HANDBOOK OF SYSTEMS ANALYSIS

VOLUME 1. OVERVIEW

CHAPTER 10. THE PRACTICE OF APPLIED 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 10. 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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CONTENTS

CHAPTER 10. THE PRACTICE OF APPLIED SYSTEMS ANALYSIS

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1. INTRODUCTION

The previous chapters of this *Handbook* have described the context, nature, and use of applied systems analysis, sketched its history, given examples of good systems analysis studies, laid out the methods that such work exhibits, dealt with the content of a good systems analysis study and how it is evolved, and provided a perspective on the work of implementing its results. The purpose of this chapter is to discuss what experience has taught systems analysts about professional practice, that is, how to approach their work and what relations they should have with the clients who may use its results.

Thus, while this chapter speaks primarily to analysts, it also speaks to clients by telling them what sort of professional conduct they may expect from systems analysts.

Most of the material in the earlier chapters presumes a situation in which the systems analysts have direct access to officials with relevant responsibilities and authorities, whether the analysts are employed by the same organization or not. Thus, we make the same assumption in this chapter. In actual fact, the analysts may be employed by another organization, such as a consulting firm or independent institute, such as the International Institute for Applied Systems

Analysis in Laxenburg, Austria. The precepts and principles of professional practice as we discuss them here remain the same for all of these cases; however, the difficulties of communication may change, depending on whether or not the decisionmakers and analysts work in a common administration or different ones, whether there are a few or many relevant officials, and so on. Since each situation offers its own characteristic and highly varied properties, there is little general guidance to be offered here, beyond the obvious fact that barriers to effective communication have to be removed if systems analysis work is to have important effect, as discussed later in this chapter.

While there is literature dealing with the practice of systems analysis (see, for example, Agin 1978), it tends to be scattered and somewhat incomplete. Thus, in writing this chapter I have relied not only on relevant literature but also my own experience, coupled with that of others relayed to me through personal contact. Since systems analysis is a young and rapidly growing field, experience to come may well supplement and modify what is said here. However, the reader may rest assured that everything in this chapter has served analysts well in significant past experience.

2. THE ORGANIZATIONAL CONTEXT

The concept of decision runs through much of the literature of systems analysis—and, indeed, much of what has been said earlier in this *Handbook*. However, this concept seems to imply that whatever needs improvement in a problem situation can be changed adequately at a single stroke—an oversimplification of real life that, while useful for discussion purposes, does not represent the reality that we live with, particularly in the sorts of large-scale interactive problems that systems analysis is likely to be called on to address.

Rather, it is perhaps better to consider the more general concept of change, and to think of systems analysis being called on when there is an appreciation somewhere that change may be desirable. Change may then be achieved by a single major decision, or it may occur as the result of a complex of smaller

decisions made in a variety of places in a large institutional structure, but coordinated and informed by the findings of an intelligent, broad approach to the issue of change. The role of systems analysis then is to providee an important contribution to this approach.

Perhaps the most basic task of the analyst, on which he should gather information from the beginning and should have a well developed appreciation early in his work, is to understand the structure in which change may take place. If no decisions leading to change are possible, the work may be of absorbing interest, but it will likely be in vain, unless the situation changes. If the decision setting presents open opportunities for change, how can the work best be related to this setting? There is no simple answer to this question—indeed, much of what this chapter has to say bears on it—but it is one the analyst must ask early, and keep in his mind throughout his work, as interactions with the client organization shed more and more light on it. The knowledge accumulated during the work, as relations with the client develop, can—and should—have a major influence on how the findings are formulated, presented, and followed up. Archibald (1979), in writing about fire departments, such as the one in Wilmington, Delaware, discussed in section 3.3, puts it this way:

> The perspective taken is that of a "change agent" (i.e., a manager of change). The introduction of analysis is expected to change the end product or service delivered by the fire department. Most likely this will also mean changes in structure (the organizational system) and in process (the various methods and procedures employed to deliver the services). In turn, these changes will require members within, and perhaps outside, the organization to change their behavior. The analyst must see the issue not only in terms of solving a particular technical problem, but more importantly as the creation of circumstances that will encourage people to change their behavior. In performing this task, the analyst becomes the change agent.

Archibald also

> . . . stresses the importance of thinking about groups of people, their common motivations, their organizational positions, and their values as they influence decisionmaking. As the analyst moves from the model of the problem to the development of programs to achieve desired results, the importance of who makes the decisions and who influences the decisionmaking process cannot be overstated.
>
> Sound analytical results should be able to stand alone but they do not. People who make decisions frequently find themselves in situations in which the analysis alone is not sufficient to guide decisionmaking. A broad political rationality is likely to guide an individual's decisions more often than a narrower technical rationality. If political and managerial views are to be meshed with the specific problem-solving perspective of the analyst, the analyst needs to have anticipated, understood and tried to accommodate the values and perspectives of decisionmakers and the pressures they face. It is often too late to account for these factors (solely) during implementation.

Here are some basic questions about the decision setting on which the analyst should have clear answers before he gets to the point of formulating and presenting findings and recommendations:

1. What is the nature of the decision setting? Is there a single strong decisionmaker? Or is the decision setting a pluralistic one, in which there are many decisionmakers with varying degrees of power and influence, all of whom must be addressed? If the study is done for an organization, is its span of responsibility and authority complete with respect to the problem situation being contemplated, or will the changes needed involve compromise or coalition with other organizations?

2. What are the important properties of the decision setting? Organizations have widely differing styles of management that usually have important effects on the styles of their approaches to change. The personalities of key

persons frequently are major determinants of these styles. The analyst cannot change an organization's style in a single systems study—although an association involving effective work over a period can lead to changes in style—so he is well advised to adapt his work to it to a reasonable extent; he will have difficulty enough in prompting the changes that emerge from his work as desirable without assuming the added burden of trying to change the organization's style at a single stroke.

3. What constraints does the decision setting offer? The most basic and frequently encountered one is time: Can the systems analysis be completed in time to inform the decisions leading to change? If it cannot, there is little point in embarking on it; if it can, but only on a simplified and reduced scale, the analyst and the executives involved must consider whether or not such a "quick-and-dirty" study can help (in my experience it usually can). Are there organizational constraints such as customs, policies, laws, or regulations that will affect change? If so, they may have to be accepted—but surprisingly often they can be altered when good reasons appear. Thus, while the analyst must recognize such constraints, he would be unwise to accord them too sacred a status. It costs little to explore a constraint change in many cases, and such an inquiry can turn up information about constraints that may make eliminating them appear to be desirable.

4. If, as is usually the case, the work is to be done for an organization, what is the appropriate administrative level at which the analysis team should work? There is no simple answer to this question; rather, the proper answer will differ for each case, depending on many factors, not the least of which is the personalities and powers of the executives who may be chosen to supply the main administrative tie during the analysis. Since a problem situation leading to the need for a systems analysis almost invariably cuts across organizational lines, both horizontally and vertically, the organization's choice of a sponsoring executive offers some pitfalls. If he is ambitious and grasping, he may suppress findings he does not like, or the rest of the organization may resist even obvi-

ously desirable findings to keep him from adding to his span of power and control; if he is weak and compliant, he may not give the analysis team enough support to allow them either access to possibly embarrassing information or the freedom to develop potentially unpopular findings.

5. What is the appropriate relation of the analysis staff to the administrative staff that will have to respond to the study's findings? Can an analysis group inside the organization be the most effective? Or should an outside group be employed? Will administrative formalities encumber the work? Will the sources of support—administrative, financial, and policy—be strong and adequate? Will these sources of support guarantee the analysis team the free access to information that is essential to good analysis? Since the fact that systems analysis is being contemplated suggests that change may be called for, people in the organization are almost sure to have mixed feelings about the analysis and the analysts who are doing it; in the face of this fact, experience teaches that strong support is essential to a successful outcome.

All of these considerations are embedded in the organizational structure involved with the problem situation; the character of this structure has basic importance for the analyst and how he thinks about the problems and their possible solutions. For example, Archibald (1979) describes fire departments this way:

> Fire service organizations pose special problems and opportunities for the manager of change. For example, the quasimilitary bureaucratic organization of fire departments is a source of resistance to changes in authority structures, tasks, and procedures; but this same organizational form can help expedite compliance with changes that have been ordered by the chief executive. The traditional single entry level into the organization is often a source of resistance to recommendations of people who have not personally experienced fire-fighting. Knowledge derived from unfamiliar disciplines or distant cities is not readily accepted by fire service personnel.

The change agent must also learn to deal with the crisis orientation of fire departments, which focuses rewards on action rather than on contemplation. The lengthy, sequential decisionmaking process of systems analysis contrasts sharply with the drama of decisionmaking by commanding officers at the scene of a fire. Moreover, because most fire departments have not experienced financial pressures until recent years, fire service personnel with budgeting and planning skills are few in number.

The manager of change must understand how organizations operate, and be able to view the fire department as a collection of organizations interacting with other organizations. New policies that arise from deployment analysis are likely to have impacts on other organizations—such as labor unions and community groups—whose interests must be considered.

This summary makes it clear that the character of the administrative structure involved in potential change is important. Therefore, the analyst may look for characterizations of such structures similar to the one quoted above—perhaps one for manufacturing companies, another for sales organizations, still another for public service institutions. However, experience tells us that this is too much to hope for: I have known military organizations that were far more informal and unstructured than business organizations, and more oriented to problem solution; by the same token, some businesses are managed by very rigid bureaucracies, while others have less formal structures easily adapted to change. In sum, the analyst must make his own observations about the nature of structure and authority for each organization he deals with, and factor this information into his work.

Much more could be written about how these basic questions about the organizational context relate to successful systems analysis, but experience is so varied that on most points it is not possible to be prescriptive. However, experience does tell us that the questions are important, and that the analyst

must develop ties with the client organization that are close and continuous enough to enable him to formulate answers to them. These answers, combined with his experience and common sense, are then likely to help him find a path to effective work—or, if he cannot find this path, he has good reasons for stopping his work before a lot of effort is wasted.

3. AWARENESS OF THE PROBLEM SITUATION

As section 5.1 points out, "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 call a 'problematique,' or what Ackoff . . . calls 'a mess.'" While the manager's view may be incomplete—or even wrong—it can be accepted as a recognition that all is not well, and that an unsatisfactory posture should be examined for possible change aimed at improvement.

One might conclude that the analyst should try to get the manager to sharpen his problem statement. However, experience tells us overwhelmingly that this is the opposite of what is desirable at the beginning: the analyst is well advised to keep the manager's appreciation of his problem as broad and general as possible, so that the early inquiries into the situation are free to formulate the problem (if indeed this is possible) without the inhibiting constraint of an authoritative misperception. In fact, in my experience, perhaps the worst thing that can happen is for the executive to write a memorandum stating what the problem is, particularly if he is a very strong and dominating personality; this statement then becomes a major deterrent to developing the realistic problem appreciation needed for good analysis, and makes it doubly hard to get this appreciation accepted. The moral is plain: At the beginning, keep the discussions and interactions as broad and flexible as possible, to the end that the early fact finding and analysis can dominate how the problem is formulated.

In sum, there is considerable practical experience backing the view that a careful problem investigation and formulation effort is an essential beginning;

Chapter 5 provides an approach that can be adapted to most situations. In fact, to skip or slight this step is to risk spending effort on the wrong problem. The unhappy cases where this has happened seldom make their way into the literature, but the oral tradition contains many tales of analysis gone wrong because the problem investigation was not thorough enough to discover the true difficulty. For example, Agin (1978) describes one case where this could have happened:

> A manager asked for a study to examine the consolidation of three of his firm's plants into one. The new plant was to be constructed at a location separate from the three existing plants. A preliminary examination of the economies which would result from the consolidation indicated the plants had no operations in common and that the proposed plan could only result in an increase in costs. The executive should have known this so that prior to an investigation in detail it was decided to review with him what he expected to achieve from the study. Doing this involved several days of discussion. From this, it was discovered that the real issue was an inability for this executive and the union leader at one of the plants to work together. Once this was recognized, a Vice President of Industrial Relations was hired to deal with the union and the idea of consolidation dropped. The undertaking of a study with little or no chance for real success was avoided.

Where the initial problem-situation awareness exists may make considerable difference to how the analysis team proceeds. If the awareness comes from a high executive, to get an analysis started may be much easier than if the awareness comes from a subordinate official in an operating department. If the awareness is forced on the organization by outside pressures or interventions, the managers may resist change more strongly than if the perception originated inside. The analysis group itself may be the source of the perception, since its continuing work sharpens its views. Thus, at the beginning the analyst may be involved in discussions aimed at persuading managers that they are facing a

problem situation, rather than vice versa. Many analysts feel that this is one of their most important duties and opportunities. Certainly, experience tells us that the analysis team that only answers the doorbell is never as influential or useful as the one that takes a broader and more entrepreneurial view of its work. In fact, as section 2.2 points out, one of the earliest perceptions of the operations research community was that, as Blackett (1950) said of the 1940-45 British experience: ". . . one of the clearest lessons . . . [is] that the really big successes of operational research groups are often achieved by the discovery of problems which had not hitherto been recognized as significant. In fact the most fertile tasks are often found by the groups themselves rather than given to them." This view is heavily underlined by operations research and systems analysis experience in the ensuing four decades.

A systems analysis group may be asked to undertake rather mundane analysis tasks. If this were the entire menu, the group's purpose in being would be completely vitiated. However, such tasks should not be shunned entirely: carefully chosen and done well and promptly, they can often provide entry to larger and more important work of systems-analytic character, both by giving opportunities for insights and establishing sympathetic relations with influential executives. Too, systems analysts must learn a great deal about the organizations they serve, and opportunities to further this process have value in their own right.

A beginning systems analysis team is seldom well advised to plunge right at the beginning into the broadest and most global problems of the organization it serves. Rather, it should build up its knowledge and the confidence of the organization through a series of smaller studies; properly chosen and organized, they can often constitute building blocks in the broad understanding that will support work on the global problems.

Almost anywhere on this scale, however, the analyst looks for these three characteristics in a problem situation as being harbingers of challenging work:

- A responsible person recognizes a problem situation and wants help.
- The work that appears to be in prospect is functionally interdisciplinary, that is, it involves more than a single narrow function of the organization.
- The solutions, as well as the problem situation, appear likely to fall outside the responsibility of a single small staff organization.

They are not criteria of choice (for example, a single executive may have a very interesting problem over which he has control that is well worth a systems analysis effort), but they do suggest properties of a situation that may be particularly challenging, and therefore particularly appropriate for systems analysis.

Finally, as part of the issue of problem awareness, experience offers some advice about the management/analyst interactions and initiatives at the beginning: Keep them informal and somewhat fluid, so that the analyst is as free as possible to consider a variety of possibilities; interact as widely as possible, to the end of gaining as varied and comprehensive a picture of the problem situation as possible before formal work begins. We have noted that it is generally undesirable for the manager to hand the analyst at the beginning of the first discussion a memorandum stating the problem; it is equally undesirable for the analyst, right after the first discussion, to retire to his study to prepare a problem statement in precise terms—he is almost sure to be wrong, and thus eventually to be embarrassed by his own words as the early fact-finding and analysis probe the problem situation.

4. FORMULATING THE PROBLEM

The first step to take after the conference with the official who is aware of the problem situation is to begin a widespread, comprehensive, first-hand, on-site survey. Chapter 5 provides guidance on how to approach this activity systematically. This survey is essential to the analyst's understanding of the situation; the details he discovers here will give him a reasonably full picture of the situation. Of course, the executive most concerned can supply much information of this sort, but first-hand observation is far more useful than second-hand

description. For example, the analysts who were asked to study the possibility of increasing the productivity of a third-world steel mill, as described in section 9.3, would have been well advised to watch all facets of the operation for a substantial period of time; they would not then have been embarrassed to discover that the operators were illiterate—and their approach to the problem could well have been much simpler, the evolution of a new approach much quicker, and the results as good as what was finally achieved. The analysis team asked to consider the plant consolidation described in section 10.2, on the other hand, got to the bottom of the problem—the personality conflict—before they had wasted time on a lengthy study of the issues of the proposed consolidation.

Similarly, a bit of knowledge of fundamental importance and well known to the persons directly involved in an operation, but missed by the analysis team, can destroy the client's confidence in the findings of the analysis, *even if this fact has no bearing on the findings!* An analysis team studying the problem of efficient supply and dispatch of tank cars for a chemical company running a continuous-process plant missed the fact that the cars had to be steam cleaned before each use; while this fact had only a very minor effect on the proposed course of action—indeed, the adjustment was made in a few minutes—the executive for whom the study was done was telling strangers several years later that systems analysts were of dubious value. Had the team observed the operations of the railroad yard at the chemical plant carefully, they would not have overlooked this fact of vital importance to chemists (since even traces of some chemicals can spoil chemical processes) that embarrassed the analysis team at the time it was presenting its results.

In addition to giving the analyst a well rounded view of the problem situation, a careful initial survey may also allow him to discover aspects of it unknown to the responsible executives. It is commonplace for workers to conceal bad news from the boss, but share it with an outsider—a fact that presents the analyst with a problem: If he leaks this bad news to the executive, thus violating an implied confidentiality, his source of reliable information may be

cut off, and other difficulties may arise; but, if he ignores it in his work, he risks reaching conclusions sufficiently unrealistic to vitiate his findings, or their acceptance. There is usually a path past the horns of this dilemma, but no general principle can be enunciated beyond this one, which is supported by a large body of experience: If the analyst should behave in any way that makes him look to the workers like an "inspector," valuable information and easy relations will be lost.

The opposite case can also occur, when the executive is seeking some sort of evaluation looking to organizational adjustment, when the workers may be quite uncooperative—with a similar dilemma for the analyst to thread his way past.

It is usually wise to compare the information from this early survey with many persons involved, to be sure that early impressions are accurate, although judgment will have to be exercised about how trustworthy views and opinions might be. However, the number and variety of contacts will serve as a useful and surprisingly effective screening device.

Note that we have been talking here about a somewhat informal survey and investigation, not the formal data gathering that may ensue as the project gets launched in earnest. In fact, such a survey may be a useful prelude to a decision about whether or not to undertake a systems-analysis project.

With the results of this survey in his notebook and his head, the analyst is now ready to formulate an initial appreciation of the impacts of the problem situation and the potential effects of change, at least in broad terms: Is it a tactical matter? Is it a strategic question? Does the situation appear to have short-term or long-term consequences? Whose interests are affected, just those of the official inviting in the analysis team, or many others? Is the problem situation confined to the organization seeking help, or is it more widespread? Is the impetus for the concern an internal one, or does it come from outside the organization? This initial appreciation must be tentative, of course, but to make it explicit is an important step nonetheless—and Chapter 5 provides important

guidance on how to go about it.

Against this background, the analyst is ready to formulate his preliminary synthesis of the situation, perhaps leading to a tentative problem statement. He now has some idea of the nature of the problem, what its boundaries may be, what at least some potential responses might look like, what information may be needed to pursue the analysis, what data-gathering work must be undertaken on a systematic basis, and, most important of all at this stage, what management help will be needed to make the work proceed smoothly to an effective conclusion.

Thus, the analyst is now ready to prepare the analysis plan, a step often neglected, but one that is in my view absolutely essential to a successful project of large scale.

The skeptic may argue that, if research is exploring the unknown, how can the exploration be planned? On the other hand, the experienced applied systems analyst will respond that the precedent of pure science is only very partially applicable to applied systems analysis, and that experience shows that a well developed plan is an invaluable guide to action, even when unforeseen events or difficulties arise, not the least because having the plan shows quickly what the effects of such unforeseen matters may have on schedules, resource needs, and so on.

Too, the team leader needs to have an estimate of time, resources, and support that he can put forward early, and the more detail that underlies this estimate, the more reliable it is likely to be.

A good analysis plan will at least:

1. Describe the context of the problem.

2. State the problem in the preliminary form developed in the initial survey.

3. List the other organizations with interests in the problem and its outcome, along with suitable descriptions, including any work that they may be

doing on the problem.

4. List the data and information needed to investigate the problem, and the activities needed to gather this information and process it for use in the analysis.

5. Lay out the analysis activities that are foreseen.

6. Project a schedule of key events in the progress of the analysis and in the reporting activities that will accompany and follow the analysis.

7. Envision the products of the analysis activity (reports, briefings, backup material, and so on).

8. Specify the resources needed to carry out the work, including the reporting and followup activities.

9. Stipulate the management interactions and assistance needed throughout the activity.

10. Lay out a schedule for reporting activities that will present the results of the analysis to all of the constituencies that may be affected by, or interested in, its findings.

11. Give at least a hint, if possible, of the sort of implementation activities that might be called for (difficult, perhaps impossible, to do at this early stage when the findings cannot be forecast—but it is not too early for the attention of both analysts and client to be drawn to this issue, at least generically).

An analysis plan may be anything from a short memorandum for a small-scale study to a long document for a major inquiry. It has many uses:

- It can be used as the basis for negotiating with the client the support needed for the work.

- It serves as a useful goad to the analysis team to get on with its work (it is very easy, in the face of conflicting demands and interesting new options, to let a schedule slip drastically or to let the resources trickle away, particularly when the project is a major one over a long schedule).

• It is not only a useful check on progress, it also serves as the point of departure for adjustment when new events or unforeseen difficulties force changes on the work and its schedule.

• When the analysis team consists of many persons, perhaps at different locations, the analysis plan can be an essential instrument for keeping their work coordinated, even though a series of continuing interactions with the team leader and other workers may be needed to perfect the coordination.

Candor compels me to admit that practicing systems analysts do not always prepare analysis plans for their work—indeed, the number who do may be in a minority; however, my own experience supports the worth of this step so strongly that I have no hesitation whatever in recommending it strongly to others. Such plans are a commonplace among analysts working in consulting firms seeking analysis engagements with large organizational clients (the plan is usually incorporated in the "proposal" to the client), but for groups working inside large organizations it is less common, although perhaps more needed.

Finally, as part of the formulation process, the head of the analysis team must negotiate the administrative formalities that will be associated with the work: financial support, administrative cooperation (both in providing access to information and supplying management participants in the work), arrangements for periodic reporting and review, possible phasing (if the project will entail more than one phase), and a prospect of what the final reporting process will be (so that the client and the analysis team have a common expectation).

Experience has shown that the second of the points is particularly important: It is highly desirable that at least one member of the client organization participate in the analysis throughout in an appropriate way. This person can offer many benefits, including these:

• He can facilitate information gathering through his knowledge of the organization; indeed, he may be able to supply much of what is needed from his own resources. However, knowing where to go and whom to see can save much time and effort.

• As a bridge between the analysis team and the management throughout the project, he can keep them informed about progress between the times when formal progress reports are rendered. In some cases, this person can even serve in an informal way to help sell unusual or unexpected findings before they are finally reported.

• Most contexts have hidden presumptions that everyone takes for granted, which may escape the analyst, since everyone in the context thinks they do not need to be stated. If such ignorance persists until reporting time, it can have a fatal effect on the management's confidence in the team's mastery of the problem (as the example of the team doing the chemical-plant analysis not knowing of the need to steam clean tank cars illustrates). However, the well informed team member from the management virtually assures that this cannot happen.

The ensuing five sections of this chapter all deal with matters that, from a more technical standpoint, have been discussed earlier in this *Handbook*. However, from the point of view of practice there are some points to be added that are important, and they will be taken up here.

5. GATHERING INFORMATION

The inexperienced analyst may set out to assemble everything he can put his hands on, somewhat indiscriminately, with the result that he will have a huge pile of data with little information content. Rather, data relevant to the problem should be gathered on the basis of a carefully worked out plan (it may be the analysis plan itself, or an addendum thereto) that not only lists sources and describes how they are to be tapped, but also how the data are to be converted to information bearing on the problem (see Majone 1980). Care in planning this work and carrying it out will ensure both relevance and focus. Too, shrewd planning may well achieve considerable economy in this activity.

It is well to focus on important phenomena from more than one perspective, in order for internal consistency to be measured, to the end that one has evidence to support his trust in the information—or lack thereof. External

sources may be especially important in this regard, if they can be tapped. It is especially important for operational and technical expertise to be incorporated in the available information; one of the best ways is to have such specialists as members of the interdisciplinary team to contribute their knowledge throughout the work.

The process of collecting information to support a systems study needs to have continually before it the fundamental lesson of census taking: that a carefully controlled sample is almost always going to give better estimates than a poorly controlled attempt at complete enumeration. More important, perhaps, is the central lesson of my experience: that what one knows about the supporting evidence will play a very large role in how the findings of the analysis are interpreted. This point argues against using data already gathered unless absolutely necessary, and certainly against using it without knowing how it was gathered and—equally important—how it was processed. Now, systems analysts in many cases cannot avoid using data gathered elsewhere for other purposes (such as population statistics, economic data, government-generated time series, and the like), but considerable effort should be devoted to learning how these data were developed, and what their strengths and weaknesses are, so that the findings of the analysis can take account of such knowledge. Perhaps one of the most important pitfalls of analysis is to put more credence in data generated elsewhere than the way it was developed warrants.

Another pitfall is to gather too much material together—thus consuming valuable time to excess—rather than just the right amount. There is no simple rule to follow, except perhaps the truism that it is usually better to have a small amount of reliable information than to have a great deal in which one has little confidence.

6. FORMULATING ALTERNATIVES

Since Chapter 6 deals with this matter, we need not repeat the main points here. However, it is worth reemphasizing the central importance of dealing with this issue imaginatively and continually throughout the systems analysis study. It should never be too late to introduce a new alternative if ideas and consequences come together to generate a new concept with preferred properties.

If one doubts the importance of generating and considering the most imaginative and promising alternatives, he should contemplate the poverty of a large-scale systems analysis complete with the full panoply of computer runs, economic concepts, optimization models, etc., etc., that confines its attention to relatively simple primitive alternatives. For example, the IIASA study of future world energy supply and demand described in section 3.5 and discussed further in sections 6.1 and 6.3, if it had restricted itself to simple alternatives of oil, coal, water power, nuclear generation, and so on, would not have been able to consider the contribution of the allothermal coal liquefaction and gasification process that uses heat from breeder reactors or from hydrogen and that therefore adds greatly to the potential life of the world's coal reserves.

On the borders of the process of formulating alternatives there are some issues of practice and professionalism that deserve mention, although little prescriptive guidance can be offered.

An alternative may be deemed to be impractical because it breaches established laws, customs, prejudices, or attitudes. This does not necessarily mean that the alternative should not be considered; rather, it means that, if it is considered, the analyst will have a much larger burden of persuasion at the end of his study if it turns out to be attractive on other grounds. At this point he may face the issue of whether or not to introduce these social issues into his work, or to leave them for the client to judge. There are fundamental difficulties here, as Churchman (1979) points out. However, my counsel is one of courage on the one hand (the client may surprise you with a burst of venturesome advocacy for change) but prudence on the other by having other arrows in the quiver, even

though they may not be as attractive. Impractical alternatives have been known to become practical after being pushed by someone with influence.

Similarly, since a truly important issue worth a major systems analysis is bound to harbor political issues that will flower into debates when the findings emerge, political feasibility may be an issue to consider in formulating alternatives. Here again experience offers little advice, although some encouragement to be venturesome, the analyst being left for the most part to his own best judgment, which he should develop in concert with his client.

It is here that the analyst may face two of the most important dilemmas of his profession:

- How can he balance his loyalty to science and the profession of systems analysis with the loyalty to his organization when they come into conflict?

- In the face of potentially negative responses to alternatives—some responses being possibly so strong as to threaten the analyst's survival in his post—how can he best exhibit the venturesome courage to design and explore controversial alternatives, and present them as preferred if they occupy this place in the findings?

The inexperienced analyst's first reaction to these dilemmas may be to seek simply to avoid them—perhaps by dealing only with problems in which they cannot occur. But this is to doom him to the relative unimportance of problems of little moment: it is almost axiomatic that the coin of importance has a reverse that is controversy. Thus, the price the analyst must pay if he is to deal with problems of large and central importance is that he will be involved in the dilemmas of loyalty and controversy.

How is the analyst to behave in the face of these dilemmas? This matter will be discussed later in section 10.14.

7. CHOOSING MODES OF ANALYSIS

Applied systems analysis is driven by its problems, not its methods. Therefore, the analyst should allow the problem to rule his choice of method, and this choice should be taken from an eclectic menu. He should choose methods and techniques that are appropriate, avoiding the seduction of popular or convenient technologies that may seem to add "class" to the analysis, but that are essentially inappropriate. In the same vein, complications appropriate to the problem are necessary, and must be incorporated into the analysis, but those introduced merely to add analytic glitter to the product are to be shunned.

Five positive principles may be enunciated: Choose analytic machinery that is:

1. Appropriate to the problem and the prospective solutions to it that may emerge.

2. Internally consistent (the delicate analytic machinery of one part should not be bludgeoned by a hazy speculation in another).

3. Balanced in detail and accuracy (if one enters with order-of-magnitude estimates, he is seldom entitled to five-figure accuracy in his results, or, if accurate estimates are combined with very questionable estimates, this fact should be reflected in how the results are presented).

4. Appropriately interdisciplinary in the light of the appreciation of the problem with which the work began and is being continued.

5. Appropriate, if at all possible, to the process of presenting the findings that will emerge at the end of the study (the client will surely not want to poke into the details, but a realistic understanding of the main building blocks and key relations has persuasive value for many users of systems analysis results).

This last point deserves further discussion. The complications that must be represented by models in a systems analysis arise from the problem being treated, and therefore one may argue that the model complications are intrinsic. However, in practice it not infrequently happens that the choice of a model

is not so constrained as this remark would imply; for example, it may be possible to choose a series of relatively simple connected models rather than one very complicated comprehensive model, and yet get adequate results. When such a choice exists, there is some merit in making it at least partially in the light of how the results of the work will have to be presented to the client. If the model used also provides a simple line of argument that will be persuasive to a nontechnical person, this value should be weighed in making the choice.

Howard Raiffa, the founding Director of the International Institute for Applied Systems Analysis in Laxenburg, Austria, describes his experience this way (Raiffa 1978):

> As an analyst I have participated in several policy studies; as a professor in a public policy program I have critiqued a host of such studies; and as a decisionmaker myself or as a consultant to decisionmakers I have seen how such policy studies are used or not used.

And, on the basis of this experience he offers this advice:

> In modeling reality for policy guidance there are a host of options to consider. First of all, some advice: Beware of general purpose, grandiose models that try to incorporate practically everything. Such models are difficult to validate, to interpret, to calibrate statistically, to manipulate, and most importantly to explain. You may be better off not with one big model but with a set of simpler models, starting off with simple deterministic ones and complicating the model in stages as sensitivity analysis shows the need for such complications. A model does not have to address all aspects of the problem. It should be designed to aid in understanding the dynamic interactions of some phase of your problem. Other models can address other phases.
>
> Time constraints, however, may not allow you the luxury of tailoring models to fit your problem. You may have to choose a model off the shelf, so to speak, and fiddle with fitting it as well as possible to your problem. But in these cases my advice is even more cogent: Keep it simple.

8. CARRYING OUT THE ANALYSIS

This issue has been discussed so thoroughly in earlier chapters that little needs saying here. However, three points deserve emphasis:

- The issue of documentation should be kept in mind from the beginning. The work should be documented as it proceeds, so that, at the end of the work, when attention is properly focused on communicating the findings and following up on them, it will not be necessary to return to the earlier work to reconstruct—sometimes with considerable difficulty—what was done. Documentation is as much a part of the professionalism of systems analysis as it is of pure science, and the need to have full and clear records at the end of the project should be recognized and responded to. The easiest way to achieve this essential standard is to keep it in mind throughout, and to do what is necessary at each step of the analysis to build the records that will allow others to see clearly what was done, and, if they should ever desire, to duplicate or extend the work.

- The work of the analysis should be done openly, so that the participating management personnel can understand, interpret, and report informally to their colleagues what is going on. This policy risks possible misinterpretation, but this risk is more than overcome by the benefits to be accrued. This openness should also extend to others who may have legitimate interests in what is being done.

- Any systems analysis contains the results of major decisions about how to proceed and how to interpret evidence—but there are also smaller ones that the analyst must make from day to day as his work proceeds (can we ignore this factor? is this small-sample estimate adequate? can this result from another study be relied on? is this small effect apparently exhibited by the data a realistic representation? and so on). Controlling these secondary analysis decisions so that they do not cumulatively vitiate the main thrust of the analysis is important, particularly in a large study with many parts and many analysts. There

are no simple rules for doing this that I know of, beyond the one that says the leaders of the project should keep careful watch over this issue day by day as the analysis develops. If they do this, they will assure that the decisions are consistent, and that the potential impact on the findings can be assessed and reported candidly; if they do not, important flaws may seep into the work. Pursuant to the first point, it is also important to document these secondary decisions as carefully as the primary ones, together with estimates of their potential effects.

Finally, after the analysis is complete, and the findings tentatively formulated, it is wise for the analysts to stand back and review their work. The background context may have shifted, key client personnel may have changed, the analysts themselves will have developed new perspectives arising from their involvement with the problem, and so on—and such factors may have shifted the perspective on what was done and should have been done. This review may prompt some change of focus—perhaps even the development of some new alternatives for last-minute investigation.

In addition, the review should assess key variables and their impacts, be sure that the needed sensitivity analyses have been carried out, and carry out the supplementary analyses that the analysts and their clients may need to round out a good understanding of why the results came out as they did, and what their implications are.

The analyst may argue that, with the work already behind schedule and with demanding reporting needs staring at him, there is no time for this final review. However, if he skips it, he may deny his reporting the balanced current perspective that his client will find most persuasive.

9. FORMULATING THE FINDINGS

The scientist inexperienced in systems analysis may well wonder why this topic needs taking up at all—since the work was aimed at discovering results; when they emerge surely the analyst recognizes and understands them.

However, the client may not, and it is *his* understanding that is the goal of the analysis. Therefore, the experienced analyst knows that formulating the findings properly and effectively is a key task in his work, and involves some matters that deserve his careful attention:

- The first of these is the most important: The formulation must be based, not on the interests of the analysts, but those of the client officials.

- The formulation should be balanced in terms of their needs and perspectives. Thus, matters of particular interest to them should be emphasized; others of minor interest should be passed over lightly, or even omitted entirely if time or space is limited.

- Special attention must be given to important results that may run counter to intuitive beliefs of the client officials; if their outlooks are to be changed, the evidence aimed at changing them must be carefully thought through and effectively presented.

- Care must be exercised in choosing the form of argumentation—the flow of evidence and logic—that will be persuasive to the client (Majone 1980), for, if the client does not factor the findings into his thinking in an effective way, much of the value of the work may be lost.

In sum, while the findings of the analysis may present numerous matters of interest to the analysts, the items of value and interest to the clients deserve special attention devoted to their formulation, an effort that will extend to how best to present them. The analysts dealing with the estuary-protection problem discussed in section 3.4 faced this problem, and devised a special approach, as we saw there.

Generally, the approach to systems analysis presented in this *Handbook* has advocated continuing reconsideration of the problem as the analysis proceeds; in fact, of the nine steps in systems analysis listed in section 1.4, the fourth was: "Reconsider the problem in the light of the knowledge accumulating during the analysis." Raiffa (1978) argues the case even more strongly, urging that it is

> . . . helpful occasionally for analytical groups, even in their early deliberations, . . . to dwell a bit on the big picture: From problem formulation to policy generation to analysis to conflict resolution to advocacy to implementation and to evaluation; to try to identify those crucial issues that are at the cutting edge of the policy arguments; to examine, all along the way and not only at the end of the analysis, how the separate pieces of analysis can be fused together into a holistic, balanced, coherent, realistic, acceptable, implementable policy recommendation.

In formulating the findings of the analysis the systems analyst has his last—and perhaps most important—opportunity to conduct a sweeping reconsideration of the problem and the analysis response to it in the full panoply of its surrounding circumstances. He must make good use of this opportunity.

The analysis plan that was prepared at the beginning of the work included a section on communicating the findings, and therefore on the sorts of communication instruments that would be needed. When the findings are being formulated it is time to review this section and evolve a more detailed plan for communicating them, especially since the analysis team has now grown much more familiar with the client organization and its people. This combination of knowledge of the results of the study and the needs and interests of the client will yield a changed and refined communication plan. The next section will discuss preparing items that may appear in such a plan.

10. PREPARING THE COMMUNICATION INSTRUMENTS

A major systems analysis study calls, not only for a variety of communication instruments aimed at the varied audiences who are—or should be—interested, but also great care in preparing them. Indeed, the analysts who conducted the forest-pest analysis described in section 1.2 say (Holling 1978, p. 120): "Our experience is that at least as much effort must go into communication as goes into analysis"—and they cite other experience to confirm this

judgment. While the amount of effort involved in preparing communication instruments varies from case to case, there can be no doubt that it is a very important step in the analysis activity, and one that deserves careful and creative thought.

While several forms of reporting involving a number of media may be called for, the written report usually lies at the core of the communication process. Not only is this document the central reference for all concerned, but also its preparation is the final testing ground for how the findings will be presented. It is the wellspring from which all of the other communication instruments flow. Therefore, I will discuss this document first.

The systems analysis report. It should contain three parts:

1. A summary (complete enough to tell the busy executive in a few minutes what the problem was, what ground the analysts covered in their work, what the findings were, and what suggested courses of action are being proposed).

2. The main report (written entirely in the language of the client organization and containing the complete story of the work from a nontechnical point of view, but not including the details of the technical aspects of the analysis).

3. The appendixes or supporting technical reports (containing the complete technical presentation of the analysis).

To provide perspective, such a report could have a main body of several hundred pages, a summary of 25 pages, and perhaps more than a thousand pages of supporting material, perhaps available in several documents. For a less comprehensive study, the summary might be ten pages long, the main body 80 pages, with 150 pages of appendixes containing the technical material. For example: The global analysis of energy supply and demand described in section 3.5, which occupied an analysis team over a seven-year span, was supported by some 80 technical reports (which in turn rested on a vast literature); the technical report is a book of over 800 pages. This book and its supporting reports con-

stitute for this case the third item in the list above. The "main report" is a book for the general reader of some 200 pages; the summary was published separately in a paperback report of about 60 pages. See Energy Systems Program Group (1981).

The audiences are important in deciding what to say and how to say it: the summary is for busy officials who only want a quick view, the main body is for the officials and members of their staffs who want a full story in nontechnical terms, the appendixes are for technical experts who may want to review details, or perhaps even extend the work at a later time.

The academic scientist accustomed to the space exigencies of today's technical journals may be startled by the redundancy of this approach: the same story is told three times in differing versions, depending on the audience. However, experience shows that academic conciseness will fail to communicate with the key audiences, while this redundant form, if well executed, will be effective.

The other novelty of this outline is the order in which it should be filled in. The experienced analyst does not start at the beginning with the summary; rather, he starts with the appendix material, shaping it so that it will support the main body when it is written. This supporting material should be complete: data, assumptions, models, results of calculations, rationales for interpretations, and so on and so on. After completing this foundation, at least in draft form, the analyst proceeds to write the main body of the report, keeping careful watch that its text rests solidly on the supporting material and that it speaks to the client and the members of his staff. At the same time, he has an eye on the exigencies of the summary that will bring the writing to a close. In fact, if the main body is shaped properly, the summary will almost write itself—after the heavy labor that preceded, an unalloyed joy! Finally, he writes the summary and the report is complete. For example, the reports describing the findings of the global energy analysis mentioned above were written in the sequence just described.

There is another piece of advice that comes from experience: throughout the process of preparing the written report, it is wise to keep in mind the other communication instruments to be used, such as briefings with charts, slide shows, computer demonstrations, and so on (Holling 1978, Chapter 9, suggests some of the variety that has been useful in ecological work). Thus, material such as illustrations, charts, and tables can be worked up early that will be useful later in the various media of communication that are adopted. Then the written outlines, structural elements, and carefully worded findings will be all that will need to be added close to the times they will be used.

Let us now turn to a more detailed discussion of the content of the main report. It should contain:

- Key aspects of the context surrounding the problem (while the audience for the report can be assumed to have a general knowledge of this context, it is usually the case that the appreciation of key aspects of it needs sharpening if the analysis and its findings are to be understood properly).
- A statement of the problem as it was finally evolved during the analysis.
- The principal facts and assumptions on which the analysis is based.
- The alternatives considered (it is very important to take particular care with this section if, as is likely, any of the alternatives considered are novel or likely to be surprising to the client, or if it is necessary to explain why some "obvious" alternatives have not been dealt with).
- The key elements in the chain of logic leading to the analysis results (this item is discussed further below).
- The findings.
- The implications of the findings (this section foreshadows the next one on courses of action).
- Possible courses of action, their advantages, disadvantages, and consequences.

- New demands posed by these courses of action: resources, reorganization, new outlooks, etc.

- Recommendations, if the analysis warrants them.

- A careful delineation of the ground covered by the analysis, and, even more important, the limits of the analysis and the ground not covered (this last point is an essential item of good professional practice, since it marks out the area in which the systems analysis can help the client, as well as the area in which the client must continue to rely on his own judgment and such other information as he has; thus, the analyst avoids the pitfall of appearing to have done more than he actually did).

The scientist entering systems analysis from another field may be surprised that this outline contains only one passing reference to the center of much of his professional interest, the analytic machinery that produced the results, and this reference is in novel language ("the key elements in the chain of logic leading to the analysis results"). There is a good reason for this: Unless the client is very unusual, he is not interested in such details, nor will an attempt to educate him about them be anything but counterproductive. However, there may be a simplified chain of logic based on the analysis details that sheds light on why the results came out as they did; in fact, this is usually the case, at least partially. To present this logical chain will be helpful; it should be included if it does not take too much space.

The technical appendixes provide the support for the findings presented in the main body of the report; however, they need not repeat the peripheral material from the main body—although they should be full enough to stand pretty well alone. Here the analyst is talking to his professional colleagues, and may use any of the jargon, formulas, or other technical paraphernalia common in his field.

The summary is written for the busy executive, and thus it should be relatively short. However, it must contain a boiled down version of all of the important material in the main body of the report, so that this busy executive gets a

rounded picture. Thus, it cannot be too short (such as the length of the usual technical-paper abstract), since it must be long enough to exhibit the problem formulation, the structure of the solution, the findings, and the recommendations. It should contain, not only the text needed to convey the central message of the study, but also the figures and tables (very carefully chosen and prepared) that will illuminate this message. Careful preparation of this summary is also the best preparation for the oral briefings and discussions that will almost inevitably follow completion of the analysis.

With the written report prepared, the analysis team is ready to turn to other forms of presentation, such as oral briefings, slide shows, movies, articles, and so on. What needs to be done is dictated by the context of the study itself. However, the commonest form of presentation other than the written report is the oral briefing, to which we now turn.

Oral presentations. The dominant constraint for the oral presentation is time. The scientist used to the leisurely fifty-minute academic lecture will, no doubt, experience considerable shock to find that client executives may expect the findings of a major systems study to be presented in half an hour—or perhaps even as little as twenty minutes! Such short allotments of time are not usual, but they are not unknown—and, if they represent the opening that presents itself, the analysts should be prepared to use it to good effect. In any case, time will be limited, and the analyst who is the spokesman for the team must plan to make the best use of it.

The scientist comfortable with the blackboard talk with chalk in hand, occasionally used to jot a note or graph on the blackboard, may feel that this experience will carry over easily to this new situation—but he couldn't be more wrong. The goal is to squeeze as much hard information as possible into a very limited time: Therefore, techniques to achieve this goal are called for, and how to use them must be carefully planned. The central lesson of experience here is that a briefing built around carefully prepared visual aids can be made to meet the need. Such visual aids can be an outline of the main parts of the talk, lists of

points, tables, graphs, maps, photographs, charts, and so on. The goal is to give the audience dual impressions of key points, oral and visual.

This visual material can employ a variety of media:

- Stiff chart boards set on easels that the speaker can set down as he finishes with them.
- A large tablet on an easel whose pages can be turned by the speaker as he passes from one to the next.
- Transparent plastic sheets that are set horizontally on a projector that throws the images on a vertical screen (sometimes called a "viewgraph").
- Slides projected on a screen, with a trigger available to the speaker.

The first three are appropriate for small to medium-sized groups, but do not work very well for large groups, because it is difficult to make them large enough to be seen clearly from the back of the room. Slides are the best option for large groups, but they have the disadvantage that the room must be darkened for them to appear to best advantage; this fact makes them undesirable for smaller groups, where the other options are better (the transparent-plastic projector being perhaps the least desirable of the three possibilities). For anything less than the large group, the media list above is in the order of effectiveness and preference.

Before proceeding to discuss the briefing and its charts further, there are three pitfalls that are so astonishingly common that they must be mentioned here:

- The visual material is not legible, particularly to persons sitting at the back. This pitfall produces a doubly negative effect: the persons at the back will not get the message fully, and they will not respect the sense of reality of anyone who ignores so simple a problem. The principle is simple: The visual material must be clearly legible to everyone in the room, and this visibility should be carefully checked before the visuals are prepared.

• The visual material is so crowded with words and other information as to force the audience to make a choice of listening to the speaker or mastering the details of the visuals. This also detracts from the audience's ability to appreciate the message, and reduces their receptivity to it by producing a strain on their attention. The principle again is simple: Keep the visual material simple enough to be comprehended at a glance: In a list of points do not write whole sentences, put down two or three key words that will be explained by what you say; in a table, do not display several dozen numbers that the audience cannot analyze, show in a reduced table the few that are significant to your point; keep graphs simple, but be sure to label the axes and units clearly.

• The speaker, wanting to cover everything very carefully, prepares a complete text of what he has to say and then drones through it, with the visuals, whether changed by him or a helper, not always well coordinated with the text, owing to the speaker's full attention being paid to his papers. The speaker plunged into this pitfall fails to establish the appearance of smooth competence suggesting to the audience that he has a full mastery of the work and its results, and distracts the audience by drawing its attention to mechanics. There are various ways to avoid this pitfall: The man with a good memory that works well while he is on his feet can leave the manuscript in the file and do splendidly; most, however, hesitate to rely on memory at so crucial a time, and want props to be sure that all points are covered in the right order, and there are three possibilities: (1) if the visuals include enough points—and a well prepared set usually will—they will serve alone to keep the speaker on his chosen path, allowing him to keep his hands free and giving the audience the feeling of relaxed discipline that makes the best impression; (2) if there are points that must be made that are not on the visuals and the speaker has chosen to use either board charts or tablet pages, these points can be penciled lightly on the edges of the visuals so as to be clearly visible to the speaker but invisible to the audience; and (3) some inconspicuous papers or cards can be laid on the stand in front of the speaker. These possibilities are listed in order of effectiveness and prefer-

ence.

These remarks about the oral presentation of the study results may appear to suggest that this is the most difficult part of all—but this lies counter to my experience. One has only to remember that the study has been done, the report and its summary written, and the material developed there available both in hard copy and the team leader's mind to realize that the job is merely one of selecting and shaping; indeed, it is one of the most pleasurable of the systems analyst's tasks.

The project spokesman prepares a careful outline for his briefing, assembles the relevant graphs and charts, prepares the material for the charts listing points, goes over the combination several times to establish continuity and completeness to his satisfaction, and he is ready for the final steps of preparation. Here there is a fact from experience that may seem at odds with all of the foregoing admonitions to take care: to achieve a good effect the visual material does not have to be prepared by commercial artists or engineering draftsmen; in fact, many analysts with modest drafting and lettering skills prepare their own, especially when time is severely limited (as is often the case). Felt pens, which are available in many colors, used on paper which shows a dim set of straight lines directly or through from a sheet below produce effective visuals even in amateur hands when some care is taken. If the speaker prepares his own, he inevitably finds some further refinements emerging from the rethinking forced on him by the preparation process.

Next, with the briefing and its visuals prepared, it is essential to have a practice run in front of a friendly audience—the rest of the analysis team and perhaps others close to the work are the choice. This "dry run" will yield many benefits, not the least of which will be the speaker's confidence in what he is saying and how he has chosen to say it—and how long it will take.

Finally, there are some points to be made about time. If the manager has allotted 30 minutes for the meeting, it would be imprudent to prepare a 30-minute briefing for it. Schedules often do not hold exactly; most meetings

spend at least a few minutes on introductions, pleasantries, and orienting remarks; and even a single question from an interested official will shoot down so tight a schedule. Thus, the formal talk should be planned to fill only a portion of the time; how much should be left for questions, discussion, and delay is a judgment best left to persons familiar with the administrative setting involved.

If the study deals with an important problem and has reached challenging results, there will be questions and discussion, and lots of both. The speaker can answer some points, but his team should be there to expand on them and to answer ones on which their knowledge is more thorough. It is also well to have some additional charts available that can be used to discuss these questions. Even though one cannot be sure just what questions will be asked, his knowledge of the subject allows him to make some shrewd and accurate predictions, and if there is material ready to help respond to a significant number of them the impression of the analysis team's care and thoroughness is greatly enhanced.

Concluding remarks. There are other forms of presentation that may emerge from a major systems study, such as slide shows, movies, articles for the nontechnical press, and so on, but they will not be discussed here, since they are likely to involve experts who can bring appropriate standards to bear on them.

Throughout these processes of preparing the communication instruments, there are key charts and tables that play central roles. Thus, at the beginning when the appendix technical discussions are being prepared it is time to think about them and prepare them. The result will be that they—or simplified versions—will carry through the main body of the report, its summary, and the briefings. Preparing them early will help tie all of the versions together; indeed, all of the later versions can be built around these carefully prepared charts and tables worked out during the preparation of the most technical version of the report.

Finally, throughout the process of preparing the communication instruments, the audience should be uppermost in the minds of the analysis team, and

the language and mode of argument should be appropriate to this audience (or, as may be the case, these audiences). This does not mean talking down to these people—they differ from the analysts not in intelligence, but only in background training—but rather using their vocabulary whenever possible, and taking care to define and illustrate the new terms that must be introduced into the explanations. The most important thing to do is to present a line of evidence and logic that will be persuasive to the audience, and that will build their confidence in the reliability and acceptability of the findings; the concepts and language must be the ones appropriate to this purpose, even if they present difficulties to the audience. Thus, our warning here is not against difficulty, but only against difficulty that is not needed for this purpose.

11. ADDITIONAL ANALYSIS

While any thorough systems analysis will have explored its problem area carefully, and performed a variety of analyses, including those to explore the sensitivities of the results, time is always limited and not everything possible will have been done. Thus, during the communication process there will inevitably arise questions that call for additional analysis. The team should anticipate this need, and be prepared to respond to it.

12. THE COMMUNICATION CAMPAIGN

When the problem dealt with by a systems analysis is relatively simple and there is only one decisionmaker with relevant responsibility and authority, the naive view may be correct: the analyst completes his work, reports its findings to this official in the form most appropriate for him, observes this decisionmaker choose the desirable course of action, and then retires in satisfaction to a well earned period of relaxation, with congratulations echoing in his ears. Regrettably, life is seldom this simple, particularly when a large-scale problem is in hand and many interests are affected.

Here the analyst cannot just prepare a communication instrument and use it once; rather, he must plan a comprehensive communication campaign. One of the most basic reasons is that in large organizations decisions can be made widely and at many levels of responsibility—and for a major course of action to be effective all of these decisions must be coordinated by being based on a common understanding, not only of what course has been chosen but also the factors affecting it and how subordinate actions and decisions fit into the scheme. Thus, the analysts will in all probability find that they have many people to communicate with on many levels; instead of one briefing, they may find themselves involved in many, supplemented by a large number of private consultations.

Thus, this campaign must be planned and resources allotted to it, so that it can proceed effectively.

Two examples will serve to offer some insight: the first, based on a personal experience not documented in the literature, was a systems analysis that occupied a small team about three months and that led to a well defined decision by a high-level advisory committee; the second deals with the study of world energy supply and demand mentioned earlier in this chapter (see section 10.10) and that has been described elsewhere in this *Handbook* (especially section 3.5).

Space surveillance. It is a regrettable fact that the space around the earth contains many pieces of junk, fragments of various sorts from various activities in space, all orbiting the earth at various altitudes and in various planes with respect to the plane of the equator. Thus, if one wishes to keep careful watch on some vehicle, either one's own or someone else's, it must be discriminated from other items, a process that makes it necessary to keep careful track of everything.

This need dictates that surveillance instruments be placed about the earth so as to keep watch, and to feed the information from the watch into a central place where it can be sorted, identified, and tracked. A number of years ago the responsible US officials were considering four new potential alternatives for maintaining this surveillance, and a high-level advisory committee was expected

to make a recommendation within about 90 days. To support this recommendation, the committee asked a systems analysis team to study the feasibility, operating properties, and costs of the four possibilities, with one of the important costs being the trained manpower that would be required for each alternative.

A team of some eight experts in the major contributing technologies assembled under my leadership to undertake the work. Fortunately, all were familiar with the problem setting, so that the exploratory phases of the analysis were not so time-consuming as is usually the case. This enabled the team to reach a consensus on the problem outline early, and obtain the agreement with the committee secretariat that it was what would respond to the request. Then, based on this consensus, the analysis plan was laid out. However, owing to the very short time allowed for the work, each expert had to work separately, relying on the team leader for coordination, and each prepared what became a chapter in the appendix to the final report. As these drafts came to the team leader for review, he was able to abstract from them the material needed for the main body of the report, while at the same time preparing visual material and tables that would be used, not only in the main report, but also in its summary and the oral presentation of the results that had already been scheduled for the end of the analysis period.

Thus, in a final period of only two or three weeks, all of the basic material was completed: the technical appendixes, the text of the main report, the summary, and the visual material for the oral presentation. The whole consisted of some 300 pages, about two thirds of which was technical appendixes, about 75 pages the main report, and about 25 pages of summary. The team leader gave the oral presentation to the advisory committee on schedule, some 40 minutes having been allotted. After about twenty minutes of discussion, the committee agreed on recommendations and sent them forward within a few days.

Some of the good impression created by this analysis was the analysis team's candor, not only about the analysis that had been done and the results

achieved, but also about the limitations of the work and the technical problems (there were several) that it had not been able to solve.

To the best of my knowledge, the members of the advisory committee never read the analysis report. However, it served two vital functions: writing it enforced the discipline of getting the results and testing them carefully before presenting them, and later it allowed a number of technical specialists elsewhere to check the work for adequacy before incorporating its findings into their own ongoing investigations.

In this relatively simple case, the time allotted was short, the number of people involved directly was less than ten (although quite a few others were consulted or made small contributions), and the advisory committee acted essentially as a single decisionmaker. During the first half of the analysis period, the team leader was primarily concerned with setting the problem, assembling the analysis team, laying out the analysis plan, and getting the work started; during the latter half of the analysis period, much of his effort was devoted to coordinating, focusing, and carrying out the communications work (working with the team members to improve the appendixes, preparing material for the main report and then the report itself, writing the summary, and preparing the briefing material), these activities also serving to bring the analytic work to well defined closure focused sharply on the needs of the client.

Providing energy for the future. This study was conducted at the International Institute for Applied Systems Analysis, Laxenburg, Austria, and began in the summer of 1973. The team leader, Wolf Haefele, summarizes the phases of the study this way: "The study . . . focused for the first two years on understanding and conceptualizing the energy problem. This led to the design of a set of energy models that were subsequently used for developing two scenarios—the principal tool in our quantitative analysis. A preliminary draft of our findings was completed in 1978 and sent out for review. The widespread substantive comments received on this draft were carefully considered in finalizing our report. This book, which was completed in December 1979, reflects our work up

to this date" (Energy Systems Program Group 1981, volume 2). In the meantime, although the team at work at any one time was never very large, some 140 people from more than 20 nations had been involved in the work over a period of seven years. While the volume Haefele refers to here (the 800-page technical report mentioned earlier in section 10.10) was being given final review and being prepared for the press, work on the 200-page book that occupies the place of the main report was going forward. Both books appeared in the spring of 1981, followed shortly thereafter by the 60-page summary.

In the meantime, a program of other forms of communication had begun with speeches (see, for example, Haefele and Basile 1979), summary articles (for example, Haefele 1980), and too many consultations to mention. As this is written in late 1981 a major communication program is under way with industry and government groups and individuals involving dozens of oral presentations and hundreds of hours of consultations and cooperative work with teams wishing to incorporate facets of the IIASA findings into their own work—in sum, a communication program too widespread and various to be susceptible of easy summary here. The point, however, is clear: the analytic work has had to be followed up with a major communication campaign leading to activities in implementation, as described at the end of section 9.3.

Concluding remarks. This discussion has been intended to underline the importance of having an appropriate communication plan, assigning the effort to carry it out, and pursuing it with the same vigor and attention that was devoted to the analysis. Indeed, such an effort is an essential complement to doing the analytical work; it may consist of writing the report and giving a single oral presentation, as in the space surveillance example, or it may demand the effort of several people over an extended period, as in the case of the IIASA energy study—but without it the work may be wasted.

A communication plan depends so intrinsically on the problem and its administrative setting that there is little guidance of a general sort that can be given beyond urging that it get careful attention and adequate effort.

However, I can stress the importance of having the analysts preserve a balanced, objective posture throughout. They must appreciate and accept, not only the analysis findings and their implications, but also the concerns of the many persons potentially affected by the new course of action and the additional matters that they must consider.

In the earlier chapters of this *Handbook*, especially Chapter 9, we have stressed the importance of following up in the implementation phase after a course of action has been chosen. Thus, there is little to add here, except to affirm the importance of planning for this work, at least tentatively, so that in the happy event it should have to be done, all will be ready. It may involve additional analyses to respond to new conditions or unforeseen problems, as well as fairly comprehensive consultation interactions as the course of action is pursued.

13. SYSTEMS ANALYSIS AS AN AGENT OF CHANGE

Systems analysis is intrinsically a discipline aimed at solving real problems of sociotechnical systems. As Chapter 2 argues, it

> . . . is concerned with theorizing, choosing, and acting. Hence its character is three-fold: descriptive (scientific), prescriptive (advisory), and persuasive (argumentative-interactive). In fact, if we look at the fine structure of analytic arguments we see a complex blend of factual statements, methodological choices, evaluations, recommendations, and persuasive definitions and communications. An even more complex structure emerges when we look at the interactions taking place between analysts and different audiences of sponsors, policy makers, evaluators, and interested publics. Moreover, descriptive propositions, prescriptions, and persuasion are intertwined in a way that rules out the possibility of applying a unique set of evaluative criteria, let alone proving or refuting an argument conclusively.

Further, as this *Handbook* shows, and as Chapter 2 states, systems analysis "is a craft. The systems analyst as craftsman is a producer of data, information, and arguments, but also a social change agent. He must influence some people to accept his proposals, and other people to carry them out; he is expected to take some responsibility for implementation." In sum, to use Boothroyd's (1978) suggestive phrase, he is engaged in "articulate intervention" into the activities of sociotechnical systems.

However, the matter goes even deeper: The systems analysis team cannot stand aside from the sociotechnical system it is investigating; rather, it is both easy and realistic to argue that the team is itself a subsystem in this larger system—a state of affairs that faces the analyst with deep and important philosophical questions, as well as more practical ones of standards of professional behavior and ethical choice. Problems of philosophy and ethics, as they relate to systems analysis have been explored (notably by Churchman 1978 and 1979), but remain in a sufficiently restless state to make summarizing them inappropriate for this *Handbook*. However, this is not to say that they are not important, or that we should not put discussions of the common views in a leading position if they existed; rather, it is to say that the stream of thinking has not as yet, unfortunately, permeated the community of systems analysts to an extent sufficient to allow us to state a view that represents the center of gravity of this community's outlook. It is my view that problems of philosophy and ethics, as they relate to systems analysis, are very important, and deserve more investigation and wider recognition than they have as yet received.

On the other hand, issues of professional behavior have been given some attention by the systems analysis community, and it is to the discussion of these that I turn in the next section.

14. GUIDELINES FOR PROFESSIONAL BEHAVIOR

A systems analysis can be judged by its outcome, that is, by whether or not its implemented results improve the operation of the system that has been subjected to study. By this criterion the investigation of improving blood availability and utilization described in section 3.2 can be judged to have been successful, since the new system of managing the supply showed properties that were substantially improved over what was experienced before the new system was installed.

On the other hand, many system studies deal with problems and issues where the outcome test will be intrinsically denied. For example, the IIASA study of how best to supply the demand for energy for the next 50 years cannot be judged by testing its outcomes as in the blood-supply case. Even if world energy leaders adopt and implement some of its findings, the outcome test will in all probability not be possible, as experience with alternative courses will not be available for comparison. Here we must base our judgment of the quality of the work on criteria relating to the process by which the results were achieved.

Thus, the professional behavior of a systems analyst can be judged by standards internal to his work (relating to the process by which the results are obtained) or external to it (by judging both its outcomes and the analyst's relations to society).

Internal evaluation. The previous section reminds us that systems analysis must be viewed as a craft. Majone (1980) carries the argument forward in this way:

> The systems analyst as craftsman goes through essentially the same operations that the scientist performs; and both scientist and analyst replicate on an abstract conceptual level what the traditional craftsman or artisan does with material objects and physical tools. The artisan applies his tools to certain materials in order to produce an object fulfilling a given function. The intellectual craftsman (analyst or scientist) works on abstract materials (data, concepts, theories)

using different tools and methods (mathematical, logical, "hardware") in order to produce an argument supporting certain conclusions and/or recommendations . . .

The notion of craft is intimately related to that of quality standards. Indeed, the main function of the master craftsman (and also, to some extent, of the patrons and connoisseurs of the craft) is creating standards of quality for the other practitioners. These standards usually remain inarticulate (they are taught more by example than by preaching), but they are nonetheless quite effective in guiding and controlling the work of the craftsmen. Scientific leaders fulfill similar functions for their disciplines, with the support of institutional mechanisms like professional organizations, refereed journals, and academies.

. . . the profession [of systems analysis] is beginning to understand that quality control (in the case of [systems analysis] . . . as of all other intellectual activities) is intimately related to a sophisticated understanding of process.

One of the main purposes of this *Handbook* has been to make quality standards of the craft of systems analysis explicit, and much of the discussion in the previous chapters serves this purpose. It is also useful to examine the pitfalls into which unwary analysts have stumbled, and some of these have been described at appropriate places; however, Majone and Quade (1980) have compiled a large and very useful collection, together with leads to other literature on this important subject.

Systems analysis is still relatively young, and its standards are still developing. Thus, both the producer and user of systems analysis results would do well to conduct a continuing examination of such work as it emerges in order to refine their understanding and application of such standards.

External evaluation. Whenever possible, the most important external standard of evaluation for systems analysis results is to compare their implemented outcomes with earlier experience. In fact, in section 1.4 the list of nine possible steps in a systems analysis study has as its last one "evaluate the results of implementing the chosen courses of action." Thus, from the beginning we have considered this form of external evaluation to be an important step in systems analysis itself.

Relations with society. However, society, whose future may well be affected by systems analysis results, has other concerns about systems analysis. Since it is not, in general, well equipped, either to judge whether or not craft standards have been met or to evaluate fully the efficacy of outcomes (particularly when no relatively simple comparisons can be made), it expects this new profession to hew to high standards of professional behavior. Such standards could be imposed by society from outside the profession, or they could be established by the profession itself. And, of course, society's chief concern with such standards is how they might govern the profession's relations to society.

So far, while there have been scattered expressions of concern about such standards by persons not in the profession (see, for example, Miser 1973, which mentions some examples), there has been no movement to impose such standards from without. However, there have been some efforts within the profession, although it cannot yet be said that a consensus has been reached. Thus, I must content myself here with sketching some of the key strands of thought that have appeared in the writings on this subject by professional leaders in systems analysis.

The need for standards of professional behavior was recognized early: the constitution of the Operations Research Society of America adopted in 1952 stated that one of the objects of the Society was "the establishment and maintenance of professional standards" and the Society's second president called in 1954 for professional and ethical standards (Rinehart 1954), as did the eleventh president nine years later (Miser 1963). However, as section 2.6 describes, the

issue lay dormant until 1971, when ORSA proposed a tentative set of "guidelines" (Caywood et al. 1971), which failed, however, to achieve a position of authority in the profession. Since then, there has been no effort by a professional group of systems analysts to promulgate standards aimed at acceptance by the professional as a whole, although in the United States there has been a growing more general concern about the relations of science and technology to society, and, in particular, the appropriate ways for scientists to affect public policies (Chalk, Frankel, and Chafer 1980). However, some writers have addressed the subject, and several threads have emerged as commonly important.

- *Openness.* Section 10.8 declares that "documentation is as much a part of the professionalism of systems analysis as it is of pure science, and the need to have full and clear records at the end of the project should be recognized and responded to." However, this principle extends beyond the written reports (which were the context in which this statement was made) to other forms of communication and discussion. The systems analyst should be as candid about the weaknesses, arbitrary judgments, and limitations of his work as he is about its findings and their strengths. Curiously, in my experience this does not weaken his case (as the inexperienced might expect); rather, it strengthens his authority as an analyst who knows what he knows, and, more importantly, knows what he does not know. The space-surveillance example of section 10.12 illustrates the point: "Some of the good impression created by this analysis was the analysis team's candor, not only about the analysis that had been done and the results achieved, but also about the limitations of the work and the technical problems (there were several) that it had not been able to solve." Thus, in my experience, the professional principle of openness is an inviting one, rather than painful and forbidding.

Sugden and Williams (1978) say that "The analyst must owe some allegiance to intellectual honesty," a loyalty that is almost certainly supported by the principle of openness.

Similarly, a number of writers call in various ways for objectivity—an elusive property hard both to define and achieve. However, candor about one's work and its background can move the communication firmly in this direction, even though the difficulties are severe, as Quade (1975) points out:

> It is rarely possible to carry out an analysis of a public issue in such a way that all those who hold various views of the issue involved will consider it fair and objective. Generally, this is unavoidable owing to the nature of the issues, uncertainty and differing views of values. . .
>
> . . . Openmindedness, willingness to follow evidence wherever it may lead, and readiness to reconsider conclusions when doubts arise are supposedly the marks of a scientist. But these are more ideals than marks. Policy analysts are people like anybody else.

• *The obligations of a profession.* Professions stake out claims with society and bind themselves to address classes of problems appropriate to their knowledge and skills; for example, medicine addresses problems of health, law problems of social regulation, systems analysis the operating and policy problems of sociotechnical systems. In return, society accords these groups certain rights, privileges, and respect—usually including setting standards of training, behavior, and self-regulation. The bargain implies that society will be better off as a consequence of the intervention of the professions, and that, in turn, the professions will be suitably supported. In sum, there is a mutual obligation.

But this view places a burden on the individual members of the profession; they must not only be loyal to their employers (for the systems analysts, their decisionmaking clients) but also to their profession and, through this profession, to the society that supports it and accords it its privileges. Sugden and Williams (1978) present the argument for cost-benefit analysis, but it applies equally well to systems analysis:

> An ethical justification for the decision-making approach to cost-benefit analysis must start from beliefs about how a political system

ought to operate. Given particular beliefs of this kind, one can argue that in a democratic community the use of cost-benefit analysis contributes to the good of society; cost-benefit analysis *ought* to be used. The argument begins from the assertion that the role of the analyst is to assist, not simply a decision-maker, but a decision-making process that has the assent of the community as a whole. In this process the community, as well as the decision-maker and the analyst, is involved. The decision-maker is responsible for making a decision, according to his own lights, but he is responsible to the community. His right to decide stems from the consent of the community, expressed through the political system. The community, then, ought to have the right to call upon the decision-maker to account for his decisions.

In this framework, cost-benefit analysis has a dual function. It assists the decision-maker to pursue objectives that are, by virtue of the community's assent to the decision-making process, social objectives. And by making explicit what these objectives are, it makes the decision-maker more accountable to the community.

This view of cost-benefit analysis, unlike the narrower value-free interpretation of the decision-making approach, provides a justification for cost-benefit analysis that is independent of the preferences of the analyst's immediate client. An important consequence of this is that the role of the analyst is not completely subservient to that of the decision-maker. Because the analyst has some responsibility to principles over and above those held by the decision-maker, he may have to ask questions that the decision-maker would prefer not to answer, and which expose to debate conflicts of judgment and of interest that might otherwise comfortably have been concealed. [Italics in the original.]

• *Forms of intervention.* This *Handbook* has dealt from first page to last with the intervention of systems analysts (scientists from a variety of

disciplines) in the operations, plans, and policies of sociotechnical systems—and the emphasis throughout has been on careful study, documented as fully as possible and reported as openly as feasible. However, social history of the last two decades has seen scientists (including some calling themselves systems analysts) widely involved in public advocacy in a variety of ways.

Milton Katz of the faculty of the Harvard University Law School has provided the US National Academy of Sciences an illuminating discussion of how this problem has been dealt with by the profession of law (Katz 1972):

> When the expert speaks within the scope of his expertise, he may justly claim—and be accorded—a degree of special authority for his opinion. When he speaks as a citizen on a question of general policy, he is entitled—no more and no less than any other citizen—to have his views considered fairly and objectively on the basis of such merit as they may be found to contain. If he should purport to speak as an expert on matters outside the sphere of his special knowledge and skill, he would be assuming a false mantle of authority . . .
>
> . . . The legal profession has had its own difficulties with this . . . problem. It has tried to protect itself—and others—by formalizing the distinction between a legal opinion and a legal brief. When a lawyer renders a legal opinion, he is expected to give a coldly analytical objective opinion, letting the chips fall where they may. When he presents a brief, it is understood that he is making the best argument that he can make under the circumstances, whatever his objective analysis may be. When the stakes are high or when energy, patience and time are short, the distinction may become blurred; but the lawyer's code of professional conduct enjoins him to keep it clear. When he is at his best, he does so.
>
> I do not intimate that the form of the lawyer's distinctions between legal opinion and a statement of policy or between a legal opinion and a legal brief should be adopted by the National Academy of

> Sciences . . . or its members. I do venture to suggest that the substance of the distinctions may usefully be adapted to the situation of the Academy . . . and its members if and when they address themselves to societal problems and seek to feed their insights into the legislative process or the processes of the executive branch. Such an adaptation would import the gradual evolution and refinement of an accepted practice under which the Academy . . . and its members would regularly take pains to sort out, recognize, and identify the mode in which they are proceeding: whether they are rendering an objective assessment or advocating a cause, and whether they are speaking as experts within their field of special knowledge and competence or as citizens concerning a question of general public policy. Under such a practice, there would be no suggestion that they must restrict themselves to any one mode. But they would be expected to be clear themselves and to make clear to others which mode they were choosing; and they would be expected to recognize the different implications of the respective modes.

If, following Katz, we speak of a "scientific opinion," which states what science knows and (equally important) what it does not know relating to an issue or problem, and a "technical brief," which presents technical evidence aimed at making the most persuasive case for certain conclusions and recommendations, then we can by extension speak of a "systems analysis opinion" and a "technical brief," the latter perhaps containing some of the sort of work that would be considered as systems analysis. With this terminology in mind, it is clear that what we have been talking about throughout this *Handbook* is the systems analysis opinion, as Katz puts it, "a coldly analytical objective opinion, letting the chips fall where they may," even though we recognize the difficulty of reaching so high a standard, as the quotation from Quade above suggests.

This is not to suggest that the systems analyst should not be willing from time to time to help his client with a technical brief; rather, it is to suggest that

he and his client should be clear that this is what he is doing—and, most important of all, that the recipients be told clearly that what they are being given is a technical brief.

Alvin Weinberg has recently introduced the concept of "trans-science" (Weinberg 1972):

> Many of the questions that lie at the interface between science and politics involve questions that can be stated in scientific terms but that are in principle beyond the proficiency of science to answer . . . I [have] proposed the term trans-scientific for such questions . . . For example, the biological effect on humans of very low level radiation . . . will probably never be fully ascertained, simply because [of] the huge number of animals required to demonstrate an unequivocal effect . . .
>
> Scientific truth is established by the traditional methods of peer review: only what has value in the intellectual marketplace survives. By contrast, where trans-science is involved, wisdom (rather than truth) must be arrived at by some other mechanisms . . .

Society faces many problems involving trans-scientific components, as Weinberg points out, and the experienced systems analyst has not infrequently had to wrestle with how to handle such components in his work, as well as how to report on them.

These considerations led me some time ago to these conclusions for scientists (Miser 1973), equally applicable to systems analysts:

> 1. The objective scientific opinion—as I have defined it—is the best tool for most situations, be they consultations or studies related to possible courses of action, participation in adversary proceedings, or involvement in trans-scientific debate. In this last category, they can play the fundamentally important roles of defining what is known and what is not, estimating the uncertainties of possible projections, mapping the boundary between science and trans-science, and clarify-

ing the central issues.

2. The role one is playing should be clear; if it is the scientist's role, the norms for this role should be so scrupulously observed as to be obvious; if it is the advocate's role, then the technical brief should make this disclaimer forcefully clear, both when the debate is an adversary one and when it deals with trans-scientific issues.

3. While all agree that the scientist is a citizen, and can participate freely in advocacy and rough and tumble debate, nevertheless society will never allow him to divest himself completely of his responsibility as a scientist, and will, fairly or unfairly, allow its judgement of his behaviour in these roles to reflect on his dignity as a scientist, and even on the dignity of all scientists. The man who would enjoy the freedom and pleasure of science must pay the tax for this simple fact of life, some of it incurred by his own conduct, some by the conduct of colleagues over whom he has no control.

4. Thus, it is in the long-term best interests of all, of science and for the scientific community as a whole, to try to evolve standards of proper practice for giving advice and advocating public courses of action and for participating in trans-scientific debate. The price of failure could well be a significantly reduced confidence in, and support for, all of science.

• *The need for standards of professional behavior.* The last conclusion just stated about the need for standards of professional behavior for systems analysis work, *ipso facto* aimed at decisions and policies affecting the public interest, is only part of a much wider recognition by the science and technology communities (Chalk, Frankel, and Chafer 1980). While some of these communities have made considerable progress, others, including systems analysts, have only begun to think seriously about this matter. However, it is clear that this is one of the most important professional issues facing the community of systems analysts today. So far, society has been willing for this community to undertake

to regulate itself; however, if it postpones rising to this responsibility for too long, society could well impose regulation from without.

This view raises the question of what the content of such regulation should be—on which there is no agreement presently. It could consist of some principles governing the internal behavior of systems analysts (such as many that are discussed in this *Handbook)*, or it could deal with the relations of the profession to society, or perhaps it could contain elements of both. Dror (1971) has suggested a challenging set of principles to govern the analyst's relations with his client (although written in the language of policy science, it can be understood to apply to the virtually synonymous systems analysis):

a. A policy scientist should not work for a client whose goals and values, in the opinion of the policy scientist, contradict basic values of democracy and human rights.

b. When the goals and values of a particular client contradict basic beliefs of the policy scientist, the policy scientist should resign rather than help in the realization of goals and values with which he intensely and fundamentally disagrees.

c. The purpose of policy sciences is to help in better policymaking, and not to displace legitimate policymakers and decisionmakers with policy scientists who become "gray eminences." Therefore, policy scientists shall try to preserve and increase the choice opportunities for their clientele, e.g. by always presenting a number of alternatives. In particular, a policy scientist should not hide an alternative because it contradicts his own personal values and preferences.

d. Policy scientists should explicate assumptions and should present clear value sensitivity analyses, so as further to increase the judgment opportunities for their clientele.

e. A policy scientist should refuse to prepare studies, the sole purpose of which is to provide a supporting brief to an alternative

already finally decided upon for other reasons and considerations by his client.

f. Policy scientists should not work for clients who do not provide necessary access to information and opportunities for presentation of stud ies and their findings.

g. All forms of conflict of interest should be avoided, including utilization of information for private purposes and presentation of recommendations in respect to subject matters in which a policy scientist has a personal and private interest.

However, the experienced analyst will recognize quickly that a code cannot be applied to real situations in simple black-and-white terms. Suppose, for example, that an analyst has completed a major study as a member of a large bureaucratic staff with the support and cooperation of many members of this staff, only to find that the superiors ignore his findings and decide on a course not recommended for reasons that are offensive to the analyst's principles. Under Dror's second ethical principal, should the analyst resign, thus honoring his principles but depriving himself of any chance of effective further influence? Or should he continue in his post, recognizing that, in any large bureaucracy, persistent effort may well effect ultimate change in its direction? Meltsner (1976), who has studied the experience of systems analysts in large US federal government establishments, says that

> . . . Persistence does pay, but evidently it is the quality of the persistence that counts. Unfortunately, the quality that is desired is hard to capture in words, but I do know policy analysts who have acquired it . . . Staying in the bureaucracy and learning from it can enhance the value of persistence.

There is no simple answer to these questions. Rather, the analyst, using his personal outlooks, knowledge of the situation and its future possibilities, and perhaps taking account of the advice of more experienced analysts, must himself work out the answer most satisfying to him.

There is little help here, however, for the fledgling analysts, who, as Meltsner (1976) says:

> . . . After their liberal education and professional training, analysts generally start off their careers with a respect for data, norms of openness, objectivity, and full disclosure and with a sense of loyalty to the client.

What the professional of systems analysis is saying to the beginner is that it cannot yet hand him a code of ethics and good practice as a comprehensive guide, and that he must rely to some extent on his own background of ethical training to guide him as he works out solutions to these dilemmas for himself. However, it can offer him the challenge of contributing constructively to the common experience of the profession that will lead to an appropriate code of ethics and good practice, together with a body of experience to illuminate it, that will guide analysts in the future. The scattered beams of light in this *Handbook* will help him in meeting this challenge, perhaps, but the major contributions are yet to be made.

- *The systems analyst as citizen.* A systems analyst is a citizen, and nothing we have said so far should be construed as limiting his rights to exercise the roles of a citizen. However, whether he likes it or not, his public behavior can, and will, reflect on the standing of his colleagues, as my third conclusion above brings out.

The nub of the matter has been put well by Don K. Price (1978):

> Scientists are citizens too, and ought to be encouraged to participate fully in politics, to which they may make a unique contribution as long as they make clear the limits of their competence as scientists to answer unscientific questions.

15. CONCLUSION

Throughout this *Handbook* we have been at pains to be not only descriptive and illustrative but also, wherever possible, prescriptive and normative whenever the state of the systems analysis art allows us to do so. However, the reader must not carry away the impression that the field has a rigidly prescribed paradigm, either over all or in any of its parts, that must be followed if the work is to be judged by systems analysts as correct and of high quality. Rather, the problem and what is appropriate to it must rule. What is presented here is much of the available menu of possibilities; in the face of the problem situation the analyst must exercise his judgment in choosing what is effective. The worst pitfall of all would be to adhere slavishly to a preconceived outline of work or arbitrarily restricted menu of technical choices.

The material presented in this *Handbook* offers a varied set of possibilities and examples, pointing to challenging directions in which the systems analysis profession may go. This view of where the profession is now provides a basis for its continued growth in scope and effectiveness.

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