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Handbook of Systems Analysis: Volume 1. Overview. Chapter 5. Formulating Problems for Systems Analysis

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HANDBOOK OF SYSTEMS ANALYSIS

VOLUME 1. OVERVIEW

CHAPTER 5. FORMULATING PROBLEMS FOR SYSTEMS ANALYSIS

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FOREWORD

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 and other members of systems analysis teams 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 Chapter 5. Correspondence is invited.

Volume 1 will consist of the following ten chapters:

1. The context, nature, and use of systems analysis
2. The genesis of applied systems analysis
3. Examples of applied systems analysis
4. The methods of applied systems analysis: An introduction and overview
5. Formulating problems for systems analysis
6. Objectives, constraints, and alternatives
7. Predicting the consequences: Models and modeling
8. Guidance for decision
9. Implementation
10. The practice of applied systems analysis

To these ten chapters will be added a glossary of systems analysis terms and a bibliography of basic works in the field.

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CHAPTER 5. FORMULATING PROBLEMS FOR SYSTEMS ANALYSIS

P. B. Checkland

1. INTRODUCTION

As he begins a new study, a systems analyst can usefully write down, as his first contribution to the work, the sentence from science-fiction writer Poul Anderson that Koestler (1969) calls "my favorite motto": "I have yet to see any problem, however complicated, which, when ... looked at ... the right way, did not become still more complicated." It is not intended to be a flippant opening remark, but rather a useful reminder of the essential nature of a mode of inquiry that aspires to use rational means to help bring about change in the world's sociotechnical systems. Systems analysis aims at results that affect complex human operating systems, and the analyst does well to remind himself that he is dealing, at least in part, with creatures who, in themselves and their interactions with each other and their surrounding environment, often exhibit a level of complexity far beyond what his intellectual weapons can cope with. So he is well advised to approach his task circumspectly, recognizing that his activity, while carried out in the spirit of science with a view to achieving testable results, is rather a form of social architecture.

Because the systems analyst addresses problems of real-world sociotechnical systems, in considering how to formulate problems he must realize how this context differs from that of classical science and technology, where the laboratory is a natural domain (Checkland 1977). In the laboratory a scientist reduces the variety of factors that he must consider, and thus is in a position to define with some precision the problem that he proposes to work on; with considerable arbitrariness he can decide which factors to vary and which to keep constant, and where to draw the boundary around his investigation.

On the other hand, the position of the systems analyst is quite different. His problems arise in the real world, the phenomena he wishes to investigate cannot be taken into a laboratory, and they are usually so entangled with many factors as to appear to be linked inseparably with them. Thus, an apparently simple technical problem of transportation becomes a land-use problem, which is seen to be part of an environment-conservation problem—and all of these matters are now issues of political choice as much as they are of technical analysis. As the problem widens, do all of the wider factors of necessity become part of the original problem? Can any boundary be drawn? Can the analyst justify the limits that practicality forces him to impose? An analyst trained in the methods of science who wishes to extend them as far as he can into the problems of sociotechnical systems thus faces an important challenge, one that Churchman (1968) calls the "challenge to reason."

In fact, the systems analyst, seeking to contribute to real-world decisions, always finds himself facing, not a well defined problem, but a problem area or situation; his problem turns out to be a nexus of problems, what the French refer to as a "problématique," or what Ackoff (1974) calls "a mess."

The systems analyst's problem arises because someone feels that something in the real world needs changing, and decisions need to be taken to move it away from an unsatisfactory position. But, whether the decision makers perceive and state the problem in precise terms ("Which vehicle design should be adopted?"), or merely indicate an area of concern ("How can we design a better health-care system?"), the analyst knows that he faces an expanding network of concerns, institutions, actors and values.

While his mode of thought and discourse follows the pattern, insofar as possible, of the public rational discourse of science, he should prudently avoid two pitfalls: In his initial task of problem formulation, he should avoid committing himself to a single point of view, and he should avoid thinking too quickly in terms of possible "solutions."

At the end of the problem-formulation phase of the work, the study outline, at least in its first form, is clear. The problem area has been explored and the main issues defined. The client of the study has a clear appreciation of what kind of work he can expect in subsequent phases, what kinds of alternatives will be examined, what kinds of criteria will be used to judge them, what major relations exist within his decision-making situation, what kinds of risks he is taking. All this has been made clear and, importantly, it has been expressed in explicit issue papers and other documents.

Since the systems analyst is dealing with a problématique, he is not surprised when the eventual outcome of his work strays somewhat from what he anticipated in his initial problem formulation. His process of inquiry will itself educate, and thus possibly lead to changes in outlook or modified values, even changes in the situation itself. The situation may also be changed by new external factors emerging during the course of the work. However, if the analyst has made his initial formulation clear and explicit, then it will be possible to adjust both the problem boundaries and the crucial issues realistically and coherently. It is in the nature of systems analysis that the process of carrying it out continually enriches the perceptions of the problems, and iteration to previous phases of the analysis is frequent, as Chapter 4 brings out. Thus, the analyst should formulate the problem so as to facilitate reformulation. This point is important because the work done at the beginning determines the shape and content of what is done later.

The next section discusses the concepts the analyst needs in order to formulate a problem, and the one that follows it deals with organizing the formulation activities. The final section summarizes the conclusions reached.

2. FORMULATING THE PROBLEM: THE CONCEPTS

As the systems analyst begins his work—cautiously because his initial aim must be to appreciate the context of his study without imposing a rigid structure upon it—he must have available a number of concepts relating to the idea of formulating a problem. Since an awareness of these concepts must precede and inform any use of prescribed activities, this chapter describes them before discussing an operational sequence of activities appropriate to the problem-formulation phase of the systems analysis.

Problems and Problem Solving. Since systems analysis aims to generate and present information in order to improve the basis upon which decision makers exercise their judgment, a setting in which this approach is being used will have players with two different roles: a problem giver, the would-be decision taker who welcomes aid as he tackles his problem, and a problem solver, here the systems analyst, who aims to improve the basis for decision making. It is possible, of course, for one individual to occupy both roles: a systems analyst may adopt the approach to problems he has himself; or a decision maker may carry out his own systems study. Nevertheless, it is important to distinguish between the two roles and to be aware of the relations between the problem itself and the effort to alleviate or solve it. Each affects the other. For example, the problem content implies the problem-solving resource requirements, which may be a factor affecting the boundaries chosen for the problem's formulation.

In any systems analysis, then, we may assume that there is a problem content and a related problem-solving activity. Since any real-world problem is a problématique, and since problem solving is a net of different but connected activities, we may refer to a problem-content system and a problem-solving system. These systems contain the roles of problem giver and problem solver, respectively.

With this general model for any systems analysis, the problem-formulation phase is an elaboration of it for a particular issue and a particular problem-solving activity. The problem-formulation phase defines the problem-content system (what its boundaries and limits are, what is inside and what is excluded) and the nature of the problem-solving system and its resources. Finally, the relations between the two have been examined, in order to ensure that there is a reasonable balance between the task and the available resources. The problem-formulation phase will describe the problem and examine the implications of doing something about it. The task of resolving the issue, making the decision, or solving the problem can then begin.

This general model of systems analysis is the first concept appropriate to the analyst. The second is an awareness of different problem types and their characteristics; the problem spectrum stretches from well-defined problems, which I shall term "hard," to ill-structured problems which, following Rapoport (1970), I shall term "soft."

Systems analysis had its origins in relatively well-structured problems calling for expertise in economics and technology (as described in Chapter 2), but its aspirations are to help decision making in a very wide range of problems, not excluding those in which, as Quade (1975) puts it, "a decision is made by society for itself . . . or for society by its elected representatives—decisions . . . that have material effects on individuals other than those involved in making the decision." Indeed, the aspirations extend to making substantial contributions to problems on an international scale that are, in Raiffa's terms (1976), "politically sensitive." Analysis aimed at improving the basis for decision making for public decisions of this kind will always involve problems of the soft variety. It is important for the analyst to retain a sense of the hard and soft elements in any study he undertakes, and avoid treating one as if it were the other.

Although the terms "hard" and "soft" are difficult to define precisely (and we probably ought to resist defining them too sharply, since their role is to remind the analyst of connotations, rather than to provide a formula) we can get an insight into them from the history of systems analysis. Examination of the literature of systems analysis as it emerged within the Rand Corporation—as well as the literature of the closely-related systems engineering—shows that both activities were based on the same model of what constitutes a problem (Checkland 1977). Both take it that problems may be posed as a matter of selecting an efficient means to achieve a defined end. Hence, problem solving becomes a matter of defining objectives and creating possible means of achieving them with criteria to measure their effectiveness. This is an exceptionally powerful idea, and it has supported most systems analysis successfully. But a systems analyst who aspires to tackle problems in the public arena—problems of energy, health-care systems, or urban renewal, for example—will necessarily have to ask: What makes the objectives meaningful? What are the values they embody? Whose values are they? What other values may be expressed in other objectives? Work on the philosophy underlying systems analysis (such as Churchman's 1968, 1971) and on its application in soft problems (see, for example, Checkland 1973) shows how quickly such questions assert themselves, even in studies that might at first inspection seem to be well defined.

Hard problems are ones that may be posed as selecting a means to achieve desired objectives, a formulation that leads to problems having relatively sharp boundaries and well-defined constraints. Appropriate information flows for the decision process are capable of clear definition, and, most important, what will be recognized as "a solution" to the problem is clear. All this contrasts with the content of soft problems, which may be defined as ones in which all these elements are themselves problematical. Here no objectives are clear, some important variables are unquantifiable, and the analysis will necessarily have to include examining the value systems underlying the various possible objectives.

A given study is likely to contain both hard and soft aspects: real-world problems rarely fit entirely into any predefined category. But it is important for the analysts in the problem-solving system to keep the two concepts clear in their minds. They may then formulate the hard aspects with precision, marshaling the appropriate intellectual tools (often quantitative ones), and make the appropriately different kinds of explorations of the softer aspects. Doing this explicitly does not guarantee that the systems analysis is a good one, but it at least makes possible the examination of a significant piece of decision making in the spirit of science, which is the aim of systems analysis.

The significance of this hard/soft separation is nicely illustrated by Kahn (1960) in an account of the development of the early thinking in the Rand Corporation:

> In the early days at Rand most studies involved an attempt to find the "optimum" system, given some reasonably definite set of circumstances, objectives and criteria.

But then occurred a "technological breakthrough." A new viewpoint emerged, and softer considerations became paramount:

> We now tend to compare a rather small number of different systems under widely varying circumstances and objectives. No simple criteria of performance are used. The major attention is focused on the uncertainties. A system is preferred when it performs reasonably well under probable circumstances in terms of high-priority objectives, and yet hedges against less probable or even improbable situations, and does more than just pay lip service to medium- and low-priority objectives.

The conclusion is that it is important to realize that

> ...overall planners must design from the beginning for the complete range of plausible objectives.

An interesting illustration of the relevance of this important (but hard-to-follow) advice occurred when a colleague and I made a presentation to a decision-aiding group associated with high levels in the government of a Western European country, the kind of group frequently described as "a think tank." They described how they would analyze an ill-structured problem and produce a report or make a presentation which analyzed several possible courses of action and the likely consequences of following them. Their lament was that, when a government decision in the area was taken some months later, it always turned out to be taken "for purely political reasons," rather than on the basis of their analysis of alternatives! In their striving for objectivity and, where possible, quantification, they had failed to notice that, in a study whose clients are professional politicians, Kahn's "complete range of plausible objectives" includes, high on the list, political objectives. The political consequences of their analyzed courses of action were a legitimate part of all of their problem-content systems—but one they had tended to ignore.

Exploring the problem area. The distinctions between the problem-content and problem-solving systems and between the hard and soft problem types are important general ideas that should guide the investigations in the problem-formulation phase. At a more detailed level there are now a number of other considerations to be discussed; they concern the concepts that the investigation should weld into a coherent whole.

The map-making activity of problem formulation focuses on a problem situation in which there is a decision maker and a client for the study; the latter may or may not be the decision maker himself, but he wants something done about the problem and commissions the study. The decision maker and his problem situation exist within an environment that affects both, and that the decision maker can himself affect to some extent. Considerations arising as part of the problem situation or the environment place limits and constraints on both the problem and the decision maker and the problem-solving effort. These concepts and terms all need more detailed consideration.

The problem situation may be perceived by the client, the decision maker, and the participants in the situation in different ways. But the perception of a situation as problematic implies that there is a recognized need for action to change things, and the systems analyst's task is to build a rich picture of who perceives what kind of change to be necessary and for what reasons. His own position should be one of disinterest. The analyst's response to client, decision maker, and participants alike, as he asks questions and explores their perceptions, should be neither "I agree with you" nor "I disagree," but rather a response in the sense of "I hear you." Questions that the analyst can usefully ask at this stage are of the following kinds (see also Jenkins 1969, Pogson 1972, Quade 1975):

- What is said to be the problem? Why is it a problem? How did it arise? What previous actions have led to it?
- Who believes it to be a problem?
- Why is it important to solve it?
- If an analysis is made, what will be done with it? Who might act on the recommendations?
- What would a solution look like? What sort of solution is at present regarded as acceptable? What kinds of changes would a solution imply?
- Of what larger or deeper problem is the stated problem a part? What are the implications of tackling the problems related to the stated problem?
- Does it seem likely that there will be a positive return (in the problem-content system) for the effort spent in the problem solving? Where else may the analy tic effort be applied?

There is a general set of questions concerning resource deployment that can usefully follow the ones just posed (if it can be answered in detail, then the analyst has a reasonable initial knowledge of the structures and processes in the problem situation):

> What resources are deployed in what operational processes under what planning procedures within what structure, in what environments and wider systems, and by whom; and how is this resource deployment monitored and controlled?

It has been found that the ideas of "structure" and "process" are very useful guides in obtaining a rich picture of the problem situation without imposing a spurious pattern upon it in the way that technique-oriented approaches frequently do. (The queuing theory fanatic will always see the problem situation as a queuing problem!) Structure means the elements that do not change over a short time span such as, for example, the physical structure, the organizational structure, and the formal and informal reporting/communicating structure. Process means the elements that by their nature change continually (and/or continuously); in any organizational context these may be analyzed in terms of basic activities: planning to do something, doing it, monitoring how well it is done and its external effects, and taking action to correct deviations. More subtle, but a core characteristic of any problem situation, is the relation between structure and process, the "climate" of the situation. Many problems are problems of mismatch between structure and process; it is worth pondering and repondering this relation as familiarity with the situation increases. In one study I carried out in an engineering company that was organized functionally, prestige and power went with demonstrated technical competence within, for example, the Electrical Systems Section or the Procurement and Purchasing Department, but the organizational task overall was a project task, creating a new aircraft. The processes associated with this task did not match the functional structure, but middle-manager enthusiasm and commitment enabled unsuitable structures to survive. The problem posed was one concerning the need for improved information flow between the Design Department and other functions; but the real problem was the structural one, and the structure/process analysis revealed this clearly.

Building knowledge of the problem situation in this way enables the analyst to begin forming a view on a possible direction for his work, that is, a perspective on the work to be done within the problem-solving system. Is it to present alternatives (and their implications) among which a decision maker can choose, a "satisficing" solution feasible under various likely uncertainties, or is it to recommend a single specific solution arrived at by formal optimization procedures? In other words, the analyst will have decided on whether the problem is hard or soft, or whether it is to some extent both. This is crucial to the task of assembling an appropriate study team.

Exploring the problem situation in the way described will, of course, reveal much about both the client who initiates the study, and the decision maker whose purposes will be served by it. It will tell the analyst about the perceptions of the problem that client and decision maker have, and about their expectations for the study. To focus on client and decision maker in this way is to focus on their objectives, and hence on any other objectives that may be present in the problem situation. It is useful to remember Kahn's statement (1960) that conflicting objectives are "an essential of good planning." Although the analyst will pay much attention to the client's and the decision maker's stated objectives, systems analysis should not assume that client and decision maker actually know explicitly what their objectives are. The decision to undertake a systems analysis implies that objectives are to be debated, and examining the roles client and decision maker by examining their objectives must include examining objectives counter to those most readily stated. Asking "whose objectives would these counter-objectives be?" initiates analysis of the political process through which the action to be taken will be decided. If the analysis concerns a matter of public policy within a climate of public debate, then skepticism concerning the decision maker's stated objectives is essential; the broader the policy issue under review, the more skeptical one should be. Concerning such high-level objectives, Hitch (1960) reminds us:

> Even in the best of circumstances ignorance and uncertainty about high-level objectives make reliance on official definitions a precarious procedure. We know little enough about our own personal objectives...National objectives can only be some combination or distillation of the objectives of people who comprise (or rule) the nation; and we should learn to be as skeptical and critical of the verbalizations and rationalizations that pass for national objectives as we have learned to be of apparent or claimed personal objectives.

This is no less true of objectives stated for problems of smaller organizations.

The scale and time dependence of objectives are other important aspects to be examined. For a study carried out by one of my colleagues, the client was a holding company, and the decision makers were the managers of one of the constituent companies of the group. The issues concerned launching a new product that would take the company into a new market and a new kind of business. The decision makers had a number of specific local objectives related to the new product, linked to a relatively short time scale of one or two years. But the relation between the client and the decision maker in this study illustrated sharply that these objectives were themselves part of a larger objective tree, the higher levels of which concerned less concrete objectives (the new shape of the company's business) over a longer time (5 to 10 years). These more abstract and more distant objectives and purposes were very much a part of the problématique.

Clients and decision makers (and analysts!) can rarely define a hierarchy of objectives at the start of a study; part of its purpose is to debate possible hierarchies and to elucidate and compare possibilities. If, on the other hand, the roles of client and decision maker, together with their relevant objectives, are clear and unequivocal, and resist challenge, then the study—by definition now "hard"—is more likely to involve, not debate and satisficing, but formal optimization.

The problem situation, which contains the study client and those who will make decisions in order to resolve the problems, is itself located in a number of environments, some of which are concrete, and some others of which are abstract; all are important in the analysis as a source of influences, possibilities, and constraints. The first point to note is that an environment is somehow "outside" the problem situation; that is to say, it is outside both the problem-content and the problem-solving systems. In other words, there must be boundaries between the systems that are the analyst's prime concern and the environments in which the systems are embedded. If we can define a system's boundaries (and there may be a number of different kinds), then we have said something important about the system's environments. Churchman (1971) suggests a method of doing this formally that I have found to be a useful practical idea in a number of studies. He suggests that the decision-maker role be defined by the precept that the decision maker has control over what is within the system. The boundary of the system encloses the set of things (physical and concrete) over which decision-making control can be exercised. An item outside the decision maker's control is by definition in the system's environment. In soft systems studies it is frequently illuminating to plot boundaries based on this definition and to compare the outcome with decision-making responsibilities in the real world. Problems in organizations often stem from a failure to match institutionalized system boundaries (the areas of responsibility of sections, departments, and so on) with actual managerial decision-making authority. Experience suggests that the existence of a role of "coordinator" is quite often an indicator of the existence of a mismatch of this kind.

Optner (1965), writing on business problem solving with the idea that business operations constitute a system, defines the environment as "a set of all objects, within some specific limit, that may conceivably have bearing upon the operation of the system." Since he allows that the "objects" may be abstract or concrete, this is a frightening definition for the systems analyst! Hall (1962), who is more technologically oriented, but otherwise writes in the same vein, points out the importance of the environment in this way:

> Opportunities for new systems arise in the environment. Boundary conditions for new systems are determined by the environment. Facts for making all kinds of decisions come from the environment, as do all the resources needed for new developments.

He goes on to urge examining the physical and technical environment, the economic and business environment, and the social environment; to these, for most systems analyses, we may add the political and legislative environment, as well as the sets of attitudes, values, and standards of judgment—what Vickers (1965) terms the "appreciative" environment—that will profoundly affect what is possible and what is not.

Obviously, the systems analyst must pay great attention to the environment surrounding the problem situation; equally obviously, the full variety of all relevant environments cannot possibly be absorbed, and some means of reducing the potentially overwhelming inflow of information has to be found. This is a fundamental problem of the whole problem-formulation phase, and I shall return to it shortly. But at this stage we may note that the other major idea relevant to exploring the problem is here extremely useful: the idea of limits and constraints on the study. An initial scanning of environments may be done by regarding them as sources of constraints on the study that are "given," either because they are fundamental natural characteristics (such as physical limits imposed by geography), or because they are beyond any powers that the identified decision makers possess or are likely to possess in the future. Laws, for example, are not permanent and may be changed over a period of time. But in most studies the legislative environment is one that is given; knowing the limitations and restrictions it imposes may reduce the analyst's task, and help to define a solution.

Defining other limitations on the study is less straightforward when they derive from less explicit sources: convention, tradition, or common practice. Here the mood is one of impatience with such restrictions, and the analyst

> should seek to establish the boundaries of the issue under investigation where thought and analysis show them to be and not where off-the-cuff decision or convention, whether established by government jurisdiction, academic tradition, or industrial practice, would have them be (Quade 1975).

What is most important of all is that the analyst should record at various times what he is accepting as limitations and constraints. Only if this information is clearly recorded will it be possible later on, as knowledge increases and perspectives change, to redefine limitations with clarity, or to lift constraints so that the implications of doing so can be explored coherently.

To summarize the ideas relevant to the problem-formulation stage of a systems analysis: In a perceived problem situation there is a client who causes a study to be carried out and there are decision makers. The problems perceived may be hard or soft or—most frequently, perhaps—a mixture of both. There are possible definitions of the relevant problem-content system, these depending upon decision makers' objectives, either explicitly stated or implicit in the situation. Such systems are affected by a number of environments that are a source of constraints on what can be achieved. The aim of problem formulation is to explore the study situation, making use of these ideas, so that a study outline can be prepared.

Now it is obvious that these concepts are related to each other, and that it is in fact not possible to examine any one of them in isolation from the others. This is the fundamental problem of the problem-formulation phase. The choice of decision-maker determines which systems and which environments are relevant, and hence what constraints there are on the study. Decision makers' objectives are affected by various environments, but also themselves affect these environments, and so on. The important consequence of these interactions is that it is essential that problem formulation be carried out, not in a straight-through, once-and-for-all way, but in a way that allows initial tentative findings and judgments to be modified continually as knowledge is gained.

3. FORMULATING THE PROBLEM: THE ACTIVITIES

It is not always easy to take seriously the activities involved in problem formulation. There is sometimes a feeling that, until models are being constructed, for example, or alternatives are being evaluated, the "real" work has not begun. But, in fact, which models to construct, which alternatives to compare, and whether the study outcome is to be a solution feasible under defined uncertainties, a formal optimization, or a presentation of alternative possibilities, are all decided in the problem-formulation phase. In the kinds of situations in which systems analysis is appropriate, problems are far from obvious, and the way the problem is formulated determines what action is eventually taken. A philosopher of the process of inquiry, John Dewey (1978) summarized the importance of the initial stages thus:

> It is a familiar and significant saying that a problem well put is half-solved. To find out *what* the problem and problems are which a problematic situation presents to be inquired into, is to be well along in inquiry. To mistake the problem involved is to cause subsequent inquiry to go astray ... The way in which a problem is conceived decides what specific suggestions are entertained and which are dismissed; what data are selected and which rejected; it is the criteria for relevancy and irrelevancy of hypotheses and conceptual structures.

In order to decide "the way in which a problem is conceived" in "a problematic situation" it is necessary to decide which facts, out of the plethora available, are what Dewey calls "the facts of the case." The starting point must be the problem situation (rather than what is said to be the problem) and the first activity is to gain an understanding of the history of the situation. Using the kind of questions discussed above, the analyst seeks an understanding of how the situation now regarded as problematic developed. What experiences led these particular role occupants, in this particular culture, embodying these particular values, to perceive a state of affairs as "a problem"?

Knowledge of how the situation evolved to its present form enables the analyst to begin the next activity: documenting the problem-content and problem-solving systems. The crucial question for the latter is: what are its resources? That for the former is: what is the nature of the study to be? and this may be answered by using the concepts discussed above. Answers to both questions enable problem-solving resources to be matched against problem-content requirements, and iteration enables a suitable balance to be achieved. The position at this point is somewhat analogous to that at which a scientist selects the most difficult problem that he has a reasonable chance of solving, given the resources, both intellectual and physical, available to him (Medawar 1967). Here the systems analysts's aim is to define the potentially most useful study that the problem-solving resources likely to be made available can carry out. Figure 5.1 shows how these activities interact, and includes, in the case of the problem-content system, iteration deriving from the basic ideas of client, decision makers, objectives, etc. (Appendix A includes a work book, discussed below, that can help in the process of documenting the problem content.)

The sequence illustrated must be regarded as a single entity, in the sense that it is unlikely that any activity will be carried to completion at the first attempt. The problem-formulation stage may be taken as complete when iteration around the cycle of activities increases understanding to the point that "issue papers" can be prepared. And even then it is, of course, possible at later stages of the study that new information, changing judgments, or new environmental forces may cause a return to problem formulation. If this happens, it is extremely valuable to find that the early work has been carefully documented. If it has, then it will be clear what changes are being made, which parts of the initial work stand, and what now needs to be done.

Experience with a large number of systems studies has suggested that the general shape of their initial stages was sufficiently similar to justify preparing a workbook to help in documenting problem-content and problem-solving systems. The context in which the workbook was developed (Checkland and Jenkins 1974, Checkland 1972,1975) enabled its use to be studied experimentally. Initial difficulties pointed to the need for precise definitions of the main terms used in it; once this was done, it has been found helpful in both large and small studies in both industrial firms and in the public sector. The questions answered in the workbook are in Appendix A. Use of it in about twenty studies suggests that the most difficult question the systems analyst has to answer, and the one whose answer has the biggest effect on project outcome, is: who are the problem posers and decision makers?

Once documentation of problem-content and problem-solving systems has been completed, and a balance achieved, so that the task defined is commensurate with the resources available, data collection can begin. The aim now is to explore the problem content further, so that papers can be produced that isolate the main issues, clarify the objectives of the study, and set out the major

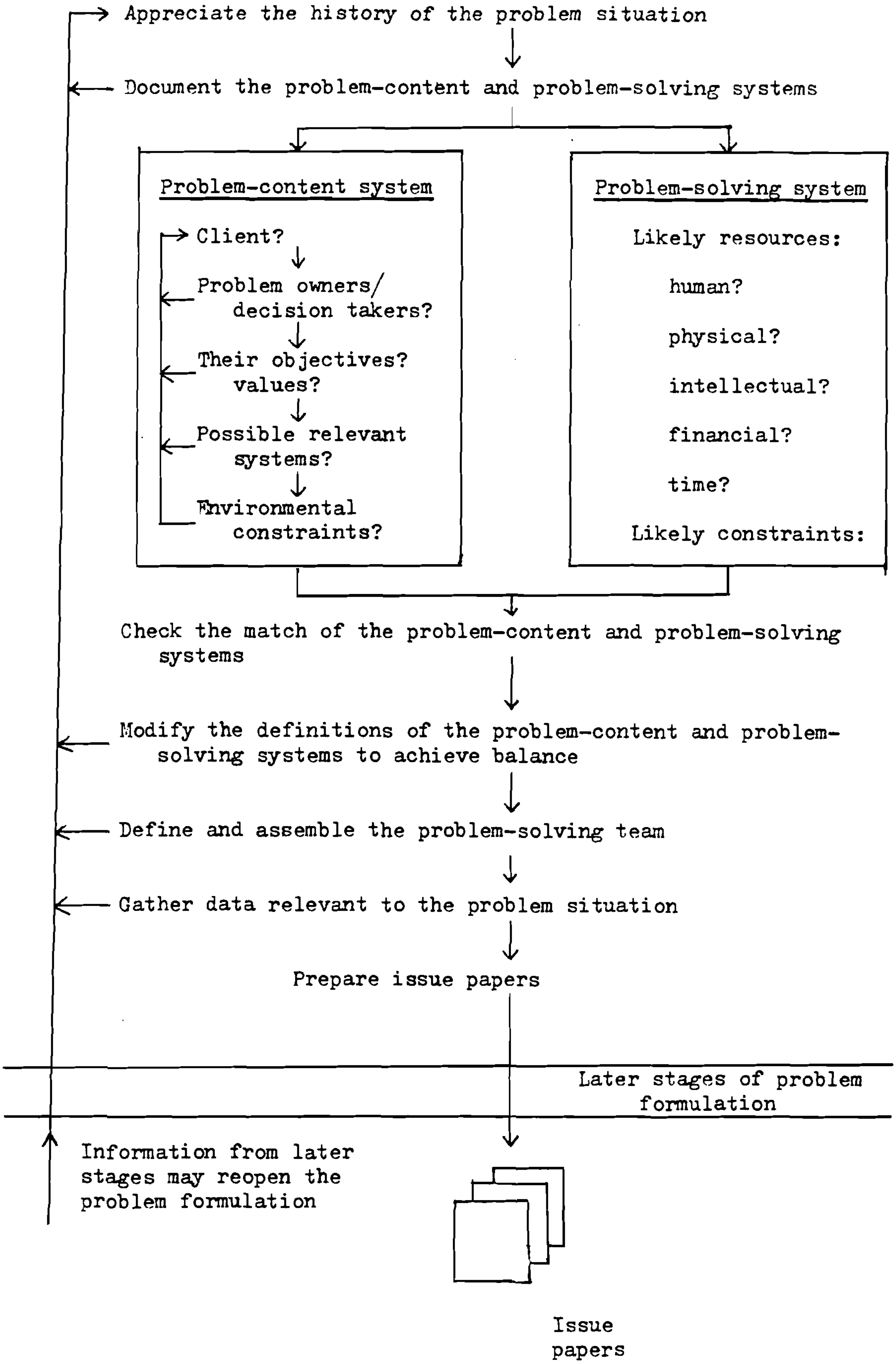

Figure 5.1. Concepts and activities involved in the problem-formulation stage of systems analysis.

factors that will influence the final outcome. This must be done before the process starts, because there is always far too much data possibly relevant to the study, so the analysts must make prudent choices about what to gather and consider. It is here that the definition of the problem-content system begins to be useful: it provides an initial basis for data collection, it defines the starting points for gathering information (on the problem posers, decision makers, objectives, values, measures of performance, environmental constraints and so on), and gets the detailed work underway.

But when does the analyst stop? It is useful for the systems team to make a distinction between "data" (Latin "datum," what is given), and what we may call "capta" (Latin "captum," what the analysts decide to fetch from the problem area). When the team develops the feeling (and there can be no certain test that their feeling is appropriate) that they have moved from collecting data to defining and seeking out capta, then it is time to describe the problem area in some issue papers. Completing the issue papers may be taken as the formal end of the problem-formulation phase. They should set the scene for the study, indicate its scope, and define the kinds of alternatives that may be regarded as solving the problems perceived. They should not be the analysis itself, because they are based only on the most readily available data and capta! Quade (1975) points out that when the idea of such papers was developed in the Rand Corporation, they were thought of as providing the person or group who had commissioned a study with the opportunity of calling a halt or going ahead:

> The original idea of an issue paper was to explore the problem at a depth sufficient to give the reader a good idea of its dimensions and the possible scope of the solution, so that it might be possible for a decision maker to conclude either to do nothing further or to commission a definitive study looking toward some sort of an action recommendation.

Appendix B gives an outline content for such papers.

It is difficult to say when such papers should be written, but my experience is that out of a total study effort the problem-formulation phase usually consumes 20 to 25%.

4. CONCLUSION

A recent encyclopedia that aims to keep the educated man abreast of "modern thought" (Bullock and Stallybrass 1977) defines "problem solving" as

> That form of activity in which the organism is faced with a goal to be reached, a gap in the 'route' to the goal and a set of alternative means, none of which are immediately and obviously suitable.

Recent work on systems analysis has suggested that, the softer the problem, the more the emphasis has to be on the way in which concerned actors perceive problems; and on bringing out the underlying values and their conflicts, rather than on "engineering" a preferred alternative (Checkland 1972, 1975, 1977; Vickers 1965,1970; Hammond, Klitz and Cook 1977). Checkland, for example, emphasizes the need to compare aspects of the problem situation with a number of systems models, each based on a "root definition" with one of a set of possible viewpoints. This process allows examination of what Vickers calls "appreciative systems" in which decision makers notice only certain aspects of reality and evaluate them according to particular standards of judgment; both the aspects noted and the standards of judgment change with time and experience. Hammond, Klitz, and Cook emphasize the need to examine, not only the "analytical models of external systems, that is, systems that exist outside of persons," but also models of the decision makers' "internal (cognitive) systems." But, despite these developments, and the uncertainty they introduce into our vision of what systems analysis might be in 10 to 15 years time, it is certainly the case that most systems analysis is based upon, and maybe most will continue to be based upon, the model of problem solving described so far in this *Handbook*. It has been a useful model. And it is also the case that, no matter how systems analysis develops in the future, it will require an initial stage in which the area of concern is described and the issues to be faced are isolated. Such a stage will always be a key one in any analysis, since it is the one that will dictate subsequent work. It is not surprising that, in answering a questionnaire on systems analysis (Quade et al., 1976), more than 160 analysts and users of systems analysis rated "problem formulation and information gathering" as more important than the other stages of systems analysis.

Because early mistakes and false starts may be expensive in time and effort, the analyst needs a delicate touch in the early stages of problem formulation. He should be cautiously firm in making explicit use of the basic ideas that order the task, but he should be tentative in commitment. A commitment to a particular view of the problem content should emerge only slowly; the whole problem-formulation phase should be conducted in a spirit of inquiry. The analyst ought to expect to be surprised by what he learns.

In rating the problem "hard" or "soft" the analyst should err on the side of the latter, even though the specific techniques available to help during the main body of the study—modelling, simulation, optimization and the rest—are most useful in sharply defined situations in which, for example, a well-defined decision maker wants help in selecting among alternative ways of meeting a defined need. There has been much criticism of the insensitive use of hard systems analysis in public issues (see, for example, Hoos 1972,1976 and Pollack 1972 for a rejoinder to Hoos's polemic) and it is certainly the case that taking a soft problem to be hard is more damaging to useful inquiry than the reverse. A soft analysis can always become harder if the study reveals this to be acceptable; but it is much more difficult to make a problem soft that was originally defined as hard.

Finally, the systems analyst engaged in problem formulation, although he is a would-be bringer of the light of reason to human decision making, should not overestimate the part that overt rational thinking plays in most human situations. He must remember that a client setting up a systems analysis is making a political act—or at least it may be seen as such—and the political situation of which his study is a part should itself be a part of his study. Whose political aims are served by the study? Who will be affected by the different possible kinds of recommendations? Who will be able to make the damaging claims that their views were not solicited? These are all questions the analyst should not ignore.

If the analyst's contribution to decision making is ultimately less than he would wish, he may at least console himself with the thought that the very existence of his issue papers will have made more difficult the victory of the completely irrational. In a remarkable passage about the high-level decision making prior to the Allied invasion of France in June 1944, Lord Zuckerman (1978) has recently described in his autobiography *From Apes to Warlords* the "nonsensical arguments" which went on, in those days before systems analysis existed, about the use of heavy bomber forces. The argument concerned whether or not they should aim to destroy the railway network ahead of Eisenhower's invasion force or should continue to bomb the industrial towns that sustained the enemy war effort, in particular, the towns concerned with aircraft production. Apparently no study ever considered more than one option; no attempt was made to compare rationally the likely costs and benefits of alternatives, and protagonists with an emotional commitment to one option simply sought to find facts to damage the others. Zuckerman writes:

> After a thirty-year gap, I am utterly amazed by the nonsensical arguments about the plan [to destroy the railway network] to which one had to listen, and which are on record in contemporary documents and minutes of meetings. I had incorrectly assumed that planners were concerned to extract, as quickly as they could and for use in further planning, such facts as experimental enquiry and analysis of past operations could provide. This, however, was clearly not general practice. Most of the people with whom I was now dealing seemed to prefer *a priori* belief to disciplined observation. ...rational discussion...was at an end. All the opposing parties joined to defeat the apparent threat which the A[llied] E[xpeditionary] A[ir] F[orces] implied to the

independence of the strategic air forces [who wished to continue bombing Germany]. It did not matter what considerations were advanced to upturn it.

We may be sure that any instance of judgmental decision making what is formulated as a problem in accordance with the guidelines described here will at the very least provide an opportunity through which experimental inquiry, analysis of past operations, disciplined observation, and rational discussion can bring the voice of reason into what might otherwise be an uncivilized wrangle.

Appendix A

A WORKBOOK OUTLINE TO AID DOCUMENTING THE PROBLEM-CONTENT AND PROBLEM-SOLVING SYSTEMS

Definitions of Terms

Client: the person who wants to know or do something and commissions the study. The implication is that he can cause something to happen as a result of the work. (He may also have the decision maker role.)

Decisionmaker: The role player in a human activity system who can alter its content and activities and their arrangement and who makes resource allocations in it.

Problem poser: The person who has a feeling of unease about a situation, either a sense of mismatch between what is and what might be, or a vague feeling that things could be better, and who wants something done about it. The problem poser may not be able to define what he would regard as a "solution," and may not be able to articulate the feeling of unease in any precise way. (The analyst may assign to the role problem poser someone who does not himself recognize that he has posed the problem, and the problem poser may not be the decision maker. However, usually systems analyses are carried out for decision makers who are also problem posers.)

The Outline

1. The study situation. Take it to be one in which a client has commissioned the analysis; there is a problem-solving system (containing the analyst as problem solver) whose efforts are brought to bear on a problem-content system (containing the roles of problem poser and decision maker, which may be coincident).

1.1. Who is the client?

1.2. What are his aspirations?

2. The problem-content system.

2.1. Who are the occupants of the role of problem poser and decision maker?

2.2. The decision maker's and problem poser's versions of the nature of the problem.

2.3. The decision maker's and problem poser's reasons for regarding the problem as a problem.

2.4. The decision maker's and problem poser's expectations of the problem-solving system.

2.5. The expectations listed in 2.4. suggest matters highly valued by the decision maker and problem poser.

2.6. Some possible names for the problem-content system.

2.7. In describing the problem-content system initially, the likely relevant elements.

- Nouns.
- Verbs.

2.8. Environmental constraints on the problem-content system.

3. The problem-solving system.

3.1. The occupant(s) of the role of problem solver.

3.2. The other persons (and roles) in the problem-solving system.

3.3. The resources of the problem-solving system.

- People.
- Physical resources.
- Skills.
- Finance.
- Time.

3.4. Likely or known environmental constraints on the problem-solving system.

Appendix B

A FORMAT FOR ISSUE PAPERS

An issue paper is as complete an assessment of all that is currently known about the problem or issues as the readily available data will allow. The idea of an issue paper is to explore the problem in sufficient depth to give the reader a good idea both of its dimensions and the possible scope of a solution, so that a decision maker can decide either to do nothing further or to commission a study looking toward some sort of action recommendation.

A standard issue-paper format includes these main sections:

A. Source and background of the problem.

B. Reasons for attention.

C. Groups or institutions toward which corrective activity is directed.

D. Beneficiaries.

E. Related programs.

F. Goals and objectives.

G. Measures of effectiveness.

H. Framework for the analysis.

  1. Kinds of alternatives
  2. Possible methods.
  3. Critical assumptions.

I. Alternatives.

  1. Descriptions.
  2. Effectivenesses.
  3. Costs.
  4. Spillovers (side effects).
  5. Comments on ranking of alternatives.
  6. Other considerations.

J. Recommendations that may emerge.

K. Appendices (as needed).

This outline is adapted from Quade (1975).

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