RR-76-16

SYSTEMS ANALYSIS: AN OUTLINE FOR THE STATE-OF-THE-ART SURVEY PUBLICATIONS

E. QUADE, K. BROWN, R. LEVIEN, G. MAJONE, V. RAKHMANKULOV

JULY 1976

International Institute for Applied Systems Analysis
2361 Laxenburg, Austria

PREFACE

One goal of the International Institute for Applied Systems Analysis is to improve the quality of analytical assistance available to decisionmakers throughout the world. An approach to this goal is to publish a Series of volumes, and later a Handbook, to survey the international state-of-the-art of applied systems analysis. These publications will be directed primarily to practitioners of systems analysis, but occasionally volumes will be addressed to specialists, managers, or students.

This report, prepared by the Survey Project staff, lists the topics that span the field of interest for these proposed publications and presents guidelines for acceptability of manuscripts.

SUMMARY

IIASA plans to organize, commission, and publish a Series of volumes and a Handbook to survey the international state-of-the-art of applied systems analysis. This report provides the Survey Project's explication of the concept of applied systems analysis; it describes in detail the proposed Series and Handbook, including purpose, audience, international character, level of presentation, authors, reviewers, and remuneration policies. An outline spanning the field of interest of applied systems analysis is designed to help prospective authors with the choice of topics. Guidelines are provided for the acceptability of volumes for the Series, and suggestions for prospective authors on the preparation of prospectuses (outlines) for Series monographs are included. These prospectuses are submitted to the Editorial Board and special liaison committees established in each of IIASA's National Member Organizations. A summary checklist of procedures for development of Series volumes is provided in the Appendix.

ACKNOWLEDGMENTS

In preparing the outline and establishing guidelines for the Series, the IIASA Survey Project had help from many people. We particularly want to thank the liaison persons in IIASA's National Member Organizations who assisted in distributing our questionnaire containing an early version of the outline. We also want to express our gratitude to the more than 100 analysts and users of systems analysis who responded to the questionnaire.

CONTENTS

INTRODUCTION

SYSTEMS ANALYSIS: THE GENERAL CONCEPT

Systems analysis is made up of a broad collection of concepts, procedures, and techniques designed to provide guidance for future action. The word "analysis" is being used here in its most general sense to encompass the use of intuition, judgment, design, and synthesis as well as decomposition to examine possible actions and their consequences. The aim is to assist persons in making public and private choices involved in the creation and maintenance of the world's goods, the distribution of its resources, the sanctioning or prohibition of various modes of individual and organizational behavior, and the relationships among societies. To provide this assistance, applied systems analysis at IIASA utilizes research of various kinds: research to illuminate or to provide insights into the problems and issues that arise, research on methods to investigate those problems and issues (with emphasis on systems and systems theory), and, importantly, research to examine particular ways of helping a decisionmaker, or anyone who must make a choice, deal with specific substantive problems that might range from the purely personal to broadly public ones, such as those associated with urban transportation, regional environmental planning, the delivery of health services, or other unresolved public issues.

At IIASA, applied systems analysis refers to a far more extensive range of activities than is common elsewhere. Other labels -- policy analysis, operational or operations research, systems engineering and more -- are used in various parts of the world to designate a part, or on occasion all, of this conglomerate. Applied systems analysis is characterized by a wide variety of different approaches, by the absence of distinct demarcation lines between its procedures and those of various established disciplines such as cybernetics or general systems theory, and by use of concepts and methodological tools from the social sciences and economics as well as from the engineering, mathematical, and physical sciences. Also, since this goal of systems analysis is to help with decisions in the real world of practical affairs, the analysis must have great variety in application, concept, technique, and procedure.

SURVEY PROJECT PUBLICATIONS

One important function of IIASA is to facilitate widespread international exchange of experience with systems analysis and its application. To help fulfill this mission, IIASA has established a Survey Project to organize and commission timely publications whose effect will be to advance the current state-of-the-art of systems analysis and disseminate that information more widely throughout the world. To this end, the Survey Project's editorial staff developed an outline of topics to define the sphere of interest for a Series of state-of-the-art publications and other products, such as a Handbook; these publications are sponsored and financially supported by IIASA, and reviewed internationally.

THE SCOPE OF THE PUBLICATIONS

The outline was developed with the assistance of over 100 analysts throughout the world who responded to a detailed questionnaire. As a consequence of their comments and criticism, the outline was amplified.*

The editorial staff designed this outline with a threefold purpose: to provide prospective authors with an overview for generating individual monographs; to serve as a framework to guide the staff in their sponsorship and development of the material; and to invite interested persons to submit prospectuses for possible manuscripts to be included among the publications.

It should be clear without close inspection that the outline could be improved in a number of ways. Just how, however, depends on the individual judge. One criticism is that it is necessarily incomplete (modes of analysis and areas of application remain to be discovered). Another criticism is that some of the duplication, which occurs because certain items are mentioned in more than one context, could probably be eliminated. Also the degree of development of scientific topics might more nearly reflect the view held at IIASA, if not elsewhere in the systems analysis community, as to current needs and priorities with respect to monographs in the state-of-the-art Series or articles for the Handbook. In addition, one might improve the structure of the outline, arguing with considerable logic that the topics should be ordered differently. There are, of course, counter-arguments. But considering the purpose for which the outline is designed, namely to

---

*A complete list of respondents and an analysis of their responses are reported in IIASA RR-76-17, *The State-of-the-Art Questionnaire on Applied Systems Analysis: A Report on the Responses*.

bound the domain of topics to include in the Series or Handbook, the precise order has little significance. Questionnaire respondents frequently raised questions of emphasis, which are *not* reflected in the outline's contents -- for instance, that the Series should give priority to volumes treating the organizational, political, and social aspects of systems analysis rather than techniques -- but such questions are better decided by editors and reviewers.

PRODUCTS

Volumes that are derived from this outline for the Series will be prepared largely for *practitioners* of systems analysis; they may include topics of contemporary interest chosen by individual authors as well as topics from IIASA work. Volumes will be issued individually as they are completed, and in some instances may be revised or replaced to assure that they remain current. The first Series volumes should be issued by the beginning of 1977, and a goal is to publish them thereafter at the rate of eight to ten volumes per year.

The Series will be developed by the Survey Project editorial staff at IIASA, with the advice of an international Editorial Board; it will be published initially in English by John Wiley & Sons Ltd. A Series volume will consist of between 200 and 500 printed pages. There will probably be a wide variation in the size of the volumes, partly as a consequence of the differences in development of the individual topics. Monographs on similar topics might be bound together for convenience.

Later, when the Series is firmly established, a Handbook is contemplated, addressed to several audiences: practitioners, managers, scientists, and students and teachers of systems analysis. When it appears, it will be an integral publication comprising a concise and structured presentation of the underlying concepts, techniques, and practical results of systems analysis as a guide to decisionmaking. The scope of the Handbook will be similar to some aspects of the Series, but it will focus on the fundamental aspects of the theory and practice of systems analysis; the materials in the Handbook will thus emphasize the relatively unchanging features of systems analysis. Because of its nature, the Handbook will require far more time to prepare than the usual Series volume.

Audiotapes, videotapes, and films may also be considered as means of reaching specific audiences.

WHY THESE PUBLICATIONS ARE UNIQUE

The Survey Project's publications will attempt to include:

- o General principles, conceptual foundations, and objectives of systems analysis.
- o Theoretical, methodological, and practical aspects, and the lines of investigation and application of systems analysis currently in use, or being contemplated for use, around the world.
- o Standardized terminology and other materials to facilitate consistency, communication, and cooperation among a wide spectrum of researchers employing systems analysis in various areas of application.

Although a number of respondents to the questionnaire felt that there is already an excess of publications dealing with systems analysis, there are several reasons why these IIASA publications are unique and why prospective authors will benefit from participating: the international character of the Survey Project's program, the quality control maintained by the editorial staff, and the assistance to authors during all stages of manuscript preparation.

International Character

Considerable effort is devoted by the Survey Project to providing its publications with an international, particularly East-West character. The editorial staff is assisted in this effort by IIASA's National Member Organizations (NMOs), which have established liaison committees in their countries to work with the Survey Project.* These committees are called upon to:

- o Distribute prospectuses (outlines) of potential Series volumes to a small number of persons knowledgeable in the subject area, who are asked to give their opinions with respect to demand

*The countries represented by National Member Organizations are Austria, Bulgaria, Canada, Czechoslovakia, Federal Republic of Germany, France, German Democratic Republic, Hungary, Italy, Japan, Poland, Sweden, United Kingdom, United States, and the USSR.

for the volume in their respective countries and completeness of coverage.

- o Arrange, in cooperation with IIASA, for publication in the national language(s), if the need exists.
- o Identify prospective authors and reviewers.
- o Arrange for the translation into English of contributions from authors who cannot write in English.
- o Contribute to an international glossary and other reference materials.

All Survey Project products, including Series publications, will be disseminated worldwide through these NMOs as well as through the international distribution network of the publisher, John Wiley & Sons Ltd.

Quality Control

When a manuscript has been submitted by an author, it will be reviewed, generally by two referees representing different perspectives, who will check for organization, clarity, readability, relevance to applied systems analysis, etc., and who may make suggestions for modification if that seems necessary. All volume manuscripts are carefully edited by experienced technical editors on the Survey Project staff.

Assistance to Authors

The editorial staff is available to provide advice at all stages of manuscript preparation. In addition to this editorial help, the Survey Project assists authors in developing contacts and data in countries represented by the NMOs and elsewhere. In the case of a volume with multiple authors from different countries, IIASA may also be able to hold a workshop to coordinate efforts.

AUDIENCE

The project's publications are addressed to a wide audience, including practitioners of systems analysis in government, industry, and research institutions; managers at all levels in government and industry; scientists and engineers working at the frontiers of systems analysis; and instructors, graduate and undergraduate students.

IIASA is in a unique position, through its NMOs, to identify and report worldwide activities in the application of systems analysis to current international issues that are of interest to more than one nation, such as pollution, and to report the latest developments in systems analysis from research centers and individuals around the world. If this can be reflected in the project's publications, it is expected that there will be a large audience.

AUTHORS AND REVIEWERS

Because of the international character of the state-of-the-art publications, there is a need for contributions from a wide range of experts from many different countries. For this reason, authors for the most part will be chosen from outside IIASA. Prospective authors for the various products will be identified by one or more of three basic methods:

- o Recommendations by members of the Editorial Board, liaison committees of the NMOs, or IIASA staff.
- o Recommendations by experts in appropriate topic areas.
- o Prospectuses received directly from possible authors.*

Authors will be chosen by the Survey Project staff, with the advice of the IIASA Editorial Board, after careful consideration of all prospectuses and recommendations from the NMOs. The authors will be paid an honorarium and/or a portion of the royalty income.

Reviewers (usually two) are selected by the editorial staff, often after consultation with one or more NMOs, to evaluate all contributions. Insofar as possible, reviewers are chosen to complement the author's experience, both internationally and substantively. Reviewers are paid an honorarium to encourage careful, comprehensive reviews.

---

*Authors interested in participating in the Survey Project's publication program are invited to submit a prospectus for a potential monograph. The editors have prepared guidelines for the preparation of these prospectuses, which appear in the last section of this report.

SYSTEMS ANALYSIS: AN OUTLINE

Systems analysis is a complex subject that may be examined or presented in various ways. The scheme that divides the outline onto four main sections is thus somewhat arbitrary. These deal respectively with:

I. *Foundations* -- conceptual and philosophical bases of systems analysis.
II. *Activities and Processes* -- art, methods, and techniques.
III. *Applications* -- areas or roles in which systems analysis is or can be helpful.
IV. *Reference Materials* -- glossaries, bibliographies, and directories.

The structure of the outline is hierarchical within each section; each of these four main sections is subdivided and, except for the last, these subdivisions in turn are frequently further subdivided. The upper levels, including the first-level sections and second-level subsections (numbered italicized entries and entries preceded by a small bullet, "o") were originally intended to be considered as subjects for separate volumes in the Series or chapters in the Handbook; lower levels (dashed-line entries) were to provide some concept of the scope. The structure, however, is not sufficiently well defined to hold to that idea, and it is clear that many of the lower-level topics, either alone or in combination with others, are sufficiently important to serve as a subject for a monograph.

I. FOUNDATIONS OF SYSTEMS ANALYSIS

Activities we now call "systems analysis," although comparatively recent in widespread use, have beginnings deep in antiquity and roots in many sciences and disciplines. This section deals with the origins, history, and modern development of systems analysis, its main themes and classical procedures, its basis in science and other disciplines, and its philosophical, epistemological, human, social, and ethical aspects. The outline as structured emphasizes the role of systems amalysis as a practical approach to aiding decisionmakers, but its interpretation as systematic analysis of complex problems or as a device to study large-scale complex systems is not excluded, nor do we exclude the use of this analysis for advocacy or its use in the adversary process.

With the above in mind, this section is subdivided into six parts:

Development

History, main themes, classical cases and procedures, state of development.

Interpretations of Systems Analysis

Alternative themes, relationships to and differences between systems analysis and various disciplines.

Bases of Systems Analysis

Systems approach, important analytic concepts, structural/functional concepts.

Philosophical and Epistemological Considerations

Present capabilities and limitations, relationships to various philosophical systems and questions, judgment and intuition in analysis.

Human, Societal, and Ethical Aspects: Implications for Analysis

Human component in systems, social groups and organizations, ethics, the client, the analyst.

Other Uses of Systems Analysis

In an adversary process, for advocacy.

I.1 *Development*

- o History
  - -- early antecedents
  - -- precursors
  - -- post World War II evolution and development

- o Main themes
  - -- aid to decisionmaking
  - -- search for an optimal choice
  - -- concern for the whole system
  - -- system modeling
  - -- concern for the design and synthesis of alternatives
  - -- concern for criteria and performance assessment
  - -- concern for changes over time
  - -- interdisciplinarity; cross-disciplinarity
  - -- iteration
  - -- concern for choice of objectives
  - -- explicit treatment of uncertainty
  - -- introduction of objectivity into largely subjective areas
- o Classical cases and procedures
  - -- cost-effectiveness analysis to rank similar alternatives
  - -- cost-benefit analysis to evaluate major public investments
  - -- PERT (Program Evaluation and Review Technique) to plan and manage programs
  - -- PPBS (Planning-Programming-Budgeting System) as a framework for government management
  - -- large-scale simulations to test pre-operational variants
  - -- formal R&D planning methods
  - -- use of gaming to study conflict situations
  - -- large-scale regional and economic models for planning
- o State of development
  - -- in various countries
  - -- open problems
  - -- desired future directions

I.2 *Interpretations of Systems Analysis*

- o Alternative themes
  - -- systematic analysis of complex problems
  - -- study of large-scale systems
  - -- formal techniques of decisionmaking
  - -- practical analysis to aid decisionmakers
- o Relationships to and differences from various disciplines
  - -- operational or operations research
  - -- systems engineering
  - -- cybernetics
  - -- economics
  - -- control systems theory
  - -- sociology
  - -- futures research
  - -- other relationships

I.3 *Bases of Systems Analysis*

- o Systems approach
  - -- comprehensive
  - -- interdisciplinary
  - -- future- and design-oriented
  - -- analytical
  - -- iterative
  - -- objective-oriented
  - -- sensitive to inherent complexity of problems
  - -- simultaneously qualitative and quantitative
  - -- oriented towards practice
- o Important analytic concepts and issues
  - -- clarification of the problem
  - -- specification, synthesis, and design of alternatives
  - -- consideration of all the impacts, including the distributional consequences of the decision
  - -- evaluation in terms of consequences: cost, performance, risk, etc.
  - -- explicit treatment of uncertainty and temporal factors
  - -- sensitivity analysis
  - -- quantitative models when feasible
  - -- robustness, resilience
  - -- feasibility and constraints
- o Structural/functional concepts
  - -- structural: elements, subsystems, hierarchy, linkage; dynamic, structural analysis and changes in the structure
  - -- functional: flow of information, control, incentives, objects; assignment of goals, tasks, resources; dynamic changes in functions

I.4 *Philosophical and Epistemological Considerations*

- o Present capabilities and limitations
  - -- in principle
- o Relationship to various philosophical systems and questions
  - -- scientific methodologies
  - -- contemporary epistomological theories
  - -- holistic thinking
  - -- inquiring systems
  - -- other supporting philosophical concepts
- o Judgment and intuition in analysis
  - -- necessity for
  - -- limits of formal analysis

I.5 *Human, Societal, and Ethical Aspects: Implications for Analysis*

- o Human component in systems
  - -- personalities
  - -- cultures
  - -- societies

- o Social groups and organizations
  - -- influence of organizational setting
  - -- organizational design and problems of scale
  - -- distributional impacts
  - -- social utilization of systems analysis
- o Ethics
  - -- professional responsibility and integrity of the analyst
  - -- values, objectives, and the morality of intervention
- o The client and the utilization of systems analysis
  - -- overcoming resistance to its use
  - -- client problems with systems analysis
  - -- client-analyst relationship

I.6. *Other Uses of Systems Analysis*

- o In an adversary process
  - -- techniques of argumentation, uses of evidence
- o For advocacy

II. ACTIVITIES AND PROCESSES OF SYSTEMS ANALYSIS

Given the broad range of activities spanned, there is no general agreement as to what constitutes a standard or even an appropriate way to conduct a systems analysis. Nevertheless, there are a number of frequently employed activities and processes, ranging from the use of judgment and intuition to well-established algorithms. This section attempts to bring together these various aspects of the practice of systems analysis into an ordered structure.

For the purpose of this outline, it is useful to distinguish three aspects of the practice of systems analysis:

A. Art

Systems analysis requires considerable insight and initiative on the part of the analyst. There are many tasks that he must complete or issues he must decide that are subjective and cannot be described exactly -- in the way he decides to look at the problem or limit its extent, in the design of alternatives, in the choice of tools.

B. Methodology

The formal bases of systems analysis and methods to aid decisionmakers come largely from decisionmaking experience and practice but to an increasing extent also from decisionmaking theory.

C. Techniques

Specific tools (both qualitative and quantitative), often coming from disciplines such as statistics, mathematics, physical science, or economics, are frequently useful during the conduct of a systems analysis.

II.A. Art of Systems Analysis

While it is not possible to a give a precise prescription for the conduct of a systems analysis, the experience of the past 30 years has revealed patterns of activity and suggested generalizations that can be distilled and presented. These activities, which constitute the art of systems analysis, are covered in the outline in five subsections:

Features of Systems Analysis

Participants, purposes, inputs, modes of analysis, outputs, complexity.

Stages of Systems Analysis

Problem formulation, information gathering, system identification, specification of alternatives, assessment of implications, implementation.

Case Studies

Critical examinations, comparisons.

Human Aspects of Decisionmaking

Value systems, human information processing, personal versus institutional objectives.

General Guidelines

Pitfalls, difficulties, first-order analysis.

II.A.1. *Features of Systems Analysis*

- o Participants
  - -- analysts
  - -- decisionmakers
  - -- other interested parties (e.g., target groups, interest groups, citizens in general)
- o Purposes
  - -- resource allocation
  - -- evaluation of proposed action
  - -- evaluation of ongoing program
  - -- knowledge on which to base action
  - -- forecasting, planning, and/or programming
- o Inputs
  - -- perception of the problem
  - -- goals and objectives
  - -- problem context and environment
  - -- constraints
  - -- decision environment
  - -- possible alternative decisions
  - -- assumptions about unknown and uncertain factors
- o Modes of analysis
  - -- mathematical or computational models
  - -- computer simulation
  - -- verbal (e.g., explicit, logical) models
  - -- social experimentation
  - -- judgment by an individual expert or groups of experts
  - -- operational gaming
  - -- empirical data analysis
  - -- sensitivity analysis

- Outputs
  - -- comparison, possibly a ranking, of alternatives
  - -- clarification of objectives, improved understanding of issues
  - -- invention of new alternatives, options, means
  - -- explicit presentation of assumptions, uncertainties, estimates, costs, etc.
  - -- specification of alternatives
  - -- evaluating performance of selected alternatives
  - -- system description
  - -- relative importance of factors affecting output
  - -- techniques for implementation
  - -- design of procedures and policies
  - -- argumentation and advocacy briefs
- Complexities
  - -- participants (analysts, decisionmakers, target groups, etc.): multiple, competing, not completely known
  - -- inputs (objectives, purposes, context, alternatives, etc.): multiple, competing, vague, incomplete, ill-defined
  - -- modes of analysis: many, impossible to quantify
  - -- outputs (impacts, results, conclusions): unclear, low confidence, many, time-dependent, inequitable

II.A.2. *Stages of Systems Analysis*

- Problem formulation and information gathering
  - -- isolation of issues
  - -- identification of decision framework, criteria
  - -- determination of global and local objectives
  - -- specification of problem for analysis
  - -- gathering information about problem, context, and system
  - -- deciding what approach to take
  - -- making necessary assumptions
- System identification and specification of alternatives
  - -- definition of factors affecting objectives
  - -- specification of linkage among variables in the system
  - -- construction of formal or informal model(s), including identification of system boundaries, subsystems, levels of aggregation, interrelationships, input/output functions, choice of analytical tools, validation of model(s)
  - -- identification of possible decisions and actions open to decisionmakers, including creative design and synthesis of new alternatives, feasibility and constraints
  - -- identification of the limits to the range of possible actions

- o Assessment of alternatives and presentation of the implications
  - -- choice of methods of accounting for uncertainty and outcomes for various time streams, sensitivity tests
  - -- selection of a method to test consequences (in terms of outcome measures) of each alternative in context, under specified constraints
  - -- assessment of the consequences of each alternative according to chosen methods
  - -- determination of outcomes to consider: costs (including nonmonetary costs), performance, risk, etc.
  - -- selection of a method to present the results of the analysis to individual decisionmakers or to multi-person decisionmaking bodies and managers
- o Assistance in implementation
  - -- adapting a special alternative for implementation including detailed design (e.g., scheduling, organizational changes)
  - -- informing and training persons who must adopt the alternative
  - -- monitoring the performance of the adopted alternative
  - -- revising the alternative on the basis of performance
  - -- preparing the people who must change as a consequence of the alternative to be implemented
  - -- systematic examination and alternative implementation strategies
- o Evaluation of implemented alternatives
  - -- determination of reason for evaluation
  - -- choice of performance outcomes to evaluate: cost, performance, risk, distributional effects, etc.
  - -- design of evaluation procedure
  - -- conduct of evaluation
  - -- report of results to decisionmaker/manager

II.A.3. *Case Studies*

- o Critical examination of individual systems analysis
- o Exemplary analyses of particular problems
- o Case studies to illustrate good and poor practices in analysis, with emphasis on the process rather than on the specific findings
- o Comparisons of different treatments of the same or similar problems, e.g., by analysts with different training or from different organizations
- o Retrospective analyses of actual decisions
- o Investigation of characteristics of applications where systems analysis tends to be most useful, least useful.

II.A.4. *Human Aspects of Decisionmaking*

- o Value systems of individuals
- o Human information processing
- o Personal versus institutional objectives

II.A.5 *General Guidelines*

- o Pitfalls and common difficulties
  - -- in the nature of the problem, argument, tools, and solution
  - -- introduced by the analyst or decisionmaker
- o First-order analysis
  - -- matching level to decision urgency, time availability, etc.
  - -- rules of thumb and tricks-of-the-trade

II.B. Methodology of Systems Analysis

While many aspects of the practice of systems analysis continue to be what we would call "art," others are clearly scientific in nature and attempts are being made to give still others a scientific basis. One approach is through the development, both theoretically and empirically, of analytical frameworks that can be used to give structure to the analysis of practical decisionmaking problems. A second, more widespread, approach has been through the systematic study of fundamental issues that arise in and the procedures that are required for the successful use of these frameworks. The need for considering both the basic structures for analysis to help with decisionmaking and the problems with their use has led to the division of this part of the outline into two subsections:

Analytical Frameworks for Decisionmaking

Traditional investment analysis, the economic theory of choice, decision analysis, cost-effectiveness analysis, cost-benefit analysis, multiattribute impact assessment, game theory approaches, possible new analytical frameworks, comparisons and evaluation of alternative frameworks, ways in which systems analysis improves traditional methods.

Issues, Problems, and Procedures in Decisionmaking Methodology

Problem formulation, determination of objectives, synthesis of alternatives, definition of probable states of the world, prediction of consequences, application of decision rules, methodological problems.

II.B.1. *Analytical Frameworks for Decisionmaking*

- o Traditional investment analysis
  - -- costs and returns calculated in pure monetary units
  - -- decision guided by the relationship between costs and returns

- o The economic theory of choice
  -- objectives, criteria, alternatives, models, costs
- o Cost-effectiveness analysis
  -- effectiveness calculated in "natural" units
  -- decision guided by relationships between cost and effectiveness
- o Cost-benefit analysis
  -- costs and benefits translated into monetary units
  -- decisions guided by relationships between costs and benefits
- o Decision analysis
  -- outcomes calculated in terms of utility
  -- decision guided by expected utility or other criteria of choice
- o Multiattribute impact assessment
  -- multiple consequences determined in different "natural" units
  -- decision by judgment based on relationships among all consequences
- o Game theory analysis
- o Possible new analytical frameworks
- o Comparisons and evaluation of alternative frameworks
  -- limitations of traditional analytical frameworks
  -- appropriate areas of use for each of the different analytical frameworks
- o Ways in which systems analysis improves traditional methods

II.B.2. *Issues, Problems, and Procedures in Decisionmaking Methodology*

- o Problem formulation
  -- consideration of source, pressure of time, available information
  -- importance of perspective
  -- procedures, use of issue papers
- o Determination of objectives
  -- methods, including objectives trees and scenarios
  -- goals, targets, measures of effectiveness
  -- single- and multiple- objective functions, multiattribute solutions
  -- conflicting objectives
- o Synthesis of alternatives
  -- relationships to objectives, constraints
  -- identification and design procedures, iteration, "fine-tuning"
  -- uncertainty and means of reducing its impact
  -- feasibility analysis, importance
- o Definition of probable states of the world
  -- assumptions, explicit treatment of uncertainty, time
  -- structuring the uncertainty
  -- statistical and subjective possibilities

- o Prediction of consequences
  - -- models, for each alternative-state pair
  - -- types of models, model building
  - -- model verification and validation, confidence methods
  - -- controlled experimentation
  - -- competitive aspects and the resolution of conflict
- o Application of decision rules
  - -- choice of a decision framework
  - -- determination of utility, different formulations
- o Methodological problems
  - -- treatment of inherent complexity
  - -- determination of multiple values and criteria
  - -- risk analysis and assessment of the consequences of risk
  - -- preference structures and choice procedures
  - -- comparison of qualitative features
  - -- analyzing sensitivity
  - -- aggregation and decomposition, procedural issue of system divisibility and integrity
  - -- analyzing decision efficiency and feasibility
  - -- heuristic decisionmaking, heuristic programming
  - -- searching and optimizing methods involving deterministic and random search
  - -- analyzing stability of conditions
  - -- vector and scalar optimization
  - -- handling several local optima
  - -- identification and design of alternatives
  - -- quantification in social systems
  - -- modeling and analysis of human behavioral systems (political systems, conflict systems, etc.)

II.C. Techniques of Systems Analysis

During the conduct of an analysis the analyst may have to call upon a wide range of specific techniques to assist in such tasks as data gathering and analysis, measuring, modeling, forecasting, synthesizing, and optimizing, and so on. A few of these are unique to systems analysis, but generally they are drawn from other sources. Nevertheless, they form an important, in fact central, part of the tools needed for the conduct of systems analysis. Although much has been written about most of these techniques, publications in the Series on the state-of-the-art of systems analysis might still be devoted to some of them.

The proposed subdivision for this part of the outline is:

Description Techniques

Data gathering, handling, analysis.

Modeling Techniques

General model types, specific model types, model building, validation.

Forecasting Techniques

Qualitative, quantitative.

Estimation Techniques

Cost and resource use estimation. Performance and risk estimation, common estimation issues.

Synthesis and Design Techniques

Qualitative, quantitative, feasibility analysis.

Optimization Techniques

Computational; experimental.

Experimental Techniques

Experimental design, large-scale social experiments.

Planning and Management Techniques

Program-oriented planning and budgeting, event-oriented planning and scheduling, sectorial planning and management, regional planning and management.

Implementation Techniques

Program specification, program introduction, program monitoring and revision.

II.C.1. *Description Techniques*

- o Data gathering
  - -- sampling theory
  - -- survey methodology
  - -- experimental design
  - -- secondary and indirect sources
  - -- data generation
- o Data handling
  - -- data entry
  - -- data structures, files, bases
  - -- data selection, manipulation, retrieval
  - -- data display
- o Data analysis
  - -- data screening, reduction
  - -- multivariate statistical techniques (including regression analysis)
  - -- time-series analysis
  - -- pattern recognition
  - -- statistical inference

II.C.2. *Modeling Techniques*

- o General model types
  - -- qualitative and verbal models
  - -- structured data arrays
  - -- continuous mathematical models
  - -- discrete mathematical models
  - -- stochastic models (queuing, inventory,etc.)
  - -- computer models (including simulations)
  - -- operational games
  - -- man-machine models
  - -- mixed models (e.g., continuous-discrete mathematical models)
  - -- fuzzy models
- o Specific model types
  - -- special-purpose physical models
  - -- economic models (e.g., interindustry models, production models, demand models)
  - -- engineering models (e.g., control system models, communication system models)
  - -- operational research/management science models (e.g., scheduling models, transportation models, queuing models)
  - -- conflict and competitive models (e.g., game theory models, game simulations)
  - -- interactive models
- o Systems of models
- o Learning processes in modeling, model building
- o Model validation and verification

II.C.3. *Forecasting Techniques*

- o Necessity for including scientific forecasting
- o Qualitative
  - -- scenario writing
  - -- case analysis
  - -- objectives trees
  - -- expert opinion, individual or group (Delphi)
- o Quantitative
  - -- trend interpolation and extrapolation
  - -- relevance trees
  - -- multivariate and structural models
  - -- cross-impact analysis
  - -- systems decomposition

II.C.4. *Estimation Techniques*

- o Input--cost and resource use estimation
  - -- cost accounting
  - -- cost estimation
  - -- resource use accounting
  - -- resource use estimation

- o Output--performance estimation
  - -- effectiveness (measured in "natural" performance units)
  - -- benefits (measured in monetary units)
  - -- utility (measured in abstract units)
- o Indirect measurement, use of proxies
  - -- measurement of values
- o Risk estimation
  - -- absolute risk assessment
  - -- relative risk assessment
- o Common estimation issues
  - -- treatment of uncertainty
  - -- treatment of multidimensional system attributes
  - -- treatment of time-streams of attribute values
  - -- fuzzy set method
  - -- treatment of residual values
  - -- distribution of benefits and costs
  - -- discounting utility over time

II.C.5. *Synthesis and Design Techniques*

- o Qualitative
  - -- individual and group creativity, brainstorming, shift of perspective
  - -- use of expert judgment
  - -- use of manual gaming, scenario-writing
  - -- learning processes in modeling
- o Quantitative
  - -- randomized alternatives
  - -- simulation
  - -- use of feedback
  - -- morphological analysis
- o Feasibility analysis
  - -- constraints, social, legal, etc.
  - -- cost of constraint removal

II.C.6. *Optimization Techniques*

- o Computational
  - -- mathematical programming
  - -- optimal control theory
  - -- combinatorial techniques
  - -- sequential decision: dynamic programming
- o Experimental
  - -- trial and error
  - -- pseudo, simulation, automatic and man-machine interaction

II.C.7. *Experimental Techniques*

- o Experimental design
- o Large-scale (social) experiments
- o Pseudo-experimentation (i.e., experimentation in a simulation model instead of in the real world)

II.C.8. *Planning and Management Techniques*

- o Allocation of effort to analysis; costs and benefits of formal analysis
- o Program- and event-oriented
- o State, regional, local
- o Sectorial and industrial
- o Human resources and manpower
- o For acceptance and implementation of proposed solutions
- o Evaluation

II.C.9. *Implementation Techniques*

- o Program specification (in detail for implementation)
  - -- programmed selection of routine and repetitive tasks
  - -- design of group and individual incentives
  - -- design and selection of policy levers
  - -- scheduling
  - -- organization analysis and development
  - -- partial and complete documentation
- o Program introduction
  - -- convincing the operational levels
  - -- training procedures and programs
  - -- management procedures and programs
- o Program monitoring and revision
  - -- sampling, measuring, and testing
  - -- information feedback and program modification
  - -- computer support
  - -- validation

III. AREAS OF APPLICATION OF SYSTEMS ANALYSIS

Systems analysis is characterized by the great variety of different areas in which it can be applied, and the complex interrelatedness of many of those areas. In view of these features, applications of systems analysis may be divided into three groups:

- o Application to systems distinctly specialized by the characteristics of the system or by the objects within the system (e.g., water resources, industrial production, industrial trade, or health care)
- o Integrated applications, which include some or all of the above applications (e.g., energy-environment-industry or agriculture-food-population)
- o Applications linked functionally (e.g., distribution systems, allocation systems)

The lines of demarcation between these three types of application are by no means clear-cut. How one categorizes a particular application depends largely on the point of view and the purpose for which the application is being considered. Assignment to a particular category is thus not necessarily unique. In spite of this ambiguity, this section on applications has been divided into:

Specialized Systems
Environmental, societal, industrial, economic, etc.
Integrated Systems
Agriculture-food-population, territorial-industrial, etc.
Functional Systems
Distribution, supply, regulation.

As elsewhere in the outline, but even with more emphasis here, the list of subtopics is not exhaustive. In fact, it cannot be, for systems analysis is being increasingly applied to more areas of human concern.

III.1. *Specialized Systems*

- o Resources and environment
  - -- mineral resources, including energy resources
  - -- water resources, including energy uses
  - -- climate
  - -- environment
  - -- ecology
  - -- agriculture, including forestry and animal husbandry
- o Human and societal
  - -- population
  - -- urban and regional planning, development, and management
  - -- housing
  - -- education
  - -- health services: planning, organization, management of health care
  - -- social and welfare services
  - -- manpower training and placement
  - -- emergency aid
  - -- criminal justice
- o Economic
  - -- international trade and economics
  - -- national economic planning, development, and management
  - -- sectorial and industrial planning
- o Industrial
  - -- research and development (including new technologies)
  - -- planning and management
  - -- production and distribution
  - -- energy sector
  - -- petrochemicals
  - -- electronics
  - -- transportation vehicle construction (e.g., automobile, aircraft)
  - -- food distribution
  - -- textiles and clothing
  - -- nuclear energy
- o Biological
  - -- elementary biological systems
  - -- human biology and psychology
  - -- bionics: modeling of human and other biological functions
  - -- artificial intelligence: modeling of psychological functions
- o Information and computers
  - -- telecommunications and computer networks
  - -- information storage and retrieval
  - -- computer hardware and software design and choice
  - -- management information

III.2. *Integrated Systems*

- o Agriculture-food-population
- o Energy-environment-industry
- o Industry-environment-health care
- o Territorial-industrial complexes
- o Global and regional

III.3. *Functional Systems*

- o Distribution
- o Allocation
- o Monitoring
- o Supply
- o Regulation

IV. REFERENCE MATERIALS

The international exchange of information on systems analysis can be facilitated by the provision of information about the "system" through which systems analysis itself is conducted and about the specialized language of systems analysis. This has let to inclusion in the outline of three subsections: glossaries, bibliographies, and directories.

IV.1. *Glossaries*

Definitions of key terms used in various areas of systems analysis, possibly also in languages other than English.

IV.2. *Bibliographies*

Indexed listings of international publications in various systems of systems analysis.

IV.3. *Directories*

Indexed listings of individuals and organizations active in various areas of systems analysis, including those offering training programs for systems analysts and decisionmakers.

GUIDELINES FOR ACCEPTABILITY OF SERIES MANUSCRIPTS

It is difficult to spell out guidelines for acceptability of manuscripts with complete objectivity; the decision is largely a matter of subjective judgment by our various reviewers. Certainly a manuscript must deal with systems analysis, and the outline is a fairly competent guide, although it cannot specify precisely what a monograph must include to be within the domain of systems analysis -- that may depend on the way a topic is treated as well as on the topic itself. Some monographs may treat topics that are of greater interest to our international audience than others. A presentation that is isolated nationally or one that covers an aspect of systems analysis that is little used or is separated from the mainstream of systems-analytic activity will be less desirable. At the same time, topics that do not appear in the outline may be acceptable if they are sufficiently related to systems analysis. Needs and priorities of the systems analysis communities in IIASA's various National Member Organizations are also matters of concern and, again, matters of subjective judgment.

In this section of the report we attempt to provide some guidance for the acceptability of Series manuscripts, both as a further clarification of systems analysis and as an indication of features for an author to consider when proposing a monograph for the Series. Ultimately, of course, acceptance of a manuscript depends on the judgment of the reviewers: initially that of the persons who evaluate the prospectus and finally that of the referees who provide technical reviews of the completed manuscript.

EMPHASIS ON SYSTEMS ANALYSIS

The all-important criterion for inclusion in the Series is that the proposed volume be concerned with systems analysis. Systems analysis was characterized broadly in the Introduction and the detail in the outline; this section attempts a further clarification.*

There are in many nations traditions of analysis as an aid to decision-makers but these traditions are by no means identical. The stages of devel-

---

*The discussion of systems analysis that follows on pp. 27-30 is based on material presented by Roger E. Levien, Director, at The IIASA Conference held in Vienna, May 10-13, 1976.

opment differ widely in different countries, as does procedure and purpose. In some places the activity is still a field of academic research, in others it is a working tool for operating agencies; in some settings the emphasis is on the study of complex systems or issues to gain understanding; in others the emphasis is on providing direct assistance to decisionmakers. Differences exist within countries too, particularly with respect to skepticism about the validity and potential benefits. And there are differences with respect to the name. At many places, including IIASA, it is "systems analysis"; elsewhere it is "policy analysis," "operations research," "cybernetics," "qualitative planning," or possibly something else.

Moreover, there is no single paradigm or model that this activity we call systems analysis can follow. Instead, there are a number of distinct patterns, adapted to the circumstances surrounding the issue or system being investigated and the decision that the analysis seeks to help.

A common type of systems analysis is illustrated by the first study undertaken by the Ecology Project at IIASA. The problem was to design and evaluate alternative policies for the control of the spruce budworm -- a destructive pest in forests in northern latitudes, particularly in New Brunswick, Canada. These policies, to be implemented by the government, logging enterprises, and landowners, involved decisions about tree planting, cutting, and spraying. A change in policy results in a new pattern of infestation, tree growth, and harvesting that translates into economic costs and benefits for individuals, enterprises, and the government. There will also be changes in the social and recreational benefits for individuals less directly involved. Once policies had been designed, the problem became: Which policy should the decisionmaker select to achieve the most desirable consequences? The decisionmaker would ordinarily rely upon his trained intuition and the lessons of previous experience to decide upon a policy to follow. But there are severe limitations to trial and error or intuition when systems have complex interactions over long distances in space and time.

The systems analyst is able to provide useful help in this instance because ecologists and biologists are sufficiently knowledgeable about the spruce forest and the budworm to be able to predict their responses under most likely conditions. This scientific knowledge can be used by the systems analyst to create a mathematical and computer model that satisfactorily simulates the behavior of the forest and the budworm under a very broad range

of circumstances. This, then, opens the possibility of testing possible policies *in the model*, rather than *in the real world*, especially since the model can trace the forest's evolution over 150 years in less than 150 minutes.

Assuming the decisionmakers can identify "the most desirable consequences" (and if not, systems analysis can help here also), the model, with the help of various mathematical techniques, can be used to find the best policy to achieve the specified goal.

Other problems, however, involve a different sort of systems analysis -- for instance, the Global Energy Program at IIASA. Here sociological elements are involved, individuals and groups of prople whose behavior is by no means well understood by science. Systems with these elements cannot be adequately modeled as a whole and policies involving them cannot be examined in one comprehensive computer model. The decisionmakers are a very large number of independent policymakers in industry, various governments, and elsewhere whose interests by no means coincide.

Systems analysis here becomes an overlapping, interlinked series of investigations of such questions as the evolving pattern of demand, the availability of resources, the feasibility of various technologies, and the existence of constraints. And instead of a quantitative evaluation of alternative policies, there is the identification of a range of strategies responsive to different possible national and international goals. Here, as in many analyses, the desired result of analysis is synthesis -- the design of alternatives that satisfy specified demands by selecting from among various options that satisfy the constraints and best serve given goals. The systems analyst's hope must be that, armed with this knowledge, the decisionmakers will choose policies that are better not only from the standpoint of their own nations, but for the globe as well.

A third type of systems analysis might be illustrated by the attempt to help decisionmakers concerned with regional development select effective planning, managerial, and organizational policies. Here, although the conduct of regional development involves complex systems that defy realistic modeling on computers, numerous regional development activities are actually occurring at different locations. That means that the systems analyst may be able to learn about the potential consequences of different policies by examining "natural experiments" under way around the world. The testing of alternative policies in a model simulating reality is thus replaced by examination of reality itself.

These three types of systems analysis do not exhaust all the possibilities, but they do illustrate some of the variety that exists. All, however, share certain common features:

- o The purpose is to provide aid to decisionmakers in making decisions about complex issues or systems.
- o The analyst seeks, to the extent possible, to separate the determination of factual, objective information from the making of value judgments -- which is the role of the decisionmaker.
- o The systems analyst brings a broad viewpoint that cuts across the conventional disciplinary or organizational division to establish boundaries of investigation appropriate to the problem. This means, in turn, that the analysis must rely upon and draw together the knowledge and approaches of many distinct disciplines.

One of the characteristics of modern science that has underlain the development of systems analysis has been the development of quantitative and computational tools to deal with complexity and uncertainty. Many, but not all, systems analyses employ the computer or sophisticated mathematics to organize and trace the consequences of complex system interactions, to account for uncertainty, or to search for optimal policies. But despite its reliance on the findings of science and the precise tools of mathematics and computation, systems analysis remains, like science, an inherently human enterprise calling for individual judgment, skill, and creativity. Like science -- it is an art.

Although the aim of systems analysis, at least ultimately, is to assist decisionmaking, that assistance does not have to be direct. It may, in fact, be no more direct than research to provide insight into a problem or issue about which someone must make a decision later or it may even be research on methods to investigate such a problem or issue. There must be a line drawn somewhere, however, since not all applied mathematics or economics or every study of ecology should be considered systems analysis. Even though it may be possible to identify an application area for a particular theoretical analysis, that does not make it an application in the sense of implementation in the real world.

PRIORITIES AND NEEDS

With respect to the priorities and needs of the international systems analysis communities for volumes on various topics, we have very little information. What little data we have come largely from a questionnaire* circulated by the Survey Project in 1975 to analysts and managers in IIASA's member countries. Unfortunately, not all of the respondents supplied information specifically addressed to these points and, of those that did, there were almost as many opinions as respondents.

Nevertheless, from the comments and criticism we received, three areas of greatest interest emerged:

- o The analysis of analysis, i.e., epistemological and sociological studies of analytic activity; techniques of argumentation; control of the quality of analytic results; institutional factors that hinder or facilitate the use of analysis.
- o In-depth case studies, presented in a way that provides methodological insights, particularly new ones, but written in a more or less standard format.
- o Policy studies in areas of current international interest, e.g., in energy, health care systems, urban development, to bring into focus complex problem situations, reveal constraints, suggest possible lines of attack, and provide essential data and information.

There were also a number of general suggestions with respect to the Series:

- o Include the social, political, organizational, and institutional aspects of systems analysis.
- o Avoid emphasis on particular techniques. Identification of systems analysis with decision theory was mentioned several times as something to avoid.
- o Develop monographs that tend to present a more articulated and better theoretical basis for systems analysis.

---

*For an analysis of the responses see IIASA RR-76-17, *The State-of-the-Art Questionnaire on Applied Systems Analysis: A Report on the Responses*.

- Deemphasize the chronological history and development of systems analysis.

Topics suggested by the respondents and others who saw our outline are listed below, with brief comments on possible treatment.

A Historical Treatment of the Development of One or More Aspects of Systems Analysis

Even though most analysts seem to feel that the section of the outline entitled "History of Systems Analysis" should be treated very briefly, if at all, and that finding precursors is a highly controversial matter, it is not completely ruled out. For instance, the study of the development of systems analysis can be used as a good example of the practical relevance of general methodological principles. For this purpose, one might take a genetic approach (rather than a chronological approach, which so many analysts look upon with disfavor). The difference of emphasis is expressed clearly by Otto Toeplitz in the preface to his *The Calculus: A Genetic Approach:*[*]

> The historian ... must record all that has been, whether good or bad. I, on the contrary, want to select and utilize from mathematical history only the origins of those ideas which came to prove their value ... . It is not history for its own sake in which I am interested, but the genesis, at its cardinal points, of problems, facts, and proofs.

Applied to systems analysis, this approach would focus on situations whose novelty required the development of new analytic concepts, techniques, and methods. (Examples: the impact of new technology on military problems during and after World War II; the development of nationwide electrical, radio, and television networks; automation; large-scale allocation problems in the social field, etc.).

History as a Guide to Decisionmaking

An investigation is needed as to whether the use of history as a guide constrains choice among current options for dealing with parallel problems, how history should be used as a guide, and whether historical knowledge can be brought to bear in choosing policy alternatives or in improving the quality of the choice.

---

[*] O. Toeplitz, *The Calculus: A Genetic Approach*, trans. by Luise Lange, The University of Chicago Press, 1963, p. v.

Ethical Problems in Systems Analysis

Intervention into societal issues, based on the results of analysis, can create ethical problems for the analyst and the decisionmaker. The analyst needs to know how to deal with ethical questions involved in intervention, advocacy, argumentation, and what can be done when personal goals conflict with those of his client when his client's goals are not in the public interest. Thus, there is a need to develop guidelines for resolving ethical dilemmas and case studies (real or hypothetical) that pose ethical questions for analysts. There are few, if any, existing publications suitable for guiding students in how to deal with ethical questions arising in the application of systems analysis, particularly application to public problems.

The Design of Regulatory Systems

Application of systems analysis is needed in the design of regulatory systems, in which systems frequently do not accomplish the designer's goals. In choosing among alternative regulatory designs, attention must be paid to information-acquisition costs; compliance costs; the costs of avoidance, monitoring, and determining punishments for noncompliance; carrying out punishments, etc. Regulation systems are becoming increasingly important in all societies; hence, systems analysis of how to do it should be of interest.

Case Studies and the Uses of Analysis

Monographs are needed to illustrate what one can learn from case studies (other than a possible way to approach a very similar problem). Also needed are case studies to illustrate how analytic results and/or decisions are constrained or influenced by organizational structure, technological parameters, legal restrictions, or the background of the analyst. Simulated case studies that force the student to make a decision are also desirable.

Social Experimentation

Another area of interest is analysis of how to organize and evaluate very large-scale experiments (for instance, to explore alternatives for medical insurance or welfare administration), where the type of controls possible with small-scale experiments cannot be used. Experiments of this type are full of pitfalls for the analyst and decisionmaker: publicity, pressure from those excluded (or included), the desire to act on the basis of preliminary results.

The above list might be extended almost indefinitely, depending on topics that the outline suggests to a perceptive analyst or topics that prospective authors might propose to IIASA that are missing from the outline but in keeping with its spirit and intention.

Two other guidelines warrant attention.

INTERNATIONAL FLAVOR

The ideal Series volume is a monograph written jointly by authors from both East and West. If this is not possible, an international character of some sort is desirable,* even if it is no more than a projection as to how a problem might be handled in different countries or a selection of comparative examples from different countries.

INTEGRATION, NOT ISOLATION

The structure of the outline has given some respondents to the questionnaire the impression that the topics listed therein can be examined in isolation. This is not and cannot be the case, and to attempt to do so is contrary to the nature of systems analysis.

The field of interest of applied systems analysis is widespread and heterogeneous. There are many different applications and many kinds and levels of analysis. Monographs in the Series can deal with a single topic or with many topics and in various ways. One monograph might present a full systems study with attention to all its aspects from data collection to the organizational and political problems present in the implmentation process; another might deal with a single subject, say, the construction of a computer simulation to predict the location of noise contours about a source. In a case such as the latter, however, it should be considered in context rather than in isolation with examples given to show its value in the world of practical affairs. To present, for instance, a computer model designed to estimate water quality, sufficient information should be provided to enable a potential user to determine whether the model might serve his purposes. Systems analysis requires more than computer information (language, hardware, program, running time, and cost), accessibility (location), and type of output. The user needs to know the context, what is left out of the model and why, what has been done for verification and validation, the economic (op-

*It is the overall Series that requires the international balance.

portunity) cost of using this particular model, its limitations, the existence of implementation problems (social, political, and bureaucratic resistance, if any), and so on. Not every topic, however, can be presented as systems analysis even though it might deal with social, behavioral, or organizational concerns; it might be too narrowly disciplinary or be merely background material too far removed from actual systems research.

LEVEL OF PRESENTATION

The practitioner to whom the Series is primarily directed is not a member of a narrowly defined professional group, for systems analysts may have backgrounds that vary from law, political science, and sociology to economics, engineering, and mathematics, with most coming from the last three categories. It is not the editors' intention that every practitioner is able to read and understand every volume that appears in the Series or every article in the Handbook; it should be sufficient that a large precentage of the potential audience is able to understand and appreciate a correspondingly large percentage of what is written.

What, then, should be assumed about the "typical" reader? We have in mind a practitioner who holds a baccalaureate degree in economics, mathematics, statistics, operations research, or industrial engineering. He would have completed college courses on calculus and matrix algebra, applied or mathematical statistics and probability, an elementary course in computers and programming, a course in the techniques of operations research, a course in economics, and possibly a study of some functional or application area. He will very likely have had some graduate work and some practical experience.

In general, authors should keep the sort of background described above in mind in deciding what technical terms should be defined or when the reader should be referred to another (readily accessible) source for definition or elaboration. The Handbook, when completed, will contain a glossary.

While it might be possible to achieve a uniform level of presentation, it is certainly not desirable in the Series and probably not in the Handbook. We expect these publications to be of interest throughout the world to a diverse collection of people, largely analysts but also students, teachers, managers, and scientists, whose fields are not systems analysis.

PREPARATION OF PROSPECTUSES

The Survey Project has developed guidelines to advise authors who might wish to prepare prospectuses and manuscripts for publication in the state-of-the-art Series. Prospectuses submitted for consideration can be handled expeditiously if they are prepared in the form described here.

FORMAT

Cover Page

The cover page for the prospectus should contain the title of the proposed volume, the proposed authorship (with co-authors listed, if appropriate, or editor/compiler(s) if it is to be a volume with contributions prepared by others under the editor/compiler's supervision), and the date of submission.

First Page of Text

The first page of the text should repeat the title and authorship at the top before the text begins.

The Text

The text should be in English, typed double-spaced, on one side of the page only. Allow ample margins at all edges (about 1" or 3 cm. is desirable).

Length

Length is arbitrary, depending upon the topic and the amount of space required to describe adequately the nature of the subject. Our experience has been that prospectuses of 10 to 20 pages are sufficient to cover most of the information needed for decision.

CONTENTS

The material contained in the prospectus should be presented with an international audience in mind. Reviewers who evaluate these prospectuses will be practitioners of systems analysis who are familiar with the partic-

ular topic, but a reviewer in one country, for example, may not be acquainted with the specialized jargon or acronyms of a prospectus author from another country. Provide explanations where necessary.

Headings

Major, first-level headings should be set off in capital letters and underscored to label clearly the material included under them. Any consistent system is acceptable for second- and third-level headings; the system used in this report can serve as an example.

Included among the headings should be the following:

Background

An indication of how the topic has been developed -- what has (or has not) been done in the field, a brief historical account of scientific achievements, findings pertaining to the topic, experiments or results of research in various parts of the world to date.

Purpose

The task an author hopes to accomplish in producing a volume (for example, to present a concept or theory and its verification in a unified way when it has not been done before; to give a few selected, detailed examples of its application in several different contexts, etc.).

Importance of the Topic

A statement of the significance of the topic or problem -- the need for the volume and its possible use by scientific communities.

Audience

The groups of persons the author would address -- practitioners, decisionmakers, managers, government officials, urban planners, agricultural researchers, etc.

Outline of Chapters

It is desirable to have, in addition to a general overview and discussion of the component chapters, a detailed, separate outline that provides as much subdivision as necessary to clarify specifically what the individual chapters will contain. If the volume will have contributed chapters from other authors, and their willingness to contribute has been

or will be obtained, indicate this together with their names and countries in parentheses in the detailed outline.

Time Schedule

An approximate time schedule for completion of the volume should include, when an estimate can be made, target dates for the various stages or milestones in its preparation (for example, probable date for completion of data gathering, data processing, analysis; completion of theoretical work; applications or descriptions of case studies). If authors have previous commitments that will delay the beginning of the work or the progress of the volume, it should be noted here.

References

A list of references used in the preparation of the prospectus should be attached, preferably numbered to correspond to superior numbers that mark the citations in the text. Include in the references previous publications related to the topic as well as documented surveys, results, or applications that pertain -- East and West -- wherever possible. Examples of the preferred style of listing references are as follows:

Book

Dantzig, G. B., *Linear Programming and Extensions*, Princeton University Press, Princeton, New Jersey, 1963.

Journal Articles

Zelinsky, W., "The Hypothesis of the Mobility Transition," *Geographical Review*, Vol. 46, pp. 219-249.

Indicate, when listing a title in a foreign language, the language of the text; for example, "Einfluss des Spin-Paramagnetismus der Elektronen auf Supraleiter kurzer freier Weglänge," (in German), Ph.D. Thesis, University of Karlsruhe, Federal Republic of Germany, 1967. Cite an English version if it is available.

Refer to a manual of style for special problems such as translated editions, proceedings, or government reports and documents.

Biographical Information

A brief but informative one-page biography should be included for each volume author, co-author, or editor/compiler (chapter contributors to an editor/compiler's volume should not be included). Biographies should include statements of educational background (specific degrees held, universities, and years received), past and present experience and affiliations, research interests, and a current list of publications.

Appendix

CHECKLIST: SUMMARY OF PROCEDURES IN THE DEVELOPMENT OF A SERIES VOLUME

When the prospectus for a Series volume has been received it will be checked by the Survey Project editors, whose main concern is to ensure that publications meet a high standard of quality in general and, more specifically, that they effectively and clearly communicate to the intended audience the substance of the proposed volume.

DISTRIBUTION TO NMO LIAISON COMMITTEES

Several experts in the topic under consideration in each of the NMO countries will have the opportunity to give their opinions on the prospectus by filling in a one-page evaluation sheet and returning it to the Survey Project editors.

COMMISSIONING THE VOLUME

If the evaluation of the proposed volume is positive, a contract will be drawn up between IIASA and the author (editor/compiler). This contract for publication is dependent upon the favorable reviews of the referees when the manuscript has been completed.

WRITING THE VOLUME

The Survey Project's editorial staff will assist authors by providing guidelines for the preparation of manuscripts and illustrations, technical editing, and will help in other ways mentioned previously, e.g., by assisting in the development of data and contacts in the NMO countries and elsewhere, and possibly providing support for a workshop to coordinate efforts in the case of a volume with multiple authors from different countries.

TECHNICAL REVIEW

When the completed manuscript is received by the Survey Project, it will be subject to technical review by at least two reviewers who are experts in the subject. The Survey Project editors, in consultation with the Editorial Board, will examine the manuscript in the light of the re-

viewers' comments and decide whether or not it should be included as a volume in the Series. If the decision is positive, the manuscript, together with the comments of the reviewers, will be returned to the author* for any necessary revisions.

REVISION AND EDITING

After revision of the manuscript by the author and a check by the Survey Project staff to ensure that there has been adequate response to the comments, the revised draft will be assigned to a technical editor from the Survey Project to check for exposition, readability, and style. The editor assigned to a manuscript will consult with the author or editor/compiler directly if there are questions or problems.

PRODUCTION OF FINAL COPY

The author will receive a copy of the edited original text and an attachment for recording approval. The final page proofs will be read by the editorial staff and checked for typographical errors.

PUBLICATION AND DISTRIBUTION

The volume will be published and distributed by John Wiley & Sons Ltd., through their international network. Authors will receive a short questionnaire form to provide suggestions regarding the marketing and promotion of their volumes. Publication should follow approximately three to four months after the camera-ready copy is received by the publisher.

---

*If the decision is made that the volume is not acceptable, the manuscript, together with comments by the reviewers and the Board, will be returned to the author, accompanied by a letter that explains the decision.