IIASA-PC-2

International Institute
for
Applied Systems Analysis

PROCEEDINGS
OF
IIASA PLANNING CONFERENCE
ON
DESIGN AND MANAGEMENT OF LARGE ORGANIZATIONS

July 4 - 6, 1973

Schloss Laxenburg
2361 Laxenburg
Austria

The views expressed are those of the contributors and not necessarily those of the Institute.

The Institute assumes full responsibility for minor editorial changes made in grammar, syntax, or wording, and trusts that these modifications have not abused the sense of the writers' ideas.

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Agenda for

Research Planning Conference

DESIGN AND MANAGEMENT OF LARGE ORGANIZATIONS

4 to 6 July, 1973

Hotel Krainerhütte near Baden, Austria

Chairmen: Professors Joseph Bower and Boris Milner

4 July

9:00 - 10:30	Welcome by the Chairmen. Welcome and introductory talk about IIASA by the Director, Howard Raiffa.
10:30 - 10:45	Coffee
10:45 - 12:00	Presentation by Professor Milner of his own thoughts and those of other U.S.S.R. scientists upon a research strategy for IIASA in the area of organizational systems. Brief discussion.
12:00 - 2:00	Lunch
2:00 - 3:30	Presentation by Professor Bower of his thoughts and of those brought forward at the U.S. Advisory Committee meeting regarding IIASA research into organizational systems. Brief discussion.
3:30 - 3:45	Coffee
3:45 - 5:00	Fuller discussion springing from but not restricted to the presentations made by the Chairmen upon the goals, the means, and the modes of IIASA research in the organizational area.
Evening	Entertainment will be arranged by the Institute for those interested.

6 July

9:00 - 10:30 and 10:45 - 12:00 — Discussion of IIASA planning - for a project or projects - in the area of organizational systems to cover:

a) the planning phase,
b) manning,
c) budgeting,
d) timing,
e) long-range objectives of the project,
f) intermediate way stations of project accomplishment,
g) incorporation of flexibility for the reorientation of project directions over the course of research and to allow freedom of scope to individual researchers,
h) modes for evaluating project results,
i) liaison with other research institutions,
j) structure - decomposition of the project staff to groups or individuals with specific, limited responsibilities, and
k) publication of research.

12:00 - 2:00 — Lunch

2:00 - 3:30 and 3:45 - 5:00 — Continuation of the discussion of the morning to take into account the nesting of the organizational project within the Institute. Special notice will be given to:

a) considerations of liaison between the project or project staff and other ongoing projects,
b) documentation and library demands of the project, and
c) computational demands of the project.

No attempt will be made to arrive at a formal set of conference recommendations. The minutes will reflect all views presented. The Chairmen of the conference, the Director, the Deputy Director, and other research scholars of the Institute will make use of the opinions advanced in formulating a proposed research program in organizational systems for discussion and possible approval at the November meeting of the Council.

5 July

9:00 - 10:30 and 10:45 - 12:00 — Presentations by conference participants upon possible research strategies for the organizational systems of IIASA to cover:

a) Recommendations to the Institute;
b) Designation of especially promising areas for IIASA research;
c) Specificiation of research categories for IIASA thought especially likely to benefit their institutions or countries; and
d) Identification of institutions and individuals - in the nations represented by the conference participants and elsewhere - with which IIASA should seek research coordination.

12:00 - 2:00 — Lunch

2:00 - 3:30 and 3:45 - 5:00 — Broad discussion upon the parameters of the IIASA research strategy in organizational systems to cover the identification of:

a) Areas where work is needed;
b) Areas in which IIASA would have a high likelihood of producing notable work;
c) Areas in which the possible payoff is high but the prospect of success uncertain;
d) Areas where the international position and perspective of IIASA would give it comparative and absolute advantages over existing research institutions;
e) Empirical projects of high priority;
f) Methodological and conceptual issues of high priority;
g) Mathematical methods of importance for the modelling and investigation of organizational systems;
h) Aspects of information flows in organizations - their functioning and design which merit IIASA research; and
i) Roles which IIASA ought to adopt as researcher, research instigator, catalyst, disseminator, or educator in the area of organizational systems.

Evening — The IIASA staff will arrange entertainment.

Minutes of the IIASA Planning Conference: Design and Management of Large Organizations*

Introduction

Setting the Stage--The State of IIASA

The conference was opened by a joint welcome from the Co-Chairmen who yielded the floor to Howard Raiffa, Director of IIASA. Professor Raiffa reviewed briefly the history of the Institute from the original conception to the present stage of realization. He sketched the contemplated organizational structure and invited professional comment upon it during the course of this meeting. The scientific support services of IIASA--comprising the three main areas of computers, library, and publications--were described in detail.

Professor Raiffa described the state of crystallization of the research plans of the Institute. He prepared a first research paper for the London Inaugural Meeting of the Council and a second for the January meeting of the Council. In February he drew up a provisional research strategy for the Institute which is now the best extant definition of the research intentions of IIASA. Each subsequent version of these papers has reflected the valuable commentary of Council Members and of other scientists affiliated with the Institute. For the purpose of fleshing out the details in the research strategy, IIASA is hosting a series of scientific planning meetings during the summer of 1973. Experts in various realms of systems analysis are coming together in Baden to identify research areas for which a structured analytic approach is especially suited and where IIASA could realize important results. This is the second of these meetings. It was preceded by a conference on the complex use of water resources. On the basis of the information brought forward and the opinions voiced during these meetings, Professor Raiffa, Deputy Director Letov, and other research leaders of IIASA will propose to the Council a more formal research strategy for the Institute.

Research Plans and Problems

Director Raiffa voiced some of his concerns in planning the scientific work of the Institute. It is essential that a healthy geographic balance be maintained across the research team structure of research. The teams must be so designed

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* These minutes were prepared by M. Thompson.

that scientists of different nationalites supplement each other, communicate with each other, and learn from each other. The structure should be such that this occurs naturally--without constant interference from the leadership.

As important and perhaps as difficult as the balance of nationalities is the balance of disciplines. Applied and methodological researchers, control mathematicians and engineers, statisticians and organizational theorists, social scientists and operations researchers, economists and decision analysts have much to contribute to one another if only they can be induced to communicate. IIASA projects should be structured so that each group feels vitally a need for the others. Perhaps the best way to achieve this is through concentration upon applied projects in which the disparate disciplines require supplementation from each other in order to achieve concrete results. Advice to resolve this problem was invited.

Results of the Water Resources Meeting

Professor Raiffa reviewed some of the important ideas brought forward in the water resources conference which he thought might be of interest to the planners of the organizational research. It was generally agreed there that an international review of the state of the art was an essential preliminary to the commencement of research. Opinion diverged, however, upon the proper scope of this review. One important area recommended for IIASA research was the reanalysis of recently completed water resource studies. Such reanalyses would enable IIASA to bring to bear its wealth of cross-cultural and cross-disciplinary viewpoints, and to see what the past teaches us. Another possibility was that IIASA could permanently maintain--or at least keep contact with--a group of high level experts that could be convened to discuss specific water resource problems. Individual research organizations could consult with this group for advice in planning and implementing water resource projects. The Water Conference urged that IIASA researchers work on a concrete small project--like a small fresh-water lake--but that it not get bogged down by doing hydrological planning for a large river basin. Rather, the group felt that a IIASA group of organization experts, juridical specialists, and political scientists should investigate how a complex water resource project could overcome the organizational, bureaucratic, and political hurdles impeding the implementation of systems analytical studies.

The Identity of IIASA

The Distillation of a Role

The presentation of Professor Bower posed and sought to answer the question of what the proper research role of IIASA should be. Not until serious thought had been devoted toward the identification of what Bower termed the "distinctive competence of IIASA" could the details of the research program be fleshed out.

Before committing itself to any course of research, IIASA must assure itself 1) that this research will contribute valuably to scientists and to those who make wise use of science, 2) that it does not represent work which might as well have been performed at previously existing research organizations, and 3) that it is consonant with the international stature and aims of the Institute.

Bower granted that the identity of IIASA would not be fully known in the course of this conference, nor even in its first years. Nevertheless all counsel given now for the initiation of IIASA research will be the more valuable for having explicitly pondered the proper role for IIASA.

Professor Bower presented his own thoughts and those of participants at a special meeting hosted by the National Academy of Sciences (Document E). He summarized the two primary aims of IIASA:

1. "To achieve first order significance as a scientific institution ..." and

2. "To act as a political bridge, especially between the Eastern and Western nations."

These aims entail the avoidance of politically sensitive research topics.

Professor Bower mentioned a number of considerations that had been voiced at the meeting in Washington:

1) IIASA may be tempted to foster, coordinate, and invigorate research in other institutions in many nations. Laudable as this end is, it should not be pursued to the extent of diminishing the importance of Laxenburg as a research center in its own right;

2) IIASA should beware of the dangers of excessive abstraction. There should always be a solid empirical core;

3) IIASA projects should

   a) interest member organizations,

   b) afford opportunities for significant empirical research,

   c) steer clear of political stumbling blocks, and

   d) be sufficiently bounded that the finite resources of IIASA can achieve worthwhile results;

4) a valuable contribution to scientific literature would be the translation and compilation of outstanding articles from many different languages. IIASA could act as an international clearinghouse for important works;

5) IIASA might achieve an empirical leavening by addressing its projects to client problems. Bower noted that two participants in the room led research institutes whose success has often been attributed to their explicit client orientation. The dangers of this approach are

   a) that the choice of the appropriate client is difficult,

   b) that the ideal client might not entrust its problems to a nascent international institute, and

   c) that research teams might become excessively tied to the perspectives of their clients which would result in the narrowing of their interests and capabilities; and

6) the interdisciplinary nature of the Institute as a whole and of the individual projects should be stressed. Bower argued that many universities have found that their best work enlisted vital contributions from disparate disciplines.

Further Thoughts on the IIASA Role

Several participants responded to the difficult questions posed by Bower. Throughout the conference attempts were made to identify the "distinctive competence" of the Institute. Some felt that the answer lay in the international aspect of IIASA and urged activities--clearinghouse functions, cross-

cultural studies--that furthered the international flavor. Others emphasized the commitment of IIASA to the systems approach and felt that the research efforts should be overwhelmingly devoted to the systems optimization of complex problem situations.

Constituencies

Bower's consideration of a possible client role for IIASA brought up the question of a constituency for its research. A number of speakers argued that IIASA cannot derive satisfaction merely from adding to the shelves of unread scientific literature, that it will realize success only as it achieves institutional change.

In the organization field two important possible constituencies were identified: practitioners and scientists. It was alleged that, if the two groups were to rank the significance of different advances in the understanding of organizations, the correlation of their ordering would approach minus one. It was argued that IIASA must attempt to make vital contributions along the scales set by both of the groups.

Political Sensitivities

Two participants disagreed with Bower's assumption that the Institute must avoid politically sensitive topics. They granted that certain politically neutral subjects--as those suggested by Bower--might serve as the foci for valuable research. Nevertheless, they maintained that to restrict oneself from the outset to study areas without political facets was consciously to exclude from consideration a most important class of determinants of organizational behavior. This could amount to a self-limitation to study only the blandest of problems and to the neglect of many vital current trends in organization science. When the Handbook of Organizations came out, its total neglect of constituencies did not prevent it from standing as a landmark in the field. Nevertheless, it would be naive, argued one speaker, to hope that IIASA today could maintain relevance while shying away from all questions touching upon political sensitivities.

Concepts of Needed Organizational Research

Research Aspects in the Field of Organizational Systems

Co-Chairman Milner approached the problem of the appropriate organizational research for IIASA from a different perspective. Instead of inferring the research program from a careful reflection upon the proper role for IIASA, he began with the

consideration from a broad perspective of the areas in organization science where further study is needed.

In his paper "Design of Organizational Systems: Principles and Methods," (Document S), he identified four important sub-areas for research into organizations. The first sub-area was that of improving research methodology itself. This covers improved methods for the description, classification, and differentiation of organizations and of their components. Decision theory, man-machine simulations, and formal feedback analysis could all be studied with the goal of improving their utility for the organizations researcher.

A second area of organizational research is that employing mathematical methods and simulations. These techniques would be used to improve the description and the optimization of organizational systems.

A third area is that of information flows within organizational flows within organizations. This would would cover the modelling and investigation of information networks, inquiry into social and psychological effects of communications, and studies of the effects that management information systems (MIS) have upon the structure and practice of management.

The fourth important theme of organizational research identified by Professor Milner was that of the goal realization problems in the organization--particularly the measurement of effectiveness and efficiency. He argued that much fundamental work into the criteria and frameworks for organizational achievement is required before confident judgments upon the adequacy of the designs or the performances or organizations can be made.

Structure, Content, and Values

Professor Milner's paper and presentation laid the foundation for detailed consideration of the possible components of IIASA research into organizational systems. The paper was welcomed by one participant as a needed departure in systems science. He felt that the science has, in the past, placed inordinate emphasis upon structure to the exclusion of content and values. Content he as the union of disciplines brought to bear upon a given problem and having special concern with human behavior. Values in the organizational context might be individual, corporate, social, or humane, and depend vitally upon the client identified. This speaker lauded Professor Milner's inclusion of social science aspects and his emphasis upon measuring effectiveness and efficiency--entities intrinsically dependent upon values.

A Systems Framework for Research

Another conference member felt that the delineation of research areas drawn by Professor Milner could serve as a useful framework for the cross-cultural comparison of organizations. He suggested as one possible format for such comparative studies the following.

1. Definition of the system. His personal experience has found that the systems approach has universal adherents few of whom could explain what it is. As his own outlines of a solution, he suggested that there are three basic categories of systems. The first is the concrete system which exists in four-dimensional space-time. The second is the conceptual system which may be variously defined in mathematical, computational or verbal terms. The final type is the abstracted system--not identical with an abstraction--but derived from careful observation and generalization of related events.

2. Identification of system structures. In this respect it is first vital to agree upon a definition of system processes. He suggests that these be defined as the transformation of matter, energy, and information.

3. Examination of the hierarchical structure of systems levels--including echelons of command and control.

4. Identification of systems components. He argued that medical advances were impeded by the lack of a scientifically established definitional groundwork. By analogy, an important prerequisite for systems analysis at IIASA is an agreement upon terms of reference.

5. Investigation leading toward measures of effectiveness and efficiency. Various tacks may be adopted here. It is essential that the factor of costs not be overlooked. IIASA might proceed with a clinical examination of institutions to determine what is normal and what is pathological behavior. A goal might be the description of systems in terms of input-output analysis.

The thesis put forward above was supported by another speaker who noted that medicine made dramatic progress only when--at approximately the time of Claude Bernard--the body came to be seen as a system. He argued that organization science lacks a sound underpinning of anatomy or comparative anatomy. It may be premature even to develop a taxonomy before this necessary groundwork has been laid.

A Survey Project

The argument for the need to distill a common starting point before embarking upon a formal research program was put forward in a new form by another conference member. He felt that the immediate emphasis should be laid upon determining the common assumptions of the researchers--for instance whether various researchers tend to assume the existence of a single decision center. A mode of obtaining this preliminary self-knowledge would be a multi-national survey which would have its goal a typology of basic assumptions across disciplines and countries. We should not, he argued, just open a "duck" to see what it contains without first having a groundwork vocabulary to describe what might be discovered.

Physical Systems

The discussion turned to examine more closely the nature of systems proposed as objects for study. A participant felt that, of the three types of systems defined above, the physical systems merit the greatest attention. When other types of systems should become the focus, he urged that their physical representations and manifestations be stressed. As an example of concrete systems worthy of study, he proposed the space exploration programs of the US and the USSR.

Open Systems

Another speaker felt that the paper of Professor Milner tended implicitly to assume the closure of organizational systems. He argued that greater attention should be given to open systems and specificially to their interactions with their environment. Only by studying the reactions of organizations to external influences can their dynamic properties and their stability be assessed. A particularly important set of external variables, he felt, were the economic ones. Another participant felt that Professor Milner's concern for measuring the effectiveness of systems implied that attention be given to such external influences. Yet another argued that, sensitivities being damned, the political array of external influences must be understood in order to understand organizations.

Lexicography

Professor Levy, as a means of clarifying the debate, advanced differentiated definitions for "systems science" and for a "system" (Document Q). "Systems science" he defined according to Bertalanffy as "a metascience to be applied to all fields of knowledge." A "system" he posited to be "a combination of means and of activities performed by men in order to attain one or more objectives."

When a participant requested a working definition of an organization, Co-Chairman Bower responded in terms parallel to the latter definition of Professor Levi: An "organization" he defined as "two or more individuals united about a task."

Systems and Values

One member declared his liking for the characterization of systems study foci as content, structure, and value. He felt that a useful first task might be the initiation of research and debate to arrive at a set of values, or at least to identify the areas in which values are inevitably subjective rather than commonly held. Many crises of modern society result, as he saw it from the proliferation of competing values. Organizational management is relatively easy when a single clear objective--as maximizing GNP or reaching the moon--overrides all others.

This theme was picked up by the following speaker who noted that research has already shown the impossibility of defining an appropriate multi-objective utility function for groups of people with disparate preference structures. This may also be viewed as a vector-valued optimization problem. In an academic sense, such problems may be insoluble; yet to proceed no further than to state their insolubility is an academic trap. Searching for ways to effect improvements--seen as improvements across all relevant value functions--is a worthwhile task even though absolute optimization may be impossible.

Matrix Organization of Research

Professor Bower, in his presentation, urged a matrix conceptualization of IIASA research in the organization area. He argued that the various projects of IIASA should be structured and guided to support one another. Thus water researchers would assist the energy project in its consideration of the hydrological consequences of alternative energetical technologies and so on. This mode of research organization may be pictured as a square n-by-n matrix--where n is the number of IIASA projects. He also proposed an alternative matrix description of organizational research. Along the horizontal dimension he arranged the research targets, the types of organizations that could be studied. Along the vertical dimension, he arranged the research targets, the types of organizations that could be studied. Along the vertical dimension, he listed the alternative research themes--centralization-decentralization problems, strategic planning, managing innovation--that would guide investigating teams. Within such a format, Professor Milner's listing of the methodological, mathematical, informational, and measuremental aspects of

organizations would provide a basic differentiation of Bower's vertical axis. The second matrix of Bower, modified variously by the participants came to serve as the vehicle for visualizing, and describing, and debating IIASA research into organizations.

Modifications of the Matrix

Professor Straszak made the first contribution to adapt Bower's conceptual framework as the format for a concrete plan of action. As the study targets--the horizontal dimension--he proposed urban systems, industrial units, and service operations--such as banking and postal functions. On the vertical axis--as modes for investigation--Professor Straszak suggested the disciplines of mathematical modelling, structural analysis of organizations, man-machine interaction studies, feedback analysis, and political science. The appropriate degrees of stress to be placed on the various alternatives within this grid could only be determined by the continuing experiences and learning of IIASA.

Professor Bower felt, upon examining the matrix of Professor Straszak, that his own two-dimensional conceptual framework had been inadequate. He noted that the vertical scale--research themes--contained two distinct classes of criteria. The first was that of systems phenomena--the problems of decentralization, of goals and efficiency, of structure, of information, and of measurement. Professor Bower felt that this group should be distinguished from the research disciplines per se--computer simulations, mathematical modelling, clinical investigations, and descriptive research.

Professor Beneš (Document A) brought forward a more detailed breakdown of the distinctions suggested by Bower. He recommended that the research area be subdivided into seven more limited domains: those of 1) measurements and organization of data, 2) examination of large system situations--as defined by Zadeh, 3) man-machine interactions, 4) computer control of organizations, 5) telemechanics, 6) optimization methods, and 7) economical problems. Professor Beneš felt that the view of large organizations as objects for control was especially important. In the terminology of general feedback control theory, he identified nine basic problems: 1) thresholds of resolution of the controller, 2) situation recognition, 3) observability of complexes, 4) information flows, 5) sequential machines as models of complexes, 6) feedback control of Markovian models, 7) decomposition, 8) hierarchical structures, and 9) the goal of optimal control.

A Theoretical Formulation

A different tack in the decomposition of the problem area

was provided by Professor Miyasawa (Document T). His formulation was that of the general mathematical approach to the theory of cooperative games. Using precise definitions of action spaces, states of nature, preference relations, environmental information, subjective prior probabilities, and command structures, Professor Miyasawa showed how various units--as the team or the economic system--could be formulated in theoretical terms. His framework generalizes and extends the work of Marschak and Radner on organizational theory and he proposed that his formulation could be used as a tool for the unification of the research into formal modelling of organizations, others felt that the abstract approach of Miyaswa abstracted ou out the "heart" of the management problem. Still other participants felt that a dual approach--Miyasawa's and a more management-oriented approach--would serve to complement each other.

The Final Formulation

Dr. Evenko presented a modified and extended version of the original Bower matrix. It incorporated many of the comments made during the course of the meeting and in addition was fleixibly structured so that subsequent comments were readily subsumed into its framework.

Dr. Evenko adopted the three dimensional concept of the modified Bower matrix. The three axes designated 1) the projects--or the objects of study, 2) the methodologies to be applied, and 3) the specific problem themes to be pursued. In his listing of project topics, Dr. Evenko followed that of Professor Straszak in suggesting as study subjects international systems, industrial and non-industrial organizations, and governmental organizations. As the methodologies, Dr. Evenko listed those of:

- the case or prototype approach
- the clinical investigation
- methods of non-quantitative analysis, as those based upon organograms, mathematical modelling and optimization, and computer modelling and simulations.

The list of problems themes presented included the following:

1) formal and less formal structuring of the environment;

2) goal-setting mechanisms of organizations;

3) formal structuring of organizations--departmentalization, centralization and decentralization, integration, and hierarchical layering;

4) decision-making systems--including communications considerations and information flows;

5) organizational dynamics--life cycles, management of innovation; and

6) informal structures as the incentive systems for organizational components.

Research Priorities

Delineation of Project Tasks

The thought which led to the matrix conception above had produced a better formulation of the problem before the conference. There remained the formidable task of modifying the category list represented along the axis of the Bower-Straszak-Evenko matrix and of identifying those elements within the matrix deserving of special attention.

The first participant to address himself to this problem urged that IIASA focus upon large, complex organizations. It is here that the problems of proliferating information flows and the obstacles presented by sheer complexity have led organization science to founder. The problem he saw as especially acute in the area of multi-hierarchical organizations--perhaps the most complex of all. Advances in the understanding of large, complex organizations will have immediate value in many nations.

This speaker referred to the difficult problem of values in the organizational context. He agreed that these are vectors rather than scalars and pointed out the obstacles to the comparison of values across different economic and social systems. Nevertheless, he argued that the problems themselves are common to all systems and amenable to common improvements if not to outright solutions. Should the avoidance of politically sensitive topics be a concern, the speaker felt that studies of information flows would not occasion objections.

Systems Aspects of Organizational Research

Professor Koziolek (Document M) supported the research outline presented by Professor Milner. He felt that, while the four study foci of Milner were amenable to various modes

of analysis, they were especially apt targets for systems inquiry. They provide the opportunity to investigate the high level complexity of input-output relationships in production and managemental systems. Three aspects in particular he saw as important to the systems approach: 1) the penetration of external goals into the internal processes of organizations, 2) the establishment of internal requirements which induce the efficient realization of the external goals, and 3) the interrelationships among production systems, economic organization, and management operations. Two research approaches which Professor Koziolek recommended to IIASA were those of comparative analyses and the development of a classification system for organizations. As apsects of management systems deserving of special attention, he proposed their flexibility--their adaptability for the realization of diverse external goals--and their reproduction--the creation of new organizational systems.

Professor Koziolek proposed three intrinsically different types of tasks for the development of mathematical methods in organizations research:

1) the use of mathematical methods to enhance the efficiency of organizations;

2) the use of mathematics to determine the optimal sizes of systems and subsystems in effect to resolve the problems of centralization and decentralization; and

3) the formalized description of hierarchical structures--perhaps through digital simulations.

Information Systems

In his recommendations of concrete tasks to IIASA, Professor Koziolek stressed the importance of informational susbystems and particularly that of applied electronic data processing (EDP). This suggestion was supported by Professor Winkler in his paper, "The Communication and Production of Information" (Document X). Within this topic, the following questions should be examined:

1) what influence the information system and EDP exert on the organization;

2) what areas in organizational systems offer most promise to the application of EDP;

3) how the material nature of the process managed affects the structure of the optimal information system;

4) how to evaluate the cost and the effectiveness of information flows;

5) how to classify the functions of information systems according to their organizational functions;

6) how the information system effects the reaction times of management;

7) how information systems should be structured to provide decision makers with facts pertinent to their decisions; and

8) what is the proper level of centralization in the information system itself.

Organizational Research Targets

Professor Bower reported that at a small meeting held at the US National Academy of Sciences, a number of possible research projects were identified which satisfied the constraints he had delineated. These projects covered:

1) the organizational and managemental aspects of universities and higher education systems,

2) national computer development and implementation strategies,

3) long-range planning studied generally,

4) health care delivery,

5) management information systems, and

6) management of innovation.

In addition, the National Academy felt that sub-projects making use of organizations specialists might well complement many of the applied projects. Thus the energy, urban, and water resource projects might benefit from the contributions of organization scientists while the latter would be grateful for concrete problem situations within which to ply their trade.

Other organizations were mentioned by the conference as appropriate specimens for IIASA investigation. These included:

1) banking institutions and systems,

2) postal services,

3) electrical utility companies, and

4) national space exploration programs.

Research Themes

The specific themes mentioned as a menu of research foci have largely been spelled out above. The comprehensive list of such themes is given below with brief commentary given upon those introduced for the first time here:

1) Description of business organizations

2) Classification of organizational structures

3) Processes of goal determination

4) Decision making in organizations

5) Informal organizational structures

6) Man-machine simulations

7) Feedback and control theory

8) General systems properties of organizations--e.g. dynamic adaptability, stability

9) Mathematical optimization and problem resolution

10) Cooperative and non-cooperative gaming aspects

11) Computer simulations--digital, analog, and hybrid

12) Assimilation of specialized inputs--e.g. that of experts

13) Information networks-especially MIS's

14) Affective aspects of communications

15) Derivation of effectiveness measures

16) Centralization-decentralization

17) Debureaucratization

18) Clinical analysis of healthy and pathological organizations

19) Processes of institutional change

20) Learning processes of organizations

21) Inter-institutional relationships

22) Interrelationship of work and health

23) Management of innovation.

Disciplines

A number of participants stressed the importance of interdisciplinary research for IIASA. The paper presented by Leontiades (Document P) laid particular stress upon this point. Disciplines explicitly mentioned as candidates for representation on the organizational project of IIASA included the following:

- organization scientists per se--to cover the behavioral and structural schools
- computer specialists
- control theorists
- cultural anthropologists
- economists
- historians
- legal experts
- managerial specialists
- social psychologists--to cover the affective and cognitive perspectives.

Considerations for a Concrete Research Program for IIASA in the Organizational Field

As the participants came to grasp better the philosophy and goals of IIASA and as they identified areas in the organization sciences worthy of Institute research, they

spelled out caveats, guidelines, and operational recommendations for the planning of possible projects. The tenor of the discussion was not the setting of IIASA policy but the informal proffering of advice that stemmed from experience.

The meeting considered the goals of the research and pondered the question of the constituency of IIASA. Possible constituencies mentioned were the national member organizations (NMO's), the scientific communities represented by the NMO's, or the nations represented by the NMO's. Although this question could not be definitively resolved, it was felt that IIASA should assume for the present a double obligation: to practitioners who could apply concretely the research results and to scientists who require strengthening in the infrastructure of systems methodology.

Time

The question arose of the time horizon over which the research achievements should be realized. In order to satisfy the various constituencies of IIASA, early scientific payoffs will be valuable. On the other hand, it was argued that certain of the research themes put forward could only be expected to realize fully adequate results over the course of decades. The more rapidly Institute scientists hurry to publish their findings, the more shoddy the published work is likely to be. Somehow a median between unconscionably long delay and between premature and hurried publications must be found. It was suggested that, as a new institute with the natural necessity for producing an early payoff that would justify its existence, IIASA should concentrate in its first years upon research projects which are bounded in scope, which have concrete objectives, and which afford the strong presumption of feasibility over the short term.

On Going Bankrupt

Professor Rhenman advanced the thesis that IIASA research should not fear but should welcome periodic bankruptcies in its program. He argued that virtually all successful enterprises have a history of bankruptcy and that this is not oddly anomalous but causally significant. The bankrupt firm is able to reenter its lists without any baggage of investment or obligation. It carries with it from its bankrupt experience only its memory and understanding of that experience itself. Thus equipped, the recently bankrupt firm is excellently suited to succeed. Professor Rhenman argued that the same mechanism would hold for a research enterprise as for a business firm:

IIASA project teams ought not to fear the abandonment of their ill-starred efforts nor to cling to their sunk investments. By declaring bankruptcy, putting aside completely their previous work and beginning afresh, they stand, over the long run, to enhance the value of their work.

Crossing Discipline Boundaries

Professor Bower argued on the first day that IIASA research, to be successful, must achieve the active interaction and the mutual support of various disciplines. Professor Raiffa admitted that he had been worying about this problem and presented some of his thoughts. He related two personal experiences with institutions that consciously sought to be interdisciplinary but which failed. The scientists of the various disciplines simply find it difficult or uncomfortable to converse across discipline lines.

The instances Professor Raiffa knows where the interdisciplinary approach has worked had the common characteristic that they involved concrete situations. The very concreteness of the problems afforded a common ground for dialogue. He hoped to use this mechanism in IIASA in order to draw the disciplines together into effective teams.

Professor Leontiades (Document P) also emphasized the dangers of exclusive disciplines withdrawing self-protectively into their parochial domains. He stressed three facets of this problem:

1) the tendency to interpret problems in terms suited to specific techniques;

2) the tendency to evaluate success exclusively upon the canons of one technique and its perspective; and

3) the tendency to ignore the time dimension.

Professor Leontiades expressed hope that the strategy outlined by Director Raiffa would enable IIASA to overcome these proclivities.

Methodology and Applications

A specific important problem of cross-disciplinary cooperation is that of the methodological and applied research groups at IIASA. As a methodologist himself, Professor Raiffa stated his own growing awareness that methodologists too often make contributions to applied projects that cannot be used. He cited the problem of the United States space

program in which myriads of sophisticated systems models were developed but were not adopted for decision guidance. Two reasons for this were 1) that the decision makers were not sufficiently comfortable in handling the models to rely upon them for assistance, and 2) that the models themselves were often ill-suited--through their neglect of such important aspects as the political and the organizational--to be the basis for policy. Raiffa hoped that IIASA might take steps to resolve this situation from both angles: to increase the capability of decision makers to utilize systems analysis and to encourage the analysts to turn out material better tailored to assist policy decisions.

International Cooperation

Some participants saw the problem of cooperation across discipline boundaries as comparable to that of cooperation across national boundaries. IIASA should not underestimate the difficulties of bringing together scientists from disparate cultures and of inducing them to conceive and to treat problem situations in a collaborative manner. One solution proffered was that IIASA might organize study teams such that experts from two or more countries would jointly investigate the problems of yet another nation.

Learning

Upon considering the obstancles facing the efficient organization of IIASA research, it was argued that they could not be immediately overcome at the inception of any project. Perhaps then, it would make sense to structure the projects in terms of a learning process. One participant felt that experience has shown that the most valuable research progress is achieved by teams that have worked together for years.

At IIASA the initial phase of the learning process might feature a methodological survey--perhaps coordinated with the contemplated IIASA handbook fo systems analysis--together with the clinical investigation of organizations. Perhaps the early stages should include a cross-cultural comparison of organizational systems. Only after such a groundwork had been laid, might IIASA be able to contribute valuable to the frontiers of organization science or to undertake the more difficult client-oriented tasks.

One participant warned that any applied consultancy tasks IIASA might accept should be approached with a wholehearted devotion to the assignment itself. IIASA would, he argued, do itself and the client a disservice it it attempted to combine its own self-education with a concrete applied task.

A serious hindrance to the structured learning process for IIASA research is the form of its organization. The founders envisioned a rapid turnover of scientific personnel that would maximize the benefits of cross-cultural scientific interchange and collaboration. They did not intend the semi-permanent transplantation of scientists who might spend years learning to work profitably together.

Form of the Research

Several suggestions were put forward regarding the structuring of IIASA research in organizational systems. Professor Bower urged in his paper (Document E) that the organization systems project be consciously seen as nested within the whole research framework of IIASA and that special attention ought to be given to its interaction with each of the other projects. Pursuant to this suggestion, Dr. Clough (Document I) outlined in detail possible future coordination between the organizations specialists and the water resources project. As a prototypical example he considered the investigation of the Danube as an international waterway. What are the various international commissions and national institutions that are concerned with the Danube? How effective are they? How do they interact and what are the legal and political constraints inhibiting them? How can systems analysis be exploited with the present organizational structures for the control of the Danube? What new organization can realistically be designed to cope with Danubian problems of today and tomorrow?

The Scope-The Need for External Coordination

One participant, upon considering the compass implied by all the matrices being drawn, was struck by its ambition. To achieve even rudimentary coverage of all the matrix elements would require the application of resources well beyond the scope of IIASA. From this he inferred that IIASA will have to make adroit use of other research institutions and of its connections through the NMO's. In this way, the resources of many institutions would complement those of IIASA and would extend its capabilities. Part-time appointments, for instance, might valuably complement the intramural staff.

IIASA and Other Institutions--An Agency Role

Professor Raiffa had, in his opening remarks, stated that IIASA is seeking creative and effective ways to coordinate its research with that of other scientific bodies. One goal would be to obtain through the exchange of personnel greater expertise and coverage of the many disciplines. IIASA would also hope to assist collaborating institutions by serving as an important node in the transfer of scientific information--

expediting the schange of publications, unpublished material, and computer software, and facilitating face-to-face interchanges. Professor Bennis (Document C) labelled this potential role for IIASA as that of an agency--catalyzing, coordinating, and expediting research at multifarious levels--and discussed its ramifications. Strong support for such a role was voiced by Professor Danzin (Document K).

A Handbook on Design and Management of Large Organizations

A number of participants strongly urged that IIASA edit a handbook on Design and Management of Organizations. They felt that this activity, if properly done, could constitute a valuable contribution to the literature and, moreover, would provide the organization project with a common basis of understanding and a common vocabulary.

Personnel

For the staffing of IIASA research, several participants urged that the best young scholars should be sought to perform the bulk of the studies. They recommended that IIASA recruit such men aggressively--perhaps negotiating with their present employers promotions upon their return from IIASA. One speaker warned that large groups of young researchers require ballast in the form of guidance by more experienced scientists.

Research Symposia

One novel form of activity that received support was that of a symposium held to discuss the practices and techniques of the healthy organization. Such an organization might be a successful corporation which might itself partially sponsor an international discussion of its activities, strategies, incentives, and internal structure.

Research Standards

It was argued by one speaker that IIASA should impose upon itself standards of the highest quality of scientific work. One such standard might be that IIASA would encourage the replicability of its work in order that it might be challenged or possibly substantiated. This would involve making freely available the data and the descriptions of the techniques used. It would also, he noted, be in keeping with the proposed role of IIASA as international catalyst.

Closing Comments

Professor Bower closed with a detailed summarization of conference achievements. This is to be found in his paper (Document F) which presents a final version of the matrix constructed and modified throughout the conference. It also encapsulates specific research proposals.

The Co-Chairman then invited each participant to put forward his own suggestions for IIASA research and his reactions to the discussions of the conference. These statements reflected consideration of many points made during the course of the conference and offered several specific bits of advice for the research program. Written statements were presented by Professor Beneš (Document B), Professors Bertele and Brioschi (Document D), Professor Braun (Document G), Messieurs Carter and Perelet (Document H), Professor Crozier (Document J), Professor Georgiev (Document L), Professor Koziolek (Document N), Professor Koziolek on behalf of the delegation from the German Democratic Republic (Document O), Professor Miller (Document R), Professor Miyasawa (Document U), Professor Nomoto (Document V), and Professor Straszak (Document W). The documents provide well-reasoned advocacies of many positions and are succinct enough that further summarization here would be inappropriate. The reader, to obtain eleven independent and concise opinions upon the substance of the meeting, is urged to consult each of these statements.

Professor Raiffa expressed his delight at the range of opinions and advice that had been aired at the conference. He pointed out that it would be impossible to implement all of the good advice received and that the specific projects adopted must depend on activity in the rest of the Institute and on the availability of the leading scientists. He ran briefly down a list of conceptions that had been emphasized and of arguments he found appealing:

1) Each IIASA project area should be structured to incorporate feedback that would lead to their improvement;

2) IIASA must have a healthy attitude toward failures, extracting from them valuable experience and not pouring unlimited resources into losing causes in the attempt to revive them;

3) A mixture of roles for IIASA as a clearinghouse or agency and as a research center seems advisable;

4) Concrete studies require delicate cross-national and cross-disciplinary coordination; and

5) He and Deputy Director Letov will have to blur the lines between projects, encouraging individuals to straddle project lines.

Professor Milner was impressed by the breadth and complexity of the problems mentioned over the course of three days. He felt that these covered many important aspects of the science and the praxis of management. That they were able to cover so much ground he attributed to the broad disciplinary and national representation achieved at the meeting.

With so much to be done and with a comparatively short time and limited resources available, Professor Milner was thankful that they had reached a rudimentary consensus upon how to begin. The conference he noted had overwhelmingly felt that the organizations project must 1) be interdisciplinary, 2) combine attention toward methodology and applied projects, and 3) study problems of effectiveness and efficiency. He felt that a good strategy would be to initiate research through a survey. Although it was not yet altogether clear just how this survey should proceed, Professor Milner had some limited suggestions. The survey, he argued, would encompass an entire organizational system from the formulation of its goals to the realization of its output. It should focus upon a situation common to both East and West, yet paying close attention to the differences. By beginning with such studies and moving to the more difficult applied and methodological problems, IIASA can establish itself as a forum of knowledge.

Professor Milner lauded the decision maker who had chosen the site for the meeting and thanked Director Raiffa and the IIASA staff for their support. He expressed gratitude to all the institutions which had sent representatives to the symposium and thanked the participants themselves for their attention, patience, and spirit of cooperation. He was confident that the IIASA research program in organizational systems could continue in the same fruitful vein in which it had begun at this meeting.

Document A

Design and Management of Large Organizations as a Broad Area of Research in IIASA

Jiri Beneš

There have been broad areas of research suggested and considered for the activity of the International Institute for Applied Systems Analysis. Four of them have an especially important bearing upon problems of human progress, where international cooperation can be of great help. These are:

I. Water Resources
II. Energy
III. Environment
IV. Urbanism

A common characteristic of these broad areas of research is that they are related to primarily technical systems where it is possible to measure physical variables, and where many case studies on national and even international scale are already available. IIASA could promote further international cooperation in these fields. It could also be a catalyst for applying the most progressive methods of design and management of large organizations in these areas of very practical and pragmatical interest to us all.

Another broad area of research has been suggested: "Design and Management of Large Organizations". This area of research must provide the methodological background for IIASA activity in the application and further development of systems analysis. It is up to the Council of the Institute to decide upon the priorities of these and other broad areas of research.

The aim of this comment is to raise a voice in favour of an orientation of the broad area of research "Design and Management of Large Organizations", if it is adopted for the Institute. This orientation should, from the very beginning, be toward the needs of the other four broad areas of research mentioned above: water resources, energy, the environment, and urbanism. We must also consider other more general aspects and lay the foundation for more basic management of large organizations. But, at the present state of IIASA, a very practical orientation in this area of research seems appropriate and indicated.

If we get a principal consensus for such an interrelation of research areas, we can then move on to a more detailed and pragmatically oriented division of the general research area, "Design and Management of Large Organizations". This research area could be divided as follows:

1. Measurements and organization of data collection and transfer in large organizations (with special view to water resources, energy, the environment, urbanism, trying to exploit aspects in common and technical solutions, both existing and potential).

2. The analysis of the situation of Large Systems. This is an expression for the identification of the state of a system, where the state is defined in the sense of Zadeh. This subarea of research can use different methods and technical means of situation recognition, related to pattern recognition.

3. Man-machine interaction in the design and management of large organizations. This includes the sophisticated use of different sorts of displays and methods of interaction with them. The importance of the pictorial representation by displays for the control of large organizations is increasing.

4. Computers for control of large organizations. Here both off-line and on-line functions are to be investigated and common aspects in the four mentioned research areas exploited. The research in computer applications must take account of rapid developments in computer technology - e.g. LSI (Large-Scale Integration), new memories - and also of national exploitation of both hardware and software. There are problems and new solutions in the computer field which have great potential value for controlling large organizations. Examples might include:

a) the appropriate and efficient use of parallelism and pipelining in computers for control;

b) the use of code-activated switching in multiprocessors;

c) symbolic data processing;

d) exploitation of the inherent parallelism of certain programming languages particularly suited for operations with vectors and matrices;

e) unconventional associative processors;

f) telemechanics, which includes methods and instrumentation for the acting upon large organizations of predominantly technical character;

g) optimization methods, first oriented at IIASA explicit to the four areas of research;

h) economic problems; elaboration of new criteria, and their testing.

These are some of the most pressing subareas of research in the general research area "Design and Management of Large Organizations". Obviously, this way of breaking down the general research area exploits the common problems existing in the different applications.

Of course, in the framework of this general research area we should provide for some sound nucleus of progress in the general methodology of applied systems analysis and control. Here the word "control" is added purposely; after all, our analysis of systems also considers generally the requirements upon control of large systems.

In the present state of the art, problems of feedback control of large organizations are investigated in many countries, even if the control is not fully automatic. In many cases, human operators still remain, and the computer is used as an adviser. In applying general feedback control theory to control problems in large systems, let us name the controlled system in this case a complex, and let us call the usual controller a formator (as it must not only control the function but also control the structure) of the large system - the "complex". The basic control problems of complexes can be seen at present in the following nine directions of research:

1) thresholds of resolution in the concatenation of transformations in the feedback loop of control;

2) situation recognition by the analyzer of the formator;

3) observability and controllability of complexes;

4) information - theoretical approach to the control of complexes;

5) sequential machines as models of complexes;

6) feedback control of Markovian models of complexes;

7) decomposition of complexes with active man-machine interaction;

8) hierarchic structure of the complex and of the formator; and

9) optimal control of complexes.

For the content - obvious to those working in this field - of these directions of research, I refer to my lecture "Basic Problems of the Control of Complexes" at the University of Cambridge in June, 1972.

In many countries scientists and scientific groups are working on these problems, and IIASA in its present initial stage could use the results for its work in applied systems analysis.

For a much broader perspective in the methodology and theory of design and management of large organizations, the following directions are promising:

1) information basis of feedback control of complexes, including the theory of thresholds of resolution and the use of epsilon-entropy;

2) homogeneous structures in topological relation to the structure of complex systems;

3) Markovian models of feedback control of complexes including the theory of controlled diffusion processes;

4) decomposition and hierarchical stratification for the control of large systems.

IIASA starts its work in a very fortunate situation. In many countries there are already successful examples of operation of large systems, and research in some of the directions mentioned is already in progress.

Document B

Proposals for the Activity of the International Institute for Applied Systems Analysis in the Field of the Design and Management of Large Organizations

Jiri Beneš

1. It is important to build up from the beginning the IIASA scientific program and to consider the scientific character and activities of the Institute as primordial. This in no sense contradicts the Institute orientation toward applied systems analysis. We should not underestimate the value of good theoretical and methodological preparation and generalisation of any applied project in the design and management of large organisations (hereafter referred to as DEMO).

2. In order to prepare properly any definite IIASA program or project in the field of DEMO, it seems advisable to gather at IIASA highly qualified specialists in this field. The group would meet only for a few days and should not exceed perhaps five to seven participants in order to have fruitful work. These specialists should discuss and work out at least the general guidelines for IIASA activities in the project. These would take account of conditions, advantages, and obstacles which might arise during the project and its fulfillment.

3. This emphasis upon the scientific character of the Institute is done on purpose. It is important to build up a scientific tradition at the Institute by organizing seminars and lectures. This will thus make IIASA attractive to scientists and their audience and help IIASA become a genuine scientific center.

4. For this scientific activity in lectures and seminars, IIASA can get concurrence and support from its national member organizations. In this connection, I suggest that the steering bodies of IIASA consider two possibilities:

a) IIASA participation in the second formator symposium on mathematical methods for analysis of large systems, organized in Prague, CSSR, by the Czechoslovakian Academy of Sciences, Institute of Information Theory and Automation for 18-21 June, 1974. IIASA participation at

this symposium could have different forms: participation of IIASA scholars and junior fellows; presentation of lectures on the five topics of the symposium; a form of IIASA sponsorship of the symposium in order to begin external activities of the Institute. The detailed topics of the symposium are attached to this document.

b) Organisation by IIASA of the third formator symposium on mathematical methods for analysis of large systems to be held in Austria, possibly at Laxenburg in June of 1975 or 1976. This could establish a tradition of organising these international formator symposia with the concurrence or sponsorship of IIASA in its various member countries. (The first formator symposium was in 1970 near Prague; the 1974 symposium will be in Prague. It would be good to have strong IIASA participation in these symposia as early as 1974.)

5. Let us now turn to the applied side of the systems analysis to be done at IIASA. In addition to the cooperation of theoreticians and methodologists, it seems most important also to have full cooperation of specialists having applied experience in the fields considered--e.g., experts in water projects, energy projects, environmental projects, urban projects, etc. These projects all need participation of people with good, professional practical experience.

6. One important part of the Institute is its computing facilities. IIASA should also possibly exploit the use of long-range data transmission in connection with a definite global trend to use of space communications. (This remark is made without expressing preference for any computer firm.)

7. The survey of the state of the art in DEMO can best be prepared, as I see it, by an editing group from different countries and geographical areas, having at most about nine members. They would be highly qualified scientists and professors, working in DEMO, and interested in this type of survey project. They would assemble and review chapters (sufficiently numerous, i.e., about twenty to twenty-four), written by selected specialists. IIASA would entrust these specialists with the task of contacting--possibly using IIASA facilities--organizations indicated by the national member organizations in order to get the necessary information and references to literature in the different countries. The NMO's might further aid these specialists.

8. As to the content of this survey of the state of the art, it would be good for the authors of the chapters to attempt as complete a review as possible of the various scientific schools and schools of thought, trends, and directions in the field of DEMO. At the same time it would be wise to maintain the good tradition of respect to the founders of important scientific and methodological directions of applied systems analysis.

9. It appears important to start this year actual work on a real project with definite technical background (even if the project is in embryonic form). Further, more extensive international cooperation can and will surely follow when there are promising initial successes.

Document C

Remarks on Organization, Management, and Work

W. Bennis

"For success, then, let me give one simple piece of advice beyond all others. Every day, year in and year out, each man should ask himself, over and over again, two questions. First, 'What is the name of the man I am now working for?' and having answered this definitely, then, 'What does this man want me to do, right now?' "

Frederick Winslow Taylor
Scientific Management, 1910

"Without work all life goes rotten. But when work is soulless, life stifles and dies."

Albert Camus, 1960

Outline of Report

I. Author's Assumptions

II. Some Neglected Areas of Research

III. Criteria for the Selection of Research Projects

IV. IIASA: A Crucial Dilemma and a Belated Resolution

I. AUTHOR'S ASSUMPTIONS

1. This paper is based chiefly on experiences and educational background in capitalistic countries.

2. Whatever else is divergent between capitalistic and socialistic forms of government, both have established and rely on the effectiveness of large-scale bureaucratic systems for their survival, defense, economic well-being, and quality of life.

3. In the U.S. especially, we have seen the growth of large bureaucratic systems in the public sector. This is one of the legacies of the Roosevelt period in America. Unable or unwilling, private enterprise has not taken on activities having to do with the invention, creation, "production," and delivery of what can loosely be called "human services;" e.g.,education, welfare, care of the aged and the dependent, and health-care. (I am not unaware, in making this assertion, of "corporate social responsibility.") In turn, this has led to the development of unwieldy, ineffective, and highly costly and inflationary organizations that few understand how to manage, let alone lead effectively.

4. Capitalistic economies are becoming truly mixed in ways that were unforeseeable in the late 20's and 30's. Canada--a so-called capitalistic economy--spends about 1/3 of its GNP on government. India spends about the same amount, perhaps slightly more now. When I lived in Calcutta in 1965, the Indian government spent a lower percentage of its GNP than did the USA. (The biggest employer in the U.S. is government and the fastest growing employment sector is local and state government.)*

*From 1960 to 1970, government workers in the U.S. increased from 12% of the civilian labor force to more than 15%.

5. More and more individuals in all industrialized countries are working in large scale organizations compared to the "self-employed." One hundred years ago, about 90 percent of all Americans were "self-employed." About 10 percent worked within corporate or organized social systems. Today, the ratio is reversed. As late as 1950, 80 percent of American workers were in large government or corporate bodies; in 1960, the figure was 90 percent.

6. Size is becoming an increasing problem. Out of 3,534,000 industrial units employing 70 percent of the civilian labor force, 2 percent of the units accounted for 50.6 percent of the employees, and more than 27 percent of the employed were accounted for in 0.3 percent of the units.

To summerize, then, it can be seen that: THE DOMINANCE AND GROWTH OF LARGE, PUBLIC SECTOR INSTITUTIONS WHOSE PRIMARY MISSION INVOLVES HUMAN SERVICES, AND OF LARGE CORPORATIONS HAVE RESULTED IN RAPIDLY INCREASING EMPLOYMENT IN LARGE BUREAUCRATIC SYSTEMS.

7. Emphasis should be placed NOT on producing new research (with some important exceptions), but on the dissemination, synthesis, utilization of existing knowledge. This can take the form of a kind of "developmental research;" e.g., a rearrangement of variables and findings so that those factors manipulable by policy makers, managers and others can be easily identified along with a weighting of their costs, value, congruity with cultural norms and net effect.

A sub-factor of this assumption has to do with the need and relevance for policy formation. On the basis of what we now know about work, organization, motivation, supervision, it is possible to develop policy with regard to:

Worker-retraining

Job redesign

Degrees of and appropriateness of worker participation

Management development

Optimal organizational structures

Communication

And, I suspect, several other areas.

8. Who is IIASA's client?

There can be no one, single client. Certainly the member nations (through their scientific liaisons) should gain from the work of IIASA. Certainly the researchers, both within the universities and within corporations and various governmental organizations should gain. Good conceptualization and better research, especially that of a comparative (cross-cultural) nature should benefit all. There should be an equally deep concern for the practitioners, managers, and workers.

Thus, the knowledge produced should satisfy esoteric requirements (literally, "knowledge produced for learned colleagues") as well as "exoteric" knowledge. "Exoteric" is an esoteric word which means knowledge produced for the public interest and rendered in useful forms.*

*Joe Bower said yesterday that "...all the best work has been based on data." How about the most influential work? There is some evidence that practicing managers and practicing researchers hold strongly divergent views about "best." Drucker, McGregor, Maslow, Argyris, and Herzberg were considered "best" by managers and turned out to be at the bottom of a list that a sample of leading researchers rank ordered.

9. The study of organizations is relatively new, rich, diverse, inchoate and still emerging, interdisciplinary, erratic--and disorganized. There is no central theoretical armature or empirical base. There is no leading center in the U.S., although there are several outstanding ones. My guess is that organization specialists are dispersing their talents within more formal academic departments within universities and possibly, though I am far less certain about this, within corporate and governmental research units.

The research is, for the most part, non-replicative (or if it is, then there are precious few examples), heavily value-laden, rarely longitudinal (this holds true, unfortunately, more for U.S. than for other countries, I believe), rarely cumulative, rarely comparative or cross-cultural, and rarely includes precise observational techniques. Further, it has tended consistently to overlook and neglect crucial areas, most especially the politics of bureaucracy, the politics of organizational decision-making, and the changing nature of the environment, which have important consequences for the firm/organization and inter-institutional relationships.

10. The study of organizations is important, if not crucial, because of the centrality of work both for the individual and the nation. The capacity to design effective organizations is related to the health, longevity and well-being (psychological and material) of each of us, the politics of workers, the nature and structure of the family, and many other aspects of our non-work lives.*

*See Work in America, 1973, MIT Press.

11. Learning, whether professional or personal, is the most significant factor in job satisfaction.* This finding holds for both blue-white collar employees as well as management. Seashore and Barnow find that among blue-collar workers "self-respect, a chance to perform well at work, a chance for personal achievement, and growth in competence, a chance to contribute something personal and unique to work" are the main correlates of job satisfaction. In a major study of blue-collar workers 40 and older, alienation was found to be highest among those workers who possess high achievement values but whose jobs were rated low in terms of variety, autonomy, and meaningful responsibility. A particularly significant factor emerged from this study: it was found that those workers who have high alienation scores also score high on the desire to change their jobs. Nearly 40% of the over-40 workers in the study have thought seriously about making an effort to enter a different occupation, and would enter an education program to acquire new skills if such a program were available that promised a reasonable living allowance.

* Recent study by R. L. Kahn.

II. SOME NEGLECTED AREAS OF RESEARCH

The following suggestions fulfill these criteria: they are applicable to all types of large-scale organizations regardless of cultural, technological, political, and economic conditions; they are in various stages of empirical and conceptual maturity; in some, but not all cases, there is a respectable body of knowledge which is either unknown to all but the researchers themselves and/or badly require synthesis and conceptualization. Above all, conceptualization and integration.

1. How do organizations change? What are the strategic leverage points for change and how much variance does each intervention produce toward the desired effect? To what extent are changes induced by the organization internally and deliberately and to what extent are they induced by external forces with virtually no control by the organization? To what extent is the causality of external forces in the environment predictable? To what extent do research, media, governmental regulations, the "new consumerism," etc., affect the internal operations of the organization?

2. Inter-institutional relationships. For a variety of reasons the environment surrounding the organization/firm has become more salient, dense, inter-dependent, and influential in determining the internal behavior of the firm. One such reason is the increasing importance of varying forms of institutional relationships, an area in which research is needed. Careful descriptive studies have to be accomplished in order to estimate their effects on the internal operation of the organization. (I have in mind the effects of relationships with other bureaucratic institutes, such as various governmental regulatory agencies, newly emerging consumer groups, media, complementary or competitive firms, sources of personnel and raw materials.)

Note how limited our vocabulary is regarding these new social arrangements. We do have one word "consortium," (whose meaning is vague enough) but we don't seem to have the variety of terms, however vague, that might imply different forms and styles of interdependence.

might imply different forms and styles of interdependence.

3. How do organizations "learn"? Too often we hear the phrase "long-range planning." It's a nice catch-phrase and very popular; especially as an excuse to convene conferences. What is unclear is its effectiveness. The phrase is misleading for any number of reasons. First of all, what does "long-range" mean? Lord Keynes once said that "...in the long-run, we'll all be dead." Even Herman Kahn now laments that he can no longer "see" in the future beyond four years! Mirabile dictu.

What we have witnessed in American industry over the past 2 or 3 decades are changes in national priorities such as the shift from a war-time to a peace-time economy leading to changes in the need for certain skill priorities, such as health care, ecologists, urban renewers, etc. These changes are rapid: the economy's need for a particular skill can double or be reduced by half in twenty years--about half the length of an average career. Within an industry growing at an average rate, there are about five new openings for every hundred workers each year--about half due to retirement and half to industry's growth.

What is needed is not long-range planning,but research on the kinds of reflective structures organizations can use to reconceive "what business they are in; "and a solid data base, at the national level, of the kinds of externalities that will

pose serious threats to the life of an organization if these factors are ignored.

4. A cross-cultural description of organizational structures, decision processes, leadership style, appropriate forms of power, recruiting practices, and management development practices.

5. A cross-cultural study of the ways in which workers and managers cope with their own needs for personal growth within organizations.

6. Cross-cultural studies of work and health. There is increasing evidence that work and health are highly associated. In an impressive 15 year study of aging, the strongest predictor of longevity was work satisfaction. The second best predictor was "happiness." An examination of the Abkhasian people of the Soviet Union revealed that 2.5% percent of the Abkhasians were 90 or older, compared with 0.1 percent of all Russians and 0.4 percent of all Americans. There are many factors that may be associated with this finding, including diet and the increasing prestige accorded the Abkhasians with advanced age. Both the Soviet medical profession and the Abkhasians themselves, however, attribute their health to work. Most Abkahasians who are 100 years or older still work at least 4 hours a day on the farm. They say: "...without rest, a man cannot work; without work, the rest does not give you any benefit."

Compare that to how Americans treat the old.

I also wonder: What differences are there in retirement ages among various countries and what benefits accrue at the time of retirement?

7. Given the increase in and the rapid growth of public sector institutions in all societies, how best can we study their effectiveness? In most cases, there

is no "bottom line," no profit or loss, no return on investment. In the U.S., certainly with respect to universities, effectiveness has been mainly associated with logistics of growth: the number of first-rate students and faculty, the number of research papers published, the number of student enrollments, the number of new programs and buildings, and so on. Most university presidents, during the period of 1950 and 1970 were basically "executors of growth."

But given the politization of the university (as well as other public sector institutions) and given the absence of clear-cut operable measures (I'm not ignoring cost-benefit analysis and PPBS), how do we develop methodologies for identifying effectiveness that will basically determine the viability of the institution--especially during periods of deflation and/or "no growth?"

8. Cross-cultural studies of how decisions are made with respect to the establishment of priorities. This is especially important, once again, when we consider public sector organizations. The "free play of the market place" is not pivotal. (Even in the private sector, market forces have diminishing, though, of course, still dominate influence.) Obviously, welfare concerns, public policy, the polity, and communal values play a large role in this. But how do these factors expre themselves and how are they identified and weighted by the decision-makers?

* * * * * *

Undoubtedly every member of this seminar can add to this list--or subtract from it. I realize that in my notes, there are 20 or so more items that all seem reasonable research projects that could be conducted by IIASA with some benefit to the member nations. The important question, therefore, is: how does IIASA set priorities? I will attempt a quick answer to that and then recommend one line of research with which IIASA, in my view, can best and most successfully realize its function.

III. CRITERIA FOR THE SELECTION OF RESEARCH PROJECTS

1. All studies should encompass only systemic and manipulable variables; i.e.,controllable by organizations.

2. My favorite professor once said: "There is nothing so practical as a good theory." Hence, empirical research should be related to a conceptual scheme.

3. Too much of the literature of organizational behavior suffers from one of two "errors:" It is so abstract that it lacks any verisimilitude to the complex, sweaty, vulgar, plebian world of the individuals who work and live within "living systems." Or, on the other hand, consists of the conventional wisdom, bromides and platitudes, and case-studies which only, at best, exalt the obvious. The Institute should favor holistic, systemic research which deepens and broadens the understanding of the social architecture and alteration of large, complex social systems--especially of a nature which will benefit those who have the responsibility for leading these enterprises.

4. A methodological plea: Yesterday there was talk that computer mathematical applications not be ignored. I couldn't agree more. At the same time, there is another tremendous void in the methodology of organizational research. I am referring to careful, detailed, precise, reliable observation. In most sciences this is the most primitive as well as primal type of methodology. Abstraction without clear reference to actual behavior is of little use in the design of effective organizations. Few organizational scientists (I will exclude "operations research" from this, and a few others, primarily from Europe, who have adopted the methods of the social anthropoligist) have taken the trouble to observe closely--to observe closely the minute

the homely, the quotidian, the day-to-day acts upon which, say, a decision is made. To look closely is to be surprised. There are many surprises ahead of us, if only we care to look.

* * * * * *

Having said all of this, I wish to make one strong recommendation to IIASA. It is partially methodological and partly a focus of convenience that I believe can help define a distinctive competence for IIASA. What I propose is an equivalent to the HUMAN RELATIONS AREA FILE, located at Yale University. The HRAF, now computerized, contains central facts about every known pre-literate and some modern cultures, according to a reliable set of dimensions regarded as important by social anthropologists and other scholars.

WHY NOT AN ORGANIZATION AREA FILE? The first step would be to identify the variables or dimensions that would be of interest to the member nations. It would most certainly include such factors as: Number and types of primary mission types of organizational structure in terms of level of echelons, span of control, forms of communication, authority structures, division of labor, degrees of specialization, reward structures, socialization process, criteria for advancement, and so on.

The OAF could provide for IIASA, in Vienna, a center for research not duplicated anywhere in the world. It would facilitate cross-cultural research--and understanding. It is badly needed.

IV. IIASA: A CRUCIAL DILEMMA AND A BELATED RESOLUTION

IIASA sounds to me as if it is being established as a research center in more or less conventional ways, aside from the exotic combination of nations and scientific institutions it is bringing together in common cause. That alone is commendable. I suppose that the founding fathers thought of many models, including, I hope, the concept that IIASA be established as an agency that facilitates research and the transmission of research. There is a profound difference between an agency (as I use the term) and a full-blown research center, with its own research people, offices, etc.

An agency facilitates, coordinates, and commissions research using existing organizations, journals, and resources. An agency brings together (in temporary systems, like conferences) nuclear people, influential people for short-term or long-term projects to be implemented or conducted elsewhere. An agency produces synoptic reports, annual reviews, and state of the field reports; finances or helps to finance research filling in the lacunae of the fields; and writes critiques about the present status of the sub-fields that fall under the rubric of of organizational design and analysis. An agency coordinates, correlates, and summarizes the findings of organizational research going on all over the world and tries to bring together research undertaken by similar international research centers. An agency develops a modus operandi so that it can work with and help to develop research capacities on organizations with the infrastructures of other research centers in universities, governments, and industries. An agency

develops and publishes a census of seminal research applicable to and cutting across political, economic, and cultural boundaries. An agency can provide the impetus to determine, through its own small in-house efforts, the frontier and direction of where research should be going. The in-house effort of research which actually takes place at IIASA, as an agency, should be that which will lead the way toward major theoretical developments as well as practical achievements in making the lot of Homo Faber, not only more interesting and efficient, but joyous as well.

Document D

A Proposal to IIASA for Research in "Design and Management of Large Organizations"

U. Bertele and F. Brioschi

This short note summarizes the ideas we presented in the conference about what IIASA could do in the area of organizational systems.

During the discussions, many participants expressed the conviction that organization theory, and hence experts in organization, are essential to all IIASA major research projects (energy, water resources, environment, urbanism). This is in our opinion correct but not sufficient. In fact, we believe that IIASA should implement specific projects in the organizational area. These projects should exploit the international nature of IIASA, and more specifically, its ability to operate in both Eastern and Western nations.

In particular, a natural way of profiting from the international position of IIASA is by performing comparative analyses of organizational structures in different countries. This would single out the common problems and various approaches to their solution.

We think that this kind of research, if successful, might yield a high payoff and could be of interest to many national members of IIASA, as the discussion in the conference and some of the papers presented have shown.

As for the choice of the specific organizations to investigate, two ideas which we consider valid emerged from the conference:

a) comparative study of industrial organizations; and

b) comparative study of public services (e.g., medical assistance organizations).

Document E

Report

Meeting at the U.S. National Academy of Sciences

June 4, 1973

J. Bower, et. al.

An ad hoc panel to advise on the IIASA research program for the "Design and Management of Large Organizations" met in Washington on June 4, 1973 at 9.30 a.m. Chaired by Professor Joseph Bower (Harvard Business School) the group included: Mr. Warren Cannon (McKinsey), Dr. Richard Cyert (Carnegie-Mellon), Dr. Eugene Helms (Texas-Instruments), Dr. Roger Levien (RAND); from the National Academy of Sciences Messrs. Gleason, Nasmith and Rowan; and Ms. Cauthorn, rapporteur.

The committee's task included consideration of both the structure of the Institute and the content of specific projects. Certain themes and questions, for example, centralization vs. decentralization and the measurement of non-quantitative variables, recurred throughout the discussion of both the substantive and procedural items on the agenda.

As an introduction, Professor Bower reviewed the general concept of the Institute, operating on a $3.5 million budget, utilizing a permanent staff of about 80, attracting distinguished senior scientists, and offering a variety of scholarly opportunities to other professionals from the 13 member nations. The two major aims of IIASA are:

1. To achieve first order significance as a scientific institution (and, reciprocally, to stimulate research efforts in the member nations).

2. To act as a political bridge, especially between the Eastern and Western nations.

The aims are complementary except where the Institute's research program is constrained to avoid politically sensitive topic areas. For example, research projects would have to be acceptable and interesting to both Eastern and Western members and focused on areas where cultural differences were not too great. Yet topics and results should still be important and the problems central ones. As Dr. Helms stressed later, there should be an attempt to achieve something, to reach some "truth," as well as to sharpen skills and to run through an educational exercise in international cooperation.

Professor Bower mentioned, and the group reiterated, an additional consideration which, although negative, might provide positive guidance. He shared with the group Professor Raiffa's concern that the Institute not become totally oriented towards applied mathematics: The Institute's projects should take account of non-quantitative inputs while avoiding overblown generalities. Thus, another spur for this group was to come up with a very specific research program, with projects not superstructures, to counter possible domination of IIASA by the mathematical model-makers.

The Locus of Work

Geography provided the focus for the first centralization-decentralization dilemma of the morning meeting. In the simplest sense: How does Vienna relate to the member countries (and vice versa)? How do visiting fellows or associates relate their work in Vienna to their work, their careers, and their roots, at their home bases?

In the first place there would certainly be a temptation for visiting scholars merely to use the Institute as a pleasant stopover, to spend as much as a year's time finishing and writing up their own work. Such work might be strongly empirical, but it would really be coming from a particular scholar, or his home country, rather than from the Institute. One possibility, however, would be for IIASA to build from such national efforts, using the center to link and coordinate parallel work. This arrangement might produce worthwhile results, but it would not accomplish the political aims of the Institute.

Alternatively, the Institute could use groups of researchers from different countries who would work from and at Vienna. Through this work the Institute could gain recognition and identity. This arrangement would stress international cooperation and build up a reputation for Vienna, but as Dr. Cyert pointed out, the Center would tend to be remote from the necessarily scattered and distant field research sites. The panel agreed that the Institute's work must be empirical, especially to combat the already observable tendencies towards mathematical abstraction; yet such an emphasis might be difficult to keep up from Vienna.

Accordingly, the dilemma for the Institute is to work out a balance between the thrust for empiricism, a decentralizing force, and need to maintain the integrity and importance of Vienna as a real research center. Flexible arrangements regarding the selection, status, and tenure of visitors might help, but the basic problem was to find the right kinds of projects - ones which would be both based in Vienna and tied to empirical data.

Additional difficulties might result when a research team from Vienna actually tried to gather data at sites in different countries. Accordingly, the panel tried to think of topics that:

a) would interest the member countries,

b) would offer opportunities for significant empirical research, and

c) would present no insurmountable political or cultural difficulties.

Topics for Research

Various suggestions were offered, fulfilling some of these criteria. A question like the centralization-decentralization continuum itself might prove both worthwhile and acceptable to most national member organizations. Or topics like Management Information Systems or health care delivery, which could be studied across national boundaries, sounded promising. The panel felt that an institutional locus, perhaps from a municipal government or university location might be more open to IIASA teams than industries in the different countries. And they agreed that any topic would have to be more narrowly defined - the topic of urban management would really become a project on solid waste disposal, for instance.

On the other hand, Professor Bower, supported by Dr. Helms, emphasized that industry field work, even if difficult, should not be ignored. That is where most research and much that is new and exciting in the designs and management of organization is happening. If an industrial topic were chosen carefully, it might prove feasible and especially rich. Dr. Helms suggested stressing methodology of management questions, which would not be excessibely sensitive. Mr. Cannon mentioned the topic of systematic long-range planning in different companies in different countries. The management of innovation is another possibility. These industry studies could be fascinating even if they consisted simply of description and comparison. In fact, Professor Bower stressed the great importance of just such straightforward analysis.

One particular topic which seemed to satisfy many of the requirements and intrigue the Committee, was the computer industry as a problem for national or multi-national policy planning (in the smaller countries if not - of necessity - in the US and USSR). This project would tie in the centralization-decentralization threads, could include far more than applied

mathematics, and could be both exciting and significant on the levels of description and comparison.

A Translation Project

Another potential task for the Institute suggested by Professor Bower was more of a staff activity than a research project. He stressed the need for translation work and suggested tentatively an Institute series of distinguished papers drawn from all member countries. The field of organization and management suffers from language barriers and limited translation. Such a series, perhaps even including classic case studies, could provide a basis for future work and help to eliminate duplication of effort. Although the committee agreed that this activity could be important, they were not sure that a major commitment to translation was necessary. Perhaps bibliographical references, as part of the Institute's library services, would be adequate.

The Need for a Client

Drs. Levien and Helms introduced another variable into the discussion: the idea of a client-directed project (such as RAND works on) which gives boundaries and definition to research. IIASA would not want to be trapped by a client's deadlines or constrained by the client's immediate needs, but the client's problems could be valuable. The problem-solving potential of the Institute could be developed, and interesting problems would attract talented researchers.

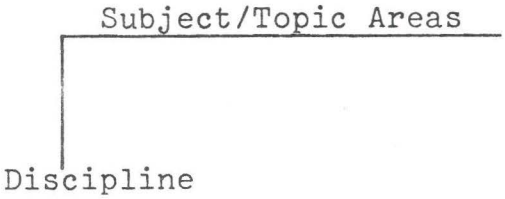
An interesting variant of the idea led to an important proposal: this quasi-consulting status could be adapted to work on many of the topics already mentioned - to the study of municipal problems, for example, or to an analysis of the computer industry in the Netherlands or Italy. The Institute would not need to carry this orientation to the extreme of action research sometimes practiced by Rhenman's group in Lund, but at least some consideration of a potential decision maker would seem to be a necessary component of the research design. And, repeating Professor Bower's concern with the non-quantitative forces, how can the validity of non-mathematical results be tested except by implementation?

The Organization of IIASA Research

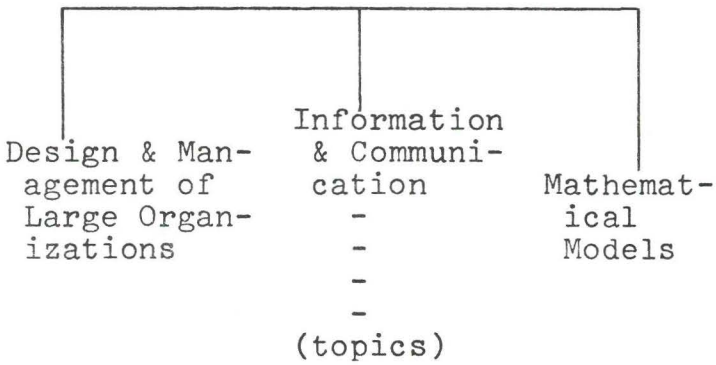
These considerations led to one of the central ideas of the meeting: the fusion of research strategy and program

structure which surfaced at this point as the issue of "linkage". The projects suggested at the meeting and the projects already planned (see IIASA booklet for listing) were not, in fact, parallel: some were "things"; some were "processes." Thus, the important question became: How do the "Design and Management of Large Organizations" topics stand in relation to the other topics? Are all the projects separate and equal? Alternative answers to these questions can be diagrammed as:

MATRIX



DEPARTMENTAL



These schemes are not necessarily mutually exclusive, but would seem to involve rather different approaches to both the topics and project teams. The "Departmental" chart includes the subjects presently proposed for study under the Information and Communication heading of the Preliminary Research Strategy document. That is, "Energy," "Water Resources," "The Design and Management of Large Organizations," and the others are presented as independent, possible concurrent projects, each with its own team of researchers working on the particular area.

In contrast, under the matrix plan, topic barriers would be crossed. Energy people would still study energy, and organization people would study organizations, but organization researchers would also study energy and water resources as members of those teams as well as their own. Organizational design questions would be simultaneously the subjects of one project and the tools for other projects under this plan.

The matrix approach has worked in the past for particular problems and seems to be working now in some industrial settings (Dr. Helms explained some of its implications at

Texas Instruments where a dual management matrix is operative). Although it was used by RAND in its early years, and characterizes almost all the best Operations Research - in fact, it might be too sophisticated an approach for the state of the IIASA program at this time. It might also lead to a diffusion of research and might attract lesser names than the departmental structure where "stars" could shine in more solitary and visible splendor.

Nevertheless, the panel believed that the matrix format, shaping both the content and design of the IIASA research, would be one way of coping with the various problems mentioned above. It would allow non-mathematical types to infiltrate the bastions of mathematical modelling; it would prevent the rigid departmentalization which has come to characterize too many professional schools; its international teams would lead to one resolution of the location question. Empirical work would go on concerning various topics in various places but researchers would be tied to Vienna by their disciplinary trust.

The group's consensus was that this approach was both acceptable and feasible, and could be adopted to fit the research requirements and topics discussed earlier. Their conclusions really form another matrix, a specific proposal for research into the Design and Management of Large Organizations at IIASA. This matrix includes on one side the location/sites agreed upon and, along the other, the topics - really the organizational design problems - which would be pursued, i.e.,

	Universities	Computer field	Municipalities urban management
Centralization/Decentralization			
Strategic planning			
Managing innovation			

The panel concluded the meeting by mulling over some specific questions. They agreed that some kind of research director was needed for the Design and Management group (who might or might not actively participate in other projects), that various gradations of researchers (Fellows, Associates, etc.) would be helpful, and that it was vital to keep industry

and government leaders involved - through mailing lists, seminars, meetings with key people, or a network of communication and criticism. The tensions evident throughout the discussion (between on-site work at Vienna and off-site work in the member countries, between theory and practice, between individual and team, between quantitative and non-quantitative science) did not disappear in the course of the meeting, but they had certainly been explored creatively.

Document F

Miscellaneous Ideas about the Project

Design and Management of Large Organizations

J. Bower

I. The basic program sketched out at the meeting is based on a simple, logical agreed-upon framework.

Problems of Organization	Methodologies for Studying the Problem	Projects
The problems fall into a natural sequence: a) Analysis of the environment b) The setting of goals and the related problem of determining what will be efficient or effective. c) Building a formal structure. d) Establishing an information system and appropriate measures (back to (b)). e) Managing the informal processes by which operations are carried out and resources allocated.	The methodology covers a wide range: a) Description Anthropological Historical Clinical Formal Models i) mathematical ii) simulation b) Analysis Anthropological Historical Managerial Quantitative	The projects proposed represented a mixture of ideas people wanted to pursue and notions of what the program should be.

II. The research program has four parts

A. An Initial Survey

It was decided that the survey would be directed by a small team in Vienna synthesizing the work of national panels. This survey would serve as an input to the Institute's Handbook project.

B. A Pilot Project

Crozier suggested that before mounting a major effort, it would be important for a multi-national team to learn how to cooperate on a project in several countries. He indicated that the comparative study of a relatively closed organization in three countries would be a sufficiently ambitious start.

C. Major Projects

1) Mathematical analysis of hierarchical structures and information systems, leading to computer simulation--proposed by Miyasawa.

2) Mathematical analysis of technical problems, e.g., water, viewed as information systems--proposed by Benes.

3) A comparative study of operations analysis applied in industrial systems--proposed by Koziolek.

4) A comparative analysis of goal setting at the policy level in industrial systems--perhaps proposed by Koziolek, and seconded by Straszak, Brioschi, Crozier, Bower, and Milner (Rhenman?)

5) A comparative study of the management of innovation in industrial systems--proposed by Straszak, and independently by Kiss, seconded by Brioschi, Bower, and Milner.

6) A comparative study of service systems, for example, health systems--proposed by Crozier and Rhenman, seconded by Straszak, Bower, and Milner.

D. IIASA Projects

The group agreed that it would participate with other IIASA groups to consider problems of implementation and management.

Water Resources--Donald Clough proposed a water resource project consisting of a descriptive study of the agencies, organizations, and laws related to management of a simple river system.

III. Issues of Institute Organization

A. Bower and Milner will serve as a steering committee (other members?) to draft the report of the conference and to plan/monitor future research. (How will they be compensated?)

B. National panels need to be set up to support the DEMO program in several participating nations.

C. These panels can help in the manning process. We need senior fellows, associates, and junior fellows. If doctoral candidates are brought in, they need careful guidance. Good comparative research requires a shared conceptual framework.

D. We may want to arrange conferences of experts around presentations of case studies by DEMO experts serving in operating organizations, e.g., Texas Instruments or IBM.

Document G

On Conditions, Preconditions, and Factors of the Flexibility of Management Systems

A. Braun

In the outlined project, "Principles and Methods for the Structure of Management Organization Systems," the first set of questions advocates the examination of methods for the analysis of the dynamics and stability of organizational structures. We support this proposal, for what is involved here is an important problem of perspective in the development of management science whose growing practical importance is uncontested.

In this connexion I wish also to underline the project thought, namely, that the analysis of actual organization systems should constitute the most important aspect of research.

This basic principle is a point of departure in the practical organization of research activity in the GDR. The analysis of the dynamics and stability of organizational structures in the economy is undertaken with the aim of using with maximum efficiency the human and material resources of organizations. Effective use of available resources under conditions which change exceedingly rapidly is regarded as a decisive criterion for evaluating organizational management systems. The following problems appear significant in analyzing the dynamics and stability of organizational structures.

1. The union of dynamics and stability within the management system. The investigation of existing management systems shows that they contain both dynamic and stability elements. The relationship between these elements is extremely important with respect to the optimal functioning of the organization. It should, therefore, be taken into consideration when describing production and economic organizations and classifying their organizational structures.

2. A well-balanced relationship within the organization to be managed between concentration and decentralisation. This relationship depends upon a well-substantiated delimination of rights and responsibilities at all levels of the management hierarchy. Here, research faces the problem of examining the optimal relationship of the total system to

the sub-system and also the function of the sub-systems themselves.

3. Ensuring the required information as well as other subjective preconditions for making substantiated decisions at all levels of management. Changes of management systems are actuated by means of a diversity of information. It is therefore most certainly useful, as outlined in the third complex of questions of the outlined project, to investigate the influence of the information system on the structure of management.

As far as we are concerned, the analysis and classification of management systems as they exist in reality in the GDR could make an important contribution to the envisaged report during the first stage. This would consist chiefly of investigation into and classification of management systems in industrial combines in the GDR. A concentrated formulation of questions pertaining to our work would outline the conditions and factors promoting the economic flexibility of such organizations. We are thus concerned with the unity between the organizational goals and behavior ensuring optimum flexibility.

Given that both the structures and the goals of organizational systems are very different in individual countries, the question arises whether, in the first and second stages, it might be opportune to prepare comparative analyses. For example, we would be very interested in analyses and generalisations of management systems--and particularly of their flexibility-- in major industrial enterprises in the USA. We would be particularly interested in all those questions pertaining to behavior of organizations in relation to scientific-technological progress, for example, processes of diversification. Here we would consider, among others, the following questions:

a) Decision foundations for preparing diversification processes, above all under the aspect of minimising the risk.

b) Organization of the management of diversification processes, changes in the management structures, and subjective preconditions to attain the stipulated goals.

Document H

Additional Comments

R. Carter and R. Perelet

1. The framework of research was rather well presented in Dr. Evenko's table, especially in the sections that dealt with problems and methodology. The typology of projects, however, needs to be more carefully delineated. At the same time caution should be given the interpretation of methodological approaches per se. For instance, although mathematics and EDP were rightly identified as a separate category of methodology, a certain quantitative bias could be applied even in the social science subject areas.

2. The use of Systems Analysis for organization and management of industrial systems should be given more emphasis since they serve as a major source of national GNP. The spin-off of research into industrial systems could also be very useful for the developing countries which increasingly are a factor of modern life.

3. Concerning possible areas of mutual interest and/or collaboration, we might consider at some point the merits and possibilities of including certain IIASA clinical research within selected and agreed upon operational activities of UNIDO. For instance, it might be possible for the IIASA researcher(s) to join a team of UNIDO experts and enjoy the firsthand observation of actual work being done in the field. But please realize, at this stage of consideration, that this is more of an idea than a proposal per se.

4. Additionally, note might be made that UNIDO is currently studying and planning the ways and means of promoting technological forecasting as a management technique for the developing countries. Thought has been given to the posting of a Consultant within an ongoing project in Yugoslavia, e.g., the Centre for Organization and Development. Perhaps, in this field, or another related one, IIASA might be interested in pursuing prescribed research efforts. Certainly, there would be mutual benefits accruing to both sides--not the least of which would be IIASA's concern for the developing countries. Incidentally, such a concern would mitigate against the possible accusation that IIASA is a "rich man's club."

Document I

Proposal for a Study of Organizational and Institutional Constraints on Multi-Agency, Multi-National Water Resource Systems Management

Donald J. Clough

1. Connection with IIASA areas of interest: Provides input to Professor Letov's proposed continental river system model. (This is only one of several component studies required.)

2. Importance:

Modelling - requires identification of legal and institutional constraints (e.g., engineering practices, water quality standards, financing conventions, multi-agency involvement in decisions), as well as physical and economic constraints.

Implementation - requires a plan that takes into account what is leagally feasible, what is politically feasible, what is institutionally manageable, and that specifies a procedure and timetable for sequential political decisions. (The"levers" of political power have to be identified.)

3. Content of study

- Select a particular river system for study, preferably one with relatively few multi-national and multi-lingual ramifications (e.g., the Tiber River in Italy).

- Investigate the set of all laws pertaining to the river system (e.g., regarding pollution, flood control, hydro-electric power development, navigation), and to related watershed factors (e.g., land use, transportation, irrigation).

- Investigate the institutional (organizational) arrangements for the administration of laws.

- Investigate the official organizations that are involved in decisions affecting the river system (e.g. municipal, provincial,

federal government departments, and agencies).

- Investigate the unofficial organizations that are involved (e.g., industrial groups,citizen groups, taxpayers associations, professional engineering associations, medical associations).

- Investigate the processes of involvement in decision making, including e.g., public hearings, plebiscites, pressure group tactics, political lobbies, as well as formal procedures and legislative changes.

- Repeat for every country in the watershed of the selected river system.

- Investigate the institutional arrangements for international cooperation, such as ministerial/ diplomatic channels, associations such as UNESCO, OECD, NATO, COMECON, etc., international scientific societies, etc.

4. Outcome of study

- Report on legal and institutional constraints and conditions affecting systems modelling, planning and implementation of the model.

- Suggestions or recommendations of feasible alternative organizational structures and strategies for cooperative management of river systems, taking into account the needs and the powers of all agencies and people involved.

5. Study resources required

- The requirements will depend on the particular river system.

Document J

A Research Strategy for IIASA in the Area of Organizational Systems

Some Second Thoughts

M. Crozier

1. One should stress, to begin with, the peculiar yet crucial importance for IIASA purposes of organizational analysis--i.e. the scientific study of human relationships of implicit and explicit governing mechanisms and of steering capacities in organizational systems. Rational systems analysis can be used only inasmuch as the human capabilities of the actors allow it. These human constraints are not the result of incompetence or of personal idiosyncracies. They are the product of the organizational systems themselves when considered as human systems. To understand the limitations of mathematical models and the possibilities to broaden them, one must, first of all, be able to analyze the present capacities of organizational systems as human entities and to develop the necessary rationale for increasing these capacities more rapidly.

2. Studies of organizational design seem to me for the present period premature or at least insufficient. They tend to be much too abstract and much too culture-bound and cannot therefore raise the proper problems that will prevent mathematical solutions to be utilized fully. Whatever its genuine contribution, the American management literature on the subject proposes only empirical patterns whose efficiency depends on its implicit adjustment to American cultural models.

There cannot be one best way in organizational design. Improvement of the present ways will depend at least as much on a good understanding of the organizational cultures and subcultures of the different nations and trades as on an appraisal of the rational problem in a mathematical sense.

3. This leads me to believe that for the next few years the main effort should have a descriptive, rather than a prescriptive or normative, orientation. We do not know enough yet to prescribe across cultures and social systems. What we do know is too culture-bound to be very useful. Even transference of this knowledge from the US to Western Europe has led to many mistakes.

But this does not mean that one should advocate a non-

utilitarian extratemporaneous kind of research. Descriptive research may be of considerable practical value. First of all it will provide very quickly an invaluable background knowledge for applied systems analysis. Second, it is a longer but more efficient way in the long run to propose prescriptive models for increasing organizational capacities.

4. Focusing on organizational analysis is not only a necessary research strategy but it is also a good research investment. IIASA is likely to get extremely interesting useful and stimulating results because of the possibility it will have to plan for the first time broad enough comparative studies in a field where case studies and prescriptive theories have been prevalent.

To be able to assess the value of the current generalizations we are using by testing their validity across different cultures and different political systems will develop enormously our theoretical knowledge. A lot of background studies have been done. We have a good prior understanding of the problem. We should not be wary of the risk involved. We can be sure of a very good return in increased knowledge.

To succeed however, we should still be cautious at the beginning, not in the general orientation but in the methodology. Organizational analysis has not been successful yet when it has tried to go too quickly to survey methods. It is ready to move from the case study to the comparative case study. This means that in planning the size of the studies to be launched, we will have to move slowly at least for a first period.

5. If this general argument is true a good strategy of IIASA should be:

a) to use organizational analysis to help substantive projects succeed by introducing social scientists into the teams of specialists. Not only will this have direct practical results, but it will give us experience for the use of social and behavioral sciences in systems analysis and will train social scientists for cooperation. But we should not believe this will solve our more basic problems because this will be still a very indirect approach;

b) not to give too much importance in this perspective to the proposed general survey of existing knowledge because such a survey will be biased in the direction of theoretical--i.e. explicitly or implicitly normative--knowledge; and

c) to concentrate our efforts as soon as possible on

a set of comparative empirical research that will help stimulate all our thinking. Such an effort will enable IIASA at the same time to get new first hand knowledge to use such knowledge to bridge the gap between experts who tend to be too culture-bound in such domains to interact easily, and to train the first small groups of research specialists on whom it will later rely to launch more systematic studies.

6. Granted, it is impossible to start with a huge project of the survey type with many countries and several branches of activity. I would suggest starting with one or two pilot studies of eighteen months/two years duration involving three or four countries.

Each of these studies should be conducted under the direction of one or two senior specialists on a special commission. Each team should consist of one or two qualified researchers of each of the countries participating in the study but the field work should not be done in each country by the nationals. The whole team would have to be involved which means a real command of each other language by the members of the team. It should be finally the responsibility of the team leader to train the members of the team very thoroughly not only in the techniques but also on the intellectual approach and the specific modes of reasoning of organizational analysis. This means a rather long training period in Vienna before the field work begins.

Because of the difficulty to assemble good teams, and to prepare them, I doubt that more than two studies can be launched to begin with. Maybe only one will be possible.

But such studies should be used extensively for training and stimulating purposes. This means that a constant feedback should be organized around the first and intermediary results of the studies. Panels of experts should be organized to follow them. The teams should discuss their results with them in two or three days seminars. Two kinds of panels could be organized: some with the experts of a single country and with discussion of the results in that country, and some with experts from countries not taking part in the studies. These panels however should remain small, a dozen people at most, and made of people really committed, willing to participate in further studies themselves. With such a method, one would gradually develop a strong network of committed and qualified people speaking a reasonably common scientific language.

One could also use these studies as a training ground for young researchers to prepare their theses on related subjects. Individual projects should be encouraged at the same time, but one should rely greatly on the stimulation given by the main comparative effort. Anyway, priority for these individual cases

should be given to researchers willing to work in a different country than their own.

As for the country and the activity to be chosen for analysis, the decision may be finally premature. We certainly should try to have the US, one West European, and one East European country in the first study and should choose an activity which is performed in the most similar way technically. But so many angles should be considered--not the least of all the availability of talents and the willingness to cooperate--that I would suggest leaving the choice rather open until a team of experts under the leadership of the senior researcher responsible for the first study could make a good investigation and report to IIASA.

Since delays may be long, I would finally suggest that as soon as possible some exchange should be arranged or some fellowships be given to young, very bright people to get some training in another country possibly with the would-be leaders of the first studies.

Document K

General Remarks

A. Danzin

The breadth of the proposed studies compared with the budget of IIASA demonstrates the necessity for the Institute not to be organized as a research instrument. Rather, it should be a catalyst for research at national institutions and as a concentrator and diffuser for the problems and for their solutions.

This role could consist of:

a) knowing who is working on interesting subjects, where they are working, with what means, and with what reputation;

b) widening discussion by means of seminars, interviews, and visits in order to learn appropriate problems for study in the fields of management and applied systems analysis of large organizations;

c) bringing the "right people" together to discuss the "right problems" and to organize bi- or multi- lateral cooperation;

d) following the work done and organizing information meetings to exchange conclusions and to make syntheses;

e) publicizing results in non-scientific language to inform and educate politicians, managers, labor leaders, and representatives of journalism, radio, and television.

The Institute could fulfill this role with a small permanent staff of specialists in large organizations systems. This staff would be composed of a few excellent senior people and two intelligent junior fellows.

For certain specific problems, one national institution could be the leader and assume a part of the expenses for organizing conferences and seminars, and for publication costs.

Remarks Concerning Studies of Industrial Enterprises

It would be simpler in the first stage to disregard questions of market and distribution and to restrict the studies to what the different countries of IIASA obviously have in common.

These studies about internal organization of large industrial enterprises could concern the following problems:

a) Centralization of policies and controls and decentralization of their implementation.

b) Circulation of information; "Communicagrams."

c) Behavior and motivations of managers, staff specialists, other officers, and workers.

d) Development costs and introduction of innovation; solution of implementation problems in passing innovations from the laboratory into the production process.

e) Means of preserving the quality and specificity of the different information passing through various administrative levels in the enterprise, and taking into account that this information is ultimately transformed and expressed in terms of money.

In later stages, when the international team is formed satisfactorily, relationships to markets must be taken into consideration.

Several Important Questions Not Examined in the Conference

1. Many studies and publications of practical examples of excellent systems analyses of operating management are available to specialists. The information about this subject is so vast that it discourages examination and synthesis. If IIASA studies only add to this mass of information, we will have wasted time and money merely "adding a little water to the ocean." What managers need are:

a) Some simple rules and a rather basic methodology to solve their problems. They are at the center of the action - unable to devote time and energy to understanding mathematical models but needing to understand in a common language the work done by theoreticians.

b) A method to educate their people. In Western Europe, for example, the most difficult obstacle for good management is not knowing what must be done, but obtaining acceptance by executives, managers, engineers, researchers, and workers of the constraints imposed by modern society.

It would be a mistake to believe that Applied Systems Analysis could solve the management problems of large organizations (i.e., governments and their agencies, factories, municipal services) by providing the right models for the right solutions. It would be a limited beginning. There is a gap created by the absolute lack of education of the people concerned with these questions. They do not understand the constraints of our scientific civilization and are always thinking in terms of industrial civilization already obsolete.

For this reason, I think it will be necessary for IIASA not only to develop a research program, but almost simultaneously to propose solutions for an educational program.

2. In a few years (or, if we disregard monetary inflation, even today), a new problem in the management of large organizations will arise. Until now, every incentive and regulatory structure has resulted in an increase in the quantity of goods for production and consumption. Obviously, we cannot continue for long with this policy of exponential growth. We must pass from quantitative to qualitative growth. No one is experienced in such a situation, and no management model exists to propose a solution. Has the time not come to think about this problem? Why could IIASA not inspire good studies about this subject on an international basis?

3. The preceding problem is an expression of the general problem of quality of life. How do we manage an industry, an administration, or a governmental agency in order to achieve progress toward concrete applications of this inconsistent idea -- inconsistent in fact if not in intention -- of quality of life? Is this not a problem to solve or to approach by using applied systems analysis?

Document L

Comments on the Symposium on

"Design and Management of Large Organizations"

L. Georgiev

I would like to make the following proposals:

1) Aspect of the project: At the beginning, IIASA efforts should concentrate on the following:

   1.1 International projects (e.g. water, energy, etc.)

   1.2 Non-industrial systems (e.g. health)

   1.3 Industrial systems (e.g. steel production, machine construction)

2) Aspect of the problem: Emphasis on

   2.1 Analysis of the structure of the environment

   2.2 Dynamics of setting goals

   2.3 Dynamics of organization

3) Aspect of methodology: Emphasis on

   3.1 Mathematical modelling

   3.2 Behaviour problems

4) Aspect of implementation: Emphasis on

   4.1 Reducing the time lapse between conception of an idea and its implementation

   4.2 Dynamic implementation of the modular principle

   4.3 Economic cost analysis

5) Aspect of cooperation:

   5.1 Team of 2-5 IIASA scholars plus 1-2 national institutes.

5.2 Team for common projects for socialist and non-socialist economic mechanisms with priority

5.3 Team for separating projects for socialist and non-socialist economic mechanisms (only as an exception)

5.4 Purely national teams (only in single cases)

6) I would like to suggest the following new ways for cooperation:

6.1 Study of pilot projects from 5-6 national institutes

6.2 Analysis by IIASA scholars of the pilot projects from a methodological view point

6.3 Analysis of similarities and differences in the pilot projects; clarification of common problems

6.4 Preparation of common methodology

6.5 Cooperation (see point 5)

Document M

Thoughts And Proposals For The Project "Principles And Methods For The Structure Of Management Organization Systems"

H. Koziolek

Introduction

The project outlined by Prof. Milner and Dr. Dorofejuk, "Principles and Methods for the Structure of Management Organization Systems" raises problems concerning important factors of economic growth: management organization and its efficiency. For management activity to become an immediate factor in productivity, there is a significant precondition: Flexible, dynamic management organization systems must be created to make possible rapid taking and implementation of optimal decisions. The systems design of organizations is clearly one line of development in management science whose importance will continually grow in the wake of the international transition from the confrontation to cooperation.

The scientific tasks formulated in the project reflect, in my opinion, the requirements of practical life. These requirements have assumed greater weight under the conditions imposed by the rash tempo of scientific progress, by the growing concentration of social production, and by the increasingly complex relations between various sectors of large organizations. The project concept outlined by Prof. Milner and Dr. Dorofejuk constitutes a very sound basis of departure for effectively applying systems analysis in this field.

I also support fundamentally the path charted for this project proposal, namely, the adoption of four problem complexes which must be studied:

1. Methodology of research into organization structures of management

2. Mathematical methods for research into and modelling of organization systems

3. The information aspect of the function and structure of organization systems

4. The efficiency of design and function of organization systems.

In this connection, I feel that the specific approach of systems analysis is particularly important. Above all, this means a consistent compulsion to undertake systematic goal and problem analyses in order to outline and examine alternative solutions and to observe and compare their overall efficiency. I will later deal in greater detail with the major significance of the principles and methods in the outlined project as they relate to the organization research project and to other IIASA projects.

The Systems Approach to Analysis, Creation, and Perfection of Organization Structure of Management

The proposed focal points of research are well-suited for investigating the complexity of the diverse inputs, outputs, and connections in actual production and management systems. This applies above all to methodological research. Here it is especially important always to keep firmly in view the economic goal of analysis and design of organization systems. The ultimate aim here is to ensure, through rationally organized management, the most effective functioning of production and economic organization. In my view, this is the main aspect under which the outline project has fundamental importance for most of the other IIASA projects (above all, the resource projects). All these projects demand the mastery of organizational and management problems.

In implementing the submitted project, I therefore attach particular importance to the concept of unity in analysing actual processes in action, their economic-organizational arrangement, and the adequate organization of the management system. We should therefore ensure that no analyses and modelling of the organizational structures of management may exist isolated from the processes to be managed.

In the project presented, three aspects of the systems approach to the analysis assume special significance:

a) the exploration - using criteria and goals of efficiency - of internal relationships in the processes to be managed;

b) the analysis and stipulation of the requirements for the organization management system - in line with goals and efficiency criteria - and for specific

conditions pertaining to the process to be managed; and

c) the analysis of interrelations among the production system, the economic organization, and the organization systems of management.

To this extent, it is worthwhile to stipulate those factors which influence the efficiency of the organization system. Presumably, whether the derived determination factors for the organization system of management can be correctly weighted, analysed, and arranged will depend considerably upon the approach outlined above.

One should also fully approve the idea of differentiating between:

a) the creation of organization systems of management (in the sense of new structures), and

b) the analysis of and increase in the functional stability of existing organization systems by perfecting them in line with changing goals and environmental factors.

Initially, the focal point could be the analysis of functioning organizational structures of management under conditions of changing goals and environmental factors. This would be a comparative analysis of differing economic and management organizations and would employ methods of the systems approach. The theoretical generalization of findings derived from such an analysis would probably make it possible, in a substantiated manner, to outline proposals for perfecting organization systems of management.

Here I am not only thinking of "self-contained" economic organizations (enterprises) for analysis. More important are production systems which aid the creation of comprehensive product systems. This also includes those sub-systems operating in an economic-organizational sense as "cooperation partners" (e.g suppliers, service organizations).

Moreover, operations for classifying organizational management structures should, to a large extent, be based upon analyses done by the participating countries cooperating with existing organizations in the respective states. This would reduce the danger of making the classification one-sided, i.e. done only from the theoretical viewpoint. It would also prevent unnecessary conflicts from arising between existing structures

and the new scientifically-substantiated structures once the classification was realised in practice. Furthermore, theoretical generalization of existing management systems and structures of several countries would reflect an independent scientific achievement creating new theoretical problems.

Such an approach would make it possible to prepare methodical recommendations. For example, one recommendation might show how the organizational management structure could permanently (and not only in the manner of adaptation) be placed in a position to itself create new, changed conditions in the processes to be managed. It could thus ensure a greater degree of efficiency and, simultaneously perfect its own organizational structure of management. The aim is therefore to determine ways and methods which guarantee the flexibility of the organization system of management.

The flexibility of management systems - i.e. the ability of management systems to employ the personnel and material resources with great efficiency in accordance with altered goals - is a key problem for planning management systems in the economy. It should thus play an important role in the research into organizational structures of management.

The problems involved in creating new organizational systems of management will differ somewhat, for here one is concerned with modelling a future production and management system. This modelling must therefore include:

- the analysis of requirements, e.g., the complexity of demand;
- the long-term outline of entire product systems under the aspect of satisfying the "applicant requirements";
- the conception, as to economy and contents, for the future production system and its economic-organizational arrangement (large enterprises, loose form of organization by means of cooperation, etc.); and
- ideas about the organizational system of management.

The economic-organizational models prepared on the basis of systems approach should always unite:

- research into and stipulation of the goals and criteria of efficiency;

- stages of realization; and

- pattern-norming arrangement of the organizational structure of management to cope with these processes.

The use of such models is not primarily determined by the extent to which they are mathematically formulated, but rather by the extent to which merely verbal modelling can apply the outlined criteria.

Mathematical Methods for Research into and Modelling of Organization Systems

In formulating the tasks for developing mathematical methods of research and modelling of organizational systems, it seems, in our view, necessary and opportune to differentiate among the following series of tasks:

1. The use of mathematical methods and models to improve the mode of functioning of organizational systems should above all serve the purposeful internal arrangement of those systems. Its point of departure should therefore be the project-derived characteristic of organization systems as an extensive, complicated diversity of coupling mechanisms for resources, activities, and functions. Thus, on the one hand, basic economic processes in organizational systems assume prime importance during investigations. Simultaneously ensured, on the other hand, is the necessary connexion between decision processes, mathematical models of operations research, and information processes.

This object and problem-linked use of mathematical models and methods through organizational systems should be seen and investigated under the following aspects:

a) quantitative description of all aspects of the production process, particularly mathematical substantiation of norms, e.g., normatives (also through use of simple algorithms);

b) quantitative substantiation of decisions, particularly through mathematical methods and operations research models;

c) logical-mathematical substantiation of an effective production control system (including the commensurate system of decision-making).

In real systems of organization these aspects are interrelated. In our view, the system of decision making plays a

key role in the efficient functioning of organizational systems and in controlling their complexity. In this connexion, classification, description, and analysis of the essential decision problems in organizational systems would be necessary. Furthermore, the most diverse mathematical models--above all those of operations research--should be investigated for their usefulness in solving these decision problems. On this basis, they should be selected and used. In addition, it would be useful to devise an efficient system of decision making and to develop for it the necessary appropriate system of mathematical models.

In my view, the categories of mathematical methods and models valid for the three complexes should be seen somewhat more broadly than in the previous project.

The arrangement of an information system, and what the information system to be devised should tell us, is connected with the preparation of suitable mathematical models for decision making in organizations and their coupling with mathematical model systems. Furthermore, there arises a close interrelationship to the computer techniques to be employed, to the extent that the computer system constitutes the technical basis for accomplishing the required mathematical calculations within the framework of decision preparation.

2. The use of mathematical methods and models in order to determine optimal sizes of organizations and a satisfactory relationship between centralization and decentralization. This would include such problems as optimal production quantities (optimal enterprise size), optimal distribution of locations, etc.

This field of research is important, since in actual economic life--in connexion with questions pertaining to the concentration of production--aspects of the following question must be answered: Economically-speaking is it more efficient to establish an economically self-contained organization or to have relatively economically independent organizations concentrated and linked cooperatively in more extensive systems? Which method is selected depends on the concrete political, economic, and technological conditions.

In each case, we must master the intermediate elements by which cooperation is implemented (e.g. optimal arrangement of communications systems, distribution of locations, storage, etc.)

In my opinion, foremost consideration should be given to these two directions in the application of mathematical methods in organizational systems research.

3. A further important IIASA field of research could, in my view, be the gradual scientific penetration of problems such as the formalized description and analysis of the structure of hierarchial pyramids or the digital simulation of the functions of organizational systems. These fields are obviously rather more fundamental research. We are of the opinion that it is currently very difficult to determine the extent to which such operations might be absorbed into the immediate practical results of the project on hand.

The Information Aspect of the Function and Structure of Organization Systems

The proposed focal points of research in the information aspect of the function and structure of organizational systems are extremely significant and of considerable practical importance. However, it seems necessary to point out that greater emphasis should be given to the connexion between the problems of information and the modern information and computer techniques detailed in the project.

Here, in particular, we mean interactions which objectively exist between the material-technical basis of management activity --i.e. modern information and computer techniques--on the one hand, and on the other, the concrete organizational structures of management. Therefore, in this research project, more attention should be paid to relating the overall project to the problems of applying electronic data processing in management as carried out, for example, in the Soviet Union. There, this is known as automated management systems and constitutes the focal point of research and practice.

In this area, there will be an investigative problem. It is not just a matter of achieving a higher degree of mechanization, e.g., automation of existing information processes, but of ensuring a unity of realizable integration, optimization, and information effects in the whole system.

Thus the following questions would also come to the fore:

- What influence does the information system exert on the organizational system under conditions brought about through the application of electronic data processing techniques?

- What are the principal fields of application of electronic data processing to rationalize the information system as part of the organizational system?

- What influence is exerted by the material-technical conditions of the process to be managed on the arrangement and technical level of the information system?

A further investigation complex is, in my view, the scientific substantiation of criteria and factors determining the rationality of the information system in relation to its functions in the organizational system.

This deals with questions such as:

- cost and usefulness of information streams; multivalance of the use of information; determination of the quality and quantity of information with relation to its function in the organizational system;

- classification of information streams in conjunction with their respective purposes in the organization system of management;

- investigation of the influence of the information system upon the reaction times of the management system;

- design of information relations which ensure adequate complexity in the decision taken by the manager;

- centralization and decentralization of phases of the information process; and, in this connexion, determination of conditions for establishing "information-intensive" management organs.

Conclusions

As a whole, the outlined project meets with my full approval. Our common endeavour to apply the most modern scientific findings of systems analysis for mastering these complicated organizational management problems, should not, however, induce us to lose sight of the continuity of development. In order to solve the tasks we will face, it will not only be necessary to employ the latest mathematical and cybernetical models. The success of our activity will, to an equal extent, be determined by the degree to which we can use the findings of the traditional sciences, above all business economics and other economic disciplines.

Finally, I wish, once again, expressly to support the proposal outlined in the project: The experimental preparation of the concrete organizational structures should be connected with other IIASA projects, for example, with the design of major international industrial complexes.

Document N

General Comments

H. Koziolek

We support the project proposal made by Prof. Milner and refer to our written statements (see papers of Mr. Koziolek and Mr. Braun).

In general we would like to draw the attention to the fact that the problems of large organizations are to be solved in twofold aspects:

1. to support the IIASA projects on the complex use of water resources, medical systems, energy systems, etc., by basic research on organizational systems in connection with the analyses of resource problems;

2. the investigation of large organization systems by means of systems analysis by IIASA should first of all proceed as a self-standing project (management of industrial organizations or another suitable non-industrial project).

In order to work out the result of our discussion, we consider the following points necessary:

a) Concretization of the submitted draft of the project by Mr. Milner under consideration of our proposals submitted in written form, as well as supplementation of the matrix schemes of Messrs. Milner, Evenko, and Straszak. This would be a condition for the start of the research activities (preparation of a project on the design and management of large organizations until the next meeting of the Council).

b) All participants should send to IIASA within a month their concrete, more detailed views as a support of the further activities of Messrs. Milner and Bower.

c) Formation of a small theoretical group which should start outlining and investigating the basic questions of the project as well as the basic questions emerging in this connection for the planned handbook.

Document O

Uses of Economic-Mathematical Models of Operations Research for Solving Principal Tasks in Managing Industrial Enterprises.

H. Koziolek, et. al.

Principal Management Tasks	Useful Economic-Mathematical Models
Planning according to demand	Matrix models Input-output models Needs and demand models Evaluation models
Managing decisions about input-output relationships in cooperative efforts	Matrix models Input-output models Optimization models
Coordination of planning of industrial branches and territories	Matrix models Input-output models Optimization models
Growth and development of production organization, including: capacity exploitation of machinery production planning technology transport planning run-through-planning operating of several machines material-technical supply planning of the use of materials choice of products cutting problems blending problems storage economy	Optimization models Sequency models Network planning models CPM, PERT, Pattern, etc. Storage models Operating models Optimization models Input-output models Storage models

Principal Management Tasks	Useful Economic-Mathematical Models
Exploitation of capital investment capacity planning	Optimization models Operating models Network planning models CPM, PERT
Planning of replacement and repair Terms and dates Planning of specialization Investment planning Measuring of storage facilities Technology	Replacement and maintenance models Competition models Storage models Sequency models

Document P

Some Suggestions

J. Leontiades

Search Strategy

Professor Bower rightly emphasized the need to consider IIASA's "distinctive competence" as a starting point for considering possible research subjects. This was done, although I believe a more formal statement of what this competence is considering to be should be made toward the beginning. Among other things - this should stress the East-West composition of IIASA as a major research asset.

Having defined IIASA's distinctive competence, the next task of a research strategy is to consider which areas of possible research provide the best "fit." It goes without saying that all subjects which are interesting are not optimal choices relative to this distinctive competence, however defined. The interest in the area, the possibility of a breakthrough, and the interpretation of the problem area as a system may all be necessary, but they are not all that is sufficient to justify commitment of IIASA resources to a major effort.

Suggestion: Attempt rough cost and return estimates of laternatives before such conferences. The conclusion of such study to be placed before the conference as a frame of reference and debate.

The Specialist Syndrome

Almost by definition, specialists have a certain orientation and perspective which is unique to their group. This is at once a source of strength and possible weakness, hence the certain distortions in perspective. These may include the following:

a) The tendency to interpret all problems in terms of the skills and abilities of a particular technique.

b) The tendency to become a closed system, i.e. problem solving,is "successful" if it contributes to the technical competence of the speciality.

c) Tendency to interpret potential contribution independent of a specific time horizon, i.e. asking the question "can this speciality produce results?" without specifying when and how much.

d) The tendency to interpret contribution in terms of the specialists formulation of the problem: i.e. success is defined within the framework of the model.

Suggestions: Commitment to test the model and results, first of all with reference to the real world, and secondly which independent examination by other specialists as well as generalists. The Director's view on this point was well taken.

Procedural Framework

During the conference we discussed a number of frameworks. The following is a suggested procedural framework for approaching possible research topics:

Stage 1: Pre-conference group - small, multi-disciplinary group. Sets out some major alternatives with rough cost/benefit estimates.

Stage 2: Multi-disciplinary conference - selects among alternatives provided by previous stage. Provides further guidance and direction.

Stage 3: Survey committee - surveys state of the art. Provides more precise sub-objectives and time schedule.

Stage 4: Main research - generates hypotheses and formulates models. There is some basis for indicating that the earlier part, hypothesis generation, should emphasize case work and clinical studies laying a foundation for the more abstract model building position.

Stage 5: Testing - final model should itself be regarded as a hypthesis to be tested or rejected by real world.

Communication

The conference touched on the problem of bringing together "describers" and the more mathematically oriented. There is a real communications problem here as well as that mentioned earlier relative to specialists and generalists.

One approach I have heard used in one organization which may help is the following: discussion of all models is divided into two categories each taken up separately:

a) discussion of the basic assumptions and hypotheses of the model; and

b) discussion of the mathematical-logical apparatus of the model.

The former can often be treated non-mathematically. It is also often the area of prime interest to the describers and generalists. Discussing this seperately may help to bring these people into the model building at an early stage and gain the benefit of their own peculiar insights.

Composition of IIASA Conferences

The interdisciplinary approach, if it is to be adopted, should be implemented from the beginning. This includes conferences such as the one we have just attended. Although some members did come from other disciplines, systems analysts largely determined the basic approach to the problems set before the group. There is nothing a priori wrong with this, particularly with references to the river systems, energy type projects, etc., which fall in areas of traditional (if we can use that term with so new a discipline) S.A. competence. This weighting, however, is more suspect when embarking into new areas of research - such as organization theory. A number of dangers arise - notably that we may not make full use of work already done by other disciplines. For example, the very substatial work already done in organization theory was, in my opinion, greatly underestimated.

Suggestion: Make certain that future conferences achieve a better balance between the various disciplines that might conceivalby bear on the research subject. Otherwise, projects may be prematurely structured in a specific direction.

I should add that there is little doubt in my mind that IIASA will make a success of this project.

Document Q

Comments on the Symposium "Design and Management of Large Organizations"

Mario A. Levi

Before going into some remarks relating directly to the IIASA symposium on Design and Management of Large Organizations, it seems appropriate to define briefly "Systems Science" and "System" in the way these words will be used in this context.

According to Bertalanffy (General Systems Theory), Systems Science may be defined as a meta-science to be applied to all fields of knowledge. Another way to define Systems Science is to view it as a combination of techniques aiming to bring simplicity out of complexity and to reduce vast and apparently incoherent masses of data to the synthetic and multiplexing type of human recognition.

As a systems designer in a large nationwide service agency, I would refer to systems in the following way: "A system is a combination of means and activities performed by men in order to attain one or more objectives, mostly in competition among themselves. One or more global objectives exist which are subject to optimization through systems engineering." This definition gives rise to two different considerations:

a) Systems which will be considered here are concrete systems, although at the time of their design they sometimes appear to be intellectual systems.

b) Instruments used for the design and operation of these concrete systems are "engineering" instruments.

With reference to the first consideration, we have come to view the enterprise system as a harmonic superposition of two systems. The "operative system" includes all flows of material resources through the enterprise (raw materials, finished products, waste, and financial and human resources, et cetera). The "information system" includes all non-material flows (orders, reports, data, information, et cetera).

As to the second consideration, I wish to point the

fact that design and implementation of systems require "engineering," i.e., utilisation of practical techniques based on theoretical concepts of systems science. This mechanism is the same used by a structural engineer in designing a beam subject to flexion. He will use deflection and stress formulae, not the "theory of elasticity."

I have two comments regarding the summary matrix by Professor Milner. First, I would strongly support preparation of a Handbook on System Science. Particular care should be devoted to its cross-reference and indexing system. Successful work on this Handbook might contribute much to the formalization of systems science and favour its acceptance by as yet unenlightened management (a point mentioned during the seminar). At the same time, the Handbook might help "systems engineers"--as opposed to "systems scientists"--in abstracting from the total corpus of systems science those techniques which may be useful in their day-to-day work.

Second, it is my opinion that Columns Two (Problems) and Three (Projects) are not completely independent. Many problems may appear more or less relevant, according to the choice of projects to be launched.

Other considerations arise from the discussions of these past two days. First, it seems to me that the choice of applied projects--or even the suggestion of possible projects--might not be a matter for specialists in systems science. Assuming that systems science (or, preferably in this case, systems engineering) represents a means for solving problems, the problems to be solved, as well as goals of individual projects, should be put forward by those who meet them. Systems scientists should be advised about these problems and should examine the possibility of helping groups with problems to solve <u>those</u> problems through participation in projects.

A second consideration is a consequence of the preceding one. Launching of projects should be discussed in <u>mixed groups</u>, with participation of users (representing the problem-affected groups) and of systems scientists (contributing to the group work their methodological expertise).

My third observation also brings to mind the suggestion by Professor Raiffa regarding the opportunity to perform soon something useful. I would strongly support Mr. Crozier's opinion that a number of small projects should be launched instead of a very limited number of large projects.

As a fourth observation--and again partially connected to the preceding comments on project size and importance--

I would strongly suggest organizing work in two stages. The first stage might be defined as a study or feasibility stage. It should encompass a rather large field of possible work and end with one or more reports on possible detailed projects. It should include a preliminary time and resource schedule and budget. Then, when a number of such first-stage reports is available, an order of precedence might be established. Single projects might be launched once the necessary resources are available. This way of proceeding might reduce the possibility of failure to a minimum, provided good control instruments are established and properly used.

Document R

Recommended Characteristics of Projects on Organizations

J. G. Miller

1. Develop an explicit conceptual system.

2. Collect data on several organizations on comparable variables for comparative analysis of the organizations.

3. Compare several organizations that are not too complex on comparable analysis.

4. Compare several types of organizations on comparable variables.

5. Compare organizations in 5 or more countries.

6. Study organizations that make important use of technology.

7. Have a central integrating team in Laxenburg plus local teams in each country.

8. Should be organizations important to each country and so involve political human interactions but not sensitive politics in terms of national policy.

9. Cooperating countries should provide staff for local data collection and pay for it--and arrange access to it.

10. Employ computer simulations or models of the organizations.

11. Employ evaluation of cost-effectiveness of organizations as a whole and efficiency of their subsystems.

12. Include a specific evaluation of methodology used.

13. Arrange agreement with country to apply any acceptable findings and provide incentive to staff to continue work until findings are applied.

14. Seek an early payoff--in 5 years or less.

15. Design research with salvage value if findings are negative in the sense of not supporting hypotheses.

16. Staff should be

a) a mixture of young people and senior workers;
b) interdisciplinary;
c) international.

Document S

Design of Organizational Systems: Principles and Methods

B. Milner

The rapid advance of technology with the growing concentration of production and complex interrelations has made design of flexible, dynamic organizations capable of responsive decision making and implementation vitally important. However, a methodological solution of this problem has not yet been found in any country as research has concentrated on separate aspects of the problem without considering it as a whole. No scientific methodology of organizational analysis and design has yet been developed.

Systems analysis is a key to this insufficiently studied problem. It gives an integrated approach to design of goal-oriented organizational systems. IIASA research, based on a systems orientation to design of organizational structures, will help develop a wider perspective on the field of management problems. This integrated research by specialists from different nations with varied backgrounds and experiences will produce advanced methods for analysis of hierarchical organization systems and design and operation. Inherent in this research program will be the testing of new techniques, procedures, and models in real world organizational systems.

Aspects of the Problem

A brief outline here of four interrelated groups of problems will give an overview of the problem of organizational design and of a variety of approaches to this problem.

Research Methodology

Organizational systems are characterized by heterogeneous activities and functions which combine, by a variety of mechanisms, material, labor, and financial resources. Such complexity demands that a systems approach to management structures become the starting point of the research. This orientation entails study of the following problems:

- Description of business organizations
- Classification of organizational structures
- Methods of identification and formulation of goal-oriented systems
- Processes of differentiation and integration of activities, authority, and responsibility; distribution of authority and responsibility in management hierarchy
- Methods of decision making in organizational structures
- Methods of identification, analysis, description, and application of informal organizational structures
- Man-machine simulation of hierarchical organizational structures
- Feedback in organizational structures
- Methods for defining various management positions in different types of structures
- Methods for analyzing the dynamics and stability of organizational structures.

Mathematical Methods and Simulation

Mathematical models which help describe, model, and optimize organizations create great opportunities for the analysis and design of organizational structures. It is important to study the following relevant problems:

- Principles and methods of formal description, analysis, and design of hierarchical structures
- Mathematical methods of multi-stage optimization
- Mathematical methods of dynamic problem solving
- Business games for analysis and synthesis of hierarchical organizational structures
- Computer simulation of the functioning of organizational systems
- Methods for assimilating the input of experts.

Information Problems

An inherent aspect of the design of management information systems (MIS) is the definition of the nature of information: its volume, its flow, and its frequency and means of transmission. This problem is closely allied to that of computers and the implementation of computer-based systems. The following questions require research:

- Types and principles of design of information networks in organizational structures
- Principles of communication network modelling and design for various types of organizations
- Social and psychological aspects of communications
- Design of multi-goal MIS
- Design and analysis of information models in organizations
- Methods of analysis and distribution of information flows
- Implementation and use of MIS in management
- Impact of MIS on management structures.

Problems of Effectiveness and Efficiency

Satisfactory methods have not yet been found for measuring the effectiveness and efficiency of functions and improvements in organizational structures. Meanwhile, costs for development of systems have been increasing in relative and absolute figures. The problem of measuring the effectiveness of these systems has special features and must be investigated along the following lines:

- Factors influencing effectiveness of organizational systems
- A framework of effectiveness measures to use in designing organizational structures
- A framework of effectiveness and efficiency measures for judging performance of organizations.

Participants in the Research

The Institute should provide opportunities for involving firms and research centers which will do extensive research on organizational systems without necessarily being on the primary list. The primary list of participants includes the following nations and institutions:

Bulgaria - The Institute of Technical Cybernetics of the Academy of Sciences

Czechoslovakia - The Institute of Economics

France - The firm "Metra-Sema"; University of Paris; IRIA (Versailles)

Hungary - The Institute of Automation of the Academy of Sciences; The Institute of Telemechanics (TKI); INFILOR

Italy - The Laboratory of Cybernetics (Naples); the Universities of Padua, Pisa, and Rome; the Institute of Information Processing (Pisa)

Poland - The Institute of Industrial Engineering

United Kingdom - The Institute of Management of Great Britain; the London and Manchester Schools of Management

U. S. A. - RAND Corporation; Carnegie-Mellon University; Stanford Research Institute; M. I. T.; Harvard; Princeton; Stanford University; University of California

U. S. S. R. - The Academy of Sciences; Institute of Management Problems; Institute of U. S. Studies; Institute of Management Science

Yugoslavia - The Pupin Institute

Phases of the Program

Phase I - One Year

Drafting of an outline. Classification of hierarchical organizational structures. System of goals and objectives in management structures. Identification of subsystems to be the base for testing in subsequent phases of the project. Preparation of a report.

Phase II - One Year

System of distribution of responsibilities in organizational structures. Principles of design and simulation of formal hierarchical structures. Methods for collecting and assimilating input of experts. Algorithms for analysis of information flows. Decision making methods in organization systems. Preparation of a report and of a collective set of papers.

Phase III - One Year

Analysis of informal organizational structures. Mathematical methods for description and analysis of organizational structures. Research on MIS and their impact on organizational systems. Feedback in organizations. Social and psychological aspects in operations of hierarchical structures. Preliminary testing of newly-developed methods and procedures on a real world system. Preparation of a report of standard procedures and recommendations.

Phase IV - One Year

Dynamics of developing organizational structures in conditions of changing goals and environments. Systematic methods for simulating behavior of hierarchical systems. Design of multi-objective MIS. Methods for analysis of effectiveness and efficiency of design and operation of organizations. Tests of models and procedures developed in Phase III. A further report on standard procedures and recommendations and a report on test results of Phases III and IV will be issued.

Phase V - Two Years

Preparation of integrated procedures for changing organizational structures to improve their operation. Analysis of consequences of these changes. Test procedures developed in a real world organization. An experimental design of a real organizational structure. The research program will conclude with the preparation of four documents: a report on a standard procedure, a report on a pilot application of this procedure, a final report on the project, and a collective book.

Anticipated Project Achievements

Expected project results will be fourfold:

1. Research into theoretical models, and into methods of analysis and synthesis of organizational structures;

2. Design and testing of standard methods and procedures for analysis and construction of organizational structures;

3. Pilot applications of standard procedures in real world organizations; and

4. Experimental design of concrete organizational structures.

Factors to Consider in Estimating Costs

The bulk of the research effort will be done in the participating countries. The Institute will play a coordinating role for the research activities, and will assume costs for meetings, travel, computing, and printing. Cost factors listed below reflect only those costs for which the Institute will have responsibility. Travel cost estimates are shown here in man-months, computing costs in hours (based on the IBM 360/67), and printing costs in numbers of sheets (24 standard typed pages or 40,000 letters). Travel is subdivided into four categories:

a) trips by permanent experts to make joint plans and decisions (2 weeks each);

b) trips by consultants and experts attending meetings, usually multi-lateral (1½-2 weeks each);

c) missions of specialists, usually on a bilateral basis (one month each); and

d) travel for junior scientists (3 month stays).

Phase I Costs

Conferences

One meeting of permanent experts (10 people)
One meeting of representatives from participating organizations (22 people)

Travel

Permanent experts	(10 x 0.5)	5 man-months
Meetings	(22 x 0.5)	11 man-months
Specialists	(10 x 1)	10 man-months

Salaries

Scientist-coordinator	(1 x 12)	12 man-months
Junior scientists	(4 x 3)	12 man-months

Printing of report (2 pages x 200 copies) 400 pages

Phase II Costs

Conferences

One meeting of permanent experts
One extended meeting
Two meetings for writing the monograph (10 people)

Travel

Permanent experts	(10 x 0.5)	5 man-months
Meetings	(22 x 0.5)	11 man-months
Specialists' missions	(10 x 1)	10 man-months
Two meetings for writing the monograph	(10 x 0.5 x 2)	10 man-months

Scientist-coordinator salary (1 x 12) 12 man-months

4 junior scientists salaries (4 x 3) 12 man-months

Computer testing of algorithm simulation and real world testing 40 hours

Printing

Report	(2 pages x 200 copies)	400 pages
Book	(30 pages x 2,000 copies)	60,000 pages

Phase III Costs

Travel - Same as in Phase I

Salaries - Same as in Phase I

Computer time 70 hours

Printing of procedures (5 pages x 200 copies) 1,000 pages

Phase IV Costs

Travel - Increases by 5 man-months over Phase I due to extensive testing of methods developed

Salaries - Same as in Phase I

Computer time 70 hours

Printing

Procedures	(5 pages x 200 copies)	1,000 pages
Report	(2 pages x 200 copies)	400 pages

Phase V Costs

All expenses are doubled as the phase is two years long. Meetings will be more representative in this final phase. An additional meeting of permanent experts will be necessary to prepare a final Institute report on the entire project.

Conferences

2 meetings of representatives from participating countries
One meeting of permanent experts
2 meetings of authors of the monograph

Travel

Permanent experts	(10 x 0.5 x 3)	15 man-months
Meeting 1	(22 x 0.5)	11 man-months
Meeting 2	(32 x 0.5)	16 man-months
Specialists' mission	(15 x 1 x 2)	30 man-months
Authors' meetings	(10 x 0.5 x 2)	10 man-months

Salaries - Double those of Phase I

Computer time 120 hours

Printing

Procedures	(5 pages x 200 copies)	1,000 pages
Phase report	(2 pages x 200 copies)	400 pages
Final project report	(10 pages x 200 copies)	2,000 pages
Collective monograph	(30 pages x 2,000 copies)	60,000 pages

Summary of Total Project Expense Factors

Phase	I	II	III	IV	V	Total
Phase Length	1 year	1 year	1 year	1 year	2 years	6 years
Travel (in man-months)	26	36	26	31	82	201
Computer time (in hours)	0	40	70	70	120	300
Printing (in pages)	400	60,400	1,000	1,400	63,400	126,600
Salaries (in man-months)	24	24	24	24	48	144

Notes

1. The first phase of the project should be carried out in close cooperation with the scientists working on Research Theme 2, "Systems Analysis in Management."

2. In selecting real structures for testing, the Institute will consider not only suggestions from the participating organizations, but also from experts studying national and inter-industrial systems, organizational systems in international cooperation, and power systems.

3. It is expedient to investigate and test real organizational structures on a contractual basis (for example, in a developing nation), with the participation of international organizations (e.g., a United Nations agency). This would reduce expenses and help promote the international reputation of the Institute.

Document T

Decision Processes in Organizations*

Koichi Miyasawa

§ 0. Preface

There is a group G of n members 1,2,...,n which are called the decision units. Each member i is assigned the given action space A_i from which he can propose to choose any action $a_i \in A_i$, i = 1,...,n. The space A_i for member i will be determined by his technology, his available resources, and so forth. When the member i proposes to choose an action, $a_i \in A_i$, i = 1,...,n, its implementation as a member of the group G might depend in some cases on the actions proposed by other members of the group, because of the logical consistency condition which must hold among the actions a_i, i = 1,...,n proposed by the members.

We shall introduce several conditions which characterize the decision making activity of the group.

Condition (L) (Possible Actions)

(L_0): Any action $a_i \in A_i$ chosen by each member i, i = 1,...,n, can be implemented without any restriction.

(L_1): When the members i propose to choose the actions $a_i \in A_i$, i = 1,...,n, these actions can be implemented as a group if and only if they satisfy a certain consistency relation $R(a_1,...,a_n)$ among the actions proposed.

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*This paper was prepared for the conference on "Design and Management of Large Organizations," held by IIASA in Baden, Austria, 4-6 July 1973.

Condition (S) (State of the World)

(S_0): When the members i of the group choose the actions a_i, i = 1,...,n, the consequence for the member i is determined by actions a_j chosen by other members $j \neq 1$ as well as by his own chosen action a_i. (The existence of externality is admitted.)

(S_1): There is given the state space Θ consisting of the states of the nature $\theta = (\theta_1,\ldots,\theta_n)$. The group members have no control over the true state θ which occurs or prevails. When the members choose the actions a_i, i = 1,...,n, the consequence to the member i is determined by the chosen group action $a = (a_1,\ldots,a_n)$ and by the true state $\theta = (\theta_1,\ldots,\theta_n)$.

Condition (U) (Preference Relation)

(U_0): Each member i of the group has his own preference order R_i on the space of the possible consequences to him, i = 1,...,n. But here we do not assume the existence of a utility function.

(U_1): All the members of the group recognize the same consequence after choosing any action $a = (a_1,\ldots,a_n)$ and have the same utility function ω on the space of the consequences.

(U_2): Each member i has his own utility function ω_i defined on the space of consequences for him, i = 1,...,n.

Condition (E) (Information about Environment)

We shall call the behavioral character of the member i his environment e^i, i = 1,...,n. The consequence for each member does not depend on the environment $e = (e^1,...,e^n)$. The condition which specifies what kind of information about e each member can have is called Condition (E). There will be several types of Condition (E), e.g. each member i can know only his own environment e^i--called privacy or the informational decentralization (about the environment)--or a certain member can know $e = (e^i,...,e^n)$--called the informational centralization (about the environment).

Condition (J) (Prior Probability)

(J_1): All the members of the group have the same prior probability law φ on the state space Θ.

(J_2): Each member i has his own prior probability law φ_i on Θ, i = 1, ...,n.

Condition (I) (Information about State)

(I_0): Each member knows nothing about the true state θ, except for the prior probability law on Θ--called the null information structure η^0.

(I_1): Each member i may use an information structure η_i concerning the true state θ to be defined later, i = 1,...,n, $\eta = (\eta_1,...,\eta_n)$. (It is clear that η^0 is a special case of the information structure η and Conditions (J) and (I) have meaning only under Condition (S_1).)

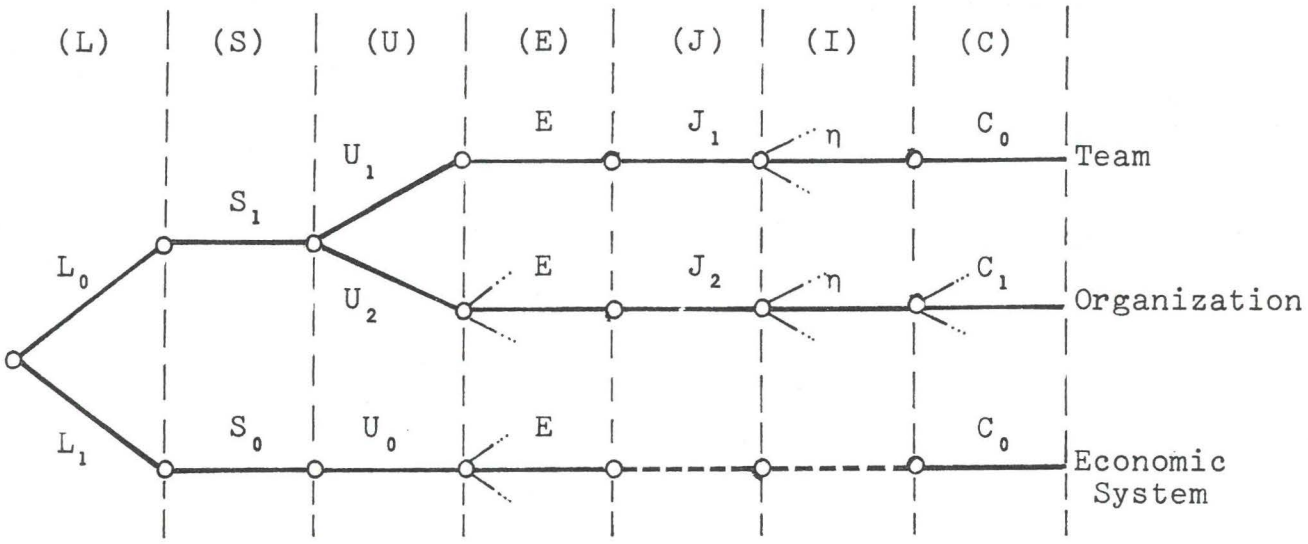
Condition (C) (Command Structure)

(C_0): Each member can propose his own action choice without being affected by other members' instructions.

(C_1): A hierarchical command relation among the group members exists in the following sense. There is given the partition of the group G into the subgroups $G_1,\ldots,G_g$, where $G_h \cap G_k \neq \phi$, $h \neq k$ and the action space A_i and/or the information structure η_i of the members i in the group G_{h+1} is determined by the actions a_j taken by the members j in the group G_h. But, contrarily, the members in group G_{h+1} have no such influence on the members in group G_h. (We shall not go into details here.)

Now, depending on which combination of these conditions applies to the group, it will be called an economic system, a team, or a hierarchical organization as is shown in the following tree-type diagram. (The dotted line o------o means that the condition corresponding to it has no meaning there.)

As can be seen from the diagram, the decision processes in the Economic system will depend on the available information structure concerning the environment, in the Team on the available information structure concerning the state, and in the Hierarchical Organization on the available information



structure concerning the environment, the state, and the given command structure.

The study of Economic System from the viewpoint of resource allocation processes will be represented by Hurwicz [1], and we shall abstract its logical character in Section I. From a practical viewpoint, indicating a difficulty in Section I, we shall briefly introduce T. Marschak's work [3] in Section II. In Section III, we shall introduce the essential points of J. Marschak and R. Radner's valuable detailed study [2] on the Team. In the last Section IV, modifying Marschak's Team in a form of Hierarchical Organization, we shall give some tentative results obtained so far. I owe this section to the work of Mesarovic et. al. [4]. But it is not clear to me whether their results can still remain valid when Conditions

(J) and (I) are taken into consideration. Our formulation is intended to overcome these difficulties in Mesarovic.

Summary

In the Team, by its definition, the comparison of values of several information structures has been studied, but not the command structure. On the other hand, in the Hierarchical Organization, the character of the command structures has been studied, but not the information structures. We would like to propose a study of the decision processes in organizations, taking into consideration--by means of analytical and/or simulation methods--both the information and the command structures.

§ I. Economic System

I.1

We consider a group G consisting of n decision units $1,\ldots,n$, $G = \{1,\ldots,n\}$. For each decision unit i, there is given two spaces X^i and Y^i (e.g. Y^i is the feasible production set for i and X^i is the set of the results after trading i with other units j in G, where X^i and Y^i are given subsets of the commodity space X, $i = 1,\ldots,n$). Let us call any pair of the elements $b_i \varepsilon X^i$ and $c_i \varepsilon Y^i$ an action a_i for the decision unit i:

$$a_i = (b_i, c_i),\ b_i \varepsilon X^i,\ c_i \varepsilon Y^i \quad , \tag{1.1}$$

that is $A_i = X^i \times Y^i$, $i = 1,\ldots,n$. There is another space Z,

and for each decision unit i, there is given a mapping ψ^i from $X^i \times Y^i$ to Z and a subset Z^i of Z which is the set of all admissible outcomes for i, i = 1,...,n.

Among the actions $a_i \varepsilon A_i$, the decision unit i will not admit the actions a_i such that $\psi^i(a_i) \notin Z^i$. We call an action a_i such that

$$\psi^i(a_i) = \psi^i(b_i, c_i) = z_i \varepsilon Z^i \tag{1.2}$$

an <u>i-admissible action</u>, i = 1,...,n. Let A^i be the set of all i-admissible actions.

Each decision unit i has the preference order $\succeq_i$ on the space Z^i. For any two actions a_i, $a_i' \varepsilon A^i$, we say the unit i (weakly) prefers a_i to a_i',

$$a_i \succeq_i a_i' \tag{1.3}$$

if and only if

$$\psi^i(a_i) = z_i \succeq_i \psi^i(a_i') = z_i' \quad . \tag{1.4}$$

We shall call this preference order by i on A^i, R^i. Each decision unit i wants to choose an action $a_i \varepsilon A^i$ which is as high as possible in the sense of R^i. Now let

$$a = (a_1,...,a_n),\ a_i = (b_i, c_i) \varepsilon A^i,\ i = 1,...,n \tag{1.5}$$

be a set of action choices proposed by i, i = 1,...,n. Then there appears one of the special characteristics of an economic system. A proposed action $a = (a_1,...,a_n)$ can be implemented

if and only if the given consistency relation among $b_1,\ldots,b_n$,

$$R(b_1,\ldots,b_n) \tag{1.6}$$

holds (e.g. even if the unit i wants to exchange his goods for goods possessed by the unit j, this exchange will not be realized if j does not agree to it).

We shall call a proposed action set $a = (a_1,\ldots,a_n)$ a possible proposal if it satisfies the consistency relation $R(b_1,\ldots,b_n)$, where $a_i = (b_i,c_i)$, $i = 1,\ldots,n$.

When each decision unit proposes to choose an action $a_i \varepsilon A^i$, and if $a = (a_1,\ldots,a_n)$ is a possible proposal, then the decision process ends there and the outcome is $\psi^i(a_i) = z^i \varepsilon Z^i$, $i = 1,\ldots,n$. The group G is then called an economic system.

Note 1.1. The outcome to the decision unit i following his choice of action a_i is determined depending only on the other units' decisions (Condition (S_0)). In this sense, the formulation is similar to that of a game. But here is required the consistency condition (1.6) whose character is logical, not technical (Condition (L_1)). We should also remark that no utility function is assumed (Condition (U_0)).

Let A be the set of all possible proposals $a = (a_1,\ldots,a_n)$. Then the concern of all the decision units of the economic system is limited to the set A.

Definition 1.1. For any two possible proposals $a = (a_1,\ldots,a_n)$ and $a' = (a'_1,\ldots,a'_n)$, we say a is Pareto-

superior to a' if

$$1) \quad a_i \succeq_i a_i' \quad , \qquad \text{for all } i = 1,\ldots,n$$

and (1.7)

$$2) \quad a_k \succ_k a_k' \quad , \qquad \text{for at least one } k \quad .$$

Definition 1.2. A possible proposal $a \in A$ is said to be Pareto-optimal if there is no $a' \in A$ which is Pareto-superior to a. Let $\hat{A}$ be the set of all Pareto-optimal a's.

Assumption B1. Each decision unit i of the group $G = \{1,\ldots,n\}$ is satisfied with his action $\hat{a}_i$ which is a component of some Pareto-optimal proposal set $\hat{a} = (\hat{a}_1,\ldots,\hat{a}_n) \in \hat{A}$.

I.2

We shall seek an adjustment process of the proposals by the decision units i, i = 1,...,n, which finally enables the group $G = \{1,\ldots,n\}$ to reach a Pareto-optimal action $\hat{a} \in \hat{A}$. Here it is essential to make clear who makes the adjustment with what kind of information.

Definition 2.1. The set

$$e^i = (X^i, Y^i, Z^i, \psi^i, R^i) \quad , \tag{2.1}$$

is called the environment of the decision unit i, i = 1,...,n.

We shall consider the following adjustment process.

1) At each stage t of the process, each decision unit i proposes a subset A_t^i of A^i and communicates it to all other decision units j.

2) At the stage t, when the decision unit i knows all units' proposals $(A_t^1,\ldots,A_t^n) = A_t$, he proposes a subset A_{t+1}^i of A^i according to the given rule $f_t^i(\cdot|e^i)$ which depends on his own environment but not on others (in this sense the process retains privacy--Hurwicz), i.e.

$$A_{t+1}^i = f_t^i(A_t,\ldots,A_t^n;e^i) \quad , \quad i = 1,\ldots,n \quad . \tag{2.2}$$

This adjustment process is denoted as

$$f_t = (f_t^1,\ldots,f_t^n) \quad , \quad t = 1,2,\ldots \quad . \tag{2.3}$$

If f_t^i does not depend on t, then the adjustment process can be written as

$$f = f(f^1,\ldots,f^n) \tag{2.4}$$

and is called temporally homogeneous.

Note 2.1. If all the decision units report their environment $e^i,\ldots,e^n$ to a certain central unit C, and C has a powerful capacity of calculation, then, theoretically speaking, it might be possible to find a Pareto-optimal proposal set for the group. This is the informationally centralized case about the environment. Contrarily, our adjustment process defined by (2.2) will be called informationally non-centralized (or decentralized) about the environment.

Definition 2.2. The adjustment process f_t is said to arrive at an equilibrium point $\bar{A} = (\bar{A}^1,\ldots,\bar{A}^n)$ at the stage T, if

$$\bar{A}^i = f_t^i(\bar{A}^1,\ldots,\bar{A}^n;e^i) \quad , \quad i = 1,\ldots,n, \; t \geq T \quad . \tag{2.5}$$

Definition 2.3. For any equilibrium point $\bar{A} = (\bar{A}^1,\ldots,\bar{A}^n)$ of the adjustment process f_t, a possible proposal $\bar{a} = (\bar{a}_1,\ldots,\bar{a}_n)\varepsilon A$ such that $\bar{a}_i\varepsilon\bar{A}^i$, $i = 1,\ldots,n$ is called a solution of the adjustment process f_t.

Assumption B2. When the adjustment process f_t reaches a solution $\bar{a} = (\bar{a}_1,\ldots,\bar{a}_n)$, the process ends there, giving the decision unit i the outcome $z_i = \psi^i(\bar{a}_i)$, $i = 1,\ldots,n$.

We shall construct a temporally homogeneous adjustment process which gives a Pareto-optimal proposal $\bar{a}\varepsilon\hat{A}$ as its solution. For this we shall assume.

Assumption 2.1. For any $b_i\varepsilon X^i$, there exists at least one element $c_i\varepsilon Y^i$ such that $a_i = (b_i,c_i)\varepsilon A^i$, $i = 1,\ldots,n$.

Assumption 2.2. For any $b_j\varepsilon X^j$, $j\varepsilon)i($, there exists $b_i\varepsilon X^i$ such that the relation $R(b_1,\ldots,b_n)$ holds. (The notation $)i($ denotes that set of $1,\ldots,n$ excepting i.)

We shall define the following adjustment process $g = (g^1,\ldots,g^n)$ which corresponds to the greed process defined by Hurwicz [1].

At the stage t, let the sets $A_t^1,\ldots,A_t^n$ be proposed by the decision units $1,\ldots,n$ respectively, where $A_t^i\subset A^i$, $i = 1,\ldots,n$. Then define a subset B_t^i of X^i by

$$B_t^i = B^i[A_t^j, j\varepsilon)i(]$$

$$= \{b_i;\ \text{for some } a_j = (b_j,c_j)\varepsilon A_t^j, j\varepsilon)i(, b_i\varepsilon X^i\}\ .$$

Let the consistency relation

$$R(b_1,\ldots,b_n) \tag{2.6}$$

hold with these $b_j, j\varepsilon)i($, and a subset of A_t^{*i} of A^i by

$$A_t^{*i} = \{a_i^* = (b_i^*, c_i^*)\varepsilon A^i \quad ; \text{ for some } b_i^* \varepsilon B^i[A_t^j, j\varepsilon)i(]\} \ . \tag{2.7}$$

(These definitions of B_t^i and A_t^{*i} are valid by Assumptions 2.1 and 2.2.) Define $g^i(\cdot;e^i)$ by

$$\begin{aligned} A_{t+1}^i &= g^i(A_t^1;\ldots,A_t^n;e^i) \\ &= \{a_i \varepsilon A^i; a_i \succeq_i a_i^* \text{ , for all } a_i^* \varepsilon A_t^{*i}\} \text{ , } i = 1,\ldots,n \ . \end{aligned} \tag{2.8}$$

Concerning the greed process $g = (g^1,\ldots,g^n)$ defined above, we shall assume the following:

Assumption 2.3.

1) The greed process g has an equilibrium point $\bar{A} = (\bar{A}^1,\ldots,\bar{A}^n)$,

2) there exists a possible proposal $\bar{a} = (\bar{a}_1,\ldots,\bar{a}_n)$ such that $a_i \varepsilon A^i$, $i = 1,\ldots,n$--i.e. the greed process g has a solution. (Although it is an essential problem to make clear the conditions concerning the environments e^i, $i = 1,\ldots,n$, under which Assumptions 2.1, 2.2, and 2.3 hold, we shall not enter this problem here. To be precise, the chief concern of Hurwicz and other economists has been to find an adjustment process which gives a Pareto-optimal solution under the weaker conditions than the classical environment which requires: 1) no external (dis-) economy in production or consumption, 2) no indivisibility, and 3) no increasing return to scale.

Proposition 2.1. A solution of the greed process is Pareto-optimal.

Proof: Let any solution of the greed process be

$$\bar{a} = (\bar{a}_1,\ldots,\bar{a}_n)\varepsilon A,\ \bar{a}_i = (\bar{b}_i,\bar{c}_i)\ ,\ i = 1,\ldots,n\ . \qquad (2.9)$$

Assume that $\bar{a}$ is not Pareto-optimal. Then there exists

$$\tilde{a} = (\tilde{a}_1,\ldots,\tilde{a}_n)\varepsilon A,\ \tilde{a}_i = (\tilde{b}_i,\tilde{c}_i)\ ,\ i = 1,\ldots,n \qquad (2.10)$$

such that

$$\tilde{a}_i \underset{-i}{\geq}_i \bar{a}_i\ ,\ \text{for all } i = 1,\ldots,n\ , \qquad (2.11)$$

and

$$\tilde{a}_k >_k \bar{a}_k\ ,\ \text{for some } k\ . \qquad (2.12)$$

Now let $\bar{A} = (\bar{A}_1,\ldots,\bar{A}_n)$ be an equilibrium point of the greed process such that $\bar{a}_i\varepsilon\bar{A}^i$, $i = 1,\ldots,n$. Then $\bar{A}^i = g^i(\bar{A}^1,\ldots,\bar{A}^n;e^i)$, and by definition of the greed process g^i, we have the following. Let

$$\bar{A}^{*i} = \{\bar{a}_i^* = (\bar{b}_i^*,\bar{c}_i^*)\varepsilon A^i;\ \bar{b}_i^*\varepsilon B^i[\bar{A}^j, j\varepsilon)i(]\}\ . \qquad (2.13)$$

Then

$$\bar{A}^i = \{a_i\varepsilon A^i;\ a_i \underset{-i}{\geq}_i \bar{a}_i^*\ ,\ \text{for all } \bar{a}_i^*\varepsilon\bar{A}^{*i}\}\ ,\ i = 1,\ldots,n\ . \qquad (2.14)$$

Since $\bar{a}_i\varepsilon\bar{A}^i$, by the assumption (2.11) and (2.14) and the transitivity of R^i,

$$\tilde{a}_i = (\tilde{b}_i,\tilde{c}_i)\varepsilon\bar{A}^i\ ,\ i = 1,\ldots,n\ . \qquad (2.15)$$

Then by (2.15) and the fact that $\tilde{a} = (\tilde{a}_1,\ldots,\tilde{a}_n) \varepsilon A$, we have

$$\tilde{b}_k \varepsilon B^k[\ \bar{A}^j, j\varepsilon)k(] \quad . \tag{2.16}$$

By the definition (2.13) and (2.16),

$$\tilde{a}_k = (\tilde{b}_k, \tilde{c}_k) \varepsilon \bar{A}^{*k} \quad . \tag{2.17}$$

Since $\bar{a}_k \varepsilon \bar{A}^k$, by (2.17) and the definition (2.14) of $\bar{A}^k$, we have

$$\bar{a}_k \underset{-k}{\geq} \tilde{a}_k \quad . \tag{2.18}$$

This conclusion (2.18) contradicts the assumption (2.12). This proves Pareto-optimality of $\bar{a}$. q.e.d.

§ II. Adjustment Process in a Team

Although it is shown in §I that the greed adjustment process brings a Pareto-optimal solution under certain conditions, it is not known how many iterations are required to achieve it. If it takes too long to reach a solution, such a solution cannot have any practical significance. It is furthermore unrealistic to assume that the environment e^i will not change over an extensive period of time.

In studying means of overcoming these difficulties, we shall introduce briefly the work by T. Marschak [3]. He considers a team consisting of n members $G = \{1,\ldots,n\}$. (A team will be defined explicitly in §III.) Let A_i be the action space, of the member i and Θ_i be the state space which the member i faces. If the member i chooses an action

$a_i \varepsilon A_i$, $i = 1,\ldots,n$, and the state of nature $\theta_i \varepsilon \Theta_i$, $i = 1,\ldots,n$ prevails, then the payoff rate to the team G is given by

$$v(a_1,\ldots,a_n;\theta_1,\ldots,\theta_n) = v(a,\theta) \qquad (1)$$

where

$$a = (a_1,\ldots,a_n),\ \theta = (\theta_1,\ldots,\theta_n) \quad .$$

Each member i wants to choose an action a_i which gives the larger value of v. It is assumed that each member has the same prior probability law φ of $\theta = (\theta_1,\ldots,\theta_n)$.

The state θ occurs successively at the discrete time points $0,1,\ldots,q,\ldots$ with the same time interval. At the time point q, the state θ^q occurs following the probability law φ. It prevails until the next time point $q + 1$ and where the state θ^{q+1} occurs following φ and independently of θ^q. It is assumed that each member i can observe θ_i^q at the time point q. The time interval between the successive time points q and $q + 1$ is taken to be the unit of time.

We shall consider the following decision procedure of the team.

At the beginning of each time interval $(q,q + 1)$, $q = 0,1,\ldots$, each member i chooses by any method an interim action $a_i \varepsilon A_i$ and at the same time begins the iteration of the adjustment process f^i which depends on the given initial action $a_i(o)$, on his observed state θ_i^q and on other arguments to be stated later.

Assuming the constant time C for one iteration, we require that the adjustment process be stopped after T iterations and before the next state θ_i^q occurs at the time point q + 1. Accordingly T is chosen so that

$$0 < CT < 1 \quad . \tag{2}$$

We write the action obtained after T iterations of the adjustment process as $a_i(T,\theta_i^q,a(o))$, where $a(o) = a(o),\ldots,a_n(o))$. Each member i takes this action at that point and adheres to it until the end of the time interval (q,q + 1), i = 1,...,n. We write

$$a(T,\theta^q,a(o)) = (a_1(T,\theta_1^q,a(o)),\ldots,a_n(T,\theta_n^q,a(o)) \quad , \tag{3}$$

where $\theta^q = (\theta_1^q,\ldots,\theta_2^q)$. Then the expected payoff to the team in the time interval (q,q + 1) is given by

$$E[v(\tilde{a},\theta^q)CT + v(a(T,\theta^q,a(o)),\theta^q)(1 - CT)] \quad , \tag{4}$$

and the total expected payoff to the team is given by

$$\sum_{q=o}^{\infty} \rho^q E[v(\tilde{a},\theta^q)CT + v(a(T,\theta^q,a(o)),\theta^q)(1 - CT)] \quad , \tag{5}$$

where ρ is the discount rate such that $0 \leq \rho < 1$.

Under this decision scheme, the objective of each team member i is to choose the adjustment process f^i, the interim action $\tilde{a}_i$, the initial action $a_i(o)$, and the number of the terminal iteration T so that they will give the largest value of (5).

We assume C is constant for any adjustment process. From our assumptions, it is clear that the above objective of the team is equivalent increasing the value of

$$E[v(\tilde{a},\theta)CT + v(a(T,\theta,a(o)),\theta)(1 - CT)] \quad . \tag{6}$$

Before defining the adjustment process, we shall describe the information structure of the team. If, at each time point q, all the members i report their observed state θ_i^q, i = 1,...,n to the member 0, called the center (the case of the informational centralization), then the center member 0 will be able to calculate the value $\hat{a}_i$, i = 1,...,n, which maximizes the value of $v(a_1,...,a_n;\theta_1^q,...,\theta_n^q)$ and tell each member the value $\hat{a}_i$, i = 1,...,n. But the team must in any case take a certain interim action $\tilde{a}$ until the center's calculation is finished; this calculation may take a long time--possibly longer than 1.

Then, we shall define an adjustment process under the condition of the informational decentralization in the following sense.

The initial action $a(o) = (a_1(o),...,a_n(o))$ is given and each member knows it. When, at the (t - 1)th stage of the iteration, the member i's tentative action is give as $a_i(t - 1)$, he transmits it to all other members of the team. But each member i never transmits his observed value of θ_i to the other team members. Therefore we define a (temporally homogeneous) adjustment function f^i as a mapping from

$A_1 \times \cdots \times A_n \times \Theta_i$ to A_i, $i = 1,\ldots,n$. Thus the tenative action of the member i at the t-th iteration is given by

$$a_i(t) = f^i(a_1(t-1),\ldots,a_n(t-1),\theta_i)$$

$$= f^i(a(t-1),\theta_i) \quad , \; i = 1,\ldots,n, \; t = 0,1,\ldots \; . \tag{7}$$

If we write the action which is given after T iterations of the adjustment process $f = (f^1,\ldots,f^n)$ as a $(T,\theta,a(o)|f)$, then the expected payoff to the team in one time unit is given by

$$V(\tilde{a},a(o),f,T) = E[v(\tilde{a},\theta)CT + v(a(T,\theta,a(o)|f),\theta)(1 - CT)] \tag{8}$$

It will be a very difficult task to determine the values of $\tilde{a}$, a(o), T, and the function f so that they will maximize the value of $V(\tilde{a},a(o),f,T)$. But we will make the following comments about this problem.

Proposition 1. If the interim action $\tilde{a}$, the adjustment process $f = (f^1,\ldots,f^n)$, and the initial action a(o) are fixed, and if the terminal iteration T must lie in the interval $0 \leq T \leq T^*$ for a fixed integer T^* such that $T^* \leq 1/C$, and if $\Delta v_t > 0$ and $\Delta^2 v_t > 0$ for integers t in this interval, then there exists a unique best terminal iteration T in this interval which maximizes $V(\tilde{a},a(o),f,T)$ given by (8), where

$$v_t = v(a(t,\theta,a(o)|f),\theta), \; \Delta v_t = v_t - v_{t-1} \; . \tag{9}$$

Proof. We write

$$w_t = v(\tilde{a},\theta)Ct + v_t(1 - Ct) \quad . \tag{10}$$

Then

$$\Delta^2 w_t = (1 - Ct)\,\Delta^2 v_t - 2C\,\Delta v_{t-1} \quad , \; 1 \leq t \leq T^* \quad . \tag{11}$$

From (11) and the assumptions in the proposition, we have $\Delta^2 w_t < 0$. Accordingly

$$\Delta^2 V(\tilde{a},a(o),f,t) < 0 \quad , \; 1 \leq t \leq T^* \quad , \tag{12}$$

and by (12) we know the existence of a unique value of T in the interval $1 \leq T \leq T^*$ which maximizes the value of $V(\tilde{a},a(o),f,T)$. q.e.d.

If the payoff function $v(a_1,\ldots,a_n;\theta_1,\ldots,\theta_n)$ is concave and differentiable with respect to a_i for any fixed θ, then as an adjustment process the following gradient-method may be convenient:

$$a_i(t) = a_i(t - 1) + h \frac{\partial}{\partial a_i} v(a(t - 1),\theta) \quad . \tag{13}$$

We shall close this section by remarking that T. Marschak [3] gives a detailed study of the gradient-method adjustment process when the team payoff rate function $v(a,\theta)$ is quadratic with respect to $a = (a_1,\ldots,a_n)$.

III. Team Decision Problems

III.1

We shall introduce the essential points of the work by J. Marschak and R. Radner [2]. There is a group G of n members i, i = 1,...,n, G = {1,...,n}. The action space A_i of the member i, i = 1,...,n and the state space X is given. If each member i takes an action $a_i \in A_i$, i = 1,...,n and the state $x \in X$ is true, then the benefit ω to the group is given by a given payoff function:

$$\omega = \omega(a_1,\ldots,a_n;x) = \omega(a,x) \tag{1.1}$$

where $a = (a_1,\ldots,a_n)$ (Conditions (L_0) and (S_1)).

It is assumed that:

1) each member i wants to make larger the value of ω, (Condition (U_1)), and
2) each member i has the same prior probability measure φ on X (Condition (J_1)).

Then the group G = {1,...,n} is called a Team.

It should be remarked that in a team, each member i is supposed to choose his action a_i at his own discretion, without being affected by directives from other members (Condition (C_0)). Accordingly, in a team, the problem of the organizational structure such as the command structure need not be considered. Rather, in the study of a team, the essential problem is that of an information structure.

An <u>information structure</u> η_i for a member i is defined as a function from the state space X to a given space Y_i. It is assumed that when the state $x \in X$ is true, the member i observes or knows the value of η_i:

$$y_i = \eta_i(x) \quad , \; i = 1,\ldots,n \quad . \tag{1.2}$$

We shall call y_i the information of the member i and $\eta = (\eta_1,\ldots,\eta_n)$ the information structure of the team.

<u>Remark 1.1</u>. In general, we will have the partition of the space X,

$$X = Z_1 \cup \ldots \cup Z_n \quad , \tag{1.3}$$

such that

1) for any x, $x' \in Z_j$

$$\omega(a,x) = \omega(a,x') \quad , \text{ for all } a \in A_1 \times \cdots \times A_n \quad ,$$

and

2) for any $x \in Z_j$, $x' \in Z_k$, $j \neq k$, we cannot have

$$\omega(a,x) = \omega(a,x') \quad , \text{ for all } a \quad .$$

Then the partition (1.3) of X is called <u>payoff relevant</u>. In such a case we shall consider a set $\Theta = \{\theta_1,\ldots,\theta_m\}$. If the true state x is in Z_j, then we shall say θ_j is the true state, and we define the function v on $A_1 \times \cdots \times A_n \times \Theta$ by

$$v(a,\theta_j) = \omega(a,x) \quad , \quad \text{for } x \in Z_j \quad . \tag{1.4}$$

Then we can take Θ interchangeably as the state space and v as the payoff function.

It should be remarked that an information structure η_i gives a probability distribution $P(\cdot|\theta)$ on Y_i depending on the true state $\theta_j \varepsilon \Theta$, because we have

$$p(y_k|\theta_j) = \frac{\varphi(\{x;\eta_i(x) = y_k\}\cap Z_j)}{\varphi(Z_j)} \quad . \tag{1.5}$$

An information structure η_i is described elsewhere as a random variable whose distribution is known depending on the given true state $\theta_j \varepsilon \Theta$. We shall note that these two definitions are equivalent.

Remark 1.2. Consider the following case. To the member i is given the function ζ_i from X to M_i, and the member i can observe the value

$$m_i = \zeta_i(x) \varepsilon M_i \quad , \; i = 1,\ldots,n \quad .$$

If some other members j transmit the value $\upsilon_{ij}(m_j)$ to the member i, where $\upsilon_{ij}(\cdot)$ is the given information function of j's observed value m_j, then the member i's information structure η_i is given by

$$\eta_i(x) = (\zeta_i(x), \upsilon_{ij}[\zeta_j(x)] \text{ , for some j's}) \quad . \tag{1.6}$$

III.2

Thus an n member team decision problem is specified by the action space $A = A_1 \times \cdots \times A_n$, the state space X, the payoff function ω, the prior probability law φ on X, and the information structure $\eta = (\eta_1,\ldots,\eta_n)$ chosen by the team. We denote this team decision problem as

$$D(A,X,\omega,\varphi|\eta) \quad . \tag{2.1}$$

In this team decision problem, each member i must choose a decision rule α_i which maps Y_i to A_i, i = 1,...,n. The choice of a decision rule $\alpha = (\alpha_1,\ldots,\alpha_n)$ by the team is evaluated by the expected payoff

$$\begin{aligned} \Omega(\eta,\alpha) &= E_x\left[\omega(\alpha_1[\eta_1(x)],\ldots,\alpha_n[\eta_n(x)];x)\right] \\ &= E\left[\omega(\alpha[\eta(x)],x)\right] \quad . \end{aligned} \tag{2.2}$$

The task of each member i is to choose the decision rule $\hat{\alpha}_i$ such that

$$\begin{aligned} \Omega(\eta,\hat{\alpha}_1,\ldots,\hat{\alpha}_n) &= \max_{\alpha_1,\ldots,\alpha_n} \Omega(\eta,\alpha_1,\ldots,\alpha_n) \\ &= \Omega(\eta) \quad . \end{aligned} \tag{2.3}$$

Now let η^0 be the null information structure. Then in the team decision problem $D(A,X,\omega,\varphi|\eta^0)$, each member i chooses his own action $a_i \varepsilon A_i$ without any further information than φ concerning the state, i = 1,...,n, and the team then has the expected payoff

$$\Omega(\eta^0,a) = E[\omega(a_1,\ldots,a_n;x)] \quad . \tag{2.4}$$

Under η^0, the team should choose the action $\hat{a} = (\hat{a}_1,\ldots,\hat{a}_n)$ such that

$$\Omega(\eta_0,\hat{a}) = \max_{a_1,\ldots,a_n} \Omega(\eta_0,a_1,\ldots,a_n)$$

$$= \Omega(\eta_0) \quad . \tag{2.5}$$

Definition 2.1. The (gross) value $V(\eta)$ of an information structure η is defined by

$$V(\eta) = \Omega(\eta) - \Omega(\eta_0) \quad . \tag{2.6}$$

III.3

In the team decision problem $D(A,X,\omega,\varphi|\eta)$, it is clear that the optimal team decision rule $\hat{\alpha} = (\hat{\alpha}_1,\ldots,\hat{\alpha}_n)$ has the following property. We write

$$\Omega(\eta,\alpha) = \Omega(\alpha) = \Omega(\alpha_1,\ldots,\alpha_n) \quad ,$$

$$\Omega(\alpha_i,\tilde{\alpha}) = \Omega(\tilde{\alpha}_1,\ldots,\alpha_i,\ldots,\tilde{\alpha}_n) \quad . \tag{3.1}$$

Then

$$\Omega(\hat{\alpha}) = \max_{\alpha_i} \Omega(\alpha_i,\hat{\alpha}) \quad , \text{ for all } i \quad . \tag{3.2}$$

Definition 3.1. A team decision rule $\tilde{\alpha} = (\tilde{\alpha}_1,\ldots,\tilde{\alpha}_n)$ is said to be person-by-person satisfactory (p. b. p. s.), if

$$\Omega(\tilde{\alpha}) = \max_{\alpha_i} \Omega(\alpha_i,\hat{\alpha}) \quad , \text{ for all } i \quad . \tag{3.3}$$

It is clear that an optimal team decision rule $\hat{\alpha}$ is p. b. p. s., but the converse if not necessarily true. We have

Proposition 3.1. If for $x \in X$, ω is a concave function of $a = (a_1,\ldots,a_n)$, then any p. b. p. s. decision rule is optimal.

In the following we shall consider a quadratic team, i.e. a team whose payoff function is given by

$$\omega(a,x) = h_0 + 2a'h(x) - a'Qa \tag{3.4}$$

where h_0 is a constant, a is a (column) vector with coordinates a_i, $i = 1,\ldots,n$, $h(x)$ is a vector valued function on X, and $Q = ||q_{ij}||$ is a positive definite symmetric $n \times n$ matrix.

Applying Proposition 3.1 to the case, the optimal team decision rule $\hat{\alpha} = (\hat{\alpha}_1,\ldots,\hat{\alpha}_n)$ under the information structure $\eta = (\eta_1,\ldots,\eta_n)$ will be obtained as follows. Writing (3.4) explicitly, we have

$$\omega(a,x) = h_0 + 2\sum_i a_i h_i(x) - \sum_i q_{ii}a_i^2 - \sum_{i\neq j} q_{ij}a_i a_j \ . \tag{3.5}$$

We write

$$\psi_i(a_i,y_i) = E[\omega(\hat{\alpha}_1(y_1),\ldots,a_i,\ldots,\hat{\alpha}_n(y_n);x)|y_i] \ , \tag{3.6}$$

where $y_i = \eta_i(x)$. Then by (3.5) we have

$$\psi_i(a_i,y_i) = h_0 + 2a_iE[h_i(x)|y_i] + 2\sum_{j\neq i} E[\hat{\alpha}_j(y_j)h_j(x)|y_i]$$

$$- q_{ii}a_i^2 - \sum_{j\neq i} q_{jj}E[\hat{\alpha}_j(y_j)^2|y_i] - 2a_i\sum_{j\neq i} E[\hat{\alpha}_j(y_j)|y_i]$$

$$- \sum_{\substack{j\neq k \\ j,k\neq i}} q_{jk}E[\hat{\alpha}_j(y_j)\hat{\alpha}_k(y_k)|y_i] \qquad (3.7)$$

From (3.7)

$$\frac{\partial\psi_i(a_i,y_i)}{\partial a_i} = 2E[h_i(x)|y_i] - 2q_{ii}a_i$$

$$- 2\sum_{j\neq i} q_{ij}E[\hat{\alpha}_j(y_j)|y_i] \quad , \; i = 1,\ldots,n \; . \qquad (3.8)$$

Therefore, the condition

$$\left.\frac{\partial\psi_i(a_i,y_i)}{\partial a_i}\right|_{a_i = \hat{\alpha}_i(y_i)} = 0 \quad , \; i = 1,\ldots,n \; , \qquad (3.9)$$

for $\hat{\alpha}$ to be p. b. p. s., becomes

$$q_{ii}\hat{\alpha}_i(y_i) + \sum_{j\neq i} q_{ij}E[\hat{\alpha}_j(y_j)|y_i] = E[h_i(x)|y_i] \; ,$$

$$i = 1,\ldots,n \; . \qquad (3.10)$$

Thus we have

Proposition 3.2. If the payoff function ω is given by (3.4) or (3.5) then the optimal team decision rule $\hat{\alpha} = (\hat{\alpha}_1,\ldots,\hat{\alpha}_n)$ is given as the solution of the equation (3.10).

Under the null information structure η^0, for the optimal team action $\hat{a} = (\hat{a}_1,\ldots,\hat{a}_n)$, the equation (3.10) becomes the following:

$$\sum_j q_{ij}\hat{a}_j = E[h_i(x)] \quad , \; i = 1,\ldots,n \quad . \tag{3.11}$$

Therefore, we have

$$\hat{a} = Q^{-1}E[h(x)] \quad . \tag{3.12}$$

From (3.4) and (3.12), we have

$$\Omega(\eta^0) = h_0 + 2E[h']Q^{-1}E[h] - E[h']Q^{-1}E[h] \quad ,$$

i.e.

$$\Omega(\eta^0) = h_0 + E[h']Q^{-1}E[h] \quad . \tag{3.13}$$

Proposition 3.3. In a quadratic team decision problem, we have

$$V(\eta) = E[\hat{\alpha}'h] - (E[\hat{\alpha}'])(E[h]) \quad . \tag{3.14}$$

Proof. Taking the expectation with respect to y_i of both sides of (3.10) we have

$$q_{ii}E[\hat{\alpha}_i] + \sum_{j\neq i} q_{ij}E[\hat{\alpha}_j] = E[h_i] \quad , \; i = 1,\ldots,n \quad . \tag{3.15}$$

From (3.15), we have

$$E[\hat{\alpha}] = Q^{-1}E[h] \quad . \tag{3.16}$$

Now multiplying $\hat{\alpha}_i(y_i)$ on both sides of (3.10) and taking the expectation with respect to y_i, we have

$$\sum_j q_{ij}E[\hat{\alpha}_i(y_i)\hat{\alpha}_j(y_j)] = E[\alpha_i(y_i)h_i(x)] \quad , \; i = 1,\ldots,n \quad . \tag{3.17}$$

Taking the sum with respect to i of the both sides of (3.17), we have

$$E[\hat{\alpha}'Q\hat{\alpha}] = E[\hat{\alpha}'h] \quad . \tag{3.18}$$

From (3.4), we have

$$\begin{aligned} \Omega(\eta) &= E[\omega(\hat{\alpha}(y),x)] \\ &= h_0 + 2E[\hat{\alpha}'h] - E[\hat{\alpha}'Q\hat{\alpha}] \quad . \end{aligned} \tag{3.19}$$

From (3.17), (3.18) and (3.19),

$$\Omega(\eta) = h_0 + E[\hat{\alpha}'h] \quad . \tag{3.20}$$

From (3.13) and (3.16),

$$\Omega(\eta^0) = h_0 + (E[h'])(E[\hat{\alpha}]) \quad . \tag{3.21}$$

Applying (3.20) and (3.21) to the definition

$$V(\eta) = \Omega(\eta) - \Omega(\eta^0) \quad ,$$

we have (3.14). q.e.d.

§ IV. Two-Level Hierarchical Organization

IV.1

We consider an organization consisting of the superior decision unit D_0 and the inferior decision units D_i, $i = 1,\ldots,n$. They face the state of nature $x = (x_1,\ldots,x_n)$ which is an element of the state space X. The task of the superior decision unit D_0 is to give a command γ in the given set Γ to each inferior decision unit D_i, $i = 1,\ldots,n$. A command $\gamma\varepsilon\Gamma$ specifies to each D_i, $i = 1,\ldots,n$: 1) the action space A_i from which D_i must choose its action a_i, 2) the objective function $\omega_i(\cdot|\gamma)$, 3) the prior probability law φ on X which is the same for all D_i, $i = 1,\ldots,n$, and 4) the information structure η_i, where $\omega_i(\cdot|\gamma)$ is a function of the action $a_i\varepsilon A_i$ chosen by D_i and the actions $a^{(i)} = (a_j, j\varepsilon)i()$ chosen by other inferior decision units D_j, $j \neq i$ and the true state of the nature $x\varepsilon X$, i.e.

$$\omega_i = \omega_i(a_i, a^{(i)}; x|\gamma) \quad . \tag{1.1}$$

The task of each inferior decision unit D_i after receiving a command γ from the superior decision unit D_0 is to choose a decision rule α_i which is based on his given information structure η_i, $i = 1,\ldots,n$. If the inferior decision units D_i, $i = 1,\ldots,n$ choose the decision rules $\alpha_1,\ldots,\alpha_n$, then the expected payoff to D_i is given by

$$\Omega_i(\alpha_i,\alpha^{(i)}|\gamma) = E\{\omega_i(\alpha_i[\eta_i(x)],\alpha^{(i)}[\eta(x)];x|\gamma)\} \qquad (1.2)$$

where the expectation is taken by the probability law φ and

$$\alpha^{(i)}[\eta(x)] = (\alpha_1[\eta_1(x)],\ldots,\not{i},\ldots,\alpha_n[\eta_n(x)]) \ . \qquad (1.3)$$

We also assume that there is the given overall objective function ω as the organization which is the given function $\Psi(\cdot)$ of $\omega_1,\ldots,\omega_n$, i.e.

$$\omega = \Psi(\omega_1,\ldots,\omega_n) \ . \qquad (1.4)$$

Contrary to this, there will be the case where the overall objective function ω is already given. Then as an ingredient of the command, D_0 assigns the objective function ω_i to D_i, $i = 1,\ldots,n$, so that ω is related to these ω_i through some function Ψ as in (1.4). The case will be considered in IV.3.

Now, the motivation to the activity of the inferior decision unit D_i is as follows. Each D_i wants to have the largest expected payoff Ω_i to him under the given command γ from D_0, $i = 1,\ldots,n$. But Ω_i depends not only on D_i's decision rule α_i but also on the decision rules α_j, $j \neq 1$ chosen by other inferior decision units. So we define

Definition 4.1. A decision rule $\hat{\alpha}(\gamma) = (\hat{\alpha}_1(\gamma),\ldots,\hat{\alpha}_n(\gamma))$ is called Nash-equilibrium (N.E.) under a command γ, if the following condition holds: for each $i = 1,\ldots,n$

$$\Omega_i(\alpha_i,\hat{\alpha}^{(i)}(\gamma)|\gamma) \leq \Omega_i(\hat{\alpha}_i,\hat{\alpha}^{(i)}(\gamma)|\gamma) \ , \quad \text{for all } \alpha_i \ . \qquad (1.5)$$

(It is clear that in the case of a team a N.E. decision rule is p. b. p. s.)

Concerning the behavior of the inferior decision units we assume

Assumption B1.1. All the inferior decision units D_i receiving a command γ from D_0, $i = 1,\ldots,n$ are satisfied by choosing a N.E. decision rule $\hat{\alpha}(\gamma) = (\hat{\alpha}_1(\gamma),\ldots,\hat{\alpha}_n(\gamma))$ and getting the expected payoff

$$\hat{\Omega}_i(\gamma) = \Omega_i(\hat{\alpha}_i(\gamma),\hat{\alpha}^{(i)}(\gamma)|\gamma) \quad , \; i = 1,\ldots,n \quad . \tag{1.6}$$

The motivation for the activity of the superior decision unit D_0 is as follows. Let Γ^0 be the set of commands $\gamma\varepsilon\Gamma$ for which a N.E. decision rule $\hat{\alpha}(\gamma)$ exists. If D_0 orders a command $\gamma\varepsilon\Gamma^0$ to D_i, $i = 1,\ldots,n$ and they choose a N.E. decision rule $\hat{\alpha}(\gamma)$ corresponding to γ, then the overall expected payoff to the organization is given by

$$\hat{\Omega}(\gamma) = E\{\Psi(\omega_1(\gamma),\ldots,\omega_n(\gamma))\} \quad , \tag{1.7}$$

where

$$\omega_i(\gamma) = \omega_i(\alpha_i(\gamma)[\eta_i(x)],K_i(\alpha^{(i)}(\gamma)[\eta(x)]);x|\gamma) \quad , \tag{1.8}$$

$$i = 1,\ldots,n \quad .$$

In the particular case such as

$$\omega = \Psi(\omega_1,\ldots,\omega_n) = \omega_1 + \cdots + \omega_n \quad , \tag{1.9}$$

we have

$$\hat{\Omega}(\gamma) = \hat{\Omega}_1(\gamma) + \cdots + \hat{\Omega}_n(\gamma) \quad . \tag{1.10}$$

Now concerning the behavior of D_0 we assume

Assumption B1.2. The superior decision unit D_0 wants to order a command γ^0 in Γ^0 such that

$$\max_{\gamma \in \Gamma^0} \hat{\Omega}(\gamma) = \hat{\Omega}(\gamma^0) \tag{1.11}$$

and we shall call γ^0 an optimal command by D_0.

Thus in our hierarchical organization, the inferior decision units D_i, $i = 1,\ldots,n$ and the organization itself a are all satisfied by D_0 choosing an optimal command γ^0 and D_i, $i = 1,\ldots,n$, choosing the corresponding N.E. decision rule $\hat{\alpha}(\gamma^0)$. Our problem is to seek such γ^0 and $\hat{\alpha}(\gamma^0)$.

Remark 1.1. In Mesarovic, assuming Condition (S_0), it is assumed that the payoff to the inferior decision unit D_i when D_0 gives a command γ and D_i, $i = 1,\ldots,n$ choose the actions $a_1,\ldots,a_n$ is given by

$$\Omega_i(a_i,u_i|\gamma) \quad , \quad \text{where } u_i = K_i(a^{(i)}) \quad , \tag{1.12}$$

where $K_i(\cdot)$ is the given function of $a^{(i)}$, $i = 1,\ldots,n$, and the overall payoff to the organization is given by

$$\Omega(a|\gamma) = \Psi(\Omega_1(a_1,u_1|\gamma),\ldots,\Omega_n(a_n,u_n|\gamma)) \quad . \tag{1.13}$$

Therefore, in his approach, the problem of choosing a decision rule based on the information structure does not appear. Now, from this calculation, just assuming that D_i can control u_i

as well as a_i, we shall find $\bar{a}_i(\gamma)$ and $\bar{u}_i(\gamma)$ such that

$$\max_{a_i,u_i} \Omega_i(a_i,u_i|\gamma) = \Omega_i(\bar{a}_i(\gamma),\bar{u}_i(\gamma)|\gamma) \quad , \; i = 1,\ldots,n \; . \tag{1.14}$$

If it happens that

$$\bar{u}_i(\gamma) = K_i(\bar{a}^{(i)}(\gamma)) \quad , \; i = 1,\ldots,n \quad , \tag{1.15}$$

then what Mesarovic [4] calls the interaction balance (I.B.) holds for $\bar{a}(\gamma) = (\bar{a}_1(\gamma),\ldots,\bar{a}_n(\gamma))$. Under a command γ, if there exists an action $\bar{a}(\gamma)$ for which I.B. holds, then all the inferior decision units D_i, $i = 1,\ldots,n$ are satisfied with it. Further, if $\bar{a}(\gamma)$ maximizes the overall payoff $\Omega = \Psi(\Omega_1,\ldots,\Omega_n)$, then what Mesarovic [4] calls the <u>interaction balance principle</u> (I.B.P.) holds with γ or the organization is coordinable by I.B.P. If Ψ is a monotonic function of Ω_i such as (1.9) and an action $\bar{a}(\gamma)$ for which I.B. holds exists, then it is clear that I.B.P. holds. Even when an action $\bar{a}(\gamma)$ for which I.B. holds exists, if Ψ is not a monotonic function of Ω_i, it is not necessarily true that $\bar{a}(\gamma)$ maximizes the overall payoff $\Omega(\gamma)$ which the organization wants to make larger, i.e. $\bar{a}(\gamma)$ satisfies I.B.P.

Now, it is clear that if I.B. holds for $\bar{a}(\gamma) = (\bar{a}_1(\gamma),\ldots,\bar{a}_n(\gamma))$, then $\bar{a}(\gamma)$ is a N.E. decision rule. On the other hand, for a N.E. decision rule $\hat{a}(\gamma) = (\hat{a}_1(\gamma),\ldots,\hat{a}_n(\gamma))$, if it happens that

$$\max_{a_i,u_i} \Omega_i(a_i,u_i|\gamma) = \Omega_i(\hat{a}_i(\gamma),K_i(\hat{a}^{(i)}(\gamma))|\gamma) \; , \tag{1.16}$$

then it is clear that for $\hat{a}(\gamma)$ I.B. holds.

It is true that the concepts such as I.B.P. and the interaction prediction principle proposed by Mesarovic [4] are interesting. But it is not clear whether these concepts can be applied to the more general situation, such as where the payoff function is given by (1.1) but not necessarily restricted to the form of (1.12), and there Conditions (S_1), (J), and (I_1) play an important role. (We are considering such situations, and our formulation seems more natural than that of Mesarovic [4].)

IV.2

We shall modify Marschak's example [2] to our case. There are two inferior decision units D_E and D_W. They must decide whether to accept the offered price in the east or in the west. Their possible actions are $a_E = 1$, $a_E = 0$ and $a_W = 1$, $a_W = 0$, where $a_E = 1$ (0) means that D_E accepts (does not accept) the offered price in the east. a_W is analogously defined. The offer will be met by manufacturing the machine in factory F_1 or F_2. When the offered price is p and the manufacturing cost is c, then the profit to the inferior decision unit is p - c. The offered price will be denoted by p_E and p_W respectively in the east and in the west. The manufacturing cost by F_i is c_i, i = 1,2. Assume

$$c_1 = 5 \quad , \quad c_2 = 8$$

and the joint distribution of p_E and p_W is given by Table 2.1.

Table 2.1

p_E \ p_W	12	3	
10	.60	.15	.75
4	.05	.20	.25
	.65	.35	1.00

Now there is the superior decision unit D_0 which gives a command γ to the inferior decision units D_1, D_2. Let the possible information structures be as follows:

η_0: $D_E(D_W)$ must choose his action without knowing $p_E(p_W)$.

η_1: $D_E(D_W)$ can choose his action knowing $p_E(p_W)$.

Further let ζ_i be the following command by D_0:

ζ_1: D_E can use F_1 and D_W can use F_2 ,

ζ_2: D_E can use F_2 and D_W can use F_1 ,

ζ_1': ζ_1, further if D_E does not use F_1, then D_W can use F_1 ,

ζ_2': ζ_2, further if D_W does not use F_1, then D_E can use F_1 .

Combining these components, let the possible commands by D_0

be as follows:

$$\gamma_1 = (\eta_0,\zeta_1),\ \gamma_2 = (\eta_0,\zeta_2),\ \gamma_3 = (\eta_0,\zeta_1'),\ \gamma_4 = (\eta_0,\zeta_2')\ ;$$
$$\gamma_5 = (\eta_1,\zeta_1),\ \gamma_6 = (\eta_1,\zeta_2),\ \gamma_7 = (\eta_1,\zeta_1'),\ \gamma_8 = (\eta_1,\zeta_2')\ . \tag{2.1}$$

It is easily seen that the profit function ω_i for D_i is given as follows ($c_1 < c_2$):

$$\begin{cases}\omega_1(a_E = 1, a_W, p_E, p_W|\zeta_1) = p_E - c_1 & \text{, for all } a_W \text{ and } p_W\\ \omega_2(a_E, a_W = 1, p_E, p_W|\zeta_1) = p_W - c_2 & \text{, for all } a_E \text{ and } p_E\end{cases}$$

$$\begin{cases}\omega_1(a_E = 1, a_W, p_E, p_W|\zeta_2) = p_E - c_2 & \text{, for all } a_W \text{ and } p_W\\ \omega_2(a_E, a_W = 1, p_E, p_W|\zeta_2) = p_W - c_1 & \text{, for all } a_E \text{ and } p_E\end{cases}$$

$$\begin{cases}\omega_1(a_E = 1, a_W, p_E, p_W|\zeta_1') = p_E - c_1 & \text{, for all } a_W \text{ and } p_W\\ \omega_2(a_E, a_W = 1, p_E, p_W|\zeta_1') = \begin{cases}p_W - c_2 & \text{, for } a_E = 1 \text{ and all } p_E\\ p_W - c_1 & \text{, for } a_E = 0 \text{ and all } p_E\end{cases}\end{cases}$$

$$\begin{cases}\omega_1(a_E = 1, a_W, p_E, p_W|\zeta_2') = \begin{cases}p_E - c_2 & \text{, for } a_W = 1 \text{ and all } p_W\\ p_E - c_1 & \text{, for } a_W = 0 \text{ and all } p_W\end{cases}\\ \omega_2(a_E, a_W = 1, p_E, p_W|\zeta_2') = p_W - c_1 & \text{, for all } a_E \text{ and } p_E\ .\end{cases}$$

In all cases, the value of $\omega_1(\omega_2)$ for $a_E = 0$ ($a_W = 0$) is 0.

Let the overall profit ω be given by

$$\omega = \omega_1 + \omega_2\ . \tag{2.2}$$

Then denoting the maximum expected profit for the inferior decision unit D_i under a command γ by $\Omega_i(\gamma)$, the maximum

overall expected profit when a command is γ is given by

$$\Omega(\gamma) = \Omega_1(\gamma) + \Omega_2(\gamma) \quad . \tag{2.3}$$

We may easily calculate the following results:

$$\Omega_1(\gamma_2) = \Omega_1(\gamma_4) = 0.50,\ \Omega_1(\gamma_6) = 1.50,\ \Omega_1(\gamma_8) = 1.95\ ,$$
$$\Omega_1(\gamma_1) = \Omega_1(\gamma_3) = 3.50,\ \Omega_1(\gamma_5) = \Omega_1(\gamma_7) = 3.75\ ; \tag{2.4}$$
$$\Omega_2(\gamma_1) = \Omega_2(\gamma_3) = 0.85,\ \Omega_2(\gamma_5) = 2.60,\ \Omega_2(\gamma_7) = 2.75\ ,$$
$$\Omega_2(\gamma_2) = \Omega_2(\gamma_4) = 3.85,\ \Omega_2(\gamma_6) = \Omega_2(\gamma_8) = 4.55\ ; \tag{2.5}$$

and

$$\Omega(\gamma_1) = \Omega(\gamma_2) = \Omega(\gamma_3) = \Omega(\gamma_4) = 4.35\ ,$$
$$\Omega(\gamma_6) = 6.05,\ \Omega(\gamma_5) = 6.35,\ \Omega(\gamma_7) = \Omega(\gamma_8) = 6.50\ . \tag{2.6}$$

Thus, if we disregard information cost, we have the following conclusion: the optimal command γ^0 by D_0 is $\gamma_7 = (\eta_1, \zeta_1')$ or $\gamma_8 = (\eta_1, \zeta_2')$. Under a command $\gamma^0 = \gamma_7(\gamma_8)$, D_E and D_W are satisfied with the expected profit 3.75 (1.95) and 2.75 (4.55) respectively, and the organization is satisfied by obtaining the maximum expected profit of 6.50.

IV.3

The organization under consideration consists of the superior decision unit D_0 and the inferior decision units D_i, $i = 1,\ldots,n$. In this sub-section, we assume the overall payoff function ω is already given, where ω is the function

of $a_i \varepsilon A_i$ chosen by D_i, $i = 1,\ldots,n$ and the state of nature $x = (x_1,\ldots,x_n)\varepsilon X = X_1 \times \cdots \times X_n$, i.e.

$$\omega = \omega(a_1,\ldots,a_n;x_1,\ldots,x_n) = \omega(a,x) \quad . \tag{3.1}$$

The superior decision unit D_0 has the prior probability law φ on X and it is assumed that all the inferior decision units D_i, $i = 1,\ldots,n$ share the same prior probability law φ with D_0. A command γ by D_0 consists of two components ζ and η, i.e.

$$\gamma = (\zeta,\eta) \quad , \tag{3.2}$$

where 1) ζ assigns the objective function $\omega_i(a,x|\gamma)$ of $a = (a_1,\ldots,a_n)$ and $x = (x_1,\ldots,x_n)$ to D_i, $i = 1,\ldots,n$ and specifies the function Ψ such that

$$\omega = \Psi(\omega_1,\ldots,\omega_n) \tag{3.3}$$

and 2) η assigns the information structure η_i to D_i which is the given function from X to Y_i, i.e.

$$\eta_i(x) = y_i \varepsilon Y_i \quad , \; i = 1,\ldots,n \quad . \tag{3.4}$$

Under a command $\gamma = (\zeta,\eta)$, the inferior decision unit faces the following problem, $i = 1,\ldots,n$. First, let $\bar{\omega}_i$ be defined on $A_1 \times \cdots \times A_n \times Y_1 \times \cdots \times Y_n = A \times Y$ by

$$\bar{\omega}_i(a_1,\ldots,a_n;y_1,\ldots,y_n|\gamma) = E[\omega_i(a,x|\gamma)|y_1,\ldots,y_n] \quad , \quad i = 1,\ldots,n \quad . \tag{3.5}$$

Let α_i be a decision rule of D_i which maps from Y_i to A_i, $i = 1,\ldots,n$. If each decision unit D_i uses α_i, $i = 1,\ldots,n$, then the expected payoff to D_i is given by

$$E[\bar{\omega}_i(\alpha_1(y_1),\ldots,\alpha_n(y_n);y_1,\ldots,y_n|\gamma)]$$

$$= E[\bar{\omega}_i(\alpha(y);y|\gamma)] = \Omega_i(\alpha_1,\ldots,\alpha_n|\gamma) \quad , \; i = 1,\ldots,n \quad , \tag{3.6}$$

and the overall expected payoff to the organization is given by

$$\Omega(\alpha_1,\ldots,\alpha_n|\gamma) = E[\Psi(\bar{\omega}_1(\alpha(y);y|\gamma),\ldots,\bar{\omega}_n(\alpha(y);y|\gamma))] \quad . \tag{3.7}$$

By Assumption B1.1, all the inferior decision units D_i, $i = 1,\ldots,n$, under the command γ are satisfied with a N.E. decision rule $\hat{\alpha}(\gamma) = (\hat{\alpha}_1(\gamma),\ldots,\hat{\alpha}_n(\gamma))$ which, by Definition 1.1, is such that

$$\max_{\alpha_i} \; \Omega(\hat{\alpha}_1(\gamma),\ldots,\alpha_i,\ldots,\hat{\alpha}_n(\gamma)|\gamma)$$

$$= \Omega_i(\hat{\alpha}_1(\gamma),\ldots,\hat{\alpha}_i(\gamma),\ldots,\hat{\alpha}_n(\gamma)|\gamma), \; i = 1,\ldots,n \; . \tag{3.8}$$

The task of the superior decision unit D_0 is to give a command γ^0 such that

$$\max_{\gamma} \; \Omega(\hat{\alpha}_1(\gamma),\ldots,\hat{\alpha}_n(\gamma)|\gamma) = \Omega(\hat{\alpha}_1(\gamma^0),\ldots,\hat{\alpha}_n(\gamma^0)|\gamma^0) \quad . \tag{3.9}$$

Proposition 3.1. If $\omega_i(a_1,\ldots,a_n;x_1,\ldots,x_n)$ is a concave function of $a_1,\ldots,a_n$ and differentiable with respect to each a_j for any fixed x, then a N.E. decision rule $\hat{\alpha} = (\hat{\alpha}_1,\ldots,\hat{\alpha}_n)$ under the information structure $\eta = (\eta_1,\ldots,\eta_n)$ is given as

as follows. Let

$$\psi_i(a_i,y_i) = E[\omega_i(\hat{\alpha}_1(y_1),\ldots,a_i,\ldots,\hat{\alpha}_n(y_n);y_1,\ldots,y_n)|y_i] ,$$

$$i = 1,\ldots,n \quad . \tag{3.10}$$

Then $\hat{\alpha}$ can be determined as the solution of the following simultaneous equation

$$\left.\frac{\partial\psi_i}{\partial a_i}\right|_{a_i = \hat{\alpha}_i(y_i)} = 0 \quad , \; i = 1,\ldots,n \quad . \tag{3.11}$$

(For the proof, refer to Marschak and Radner [2].)

Here we must assume--the weak point of our formulation--the following.

Assumption 3.1. All the inferior decision units D_i, $i = 1,\ldots,n$, transmit their equations (3.11) to a certain central unit, e.g., D_0, and it is assumed that the central unit can solve the simultaneous equation (3.11) for $\hat{\alpha} = (\hat{\alpha}_1,\ldots,\hat{\alpha}_n)$ and transmit $\hat{\alpha}_i$ to D_i, $i = 1,\ldots,n$.

Example 3.1. There are two inferior decision units D_1 and D_2, and the overall payoff function is given by

$$\omega(a_1,a_2;x_1,x_2) = -a_1^2 - a_2^2 + 2qa_1a_2 - a_1x_1 - a_2x_2 \quad , \tag{3.12}$$

where $-1 < q < 1$.

Let the command $\gamma_0 = (\zeta_0,\eta_0)$ by the superior decision unit D_0 be as follows:

1) ζ_0 assigns the following payoff function ω_i to D_i:

$$\omega_1(a_1,a_2;x_1,x_2) = -a_1^2 + qa_1a_2 - a_1x_1 \quad , \tag{3.13}$$

$$\omega_2(a_1,a_2;x_1,x_2) = -a_2^2 + qa_1a_2 - a_2x_2 \quad . \tag{3.14}$$

Then it is clear that

$$\omega = \omega_1 + \omega_2 \ ;$$

2) γ_0 assigns the null information structure η_0 to each D_i, $i = 1,2$, i.e. each D_i, having φ, must choose a_i without knowing x_1,x_2.

Under the command γ_0, each decision unit D_i, $i = 1,2$ is concerned with

$$\bar{\omega}_1(a_1,a_2) = E[\omega_1(a_1,a_2;x_1,x_2)]$$

$$= -a_1^2 + qa_1a_2 - a_1\mu_1 \ , \tag{3.15}$$

$$\bar{\omega}_2(a_1,a_2) = E[\omega_2(a_1,a_2;x_1,x_2)]$$

$$= -a_2^2 + qa_1a_2 - a_2\mu_2 \ . \tag{3.16}$$

where

$$\mu_i = E\{x_i\} \ , \ i = 1,2 \ .$$

Then

$$\frac{\partial\bar{\omega}_1}{\partial a_1} = -2a_1 + qa_2 - \mu_1 \ , \tag{3.17}$$

$$\frac{\partial\bar{\omega}_2}{\partial a_2} = -2a_2 + qa_1 - \mu_2 \ , \tag{3.18}$$

and the N.E. action $\hat{a} = (\hat{a}_1, \hat{a}_2)$ is the solution of the following simultaneous equation

$$\begin{cases} -2\hat{a}_1 + q\hat{a}_2 = \mu_1 \\ -2\hat{a}_2 + q\hat{a}_1 = \mu_2 \end{cases}, \tag{3.19}$$

and we have

$$\hat{a}_1 = \frac{2\mu_1 + q\mu_2}{q^2 - 4}, \quad \hat{a}_2 = \frac{2\mu_2 + q\mu_1}{q^2 - 4} . \tag{3.20}$$

Remark 3.1. Under the null information η_0, if the superior decision unit D_0 chose the values $\hat{a}_1^*, \hat{a}_2^*$ of a_1, a_2 which maximize the overall expected benefit

$$\begin{aligned} \bar{\omega}(a_1, a_2) &= E[\omega(a_1, a_2; x_1, x_2)] \\ &= -a_1^2 - a_2^2 + 2qa_1a_2 - a_1\mu_1 - a_2\mu_2 , \end{aligned} \tag{3.21}$$

and assigned that value $\hat{a}_1^*, \hat{a}_2^*$ to D_1, D_2 respectively, then $(\hat{a}_1^*, \hat{a}_2^*)$ would be the solution of the following equation:

$$\begin{cases} \dfrac{\partial \bar{\omega}}{\partial a_1} = -2a_1 + 2qa_2 - \mu_1 = 0 & \hat{a}_1^* = \dfrac{\mu_1 + q\mu_2}{2(q^2 - 1)} , \\ \text{i.e.} & \\ \dfrac{\partial \bar{\omega}}{\partial a_2} = -2a_2 + 2qa_1 - \mu_2 = 0 & a^* = \dfrac{q\mu_1 + \mu_2}{2(q^2 - 1)} . \end{cases} \tag{3.22}$$

It should be noted that $(\hat{a}_1^*, \hat{a}_2^*)$ is different from $(\hat{\alpha}_1, \hat{\alpha}_2)$ given by (3.20). Therefore, under the command $\gamma_0 = (\zeta_0, \eta_0)$, although $(\hat{a}_1, \hat{a}_2)$ given by (3.20) is a N.E. solution for D_1, D_2, it will not give the maximum possible value to the

overall expected payoff function $\bar{\omega}$ given by (3.21).

Next, let the command by D_0 to D_1, D_2 be $\gamma_0^* = (\zeta^*, \eta_0)$, where ζ^* assigns the inferior decision unit D_i the following payoff function ω_i^*,

$$\omega_1^* = -a_1^2 + qa_1a_2 - a_1x_1 + \Delta(a_1,a_2;x_1,x_2) \quad , \tag{3.23}$$

$$\omega_2^* = -a_2^2 + qa_1a_2 - a_2x_2 - \Delta(a_1,a_2;x_1,x_2) \quad , \tag{3.24}$$

where

$$\Delta(a_1,a_2;x_1,x_2) = \tfrac{1}{2}(a_1^2 - a_2^2 + a_1x_1 - a_2x_2) \quad . \tag{3.25}$$

Again it is clear that

$$\omega = \omega_1^* + \omega_2^*$$

and

$$\bar{\omega}_1^*(a_1,a_2) = E[\omega_1^*] = -a_1^2 + qa_1a_2 - a_1\mu_1 + \tfrac{1}{2}(a_1^2 - a_2^2 + a_1\mu_1 - a_2\mu_2) \quad , \tag{3.26}$$

$$\bar{\omega}_2^*(a_1,a_2) = E[\omega_2^*] = -a_2^2 + qa_1a_2 - a_2\mu_2 - \tfrac{1}{2}(a_1^2 - a_2^2 + a_1\mu_1 - a_2\mu_2) \quad . \tag{3.27}$$

Therefore, under the command γ_0^*, the N.E. action $\hat{a}^* = (\hat{a}_1^*, \hat{a}_2^*)$ to D_1, D_2 is the solution of the following equation:

$$\begin{cases} \dfrac{\partial \bar{\omega}_1^*}{\partial a_1} = -a_1 + qa_2 - \tfrac{1}{2}\mu_1 = 0 \quad , & (3.28) \\ \dfrac{\partial \bar{\omega}_2^*}{\partial a_2} = -a_2 + qa_1 - \tfrac{1}{2}\mu_2 = 0 \quad . & (3.28') \end{cases}$$

This equation (3.28) is the same as (3.22). Therefore the solution $(\hat{a}_1^*, \hat{a}_2^*)$ of (3.28) is not only N.E. under the command γ_0^*, but it also gives the maximum value of the overall expected payoff $\bar{\omega}$. Therefore, the command γ_0^* could be said to be better than the command γ_0 from the view point of the organization.

Remark 3.2. Further it should be remarked that

$$\frac{\partial \bar{\omega}_1^*}{\partial a_2} = -a_2 + qa_1 - \tfrac{1}{2}\mu_2 = 0 \quad , \tag{3.29}$$

$$\frac{\partial \bar{\omega}_2^*}{\partial a_1} = -a_1 + qa_2 - \tfrac{1}{2}\mu_1 = 0 \quad , \tag{3.30}$$

i.e. (3.29) and (3.30) are the same as (3.28') and (3.28) respectively. This means that under the command γ_0^*, the interaction balance principle holds, and the inferior decision units D_i by themselves can obtain a N.E. action without assuming Assumption 3.1.

Example 3.2. In the problem of Example 3.1, let η_1 and η_2 be the information structure for D_1 and D_2 respectively, where

$$\eta_1(x_1, x_2) = y_1 \varepsilon Y_1 \ , \ \eta_2(x_1, x_2) = y_2 \varepsilon Y_2 \quad . \tag{3.31}$$

We consider the case where D_0 orders the command $\gamma^* = (\zeta^*, \eta)$ to D_1 and D_2, where ζ^* is defined by (3.23), (3.24) and (3.25). Then we have

$$\bar{\omega}_1^*(a_1,a_2;y_1,y_2) = E[\omega_1^*(a_1,a_2;x_1,x_2)|y_1,y_2]$$

$$= -a_1^2 + qa_1a_2 - a_1E\{x_1|y_1,y_2\} \qquad (3.32)$$

$$+ \tfrac{1}{2}(a_1^2 - a_2^2 + a_1E\{x_1|y_1,y_2\} - a_2E\{x_2|y_1,y_2\}) ,$$

$$\bar{\omega}_2^*(a_1,a_2;y_1,y_2) = E[\omega_2^*(a_1,a_2;x_1,x_2)|y_1,y_2]$$

$$= -a_2^2 + qa_1a_2 - a_2E\{x_2|y_1,y_2\} \qquad (3.33)$$

$$- \tfrac{1}{2}(a_1^2 - a_2^2 + a_1E\{x_1|y_1,y_2\} - a_2E\{x_2|y_1,y_2\}) .$$

Now, for a N.E. decision rule $\hat{\alpha} = (\hat{\alpha}_1,\hat{\alpha}_2)$ which depends on η_1 and η_2 let

$$\psi_1(a_1,y_1) = E[\bar{\omega}_1^*(a_1,\hat{\alpha}_2(y_2),y_1,y_2)|y_1]$$

$$= -\tfrac{1}{2}a_1^2 + qa_1E[\hat{\alpha}_2(y_2)|y_1] - \tfrac{1}{2}E[\hat{\alpha}_2^2(y_2)|y_1]$$

$$- \tfrac{1}{2}a_1k_1(y_1) - \tfrac{1}{2}E[\hat{\alpha}_2(y_2)E\{x_2|y_2\}|y_1] , \qquad (3.34)$$

$$\psi_2(a_2,y_2) = E[\bar{\omega}_2^*(\hat{\alpha}_1(y_1),a_2,y_1,y_2)|y_2]$$

$$= -\tfrac{1}{2}E[\hat{\alpha}_1^2(y_1)|y_2] - \tfrac{1}{2}a_2^2 + qa_2E[\hat{\alpha}_1(y_1)|y_2]$$

$$- \tfrac{1}{2}a_2k_2(y_2) - \tfrac{1}{2}E[\hat{\alpha}_1(y_1)E\{x_1|y_1\}|y_2] , \qquad (3.35)$$

where

$$k_1(y_1) = E\{x_1|y_1\} , \quad k_2(y_2) = E\{x_2|y_2\} . \qquad (3.36)$$

Therefore the equation

$$\left.\frac{\partial\psi_1}{\partial a_1}\right|_{a_1 = \hat{\alpha}_1(y_1)} = 0 , \quad \left.\frac{\partial\psi_2}{\partial a_2}\right|_{a_2 = \hat{\alpha}_2(y_2)} = 0 , \qquad (3.37)$$

$$\begin{cases} \hat{\alpha}_1(y_1) + \frac{1}{2}k_1(y_1) = qE[\hat{\alpha}_2(y_2)|y_1] , & (3.38) \\ \hat{\alpha}_2(y_2) + \frac{1}{2}k_2(y_2) = qE[\hat{\alpha}_1(y_1)|y_2] . & (3.38') \end{cases}$$

If we assume Assumption 3.1, D_0 will be able to solve the simultaneous equation (3.38) for $\hat{\alpha}_1$ and $\hat{\alpha}_2$ (see Example 3.3) and to inform the inferior decision units D_1, D_2 of the N.E. solution $(\hat{\alpha}_1, \hat{\alpha}_2)$.

Remark 3.2. Let us consider the centralized case in the following sense: The decision unit D_0 orders the decision unit D_i to use a decision rule α_i based on the information $y_i = \eta_i(x) \varepsilon Y_i$, $i = 1,2$. Then the expected value of the overall payoff function is

$$\Omega(\alpha_1, \alpha_2) = E[E\{\omega(\alpha_1(y_1), \alpha_2(y_2); x_1, x_2)|y_1, y_2\}] ,$$

where ω is given by (3.12). The central decision unit D_0 further wants to order D_i to use the decision rule α_i^*, $i = 1,2$ which maximizes the overall expected payoff, i.e. such that

$$\max_{\alpha_1, \alpha_2} \Omega(\alpha_1, \alpha_2) = \Omega(\alpha_1^*, \alpha_2^*) .$$

It is easily seen that these decision rules α_1^*, α_2^* which are optimal from the view point of the central decision unit D_0 are the same as $\hat{\alpha}_1, \hat{\alpha}_2$ which we obtained in Example 3.2 as the satisfactory decision rules of the inferior decision units D_1 and D_2 under a command $\gamma^* = (\zeta^*, \eta)$.

Remark 3.3. If we can make $y_1 = \eta_1(x)$ and $y_2 = \eta_2(x)$ statistically independent, then the equations (3.38) and (3.38') become as follows:

$$\begin{cases} \hat{\alpha}_1(y_1) + \frac{1}{2}k_1(y_1) = qE[\hat{\alpha}_2(y_2)] \ , & (3.39) \\ \hat{\alpha}_2(y_2) + \frac{1}{2}k_2(y_2) = qE[\hat{\alpha}_1(y_1)] \ . & (3.39') \end{cases}$$

From (3.39'), we have

$$E[\hat{\alpha}_2(y_2)] = -\tfrac{1}{2}K_2 + qE[\hat{\alpha}_1(y_1)] \ , \qquad (3.40)$$

where

$$K_2 = E\{k_2(y_2)\} \ . \qquad (3.41)$$

Substituting (3.40) into (3.39), we have

$$\hat{\alpha}_1(y_1) - q^2E[\hat{\alpha}_1(y_1)] + \tfrac{1}{2}k_1(y_1) + \tfrac{1}{2}qK_2 = 0 \ . \qquad (3.42)$$

Therefore, in this case, the inferior decision unit D_1 will be able to find his satisfying decision rule $\hat{\alpha}_1$ by himself. The situation is the same for D_2: we have no need to assume Assumption 3.1.

Example 3.3. As an illustration, let me borrow an example from Marschak [2] . The overall payoff function $\omega(a_1,a_2;x_1,x_2)$ is given by (3.12) and the joint distribution of x_1,x_2 is given by Table 3.1, where r is the correlation coefficient of x_1 and x_2. Then we have

$$P_r(x_k = s_k | x_i = s_i) = P_r(x_k = -s_k | x_i = -s_i) = (1 + r)/2 ,$$
$$P_r(x_k = -s_k | x_i = s_i) = P_r(x_k = s_k | x_i = -s_i) = (1 - r)/2 \tag{3.43}$$

$$E\{x_k | x_i\} = \begin{cases} rs_k , & \text{if } x_i = s_i , \\ -rs_k , & \text{if } x_i = -s_i , \end{cases} \tag{3.44}$$

Table 3.1

		x_2	
		$x_{21} = s_2$	$x_{22} = -s_2$
x_1	$x_{11} = s_1$	$(1 + r)/4$	$(1 - r)/4$
	$x_{12} = -s_1$	$(1 - r)/4$	$(1 + r)/4$

Now we assume that the superior decision unit D_0 orders the following command γ_1^*. As the objective function for the inferior decision unit D_i, it assigns the function ω_1^* defined by (3.23) and (3.24) respectively. As the information structure η_i for D_i, it assigns the function η_i^* such that

$$\eta_i^*(x_1, x_2) = x_i \quad , \; i = 1,2 \quad . \tag{3.45}$$

Under this command $\gamma_1^* = (\zeta^*, \eta^*)$, we shall find the N.E. decision rules $\hat{\alpha}_1$ and $\hat{\alpha}_2$ for D_1 and D_2 respectively. In this case we have

$$\psi_1(a_1,x_1) = E[\omega_1^*(a_1,\hat{\alpha}_2(x_2),x_1,x_2)|x_1]$$
$$= -\tfrac{1}{2}a_1^2 + qa_1E[\hat{\alpha}_2(x_2)|x_1] - \tfrac{1}{2}E[\hat{\alpha}_2^2(x_2)|x_1]$$
$$- \tfrac{1}{2}a_1x_1 - \tfrac{1}{2}E[x_2\hat{\alpha}_2(x_2)|x_1] , \qquad (3.46)$$

$$\psi_2(a_2,x_2) = E[\omega_2^*(\hat{\alpha}_1(x_1),a_2,x_1,x_2)|x_2]$$
$$= -\tfrac{1}{2}a_2^2 + qa_2E[\hat{\alpha}_1(x_1)|x_2] - \tfrac{1}{2}E[\hat{\alpha}_1^2(x_1)|x_2]$$
$$- \tfrac{1}{2}a_2x_2 - \tfrac{1}{2}E[x_1\hat{\alpha}_1(x_1)|x_2] . \qquad (3.47)$$

Therefore, from the equation

$$\frac{\partial\psi_1}{\partial a_1} = 0 \quad , \quad \frac{\partial\psi_2}{\partial a_2} = 0 \quad ,$$

we have

$$\begin{cases} \hat{\alpha}_1(x_1) + \tfrac{1}{2}x_1 = qE[\hat{\alpha}_2(x_2)|x_1] & (3.48) \\ \hat{\alpha}_2(x_2) + \tfrac{1}{2}x_2 = qE[\hat{\alpha}_1(x_1)|x_2] . & (3.48') \end{cases}$$

Now let

$$\hat{\alpha}_1(x_{11}) = \hat{\alpha}_1(s_1) = \hat{a}_{11} \ , \ \hat{\alpha}_1(x_{12}) = \hat{\alpha}_1(-s_1) = \hat{a}_{12} \ ,$$
$$\hat{\alpha}_2(x_{21}) = \hat{\alpha}_2(s_2) = \hat{a}_{21} \ , \ \hat{\alpha}_2(x_{22}) = \hat{\alpha}_2(-s_2) = \hat{a}_{22} \ . \qquad (3.49)$$

Then applying (3.43), we have

$$E[\hat{\alpha}_2(x_2)|x_1 = s_1] = \frac{1+r}{2}\hat{\alpha}_{21} + \frac{1-r}{2}\hat{\alpha}_{22} . \qquad (3.50)$$

Therefore, by (3.50), the equation (3.48) for $x_1 = s_1$ becomes as follows:

$$-2\hat{a}_{11} + q(1 + r)\hat{a}_{21} + q(1 - r)\hat{a}_{22} = s_1 \quad . \tag{3.51}$$

By taking $x_1 = -s_1$ in (3.48), and $x_2 = s_2$ and $-s_2$ in (3.48'), similarly we have

$$-2\hat{a}_{12} + q(1 - r)\hat{a}_{21} + q(1 + r)\hat{a}_{22} = -s_1 \tag{3.51'}$$

$$q(1 + r)\hat{a}_{11} + q(1 - r)\hat{a}_{12} - 2\hat{a}_{21} = s_2 \tag{3.52}$$

$$q(1 - r)\hat{a}_{11} + q(1 + r)\hat{a}_{12} - 2\hat{a}_{22} = s_2 \quad . \tag{3.52'}$$

Therefore, solving the equations (3.51) and (3.52), we have

$$\hat{\alpha}_1(x_{11}) = \frac{s_1 + qrs_2}{-2(1 - q^2r^2)} = -\hat{\alpha}_1(x_{12}) \quad , \tag{3.53}$$

$$\hat{\alpha}_2(x_{21}) = \frac{s_2 + qrs_1}{-2(1 - q^2r^2)} = -\hat{\alpha}_2(x_{22}) \quad . \tag{3.54}$$

These $\hat{\alpha}_1$ and $\hat{\alpha}_2$ are N.E. decision rules for D_1 and D_2 under the command γ_1^* by D_0. We should note that these are the same as Marschak's result [2, page 147]. Therefore, we further know that these N.E. decision rules $\hat{\alpha}_1, \hat{\alpha}_2$ maximize the overall expected payoff under the information structure $\eta^* = (\eta_1^*, \eta_2^*)$.

Final Remark to IV.3

I must confess that the results of IV.3 are the special cases of this remark.

In a two level hierarchical organization consisting of the superior decision unit D_0 and the inferior decision units D_i, $i = 1,\ldots,n$, 1) if the overall objective function

$\omega(a_1,\ldots,a_n;x)$ is given beforehand, 2) if the information structure η_i is to be assigned to D_i is already given, $i = 1,\ldots,n$, and 3) if any objective function $\omega_i(a_1,\ldots,a_n;x)$ can be assigned to D_i, $i = 1,\ldots,n$ by D_0, then the optimal command $\gamma^* = (\zeta^*,\eta)$, where $\eta = (\eta_1,\ldots,\eta_n)$ by D_0, is given by taking ζ^* as follows: the command ζ^* assigns the function $\alpha_i\omega$ as the objective function ω_i^* of D_i, i.e. $\omega_i^* = \alpha_i\omega$, $i = 1,\ldots,n$, where $\alpha_i \geq 0$, $\sum \alpha_i = 1$.

Under the command $\gamma^* = (\zeta^*,\eta)$, the N.E. decision function $\hat{\alpha} = (\hat{\alpha}_1,\ldots,\hat{\alpha}_n)$ is given as the p. b. p. s. decision function of the team decision problem D where we assume the team to consist of the members $D_1,\ldots,D_n$ and assume its objective function to be ω.

The reason is as follows: It is clear that

$$\omega = \sum_i \omega_i^* \quad . \tag{1}$$

Now let

$$\begin{aligned}\bar{\omega}_i^*(a_1,\ldots,a_n;y_1,\ldots,y_n) &= E\{\omega_i^*(a_1,\ldots,a_n;x)|y_1,\ldots,y_n\} \\ &= \alpha_i\bar{\omega}(a_1,\ldots,a_n;y_1,\ldots,y_n) \quad , \end{aligned} \tag{2}$$

where

$$\bar{\omega}(a_1,\ldots,a_n;y_1,\ldots,y_n) = E\{\omega(a_1,\ldots,a_n;x)|y_1,\ldots,y_n \quad . \tag{3}$$

For the N.E. decision rule $\hat{\alpha} = (\hat{\alpha}_1,\ldots,\hat{\alpha}_n)$, let

$$\psi_i(a_i,y_i) = E\{\bar{\omega}_i^*(\hat{\alpha}_1(y_1),\ldots,a_i,\ldots,\hat{\alpha}_n(y_n);y_1,\ldots,y_n|y_i\} \quad . \tag{4}$$

Then from (2)-(4), it is clear that

$$\psi_i(a_i,y_i) = \alpha_i \Psi_i(a_i,y_i) \quad , \; i = 1,\ldots,n \tag{5}$$

where

$$\Psi_i(a_i,y_i) = E\{\bar{\omega}(\hat{\alpha}_1(y_1),\ldots,a_i,\ldots,\hat{\alpha}_n(y_n);y_1,\ldots,y_n|y_i\} \quad , \quad i = 1,\ldots,n \quad . \tag{6}$$

Therefore by (5), the simultaneous equation

$$\left.\frac{\partial \psi_i}{\partial a_i}\right|_{a_i = \hat{\alpha}_i(y_i)} = 0 \quad , \; i = 1,..,n \tag{7}$$

which determines the N.E. decision rule $\hat{\alpha}$ of the organization under the command γ^* is equivalent to the simultaneous equation

$$\left.\frac{\partial \Psi_i}{\partial a_i}\right|_{a_i = \hat{\alpha}_i(y_i)} = 0 \quad , \; i = 1,\ldots,n \tag{8}$$

which determines the p. b. p. s. decision rule of the team decision problem D. This proves our remark.

References

[1] Hurwicz, L. "Optimality and Informational Efficiency in Resource Allocation Processes." In Arrow, Karlin and Suppes (eds.), "Mathematical Methods in the Social Sciences"(1960).

[2] Marschak, J. and R. Radner. "Economic Theory of Teams," Cowles Foundation Monograph, 22 (1972).

[3] Marschak, T. "Computation in Organizations: The Comparison of Price Mechanisms and Other Adjustment Processes." In McGuire and Radner (eds.), "Decision and Organization" (1972).

[4] Mesarovic, M.D., Macko and Takahara. Theory of Hierarchical Multilevel Systems. Academic Press, 1970.

Document U

IIASA Symposium on

Design and Management of Large Organizations

K. Miyasawa

I completely agree with the opinion that both empirical and methodological research concerning organizations must be done.

But in the conference it seems to me that too much emphasis was put on the empirical research compared to the systematic presentation of the importance of methodological research. In designing an organization or in analyzing its activities, it seems to me that a new methodology must be developed.

I would like to propose that IIASA establish a powerful core of broad-minded methodologists as one of the research groups.

Document V

Proposition for Study Projects of

"Design and Management of Large Organizations"

Akira Nomoto

1. At the conference, extensive discussions were carried out with regard to the research project rather than to methodology. Recognizing that most of the practical projects are already involved with or closely connected to projects to be proposed by other groups, it seems worthwhile to pay additional attention to methodology. To avoid indulging in mathematical abstraction, it is highly desirable to achieve the mathematical substantiation which will supply practical information to other empirical research groups. Several methodological subjects are set forth in the statement of Professor Milner. Some would be developed taking into account their applicability in a number of Institute research projects.

2. In view of the Institute's advantageous position for assessing various types of national structures, comparative studies would be quite acceptable. Methodology developed would make such studies easier to perform.

3. For comparative studies, various cross-cultural comparisons will be possible and meaningful. One example would be the comparison of industrial systems, to be carried out, of course, in cooperation with "integrated industry" groups. At the conference, comparison of different social systems of market and planned economies was mentioned. It would also be meaningful to compare the infrastructure of industrial systems of areas in different stages of development. Scholars from a developed area could study general methodology in order to predict the future course of a developing area, and hopefully to offer an optimum development policy.

Document W

Thoughts and Proposals for the Project "Design and Management of Large Organizations"

A. Straszak

1. "Management of Large Organizations" is an extremely interesting and important subject of research from a scientific as well as a practical point of view.

2. Real large organizations exist in socialist as well as in non-socialist countries. However, up to now, the scientific and arts type management machinery which exists is not sufficient for such organizations. Moreover, computers play an increasingly important role as an aid to management in such systems.

3. Management of large organizations must be the subject of multi-disciplinary research (social sciences, applied mathematics, cybernetics, computer science, communication sciences).

4. It is a great opportunity for IIASA to start with multi-national research on large organizations. However, the organization of this IIASA research project must be very carefully chosen. Organization of research which is good, for example, for the "water resources" project may not be good for the "large organizations" project.

5. All IIASA projects must include the study of management problems. Additionally, however, there must be extensive studies of large organizations of several types (non-industrial as well as industrial) which are not subjects of other IIASA projects. In particular, comparative studies of industrial and large service organizations will be very useful.

6. It will be interesting if multi-national teams of scientists and experts can build the following matrix:

	Typical large organizations in industrialized countries
New problems which arise in large organizations	
Methods of large organizations study (applied mathematics, cybernetics, computers, sociology, economy, law, etc.	

and choose areas for multi-national research.

7. It seems to be useful to establish the multi-national steering advisory committee for the organization project.

Document X

The Communication and Production of Information

Robert L. Winkler

An area that should be of considerable interest and importance with regard to the study of large organizations is the communication and production of information. A great deal of time and effort is expended in communicating and producing information, so that any improvements in the efficiency of this process would be quite valuable. Such improvements from increased efficiency would come not only in the form of cost reductions directly related to the information communication and production, but also in the form of improvements in the decision making processes of the organization, particularly in terms of the coordination of decisions. Technology may provide increased efficiency, but the mode of communication should be equally important, if not more important, as will be indicated below. Moreover, although the study of the communication and production of information does not require the use of formal models of the organization, it is suggested at the end of this note that such models could prove highly useful in the study of the decision-making processes of organizations in general and the role of information in these processes in particular.

One way to improve the efficiency of information communication and production is through technological advances. For instance, technological advances enable more rapid transmission of information, more efficient storage of large blocks of information, more efficient search procedures, and so on. The area of information systems is concerned with such matters, and this area should make useful contributions to the area of large organizations. Further research along these lines is certainly warranted.

Although "information systems," as discussed above, have received a greatly increasing amount of attention in recent years, other means of improving the efficiency of information communication and production exist but have been ignored to a large extent. For example, studies concentrating on the mode of communication rather than the transmission of information should be very useful. Here "mode of communication" refers to the way the communication is phrased. Most communications are phrased in qualitative terms, with free use of (often lengthy) prose. Unfortunately, our language is such that ambiguities are difficult to avoid entirely, and frequently aspects of messages expressed in qualitative terms can be interpreted in more than one way. Moreover, everyday language is somewhat inefficient in the sense that lengthy communications are generally necessary to convey all of the aspects of

a situation. This is particularly true when the situation involves uncertainties (about the future, about the plans of another organization, etc.). Yet most situations of interest from a decision-making standpoint do involve such uncertainties, and it may be possible to attain considerable improvements in the process of information communication and production in such cases.

Probability is the formal language of uncertainty, so it would seem that the use of probability would provide an efficient means of communicating uncertainties. For example, suppose that a security analyst is asked to communicate his knowledge concerning the (uncertain) return on a particular investment. The analyst can think of many factors that could affect the return, and to carefully describe all of these factors and their effects on the return would require a very lengthy communication. In general, what is desired is simply the analyst's opinions concerning the relative likelihood of various returns, so the most efficient means of communication is that of a probability distribution, assessed by the analyst, for the return on the investment. In some instances, a few simple summary measures of the distribution may be adequate. If some explanation is desired, the distribution may be accompanied by a brief listing of the factors taken into consideration by the analyst.

The use of probability to communicate information should result in much shorter communications. And despite the increase in efficiency in this sense, the communications should, in fact, contain more information (or at least information of a less vague nature) than communications in everyday language. In other words, probability distributions provide an efficient representation of an individual's knowledge. Incidentally, any objections to such procedures on the grounds that the probabilities are "subjective" rather than "objective" have no rational basis. Subjective information is being used in any event, and the question here merely concerns how best to communicate such information.

Of course, it must be recognized that most individuals are not accustomed to working with probabilities, so some training would be necessary. Any research into the use of probabilities in the sense suggested here should involve not only the potential increases in efficiency of information communication, but also the training that would be required to make the procedures operational.

The above suggestions for improved communication of information have implications for the production of information as well. First of all, increased efficiencies in communication may mean that it is not necessary to spend as much time and energy on the production of information. (The term "production" is being used quite generally here, including the purchasing of information.)

An improved information flow should lead to less duplication in information production. Expression of information about uncertainties in probalistic terms makes it easier to determine the "value" of additional information to the organization and to determine what sort of additional information should be obtained. Thus, improvements in the communication of information should lead to greater efficiency in the production of information.

The study of information communication and production within organizations does not require the use of formal models of organizations. However, models of the decision-making processes of large organizations should help to determine areas needing increased communication of information and to determine how information production efforts can best be expended. Models within the framework of statistical decision theory allow the formal determination of the "value" of additional information in the decision-making process. Moreover, such models possess the desirable feature of being adaptive with respect to new information, so they allow the investigation of the dynamics of a situation. In general, there should be implications for the design of large organizations as well as for information communication and production.

In summary, the communication and production of information is an area of considerable potential importance with regard to the study of large organizations. In addition to the research conducted in the field of "information systems," some other approaches seem worthwhile. This note suggests the study of the mode of communication, with particular emphasis on the use of probabilities to communicate uncertainties. Also, the development of models of the decision-making processes of large organizations is recommended. For general discussions of the use of probabilities to communicate uncertainty and the notion of modeling within the framework of statistical decision theory and for references to more specialized works see Decision Analysis, by Howard Raiffa (Reading, Mass.: Addison-Wesley, 1968), or An Introduction to Bayesian Inference and Decision, by Robert L. Winkler (New York: Holt, Rinehart and Winston, 1972).