HANDBOOK OF SYSTEMS ANALYSIS

VOLUME 1. OVERVIEW

FRONT MATTER

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NOTE

The International Institute for Applied Systems Analysis is preparing a Handbook of Systems Analysis, which will appear in three volumes:

- Volume 1: Overview is aimed at a widely varied audience of producers and users of systems analysis studies.
- Volume 2: Methods is aimed at systems analysts who need basic knowledge of methods in which they are not expert; this volume contains introductory overviews of such methods.
- Volume 3: Cases contains descriptions of actual systems analyses that illustrate the diversity of the contexts and methods of systems analysis.

Drafts of the material for Volume 1 are being widely circulated for comment and suggested improvement. This Working Paper is the current draft of the front matter for this volume. Correspondence is invited, and should be addressed to the undersigned.

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HANDBOOK OF SYSTEMS ANALYSIS

Volume 1. Overview

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FOREWORD

The International Institute for Applied Systems Analysis (IIASA) is a nongovernmental interdisciplinary research institution located in Laxenburg, Austria. It was founded in October 1972 on the initiative of the academies of science or equivalent institutions of twelve nations (these National Member Organizations now number seventeen). By applying the approach that has come to be known as systems analysis, it works to understand important problems facing mankind today and contribute to their solution. Solving these problems—of energy, food supply, and the environment, to name a few—requires joint efforts of many constituencies, including scientists from many disciplines and countries of both East and West.

Since systems analysis is at the core of what IIASA does, it is natural for IIASA to think generically about this subject, as well as to use its approaches, tools, and results in its work. This *Handbook* —originally proposed to IIASA by the National Member Organization from the USSR in 1974—is one result of this generic concern. It aims to be both an expression of IIASA's concern for the growth and proper use of systems analysis and a tool that will find wide use in the world community of systems analysts and their clients.

All of IIASA's National Member Organizations have contributed to this *Handbook* through contributions from their scientists and critical reviews of the

manuscript. Many other persons have contributed to its preparation as individuals. To all who have helped, IIASA owes a debt of thanks. May the usefulness of this *Handbook* to the worldwide community offer them extended repayment for their efforts over many future years, as systems analysis continues to expand its contributions to understanding and solving important problems of the world society of which we are all a part.

PREFACE

Operating systems in which human beings are important parts have been part of human societies since before the dawn of human history, but they have only come under the systematic scrutiny of scientists in this century. Before 1935 the inquiries into such systems were few, scattered, and limited in scope. However, the years since 1935 saw a rapid growth in such investigations, encouraged by the successful work that took place during the second World War.

This work developed scientific knowledge of the behavior of such systems, a technology to put such knowledge to work, and a group of professionals with the relevant skills. The success of this work—often called operations research—led to a significant expansion of its scope, so that by the middle 1950s it was not uncommon for very large operating systems to be investigated with a view to improving their operations, or designing new ones to meet desired objectives. This enlarged purview necessitated bringing into the work specialists from many disciplines, so that it was not unnatural for the community doing the work to coin a name for it: systems analysis. The ensuing quarter century has seen growth in both the scope and diversity of systems analysis.

Thus, by 1980 the International Institute for Applied Systems Analysis could view the subject in this way [IIASA 1980]:

> Many of the functions of society involve structures that can be thought of as systems combining people and the natural environment with various products of man and his technology. Such complex sys-

tems abound in modern society, and their operations present many problems.

The elements of such complex systems exhibit many forms of complicated behavior. However, it sometimes happens that regularities in this behavior can be discerned, and scientific scrutiny has yielded much knowledge about these regularities. Thus, many problems that arise in these systems can be addressed by focusing such knowledge in appropriate ways by means of the logical, quantitative, and structural tools of modern science and technology. The craft that does this we call applied systems analysis; it brings to bear the knowledge and methods of modern science and technology, in combination with concepts of social goals and values, elements of judgment and skill, and appropriate consideration of the larger contexts and uncertainties that inevitably attend such problems.

Thus, the central purpose of systems analysis is to help to solve the problems of complex systems by generating information and marshaling evidence bearing on these problems, and, in particular, on possible actions that may be suggested to alleviate them.

Systems analysis can be applied to a wide range of highly diverse problems, and the patterns of analysis exhibit a corresponding diversity, depending on the context, the possible courses of action, the information needed, the accompanying constraints and uncertainties, and the positions and responsibilities of the persons who may use its results. In a rare case, a problem may fall within the sphere of responsibility of a single policy maker; h wever, it is far more usual for the relevant responsibilities to be diffused among many persons, often with significant portions of the problem lying outside existing authorities.

However, this diversity of activity has also spawned a diversity of names under which work that can be described this way is done: operations analysis,

policy analysis, policy science, evaluation research, systems research, and others.

For a field exhibiting such rapid growth and diversity—even in its basic nomenclature—is the concept of a handbook a meaningful one? With so many ramifications, and so many extensions going on in so many new directions, is it possible to take a snapshot of the state of the art that will have enduring value? If the answer is "yes," what should such a handbook be?

The key to arriving at positive answers to these questions is twofold: to restrict the attention in the handbook to the central core of the field as it now exists based on extensive experience, avoiding the temptation to stray into the many attractive and promising new branches; and to provide a challenging perspective of the future opportunities as yet unexplored, while at the same time offering normative standards of quality and substance where experience warrants.

Thus, we have centered the attention in this *Handbook* on sociotechnical systems, that is, those that "involve structures that can be thought of as systems combining people and the natural environment with various products of man and his technology." This is the context in which most systems analysis work has been done so far. It is one in which man as an individual is free to dominate only to a limited extent; the systems where he becomes dominant are only beginning to be explored, with experience in too early a stage to allow a handbook synthesis [with Checkland 1981 providing a notable exception].

We have found that, for this context of sociotechnical systems and the systems analysis work that has investigated them, it is possible to compile a summary of the main currents of knowledge and practice, accompanied by a view of the future potential of the field. This *Handbook* is the result.

Since systems analysis as it is presently practiced—and is likely to be for the foreseeable future—combines both old and new knowledge to evolve solutions

to problems of operations, policies, and planning, the audience that needs information about it is extremely varied, ranging all the way from technical specialists to intelligent nontechnical citizens with public concerns. Thus, we have divided the *Handbook* into three volumes:

Volume 1. Overview is aimed at a widely varied audience of producers and users of systems analysis—administrative officials, legislators, scientists and technologists in other fields, public-interest groups, and concerned citizens, as well as systems analysts; to keep it accessible to this broad audience it avoids the technicalities of scientific and technological tools. To attract their interest it uses a number of important examples of successful system analysis work as its chief point of departure.

Volume 2. Methods is aimed at systems analysts who need basic knowledge of methods in which they are not expert; it contains introductory overviews of such methods as have emerged as peculiarly appropriate in systems analysis. Thus, it is also useful to other technologists who may wish to acquire an introduction to them. However, it avoids treating methods that, although useful in systems analysis, are adequately treated in other handbooks—such as the *Handbook of Operations Research* [Moder and Elmaghraby 1978]—or other central sources.

Volume 3. Cases contains extended descriptions of actual cases in which systems analysis was used; thus, it illustrates the diversity of problems and approaches that have been encountered in systems analysis. While some attention is paid to technical details, so that the analyst has a view of how the results were arrived at, as well as what they were, the descriptions are written so as to be also accessible to nontechnical readers who will skip the technical details.

The work of preparing this *Handbook* has shown us that there is a great deal of existing knowledge (badly scattered, however, in the literature), that there is a substantial body of practice (also badly scattered, and poorly documented into the bargain), and that the prospects for the field are only dimly perceived in many quarters. Thus, at this early stage a handbook has an important

opportunity to bring the central core of knowledge together in systematic form, to establish foundations for the further growth of systems analysis, to map its potentials, to indicate open questions and challenges, to offer guidelines for future development, and to provide a source of valuable information for actual and potential clients for systems-analysis studies.

This *Handbook* has been aimed at these purposes, and was prepared in the hope that it would serve them well enough to contribute significantly to the growth of systems analysis. If this goal is met the contributors will be more than amply rewarded; they have worked in the belief that systems analysis, properly developed, can make important contributions to solving the important sociotechnical system problems that the world will face over the next several decades.

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