminal justice system. The DISPAC subcommittee has been studying this issue and is about to hold hearings on it later this month. A soon-to-be published study by the National Academy of Sciences suggests that the LEAA research program was simply overwhelmed by demands for short-range solutions from its parent agency as well as from departmental and congressional sources. The National Institute of Law Enforcement and Criminal Justice (NILECJ) has been subjected to these pressures throughout most of its eight year history. All we know is that, in the process, something happened to discourage top scientific talent from wanting to participate. The cost, although not entirely clear, will probably be calculated in terms of precious time lost in developing a sorely needed understanding of criminal behavior and the social mechanisms needed for controlling it.

The Department of Justice is currently reviewing the entire Law Enforcement Assistance program and legislative proposals for restructuring the federal effort to improve the criminal justice system are being considered in the Congress. This moment of reconsideration has provided DISPAC with an opportunity to assist in the deliberations, specifically with regard to the research, development and technology transfer aspects of the program. Most importantly, we will try to formulate some sound and workable recommendations for putting research in this socially critical area back on the right track.

The DISPAC subcommittee is in the process of organizing six days of hearings in mid-July on the related topics of (1) nutrition surveillance and monitoring and, (2) nutrition research priorities.

In the area of nutrition surveillance and monitoring we will concern ourselves primarily with the extent to which the federal government (most notably the Departments of HEW and Agriculture), state governments or agencies, and non-governmental organizations are engaged in nutrition surveillance and monitoring. The information gathered in a surveillance program provides invaluable baseline data which can be used to justify the establishment, continuation and/ or modification of nutrition intervention programs.

The DISPAC hearings will also examine nutrition surveillance and monitoring efforts outside the United States, in an effort to determine whether other nations have developed more effective and systematic methods. If so, we are interested in whether these approaches can be adapted to conditions and needs within the United States. The data acquired from other nations could be used to judge the justification of continuing and/or modifying nutrition intervention programs in nations receiving or requesting U.S. aid.

Last year, the Senate Select Committee on Nutrition and Human Needs published a report entitled "The Role of the Federal Government in Human Nutrition Research". It concludes that the human nutrition research conducted by the federal government is inadequate, "particularly in light of the increasing challenges confronting nutrition science".

Since the publication of this comprehensive report, several individuals and agencies have conducted their own analyses in this area. The DISPAC oversight review will seek to highlight these findings and expand the area of discussion to include non-governmental efforts in human nutrition research in the U.S., and elsewhere, and then offer some recommendations.

We are also starting an extensive review of health care delivery systems and the degree to which new technological innovations can affect the quality and particularly the affordability of health care. For example, to what extent does the proliferation of computer systems for handling patient care and hospital management information add to or help control spiraling health care costs? More generally, we hope to examine what measures can be taken to redesign our national health care delivery systems to make them more responsive to public need.

In each of these several areas, the subcommittee has been addressing one or another of its oversight concerns. With respect to criminal justice research, it involves the question of how to direct federal support to accelerate growth in this long neglected field, how to reach an acceptable balance between knowledge building and solution-oriented investigations. In the food and nutrition field, it is a question of focusing research strategies and ensuring the utilization and expansion of the considerable body of knowledge already available. In looking at health care delivery systems, the focus is on the various impacts of the application of advanced technology in obtaining improved effectiveness and cost containment.

The Congress is faced with the persistent question of how to fashion, or refashion, the conditions under which federal support is granted in order to foster rather than frustrate a vigorous growth in all science and technology development. In doing so, it recognizes that the manner in which scientific inquiry is conducted has gradually evolved from the isolated scientist in his laboratory to highly developed research teams often crossing several disciplines, and encompassing a number of research organizations. Frequently, an investigatory effort will span the continents. In the process, research operations have become increasingly bureaucratized and frequently suffer the same encumbering effects which other large bureaucracies experience. It is no wonder that directors of research programs look to the industrial experience and to some extent the management sciences for clues as to how to orchestrate such complex activities. The temptation is to divide things up into discrete objectives and milestones in order to establish a series of benchmarks against which "progress" can be measured.

Although often useful, this approach can also create the hazard of suppressed creativity; departures from the present path of research objectives becomes difficult; and each foray into unanticipated though promising avenues of research must be thoroughly justified. The result may be overcautiousness with the accompanying effect of retarding knowledge.

A major solution to the narrowing effects of bureaucratized research is the continued and substantial investment in basic research together with the encouragement of gifted theoreticians and methodologists who are acutely atuned to the practical implications of their discoveries and those of others.

The world of science and technology is not, of course, simply partitioned into a cadre of detached abstract thinkers and contract-hungry research-marketing labs. I would hope that all of us whether articulating national policy or implementing it at the research action level will do all in our power to see to it that this does not occur. A special kind of wisdom is needed in our search for the optimal mix between applied and basic research that is publicly supported. Society must be directly served by the former and ultimately by the latter. All congressional representatives will continue to rely on your help. I sincerely hope that some measure of that special wisdom will emerge from your deliberations at this conference.

MANAGEMENT OF JOINT PROGRAMS FOR ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION

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INTRODUCTION

It is important that the United States effectively employ science and technology to address the complex set of issues collectively termed "The Energy Crisis". New technology must be provided in a timely fashion and on an adequate scale to permit the identification and development of additional energy resources and the efficient conversion and application of these resources in ways that society will accept. Furthermore, there is an urgent need to provide the basic knowledge that will enable us to understand the full consequences for society of employing new energy technologies.

Particularly as evidenced by the establishment of the Energy Research and Development Administration, the Federal Government has assumed a major role in providing energy alternatives similar in some respects to the role it has already played in development of technology for national defense, public health and space exploration. However, a crucial difference between these programs is that in the case of programs to develop new energy technologies the Federal government is replaced by the private sector as the principal user of the results. Thus it is recognized in ERDA plans[1] "that the private sector and market forces are the most efficient means of achieving the Nation's energy goals." As a consequence, the three part Federal role is one of establishing an appropriate policy climate for action by the private sector, of sharing risks with the private sector and of conducting a program of research, development and demonstration that <u>complements</u> that of the private sector. The "appropriate policy climate" includes, of course, an ample measure of regulation. Risk sharing has thus far only extended to loans to open new coal mines and guarantees of loans for geothermal development. The most impelling aspect of this policy is the program of RD&D since this has resulted in the Federal Government (together with a relatively few State governments and some utility industries and industry associations, such as the Electric Power Research Institute (EPRI) and the Gas Research Institute) becoming a dominant source of funds for research and development in many areas previously funded largely by natural resource and equipment supply industries.

Thus the environment for the management of energy RD&D is one in which new technology development and basic research are substantially funded by government agencies, by user groups, and by industry, and performed by government laboratories, universities and colleges, nonprofit laboratories and industrial research, development and engineering groups. The challenge to management is to operate in this environment so as to elicit effective contributions from each institution. The measure of success will be the adoption by the private sector of new energy technology and its acceptance by society. The urgency and complexity of the tasks to be done indicates the need to re-examine some of the lessons that have been learned regarding factors that make for successful commercial innovation[2,3] as well as for the successful accomplishment of sponsored development of complex new technologies.

The balance of this paper will concentrate on aspects of the development of new technology. It is not implied that management of programs intended to provide an understanding of environmental, economical, and societal impacts of new technology is regarded as any less important a challenge. However, the output of such work goes directly to the user, a regulatory agency, in most cases. It is this agency that provides the principal integrating function in the program. Therefore, the institutional complexity of such programs is substantially less than of programs leading to the commercialization of new technology.

NEW TECHNOLOGY - THE INNOVATION PROCESS

The concept of innovation as a complex social process resulting in a new product, process or procedure has achieved almost a hallowed status among those concerned with the theory of technological change. Figure 1 is a greatly simplified way of representing the elements of the innovation process. Another way to think about the implications for management of this process is to personify the functions: a researcher provides the knowledge pool, an inventor creates the new concept, an entrepreneur (an advocate or risk-taker) sees the need or opportunity for the invention and commits to realize that opportunity, the developer reduces the idea to a workable process or product that can be economically and reliably produced, and a marketer finds those who will pay to obtain the new product or service and delivers it to them. These may all be the same individual if the innovation is a small one. However, apart from the area of conservation, most new energy technologies are of a scale that requires groups of specialists with differentiated roles. The vision and enthusiasm of the entrepreneur must be passed along this human chain together with the knowledge gained at each step. The process is described as one of transition. For those

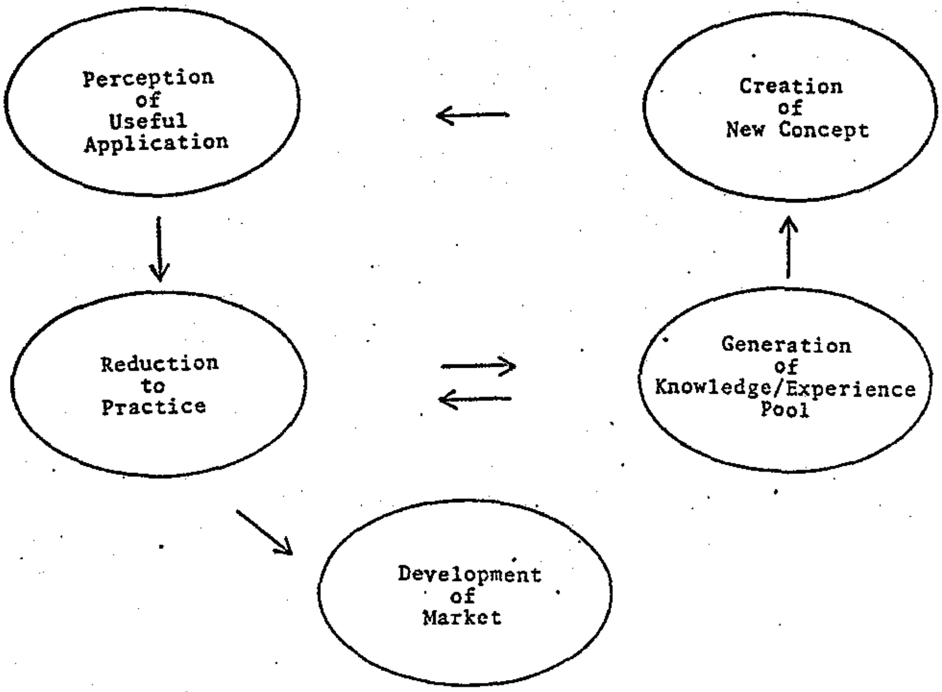

Figure 1: Elements of the Innovation Process

INSTITUTION	KNOWLEDGE/ EXPERIENCE POOL	NEW CONCEPT	APPLICATION	REDUCTION TO PRACTICE	MARKET DEVELOPMENT
	CONTRIBUTION TO INNOVATION PROCESS				
• GOVERNMENT					
– AGENCIES	0	+	++	+++	++
– LABORATORIES	++	+	+	+	0
• UNIVERSITIES/ COLLEGES	+++	+	+	+	0
• INDUSTRY					
– SUPPLIERS	+	+	++	+++	+++
– USERS	+	+	++	++	+++
• NONPROFIT LABORATORIES	+	+	+	+	0

Figure 2: Institutional Setting for Energy Technology Innovation

involved in managing innovation in a large corporation, the accomplishment of a transition to commercial use is the most important and difficult task they must perform.[2] In fact a number of companies have sought to avoid the problems of transition by creating dedicated teams for each new product to accomplish all the phases of innovation. This approach may be appropriate in the development of new energy technology within a single firm. However, if other performing groups become involved in the program the problems associated with transition are bound to occur. Some of these problems and approaches that sometimes solve them are briefly considered below.

With regard to the institutions involved in the innovation of new energy technology, Figure 2 provides a qualitative evaluation of the appropriateness or capability of an institution to contribute to each phase of the innovation process. The dominant role of industry in the reduction to practice and development of a market should need no further comment. The relatively important part assigned to Government agencies in the market development phase refers to the effects of regulation in providing a "demand pull" for innovation while the reference in earlier phases is both to the "technology push" of funding and to the part that individuals in government agencies play as channels for diffusion of information from one program area to another.

With regard to universities and colleges the role that has been conventionally assigned is one of generating the basic knowledge from which an inventor draws the facts needed in his creative synthesis. This basic knowledge is diffused to potential inventors by publications, talks and by "carriers", frequently researchers who move from one institution to another. In this model the important function of government or industry is that of providing the support needed to prevent the knowledge pool from drying up.[3] Without minimizing the importance of this aspect of university/college involvement in the innovation process, I suggest that this is an incomplete view and in fact, with respect to the development of new energy technology, misses one of the key opportunities in the innovation process. In particular, during the reduction to practice and market development phases there will frequently be requirements for providing additional basic understanding in specific areas. This is an important function that industrial research laboratories perform in relation to established products and processes. Fundamental investigations into the mechanical and corrosion behavior of alloys and ceramics, the chemistry and physics of high pressure reactions, and aspects of fluid flow and solid mechanics provide examples. Requirements for additional basic knowledge become apparent, sometimes painfully so, in the course of developing a complex new technology. Academic, government and nonprofit laboratories frequently have exactly the technical capabilities required to provide this knowledge. To become effectively involved in ongoing, engineering developments leading to commercial products is not generally a familiar undertaking for these institutions. Industry, with its ultimate responsibility for delivering the new technology to the market place, must provide the leadership required to bring about the integration.

The involvement of non-industrial laboratories in development programs creates some obvious problems requiring management resolution: restrictions on publication of results, treatment of proprietary background data, and ownership and disposition of patent equities. If the work is sponsored by a government agency or industry association, the contractual form of that sponsorship frequently spells out an acceptable range of solutions to these problems. If in addition there is proprietary work sponsored by the industrial performer, then separate agreements between the two performing groups must be obtained. Reaching agreement can be time consuming because of mutual unfamiliarity with each other's requirements and/or unrealistic initial expectations. The delay can be a source of great frustration to the manager whose program urgently requires the new information and insights.

More subtle and potentially more injurious problems arise from the nature of the organizational and, frequently, geographical setting. Experience in large corporations that carry out innovation has shown that organizational and physical separation are severe barriers to effective transition of R&D developments, and in fact that only one of these can usually be tolerated with any reasonable expectation of achieving success.[5] By analogy one would conclude that to be effective the industrial and non-industrial performers should be physically in very close proximity. Thus not only is industry likely to be more familiar with the qualifications of local non-industrial laboratories, but also the management will regard local associations as being more likely to be successful. However, there are enough exceptions to this "local rule" that it must be true either that managers ignore the problems or that they have found ways to overcome them. In fact within industry, the management of the funds for the program provides a number of opportunities for overcoming the problems of geography and organization.[2] One mechanism is to provide the industrial laboratory from which information is to be transferred with control of a significant portion of the funds needed by the receiving group. The device of placing control of a substantial portion of <u>development</u> funds in the hands of a non-industrial laboratory with the requirement that these funds be committed to work on the program in an industrial laboratory has been employed in at least one case with some apparent success.[6]

I would exclude from this category instances where a non-industrial laboratory is providing the management for programs that are seeking to establish scientific feasibility, e.g., the Princeton University and University of Rochester fusion research programs. In such programs industry has the very important role of providing the massive and sophisticated equipment needed in the experiments, but not that, as yet, of developing a product for commercialization.

In addition to the problems of geography and organization, there are fundamental problems of communication inherent in the management of joint programs of industrial and non-industrial groups. These have been categorized as technical, perceptual and value barriers.[2] The third category, that of barriers created by differences in values of the communicating groups is potentially the most difficult one for the management of joint programs. In particular, the industrial management will place a high value on meeting schedules, if need be to the detriment of producing a publishable piece of work. The scientists desire to replace empiricism with understanding will be in conflict with the need to choose a course of action and follow through on the choice. If a product for the commercial market is to be developed the industrial manager will place as his most important <u>single</u> criterion of achievement the profitability of the ultimate product, subject to constraints of societal acceptability. This may be in conflict with the criteria for achievement, e.g., contribution to human knowledge, that are applied to work in non-industrial laboratories. Other than to recognize that these barriers exist, it is difficult to provide any generalization about dealing with them. Obviously, the effective management of joint programs requires attention to factors that provide a commonality of knowledge and viewpoint: frequent and productive personal interactions, and equality of status of the participants, recognized need for timely results by the recipient and a mutual commitment by both participants to the success of the effort. Application of the useful rule-of-thumb, that transitions occur at the same technical level between organizationally separated groups, is potentially helpful. A consequence with regard to the organization of joint programs is that if the non-industrial participant is providing research results, there must be a research function in the industrial participant's group to receive and translate the results.

JOINT PROJECTS AND ALTERNATIVES

The term "project" frequently refers both to a set of tasks, completion of which results in a agreed upon objective, and to a particular way of planning, organizing and measuring to accomplish the tasks. The project approach has become a dominant means of delivering advanced technology to the government and a very important device for carrying out commercial innovation. Thus the widespread application of the methodology of project management to the development of new energy technology is readily understandable. However, this methodology, combined with the mechanics of government procurement, creates situations that are alien and perhaps detrimental to organizations primarily concerned with research.

The contrast between the characteristics of a project organization and a research or academic department is revealing. Thus a project organization is a transient one, called into existence for a spacific objective that has a measurable completion point. A number of different skills and disciplines are usually required to accomplish the objective. The organization must complete the specified work within a fixed time and subject to definite budget constraints. For the manager the uncertainty in the actual time and costs needed to complete the individual tasks can be very great in the beginning, leading to need for mid-project adjustments that may take the form of urgent demands upon or even termination of the work of participants. Because the goals of the project's sponsor may change, factors unrelated to the technical results of the project can result in its termination at any time prior to the agreed upon completion point. Finally, the project must end and the individuals groups involved must have some other work to do.

The same characteristics that result in strenuous demands being made on participants in development/demonstration projects can also result in considerable satisfaction for the participants. Since the project objectives are clearly defined, there is usually no doubt whether or not the project team has succeeded. The segmentation of tasks permits one to know, and to have others recognize, when an individual has made a contribution. Because of the relatively short duration of most projects, the response to an individual's work usually follows quickly on its completion. This rapid feedback to participants, combined with a sense of group accomplishment in overcoming barriers can provide a powerful psychological gratification. Finally, if the project was a well conceived one, the tangible result will be a new device or method that people will use to improve the quality of human life.

Compared to the turbulent organizational setting of projects, circumstances in a discipline oriented department are relatively quiet. Such organizations characteristically have a steady state existence employing people with a relatively limited range of disciplines to provide a set of continuing services. These services are provided at a level determined by a budget ceiling. The annual expenditure rate is usually quite precisely known, based on the number of people in the department. Why then would a person in a department want to become part of a project organization? The correct answer to this question is, I believe, that the project organization, for all its imperfections, is the most effective way to develop new technology. If one wants to contribute, becoming involved in a project will permit the individual to maximize the probability that his effort will lead to something useful. However, from the viewpoint of the project manager, it is essential that the participants conform to the requirements of the project and not that the project adapt to the organizational needs of the departments. Thus, the decision to enter into a development project is not one that a non-industrial laboratory, particularly at a college or university, should make without provision for the many contingencies of such participation.

It is not the purpose of this paper to present a review of the characteristics and techniques of project management.[4] However, there are some aspects of the events that occur before a contract is awarded which deserve attention because they are critical to the establishment and maintenance of an effective team. The general scheme for supporting development of a new energy technology is to execute a formal contract between a single or lead organization and a sponsor. These contracts can be awarded on a non-competitive basis, but especially as their scope is concerned with development and demonstration, they are awarded only based on responses to formal requests for proposals (RFP's). To provide additional flexibility, procurement forms such as program opportunity notices (PON's) and program research and development announcements (PRDA's) are also in use. While there are important differences among them, the general sequence of events associated with an RFP, PON or PRDA are about the same. Preferably in advance of the issuance of the procurement announcement, sufficient information about the intentions of the agency are available that a general idea of what is being sought is known. Someone must identify the opportunity as being important and must make the contacts that can lead to the formation of a proposal team. It is during this stage, the preproposal effort, that most opportunities for establishing joint programs are missed. Once a decision to submit a proposal has been made and the proposal team formed, a brief period of intense effort is usually required to develop a sound technical approach, define a statement of work, make task assignments to participating organizations, agree upon schedules and budgets, formulate a management plan, and put the proposal in a format that will assist the reviewers to recognize its merits. None of this effort can be charged directly to the final contract, even if a contract is received. Following this very active period, there is a variable interval during which a decision among competitive bids is made by the sponsoring agency. The successful bidder than has to negotiate a final work statement, contract terms and conditions and, depending on the type of contract, a fee and/or form of cost-sharing. Problems of patent rights, treatment of background data and acceptable auditing procedures are among the issues that can delay these negotiations for months or even totally prevent agreement. After this period of technical inactivity, the signing of a contract is the signal for sudden and often intense effort to meet a demanding schedule.

For most development programs it is appropriate that an industry supplier lead the team effort, while for demonstration programs it is often a user industry firm that plays that role. In either case it is likely that the proposal manager in the lead organization may not initially have a clear idea of the nature of fundamental work needed to support the development program, or of the people in non-industry laboratories who could contribute most effectively. The mechanism of cooperative agreements between ERDA and universities and colleges as well as the activities of the ERDA Office of University Programs should contribute to improving the mutual awareness among potential participants in joint programs. Increased or sustained academic involvement in major reviews of development and demonstration programs should also be an effective means of creating the connections needed to form optimum project teams. After a project is under way, deficiencies in the composition of the original team may be rectified by obtaining change orders to the contract. However, the procedures involved are frequently so cumbersome that some other mechanism, such as one of the alternatives discussed later, is often employed. The discontinuous nature of the pre-contract events can be a source of considerable difficulty for management. It is compounded in the case of a university by the circumstance that a student's progress proceeds more or less independently of the contract process, resulting in the non-availability of a planned contributor at the time the contract work starts. Post doctorals whose support is contingent on a contract may become an unsupportable burden to the department or individual faculty member in the event of delay in award of the contract. It is small comfort that industry has analogous problems on a larger scale, for which no general solution has been found except the layoff. Providing for these contingencies must be an important consideration in arriving at a decision to join the proposal team.

The principal alternative to direct participation by the non-industrial laboratory in a development project is the establishment of a separate project funded either by the industrial team leader of the project sponsor. Most commonly these result from the mid-project recognition of one or the other that additional fundamental understanding of an aspect of the development project is needed. Such separate projects avoid some problems for the non-industrial participant; chiefly those associated with the proposal preparation and pre-contract award uncertainty. This simplification is obtained at the cost of increased difficulty in information transfer and, perhaps, in commitment and timely contribution by the non-industrial participant. Three examples of parallel supporting projects carried out by non-industrial participants will be considered in a later section of this paper.

The functions of parallel investigatory projects in support of development programs should not be confused with those of the university centers of specialization funded by ERDA, e.g., for coal science technology and superconducting electrical machinery, nor with the lead-laboratory concept applied to government-owned contractor-operated laboratories (GOCOL's) by ERDA. These are intended to contribute to the knowledge pool at the front end of the innovation process rather than to accelerate particular development programs. Inevitably, however, it will be to these institutions that industry proposal and project managers will turn in seeking specific skills to complement their projects.

EXAMPLE: A NEW BATTERY TECHNOLOGY

Advanced battery technology for stationary and vehicle applications is a key to more effective use of electrical generating capacity and to a shift in fuel from petroleum or natural gas to coal and uranium. Advanced batteries may also provide one of the elements needed to make economically accessible the intermittent energy sources such as sunlight and wind power. Thus, there is a substantial national effort by government, the electric utility industry and equipment manufacturers to develop one or more new types of batteries to meet these requirements.[7]

One of these is the sodium-sulfur battery which in one design makes use of cells containing (in the charged state) sodium and sulfur, separated from one another by a ceramic material called beta-alumina and operating at 300-350°C. To be economical these cells must operate without failure for about 10 years or 2500 charge-discharge cycles. This life requirement places stringent demands on the materials used in constructing the cell and particularly on the beta-alumina ceramic. It is the remarkable sodium ion conductivity of this ceramic, combined with its chemical stability and physical strength that permit sodium-sulfur cells of this type to operate at all. It was the rapid loss of one or more of its properties by the ceramic, sometimes after only a few cycles, which caused the pre-1975 performance of the test cells in some laboratories to be unsatisfactory. In addition to the performance limiting aspect of the beta-alumina, the cost of preparing ceramic tubes for batteries is a consideration in the ultimate cost to the user. A powder must be processed into a greenware that can be sintered under industrially practical conditions. The process must be capable of ultimately being scaled up to permit the annual production of millions of tubes of uniformly high quality. Thus considerable attention has been directed by those developing sodium-sulfur technology to the structure-property-processing relationships of beta-alumina ceramic.

There are presently two major programs in the United States aimed at demonstrating the engineering feasibility of sodium-sulfur technology based on beta-alumina ceramic. One of these is a program managed by the Ford Motor Company with the University of Utah and Rensselaer Polytechnic Institute as subcontractors. This effort evolved from a Ford program to develop an electric vehicle battery that began in the early 1960's with the discovery of the properties of beta-alumina. In 1973, the National Science Foundation undertook the financial support of the program under the aegis of the RANN Program. It was at this point that Utah became part of the project team, assigned specific tasks concerned with the processing and properties of the ceramic. A faculty member was named project manager at Utah with Ford providing the program managership. The basic arrangement has persisted through the assumption of financial sponsorship by ERDA, as the result of a competitive procurement, in 1975. This is an interesting example of a form of project team participation rather different from envisaged earlier in this paper in that the non-industrial participant is responsible not only for providing whatever basic knowledge may be needed regarding the ceramic but for transferring that knowledge into practice to deliver finished tubes that are used by other members of the development team. This internalization of the interface between fundamental investigations of the physics and chemistry of the ceramic and the process development and production has undoubtedly facilitated progress, which has been excellent. The increasing requirement to scaleup the process, requiring an investment in equipment, and presumably, the hiring of production workers, to produce the tens of thousands of tubes needed in the Ford program is likely to introduce some strains into the project. It will be instructive to follow the evolution of this program as an ongoing experiment in the management of joint development programs.[8]

In 1967, investigations of the inter-relationship of structure, composition and properties of beta-alumina were started in the General Electric Company. By 1970, this work focussed on demonstrating the scientific feasibility of a sodium-sulfur battery for utility energy storage. In 1973, a program was undertaken under sponsorship of the Electric Power Research Institute to develop a practical sodium-sulfur battery system for utility load levelling application. A critical milestone in the program will be the building and operation, by 1981, of the 5 MWh test battery in the Battery Energy Storage Test Facility. This facility is now being constructed for EPRI and ERDA by the Public Service Electric and Gas Company of New Jersey.

Because of the early emphasis of the General Electric program on the fundamental properties of beta-alumina, the project team formed in 1973 relied on this knowledge to guide the ceramic development. However, as cell test results were obtained, it became apparent that significant additional improvements in the physico-chemical properties of the ceramic ware were needed. In addition to increasing the in-house ceramic effort, possible participation by non-industrial laboratories was considered. Three relatively small projects at universities were undertaken. Because circumstances and results in each case were quite different, it is instructive to consider each separately.

<u>Project A</u>: This originated with a personal contact between a General Electric research worker and a relatively new faculty member at an eastern university. The latter was interested in obtaining support for his work and was considering EPRI as a possible source. After several visits to the General Electric laboratories, the faculty member, who had no previous experience with beta-alumina, prepared a draft proposal which was informally commented on by General Electric people at EPRI's request and modified prior to submission to EPRI. The General Electric workers wanted to direct academic attention to beta-alumina for the reasons already stated. EPRI was sponsoring several programs which depended on the performance of beta-alumina for their success. The proposal was processed through the contractual procedures of EPRI and the study was rapidly begun. To prepare the specimens required for the study, the university researcher employed an approach to sintering the powder that gave quite interesting results. This information was communicated to General Electric with EPRI's approval and to EPRI who disseminated it to other groups employing beta-alumina.

Project B: At about the same time that Project A was in the conceptual stage, the EPRI program manager was approached by a faculty member at a western university with a proposal for research on a radically new way to fabricate beta-alumina tubes. This idea was discussed by EPRI with the General Electric team, among others. There seemed to be sufficient merit in the approach, that the decision was made by EPRI to fund the project. The work was carried out under the direction of the faculty member who submitted periodic and final reports. Several unexpected phenomena were observed but the results have had no observable effect on the overall battery development program. One possible significant difference from the circumstances of Project A was that there was virtually no interactive communication between the university workers and the General Electric team.

Project C: This project, funded by General Electric, was undertaken by a young faculty member and a post-doctoral at an eastern university. The impetus for this work came from recognition that while considerable pragmatic work had been done in sintering beta-alumina, no one had been able to develop a fundamental understanding of the mechanism of sintering beta-alumina in the absence of a liquid phase. Because there exists a close contact between General Electric workers and leading academic workers in the field of ceramics, it was possible to quickly identify an appropriate investigator to undertake this work. The technical approach was also agreed upon quickly. Several months were to pass in negotiation over contract clauses. Then there was further delay because the post-doctoral had become deeply involved in other work. When the faculty member and post-doctoral analyzed the problem as defined for them, they identified several factors, the control of which produced high density beta-alumina without a liquid phase or other additives. However, this ceramic contained large grains which made it undesirable for use in sodium sulfur cells. The results suggest several further lines of investigation relating sintering rates to microstructural changes.

Only Project A thus far has influenced the overall program to develop a practical sodium-sulfur battery. A key element in this was the close communication, at the request of EPRI, between people in the university and the General Electric team. Neither of the other two projects have directly furthered the objectives of the sodium sulfur battery development. In the case of Project B, it is probable that even if there had been technical success within the terms of the contract, the chances of contributing to the goals of the program were slender. In part this judgement is based on the arms length way in which the work was related to the development projects and in part on the timing---the receptive moment for affecting the direction of ceramic development had probably passed by the time the project was well under way. The results of Project C has focussed the attention of General Electric workers upon certain characteristics of the starting powder which have significance for the properties of the sintered ceramic. In addition, the basis has been laid for analyzing a whole class of ceramic problems which may yet contribute to the front end of the innovation process.

CONCLUSIONS

It is vitally important that our scientific and technical institutions be effectively employed to address the issues raised by the "Energy Crisis". With respect to the development of new technology, the environment is one in which the Federal Government and certain industry associations sponsor work intended to lead to commercialization by industry. In providing the lead for development of new energy technology, industry can most effectively integrate the work of the other institutions through forming project organizations. This management device may results in some difficult administrative problems, particularly for universities and colleges. Careful, case-by-case analysis during the formation of the project team will be needed to make the project approach acceptable. A key problem is that many opportunities for team formation are missed during the preproposal stage. ERDA actions to inform universities and colleges concerning current programs should increase the prospects for the timely formation of appropriate teams. Experience with innovation in large corporations suggests that management problems arising from geographical and organizational separation among team members can be expected. The barriers to communication between industrial and university team members are likely to require particular attention. Management's success in resolving these and other problems will be measured by the adoption and acceptance of new energy technology by the private sector.

6/77

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MANAGEMENT-BY-OBJECTIVES FOR RESEARCH: A CONTINGENCY APPROACH

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During the last decade, managers of research and development (R & D) organizations have come under greater pressure to demonstrate the value of R & D activities. Top corporate officers, in the private sector, are raising tougher questions about the payoff from research. In the public sector, both members of Congress and officials in federal agencies which fund R & D are raising similar questions. Whether this inquiry results from a national loss of faith in science and technology or from real shortcomings in the productivity of R & D organizations is a debatable issue. What is not debatable is that the era following Sputnik, which was characterized by rapid growth in total U.S. expenditures for R & D and by relatively high levels of autonomy for organizations performing R & D, is over. Since 1970, total public and private expenditures for R & D have increased at about the same rate as the cost of living. Officials who control appropriations are asking R & D organizations to show that they are pursuing appropriate goals and are being managed effectively.

These had questions have caused R & D managers to consider Management-By-Objectives (MBO). MBO is acclaimed as a managerial system with the potential to focus an organization's efforts on important goals and to reach those objectives in an efficient manner. Therefore, it is not hard to understand why MBO systems have been adopted by a number of R & D organizations including Texas Instruments, Tennessee Eastman, NASA and Oak Ridge National Laboratories. Yet, the use of MBO for R & D remains controversial. Underlying the controversy is the contention that R & D organizations are somewhat different from more conventional organizations and need to be managed differently.

The discussion which follows is based on a study of MBO application at Oak Ridge National Laboratory, conducted by Rich Arvey and myself. Before discussing the study, it seems apprpriate to briefly discuss MBO, along with the underlying theory and research.

WHAT IS MANAGEMENT-BY-OBJECTIVES?

Management-By-Objectives is both a philosophy and a system of management. The basic philosophy comes largely from the work of Peter Drucker,[1] who suggested that every manager should have clear objectives which spell out what each managerial unit is supposed to achieve. In Drucker's view, MBO should help to shift the focus away from what the boss demands to what the job demands. By having each manager determine his/her own objectives (subject to approval or disapproval by the boss), the method and focus of control is shifted away from domination by the boss toward self-control by the individual. By setting his/her own objective, the individual presumably makes a stronger commitment to meet the objective than if someone else set it for him/her. In addition to clarifying the manager's job, MBO was also seen by Drucker as a means for managers to evaluate their own performances on the basis of how well those objectives were met rather than to rely solely on the boss to indiciate pleasure or displeasure.

Drucker's philosophy could be described as liberal in the sense that it emphasized McGregor's Theory Y[2], which posits that people want to contribute, to be responsible and to achieve. A somewhat different approach to MBO can be found in writers such as Schleh[3] and Odiorne[4] whose approach expands the role of the supervisor both in determining the objectives and in evaluating employee performance. These writers also place more emphasis on quantitative measures of performance.

The applications of MBO seem to vary greatly. Carroll and Tosi's[5] study of one organization shows that some subordinate managers simply were informed about the objectives program. Next, each subordinate was handed a list of "his" or "her" objectives previously prepared by the boss. Within the same organization, other superiors first held a meeting in which general departmental and organizational goals were discussed. Later, subordinates prepared a list of objectives and target dates which became the basis for an objectives setting session between each subordinate and his/her superior. Thus, MBO varies both in theory and practice between a participative process in which subordinates are deeply involved in setting objectives and a fairly authoritarian system by which superiors impose their objectives on subordinates. Either way, the process involves a number of different steps shown in Chart 1.

1. The setting of overall organizational goals which provide a framework within which objectives for individuals can be set.
2. The communication of overall goals and direction to subordinates.
3. The mutual involvement of superior and subordinate in discussing goals and setting objectives with target dates for the subordinate.
4. The evaluation of performance based on how well the objectives are met.

From the fairly simple ideas suggested by Drucker, MBO with time became more elaborate, including work planning and evaluation steps as shown in Chart II.

It should be noted that MBO is not universally successful. It is estimated that about one third of all attempts to install MBO never get started, about one third start fairly well but fade away and the remaining one third continue. Those which do continue are characterized by a trial and error process in which the organization adapts MBO principles to its particular set of tasks and people.

It is also important to note that there is a fairly extensive body of research on the relationship between the setting of objectives by individuals and their work performance. These studies,[6] although conducted in a laboratory setting rather than as an ongoing organization, indicate that:

-people who set goals will generally outperform those who simply try to do their best.

-setting goals for people will increase performance if they accept the goals. Participation in goal setting helps increase acceptance.

-people will set goals above current levels of performance. Feedback, or knowledge of results improves performance, apparently because it is used to set new goals. This is true only if the feedback is specific. Vague feedback does not help, and will reduce performance levels if it is negative.

THE MBO STUDY AT ORNL

So much for background. Let me now shift and discuss the study. One of the early conclusions of the study of Management-By-Objectives that Rich Arvey and I conducted at Oak Ridge National Laboratory was that traditional MBO - the full blown system - is not appropriate for research and development organizations. A major reason for this is that the high levels of uncertainty and dynamic nature of research make the setting of quantifiable objectives with specific target dates unrealistic. Additionally, evaluation of performance based on how well one meets ones objectives creates great pressure to set easy, low risk objectives. Obviously, this is not conclusive to productive research climates.

Recall, however, the wide differences in MBO philosophy and practice noted earlier. Also recall that most successful applications of MBO resulted from a trial and error approach to adapt MBO to the situation in a particular organization. All this suggests a contingency approach to the application of MBO to R and D organizations. The contingency approach is based on the idea that there is not a single "one best way" or optimum way to manage organizations. The best way to manage any organization depends on the particulars of the <u>tasks</u> which the organization must accomplish and the <u>people</u> it has to work on those tasks.

I would like to suggest that while traditional full blown MBO systems may not be appropriate, certain features of MBO do make some sense for R and D management. As an example, I would like to share with you some of the data from our study. Our study included both research and development personnel. The major differences between tasks and people are shown in Chart 3. As can be seen Research tasks are more uncertain, less programmable, less likely to involve several disciplines and smaller in magnitude than development projects.

Now let's look at performance of a number of research sections (8) and development sections as related to the most critical dimension of MBO - setting and clarifying of objectives by supervisors. In Chart 4, the group performance rating (which is a composite rating by the section head and the division head) is plotted against the working level engineers and scientists perceptions of the degree to which supervisors clarify objectives. What is most apparent is that group performance for development tasks is positively related directly to the degree to which objectives are made clear by supervisors. For the research sections, a weak negative relationship appears to exist. It is also noteworthy that the average clarity of objectives score is higher for development tasks than research tasks.

The results from the development sections are in agreement with a management-by-objectives approach. The results from research sections are not. These are two reasons why this might be so. The first is that we may have cause and effect mixed up. One of the strong norms associated with science is autonomy for the individual researcher. Interviews with managers in this organization indicated a very clear tendency among research managers to allow considerable autonomy for the most productive researchers and to supervise more closely and direct more extensively the activities of less productive researchers. Thus the negative relationship may result from this relationship:

poor performance --> closer supervision --> perception of high goal clarity by subordinate rather than this one:

high goal clarity --> poor performance

I believe that if I could separate out this closer supervision effect, the research line would tilt upward, but not as strongly as the development line.

The reason for this is not that goal clarity is somehow wrong or unproductive for research tasks. As one of the managers interviewed in the study commented, "The basic idea behind MBO is really implicit in the scientific method, but somehow it seems doubtful if the organization can do it for the researchers - he has go to do it himself." It seems to me that this is essentially correct. The researcher must do it himself - and he will be more productive if he does. If he does, then an organizational system to set, or encourage the setting of objectives, is largely redundant.

An interesting area for further study would be an examination of goal setting practices by researchers to see if there are differences in productivity. John Platt, writing in Science over a decade ago, indicated that high rates of progress in certain disciplines resulted from the fact that they trained people to think about objectives and to plan their investigation to critically test the basic theory involved.

In closing, I would like to say that my study does not say that the manager or the organization should ignore objectives. A lot of research is, in fact, development - and here the importance of objectives is demonstrated. Also, any organization which has a mission should broadcast that mission widely and often, loud and clear to its researchers. It is they who must operationalize the mission in terms of specific projects and specific objectives, but it cannot happen unless they know what the mission is and are required to justify their work in terms of the organizational mission.

FOOTNOTES

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[6]See, for example: Locke, E. A., Toward a theory of task motivation and incentives. Organizational Behavior and Human Performance, 1968, 3, 157-189.

CHART 1

MAJOR ELEMENTS OF MANAGEMENT BY OBJECTIVES

- SETTING OVERALL ORGANIZATIONAL GOALS WHICH PROVIDES FRAMEWORK FOR INDIVIDUAL GOALS
- COMMUNICATION AND DISCUSSION OF GOALS THROUGHOUT THE ORGANIZATION
- MUTUAL INVOLVEMENT OF SUBORDINATE AND SUPERIOR IN SETTING OBJECTIVES WITH TARGET DATES
- EVALUATION OF PERFORMANCE BASED ON HOW WELL OBJECTIVES ARE MET

CHART 2

MBO AS A SYSTEM

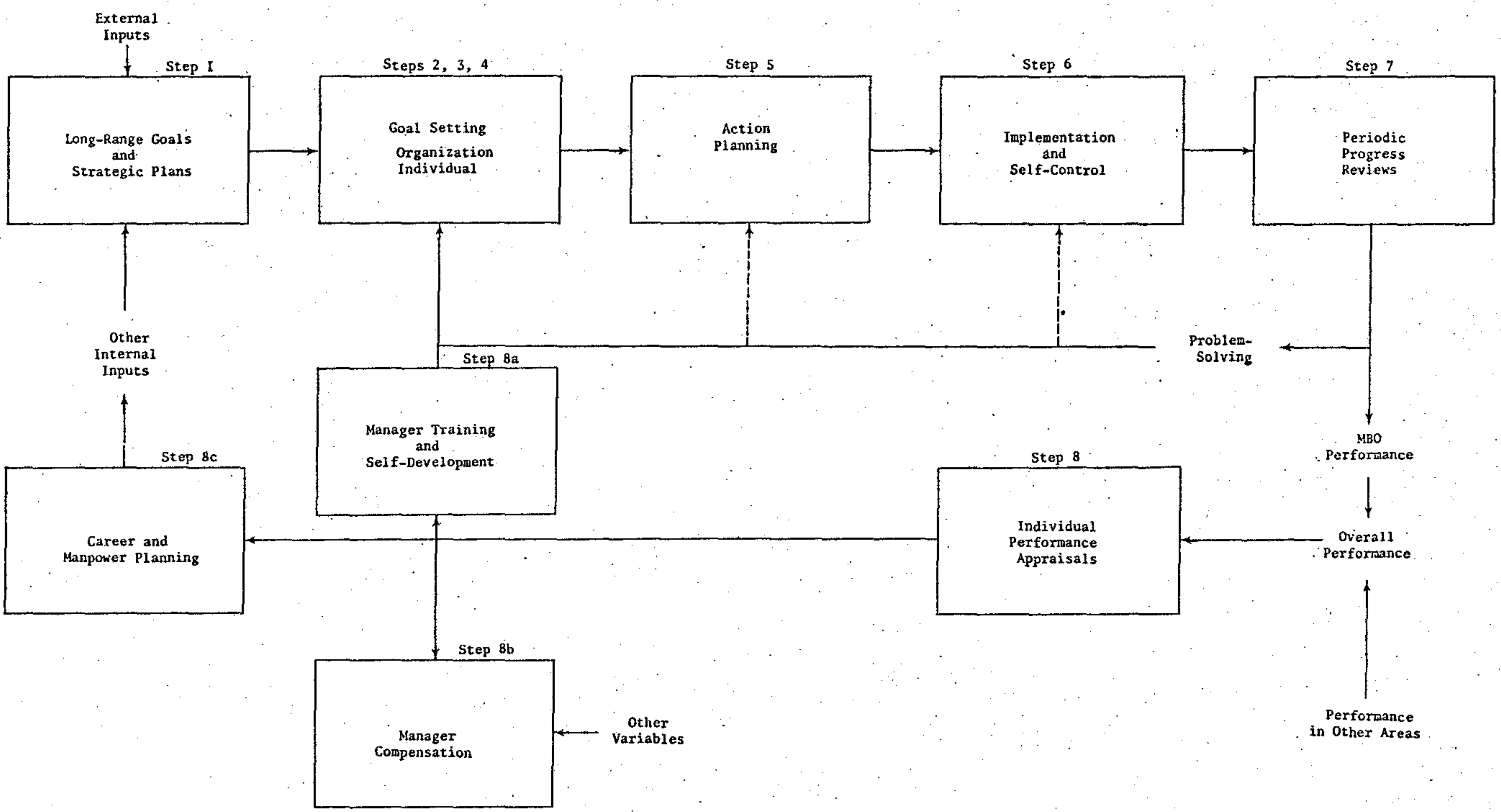


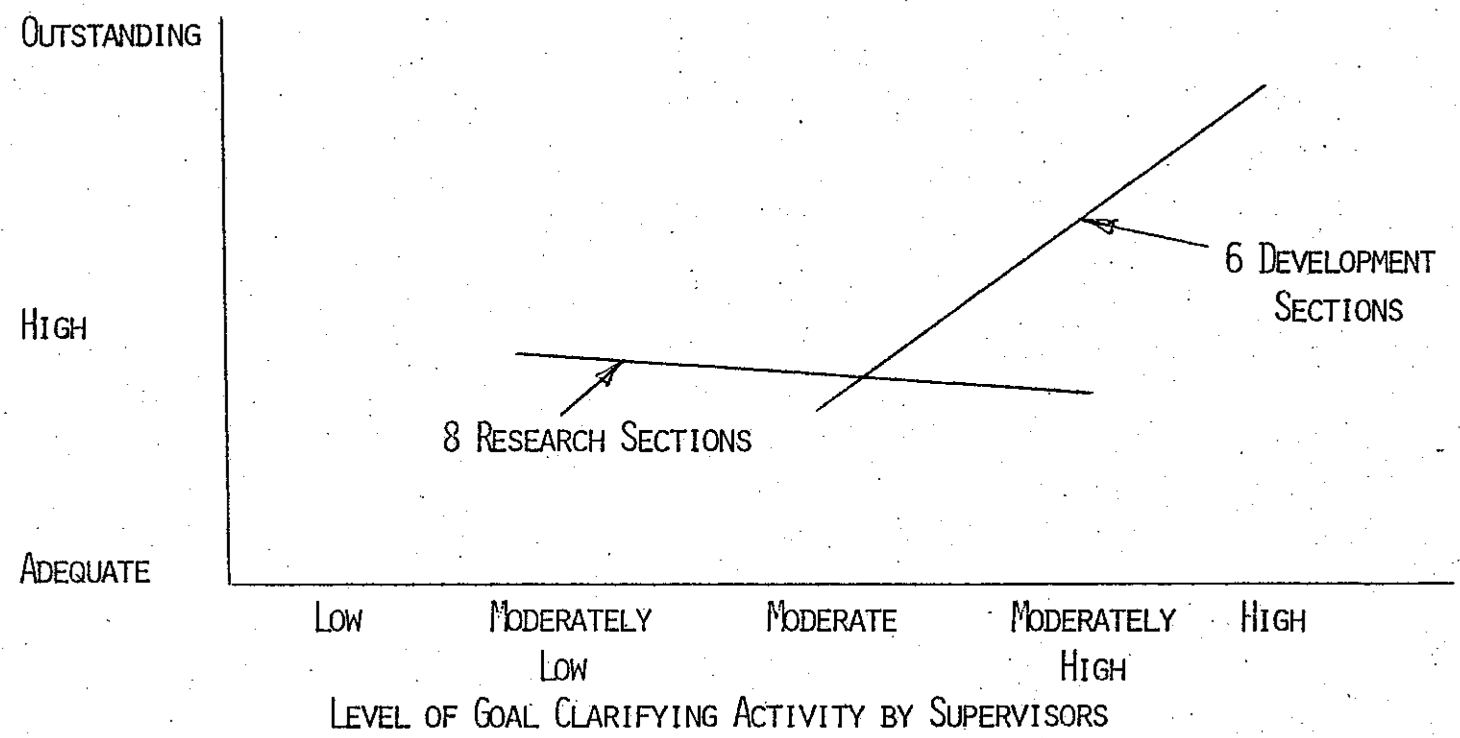
CHART 3

CONTINGENCIES IN ORNL DEVELOPMENT AND RESEARCH SECTIONS

	DEVELOPMENT SECTIONS	RESEARCH SECTIONS
TASK	1) MODERATE TO HIGH UNCERTAINTY	1) HIGH TO VERY HIGH UNCERTAINTY
	2) PROGRAMMABLE WITHIN LIMITS	2) LARGELY UNPROGRAMMABLE
	3) MULTIDISCIPLINARY	3) MOSTLY SINGLE DISCIPLINE
	4) LARGE PROJECTS	4) SMALL PROJECTS
PERSONNEL	1) MOSTLY B.S. DEGREES	1) MOST PH.D.'S
	2) MOSTLY ENGINEERS	2) MOSTLY SCIENTISTS

CHART 4

RELATIONSHIP BETWEEN GOAL CLARIFYING ACTIVITIES
BY SUPERVISORS AND GROUP PRODUCTIVITY



Application of Management Tools in the University Research Environment

by

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presented at the

Conference on University Research Management
New York University
June 7, 1977

<u>Application of Management Tools in the University Research Environment</u>

Outline

I. Management Tools are available that can make university research management more effective

A. University research management is "big business" and needs to be done effectively

B. Several tools are available to increase management effectiveness:
- project selection models
- matrix management techniques
- management by objectives
- computer-based information and control systems
- research planning models

II. Management Tools are not being effectively used in many universities because the tools have not been accepted

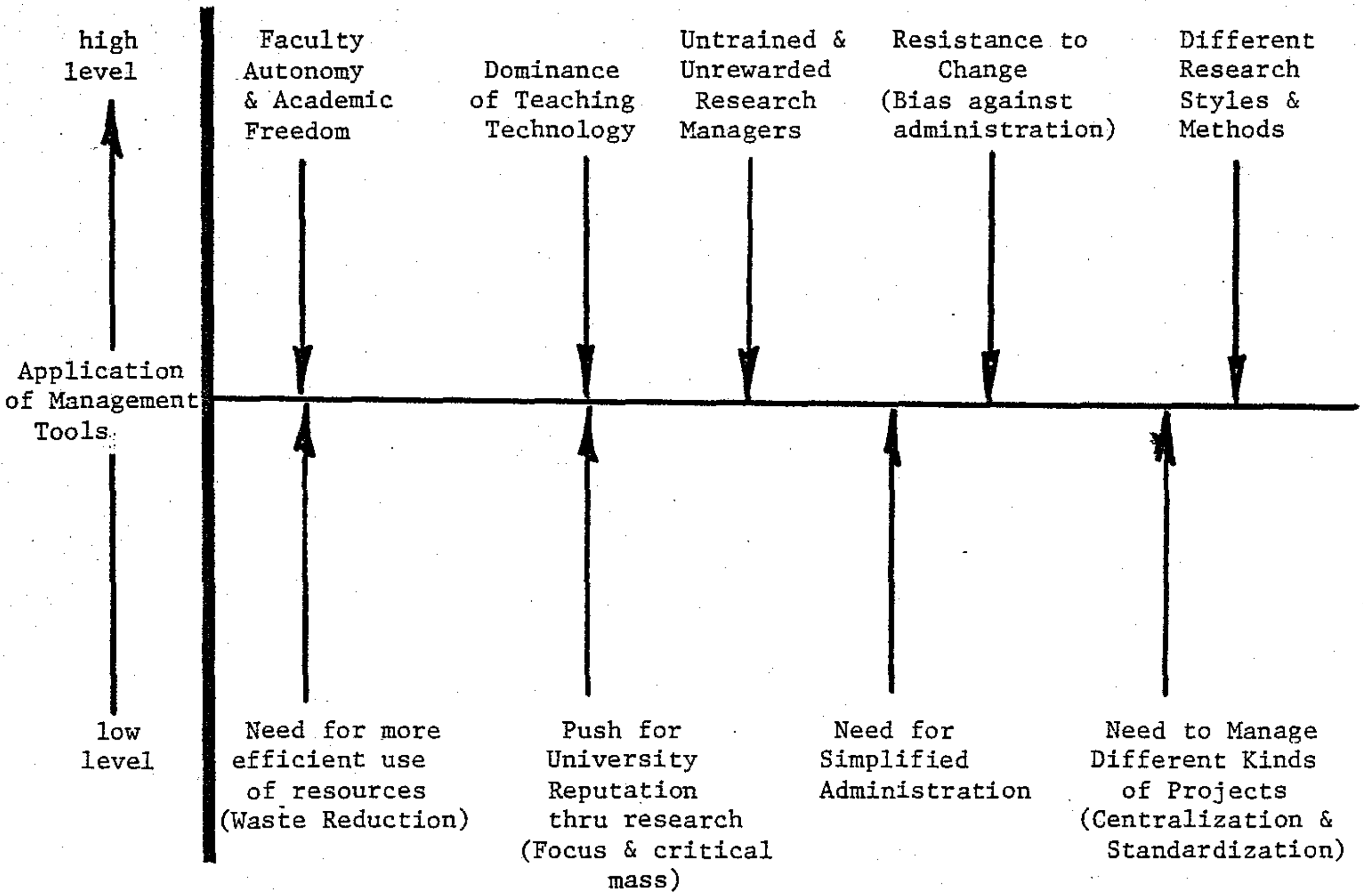
A. Many universities have tried to introduce new management tools in research administration but have failed

B. Failure has come in many cases because the organization members will not accept and use available research management tools

III. The acceptability of available research management tools is determined by a balance of forces within the university environment

A. Driving forces in the university environment encourage the acceptance/use of management tools (see Figure One).
1. The need to more efficiently use resources encourages the use of better management tools (better planning and coordination help eliminate waste)
2. University efforts to increase prestige encourage better control and focusing of projects in order to obtain critical mass in research production and publicity
3. As more research projects are undertaken, management tools that simplify and aggregate are needed and encouraged.
4. As research sponsors become more numerous and diverse, tools for standardizing and centralizing are encouraged

Forces Restraining the Application of
Management Tools



Forces Driving the Application of Research
Management Tools

Figure 1: Forces Driving and Restraining the Application
of Research Management Tools in the University Environment

B. Restraining forces in the university environment restrict the acceptance and use of research management tools.
   1. Faculty researchers may see management tools for planning and prioritizing as threats to "academic freedom" and individual autonomy.
   2. The dominance of the teaching function in many universities gives research (and research management tools) a low priority. University organization around the teaching rather than the research function restricts the use of some management tools.
   3. Many research managers and administrators lack training in management and many research managers are rewarded only for their research products and not for their management performance.
   4. Many researchers resist the use of management tools because of a "bias" toward the management function.
   5. The presence of many different kinds of research and researchers makes it difficult to aggregately evaluate and manage research projects.

IV. Strategies for implementing/applying management tools in research must take the balance of forces into account.

A. Implementation of strategies can increase driving forces or decrease restraining forces
   1. Increasing driving forces may lead to short run application of tools followed by increased resistance and rejection of tools
   2. Decreasing restraining forces may allow a more stable and enduring change (an indirect rather than a direct attempt at implementing new tools)

V. There are several strategies that can increase the chances of successfully applying research management tools: structural strategies; unit strategies; and individual strategies.

A. Structural strategies will need to be implemented at the overall university level
   1. The research function should be represented by appropriate offices at all levels of the university. The charter of the research offices should reflect the priority of research vis a vis teaching in university policy. Credible researchers should occupy key positions in the research structure. Decisions on research strategies and policies should be guided by direct impact from the community of researchers in order to minimize threats to researcher autonomy.

2. Research units may need to be organizationally or spatially linked to increase their power and their level of cooperation.
   a. Units doing similar kinds of research can be placed under a single research head <u>or</u> co-located.
   b. Research administration units should be linked both organizationally and by office location

   (Universities are now largely partitioned organizationally to accomodate the teaching function. Partitioning may need to be done by type of research as well)
3. The implementation of a matrix structure might also facilitate research and encourage the application of research management tools. (In such a matrix structure, a faculty member would be responsible to a teaching and to a research administrator.)

B. Unit strategies may be used to demonstrate the feasibility of using research management tools.
   1. Research units receptive to management tools may be encouraged to use them to demonstrate feasibility
   2. Information about the successful management of research units can be made available to units not using management tools.
   3. Research units applying effective management tools should be rewarded with more latitude and discretionary funds. Such rewards are clear signals to other units that changed management behavior would be worthwhile.
   4. Management tools should be implemented on a voluntary and participative basis in units where the probability of acceptance is reasonably high.

C. Individual strategies may be used to encourage faculty members and administrators to use management tools.
   1. Individual rewards could be given for good performance in research <u>management</u> as well as in research.
   2. University reward and evaluation systems can be modified to accomodate the constraints of the research projects involved as well as the academic calendar.
   3. University researchers and administrators can be trained in the use of effective management tools. This training must be provided in a high status setting.
   4. A "dual ladder" promotion system may be established that recognizes research and research management as important and legitimate activities that will be rewarded with advancement.

VI. In summary, a variety of strategies will need to be used to increase the chances of the acceptance and application of management tools in the university research environment.

A. The chances of acceptance are largely based on the overall climate and texture of the university research environment.

B. Application of management tools is more likely with strategies that work on the research environment than with strategies that focus on a single management tool.

CURRENT TRENDS IN GOVERNMENT PATENT POLICY

June 6, 1977

Presentation By

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Before

Conference on University Research Management

New York University

Of course, these are my own views and are not necessarily consistent with those of my Department or the Administration.

In 1971 the controversy regarding the appropriate policy for disposing of inventions resulting from Government funded research surfaced again as a public issue after being relatively dormant since the 1965 attempts by Senator Long to amend the NASA and Public Health Service appropriation bills to assure ownership of such inventions in the Government. As I will explain later, there are now serious attempts in both the Legislature and the Executive toward bringing the controversy to some conclusion. In order for you to follow the public debate that may be precipitated by recommendations already made or to be made, I thought it might be useful to comment on the more significant events leading to the present state of the policy debate.

The first apparent catalyst of the more recent discussions appears to have been the reissued President's Statement of Patent Policy of 1971. The '71 Statement differed from the previous '63 Statement by providing to the Executive agencies, not otherwise precluded by Statute, greater flexibility in (1) permitting Government contractors to retain exclusive rights in their inventions after they have been identified, and (2) granting exclusive rights in inventions owned by the Government to licensees other than the inventing organization. These changes were made to correct identified problems in agencies such as HEW in bringing the results of their research to the marketplace. The '71 Statement made no changes in the criteria governing disposition of invention rights at the time of contracting.

To implement the new exclusive licensing authority, the '71 Statement required Government-wide licensing regulations. Soon after the issuance of these regulations, Public Citizens, Inc., a Ralph Nader organization, joined by eleven Congressmen, sued the Government to enjoin their implementation on the primary basis that any grant of an exclusive license under the regulations without statutory authority was an unconstitutional disposition of property.

Shortly after the issuance of the '71 Statement, the Commission on Government Procurement, formed by a charge from Congress, began review of Government patent policy. The Commission's December 1972 report contained 16 recommendations on Intellectual Property Matters. The first and second recommendations suggest:

1) Implementation of the '71 Statement promptly and uniformly, and

2) Enactment of legislation to make clear the authority of all agencies to issue exclusive licenses under agency-owned patents.

The first recommendation did not in fact follow the recommendation of the Commission's "Task Force on Disposition of Invention Rights." That Task Force, made up of representatives from the private and public sectors, indicated in its report to the Commission a dissatisfactqon with the '63 and '71 Statements. The Task Force indicated that the Executive agencies were not uniformly utilizing the discretion provided to them by the Statements in recognizing the equities of contractors in resulting inventions in appropriate cases. The Task Force felt the lack of uniform treatment was adversely affecting contractor participation in Government research programs and ultimate delivery of the inventive results of these programs to the public. The Task Force recommended ending the discretion left to the agencies by requiring use of a single invention rights clause in all research and development contracts providing ownership in all resulting inventions in the contractor subject to strengthened march-in provisions in the Government.

One basis for the recommendation was the realization that a substantial majority of inventive ideas require "advocates" in order to reach the marketplace, and that the inventing organization, if interested, is a more likely "advocate" than a less proximate Government staff.

History is replete with examples of inventions now commonly accepted which reached fruition only due to the perseverance of an advocate. It is said that the inventor of Xerox, Chester Carlson, contacted over 100 concerns before he was able to obtain a financial commitment for development. Similarly, Samuel B. Morse argued through 5 years before he was able to obtain $30,000 from Congress to build a test line for his telegraph between Washington and Baltimore. There is little evidence that a Government organization would be willing to duplicate that kind of effort, nor is it apparent that many organizations or persons would, absent a property right.

Other factors supporting the Task Force recommendations were the recognition that the contractor had an equitable position in future invention rights on the mere basis that its selection as a contractor was indicative of its prior background position.

Further, in the case of the University contractor, the ownership of its ideas is deemed imperative to the University's continued involvement in obtaining industry collaboration in delivery to the market. This is based on the belief that inherent to the transfer of the innovative results of the research conducted in University laboratories to industrial developers is a decision on the part of the developer that the intellectual property rights in the innovation being offered for development are sufficient to protect its risk investment. Of course, not all transfers of potentially marketable innovations from such laboratories require an exchange of intellectual property rights in the innovation, but it is unpredictable in which transfers the entrepreneur will demand an exchange to guarantee its collaborative aid. Notwithstanding, where substantial risk investment is involved, such as required in developing clinical data for pre-market clearance of potential therapeutic agents and medical devices which is rarely undertaken in its entirety at Government expense, there is an identified likelihood that transfer will not occur if the entrepreneur is not afforded some property protection in the innovation offered for development. This likelihood seems even more predictable when considering the extraordinary escalation in the estimated average cost of successfully developing a new drug from one-half million dollars in 1962 to 11.5 million dollars in 1973, or 24.4 million dollars when including the cost of research on projects which did not result in marketed drugs.[1/] When it is recognized that costs to second entrants into the market after patent expiration are a small fraction of the original developer's costs, since the second entrant need not undertake the same R & D risk, it is not difficult to understand industry reluctance to proceed with development of University pharmaceutical inventions without the guarantee of some patent exclusivity.

In this context it is apparent that the existence of a licensable patent right could be a primary factor in the successful transfer of a University innovation to industry and the marketplace, and failure to protect such right may fatally affect a transfer of a major health innovation. There has been

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1/ Scherer, "The Economic Effect of Mandatory Patent Licensing," P. 59, U.S. Energy Research and Development Administration, Public Meeting 1/12/77 and Schwartzman, "Innovation in the Pharmaceutical Industry," pp. 66, 70 and 71.

much speculation that failure to recognize this axiom foreclosed private development of penicillin for over 11 years,[2/] ultimately requiring the Government to undertake all the risks under the pressure of World War II. The Commission endorsed implementation of the Task Force recommendation but only after evaluation of experience under the '71 Statement indicated a need for further policy revisions.

In partial response to the Commission's first recommendation to implement the President's Statement uniformly, the GSA issued a patent section as part of the Federal Procurement Regulations. These regulations include standard contract language to be used by all the agencies when implementing an agency decision to either (1) take title for the agency, (2) leave title with the contractor, or (3) defer determination until the resulting invention is identified. I would emphasize again that these regulations in no way provide any new instructions on when an agency is to use a title, license or deferred patent clause resulting in uniform treatment of contractors dealing with different agencies under similar fact situations.

2/ David Masters, Miracle Drug, The History of Penicillin, published by Gyre & Spotti, Woode, London (1946), pp. 104-105 and

The Law of Chemical, Metallurgical and Pharmaceutical Patents, Forman, Editor, published by Central Book Co., New York (1967).

Prior to issuance of the FPR regulations, the Justice Department raised the question of whether the disposition of future or contingent invention rights to contractors without statutory authority was an unconstitutional disposition of property. This concept was dismissed by the research and development agencies on the basis that even if the possibility of making an invention could be deemed property, the ultimate invention was the property of the inventor under law absent a future assignment to the Government.

Soon after the issuance of these regulations, Public Citizens, joined by 7 Congressmen, again brought suit to enjoin implementation of these regulations on the basis that they provided for contract clauses which permit contractors to retain in some instances the exclusive right to future inventions. The plaintiff, citing Justice as its primary authority, contended that such clauses amount to an unconstitutional disposition of property, as they are not based on statutory authority.

The Justice Department later publicly disavowed that its comments had any support in law, and both cases were dismissed on the basis of plaintiff's failure to show that it was damaged by issuance of the regulations.

Notwithstanding the fact that the Executive prevailed in these cases, the failure of the court to refute the plaintiff's contentions has had serious ramifications. Alleged patent infringers have adopted the Justice Department's initial position as a defense in recent patent infringement cases brought on a patent resulting from Government-supported research. These incidents have led to the belief that the argument that the invention in question was generated in whole or even in part with Government funds may well come to be utilized as a standard defense in patent infringement suits.

While the '71 Statement catalyzed the Court challenges discussed above, the energy crisis of 1973 has catalyzed the Congressional challenge to the '71 Statement.

At the beginning of 1974 the proposed patent clauses attached to the Federal Non-Nuclear Energy Research and Development Act of 1974 by the Interior and Insular Affairs Committee provided for Government ownership of all inventions resulting from the proposed research program. Even after a number of attempts by the Executive, industry, and universities to explain the need for a policy which would create an atmosphere encouraging contractor participation in this important program and ultimate utilization of results, the Committee agreed only to insignificant amendments. It was only after industry and university groups precipitated a fight on the floor of the House which led to the deletion of the initial patent clauses did the Executive gain the bargaining power during Senate-House conference to enable negotiation of the finally enacted energy patent clauses. These clauses, although providing that the Government will normally retain title to resulting inventions, do provide in the Administrator the right to waive title to any invention, either at the time of contracting or upon identification provided he make certain considerations, as well as including specified march-in rights deemed necessary in the public interest.

At the time these clauses were negotiated, the Executive was relatively pleased in being able to redeem the patent policy of a major research and development program from the brink of an inflexible title policy, since the clauses parallel and in some respects are superior to the equivalent provisions of the '71 Statement, especially since they are in legislative form. However, since enactment of the Non-Nuclear Energy Research and Development Act, Congress has routinely attached the ERDA patent provisions to each new research program before it.

This continued Congressional action could eventually result in an ERDA type policy applied to all the agencies. This would merely place in legislative form the same kind of policy that the Commission's Task Force found wanting, since it requires an agency to utilize its case-by-case discretion in granting a waiver of rights. Current statistics indicate that most agencies are not utilizing this discretion. Examination of agency attitudes appear to evidence the belief that waivers serve the contractor's interest only, and the burden of justifying such waivers should, therefore, be carried entirely by the contractor. If the public interest is to be met, agencies should be evaluating waiver requests and weighing the prospect of agency "advocacy" of the invention against the prospect of contractor "advocacy." Certainly, if a waiver will result in greater effort toward development than will be undertaken by the agency, its denial may well be contrary to the public interest. Yet, most of the major civilian research and development agencies have no identified waiver procedures and no or negligible waiver statistics.

During late 1975 and all through 1976 the Committee on Government Patent Policy met to discuss the dilemma generated by the events discussed above. The Committee agreed that the Congress' apparent abandonment of the President's Statement and the cloud created by the court cases challenging the constitutionality of agency disposition of patent rights were serious matters and have, accordingly, recommended the need to seek repeal of all existing legislation covering agency disposition of patent rights in favor of Government-wide legislation covering this subject. During its deliberations the Committee considered two approaches within which a uniform Government patent policy might be formulated.

The first of these approaches involved revision of the patent provisions attached to the Federal Non-Nuclear Energy Research and Development Act of 1974, discussed above, to accommodate all the Executive agencies.

The second approach adopted the alternate patent policy proposed by the Commission on Government Procurement's Task Force, also discussed above.

Of the two approaches debated by the Committee, a substantial majority favored the alternate approach, which was deemed to be more likely to maximize utilization of inventive results. This decision resulted in a draft bill which would establish for the first time a uniform Federal policy providing contractor retention of ownership of inventions resulting from Federally-sponsored research, if they have sufficient interest to seek patent protection and declare an intent to commercialize the invention subject to strong march-in rights in the Government. The draft bill repealed, amended, or abolished over 22 existing differing legislative and Presidential Federal patent policies.

Unfortunately, introduction of this bill was overtaken by the Presidential election of 1976, and all clearance procedures ceased in November. However, in a parallel exercise, Congressman Ray Thornton of Arkansas began hearings during 1976 before his Subcommittee on Domestic and International Scientific Planning and Analysis of the Committee on Science and Technology. It seems that the Congressman has arrived at the same conclusion as the Committee on Government Patent Policy, as he introduced on April 6, 1977, H.R. 6249, the "Uniform Federal Research and Development Utilization Act of 1977," which is substantially equivalent to the bill recommended by the Committee.

I understand that Government-funded research is approaching 60 percent of the total research conducted in this country and is still growing as a percentage of the total. It seems clear to me that continuation of a patent policy which permits the agencies to utilize their discretion to determine whether or not the normal incentives of the patent system should be applicable cannot help but to eventually undermine the integrity of our patent system, if substantially all decisions result in Government ownership without further effort toward commercialization.

It is statistically supportable that the delivery of goods to the marketplace in our free society has been dependent on the private ownership and advocacy of inventive ideas. If our supply of privately owned ideas is reduced due to a larger percentage of the national research budget going into public research and resulting inventions being dedicated to the public without assurance of an advocate, we should question whether our system will be able to continue to compete in the international market with countries who are taking advantage of the world's patent systems.

UNIVERSITY-INDUSTRY PROGRAMS

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ABSTRACT

An analysis of a series of joint University-Industry research programs sponsored by the Defense Advanced Research Projects Angency.

Industry does research and Universities do research. What could be more natural than having these groups involved in joint efforts? This is not a very profound or new concept. It has been recognized, implemented, and analyzed for a very long time--stretching back to the origins of universities and industries. How successful has it been? The answer is that its a mixed bag. One can point to successes and to failures. We are more apt to hear of the successes than the failures but it is my opinion that the latter are far more common than the former. Perhaps the words "success" and "failure" are too strong. It might be better to say that greater or lesser degrees of accommodation were reached and the extent of accommodation is not something that can be objectively determined.

The basic difference between research in a university and in an industry is traceable to their objectives. In the case of universities they are primarily concerned with teaching, research and public service with the first two taking a strong priority over the third. Industries are in business to obtain a return on their investment, to supply societal needs and to some extent to engage in public service. As in the case of universities the first two objectives take precedence over the third. Research in universities is tied intimately to its teaching function while research in industry is tied to the eventual pay-off on investments. On a time scale university research is long-term and basic, while industrial research is short term and applied. These are of course immense generalizations and are probably generally valid, but one can and will find exceptions.

The problem with most industry-university research is that it is a compromise of the basic objectives of both parties and too often is treated by each as a public service activity; the industry helping the university and the university helping industry. The help to the universities can be demonstrated in pointing to equipment, facilities and support of students. The help to industries is harder to quantify. It consists of increasing the pool of educated people from which they can draw employees, it enables them to support studies of an interdisciplinary nature that could not be attempted in their own laboratories, it more quickly informs them of the newer developments in research areas that they consider important to their organization.

It isn't generally recognized that of all the governmental departments the Department of Defense was one of the first to extensively use the research capabilities of universities and to adapt to their mode of operation and link their efforts to in-house capabilities and to research carried out for them in industries. They recognized the disparities in the research carried out by each of these groups. Generally the basic research (6.1) is carried out in universities, exploratory development (6.2) in the in-house facilities and advanced engineering (6.3) in industry. The classifications are of course arbitrary. All three groups can and do all three types of research. Each of the services has multiple funding sources: ONR, NRL, AFOSR, RADC, ARO, AMMRC, etc. Separate from these and not tied to services but reporting directly to the Secretary of Defense is the Advanced Research Projects Agency (ARPA). Its function is primarily to look at high-risk, high-return research areas that are critical to the Department of Defense then to search for ways to accelerate R&D in these areas.

One of the topics that ARPA started to examine about ten years ago was this problem of University-Industry relationships and it is from these studies that I have drawn some of my previous observations.

Having recognized that the interaction between industry and universities was not all that they thought it should be they funded what came to be known as "Coupling Programs." Three large research-oriented companies were coupled to three universities where both groups expressed a common interest in and possessed research capabilities in a selected area of interest to the Department of Defense. These were large, long-time commitments. They were forward-funded for three years with total expenditures ranging from 2.5 to 5.5 million dollars per program for the three-year period.

Were they successful? How does one measure success in terms of research? On balance DoD thought it was worthwhile and did derive certain benefits. The desired tight coupling however was not really obtained. For all intents and purposes the universities and industries acted as independent contractors. The universities concentrated on basic research and the support of graduate students but worked on problems which for them were a short time scale. The industries carried out longer range research then they would normally undertake. In retrospect the funding levels were too high and coupling occurred principally in determining how to allocate these funds. Industries were the prime contractors on the naif assumption that we were probably better equipped to handle the complex allocation, accounting and reporting requirements.

The next step in the development was to fund two more of these coupling programs but independently fund the industry-university segments in recognition of the fact that the accounting, reporting and management practices of the participants differ so markedly. This produced somewhat better coupling but still far short of what was expected.

The third and most successful development involved three things. DoD stepped out of the role of marriage-broker between the two parties and requested industries and universities to make their own cross-ties and bridges on joint programs. Secondly they underfunded these efforts in the sense that the programs were funded at the $150-$300 K level total per year for both participants. Thirdly the time scale was compressed in that they were not guaranteed three-year funding. Their funding depended on their year by year progress. These actions forced tight coupling since the participants now did not have the fiscal freedom nor the time to permit independent actions.

Of the two parties in these contracts the universities were disadvantaged more than the industries. They felt that the research that they were doing could not be programmed this tightly while industries seem to be more accustomed to working towards milestones or goals. Stated more directly, universities feel that they are contributing to basic knowledge and this type of work cannot be programmed, while the industries are more concerned with the possible applications of this basic knowledge to technology and this type of research is more adapted to a scheduling process.

The real advantage to DoD lay in the fact that both industry and the universities developed a better appreciation of each others strengths and limitations in R&D.

Towards the end of these ARPA programs Congress took a more active role in R&D via what is known as the "Mansfield Amendment." This stipulated that for DoD research support the work had to be relevant to the needs of that department. This was widely interpreted by the universities as meaning that basic research was to be bypassed. Such was really not the case but in order to fund basic research its relevance to future defense needs had to be articulated and most university investigators felt this was an undue infringement on their freedom of investigation. This stipulation did not bother the industrial researchers since they seemed to have a better appreciation of how the research related to future defense needs.

I might point out that the equivalent of the Mansfield Amendment has since that time appeared in various guises in other funding sources. NSF has its RANN, DOT, ERDA and others, while they support basic research, are quite clear in indicating that the research is in support of a national program that impacts the economy, resources, environment, et al. Much of this research is similar to that funded by DoD and the universities find it difficult to work under these constraints. This is the reason that I think that there will probably be more university-industry coupling than in the past. Universities are ill-equipped to take on large systems type of R&D efforts. Occasionally they can accomplish this (Jet Propulsion Labs, Draper Labs, etc.) but when successful, they spin out from the usual university structure and become a not-for-profit or a federally funded research center. Industries on the other hand are more accustomed to deal with these short-term systems oriented problems but in some of the more advanced problem areas will have to turn to the universities for assistance.

What then was learned from these various programs? One of the most important things was that "research" as carried out in universities is different than "research" in industry. It is more individualized. A professor-graduate student operation in its simplest form and in more complex configurations may be several professors with their graduate students, technicians, post-doctoral students and administrators. In almost all cases this is an unstable structure since the students move in and out of the system and academia objectives drive the effort. With industry one encounters a more hierarchical system, more control, less freedom of action, but greater stability.

Each system has advantages and disadvantages. Joint efforts can indeed enhance the research of each participant but that is by no means a guaranteed result. It is my personal feeling that the participants gain a better understanding of each others strengths, weaknesses and hence of their own real capabilities. The Funder on the other hand must evaluate the results of such joint efforts on a case by case basis. At this stage I see no way of predicting a priori when such coupling programs will be fruitful. As more of these joint efforts are developed perhaps a pattern or modus operandi will emerge. I have a sense at this point that we are really dealing more with individuals than with a management system. Given the right individuals any system will work but the converse is not true. I know of no research management system that can guarantee a successful research program.

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