

NOT FOR QUOTATION
WITHOUT PERMISSION
OF THE AUTHOR

INNOVATION MANAGEMENT:
RESEARCH PROTOCOL FOR
INTERNATIONAL COLLABORATION

Alvin Jay Harman

November 1980
WP-80-162

Working Papers are interim reports on work of the International Institute for Applied Systems Analysis and have received only limited review. Views or opinions expressed herein do not necessarily represent those of the Institute or of its National Member Organizations.

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 Laxenburg, Austria

TABLE OF CONTENTS

INTRODUCTION	1
SYNOPSIS	2
OUTLINE	4
I. PROBLEM	5
Innovation: What is Known?	6
Problem: Coordinating Analysis and Action	7
II. SCOPE	8
Perspectives	9
Sectors	11
Telecommunications: The Issues	12
Assessing the Effectiveness of Innovations	14
III. THE RESEARCH PROCESS	16
Collaborative Research Experience	19
Conceptualization for this Process	21
IV. BENEFITS	24
V. STATUS	26
Bulgaria: For example	27
VI. SUMMARY	28
VII. ACTION?	30

REFERENCES	31
ACKNOWLEDGEMENTS AND EPILOGUE	37
APPENDIX	39

INNOVATION MANAGEMENT: RESEARCH PROTOCOL FOR INTERNATIONAL COLLABORATION¹

Alvin Jay Harman

INTRODUCTION

In this paper I will present the plans that have been developed at the International Institute for Applied Systems Analysis (IIASA) for collaborative studies of innovation management. We hope that a sizable number of research institutions in IIASA's National Member Organization (NMO) countries will participate in a joint effort to investigate the process of technological innovation and the government policy instruments that affect it.

For some time interest has been expressed in studies of innovation at IIASA. At the first workshop on Industrial Innovation held at IIASA in late 1979, many of the participants suggested that IIASA pursue a line of research involving empirical analysis of innovation.² Early in the spring of 1980, Walter Zegveld and a group from the Netherlands Organization for Applied Scientific Research (TNO) visited IIASA and urged that an international network of researchers be organized to study innovation in both the market and planned economies. They suggested that the network for collaboration could be patterned after the Six Countries Programme on innovation chaired by Zegveld. The East-West nature of the collaboration made IIASA an ideal location for a secretariat. However, IIASA's management is strongly concerned that the Institute remain a *research* organization and not simply a meeting place. Thus, the practical considerations of organizing such an effort, while important, are secondary to the concern that a legitimate program of research be carried out at IIASA, building on past research at IIASA and elsewhere.

¹This protocol is the product of many discussions with others, and even with contributions of text. Please see the "Acknowledgements and Epilogue" section at the end of the protocol.

²See A. J. Harman, H.-D. Haustein, and H. Maier, "Epilogue: Suggested Research Priorities from the First IIASA Workshop on Innovation," in H. Maier (ed.), *Innovation Policy and Firm Strategy*, forthcoming.

SYNOPSIS

- **RESEARCH FOCUS**
 - **INNOVATION IN SELECTED ECONOMIC SECTORS**
 - **ANALYSIS TO INCLUDE ENTERPRISE, SECTORAL, AND NATIONAL PERSPECTIVES**
 - **RESULTS TO INCLUDE POLICY ISSUES**
- **RESEARCH PROCESS**
 - **COLLABORATING NATIONAL INSTITUTIONS**
 - **IIASA CONTRIBUTIONS**
 - **THREE YEAR PERIOD WITH THREE WORKSHOPS**
- **BENEFITS**
 - **INTERNATIONAL PERSPECTIVES**
 - **THEORIES TESTED**
 - **SECTORS STUDIED**
 - **POLICIES EVALUATED**
 - **NATIONAL ADVISORY NETWORK**

SYNOPSIS

This research plan for analyzing technological innovation presents both a research focus and some important concerns about the research process. By "technological innovation," I will, for the moment, refer to the introduction of a new or improved product or process into the economy— including the process leading to such an introduction (e.g., technological developments, organization of activities, etc.), the diffusion of the products or processes beyond the place where it was originally introduced (e.g., to other enterprises and nations), and the social as well as economic consequences.

The research on how innovation occurs will focus on selected economic sectors. The analysis will be conducted at both the enterprise and sectoral levels, encompassing the management process for R&D, the diffusion of innovation, the dynamic efficiency of a sector as a whole— some firms more innovative than others— and the selection environments faced by enterprises in particular sectors. A national perspective will also be taken as part of the analysis of each of the sectors under study; e.g., the national policies that either deliberately influence innovation in particular sectors or that have other socially desirable goals and indirectly affect innovation. Our objective is to *apply existing theories* under present and new circumstances to particular sectors and to the exploration and evaluation of policy options.

We expect to undertake these studies in conjunction with a number of national research institutions in IIASA's NMO countries. Thus, the choice of particular sectors for investigation is likely to be made by people in collaborating institutions on the basis of the sectors that have particular significance in their countries. If several institutions in different countries analyze the same sectors, cross-national and cross-cultural comparisons and learning may be possible.

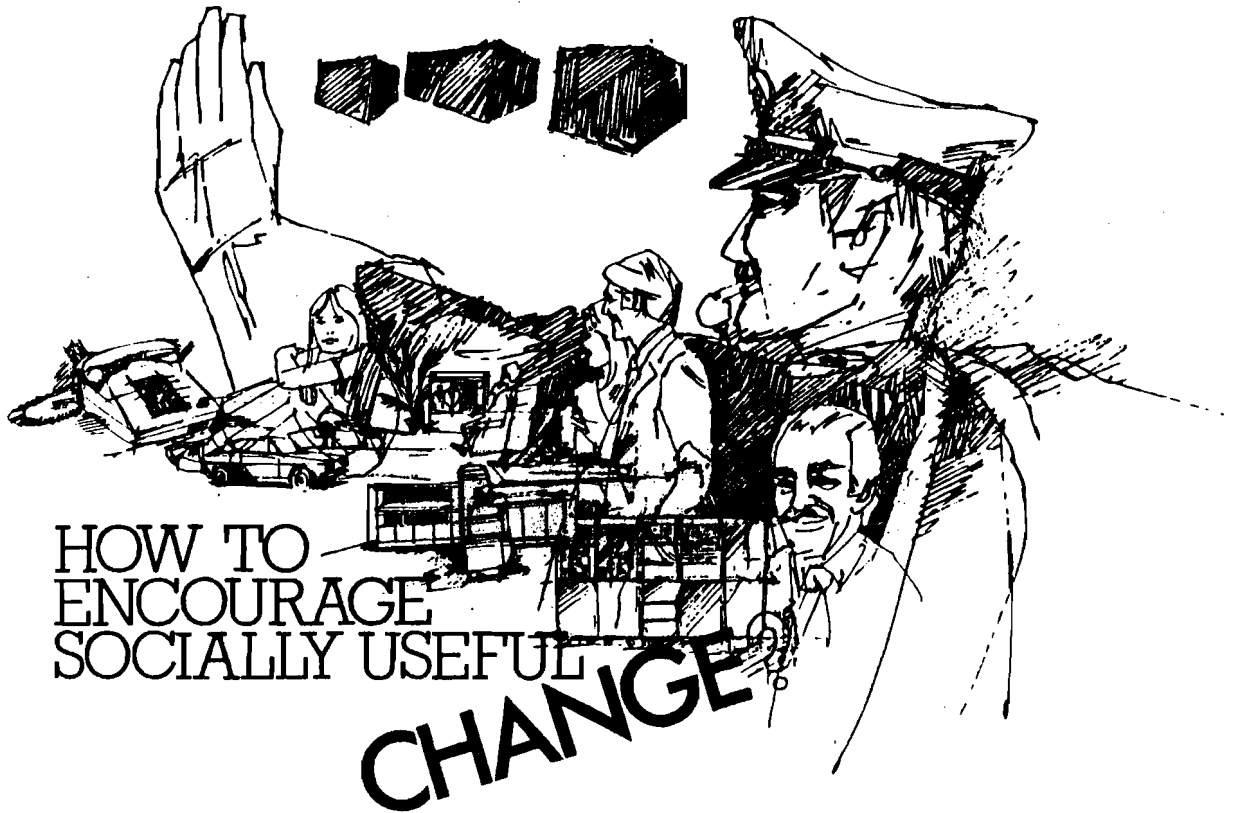
IIASA would expect to participate in the research by carrying out cross-national analyses of multi-national corporations' activities in the West and joint CMEA activities in the East; another research goal would be to develop "canonical" formulations of policy issues both for a "typical market economy" and a "typical planned economy." IIASA would also be developing technological forecasts of trends in one of the sectors under investigation in a related research activity. Finally, IIASA would provide a "hub" for the researchers from the collaborating national institutions— a place for brief or longer research tenures for international collaboration, as well as for organizing and holding workshops. At least three workshops would be held during the planned three-year period of this research task: one to launch the initial efforts, another to permit exchanges of preliminary research results and critiques by experienced industrialists, and a final workshop to share final results with researchers and members of the policy community in various NMO countries.

OUTLINE

- I. PROBLEM
- II. SCOPE OF RESEARCH
- III. RESEARCH PROCESS
- IV. BENEFITS
- V. STATUS
- VI. SUMMARY
- VII. ACTIONS

OUTLINE

The material printed in this paper is organized in seven sections, as shown in this Outline. First, I will deal briefly with the nature of the problem that we will be addressing. I will turn next to the substance and process of the research. A brief description of the kind of benefits that could arise from this research task follows. Since the subject has been under discussion since March 1980, and was extensively discussed during the major IIA SA Conference in May 1980, in which all NMO countries were involved, some steps have already been taken to organize the international collaborations the status of the organizing effort will be sketched. Finally, the research protocol is summarized and the actions to be taken next are identified.



I. PROBLEM

'The sciences of life have need of the artist's intuition and, conversely the artist has need of all that these scientists can offer him in the way of new materials on which to exercise his creative powers.' (Aldous Huxley, *Literature and Science*, 1963, pp. 78-79)

Technological innovation is not an end in itself, but rather a means to an end. Thus, society does not attempt to achieve innovation per se, but rather attempts to encourage *socially useful change*. Of course, this definition of the problem raises more questions than it answers: Who defines what is "socially desirable?" By what criteria is the usefulness of change to be evaluated. It is clear that in some societies the marketplace is relied upon for many evaluations of social desirability, while in others greater reliance is placed on central planning authorities. But in all countries there are some technological developments that appear to require social intervention—e.g., from dangerous drugs or pharmaceuticals (e.g., Thalidomide), to new energy sources (e.g., synfuels), to military weapons. Social intervention may also be required to help certain portions of societies to withstand and adapt to the changes when obsolete technologies are abandoned. The image of a policeman directing the flow of such changes on either a centralized or decentralized basis seems an appropriate way to illustrate the needs of every country. In IIA SA parlance, innovation management is a *universal problem*.

INNOVATION: WHAT IS KNOWN?

- **INNOVATION THEORIES DEVELOPED**
 - ECONOMIC
 - MANAGEMENT
 - ORGANIZATIONAL
 - SOCIOLOGICAL
 - PSYCHOLOGICAL
 - ANTHROPOLOGICAL
 - SOCIOBIOLOGICAL

- **EXPERIENCE SHARED**
 - BUSINESS PEOPLE
 - SCIENTIST/ENTREPRENEURS
 - SOCIETY AT LARGE

- **PAST POLICY ACTIONS TAKEN**
 - MANY COUNTRIES
 - MANY CULTURES

INNOVATION: WHAT IS KNOWN?

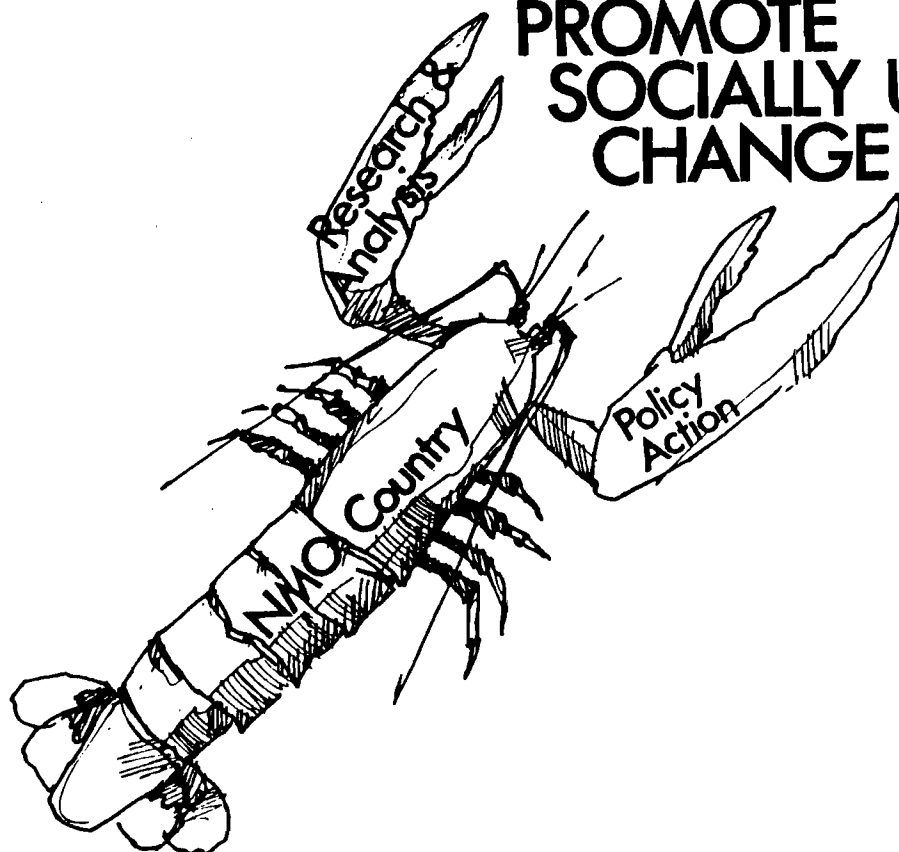
Over the last thirty or forty years, a tremendous amount of research has been undertaken on subjects related to technological or industrial innovation. This is certainly not the place to attempt even a brief review of that literature. In the bibliography to this paper, I have selectively sampled from that literature; however, I am sure that the bibliography is deficient in reports not available in the English literature and is biased by my own blinders, as an economist-turned-policy-analyst.

It seems clear, however, that there is no one theory of innovation that has been extensively tested and universally accepted. Within the economics literature, there are those who rely on neoclassical formulations, while others, such as Klein (1977) and Nelson and Winter (1977), have developed "evolutionary" and dynamic theories. The literature management and organizational behavior provides other views of the innovation process. This is also true, for example, of the psychological literature, with its focus on creativity. What also seems clear is that there have been relatively few attempts to study innovation from an interdisciplinary perspective, in part because this is an extremely difficult objective and the professional risks of failure are high. Still, it seems to us that a cross-national study effort must rely on interdisciplinary perspectives.

A great deal of experience is also available from people who have participated in the process of technological innovation—business people, scientists turned entrepreneurs, society at large—individuals who have benefited or suffered from various changes in technological options. It should be possible to draw upon this experience in the research plan outlined below, as well as benefit from the thoughtful critiques of our efforts based on such experience.

Finally, since World War II governments have been attempting to formulate policies for science, "technology" policies, and most recently innovation policies. Since such policies are promulgated in environments with many unique features, it is difficult to establish sufficient criteria for evaluating their effectiveness (see, e.g., Pavitt and Walker 1976, and DeMuth 1980).

CAN IIASA HELP NMO COUNTRIES PROMOTE SOCIALLY USEFUL CHANGE?



PROBLEM: COORDINATING ANALYSIS AND ACTION

Despite the attempts at interpreting past research results and providing policy advice, it is probably inappropriate to describe policy formulation related to innovation as analogous to the coordinated hands of a policeman directing traffic. On the contrary, the links between research and policy actions is more like the uncoordinated gropings of a lobster's claws. Many research activities do not adequately account the intangibles that are an important element of policy deliberation, and many policy actions do not draw sufficiently upon available analytical results. In part this is so because one of these "claws" is largely based on the past, and the other is largely devoted to the future. But as countries encounter problems new for them, they might very well benefit from the experience of other countries that have already coped with similar problems. We feel that IIASA can play a role in helping its NMO countries promote socially useful change through improved coordination of interdisciplinary research and analysis on innovation and its application to policy formulation and implementation.

Churchman has drawn upon the experiences of a long career, and an even longer philosophical tradition, to conclude that the "systems approach" and "politics" are "enemies." The image he prefers is the following: "Enemies are hostile, out to stop you, to eliminate you and your ideas; they are also to be loved, even as yourself," (1979, p. 156). The image of a lobster—of limited coordination—seems a more hopeful way to begin our inquiry, while recognizing that the enterprise will not be nearly as easy (or hopeless) as a "game against nature."

II. SCOPE

The objectives of IIASA and its collaborating international and national research organizations are very human in their essence. We strive for promotion of more deep vision of actual, real processes of development of mankind, a vision which is free of subjectivity and national egocentrism. We seek our goal in achieving maximum objectiveness in evaluation of ongoing processes and in supplying independent expert assessment of future development alternatives to those who inevitably concentrate their efforts on current problems, the complexity of which demands all their abilities. (Jermen H. Gvishiani, Chairman, IIASA Council, Opening Address of IIASA Conference, May 1980.)

Perspectives

Research will be conducted on innovation from three perspectives, drawing upon the existing theoretical frameworks. First, from the "enterprise" perspective, we must continue to obtain firsthand insights into the process of technological innovation to assure that our theories are useful to managers of innovative enterprises and to policymakers with responsibility for public actions affecting innovation. To do this, we must continue to derive information about the incentives and factors influencing innovation (Haustein 1979). The process of product development and product quality changes must also be considered (Harman et al. 1977). In this connection an important policy issue concerns the interrelationships between publicly supported R&D and support for R&D generated internally within organizations. Since it is individuals who undertake the creative processes at the enterprise level that are collectively described as technological innovation, we must identify and investigate the incentives and factors effecting such innovative contributions. We must analyze the organizational or higher-level strategies that make an environment conducive to human creativity and promote constructive contributions to organizations (c.f., Pelz and Andrews 1976). An important issue in this connection is the security of employment of persons in highly innovative enterprises or enterprises under severe competitive threat from the services provided by new technologies elsewhere. The case study approach with structured interviews is likely to be most suitable for studying the process of technological innovation at the enterprise level, and for clarifying the incentives that operate in this environment.³

Second from the perspective of the sectoral level, the concept of relative efficiency of various enterprises in the industry is important (Haustein and Maier 1980). Particularly in the context of a planned economy (in which entry to and exit from an industry are relatively rarely used governmental policies) the identification of the stage of maturation of a particular firm within an industry— from take off to rapid growth to saturation and to decline— can be a useful

³See especially C. Freeman (1973). For further discussion of this approach, and other methodological discussions, a draft, "Guidelines for Collaboration on Innovation Management" is in preparation.

II. SCOPE: PERSPECTIVES

- ENTERPRISES & THEIR MEMBERS
 - MANAGEMENT OF R&D
 - INCENTIVES FOR INDIVIDUALS

- SECTORS
 - RELATIVE EFFICIENCY
 - SELECTION ENVIRONMENTS
 - SECTORAL POLICIES

- NATIONAL POLICY ENVIRONMENT
 - INNOVATION-SPECIFIC
 - INDIRECT EFFECTS

classification for important investment and other decisions. The analysis of diffusion of innovation at the sectoral level will also be based on existing theoretical structures (see Mansfield 1973; Paterka 1977; and Spinrad 1980). Careful attention must be given to measurement methodologies in the application of these theories.

On the demand side, important factors underlying for the innovative activities of firms are the signals they receive from the final users and resource providers. This calls for analysis of the "selection environments" to draw upon an expression coined by Nelson and Winter (1977). The concept involves three elements: the determination of the "worth" of innovative activities of firms or enterprises; the ways in which consumers and regulatory demands shape the profitability or other "success" measures of enterprises; and the investment and diffusion or adaptation processes that are involved. (This is again related to the concept of changes in relative efficiency.) Analysis at the sectoral level is likely to rely primarily on secondary data and on statistical and econometric analysis. Some attention should also be given to policy mechanisms that are sector specific.

Finally, certain national government policies may have a direct or indirect facilitating or limiting affect on innovation. It is important, therefore, to undertake a broad review of government policy instruments and mechanisms that have a deliberate or inadvertent impact on innovation in particular sectors or enterprises. For example, such policy instruments as planning approaches, resource allocations procedures, taxation policy, regulatory policy, employment programs, and international economic policies should be reviewed. This work can certainly draw upon extensive recent research (see, e.g., Braun 1980; Hartley 1979; Pavitt and Walker 1976; and Martin in Rothwell and Zegveld, forthcoming). It will probably be desirable to develop market-oriented and planning-oriented policy scenarios for exploration of the structure of the policy process. These could be further refined by each national research group (see

Chapman, Hestel, and Arnaszus 1980).

A research agenda is defined in part by what it excludes. We are clearly suggesting that the global questions— for example, the "appropriate" extent of development activities in a particular sector for all nations, the overall industrial strategies of individual nations and their cross-national compatibility, etc.— be excluded from this research agenda for the present. This is a necessary narrowing of scope, and is consistent with Academician Gvishiani's comments to the May 1980 IIA SA Conference concerning IIA SA 's research program:

There is an opinion expressed sometimes that the analysis of local systems, or microsystems (urban systems, large enterprises, individual sectors of industry) is not a worthwhile thing to do as it has no prospects in gaining experience which might prove useful in subsequent transition to the studies of more complex systems at the global scale. We believe, however, that in the search for the solution of global problems, to isolate them from everyday human cares and deeds is not wise and will lead to abstraction both in formulation and solution of the problems... There is another factor that speaks against the isolation of global problems. Our increased understanding of their essence, the resulting knowledge and our ever increasing global concern should, even at this early stage, be transformed into purposeful actions in our everyday lives now, no matter how limited in their scope geographically or timewise.

**I
I
A
S
A**

**C
O
R
E**

SCOPE: SECTORS

- TELECOMMUNICATIONS
- PRINTING
- ELECTROTECHNOLOGY

- CHEMICALS & PLASTICS
- DIFFUSION OF NC MACHINE TOOLS
- MEDICAL TECHNOLOGY
- URBAN PUBLIC TRANSPORTATION
- OTHER

Sectors

It seems desirable to analyze individual economic sectors since the useful technologies differ by sector and the needs to be satisfied by economic activities also vary. Moreover, most countries have at least some policy instruments (planning or regulatory) that vary from sector to sector and deserve detailed analysis if the policy implementation process is to be adequately clarified.

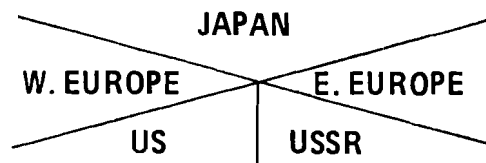
The sectors identified on the chart below include three that we expect to be examining in our own research at IIASA - i.e., telecommunications, printing, and electrotechnology - as well as several others that have been suggested by potential collaborating institutions. The first three are listed as *core* sectors, for we have high confidence at this time that research will be undertaken on them, and that IIASA will organize group meetings focusing on each of those sectors - separate from other workshops that would be held for all participants in this international collaborative effort.

Telecommunications: The Issues

To indicate the scope of the issues that may be addressed within the research framework, let me briefly discuss the telecommunications sector. This somewhat detailed chart still lists only a few of the principal issues. There is an ongoing and rapid pace of changes in technologies that is "driving" the changes in telecommunications. Many large companies are involved in these changes and, because of the sizable investment decisions involved and the public sector participation in all countries, technological developments and public policy are particularly closely linked. A first task, in preparation for the launching of a collaborative research network, will be to spell out the facts and hypotheses regarding innovation in telecommunications in an "issues paper" that can provide a common focus for the various groups' research.

TELECOMMUNICATIONS: THE ISSUES

- TECHNOLOGY TRENDS – “MARRIAGE” OF TELECOMMUNICATIONS AND COMPUTERS
 - SWITCHING
 - STORED PROGRAM CONTROL
 - CONVERGENCE OF VOICE AND DATA IN PACKAGES
 - TRANSMISSION CHANGES
 - BAND WIDTH
 - OPTICAL
 - SATELLITE
 - VLSI IMPACT
- SECTORAL RELATIVE EFFICIENCY
 - PRODUCTIVITY AT UPPER END OF NATIONAL ECONOMICS
 - ECONOMIES OF SCALE PRESENT
 - REDUCED LIFETIME OF NEW EQUIPMENT
 - LABOR COSTS/SUBSTITUTION
- SELECTION ENVIRONMENTS
 - TREND OF 18.5% INCREASE IN “TRAFFIC”
 - MARKET PENETRATIONS OF NEW TECHNOLOGIES
 - PUBLIC UTILITY ISSUES
 - APPROPRIATE STANDARDS
 - INVESTMENT DECISIONS
 - POLITICAL DECISIONS
- TRANS-SECTORAL ISSUES
 - COMMUNICATION AS SUBSTITUTE FOR ENERGY INTENSIVE ACTIVITIES
 - TRANSPORTATION
 - OFFICE COMMUNICATION NETWORKS
 - NEW “LIFE-STYLES”
 - ELECTRONIC MAIL
 - CATV AS A NEWSPAPER SUBSTITUTE
- COUNTRY-SPECIFIC POLICY OR SOCIAL ISSUES?



ASSESSING THE EFFECTIVENESS OF INNOVATIONS

- INNOVATION LEVELS
- ECONOMETRIC ANALYSIS
 - PRODUCTIVITY CHANGES
 - PRODUCT QUALITY CHANGES
 - SOCIAL VS. PRIVATE RATES OF RETURN
- PAIRED COMPARISONS
- IMPORTANCE ASSESSMENTS ACROSS SECTORS
 - RETROSPECTIVE
 - PROSPECTIVE

ASSESSING THE EFFECTIVENESS OF INNOVATIONS

It will be important that we address the question of whether an innovation has been effective or is likely to be effective in a particular sector. Without such assessments (which are intrinsically multidimensional), we can hardly determine whether a given change has led to an "improvement." In fact, evaluation of changes viewed from the individuals' perspective may be quite different from evaluation in the societal context. The Marxian notions of (1) cost of production; (2) exchange value; and (3) use value illustrate the point. A adequate measurement methodologies for "effectiveness" is one of the principle unsolved problems of analyses of innovation. As in many scientific debates, it begins with a discussion of "class membership" (Churchman 1979, pp. 84-5, 180)– what constitutes an "innovation?" On this subject, I am inclined to be liberal, and part company with my colleagues (Maier and Haustein 1979) who distinguish a class of "pseudo-innovations," and solve a measurement question partly by *a priori* criteria of class membership.

Several approaches to the measurement of the effectiveness of innovations have been developed with varying degrees of success. Various attempts have been made to define levels of innovation, based on how significantly product characteristics have been changed (see, for example, Valenta 1969). Econometric analysis has been applied to assess productivity changes resulting from innovation, to assess the product quality change that may have a direct effect on the success of enterprises in undertaking innovation, or to assess the broader societal benefits. Perhaps Edwin Mansfield and his colleagues (1977) have made the most successful attempt to evaluate such variables. The method of comparing processes that have led to successful innovations with those that have led to failures in particular companies has also been used with some success (C. Freeman 1973).

Another approach involves assessing (*a priori*) the importance of an innovation on the basis of the breadth of sectors to which it might be applied. This approach is often used in socialist countries. The criteria used to make such assessments deserve detailed investigations; an *a posteriori* assessment on the basis of the same criteria would be invaluable as a check on the efficacy of the procedure.

At the outset of this project we must focus careful attention on such approaches if we are to develop some specific dimensions and methodologies for measurement of "socially useful change" in an analytically rigorous fashion.

III. THE RESEARCH PROCESS

"It is dreamers-- not hardboiled realists--who make the most startling and lasting discoveries. Mankind consistently errs in the direction of a lack of foresight and imagination... The element of surprise is a consistent ingredient in technological development and one we have great difficulty in dealing with on a normal planning basis." (Charles Townes, Developer of the Conceptual Basis for the Laser; "Creativity: The Human Resource," Nationally shown museum exhibit in the United States, 1980)

III. RESEARCH PROCESS

- **COLLABORATIVE WITH NATIONAL INSTITUTIONS**
 - EXPERIENCE IN ANALYSIS OF INNOVATION
 - LINKS TO USERS OF RESULTS
- **IIASA CONTRIBUTIONS**
 - CROSS-NATIONAL STUDIES AND FORECASTING
 - INITIAL FORMULATION OF POLICY ISSUES
 - COLLABORATING RESEARCHERS' "HUB"
- **THREE-YEAR TASK WITH THREE WORKSHOPS**
 - FORMULATION/LAUNCHING (5/81)
 - FIRST RESULTS CRITIQUED BY INDUSTRY (6/82)
 - FINAL RESULTS SHARED WITH POLICYMAKERS (6/83)
 - *ADDITIONAL MEETINGS FOR CORE SECTORS*

The craft of applied systems analysis depends heavily on careful structuring of the analytical process itself (Majone 1980). Since the problems of encouraging innovation are national problems, not global, and since IIASA has neither all of the financial resources nor all of the talent necessary to significantly address such problems for more than a very few sectors and countries, it seems desirable to make great use of the "outer ring" of IIASA's collaborating

organizations for this research task (see Roger Levien 1976, fig. 5). We seek to work with individuals experienced in the analysis of innovation, who are situated in organizations with links to the potential users of the research results— policy makers and their staffs. In this way we can exchange ideas about appropriate and useful methodologies for understanding the process of technological innovation and also for formulating and communicating policy proposals. However, IIA SA activities should extend beyond the "coordination role", and should provide direct benefits to collaborating institutions— benefits extending beyond the normal publications available to all NMO countries and society at large.

IIA SA's contribution can take the form of selective participation in the research on each of the core sectors. We do not have the staff to do detailed investigations on many different sectors or in many countries— and to do so would be redundant if good research teams are at work in each of the countries. But it would be desirable for IIA SA scientists to participate in studies of each of the sectors, to learn firsthand about developers' problems and selection environments and to get some insights into "universal" aspects of innovation or policy formulation applicable to many sectors. Only by getting our hands "dirty" in some of the data will we be able to maintain a pragmatic and useful collaborative *research* role in this study. It would be desirable to focus our industrial research activities on more than one nation— for instance through analysis of selected multi-national corporations' activities in the West and joint CMEA activities in planned economies. Furthermore, to assist in the objective of focusing sectoral studies on future problems, the IIA SA staff could provide annual technological forecasts over a 5 to 20 year time horizon the telecommunications sector. These forecasting activities are to be undertaken in a related task of IIA SA's Management and Technology Area.

The IIA SA team could also make strong contributions in other areas. When issues concerning appropriate policy cannot be entirely and directly addressed by exposure to the "real world" (in contrast to the case studies of the developers of new technologies and of the selection environments that they face), policy scenarios can be very useful (see Chapman, et al. 1980). Separate scenarios for planned and market economies would be needed at the very minimum and it would probably be desirable to explore several of each type. IIA SA researchers would start by attempting to develop a "canonical" market- and planned-economy policy scenario, and leave to the individual participating research institutions the task of further tailoring these scenarios to their own countries.

As a further contribution, IIA SA can provide a "home" for scientists from collaborating institutions to work more closely for a shorter or longer period— from a one week workshop to a six-month or year tenure or longer. The turnover at IIA SA is deliberately high; so high in fact, that people are referred to as "old-timers" after they have been at IIA SA for six months. Although I now barely qualify as an "old-timer," I am convinced that the opportunity to work at close hand with scientists from very different cultural and social perspectives can contribute importantly to an understanding of our common problems— an understanding arising from frequent and oral exchange of views based on unique personal experiences. Though some of this benefit may never appear in the written reports of the Task's efforts, it will undoubtedly help to provide a richer perspective on analytical or policy issues.

The three year task I have been outlining will involve three workshops. The first one, now tentatively scheduled for May 1981, will bring together researchers from the institutions who elect to collaborate with IIA SA to launch the project toward consistent and useful goals. Although we are making a serious effort to describe the tasks at hand and the benefits to be achieved by committing resources to carry them out, we do not deceive ourselves that no further revision will be needed to formulate this project clearly and prudently. Perhaps one of the most important messages in Herbert Simon's IIA SA Director's Seminar in the summer of 1979 was on just this issue:

'I really think that, with the best techniques we have available or are likely to have available in the near future, our human and computerized analytical capabilities are still very minute compared with the range of

problems that we would be dealing with if we had time to deal with them. Thereby, it becomes exceptionally important, as part of our systems analysis capability for the society as a whole, to develop a very good capability for problem identification-- what in military circles is called intelligence activity-- finding out what there is way out in the horizon, just dimly seen, that is going to quickly come over the horizon, making a large blot on it, and that we are going to need to attend to in the future. We have hardly begun to think about the design of systems analysis capabilities that can effectively perform that intelligence function ... to help us rearrange the agenda so that the problems that really need to be dealt with are not left until they become more critical than we can stand in our society."

Thus, this research protocol is not a "final" write-up, but merely a initial suggestion presented for comments and constructive criticism. By the time of the first workshop, we expect to have a protocol that we and the collaborating research institutions are reasonably comfortable with-- including methodological guidelines and sectoral issues papers-- for the pursuing of our research goals at least for the first 18-months of the project. But one of the agenda items of the second workshop will certainly be a reconsideration of the protocol. For the reasons indicated by Professor Simon, our ideas about what the future holds for our countries and what useful social changes may be required will almost certainly change after 18-months.

The results we expect to achieve from this research should be of interest to experienced industrialists. Thus, after an initial 18-month study effort has been completed within each sector, and after IIASA has had significant time to formulate the policy scenarios, a mid-point workshop will be held to share interim results, to criticize and reformulate research approaches and methods, and even to revise or expand the problem formulation. Representatives from the industrial communities might be invited to engage in a panel critique at this stage. The final workshop would be a Policy Seminar involving policy makers from several countries.

In addition to our intention to publish the results of this work in book form (aside from any publication processes deemed desirable by the collaborating institutions, of course), an important part of the research strategy is to incorporate the mechanisms for the end use of the research results into the research process. For example, we expect that individuals interested in becoming collaborators will contact their government officials for indications of the policy problems currently being faced, and that these indications would in turn provide a "menu" of policy research activities worthy of exploration; subsequently the results could be disseminated within national policy circles. Some topics-- for instance, sensitive data or sensitive policy options-- that would not be desirable to discuss in an international environment, could still be shared with researchers in a nation's own research institutions; the researchers themselves could show discretion in discussing such matters within the collaborative network. There is ample precedent for such activities-- for instance, the gathering of corporate proprietary information and its use only in "sanitized" summary fashion by experienced researchers in the United States and Western Europe.

COLLABORATIVE RESEARCH EXPERIENCE

- **IIASA**
 - **RESOURCES AND ENVIRONMENT AREA**
 - **REGIONAL DEVELOPMENT CASES**
 - **FOOD & AGRICULTURE PROGRAM**

- **"SIX COUNTRIES' PROGRAMME" ON INNOVATION**
 - **PARTICIPANTS**
 - **TOPICS**
 - **RESULTS**

COLLABORATIVE RESEARCH EXPERIENCE

Virtually all of IIASA research involves international collaboration, so there is a wealth of experience to draw upon in designing this study— both from the successes and the "lessons learned." These examples of relevant experience will serve to illustrate. First, from the Resources and Environment Area of IIASA, a remarkably successful study was concluded in the late 1970's (Holling 1978). The study was the result of collaborating scientists from Canada, Argentina, the United Kingdom, the United States, the Union of Soviet Socialist Republics, and Venezuela. The effort involved the design of an adaptive process for environmental assessment and intervention, and its application to selected regions of several different countries. The classes of components whose interactions must be considered for the process as applied in Austria included recreational demand, population and economic development, farming and ecological change, and land use and development control. Not only did the results get used in the areas investigated, but the approach— involving early involvement of potential users of the results, a first task of defining the problem roughly before choosing computer techniques, and recognition that even past programs are not failures if the information provided by unexpected events is used to improve future policies— appear to have broader applicability.

IIASA has been undertaking regional development case studies since 1977— including regions in Bulgaria, Poland, Sweden, Italy, and Hungary. Each of these studies involves an integrated assessment of many factors by scientists at IIASA and in these countries. Among the lessons from this task have been the need for a "critical mass" of researchers in each collaborating country, and the difficulty to transfer computer models from one setting to another.

As a final illustration of IIASA experience, the Food and Agriculture Program began in 1977 and is pursuing in part the development of computer-based national policy models for 25

countries or groups involving roughly 80% of world food production, consumption, and trade. The models are to be linked so that, for example, global implications of variations in national policies can be assessed. This is an example of highly formalized collaboration by means of linked computer models.

As mentioned at the outset, the Six Countries' Programme "on aspects of government policies toward technological innovation in industry" provides an even more direct set of experience on which to draw for the substance of this study. Researchers from the countries-- Canada, France, the Federal Republic of Germany, the Netherlands, Ireland, and the United Kingdom-- have met regularly and frequently since 1975. They have focused their investigations and subsequent meetings on particular public policy issues-- for example, government direct financial assistance (Knox 1976), small and medium sized firms' problems (Rothwell and Zegveld 1977), government procurement policy (Overmeer and Prakke 1978), and trends in collective industrial research (Rothwell 1979b)-- as well as on overview issues-- the current international climate (Freeman, et al. 1977), technical change and employment (Rothwell and Zegveld 1979) and innovation and regulation (Rothwell 1979a).

It is our intention to draw upon the results of this programme's work over the years, rather than to duplicate it. As a small but practical example, the Programme has clearly shown that frequent meetings of the collaborating researchers are necessary to keep the collaborative efforts well focused. Thus, we have decided to schedule meetings for each of the core sectors in addition to the three workshops involving researchers from all collaborating institutions.

CONCEPTUALIZATION FOR THIS PROCESS

"The great success of science as a subculture is because it eliminates errors from dreams. Fantasies are conjured up and then science tests them." (Kenneth Boulding, IIASA, Systems and Decision Sciences Seminar, May 5, 1980.)

It is useful to step back from the detailed specification of research objectives to consider why the process should be structured in this way rather than some other way. Some of the research of Kubie and Arrow seem to be most relevant here. For example, Kubie has written about the psychological aspects of the creative processes of science:

"Both in science and in the arts, free association is the essential instrument in the process of creative search. It is the process of "*cogito*," i.e., of shaking together. Subsequently, the new patterns must be subjected to a process of retrospective, conscious, self-critical scrutiny for a necessary secondary process of checking and testing. This is "*intelligo*," the selection from among many. ... The first step is carried out, for the most part, preconsciously, the second, for the most part, consciously." (Kubie, 1958, pp. 53-54.)

CONCEPTUALIZATION FOR THIS PROCESS

KUBIE: CREATIVE PROCESSES
ARROW: LIMITS OF ORGANIZATION
CHURCHMAN: INQUIRING SYSTEMS

SYSTEM ELEMENTS

- HUMANS
- TEAMS
- INSTITUTIONS

SYSTEMS ANALYTIC PROCESS

- "PROBLEM" AND OPTIONS
- POLICYMAKERS' PERCEPTIONS

"WORLD VIEW"

**PEOPLES HAVE DIFFERING PERCEPTIONS,
UNDERSTANDINGS AND PREFERENCES**

It is clear that any research process rests on individual human scientists. They bring with them their own backgrounds and experiences— both their unique scientific capabilities and their broader understanding of the intangible features that provide the cultural backdrop to the research, innovative, and policy-formulation activities in their own countries. It is principally the interactions between such scientists that we seek to foster in this collaborative study.

The scientists collaborating on this study will be members of teams in their home countries, each having different disciplinary perspectives on the questions of technological innovation and its guidance. In his concise essay, *The Limits of Organization*, Arrow makes three important points regarding the costs of information to organizations— that is "the inputs needed for the installation and operation of information channels"(1974, p.39)— necessary for acquiring relevant information in the future:

- (1) "the individual himself is an input, indeed the chief input if quantification is at all meaningful here, into any of his information channels" (p.39);
- (2) The costs "typically represent an irreversible investment. I am not placing much weight on the physical aspects of communication.... Rather I am thinking of the need for having made an adequate investment of time and effort to be able to distinguish one signal [information from the "outside world"] from another. Such investment [in learning the "codes" necessary for interpreting signals— native or foreign languages, technical vocabularies, codes for "nature's signals"], being locked up in the individual's mind, is necessarily irreversible, though, like most irreversible investments, it is subject to depreciation" (pp.39-40).
- (3) "Information costs are by no means uniform in different directions. At any given moment an individual is a bundle of abilities and accumulated information. He may easily find it cheaper to open certain information channels rather than others in ways connected with these abilities and this knowledge...The relative costs of communication channels may also be influenced by activities of the individual other than the collection of information...so-called learning-by-doing...[or] information relevant in other, seemingly remote, areas of decision-making, a phenomenon known as serendipity" (pp.41-42).

The first two points are relevant to our hope to begin collaboration with *experienced* innovation researchers in institutions already *linked* to appropriate national users: "careful recruitment" is a crucial element of this project. The second point (the need to invest time in learning the codes necessary for interpreting signals) is also relevant to working at IIA SA, since it is to engage in collaborative research when the "codes" often have no more in common than "broken-English"— and even a common conceptual framework is lacking.⁴ Thus, the IIA SA scientist— having invested time and effort in establishing communication channels across language barriers and conceptual differences— should be in a good position to become a substantive "interpreter" to his/her compatriots in the collaborative network.

The final point is perhaps the strongest argument for a *collaborative* network— we have an important and common problem and yet have very different approaches and weltanschauungen. Separately we can each explore our "small, local terrain" very well; together we may get a much broader variety of insights, and can even hope to facilitate serendipity!

In each country the collaborating team will be part of a larger institution that has established networks of communication links with other parts of the national scientific community (and scientists abroad), with parts of the policy community, and perhaps with the public at large. Although these links transcend the contacts of any one individual, they become part of the portfolio of capabilities for disseminating research results. This is essential for the development of coordination between policy research and policy actions, which was identified as a

⁴As a beginning on this problem, a "Glossary" of innovation terminologies in English, German, and Russian is being developed at IIA SA.

principal "problem" at the outset of this paper.

The analytic process that I have described involves identification of sector-specific problems and the options for their removal or reduction, and identification of policy makers' perceptions of the problem. This parallel analysis may help to make the end result of the research more useful for real policy decisions. Because the views of policy makers are considered at the outset, an understanding may be gained of how best to communicate with them during subsequent phases of the research. Both within countries and between countries, perceptions and formulations of problems differ. The national research institutions studying national problems and advising national policy makers should help to alleviate some of the major differences in perceptions that could inhibit communication between the IIASA researchers and the ultimate clients for the research. The "hub" provided by IIASA should in turn help to communicate differences in perception, understanding and preferences across cultures.

Let me briefly draw upon the notions expressed by Simon, Kubie, Arrow, Churchman, and Gvishiani to put this process into a larger context. Simon points out that identification of problems sufficiently in advance that we can help our societies to deal with them before they become critical is a weak part of our systems analytic capabilities-- human and computerized. Kubie emphasizes the two aspects of human scientific capability-- *cogito* and *intelligo*-- with one of them intrinsically a human, preconscious process. Within the next century, perhaps, the "thinking" (as in *intelligo*) capabilities of computers (already demonstrated in modestly proficient chess playing and inelegant theorem proving) may significantly supplement the other aspects of scientific capabilities. But, as Arrow emphasizes, we must also have the communication channels to make use of these increased abilities and accumulated information. The challenge will be to focus such capabilities on "well-chosen" problems (the *cogito* capabilities) and to achieve insights that can be usefully incorporated into mankind's decision processes. In rather abstruse terms, perhaps, this project is an experiment at developing what Churchman calls an "inquiring system" (though without strong reliance on any particular machine, such as is being pursued by the linked computer models of IIASA's Food and Agriculture Program) to consider a very specific topic (innovation management) and to focus our *collaborative* efforts on problem clarification, policy formulation and implementation. Or, as Gvishiani put it in his address to the IIASA Conference last May (1980):

"Uniqueness of the Institute is not only in its conception or form of its realization. The uniqueness equally extends to the process of its research work and embraces the usage of results. The problem is that these results, in my opinion the most important of them at least, come in the form of a *vision* felt by researchers as an outcome of very deep and concentrated analysis, directed to long-term aspects of development but indispensable for intelligent and wise actions in everyday life. The process of transferring this vision is difficult, lengthy and delicate. There is no assurance that it will grow simpler as our vision becomes closer to perfection."

IV. BENEFITS

The Question of Use:

How can IIASA structure its problem formulation, its research, and its communications so as most effectively to

"benefit all mankind
and
promote the economic and social
progress of peoples"

Roger Levien,
Director of IIASA,
in "Applied Systems
Analysis: From Problem
Through Research to Use,"
IIASA Conference,
May, 1980

As summarized in this chart, the point of this project is to undertake a set of coordinated studies to investigate the common issues and problems of innovation in several countries' economies. We expect to consider sector-specific issues, and plan to address country-specific formulations of policy issues. While sector-specific issues should be specified at the outset, country-specific policy issues could be identified after initial scenario formulation by the IIASA team. The fact that policy issues would derive in part from problems raised by policy makers in the countries collaborating with IIASA, (and not just formulated in the abstract), should make it easier to implement the results of the research. In any case, there will be opportunities throughout the research to reformulate our objectives as we learn more about common problems and new ways of addressing them.

The research plan is designed to yield results before the end of the three year period, and relies virtually entirely on national institutions to advise their own national governments.

IV. BENEFITS

- DIFFERENT THEORIES EXPLORED IN COMMON FRAMEWORK
- DIFFERENT VIEWS OF THE SAME SECTORS
- POLICY QUESTIONS RAISED FROM THE OUTSET
 - MANAGEMENT OF R&D
 - INNOVATION AND DIFFUSION
 - POLICY LEVERAGE
- OPPORTUNITIES FOR REFORMULATION
 - WORKSHOP (1)
 - WORKSHOP (2)
- RESULTS AVAILABLE BEFORE THE END OF THREE YEARS
- NATIONAL INSTITUTIONS TO ADVISE OWN NATIONAL GOVERNMENTS

V. STATUS OF INTERESTS AMONG NMOs (9/80)

<u>NMO COUNTRY</u>	<u>SECTOR</u>	
	<u>CORE</u>	<u>ADJUNCT</u>
AUSTRIA	?	
BULGARIA	*	
CANADA	?	?
CZECHOSLOVAKIA	✓	
NETHERLANDS	*	✓
FRG	✓	?
GDR	✓	?
HUNGARY		?
POLAND	?	✓
SWEDEN	?	?
UK	✓	✓
USA	✓	✓
USSR	✓	
*BEGUN WORK	✓SERIOUS INTEREST	?POSSIBLE

V. STATUS

Who, then, will be our collaborators in this research? Since March 1980 we have had discussions with a number of individuals from institutions in NMO countries. This chart, shows that as of September 1980, researchers in thirteen NMO countries have indicated interest in the collaborative network, either in connection with one of the three core sectors--telecommunications, printing, or electrotechnology--or on one of the adjunct sectors. Some researchers or groups would like to undertake analysis of more than one sector, and some relevant work has been completed (e.g., Wils, et al. 1979), or is in progress.

Bulgaria: For Example

At both the Scientific Center for Management and the Institute for Social Research in Sofia, investigation of the innovative process and training of managers has gone on for some time. Recently a continuing national seminar on innovation was established, bringing together experts on the subject from throughout the country at monthly meetings. Some of their initial work was presented at the first IIA SA workshop on innovation in late 1979. A group of scientists from Bulgaria then visited IIA SA in May 1980; this was followed up by further discussions in Sofia in July, leading to the beginning of active collaboration with IIA SA. Analysis has already begun on the selection environment for Bulgarian electrotechnical components. Furthermore, plans have been made for a member of the Bulgarian research team to spend some time at IIA SA for more direct international collaboration. The first results of this work may be available for the workshop formally launching this study in May 1981.

BULGARIA: FOR EXAMPLE

- **SCIENTIFIC CENTER FOR MANAGEMENT**
 - 10 YR. OLD
 - REPORTS TO STATE COMMITTEE FOR S&T
- **NATIONAL SEMINAR ON INNOVATION**
- **BEGUN ANALYSIS OF SELECTION ENVIRONMENT FOR ELECTROTECHNICAL COMPONENTS**
- **RESEARCHER TO COME TO IIA SA**
- **TO PRESENT FIRST RESULTS AT THE "LAUNCHING" WORKSHOP**

VI. SUMMARY

"Philosophers before only explained the world; now there is the problem to change it."

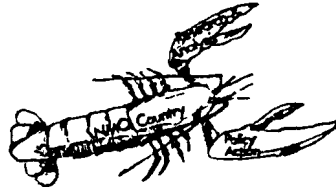
Karl Marx

'Never allow the temptation to be clear, or to use reliable data, or to 'come up to the standards of excellence,' divert you from the relevant, even though the relevant may be elusive, weakly supported by data, and requiring loose methods...We do *not* have to give up the standards of excellence in research. We do have to relinquish the notion that there is 'one best way' to conduct our research, and that this depends on the one best way of formulating the problem or hypothesis. 'Objectivity' is a characteristic not of the data, but rather of the design of the inquiring system as a whole: does it try to be open to all those aspects it deems relevant?" C. West Churchman, *The Systems Approach and Its Enemies*, 1979, pp.145, 147.

IIASA is planning to initiate a set of studies of innovation management beginning in January 1981. This work builds on past innovation research that has been in progress for some time both at IIASA and elsewhere. The problem has been posed as one of *coordination* between analysis and action.

The research focus for this work is to be empirical, rather than aimed at the development of new theory. Analysis will be conducted at several levels of *aggregation*—from the enterprise (and individual) level to the sectoral and national level. Analysis is to explicitly consider policy issues from the outset.

The research process involve collaborating national institutions, with IIASA as the catalyst and hub. The IIASA team will also make analytical contributions, and there will be meetings and workshops to assure that the research process remains well coordinated. We expect, in this way, to develop new empirical material on the process of innovation and its management, both at the enterprise and governmental levels, and to provide useful international perspectives for selected sectors and policies. This will leave the responsibility for providing useful policy advice to the individual national institutions; opportunities will be available, however, for researchers to exchange ideas on the design and formulation of new policies and their effective implementation.



VI. SUMMARY

- **PROBLEM: CAN IIASA HELP NMO COUNTRIES PROMOTE SOCIALLY USEFUL CHANGE?**
- **RESEARCH FOCUS**
 - EMPIRICALLY GROUNDED STUDIES IN SPECIFIC SECTORS
 - ANALYSIS FOR SEVERAL LEVELS OF AGGREGATION
 - CANONICAL AND TAILORED POLICY ANALYSES
- **RESEARCH PROCESS**
 - COLLABORATING NATIONAL INSTITUTIONS
 - IIASA AS
 - CATALYST AND HUB
 - ANALYTICAL CONTRIBUTOR
 - FREQUENT MEETINGS AND WORKSHOPS
- **BENEFITS**
 - INTERNATIONAL PERSPECTIVES ON
 - THEORIES
 - SECTORS
 - POLICIES
 - NATIONAL INSTITUTIONS PROVIDE POLICY ADVICE
 - IMPROVED PROCESSES OF INNOVATION
 - NEW SERVICES TO SOCIETY
 - EASING SOCIAL AND CULTURAL ADJUSTMENTS



VII. ACTION?

- CIRCULATE RESEARCH PROTOCOL AS WORKING PAPER
- DISCUSS WITH POTENTIAL PARTICIPANTS
- RECEIVE PROSPECTUS FROM NMO COUNTRIES
 - ADVISORY PANEL TO REVIEW
 - PROMPT FEEDBACK
- BEGIN: JANUARY 1981 (NOMINAL START DATE)
 - IIASA AND WHOEVER IS FUNDED
 - OTHERS MAY JOIN LATER
- "LAUNCHING" WORKSHOP
 - IIASA (MAY 1981)

VII. ACTION?

"What we call reason is not more than fantasy put into shape." (Jose Ortega y Gasset, *An Interpretation of Universal History* 148-49, p.248.)

We ask that those interested in participating in this collaborative study effort provide us with a brief prospectus on the sector(s) and approach they would like to use for their study, so that we can be sure that we have good coverage of the sectors that are to be investigated and a feasible plan for integrating the results. We are assembling an advisory panel to help us with this review, but we assure you prompt feedback on your prospectus; we understand the lengthiness of the research funding process in some countries. (For a more detailed description of the elements we hope to see in the 5-10 page prospectuses of proposed research, please see BU Chart # 2 in the Appendix.)

The nominal start date for this activity will be January 1981, with the IIASA team and several other countries probably beginning before that time; other participants may join later. The initial workshop is tentatively scheduled for May 1981.

We sincerely invite your comments and suggestions regarding this plan.

REFERENCES

- Abernathy, W., and J. Utterback. 1978. Patterns of industrial innovation. *Technology Review* 80:7, 40-47.
- Arrow, K.J. 1974. *The Limits of Organization*, New York: W.W. Norton & Co.
- Baer, W.S. 1978. "Telecommunications Technology in the 1980's," P-6275, The Rand Corporation, December.
- Baer, W., L. Johnson and E. Merrow. 1976. *Analysis of Federally Funded Demonstration Projects Final Report* Santa Monica, California: The Rand Corporation, R-1926-DOC.
- Baker, M.J. (ed.). 1979. *Industrial Innovation: Technology Policy Diffusion*, London: The Macmillan Press.
- Baruch, J. 1978. "R&D in the federal budget: R&D, industry and the economy." Prepared presentation on the industrial innovation process, AAAS Report No. 78-R-3, American Association for the Advancement of Science, D. Phillips, P. Curlin, and R. Petrilli (eds.)
- Bloor, D., and C. Bloor. Forthcoming. "Twenty Industrial Scientists," in M. Douglas and D. Ostrander (eds.), *Exercises in the Sociology of Perception*
- Boyd, R., and J. Richerson. 1980. "Sociobiology, Culture and Economic Theory," *Journal of Economic Behavior and Organization*, Vol. 1, pp. 97-121.
- Braun, E. 1980. "Government Policies for the Stimulation of Technological Innovation." WP-80-10, IIA SA, January.
- Braun, E., and S. MacDonald. 1978. *Revolution in miniature: the history and impact of semiconductor electronics*. London: Cambridge University Press.

- Chapman, W.B., Jr., R.F. Hestel, and H. Amaszus. 1980. "On the Scenario Approach to Simulation Modeling for Complex Policy Assessment and Design," IIASA, RR-80-3, February.
- Churchman, C.W. 1971. *The Design of Inquiring Systems: Basic Concepts of Systems and Organization*. New York: Basic Books, Inc.
- Churchman, C.W. 1979. *The Systems Approach and Its Enemies*, New York: Basic Books, Inc.
- DeMuth, C. 1980. "Domestic Regulation and International Competitiveness," Conference on U.S. Competitiveness, Harvard University, April.
- Denison, E.F. 1967. *Why Growth Rates Differ*. Washington, D.C.: The Brookings Institution.
- Eads, G. 1977. "Achieving 'appropriate' levels of investment in technological change: what we have learned." Santa Monica, California: The Rand Corporation, P-5998.
- Fisher, F.M. 1978. "Diagnosing Monopoly." Paper presented as the David Kinley lecture, University of Illinois.
- Freeman, C. 1973. "A Study of Success and Failure in Industrial Innovation" in *Science and Technology in Economic Growth: Proceedings*, Halsted Press.
- Freeman, C., K. Pavitt, A. Bogers, and W. Zegveld. 1977. "The Current International Economic Climate and Policies for Technical Innovation," Six Countries Programme. Secretariat, TNO, Postbox 215, Delft, Netherlands, November.
- Gerstenfeld, A., with R. Brainard (eds.) 1979. *Technological Innovation: Government/Industry Cooperation*, New York: John Wiley & Co.
- Gilpin, R. 1975. "Technology, economic growth, and international competitiveness," Paper for the Joint Economic Committee, U.S. Congress.
- Harman, A.J. 1971. *The International Computer Industry: Innovation and Comparative Advantage*. Cambridge: Harvard University Press.
- Harman, A.J. 1980. "Industrial Innovation and Governmental Policy: A Review and Proposal Based on Observation of the U.S. Electronics Sector," *Technological Forecasting and Social Change*, Vol. 18, No. 1, September.
- Harman, A., A. Alexander with M. Davis and A.D. Lee. 1977. *Technological Innovation by Firms: Enhancement of Production Quality*. Santa Monica, California: The Rand Corporation, R-2237-NSF.
- Hartley, K. 1979. "The Industrial Strategy and Manpower Policy: Some Puzzles," in F. Fishwicked, *Labour Economics*, Cranfield Research Paers in Managerial Economics.
- Haustein, H.-D.: 1979. "Factor Profiles of the Innovation Process as an Analytic Tool for Innovation Policy," WP-79-127, IIASA, December.
- Haustein, H.-D., and H. Maier. 1980. "Basic Improvement and Pseudo-Innovations and Their Impact on Efficiency," *Technological Forecasting and Social Change*, Vol. 18, pp.243-265.

- Hill, C.T., and J. M. Utterback. 1979. *Technological Innovation for a Dynamic Economy*. New York: Pergamon Press.
- Holling, C.S. (ed.) 1978. *Adaptive Environmental Assessment and Management*. Chichester, England: John Wiley & Sons.
- Hufbauer, G.C. 1970. "The impact of national characteristics and technology on the commodity composition of trade in manufactured goods." pp. 145-232. in *The Technology Factor in International Trade*, edited by R. Vernon. Universities: National Bureau Conference Series, No. 22.
- Industrial Technology. 1978. Hearings on governmental policy and innovation in the semiconductor and computer industries, October 30, 1978, together with a Summary of Previous Hearings on Industrial Technology. Committee on Commerce, Science, and Transportation, United States Senate, U.S. Congress, Serial No. 95-138, Washington, D.C., U.S Government Printing Office.
- Interfutures. 1979. Facing the future: mastering the probable and managing the unpredictable. Organization for Economic Co-operation and Development, Paris, France.
- Jewkes, J., D.Sawers, and R. Stillerman. 1969. *The Sources of Invention* 2nd ed. New York: W.W. Norton & Company, Inc.
- Johnston, R., and P. Gummert. 1979. *Directing Technology Policies for Promotion and Control*. London: Croom Helm.
- Kamien, M., and N. Schwartz. 1975. "Market Structure and Innovation: A Survey," *Journal of Economic Literature*, March.
- Kaplan, R.S., Y. Ijiri, and M. Visscher. 1976. *Tax Policies for R&D and Technological Innovation: Executive Summary*. Pittsburgh: Carnegie-Mellon University.
- Klein, B.H. 1977. *Dynamic Economics*. Cambridge, Mass: Harvard University Press.
- Klein, B.H. 1979. A dynamic view of the economy. Presented at the symposium on Technology, Innovation & Industrial Development, Massachusetts Institute of Technology.
- Klein, B.H., W.H. Medding, and E.G. Mesthene. 1958. *Military Research and Development Policies*, R-333-PR, The Rand Corporation. December.
- Knox, J. 1976. *Government Direct Financial Assistance to Industry Programmes, Experiences, and Trends*. Six Country Programme Secretariat, TNO Postbox 215, Delft, Netherlands, October.
- Kubie, L. 1958. *Neurotic Distortion of the Creative Process*, The Noonday Press.
- Kuznets, S. 1971. *Economic Growth of Nations*. Cambridge: Harvard University Press.
- Levien, R. 1976. "Applying Systems Analysis in an International Setting," Address to the First IIASA Conference, May 1976.
- Linstone, H.A. and D. Sahal, eds. 1976. *Technological Substitution: Forecasting Techniques and Applications*. New York: Elsevier.

- Maier, H. (ed.). "Innovation Policy and Firm Strategy," IIA SA, forthcoming.
- Majone, G. 1980. "The Craft of Applied Systems Analysis," WP-80-73, IIA SA, April 1980.
- McGaffigan, E. and P. Langer. 1975. Science and technology in Japan: a brief analytic survey. Santa Monica, California: The Rand Corporation, R-1736-ARPA.
- Mansfield, E. 1973. "Determinants of the Speed of Application of New Technology," in *Science and Technology in Economic Growth: Proceedings* Halsted Press.
- Mansfield, E., J. Rapoport, J. Schnee, S. Wagner, and M. Hamberger. 1971. *Research and Innovation in the Modern Corporation* New York: W.W. Norton & Co.
- Mansfield, E., J. Rapoport, A. Romeo, S. Wagner, and G. Beardsley. 1977. "Social and private rates of return from industrial innovations." *The Quarterly Journal of Economics*, Vol. XCI, No. 2, pp.221-240.
- Martin, B.R. Forthcoming. "Industrial Innovation Policy: A Comparison of Some Recent Government Formulations," in R. Rothwell and W. Zegveld (eds.), *Technological Innovation and Government Policy: Preparing for the 1980's and 1990's*
- Mitroff, I.I., and R.H. Kilmann. Forthcoming. "The Four-Fold Way of Knowing: The Varieties of Social Science Experience," in *Theory and Society*
- Nason, H.K., J.A. Steger, and G.E. Manners. 1978. *Support of Basic Research by Industry* Washington, D.C.: National Science Foundation.
- Nelson, R.R., and S.G. Winter. 1977. In search of useful theory of innovation. *Research Policy* Vol. 6, pp.36-76.
- Nelson, R.R., M.J. Peck, and E.D. Kalacheck. 1967. *Technology, Economic Growth, and Public Policy* Washington, D.C.: The Brookings Institution.
- Nordhaus, W.D. 1973. "Some Skeptical Thoughts on the Theory of Induced Innovation," *The Quarterly Journal of Economics*, Vol. 87.
- OECD. 1978. *Policies for the Stimulation of Industrial Innovation* (Vol. II-1: Canada, France, Germany, Italy, Japan, United States, United Kingdom. Vol. II-2: Australia, Austria, Denmark, Finland, Ireland, Netherlands, Norway, Spain, Sweden), Organization for Economic Cooperation and Development.
- Overmeer, W., and F. Prakke. 1978. *Government Procurement Policies and Industrial Innovation* Six Countries Programme Secretariat, TNO, Postbox 215, Delft, Netherlands, June.
- Paterka, V. 1977. "Macrodynamics of Technological Change: Market Penetration by New Technology," RR-77-22, IIA SA, November.
- Pavitt, K., and W. Walker. 1976. "Government Policies Towards Industrial Innovation: A Review," *Research Policy* Vol. 5, No. 1, pp.11-97.
- Pelz, D.C., and F.M. Andrews. 1976. *Scientists in Organizations: Productive Climates for Research and Development* Revised edition, Ann Arbor, Michigan: Institute for Social Research.

- Perry, R., G.K. Smith, A.J. Harman, and S. Henriksen. 1971. System acquisition strategies. Santa Monica, California: The Rand Corporation, R-733-PR/ARPA.
- Press, S.J. 1978. "Qualitative Controlled Feedback for Farming Group Judgments and Making Decisions," *Journal of the American Statistical Association*, Vol. 73, No. 363, pp. 526-533.
- Rettig, R.A., and A.J. Harman. 1979. The development of medical technology: a policy perspective. Santa Monica, California: The Rand Corporation, P-6291.
- Roberts, E.B. (Interview by M. Wolff). 1978. "What do We Really Know About Managing R&D?" *Research Management*, November, pp. 6-11.
- Rothwell, R. 1979a. "Industrial Innovation and Government Regulation," Six Countries Programme Secretariat, TNO, Postbox 215, Delft, Netherlands, June.
- Rothwell, R. 1979b. "Trends in Collective Industrial Research," Six Countries Programme Secretariat, TNO, Postbox 215, Delft, Netherlands, November.
- Rothwell, R., and W. Zegveld. 1977. "Small and Medium Sized Manufacturing Firms: Their Role and Problems in Innovation. Government Policy in Europe, the U.S.A., Canada, Japan and Israel," Volume I and II, Six Countries Programme Secretariat, TNO, Postbox 215, Delft, Netherlands, November.
- Rothwell, R., and W. Zegveld. 1979. Technical Change and Employment. London: Frances Printer, Ltd.
- Rubenstein, A.H., et al. 1977. "Management Perceptions of Government Incentives to Technological Innovation in England, France, West Germany, and Japan," *Research Policy*, Vol. 6, No. 4, pp. 324-357.
- Scherer, F. 1980. *Industrial Market Structure and Economic Performance*, Second Edition. Chicago: Rand McNally College Publishing Company.
- Schnee, J. 1978. "Government programs and the growth of high-technology industries." *Research Policy*, Vol. 7, pp.2-24.
- Schumpeter, J.A. 1934. *The Theory of Economic Development*. New York: Oxford University Press.
- Simon, H.A. 1979. "Rational Decision Making in Business Organizations." *The American Economic Review*, Vol. 69, No. 4, pp. 493-513.
- Spinrad, B.I. 1980. "Market Substitution Models and Economic Parameters," RR-80-28, IIASA, July.
- Stroetmann, K.A. (ed.). 1977. *Innovation, Economic Change and Technology Policies*, Basel and Stuttgart: Birkhaeuser Verlag.
- Tilton, J.E. 1971. *International Diffusion of Technology: The Case of Semiconductors*. Washington, D.C.: The Brookings Institution.
- Utterback, J. and A. Murray. 1977. The influence of defense procurement and sponsorship of research and development on the development of the civilian electronics industry.

Center for Policy Alternatives, Massachusetts Institute of Technology, CPA-77-5.

- Valenta, F. 1969. *Creative Activity, Innovation, and Effects*. Prague, Czechoslovakia: Suoboda.
- Vernon, R. 1966. "International investment and international trade in the product cycle." *The Quarterly Journal of Economics*, Vol. 80, No. 2, pp.190-207.
- von Hippel, E. 1977. The dominant role of the user in semiconductor and electronic subassembly process innovation. *IEEE Transactions on Engineering Management* EM-24, No. 2, 60-71.
- Wils, W., A.W. Gottschalk, with R. Beijdorff. 1979. *Job Futures in Telecommunications*, Anglo-Dutch Telecommunications Research Project.
- Wolf, C. Jr. 1979. A theory of non-market failure: framework for implementation analysis, *The Journal of Law and Economics*, Vol. 22, pp.107-139.
- Yin, R.K. and K.A. Heald. 1975. "Using the Case Survey Method to Analyze Policy Studies," *Administrative Science Quarterly*, Vol. 20, September, pp. 371-381.
- Zaltman, G., R. Duncan, and J. Holbek. 1973. *Innovations and Organizations*. New York: John Wiley & Sons.

ACKNOWLEDGMENTS AND EPILOGUE

This working paper is the product of the joint effort of a number of individuals, with the author principally charged with assembling the ideas and briefly presenting them. Thus, he is indebted to his colleagues, within and outside IIASA, for sharing their thoughts on the innovation process, on the problems that should be addressed, and on the research process. In particular, H.-D. Haustein, H. Maier, J. Robinson and T. Vasko have been generous with ideas as collaborators on the 'Innovation Task' in the Management and Technology area at IIASA, and G. Fick, L. Hervey, D. Jones, V. Kelle, A. Lee, R. Levien, A. Lieberman, C. Marchette, H. Miser, P. Ratoosh, E. Shigan, C. Sinclair, R. Tomlinson, and R. Voll were also very helpful.

Special acknowledgments must be extended to W. Zegveld (TNO-Netherlands), who originally proposed this study, and also to F. Prakke and W. Wils (also TNO), for their useful suggestions and critiques. B. Benev (CSM-Bulgaria) and his colleagues have shared stimulating ideas and notes, and R. Rettig, W. Baer, A. Palmer and A. Williams (Rand-U.S.) have unselfishly exchanged ideas with the author for some time. Other helpful comments and ideas for this protocol have come from D. Davidov of Bulgaria; W. Goldberg of the FRG; M. Zebrowski of Poland; S. Prais, G. Ray, and R. Rothwell of the UK; and the participants of the recent IIASA Social Science Seminar: 'Rethinking the Process of Systems Analysis' (especially H. Boothroyd, P. Checkland, C.W. Churchman, G. de Zeeuw, Y. Dror, and O. Larichev).

It is typical in an 'acknowledgments' note to conclude by pointing out that any remaining errors or deficiencies are solely the responsibility of the author. Not only is this statement appropriate in this case, but the author would also like to note that this is a working paper-reporting in tentative fashion a research agenda and planned research process. Constructive criticism on specific and important deficiencies, or suggestions for improvement will be welcome. For example:

First, what is the problem--specifically?

- (1) Ours at IIASA? Sectoral Issue papers forthcoming.
- (2) Each collaborating institution to have its own agenda!

Second, what is the methodology--specifically?

- (1) See BU Chart # 6 in the Appendix.
- (2) Ref. to supplementary material on case study approach (Draft "Guidelines" forthcoming)
- (3) Desirable to have as common a methodology as possible at the outset; but must not overconstrain the research!

Third, how will the study elements be integrated--specifically?

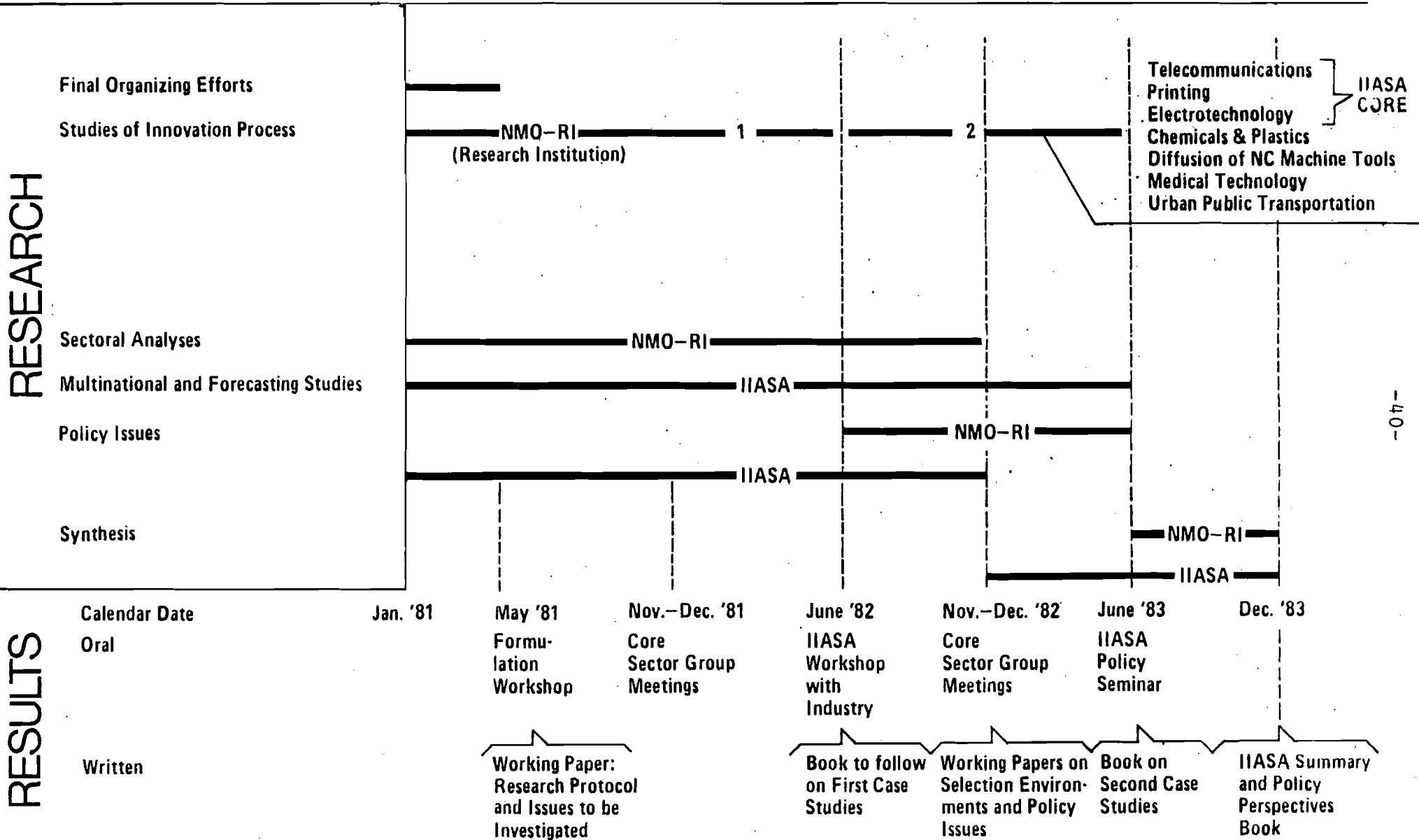
- (1) See BU Chart # 3 in the Appendix
- (2) Discussions in meetings and workshops

APPENDIX

Charts with additional details regarding research protocol to be found in this section.

- BU # 1 Innovation Management International Collaboration: Project Structure and Timing
- BU # 2 Content of Research Prospectus Requested
- BU # 3 Possible Research Integration Mechanisms
- BU # 4 Printing: The Issues
- BU # 5 Electrotechnology: The Issues
- BU # 6 Methodologies for Analyses of Sectors
- BU # 7 Decisionmakers for End Products Influence "Socially Useful Change"
- BU # 8 MMT Research Plan 1981-83 Revised Proposal

**INNOVATION MANAGEMENT INTERNATIONAL COLLABORATION:
PROJECT STRUCTURE AND TIMING**



BU#2

**CONTENT OF RESEARCH
PROSPECTUS REQUESTED**

- **THE PROBLEM AND RELATION TO TECHNOLOGICAL INNOVATION**
- **ECONOMIC SECTOR(S) OF INTEREST**
- **RESEARCH STRATEGY, INCLUDING**
 - **THEORETICAL APPROACH/PERSPECTIVE**
 - **TYPE OF DATA SOUGHT**
 - **METHODOLOGY**
 - **LEVEL OF EFFORT (FULL TIME EQUIVALENTS)**
- **RESULTS EXPECTED (INCLUDING ASSESSMENT OF EFFECTIVENESS)**
- **POLICY IMPORTANCE/IMPLEMENTATION**

BU# 3

**POSSIBLE
RESEARCH INTEGRATION
MECHANISMS**

- **PREPARE METHODOLOGICAL "GUIDELINES"**
- **QUALITATIVE CONTROLLED FEEDBACK (PRESS)**
- **CASE SURVEY METHOD (YIN & HEALD)**
- **OTHER?**

BU#4: PRINTING: THE ISSUES
(forthcoming)

BU#5: ELECTROTECHNOLOGY: THE ISSUES
(forthcoming)

METHODOLOGIES FOR ANALYSES OF SECTORS

<p>FOCUS</p> <p>SECTOR</p>	<p>INNOVATION PROCESS</p> <p>Organizational and Individual</p>	<p>SECTORAL ANALYSIS</p> <p>Relative Efficiency and Selection Environment</p>	<p>POLICY ISSUES</p> <p>Sector Specific and National</p>
<p>Telecommunications } Printing } IIASA Electrotechnology } CORE Chemicals & Plastics Diffusion of NC Machine Tools Medical Technology Urban Public Transportation Other</p>	<p>C A S E S T U D I E S</p>	<p>S T A T I S T I C A L & E C O N O M E T R I C</p>	<p>S C E N A R I O & S I M U L A T I O N</p>

Illustrative Issues for each sector

- Management of R&D
- Individuals' incentives

- Trends, market penetration
- Investment patterns and criteria
- Productivity changes
- Economies of scale
- Rewards to successful innovation
- Sectoral policies

- Innovation specific
- Assessments and forecasting of effectiveness of innovation
- Indirect effects of other policies

BU#7

**DECISIONMAKERS FOR END PRODUCTS INFLUENCE
"SOCIALLY USEFUL CHANGE"**

Final Goods and Services

**"Appropriate"
Decisionmakers**

PEACEFUL ←

→ DANGEROUS

**Private
Choice
"Should
Prevail"**

**Public
Choice
"Should
Prevail"**

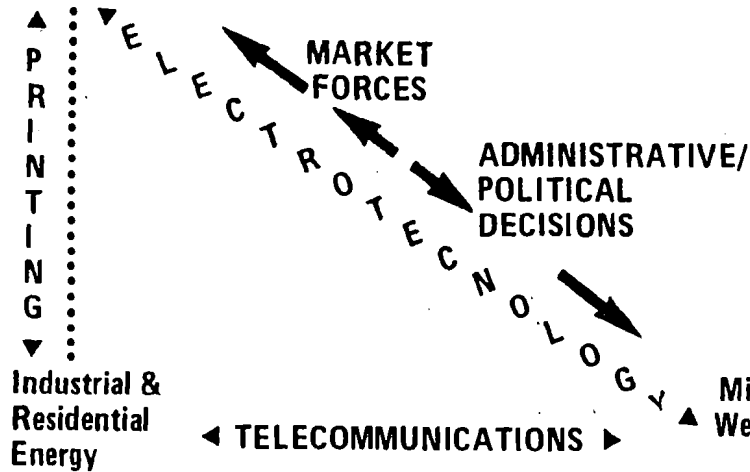
**Agricultural Produce
Consumer Goods**

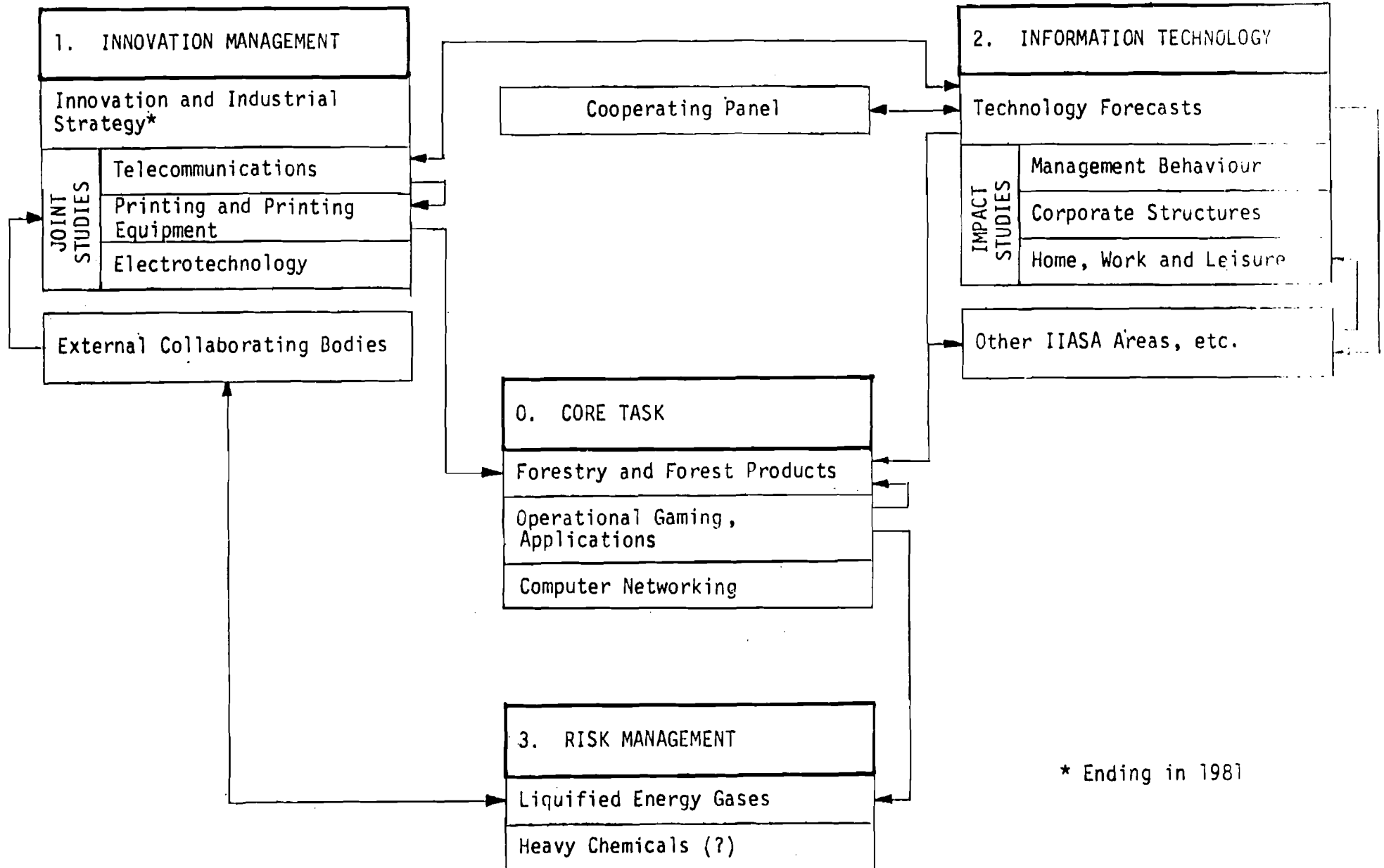
**Pharmaceuticals
Firearms**

**▲
P
R
I
N
T
I
N
G
▼**

**Industrial &
Residential
Energy**

**Military
Weapons**





* Ending in 1981