U T O P I A Project

PRELIMINARY RESEARCH STRATEGY OUTLINE FOR THE SIMULATION OF THE NORMS STRATUM, NORMATIVE CHANGE, AND DECISION-MAKING

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Research financed by Stiftung Volkswagenwerk and conducted
in association with the Mesarovic-Pestel Multilevel World Model Project.

Working Paper - Not to be quoted

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1. Questions to the Voyager: Purpose of this Report

On their journey to Terra Incognita, the members of an expedition face many questions by onlookers and critics, by sponsors, by natives encountered along the way, by fellow participants, and especially by those who are interested in the venture and would like to contribute themselves. In facing up to these questions, the voyagers themselves acquire a clearer picture of their purpose and their goals.

We have prepared this report in order to acquaint the reader from any of the categories listed - with Project UTOPIA (see below) presently being undertaken at Institut für Systemtechnik und Innovationsforschung (ISI) in Karlsruhe in cooperation with an international group of scientists from different disciplines. This is therefore not a scientific report. Background material on some of the topics discussed below is available or will eventually be available (consult the current List of Reports and Publications appended to this report).

In order to attract the cooperation of qualified scientists, ISI lets subcontracts of variable duration covering specific areas to researchers in a variety of disciplines. The spectrum of these subcontracts ranges from literature surveys through the development of compute r programs to basic research. Interested persons are invited to contact the Principal Investigator (H. Bossel).

2. Milestones Along the Way: Research Stages

Any research project proceeds by stages; each stage requires attention to a number of different aspects. We shall discuss these aspects in succession. The stages are:

- formulation
- preparation
- research process
- distillation

2.1 Formulation

Nomen est Omen: Project Name

The official title of the project (" Simulation of the Normative Stratum and of Normative Change Exemplified by the Relationships between Industrial and Developing Nations ") does not adequately capture the intent of our research. We have therefore settled on " Project UTOPIA " (Undertaking to Operationalize Policy-Directive Indicators of Action). No further explanations, no apologies, no questions, please.

Paying for the Journey: Sponsor

The research is financed by Stiftung Volkswagenwerk, Hannover, F. R. Germany

Many a Moon: Duration of the Project

The project began on January 5, 1974 and will end on December 31, 1976.

Where Are We Going: Research Goal

Societal processes are controlled by human actions, resulting in particular from conscious decision-making; actions are determined by the normative set of a given actor; these normative sets change dynamically in response to a changing environment. Thus normative change causes societal change; societal change causes normative change. Any attempt to understand societal development must include these components. Any attempt to simulate societal development must include a quantified description of them. Here lies the rub: there is little help to be found in the literature.

Our goal is to contribute in the following areas:

(1) Collection and description of complete normative sets for a given decision-maker (individual or collective) in a given decision situation.+

(2) Description of change processes of normative sets in a manner which allows simulation by computer programs.

(3) Making decision processes more transparent by clarifying decision premises, using results under (1) and (2).

(4) Simulation of complete decision and action processes (including normative change) over long time periods, in order to improve long-range planning capability.

(5) Development of planning tools and decision-making aids using model banks and interactive (man-machine) simulation.

+ The terms " decision-making " and " decision-maker " are applied here also to subconscious action-choice using internalized state pattern classifiers and corresponding response programs.

Why Go: Reasons for the Research

Major reasons for undertaking this research:

(1) Simulation offers the possibility of significant increases in the efficiency and accuracy of planning and decision processes.

(2) There exists a dearth of research results directly applicable to simulation of societal processes, especially those dealing with normative systems and their change.

(3) Understanding of normative systems and their change processes is required for design of (a) interactive simulations (man-machine dialogue) and (b) all-machine (automatic) simulations of decision and action processes.

(4) Simulation methods for normative processes and their interaction with decision and action processes have yet to be developed; they are the still missing links in advanced simulation models.

The Part and the Whole: Project Context

A societal system can be seen as being composed of three layers or strata (Mesarovic): a causal stratum (incorporating mainly the ' mechanistic ' normal functioning of the system), a decision stratum (where decisions are made to change parameters or structure of the causal stratum by applying control variables), and a normative stratum (incorporating the normative constraints applied in arriving at decisions, and their change processes). Our research is concerned with the decision and normative strata. In order to test and to apply whatever approaches will be developed, orientation to a practical problem and the coupling to a relevant causal stratum are necessities.

The present project is therefore embedded in the on-going Multilevel Regionalized World Model Project (M. Mesarovic and E. Pestel, directors[+]) being undertaken mainly at the Systems Research Center of Case Western Reserve University, Cleveland, Ohio, and Technische Univers ität, Hannover. ISI has contributed modelling work

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[+] M. Mesarovic and E. Pestel have suggested and actively encouraged the present project.

in the energy area to this project. In order to use this special expertise of our group, our research will be initially oriented towards application in the energy sector of the Mesarovic-Pestel World Model. This gives us full access to a very substantial data base, to a highly developed - and continuously improved - collection of models for all world regions, and to substantial know-how in the area of systems science and simulation.

Apart from the cooperation with the Mesarovic-Pestel groups in order to increase research efficiency by division of labor and sharing of know-how the present project is also embedded in the long-range research objectives of ISI. The institute has as a major goal the development of computer-aided methods for the support of planning and decision-making tasks in government and industry. An understanding of normative components of decision-making processes and of their change is a major precondition to any work in this area.

Getting Down to Brass Tacks: Specific Applications

Results and methods developed in the initial phase of the project are applied to problems of energy policy involving initially one and later two or more of the world regions within the framework of the Mesarovic-Pestel world model project.

The work on implementation proceeds in several distinct stages (see also Time and Work Schedule):

(1) Addition of interactive components to an existing model of the energy supply system in order to extract decision criteria, their weights, and subjective evaluation scales from decision-makers interacting with the simulation model.

(2) Use of this information in an optimization program which suggests particularly promising scenarios to the decision-maker for further investigation. Application to Western Europe.

(3) Development of a formalized model of the normative stratum, and of normative change, and of decision-making processes, and application to a comprehensive model of the Western Europe energy system developed by the MP-groups and ISI. Simulation of energy policy developments under given external constraints (scenarios), and investigation of different possible scenarios of transition from a fossil-fuel based energy system to one having a more permanent energy base.

(4) Coupling of energy - exporting to energy - importing regions (Western Europe and the Middle East) using fully simulated normative and decision strata. Study of different scenarios and identification of strategies leading to mutually beneficial long-range cooperation during and after the transition period to a more permanent energy base.

2.2 Preparation

Charting and Changing a Course: Research Strategy

Crossing an unknown mountain range in order to reach a distant goal requires an initial plan and a willingness to change that plan if warranted in the light of new information obtained along the way. In this report we describe our initial research plan. It is extremely unlikely that it will not be changed substantially in the course of the project research - the adoption and pursuit of a rigid research schedule would be tantamount to claiming advance knowledge of the outcome, and to a refusal to learn along the way.

The elements of our research strategy are

(1) A strong committment to the research goals stated above.

(2) A flexible approach with regard to the means used to achieve the research goals. The utility of staying on a given course will be judged against the utility of change-over costs and a different approach.

(3) A small nucleus of full-time project staff (system analyst, social scientist, computer specialist) reinforced by temporary assignments of ISI scientists and staff, and by work contracts to outside specialists as required.

(4) A multi-disciplinary approach throughout, with major contributions from systems science and mathematics, psychology, social psychology and empirical sociology, management science, political science, theoretical sociology , and philosophy. These contributions will either come from the existing literature, or will be original research done at ISI or in the context of work contracts.

(5) Use of the computer wherever appropriate. Aside from all aspects of simulation, the computer will be used in the extensive documentation stage and in the subsequent retrieval for evaluation of stored bibliographic material. Programming will be done exclusively in FORTRAN for reasons of compatibility, while documentation will use the GOLEM documentation and retrieval system.

(6) An attempt to base the research as much as possible on the concepts and approaches developed in the individual disciplines concerned, both through use of the relevant literature and through cooperation with specialists in individual fields.

(7) Full verification and validation of all elements and concepts used.

Time is Money, but Haste Makes Waste: Time and Work Schedule

The present research program is outlined in the time-graph of Fig. 1. The height of each horizontal profile represents approximately the expected intensity of each individual subprogram at a given point in time. Some subprograms are conditional on the completion of other subprograms; arrows show the connections and the approximate point in time where a significant contribution is expected. Where no connections are shown (e. g. literature search), a continuous contribution is expected.

The major subprograms and approximate dates of major contributions:

(1) Literature search (summer 1975)
(2) Data collection (summer 1974; winter 1975/6)
(3) Energy/Economy integrated causal model (summer 1974)
(4) Interactive approach and ergonomics (winter 1974/5)

(5) Normative model (fall 1974)
(6) Interactive energy model (fall 1974)
(7) Fully simulated energy/economy integrated model (summer 1975)
(8) Historical validation of normative model (summer 1975)
(9) Coupling of fully simulated models (spring 1976)
(10) Inclusion of actual decision-makers (spring 1976)
(11) Programmed text for system users (fall 1976)
(12) Final reports (fall 1976)
(13) Book (spring 1977)

An Image of the Unknown: Hypothesis

On the basis of a preliminary literature survey (see appended Bibliography) covering the fields of systems science, psychology, social psychology and empirical sociology, management science, political science, theoretical sociology and philosophy, and previous research in this area (see List of Project Reports and Publications) a preliminary hypothesis has been chosen to guide further research.

Hypothesis: Normative systems, normative change processes, and all aspects of conscious or subconscious behavior - specifically decision-making - of individuals or collectives are aspects of information processing and describable by such systems.

This hypothesis will be modified or rejected as required on the basis of valid evidence.

Specifically, the information processing systems of individuals or collectives have the following components:

- sensory systems
- filters
- short-term memory
- long-term memory
- emotions
- processor

Details of this approach, which forms the backbone of present model formulation attempts, are presented in a back-up report (see List of Project Reports and Publications). An outline of the function of

the different components is given here in Sec. 3 (see also Fig. 2).

2.3 Research Process

The Starting Point: Research Background

Practically all aspects of the present research project have been the object of serious research for some time in several scientific disciplines. Even a cursory and preliminary examination of the literature (see appended Bibliography) reveals substantial contributions especially of systems science, of psychology, of social psychology and empirical sociology, of management science, of theoretical sociology, and of philosophy. It is not to be expected that entirely new aspects will be introduced by the present work. Instead, we have the more modest aim of tying a few loose strings together and operationalizing concepts which presently exist mostly in verbal form.

Table 1 lists aspects of the proposed simulation model together with the disciplines and their individual contributions as they appear to be relevant to the project.

Preparing for Take-Off: Literature Survey

The large amount of relevant literature spread over many disciplines requires evaluation by different individuals well-versed in particular disciplines, and an effective evaluation system permitting quick retrieval of information on the basis of specific descriptors.

It is hoped that the majority of literature surveys and evaluations can be subcontracted to qualified individuals outside of ISI. Relevant findings in the literature surveyed are coded by descriptors, author, and location in order to permit storage and later retrieval by the GOLEM documentation system in response to any given retrieval question (descriptor combination).

Fitting Out the Expedition: Research Tools

The major tool of the research project is the computer, with the specific applications: simulation and documentation. Simulations are programmed in FORTRAN IV to ensure compatibility with practically all computer systems. The documentation uses the GOLEM information storage and retrieval system. In-house computer capacity includes a Siemens 4004/151 processing system with timesharing terminals and an IBM 1800 process computer. Part of the associated program development is being handled at computer centers of the Technische Universität, Hannover, of the Medizinische Hochschule, Hannover, of the Psychological Laboratory of the University of Nijmegen, of the Informatics Institute of the University of Grenoble, and at the Systems Research Center of Case Western Reserve University at Cleveland, Ohio.

Methodological tools developed mainly in the social sciences are used to obtain normative sets and other subjective information. These tools include content analysis, interviews, role-playing, delphi techniques, scaling techniques, factor and cluster analysis, and extraction of information in man-computer dialogues.

The project language is English in order to facilitate easy communication and exchange of ideas among the various participating researchers of different nationality.

Who Goes: Project Staff

The project requires the participation of scientists from different disciplines. It has only a small permanent staff of scientists representing the major disciplines involved (systems science, social sciences, computer science, see appended List of Participating Scientists).

Asking the Natives: Outside Assistance

As the research required for the project cuts across many different disciplines, use of the services of specialists becomes necessary. However, such tasks are usually of limited scope and duration and do not warrant the hiring of full-time staff. These tasks

are therefore contracted out to specialists from different disciplines. A current list of scientists who have contributed or are presently contributing to the project is appended. At a later stage of the project the cooperation also of actual decision-makers becomes vital. Judging by initial contacts, little difficulty is expected in this area.

Where Are the Others: Keeping Up with the State of the Art

The initial literature survey must be continuously updated and supplemented by information gleaned from other sources. This task is accomplished by both the project staff and associated consultants in several ways:

(1) by keeping up with the relevant journal publications;
(2) by scanning ' Current Contents ' for relevant material;
(3) by maintaining personal contacts with individual researchers and groups working in related fields;
(4) by exchanging informal working papers with such individuals and groups;
(5) by presenting concepts for discussion in small specialized working conferences.

Making a Little Go a Long Way: Efficient Use of Resources

The major portion of the project budget is represented by personnel expenses; a small part is scheduled for travel, small working conferences, literature and supplies. Computing expenses are not allowed; the project is therefore dependent on free computer access at sympathethic computer centers.

In order to allow greater flexibility and efficiency, the regular staff is held to two full-time positions. The equivalent of an additional 8 scientific man-months per year is contracted out in smaller or larger chunks, depending on scope and duration of the specific task.

Reporting Our Position: Progress Reports

As required by the sponsor, formal progress reports are issued once a year. Progress reports (in German) only summarize work documented in working reports, computer programs, and publications. The latter documents are issued promptly after conclusion of individual research stages. A current List of Project Reports and Publications is appended. Qualified individuals and institutions may receive copies of these reports with the understanding that the use of this (mostly preliminary) material must be cleared with the respective author(s). Publication of results in the scientific literature will be undertaken only after full and satisfactory completion of individual research stages.

Finding Out Whether the Goal Has Been Reached: Verification and Validation

Verification and validation of models and of their results constitute an essential part of the project. The greatest possible validity will be insured by:

(1) incorporating only - as far as possible - undisputed concepts taken from the individual disciplines;
(2) attempting to falsify new or disputed concepts by subjecting them to tests covering the possible domain of application;

(3) running validation checks of models or model components using well-documented historical time series as input data.

2.4 Distillation

Telling the Story: Final Report

The final report, issued after completion of the project, will draw together the results previously reported in individual working reports. If the amount and quality of the completed research warrant it, the results will be published in book form.

Sharing Treasures Found: Products of the Research

The possible contributions of the project will be in the following areas:

- comprehensive literature surveys
- formalized models
- general results of scientific interest
- computer programs for specific applications
- methods for man-machine and all-machine simulation of societal processes

Contributions in the first three areas will be published in the scientific literature. The existence of specialized computer programs (fourth item) will be brought to the attention of potential users. Finally, if generally applicable computerized aids for long-range planning and decision-making should result from the project, the corresponding software will be made available, complemented by a comprehensive user's manual.

3. Outline of the Information Processing Approach

The information processing systems of individuals or collectives have the following components (see Fig. 2): +

- sensory system
- filters
- short-term memory
- long-term memory
- emotions
- processor

Features of these components will now be discussed in a little more detail. The discussion is preliminary and should not be taken too seriously. Full discussion and formulation of the concepts involved is the subject of the project research (consult the current List of Project Reports and Publications for available contributions).

Sensory system: Each sensor (e.g. human senses, measuring instruments) is able to sense information about the state of one or a limited number of the state variables of the system and its environment. The limitations of the sensory systems are a first restriction on the set of state variables that can potentially be monitored by the system. The potentially sensible set constitutes the maximum dimension of the perceived reality space of the system. In the present research we will not be expressly concerned with sensory systems; all state variables of models of the system and of its environment are potentially available as monitor variables. Their selection as monitor variables for the system depends on filter settings.

Filters: The term " filter " is here used in a broader sense to describe black boxes introducing all possible kinds of information distortion such as: information suppression, bias, stochastic elements , exaggeration, addition of false information about nonexistant state variables (fabrication), and time lags. The filters may be internal or external to the system. In the case of individuals, internal filter settings are controlled by the state variables making up the momentary psychological set of the individual; similar concepts apply to collectives. External filters are not directly controlled by variables of the system itself; their control is effected rather by external agents (examples: government propaganda; fog drifting over a landscape). Finally, the location of a system at a given point in time and space can be viewed as amounting to a specific filter set: obviously it is mostly information about the present and about the immediate system surroundings which will be received.

+ The approach essentially follows the concepts of Simon, Maslow, and others.

Short-term memory: The short-term memory plays an all-important role in the information-processing capability of individuals. As collective decision-making is composed of (but certainly more than the sum of) individual decision-making, the short-term memory can be expected to have a part in the corresponding information processing, although perhaps less so.

A major feature of the short-term memory of individuals is its limited capacity (the famous 7 ± 2 chunks), which is generally slightly extended by storing lists of lists in the long-term memory and retrieving by list name. With these tricks the short-term memory contains, resp. has quick access to, the current psychological set, the definition of the situation (incl. decision premises), and the current state of reasoning in the processor. By association using list processing, information contained in the long-term memory can be recalled into the short-term memory and used in on-going information processing.

Long-term memory: By supplying structured or unstructured information to the processor, the long-term memory directly influences the quality of the behavior and response of the system. The major aspects, functions, and contents of the long-term memory:

(1) Random - access storage of unstructured and encyclopaedic information. List names (" patriarchs ") are used as access points; list items usually represent the patriarchs of other lists. Tracing through such associative chains, apparently unrelated items can be recalled quickly. While an important factor in the heuristics of decision-making processes of individuals, no particular benefit of simulation of random-access storage in collective decision-making is seen at present. It will be assumed that all information of relevance to, previously recorded, and not forgotten by a given societal system, will be recalled when necessary (i.e. in a collective composed of many members, the chances are very high that someone will recall ist).

(2) Historical record of the system itself and of its perceived environment. As long as this record does not express itself in acquired response programs, classifiers, internal models, or constraints (see below), it has no direct influence on systems response and can be treated similarly to the unstructured encyclopaedic information considered under (1).

(3) Pattern classifiers for classification and recognition of perceived state patterns of the system and of its environments. An individual begins life with a minimum set of ethologically determined classifiers; the great majority of classifiers used in later life are learned. Socialization insures that individuals in more or less homogeneous collectives apply very similar classifiers to a given situation. The concept therefore seems to apply equally well to individual and collective behavior.

(4) Internal models of the behavior of the system itself and of its environment. These models are gradually built up as one aspect of " experience ". They may consist of simple causal chains (" if ..., then...."), or of more complex intuitive and often dynamic models (example: pilot preparing mentally to fly new aircraft). In collective decision-making the internal models of individuals are used, and no new point of view enters into the description of the process.

(5) Acquired responses to certain classifiable perceived state patterns. These represent the other aspect of " experience ". Not all classifiable state patterns will evoke acquired responses; but classification is precondition before an acquired response can be meaningfully applied. Again, individuals at birth are acquipped with a minimum ethological set of responses; many others are built up additionally in the course of a life-time. In collective behavior, the acquired responses of both individuals and the collective as a whole (" group spirit ") enter. Certain responses will be peculiar to collective situations, but a different concept is not required.

(6) Constraints of all kinds regulating behavior and decision-making. This normative set consists of the collection of physical constraints, minimum needs, aspirations, goals, values, attitudes, weights, social norms, etc. Retrieval results in situation-dependent sets of constraints. The subjective levels of the constraints are changed and updated by processor operations in response to system and environmental conditions and the psychological requirement of constraint consistency (removal of cognitive dissonance). The concept applies unaltered to collective behavior, but constraint set contents will obviously be different for an individual and a collective system, even if the former is a member of the latter.

(7) Processor routines guiding all aspects of system behavior. Subroutines are called into the short-term memory as required by the master program; the master program itself is stored in the long-term memory, with the short-term memory remembering the aspect of the master program presently active. The most important processor routines for individuals are: the master control program of behavior; and programs for random access storage by list association, for classification, for pattern recognition, for reasoning and the construction of internal models, for learning behavioral responses, for internalizing, deriving, and changing subjective constraints, for problem-solving and search processes (incl. the use of heuristics), for comparing, ordering, and evaluating, and for checking the consistency of normative constraints. In order to apply the concept to collective behavior, several new aspects must be added, in particular: programs dealing with conflict and conflict resolution, incl. bargaining and confrontation, with group interests, support, power, and manipulation, and with socialization and consent. Collective behavior is therefore obviously more than the sum of individual behaviors. However, the inclusion of these aspects does not at all change the theoretical framework:the actions of both individuals and collectives can be viewed as the outcomes of information processing systems having basically the same structure.

(8) Forgetting as an unavoidable aspect of the memories of biological systems. Forgetting is characteristic of both individuals and collectives, but not identical in both. The collective memory is (ideally) the sum of all individual memories and their extensions (records, data banks, memorials, etc.). As there is a multiplicity of access units (the retrieval capabilities of individuals), coupled with a multitude of list names under which information may be stored in many different long-term memories of individuals and artificial devices, the recall rate of collectives will be much higher than that of individuals (uses: brainstorming, scientific journals and conferences, group discussions). For operational purposes, the forgetting function of the long-term memory can be viewed as the result of an erasure routine. Basically this erasure is stochastic with a very strong superimposed influence of the psychological set, which allows some perceived state patterns to be completely forgotten while others are vividly remembered.

Emotions: It is important to realize that emotions are the driving force behind individual or collective behavior. Emotions cause motivations. Any attempt to simulate behavior without taking emotions and their influence into account implicitly or explicitly must fail. The major dimensions of emotions controlling behavior appear to be:

- satisfaction/dissatisfaction (incl. such feelings as hunger); consonance/dissonance
- affect
- curiosity
- fatigue/unrest, impatience

Important emotional components influencing behavior such as hope and fear are here understood as " projected consonance " resp. " projected dissonance ". The four dimensions (satisfaction, affect, curiosity, fatigue; there may be others) all influence the psychological set controlling the filter setting and the current contents of the short-term memory, in particular the definition of the situation. Only the first two (satisfaction and affect) have a distinct influence on the contents and change of the normative set and its influence on system behavior. Again there appears to be no qualitative difference regarding the role of emotions in the information processing systems of individuals and collectives.

Processor: For operational purposes, the processor is seen as the system which executes currently active programs. Its function could be considered as part of the function of the short-term memory. Controlled by the current contents of the short-term memory and by the emotional state, the master program in the processor calls the appropriate subprograms, information, and constraints from the long-term memory and processes them in order to guide the further behavior of the system. Differences in the information processing of individuals and collectives appear in the different set of programs used (see the discussion of the long-term memory).

This discussion of the information processing system hypothesized for individuals and collectives has of necessity been sketchy and incomplete. We hope to be able to round it out in the course of our research. We also hasten to add that we do not believe the structures, components, and processes mentioned to be fully describeable in the language of exact and deterministic mathematics. It is possible that 'fuzzy' mathematics may find an application here.

Lists, Tables, Figures

Fig. 1

UTOPIA - PROJECT: TIME AND WORK SCHEDULE

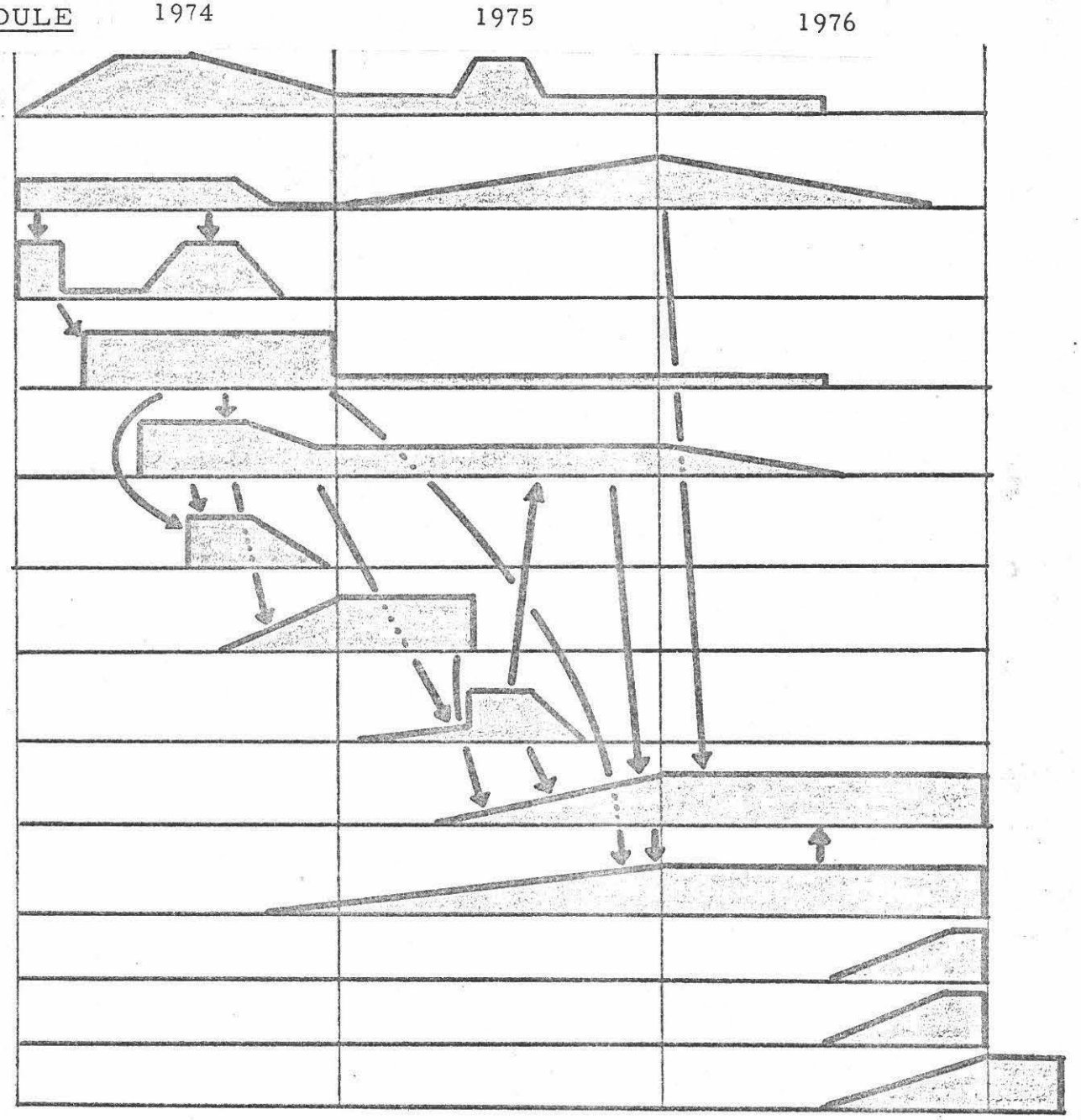

Fig. 2
INFORMATION PROCESSING SYSTEM IPS (Societal)

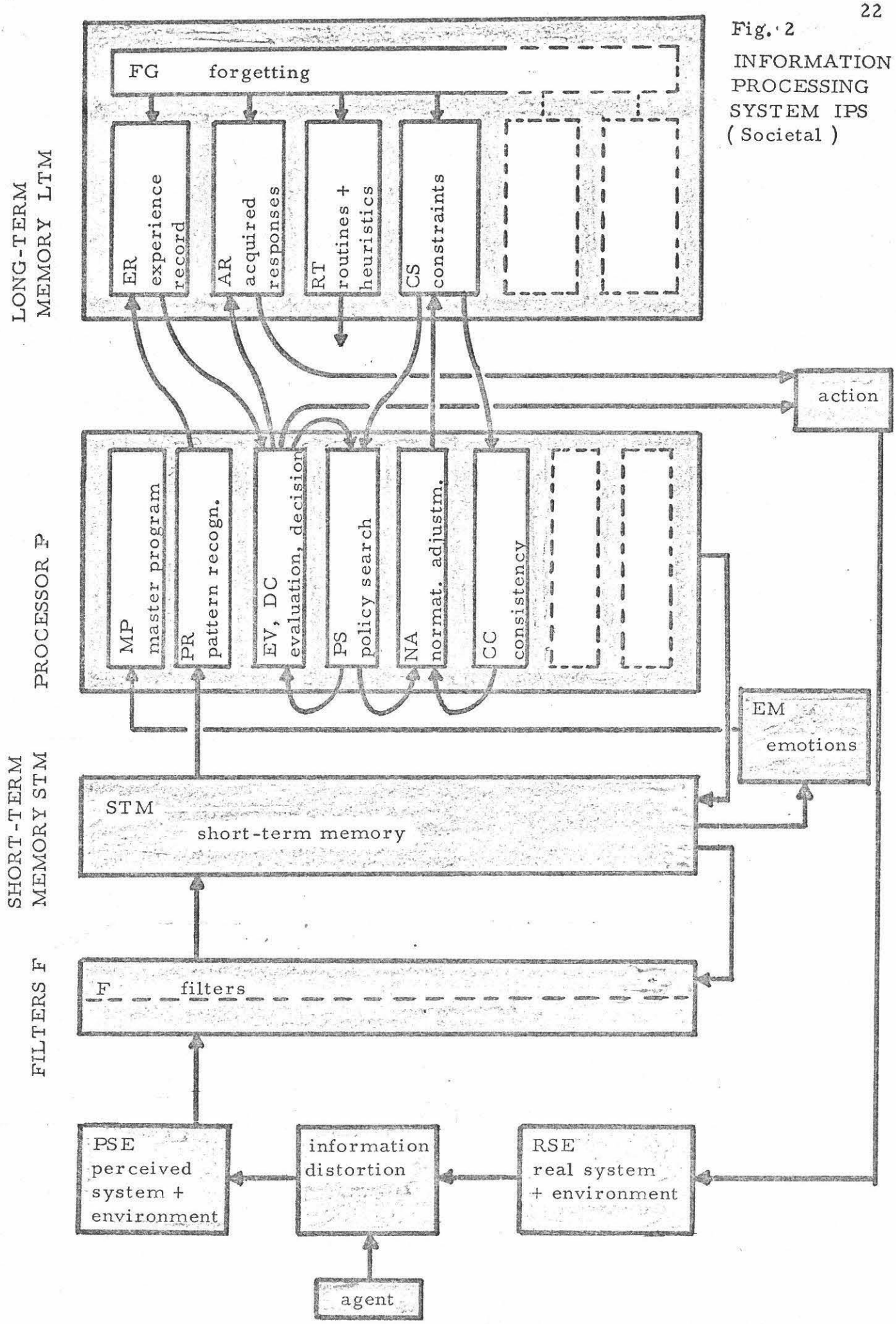

Table 1
AREAS OF
LITERATURE STUDY

predominantly INFORMATION PROCESSING COMPONENTS	CONTRIBUTING SCIENCE: systems science + math.	psychology	social psychology + emp. sociology	management science	political science	theoretical sociology	philosophy	simulation method
short-term memory	●	●						●
long-term memory	●	●						●
internal model	●	●	●	●			●	●
evaluation	●	●		●				●
problem-solving	●	●		●			●	●
policy search	●	●		●	●			●
decision-making	●	●		●	●			●
satisficing								
mixed scanning								
incrementalism								
optimization								
...								
conditioning	●	●	●					●
intelligent learning		●						●
recall	●	●						
pattern recognition	●	●						●
adaption	●	●						●
acquired routines	●	●	●					●
instinct. routines		●						
artificial intelligence	●	●						●
probabilistic elements	●	●		●				●
selective filtering, bias	●	●	●	●	●			●
forgetting	●	●						●
heuristics	●	●		●				●
information selection	●	●		●				●
relevance test								
reliability test								
consistency test								
difficulty ordering		●						
reasoning		●						
sensory system		●						
definition of situation		●		●				
decision premises		●		●				
problem definition		●		●				●

Table 1 (cont'd)

predominantly PSYCHOLOGICAL COMPONENTS	CONTRIBUTING SCIENCE: systems science + math.	psychology	social psychology + emp. sociology	management science	political science	theoretical sociology	philosophy	simulation methods
emotion		●	●			●		
(dis)satisfaction								
cognitive stress								
dissonance								
fatigue								
hunger etc.								
affect								
drives								
unrest, impatience								
curiosity								
commitment								
...								
motivation		●	●	●		●		●
indiv. behavior		●	●	●				●
intrapers. conflict		●						
stimulus		●		●				●
subconscious		●						
conscious		●						
association		●						
abstracting		●						
context		●						
utility assessment		●		●	●			
probability assessment		●		●				
decision under uncert.		●		●	●			●
set		●	●	●		●		
concept formation		●					●	
meaning		●					●	
understanding		●					●	

Table 1 (cont'd)

predominantly SOCIAL COMPONENTS	CONTRIBUTING SCIENCE: systems science + math.	psychology	social psychology + emp. sociology	management science	political science	theoret. sociology	philosophy	simulation methods
social indicators			•					
quality of life		•	•				•	
interest groups					•	•		
cleavage (betw. groups)					•	•		
interest articulation					•	•		
interest aggregation					•	•		
social influence			•		•	•		
power				•	•	•		•
conflict		•	•	•	•	•		•
conflict resolution		•	•	•	•	•		•
support					•			
socialization			•					•
manipulation				•	•	•		
group			•	•		•		•
organization			•	•	•	•		•
political system				•	•			•
executive								
legislative								
judicial								
international aspects					•			•

Table 1 (cont'd)

predominantly NORMATIVE COMPONENTS	CONTRIBUTING SCIENCE: systems science + math.	psychology	social psychology + emp. sociology	management science	political science	theoret. sociology	philosophy	simulation methods
concept, state, derivation, change of:								
values		•	•		•	•	•	
attitudes		•	•			•		
goals		•	•	•	•	•		
norms		•	•			•		
priorities, prefer.		•	•	•	•		•	
ideology			•		•	•		
role			•	•	•	•		
constraints		•						
weights		•						
performance gap				•	•			
future discounts				•	•			
decision cost: search, decision, instrument, impact				•	•			
consistency		•						
predominantly IMPLEMENTATION COMPONENTS								
theoret. formulation	•	•	•	•	•	•	•	
simulation	•							•
validation	•						•	•

PARTICIPATING SCIENTISTS

Project Staff at ISI (June 1974)

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Systems Science

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