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Chapter 1 covers six techniques of use to project planners for gathering information from clients, experts, and decision makers and for generating ideas and alternatives. The techniques include interacting group processes (Brainstorming, Synectics, and Nominal Group Techniques). Brainstorming and Synectics are group creative processes used to generate ideas in response to a stated problem. The Nominal Group Technique is a group process for drawing forth opinions about an unstructured problem and ranking the responses in the order of importance. Morphological Analysis is a method of systematically analyzing a problem and synthesizing alternatives. This method involves breaking a problem down into its elements and identifying a number of alternatives for each element. Interviews and Questionnaires are formal methods for gathering information, ideas, and opinions from selected persons in a target population.

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I
Generating Ideas

Brainstorming
Synectics
Morphological Analysis
Nominal Group Technique
Questionnaires
Interviews

Techniques for generating ideas and gathering information are essential for project planning. Eliciting information from clients, experts, and decision makers in order to generate innovative alternatives is a crucial step in a systems approach. The selected techniques structure group "creativity" (Brainstorming, Nominal Group Technique, and Synectics), promote systematic synthesis of alternatives (Morphological Analysis) and formalize interpersonal communication (Interviews and Questionnaires). Two of the techniques gain their strength through interacting group processes (Brainstorming and Synectics) in contrast to carefully structured group interaction (Nominal Group Technique).

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Foreword

This is a *toolbook*.

It can be used either as a text or a reference by people studying or doing such things as project analysis.

In principle, analysis is the mother of rationality. The word *analysis* labels a large array of orderly efforts to transform the imponderable into the manageable. People try through analysis to identify the key properties of problematical situations, to contrive promising solutions, and to frame these solutions in convincing ways.

Three things affect the success of such efforts—*the nature of the "reality" being examined, the power of the analysis tools that are used, and the decisional arrangements to which analysis contributes.* What is out there and our interest in it set the basic requirements of analysis. The tools and their use determine what we see and influence what we then try to do. This volume focuses upon tools and their uses. It indicates how they can be applied to study various kinds of realities, or to imposing a sense of order upon real-world concerns. It does not address the third factor which affects the success of analysis efforts—the decision-making settings in which the tools are applied.

The trend of our times is to demand more and better analysis tools in order to try to solve increasingly complicated problems through planned, managed action. The solutions often breed new problems. The expanding pressure to diagnose and resolve outruns our ability to respond. One American sociologist speculates that the ultimate outcome of this dynamic imbalance might be the collapse of societies in "the stupidity death," as the needs to interpret and manage fatally exceed the capacity to do so.

No single book will solve that problem. This one may make some incremental contributions to the intelligent use of analysis in sensible problem-definition and informed solution-seeking. For example, it presents a wide range of analytical tools—about forty—and it classifies them into nine functional categories, from methods of generating ideas to techniques for controlling and evaluating results. There is an important implication here: *there are many kinds of analysis which can be used for a variety of purposes.*

Why does this matter? Partly because the formal analysis strategies of social and economic change organizations are usually quite selective. They are usually skewed in favor of certain kinds of issues and techniques. The pattern of this book at least shows that there are significant categories of analysis beyond the economic and financial, and beyond determinate systems techniques for planning implementation. This is important because some of the best-established, most conventional techniques of analysis, used undiscerningly, make it possible to design unworkable programs and projects.

This book reflects another important idea: *analysis* is not solely the province of insulated experts with little responsibility for entrepreneurship or implementation. Some of the techniques presented here are as useful to "operators" as to "analysts." All of them can profitably be understood by people primarily concerned with promoting and executing projects.

In practice, the interplay of analysis and action is quite complicated. How it works depends chiefly upon the third factor mentioned at the beginning of this brief essay: the decisional arrangements to which analysis contributes.

In most organizations which rely upon analysis as an important input into decisions about programs and projects, systematic analysis and decisional action tend to be rather loosely linked.

A good part of this looseness is necessary and desirable. Studying things and doing things are frequently very different kinds of activity engaged in by different kinds of people. Even so, decision makers and people with discretionary responsibility for executing decisions had better understand the nature—and the limitations—of the analytic techniques upon which their decisions and their mandates may be based; just as analysis specialists will be wise to perceive the practical usefulness of their products and the limits thereof.

Various kinds of analyses produce knowledge for use in designing, reviewing, deciding, and executing programs and projects. Such analysis, coupled with criteria about goals and standards, helps produce decisional frameworks and programmatic targets. It also helps produce decisions about particular plans or proposals: Do they fit within the frameworks? Are they likely to achieve acceptable targets? By helping answer these questions, the analysis may reduce the uncertainty of efforts to shape the future and lessen the need to rely upon hope and intuition. Even when uncertainty defies dissipation, the authoritative use of systematic analysis techniques imposes a degree of *order* and focus upon decision making.

Order is a much valued quality in circumstances where uncertainty abounds. It is also a limited, potentially perverse quality. The quest for order sometimes buries real uncertainties beneath exhaustive analyses. These analyses tools apply techniques which look like formulas or recipes for calculating, deciding, and planning. They are often treated as if they are formulas or recipes. But they are not

decisional recipes. Analysis techniques only produce *ingredients* for cooking in decision-making pots, and for envisioning the future. With sufficient skill and judgment these ingredients—the products of analysis—can be used in cooking up programs and projects. But they are readily misused too.

The tendency toward misuse is encouraged by the lopsided, unbalanced quality of our aggregation of tools. The more *intrinsically determinate* the tools, the more attractive they are. Economic analyses and financial analyses, and schemes for "mapping" formalized plans of action (which are actually techniques for hopefully idealizing what is intended), are attractive. Quantitative analyses of costs and benefits, of cash flows, of sensitivities, and so forth, produce determinate answers, even if important data must often be stipulated. Projected maps of future sequences of events have the appeal of apparent certitude, even if they do not tell us *how* these sequences are going to be caused and controlled, or how plausible they are.

To say these things is not to reject the merit of quantitative analyses and precise-looking maps of future courses of action. Both can be valuable, just as both are dangerous in the hands of those who take the products as "true." Unfortunately, these intrinsically determinate techniques are not matched and balanced by methods for analyzing *how best to organize* the activity, *how to determine managerial resource needs* and ways to meet them, *how to specify the incentives* which will increase the probability of success, and *how to measure the full range of effects.* Our tools for doing these latter things are at best rather messy and imprecise. So decisions tend to turn more upon the findings and projections of the neater techniques; and endless effort goes into refining and applying them.

This general observation is reflected in the contents of this book. It does present heuristic techniques for addressing some of the troublesome problems of design—generating ideas, pinning down objectives, and trying to map complex relationships, for example. But, understandably, much of its bulk presents relatively determinate computational tools. Because these are the tools we have.

A longer essay on the interplay of analysis and action would address other important aspects of the subject, such as the use of analysis to manipulate consent and acceptance and the manipulation of analysis to secure acceptance for for proposals. The function of analysis in the decisional processes of development agencies is not limited to the uncontaminated generation of unassailable objective premises, nor can it ever be so limited.

But the ultimate justification of analysis as a kind of activity is its contribution to better knowledge, better understanding, better decisions—to the reduction of error and the enlargement of human capacities for auspicious action. It is to these aims that this toolbook is dedicated.

The book itself is the eventual product of a question put to two young industrial engineers at the University of Wisconsin a few years ago: "What sorts of tools and techniques do you people use in defining problems and shaping solutions which might be transferrable to the field of economic and social development?" Here are the answers provided by Professors Delp and Thesen and their associates.

These answers are neither exhaustive nor definitive; there is little limit to the full array of tools that might be cited. Many of the individual tools offered here are themselves subjects of more than one book. But this work is a valuable introduction and overview. Each tool is presented in a way which facilitates intelligent judgment about its use. The tool descriptions are buttressed by citations which enable the reader to pursue topics of special interest.

If this book should somehow cause one consequential error to be avoided, in the design or implementation of a single project significantly affecting the lives and well-being of some people, the enterprise which has produced it will stand justified. Given the limits of our ability to analyze certain kinds of cause-effect relations we shall never know.

William J. Siffin
Director
IDI/PASITAM
June 1977

Preface

The word "tool," in its strictest sense, refers to an implement, a means for effecting some purpose. When we started the project which led to this volume, we used techniques, methodologies, and tools synonymously to describe various means for planning. On reflection, perhaps the stricter definition is also inappropriate, for this collection represents a set of implements—*tools for implementing a systems approach to planning.*

Systems, system models, and the systems approach tend to blur together into a conceptual mass whose tangible aspects are represented as tools. We've called them "system tools," not because they are necessarily derived from systems concepts or systems engineering, but because they are tools which facilitate a systems approach to planning. A systems analyst uses techniques which shape plans from a systems perspective. The wholistic, future-oriented, inter-relatedness of systems thinking models the situation facing development planners—situations filled with myriad interdependencies, uncertain futures, an ill-defined present, and a data-deficient past. The alternatives to a systems approach tend to produce fragmented, incrementally effective (if not counter-productive) development efforts.

Action-oriented development activities are implemented as policies, programs, or projects. We have used the project concept to represent both programs and policies in the sense that one or more projects are specific activities in order to implement a program or policy of action. The distinction between a project and a system is not always clear.

Often the system tools describe techniques for planning a project or a system. For example, cost-effectiveness analysis is used to evaluate 1) alternative components of a system, 2) alternative systems, or 3) alternative projects (which may involve many interacting systems). In many cases, techniques for project design and techniques for system design are indistinguishable.

Planning, as we have used the term, encompasses the entire range of activities associated with achieving development ends. Planning a project requires that all aspects of the project be designed or specified. This includes identifying objectives, sub-objectives, and criteria for evaluating the achievement of objectives. It includes specifying the essentials of implementation—those messy details of getting from an idea to a project. A systems approach to planning requires that the requisites of management be incorporated into the design and that the essentials of evaluation be considered *in the planning process.* Short-term feedback systems to provide management information are designed to complement long-term feedback of project impact in order to inform development planners. This broad view of planning and its intimate connection to implementation has guided our selection of techniques and their descriptions.

One aspect of the description which needs elaborating is our distinction between decision makers and analysts. Certain techniques require special skills for successful implementation (e.g., Surveys, Cost-Benefit Analysis). An analyst, possessing these needed skills, may also be the decision maker. In some techniques the two roles are distinct (Delphi, Program Planning Method), while in others the separation of roles is not important. A decision maker has discretionary control over resources including those required for analysis. Therefore, he views the problems of project planning from a different perspective from the analyst and usually a different degree of accountability. This reflects not only the way techniques are employed, but the decision to employ a particular tool. The classic case is an analyst who needs information recommending a sample survey, and the decision maker reconsidering this approach because of political sensitivities. We have included this distinction where relative to the application of the technique.

While we have sought to be comprehensive in our coverage of systems tools for planning, we recognize the omission of a great body of planning techniques developed in such fields as econometrics, business, and operations research. Linear programming, input-output models, or matrix algebra are useful planning tools, but they represent a level of sophistication, a rigidity of models, and a dependency on accurate data and computer implementation which seem inappropriate for the intended audience of this volume.

This collection of techniques and methodologies is intended for practitioners in the many diverse fields in which development touches both the peoples' lives and livelihood. Our examples are drawn from agriculture, education, health, family planning, employment, and resource management to underscore our belief in the universal utility of these tools in planning. We have focussed on project design and implementation as the action interface of planned development.

Peter Delp
Nairobi, 1977

Acknowledgments

Producing a volume of this scope is a long and difficult process. The support, constructive criticism, and encouragement of many have helped us in this endeavor.

We must begin by thanking the many authors who developed the techniques described in this volume. We have tried to give appropriate credit in the last sections of each tool description, citing the originators of the techniques where appropriate.

We are particularly indebted to our colleagues at the University of Wisconsin, Professors Andre Delbecq, Dave Gustafson, Howard Harrison, and Gerald Nadler. Their names will be found throughout the bibliographies for the techniques. We gratefully acknowledge their contributions, while excusing them for all responsibility for any errors or misinterpretations in our renditions.

Valuable criticism and support were provided by Dr. Richard Blue and Dan Creedon, United States Agency for International Development; Richard Hook and John Thomas, Harvard Institute for International Development; William Siffin, Russell Stout, and Paul Cunningham, Indiana University. Dr. Siffin's promotion, support, and professional guidance of this project from conception to final product was highly valued by the authors.

We are indebted to the Program for Advanced Studies in Institution Building and Technical Assistance (PASITAM) for providing the support necessary for redrafting materials used in this volume.

Final editing and production has been the responsibility of Marianne Platt who deserves major credit for transforming the writing of system engineers into useful communication. Ms. Platt worked closely with Peter Delp over the course of a year, editing and revising the work of four authors into a coherent volume. Other members of the PASITAM production staff deserve much credit for professional work, especially Clancey Maloney who inked the many diagrams appearing in the volume.

We need also to thank Pat Hochmuth who edited the first working draft, and Suzanne Machett and Doreen Marquardt who cheerfully endured our endless demands in order to produce a first draft.

A final tribute is due our families and friends, especially Sandra Kalscheur, without whose support, encouragement, and (often) direct assistance, completion of this work would not have been possible.

The Authors

Abbreviations

BCR	Benefit-Cost Ratio
BSG	Brainstorming
CBA	Cost-Benefit Analysis
CEA	Cost-Effectiveness Analysis
CFA	Cash Flow Analysis
CGA	Contingency Analysis
CPM	Critical Path Method
CSM	Computer Simulation Models
DIS	Discounting
DLP	Delphi
DTB	Decision Tables
DTR	Decision Trees
EXF	Exponential Smoothing Forecasts
FEX	Function Expansion
FLW	Flowcharts
GAM	Gaming
GNT	Gantt Charts
HIS	Histograms
IDL	IDEALS Strategy
IMD	Interaction Matrix Diagramming
INS	Intent Structures
IPX	Impact-Incidence Matrix
IRR	Internal Rate of Return
IVW	Interviews
LGF	Logical Framework
MCU	Multiple Criteria Utility Assessment
MPA	Morphological Analysis
NGT	Nominal Group Technique
NPW	Net Present Worth
OBT	Objective Trees
OCA	Organizational Climate Analysis
OVD	Oval Diagramming
PPB	Planning, Programming, and Budgeting
PPM	Program Planning Method
QTN	Questionnaires
RGF	Regression Forecasting
RTS	Rating Scales
SCN	Scenarios
SDM	System Definition Matrix
SPA	Subjective Probability Assessment
SVY	Surveys
SYN	Synectics
TRD	Tree Diagrams

Introduction

Designing development projects requires some form of "systems" approach. If any plan is to succeed, the factors that will probably determine the outcome must be identified, and their relationships must be established. There will always be surprises as implementation proceeds, for our ability to predict and control the future is limited. The object of planning and design is to keep these surprises at a minimum. A systems approach, properly used, can serve this aim.

There is another justification for a systematic approach to project planning and design: Even the simplest interventions have secondary effects--consequences which are easily overlooked because they are incidental or even irrelevant to the project itself. An irrigation project, designed to raise farmer income through increased productivity, may threaten established social and economic relationships. It may introduce water-borne disease vectors. It may have other unintended consequences which, in some cases, are more important than the direct impact of the project.

In the West, the word "systems" has acquired, for some people, a certain magical quality. The term is used promiscuously, vaguely, and enthusiastically. The problem lies not in the meaning of that term, but in the way in which it is applied.

Conceptually, a *system* is simply a set of interactive elements. In conventional usage, the term refers to a set of factors which are known (or assumed) to be necessary and sufficient to some purpose or effect. Systems thinkers often work backward, beginning with a desired objective and then determining what factors are needed to accomplish that objective and how those factors must be related. The success of this approach to design depends not on the use of the term "system," but on the ability of the designers to truly know what is necessary to the desired effect.

There are many areas where such knowledge exists, for example, in designing an electric motor, an automobile, an airplane, a computerized data processing program, or a water control system. In these and similar examples, the system can be thought of, for all practical purposes, as "closed." It is a tidy system. There is relatively perfect knowledge of its parts, and of their relation to a desired effect. And the essential relationships between the system and its environment can be known and controlled.

Problems arise when this alluring idea of "system" is transferred from the fields of determinate design into the messy world of "open systems." These are loose and not necessarily stable arrangements in which the environment of an action system, such as a government program, an enterprise, or a farming venture, is always affecting the working of that system.

In the language of systems, the "environment" consists of the factors which affect the system's working but which are not subject to full control from within the system. The weather is an important environmental factor in agricultural systems. "Politics" constantly affects the behavior and potential of a bureaucratic program system. In short, open systems are not nearly so determinate or so capable

of precise specification as the more closed systems of insulated engineering. There are two potential dangers in applying the idea of a system to designing development projects.

The first is the danger of failing to identify essential elements of an open system, or to effectively judge their probable working. A systems perspective cannot guarantee against this danger. It cannot tell you ahead of time what the factors are or how they will work. It can, however, make you aware that they exist and that you had better try to find and assess them.

The second danger might be labeled "undue narrowness," the danger that "incidental" effects may be ignored or undervalued. This can result from systems analyses which, as noted above, start with some desired aim or goal and then work backward to identify the necessary and sufficient factors for meeting the goal without also considering the *other* effects which those factors will have.

It is possible to examine and analyze the larger array of effects produced by any system. Some systems approaches fail to address this vital matter, but *only* a broad systems perspective can consider these effects in a reasonably orderly way. Therefore, the systems approaches reflected in this collection of tools and techniques are *comprehensive*. The aim is to help people search systematically for the broad implications of planned change. The approaches supported by these techniques are *future-oriented*. They offer help in trying to forecast immediate and longer-term effects in open systems designs. The approaches supported by the following tools are essentially *pragmatic*. They address the realities of the socio-political environment of any of the kinds of systems likely to concern us.

In these approaches, the systems analyst attempts to deal with unbounded complexity by identifying a set of salient variables which describe the problem. The organizing concept is the notion of a system, defined not as a static but as a dynamic entity. The values of descriptive variables and the status of relationships are projected into the future in order to look at the consequences of planned interventions. The systems designer recognizes both the limitations of deterministic analysis and the realities of power as it invariably affects the best laid plans. Consequently, a hallmark of a systems approach is pre-planned adaptability. Adaptive systems are better equipped to deal with uncertain futures, the vagaries of power, and the realities of complex political, social, and technical interactions.

Engineers have long straddled both hard and soft approaches to problems. In true engineering fashion, he/she uses whatever technique fits the task or promises insights into solutions. For the non-technical aspects of problems, the systems engineer must turn to other disciplines.

APPLYING A SYSTEMS APPROACH

Tackling complex problems requires a variety of techniques. Flowcharts (FLW, page 107), a diagramming technique which flourishes in the computer sciences, show the logic and sequence of complex computer programs. Not much imagination is required to adapt the technique to the complex decision processes confronting development planners. The aim for design remains the same: using the technique to understand the determinants of decision and action.

This adaptation of systems technology (software) to the complex realm of human behavior is a two-way street. Behavioral scientists have developed systems oriented techniques which have been readily adopted by project designers. Brainstorming (BSG, page 3) and Nominal Group Technique (NGT, page 14) emerged from a marriage of small group theory and empirical creative process analysis. System designers utilize the techniques because of their demonstrated power in generating ideas and innovative solutions.

Criteria used for selecting (or excluding) techniques from the volume were based on the needs of the intended audience. Many sophisticated techniques utilizing optimization theory and computer technology fill the systems literature and seem inappropriate for meeting the needs of a project planner in the field. Consequently, linear programming techniques, queuing and game theory, input-output models, and cross-impact matrices have not been included. By and large nothing more sophisticated than a pocket calculator is required for any of the tools. The exception is Computer Simulation Models (CSM, page 120), which was judged sufficiently important that a summary description was included. Complex mathematical formulations have been avoided, except where a step-by-step procedure can be described (see Regression Forecasting, RGF, page 160, and Discounting, DIS, page 184).

TOOL DESCRIPTIONS

Each tool describes what the project planner needs to know in order to 1) select a tool, 2) utilize the tool, and 3) understand its implications and underlying theory.

To aid selection, each tool begins with a brief statement of purpose and a summary of uses. A short description follows (supplemented by key definitions) and is augmented by a listing of advantages and limitations. The decision maker is thus given a brief overview of the tool to help him decide if the technique is a candidate for addressing a problem. To this end, a section on required resources (effort, skills, time) concludes the first part of each tool description.

In order to use a tool, a detailed description is needed, beginning with required inputs, expected outputs, and im-

portant assumptions. Moving from inputs to outputs involves a procedure, which is described for the tools at differing levels of detail. An example illustrates the procedure.

Finally, a brief section on the underlying theory and a bibliography conclude the tool description. Together with the listing of assumptions and limitations, these attempt to give each tool a theoretical base, while leading the reader to additional sources.

Ideally, each tool description should be self-sufficient, but in order to save space and provide essential continuity, the prerequisites of each tool precede the description. For example, the description of cost-benefit analysis (CBA, page 212) takes the form of a summary linking prerequisite tool descriptions comprehensively. In some cases, a common example is carried through several tools.

The examples draw on a broad range of problems and situations confronting project planners in the development fields, ranging from education and health to agriculture and economic policy. Most of the examples refer to the developing country of Temasek which (for convenience) has a widely varying climate and diverse ecological zones. The population is mostly agrarian. The examples are drawn from first-hand experiences, hypothetical situations, or the literature.

USING THE SYSTEM TOOLS HANDBOOK

The tools included in this volume fall into a number of categories: generating ideas; assessing qualitative factors; defining objectives; describing complex relationships; analyzing complex processes; accounting for alternative outcomes; forecast and prediction; analyzing projects; and planning, controlling, and evaluating projects. Clearly, many techniques could be included in more than one category. For example, computer simulation models (CSM, page 120) could be used for the last six purposes listed. It is presented in analyzing complex processes because that is the most basic use of computer simulation.

Each tool is designed to stand alone as a source of information for a decision maker, as an aid to the analyst, and as a catalyst for multidisciplinary design teams. The tool description (together with any prerequisite tools) provides a basis for action and/or the evaluation of actions by others (e.g., permitting a decision maker to interpret the models used by analysts).

DEVELOPING SYSTEM MODELS

Three tools are paramount to the description of any system: Tree Diagrams (TRD, page 74), Oval Diagramming (OVD, page 81), and Interaction Matrix Diagramming (IMD, page 92). Each describes the complex relationships of a system and defines a system as distinct from its environment.

One possible sequence for using the tools is given in figure 1a. The analyst uses a tree diagram (more specifically, an influence tree) to develop the relationships which prescribe system behavior. This leads to a specification of system variables and environmental factors which influence variables within the system. At some point, the tree diagram is redrawn as an oval diagram to show the feedback relationships and multiple interactions of system variables. If the oval diagram becomes too unwieldy, the analyst may turn to a matrix description. This has the distinct advantage of systematically pinpointing every possible interaction among system and environmental variables, while refining the oval diagram.

The analyst may wish to begin with an interaction matrix diagram rather than a tree diagram (see figure 1b). This approach appeals to those who are more comfortable separating the identification of variables from the specification of relationships. A tree diagram or an oval diagram is then used to interpret the interaction matrix in a form which permits tracing the sequence of cause and effect. An interaction matrix diagram is particularly useful in breaking down information-gathering and analysis tasks into distinct groups, thus facilitating task assignments.

The oval diagram constitutes a first attempt at a causal model of the system: it presents an explicit statement about key variables as well as hypotheses about cause and

FIGURE 1a

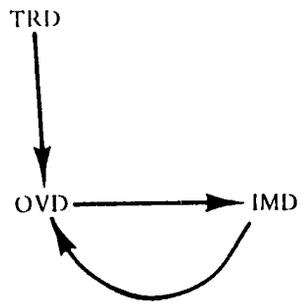
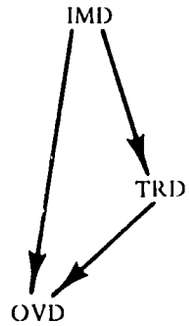
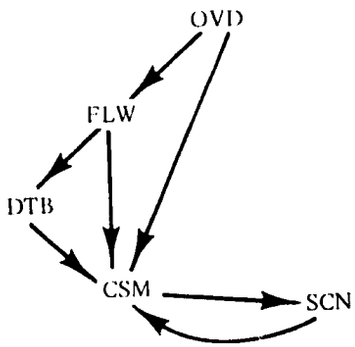


FIGURE 1b



effect relationships. These hypotheses may be tested by regression analysis (see RGF, page 160) and then quantitatively modeled. The oval diagram is then used in various ways to gain greater understanding of system behavior (see figure 2). For example, a computer simulation model (CSM, page 120) can be constructed in order to predict the consequence of changes in the system. A scenario (SCN, page 164) may be developed using the oval diagram as a basis for describing the base state and the kinds of changes expected in the future.

FIGURE 2



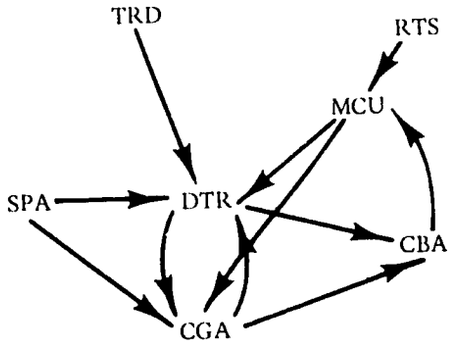
GENERATING AND ANALYZING ALTERNATIVE PLANS OF ACTION

Tree diagrams in the form of ends-means diagrams (see TRD, page 74) are useful for breaking a system into components or an objective into alternative means. This begins a sequence using several techniques to analyze alternative plans (see figure 3). The central tool in this process is the Decision Tree (DTR, page 141). Branches of a decision tree map alternative actions and probabilistic outcomes. The alternatives may be identified by the tree diagram branching process or the matrix format of morphological analysis (MPA, page 10). The probabilities of various outcomes are often subjectively assessed (SPA, page 137). Closely related to the decision tree, contingency analysis (CGA, page 147) tabulates alternative plans against the various possible states of nature which affect their outcomes.

Outcomes for both techniques are expressed either as monetary units (costs and benefits) or as utilities, using a concept which translates preferences for an outcome into a dimension on an interval scale (see RTS, page 29). Utilities assessed for various criteria are combined in Multiple Criteria Utility Assessment (MCU, page 32).

In short, these possible sequences of tools (figure 3) describe a process of analysis which begins with generating alternatives and results in an evaluation of alternative outcomes. The end use may be employed for a cost-benefit analysis or for the selection of plan elements.

FIGURE 3



CO-OPTING CLIENTS, RESOURCE CONTROLLERS, AND EXPERTS INTO THE PLANNING PROCESS

There is a set of techniques which claim their greatest strength in their ability to generate cooperation among various actors on the planning stage. The central tool is the Program Planning Method (PPM, page 227). Supporting this tool are a number of techniques, each of which is powerful when used alone and potentially more so when incorporated into a strategy (see figure 4). The Nominal Group Technique (NGT, page 14) permits maximum efficiency in generating ideas. It is particularly effective when used by diversely composed groups.

A companion technique is the Delphi process (DLP, page 168) to which experts and decision makers contribute without face-to-face confrontation. This anonymity is often necessary if the pursuit of ideas and constructive problem exploration is not to be hindered by social and bureaucratic sanctions. The Delphi utilizes repeated rounds of questionnaires (QTN, page 19).

The Program Planning Method combines these techniques to produce plans which co-opt clients, resource controllers, and experts in a carefully orchestrated planning process.

A NORMATIVE APPROACH TO PLANNING

One planning strategy begins with a normative concept of the ideal system, rather than analyzing what could be

FIGURE 4

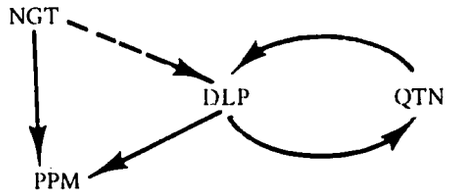
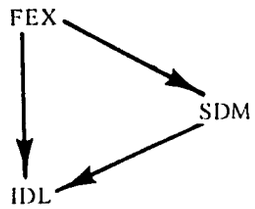


FIGURE 5



wrong with the existing one. This strategy is embodied in the IDEALS Strategy (IDL, page 231). Two other techniques support this approach (see figure 5).

Function expansion (FEX, page 45) forces the system designer to think in terms of the purpose of the system desired—what the system should be doing. This leads to a specification of the "ideal system target" which becomes the basis for designing a feasible system, using essentially the system design strategy. The form of the specification is the system definition matrix (SDM, page 67), which is the output of the IDEALS process.

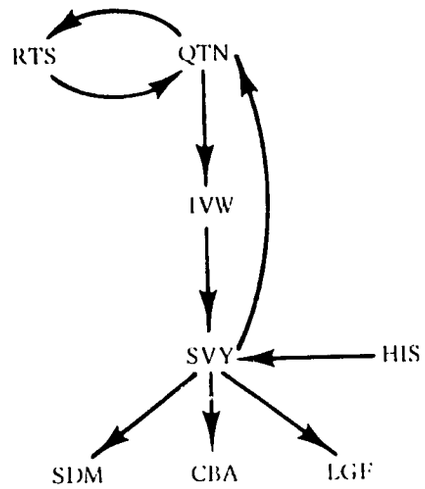
Focusing on function rather than on problems gets people involved in a constructive assessment of what should be, rather than what's wrong and who's to blame. There are sound arguments for both approaches. The IDEALS Strategy often comes under attack because its emphasis on normative specification may possibly ignore experiences gained from problems with the existing system. If the ideal system target proposes a radical change, where only incremental changes are acceptable, normative prescriptions may be counterproductive. Still, there is an intuitive appeal to any process that encourages minds to explore an unlimited problem-solution space, unbounded by existing system descriptions.

USING SAMPLE SURVEYS TO GATHER INFORMATION

A sequence of techniques is particularly useful for gathering information across a broad spectrum. The principal technique is the sample survey (SVY, page 36), which begins the design of the survey questionnaire (see figure 6). Where subjective assessments are to be quantified and aggregated, the questionnaire may incorporate rating scales (see RTS, page 29).

The questionnaire (QTN, page 19) must be pretested and refined so that the objectives of the survey may be realized. The means for obtaining the desired information may vary greatly, but one useful technique is the direct interview (see IVW, page 23). This is usually the preferred approach in pretesting the survey because it requires less time and gives more design information than mailed questionnaires. The latter technique, however, is widely used

FIGURE 6



when a large sample is to be covered by the survey, even though a high return is seldom possible.

The survey results are quantified and aggregated, often in the form of histograms from which statistics may be computed (HIS, page 131). These results are then used to formulate policies, to specify system design (see System Definition Matrix, SDM, page 67), to quantify costs and benefits (CBA, page 212), and to evaluate programs (see Logical Framework, LGF, page 260).

PROJECT FINANCIAL ANALYSIS

The financial analysis of projects is a sequential process which begins by identifying costs and benefit time streams (Cash Flow Analysis, CFA, page 177) and culminates in the presentation of recommendations (and assumptions) to decision makers (see figure 7). Many techniques support this analysis at each stage. A survey may be necessary to gather financial and production data. The various impacts of a project may be tabulated across directly and indirectly affected groups in an impact-incidence matrix (IPX, page 207). This technique attempts not only to quantify all impacts of a project, but nonmonetary impacts of a project using rating scales (RTS, page 29).

The time streams of costs and benefits are discounted to give their present value in order to compare project alternatives (see Discounting, DIS, page 184). The criterion for comparison may be net present worth (NPW, page 188), benefit-cost ratio (BCR, page 194), internal rate of return (IRR, page 200), or a combination of these.

The cash flow analysis, the evaluation criteria, and the impact-incidence analysis are brought together in cost-benefit analysis (CBA, page 212). The end result may take the form of a single go-no go decision on any one project, or a ranking of alternative projects for funding.

FIGURE 7

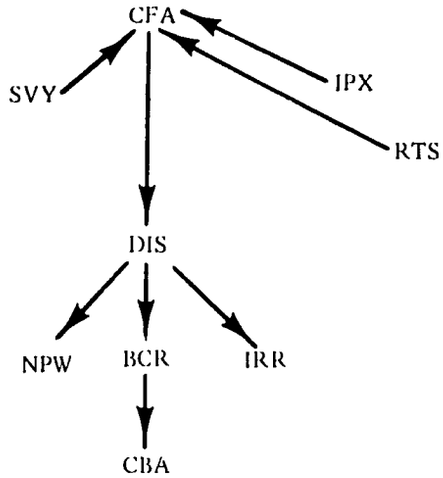
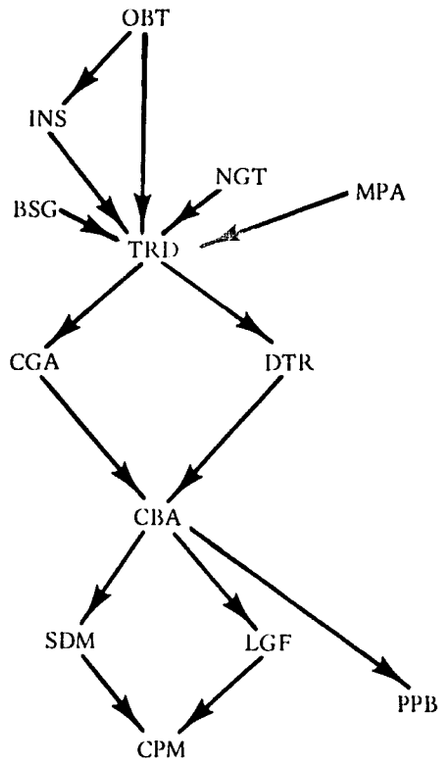


FIGURE 8



THE "CONVENTIONAL" SYSTEMS APPROACH

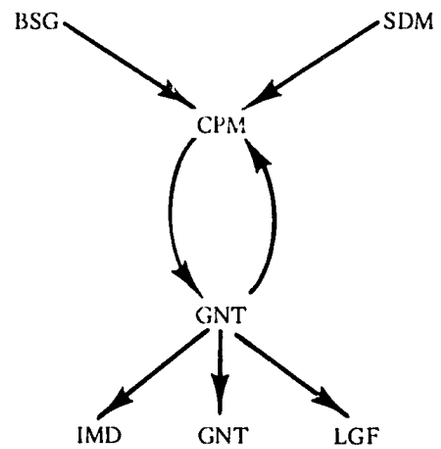
Systems analysis begins with identifying objectives, specifying alternative means, specifying the criteria for selecting among the alternatives, and then synthesizing a system or plan from the choices. A sequence of techniques for applying the systems analysis strategy begins with Objective Trees (OBT, page 49) and/or Intent Structures (INS, page 55) (see figure 8). Brainstorming, Nominal Group Technique, or morphological analysis may be used to specify alternative means (see also Tree Diagrams, TRD, page 74). The alternatives are analyzed using either decision trees or contingency analysis to develop the project plan. Cost-effective analysis, multiple criteria utility assessment, or both are used as criteria for evaluating alternatives. The plan may be specified as a System Definition Matrix, Logical Framework, or as an operating Planning, Programming, and Budgeting system (PPB, page 236). This strategy is not altogether different from the IDEALS approach; however, the starting point of the latter is the function of the system rather than objectives for a project.

PLANNING PROJECT ACTIVITIES FOR IMPLEMENTATION AND CONTROL

Two complementary techniques which specifically address the scheduling of project activities are the Critical Path Method (CPM, page 241) and Gantt Charts (GNT, page 252). The techniques may be incorporated into a strategy which plans and facilitates the implementation of a project.

Critical path techniques begin with a list of project activities essential to the achievement of project goals (see figure 9). The list may be generated using techniques such as brainstorming or, more formally, from a system

FIGURE 9



specification (see System Definition Matrix). From the critical path network, a Gantt (bar) Chart may be prepared, enabling a planner or manager to schedule activities and resources. He may wish to present the activities and officers responsible in an interaction matrix (IMD, page 92) in order to emphasize both the interrelatedness of tasks and the multiple staff responsibilities. A Logical

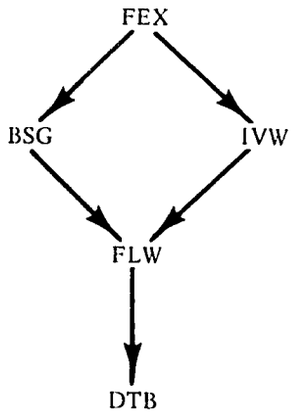
Framework may also be used to sharpen the identification of objectively identifiable indicators of progress. These milestones are shown as vertical lines on specific dates of the Gantt Chart and written on the Critical Path Method network at the appropriate nodes.

Altogether, the techniques serve to ease the manager's job by breaking down a complex project into finite tasks with planned start and end dates. Progress monitoring permits effective use of staff which is essential to successful project implementation.

ANALYSIS AND PROGRAMMING OF DECISION PROCESSES

A decision-making system exists for a specific purpose. The first step in any analysis is a function expansion to specify that purpose (FEX, page 45) (see figure 10). The aim is to specify the key decision points and the conditions which lead to particular actions, i.e., the decision-making policies. Two processes may be used to obtain this information. If the system exists, decision makers may be interviewed (IVW, page 23). If the task is to design a system, then idea generating techniques (e.g., Brainstorming, BSG, page 3) are used.

FIGURE 10

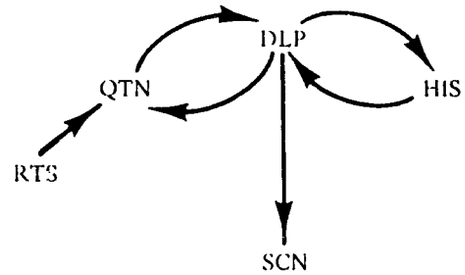


The results of this analysis are presented in the form of flowcharts (FLW, page 107) or decision tables (DTB, page 113). The flowchart uses different symbols to display and analyze complex processes. The decision table presents the decision as a preprogrammed process by specifying the conditions which precede—and the action which follows—a decision. Both techniques are usefully employed in management training as well as in diagnosis of potential problems in implementation.

QUALITATIVE FORECASTING

A scenario draws on a variety of expertise to produce a map of the future states of a system (SCN, page 164). It is the result of a strategy which incorporates intuition and judgments into a coherent framework (see figure 11).

FIGURE 11

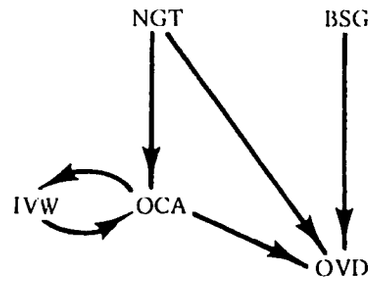


The Delphi technique (DLP, page 168) begins by directing questionnaires to a selected group of prognosticators. The results of each round are summarized for the Delphi group, often in the form of a histogram which aggregates the individual judgments. Rating scales attempt to quantify priorities and opinions. The Delphi rounds are then used to produce the successive state descriptions of the scenario. The desired result is a clearer understanding of the forces and constraints which are involved in planned change.

PROBLEM ANALYSIS STRATEGIES

Problems in systems (whether ongoing organizations or newly designed projects) may be analyzed by using a number of techniques, none of which guarantees a solution. Rather, they promise a greater understanding of the dimensions of the problem. Two techniques are central to the analysis of problematic behavior: Oval Diagramming (OVD, page 81) and Organizational Climate Analysis (OCA, page 40) (see figure 12).

FIGURE 12



Problems are first identified using a technique such as Intent Structures (INS, page 55) to specify conflicting objectives and competing interest groups. The Nominal Group Technique (NGT, page 14) or brainstorming (BSG, page 3) may also be used. The problems lists may be employed to guide the information-gathering, the interview-

ing necessary for an analysis of organizational climate, or the tackling of identified problems by a Synectic problem-solving team (SYN, page 6). The very least to be expected from a Synectics group is a better definition of the problem and a creative attempt at a solution.

One highly recommended technique for combining all these analyses is an oval diagram which describes the system or organization. Most problematic behavior stems from poorly designed feedback of information within a system, and poor understanding of the far-reaching effects of actions.

The analyst may ultimately wish to test the problem analysis by using management games (see Gaming, GAM, page 124) which are carefully designed to identify problems which arise from simulated interaction among system and organizational components.

CONCLUSIONS

This volume is a collection of techniques drawn from a variety of disciplines and presented in a standard format in order to bring together various means to a common end—better development project design. The organizing theme is a systems approach to project planning. The techniques are means to developing project designs which are comprehensive, future-oriented, and pragmatically shaped by the realities of power and uncertainty. While no single technique is the systems engineer's unique contribution, all should contribute to better project design.

Brainstorming

PREREQUISITE TOOLS

None.

USAGE

PURPOSE

Brainstorming is a group creative process used to generate alternative ideas and suggestions in response to a stated question or problem.

USES

Brainstorming is used to:

1) Generate many alternative solutions to a problem.
2) Generate alternative ways of looking at a problem.
3) Identify experts who will aid in different problem-solving phases.

SHORT DESCRIPTION

Brainstorming is a group process where the members, usually from different backgrounds, respond to a central question or theme. Emphasis is placed on generating a large number of ideas while deferring criticism and evaluation. Brainstorming is especially useful for attacking new problems or for identifying new ways of looking at old problems.

ADVANTAGES

1) Original and innovative ideas may be generated if premature criticism is not allowed to inhibit spontaneity.
2) Cross-fertilization of ideas occurs, especially when the group is composed of experts from different fields.
3) The relatively unstructured nature of brainstorming is sometimes preferred over methods like the Nominal Group Technique (NGT, page 14).

LIMITATIONS

1) Brainstorming may be unproductive if the group members are meeting each other for the first time during the session. The effectiveness of a brainstorming session is greatly enhanced when the members know each other before the session and when they are motivated to solve the problem under consideration (Bouchard, 1971).
2) Superior-subordinate relationships outside the session may affect the free interchange of ideas within the session.
3) A brainstorming session often involves misdirected discussion which may be unproductive and a waste of time.
4) Discussion may be dominated by one or two members, and may stifle the participation of other members. This is in contrast with Nominal Group Technique (NGT, page 14).

REQUIRED RESOURCES

LEVEL OF EFFORT

For brainstorming sessions to be effective, all participants should contribute to the discussion in order to facilitate the cross-fertilization of ideas. It may require some effort by group members to defer their natural tendency to criticize or otherwise evaluate the ideas presented.

SKILL LEVEL

No special skills are required. Some practice may be necessary before brainstorming sessions are productive. Generally, members will bring expert skills, but they must be able to extrapolate beyond their own experience. The group leader will be more effective if he has some training or experience in conducting brainstorming sessions, particularly in order to recognize when the group becomes misdirected.

TIME REQUIRED

Brainstorming sessions which last longer than an hour are usually unproductive. The time span is proportional to the number of participants. It also depends on the novelty of the question under consideration.

SPECIAL REQUIREMENTS

Blackboard and chalk, or a flip chart and marking pens, are used to record all suggested ideas. Writing materials for each member are needed. A tape recorder may be used to record the session.

DESCRIPTION OF TOOL

REQUIRED INPUTS

1) A statement of the problem, usually in the form of a question, focuses participants' ideas, e.g., "How can the increase in Temasek's population be stopped?"

2) Participants may be experts, consumers, clients, or practitioners. Contributions, however, may be made by experts or creative people from unrelated fields.

TOOL OUTPUT

The principal result of a brainstorming session is a large number of ideas which may serve as possible answers to the question. For example, brainstormed answers to the problem of slowing population increase may be:

Educate on family planning
Make contraceptives free
Shoot people regularly
Sterilize men or women
House men and women separately

These answers are not qualified or evaluated. The evaluation is done by using techniques like Decision Trees (DTR, page 141) or Cost-Benefit Analysis (CBA, page 212). Seemingly outlandish ideas are not immediately rejected; they may generate more practical alternatives.

IMPORTANT ASSUMPTIONS

1) The brainstorming technique assumes that the group process of generating ideas will be more effective than independent efforts (if not in total number of ideas, then in quality of ideas generated).

2) It is assumed that participants will overcome their inhibitions and discuss ideas freely.

METHOD OF USE

GENERAL PROCEDURE

The procedure is addressed to the person who will conduct the brainstorming session.

1. Organize the group.
   1.1 Identify potential participants, keeping in mind the nature of the problem. For example, if the problem concerns population control, potential participants are a physician, a psychologist, a government official, a health care administrator, community workers, potential clients, etc. The organizers of a brainstorming session may use the technique to generate the list of potential participants for future problem-solving groups.
   1.2 Limit the group size to seven to ten. Sometimes larger groups are used, though they tend to decrease the usefulness of the sessions.

2. Instruct the participants.
   2.1 Explain the four guiding principles of brainstorming:
      a) There are no correct or incorrect ideas. All ideas are accepted on equal ground.
      b) Novel and creative ideas are encouraged regardless of how foolish they may seem. Criticism is not allowed.
      c) Emphasis is on generating a large number of ideas in order to get "all around" the problem.

d) Combinations and extensions of ideas are encouraged.

2.2 State the question or problem under consideration and discuss it briefly in order to clear up misunderstandings. Let the participants think about the problem for a few minutes. Indicate that they can make notes, but discourage any outbursts like, "I've got the solution!"

3. Conduct the session.

3.1 Ask a participant to respond to the question and to briefly explain it. Participants may take turns, giving one idea at a time, or the process may be spontaneous. In both cases, an idea suggested by one member often triggers an idea from another. This is referred to as "leap-frogging." Encourage "leap-frogging" in the group, since one aim is the generation of a large number of ideas. However, the leader should exercise his judgment in keeping order in the session.

3.2 If necessary, remind members about the rules of brainstorming during the session. Sometimes members need a new direction, or they may be tactfully asked to curtail extraneous discussion. An atmosphere of cordiality and free expression must be maintained at all times. The session leader must exercise careful judgment.

3.3 Sometimes it is useful to present a mock problem to the group to familiarize members with the method. An exercise where members generate all possible uses of a machine or technique is helpful. A problem example might be "list conventional and unconventional uses for a bicycle." Such an exercise might relax the members and make the main session more effective.

3.4 Have all ideas recorded as they are generated. A tape recorder may be used to provide a record, but this method doesn't allow for immediate reference to previous responses. When no more ideas are generated, end the session.

EXAMPLE

Consider a situation where the help and authority of a local government official is needed to implement a health care project. The problem is how to obtain the cooperation of this person in a reasonably short time. Commandeering bureaucratic support from his higher authorities can often be a lengthy and uncertain process.

A brainstorming session is organized. Participants include the project leader, a local person affiliated with the project, a troubleshooter in an election campaign, etc. Some brainstormed suggestions are given below.

1) Appeal to the local official, emphasizing the importance of the project.
2) Bribe the local official.
3) Bribe the higher authority (triggered from idea 2).
4) Disregard authority and do without local help.
5) Move to another area where the local official is more cooperative.
6) Use the media to apply political pressure on the authorities.
7) Convince the local elite of the importance of the project and work through peer pressure.

THEORY

One principle in the theory of creativity is that evaluating or ranking an idea stifles the generation of further ideas. Therefore, generation should be separated from evaluation. Another principle states that group processes may be more effective than individual efforts in generating ideas, largely because of cross-fertilization. See Bouchard (1971) and Osborn (1963) for a more detailed discussion of the theoretical bases of brainstorming.

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Synectics

PREREQUISITE TOOLS

None.

USAGE

PURPOSE

Synectics is an interacting group process for generating creative ideas in response to a problem.

USES

Synectics is used to:

1) Identify possible solutions to a given problem.

2) Infuse novel thinking into one technology or discipline by transferring knowledge and expertise from another technology.

SHORT DESCRIPTION

A group effort is directed to problem definition and creative problem solving. The group discussion relies on two basic concepts: "making the strange familiar" and "making the familar strange" (Gordon, 1961).

Synectics depends, first of all, on finding analogies to a strange or novel situation (in the problem context) in order to make it familiar (making the strange familiar). In contrast, "making the familiar strange" means to enhance the possibility of new solutions by looking at something familiar from a different viewpoint.

Different kinds of analogy are used during a Synectics session to draw out these ideas, e.g., comparing parallel situations in different fields. The group's ideas may then be explored and developed into possible solutions, often by a technical staff member who sits in on the session.

ADVANTAGES

1) Solutions generated by the Synectics method may be quite novel and innovative. The technique draws out the creative expression of participants.

2) Different analogies used in Synectics provide creative insights into the problem.

3) After participating in repeated Synectics sessions, a trained team is available for attacking new problems.

4) Regular participation in Synectics sessions may improve a member's creative thinking outside of the sessions.

LIMITATIONS

1) Synectics requires that the members communicate freely and often impersonate inanimate objects or abstract ideas. Some people may be inhibited and may not participate actively in the group sessions. Also, superior-subordinate relationships outside the sessions may limit

discussion. If such problems are anticipated, Nominal Group Technique (NGT, page 14) may be a better method to employ.

2) Initial use of the Synectics method may not be productive. However, experience with trial problems increases the effectiveness of the method.

REQUIRED RESOURCES

LEVEL OF EFFORT

A Synectics session includes eight to twelve members. They must meet and be organized into a group session. Participants must be made familiar with the technique. It is often possible in organizations to arrange a pool of potential members for Synectics sessions. This will minimize the effort required to arrange any one Synectics meeting.

SKILL LEVEL

A Synectics group usually includes one or two technical experts in the problem area. Other members should be able to fantasize, empathize, and role play. The group leader needs a thorough understanding of the technique, as well as some training as a session leader.

TIME REQUIRED

Most problems require only one session lasting at most four hours. The novelty of the problem situation and the variety in the background of the members affect the length of the session. Progress is also affected if group members are inexperienced or overly inhibited.

DESCRIPTION OF TOOL

DEFINITIONS

1) *Personal analogy* is used in Synectics sessions where a group member identifies with an element of the problem and looks at it as though he were that element. For example, if the problem is to develop inexpensive ways to dry and store grain in a wet climate, a member identifies with a single grain in a storage bin.

2) *Direct analogy* compares the problem being faced to a parallel situation in another field, technology, or discipline. For example, the grain storage problem may be compared to a bacterial colony whose propagation is to be controlled against disturbances in moisture and airflow.

3) *Symbolic analogy* describes the problem by objective and impersonal titles. These titles are used to identify other problems which may be described by the same title. They are generally expressed in two words, usually describing two conflicting attributes of the problem. For example, the grain storage problem may use "Crowded Separation" to describe the facets of the problem—that of packed storage and that of sufficient grain separation to allow for airflow.

4) *Fantasy analogy* is the participant's wishful thinking that the problem may solve itself or cease to exist. For example, in the grain storage problem, one fantasy analogy may be that "Grains do not germinate, even if stored moist." This leads to the idea of irradiating the grain in order to cease germination.

REQUIRED INPUTS

1) A statement of the problem is necessary. For example, "Grains must be dried and stored economically in a poor region where the climate is wet."

2) Participants in a Synectics session are experts concerned with the problem, along with six to eight other members preferably from a variety of disciplines.

TOOL OUTPUT

1) A restatement of the problem definition can be expected. In the grain storage problem, the restatement may be, "It is required to store grain so that it does not spoil."

2) A Synectics session results in a number of possible solutions to the problem, e.g., "irradiate grain and store in any ordinary place," "store with bags of chemicals that absorb moisture," or "plant crop so that the harvest is in a dry season." The merits of each solution may then be evaluated for feasibility.

IMPORTANT ASSUMPTIONS

People vary greatly in their ability to utilize analogies, and consequently, their contribution to a Synectics group will differ markedly. The assumption behind Synectics is that cross-fertilization of ideas will lead to innovation and creative responses.

METHOD OF USE

GENERAL PROCEDURE

A Synectics session has basically two phases. The first phase is to introduce the problem to the group and obtain a redefinition of the problem. The second phase utilizes four analogy methods to generate possible solutions. It is sometimes necessary to identify new and related problems that must be solved before the original problem solution can be attempted.

The following is a guide for the Synectics leader.

1. **Define the problem.**
   Present the problem to the group. Have a technical expert or the decision maker briefly explain and analyze the problem.

2. **Purge ideas and criticisms.**
   2.1 Ask that the members suggest any solutions or ideas immediately after the presentation of the problem.
   2.2 Have the experts discuss the feasibility and suitability of these ideas as they are suggested. This gives participants a better and deeper understanding of the problem.

3. **Restate the problem.**
   3.1 Ask the participants to propose restatements of the problem.
   3.2 Select one definition that seems most acceptable to participants.

4. **Use direct analogies.**
   4.1 Ask evocative questions to generate a number of direct analogies by drawing from similar problems in other fields.
   4.2 Choose one analogy for further exploration.

5. **Use personal analogies.**
   5.1 Request some members of the group to play the roles of some elements of the problem. The elements may be animate or inanimate. For example, participants might be asked to be trees and examine the problem of preventing forest fires. Ideas and feelings expressed by participants may trigger solutions to the problem.
   5.2 It may be necessary to ask questions of participants to generate further insight into the problem.

6. **Use symbolic analogies.**
   6.1 Ask participants to generate symbolic titles for the problem. Such titles should be expressed in two words, usually describing two conflicting attributes of the problem.
   6.2 Select one analogy and have members explore it.

7. **Use fantasy analogies.**
   7.1 Suggest some physical or theoretical impossibilities related to the problem that may eliminate or simplify the problem.
   7.2 Let participants suggest other fantasy analogies. These ideas often generate possible solutions.

8. **Force fit some analogies.**
   8.1 If the analogies do not directly aid in solving the original problem then "force fit" an analogy.
   8.2 State some aspect of the problem and then apply it directly to the analogy to provide greater insight into the constraints and circumstances of the problem situation. For example, stored grain germinates if it gets wet. What would happen to a bacteria culture (force fit to direct analogy)?

9. **Repeat necessary steps.**
   9.1 Generate analogies (steps 4-7) in any convenient order. It may be necessary to use one or more of these analogies during the discussion.
   9.2 Direct the group into using these analogies in combination or to help the members force fit an analogy.

10. **Redefine the problem or present the solutions.**
    10.1 Determine if the results of the session are satisfactory. If not, it may be necessary to go back to step 3 and redefine the problem. Sometimes other related problems may be identified which should first be solved.
    10.2 Present the summarized results to the group and call the session to an end.

EXAMPLE

The following example gives some excerpts from the discussion in a Synectics session. The steps are identified in parentheses.

LEADER: We want to develop ranking or rating procedures for illiterate or semi-literate decision making or client groups (**Problem as Given**). The leaders of these groups would be literate. The group is to choose between different alternatives. As an example, a group might choose between different modes of health care delivery.

PETER: Have the leader explain alternatives orally to the group and associate a symbol with each alternative. Let the group order the symbols to show their choices (**Purge**).

EXPERT: But the members may not be able to retain the associations (**Criticism of Ideas during Purge**).

LEADER: Pat, if you were illiterate and if Peter's method were adopted, what would you do? (**Personal Analogy**) Peter, why don't you demonstrate the method.

PETER: I've given symbols to each of the alternatives, Pat. Now choose the symbol which indicates your choice of alternatives.

PAT: I am confused. I don't remember the symbol for one of the alternatives (**Personal Analogy**).

PETER: We could try choosing between two symbols at a time.

EXPERT: There is a problem though. Someone might choose B before A, C before B, C before A! The preferences are not transitive.

LEADER: Okay, let's consider another situation. There is a pet, say a cat. You want to communicate to it that it can choose only one kind of pet food (**Direct Analogy**).

RAJA: Make the cat taste a little from each container and find out which it prefers.

PAT: What if there are six types of pet food. It may have forgotten how the first type tasted.

PETER: Also there is the problem that the cat might be influenced by the order in which it is given the food. Hence the order that the alternatives are presented might be important.

LEADER: Okay, here we have a group of people who have to choose a health care plan. They look up to the leader. They want to please him, and they know he will only let them choose one plan. At the same time, they would like any or all of them.

PAT: You mean the cat is hungry and would like all of the different foods.

RAJA: You have a situation where there are many alternatives and the group would like to have all of them (**Force fitting analogy from cat wanting all different foods**). But the choices are limited, and only one can be selected.

LEADER: How about the phrase "Plentiful restrictions" to describe this? (**Symbolic Analogy**)

JUZAR: I think I would like the phrase "Eagerness Obedience." You see, the cat is eager to eat it all but looks up to the owner. In the same way, the members respect the leader.

PETER: The problem might be that the members will understand the alternatives and know what they want. It is only needed to communicate that they have to make a choice.

JUZAR: They may not want to make a choice. Often this is true.

PAT: Quite true. They may not wish to make any choice. They may not like any, but do not wish to say so.

RAJA: Why does the leader want the members to choose? I want to fantasize that there is no problem. So there is no group meeting. The leader simply makes the choice (**Fantasy Analogy**).

LEADER: Let us try posing the problem this way. The leader just wants the members to rubberstamp his choice. . . .

LEADER: Okay, this is what we concluded. The problem is not that of developing a rating procedure, but one of how to communicate that choice is actually being made by the members. So related questions of motive behind the meetings need to be resolved. For example, are members voting merely to rubberstamp the leader's choice? Are they there to make a democratic decision? Does the leader hope that letting members vote will mean easier implementation of the plan, etc.?

The result of this exercise was not a problem solution but a redefinition of the problem which brought to light various constraints on the rating system procedure (see also Rating Scales, RTS, page 29).

THEORY

Gordon (1961) gives a theoretical basis showing how the use of analogies stimulates creativity.

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Morphological Analysis

PREREQUISITE TOOLS

None.

USAGE

PURPOSE

Morphological analysis generates a large number of element combinations for further examination.

USES

Morphological analysis can be used to:

1) Analyze a problem systematically.

2) Develop alternative projects and programs.

3) Identify a number of possible future states in a problem situation.

KEY DEFINITIONS

1) An *element* is a part of a problem description, e.g., population, land use, and climate may be some of the elements in an agricultural policy program.

2) An *attribute* of a system includes the elements or components of the system and their relationships.

SHORT DESCRIPTION

Morphological analysis involves decomposing a problem into its elements, identifying a number of alternative attributes for each element, and synthesizing alternative solutions by combining the attributes in different ways. The attributes are written in the form of a matrix to simplify the process (see figure 1). The elements may describe a future environment, in which case the combinations will be different futures.

ADVANTAGES

1) A large number of possible solutions are generated.

2) The method's exhaustive nature decreases the likelihood of overlooking possible solutions. It often identifies solutions that may have been overlooked if other methods, such as Nominal Group Technique (NGT, page 14), were used.

3) Because the process of synthesizing alternative solutions in morphological analysis is systematic, the biases and prejudices held by the person using the tool are avoided while generating ideas.

LIMITATIONS

1) Large problems lead to a large number of elements and attributes. In such cases, morphological analysis leads to so many possible solutions that evaluation becomes unwieldy.

2) If any significant element in a problem is overlooked, the morphological analysis suffers accordingly. This is the major limitation of the technique: it does not ensure that all elements are specified. The systems defini-

FIGURE 1
Attributes for an Energy Policy Situation

ELEMENTS	ATTRIBUTES				
Energy Demand	Low Demand	High Demand			
Growth Rate	Zero Growth	Slow Increase	Rapid Increase		
Primary Source of Energy	Oil	Gas	Solar	Nuclear	Fuel Cell
Primary Use of Energy	Industrial	Household	Transportation		

tion matrix (SDM, page 67, or Tree Diagrams.TRD, page 74) may be useful in this regard.

REQUIRED RESOURCES

SKILL LEVEL

Knowledge relating to the problem area and the skill to decompose the problem into its elements are essential to use this approach effectively. The analyst requires the ability to recognize potentially interesting combinations.

TIME REQUIRED

The time required depends on the complexity of the problem and the number of elements identified. A simple problem may need less than a day. The time required increases very rapidly as more elements are identified.

DESCRIPTION OF TOOL

REQUIRED INPUTS

A statement of the problem is necessary, such as "Give possible descriptions of the energy situation in Temasek" or "A primary health care program needs to be developed."

TOOL OUTPUT

Morphological analysis results in a number of alternative solutions to the problem statement synthesized from combinations of attributes for the different elements identified as part of the problem situation. For example, a table with six elements and four attributes can have $(4)^6 = 4096$ possible combinations. However, many of these combinations may be physically if not theoretically impossible or meaningless. The remaining feasible combinations represent the product of a morphological analysis. However, even illogical combinations may trigger feasible alternative solutions.

IMPORTANT ASSUMPTIONS

A problem or task is divisible into discrete elements, each of which has one or more alternative attributes. This is not a limiting assumption since the analysts may always define a problem in such a way that decomposition is feasible.

METHOD OF USE

GENERAL PROCEDURE

1. **Identify elements and their attributes.**
   1.1 Consider the problem as stated and think of the

elements that are part of the problem situation. Many elements can be identified directly from the problem statement. For example, elements like "type of cattle," "method of raising," and "scale of industry" follow directly from "it is required to develop a meat packing industry." Each of these elements may be described by different attributes.

1.2 Generate as many attributes as possible. An attribute often comes to mind before the element. For example, the attribute "government subsidy" may lead to the element "source of revenue." Other attributes for the element are then identified, e.g., "private donations" or "lottery tickets."

2. Develop the table of attributes.
   2.1 Organize the elements and attributes into a tabular form (see figure 1).
   2.2 List one element per row with its attributes. The table will have as many rows as there are elements identified. Often, the process of filling in the table will suggest new elements or attributes. Include them in the table.

3. Synthesize alternatives.
   3.1 Select one attribute from each element row (see dashed line, figure 2).
   3.2 Combine the attributes to describe a particular alternative.
   3.3 Throw out combinations which are unfeasible or illogical.
   3.4 Examine the remaining combinations for possible problem solutions or feasible alternatives.

EXAMPLE

In order to develop an energy policy, a government decides to use contingency analysis (CGA, page 147). A number of possible future states need to be identified. Morphological analysis was used as follows:

Some of the elements are discovered immediately, e.g., "energy demand" and "source of energy." Other elements like "use of energy" and "rate of growth of economy" follow. A table for these attributes is given in figure 1. Alternative future states are synthesized from the table:

1) A situation of high energy demand with a rapid economic growth; the largest source of energy is oil used primarily in transportation (shown in figure 2).

2) A zero growth economy with low energy demand using solar energy primarily for household consumption. Eighty-eight other combinations were possible, though only a few were used in the contingency analysis.

FIGURE 2
One Combination of Attributes Indicated in a Morphological Chart

ELEMENTS	ATTRIBUTES				
Energy Demand	Low Demand	High Demand			
Growth Rate	Zero Growth	Slow Increase	Rapid Increase		
Primary Source of Energy	Oil	Gas	Solar	Nuclear	Fuel Cell
Primary Use of Energy	Industrial	Household	Transportation		

THEORY

Morphological analysis was developed by Zwicky (1969) and used extensively in a variety of contexts ranging from new product development to problem solving. Wissema (1976) reports an interesting application of the technique in technological forecasting, particularly emphasizing that morphological analysis could be used to construct scenarios (SCN, page 164) and Delphi questionnaires (DLP, page 168).

Kaufman (1968) deals with the problem of ranking the combinations of attributes to facilitate the selection of feasible alternatives. He explores the implications for decision theory. The parallel between the morphological box representation of a problem and interaction matrix diagrams should be clear from examining the format of the products of each technique (see IMD, page 92).

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Nominal Group Technique

PREREQUISITE TOOLS

None.

USAGE

PURPOSE

The Nominal Group Technique (NGT) is a group process for eliciting opinions and aggregating judgments to increase rationality and creativity when faced with an unstructured problem situation.

USES

NGT may be used to:

1) Identify the elements of a problem, especially where there are political, social, and cultural elements.

2) Identify and rank goals or priorities.

3) Identify experts whose experiences or skills may be useful in other decision-making techniques.

4) Involve personnel at all levels in the decision-making process in order to promote the acceptability of the final decision.

KEY DEFINITIONS

1) A *nominal group* is a group process in which the members work independently but in each other's presence.

2) An *interacting group* permits discussion between participants (e.g., Brainstorming, BSG, page 3, is an interacting group process).

3) *Rank-ordering* is the process of weighing one item against others and then ordering the items by weight on a scale such as importance or priority.

SHORT DESCRIPTION

The Nominal Group Technique is a structured process which taps the experiences, skills, or feelings of participants. A question is posed to the group. Each member writes down as many responses as possible. The group leader asks each member in turn to state an idea from his or her list and writes it on a flip chart placed before the group. No discussion is permitted until all ideas have been listed. Each item is then briefly discussed in an *interacting group* format. The participants indicate their preference for important items by *rank-ordering*, a process which may be repeated with intervening discussion and argument.

The outcome of the process is the mathematical aggregation of each member's preferences to give the group's ranking of responses to the question.

ADVANTAGES

1) Dominance by high-status, aggressive, or articulate members is reduced since each has an equal opportunity to participate.

2) The group remains problem-conscious; and premature evaluation, criticism, or focusing on ideas is avoided.

3) The silent generation of ideas minimizes the interruptions in each person's thought processes.

4) A written record increases the group's ability to deal with a large number of ideas. It also avoids the loss of ideas.

5) Discussion only to clarify items helps eliminate misunderstanding, without reducing the group's efficiency.

6) Some studies have shown that, compared to interacting group processes, e.g., Brainstorming (BSG, page 3), the Nominal Group Technique (NGT) enhances the conditions for creativity when generating information on a problem. It avoids rambling discourse and other deficiencies found in group processes.

LIMITATIONS

1) Cross-fertilization of ideas is diminished due to the structure imposed by the NGT.

2) The NGT may reduce flexibility, e.g., some group members may feel that the purpose of the meeting or the question posed is irrelevant or misleading, but they have no opportunity to change it.

3) Bringing group members together may be cost-prohibitive.

REQUIRED RESOURCES

LEVEL OF EFFORT

Some administrative effort is required to determine the purpose of the meeting and to structure the proposed question. Potential group members need to be identified, notified, and assembled.

SKILL LEVEL

The leader of the nominal group should not bias the group toward his view; yet he must control unwanted group behavior without alienating people.

TIME REQUIRED

In a study quoted by Delbecq, et al. (1975), the total administrative man-hours to prepare, conduct, and follow through for one group required an average of 4.4 hours for NGT, 4.2 hours for interacting processes, and 7.1 hours for the Delphi process (DLP, page 168).

SPECIAL REQUIREMENTS

A flip chart and marking pens are needed for each group. Index cards (or similar small cards), approximately six per participant, facilitate the voting process.

The seating arrangement must allow all members to easily focus on the ideas listed on the flip chart. Some means of displaying the completed chart pages is necessary (e.g., tacks or masking tape to afix them to the walls).

DESCRIPTION OF TOOL

SUPPLEMENTAL DEFINITION

Round-robin is a process for serially recording ideas where each participant provides an idea in turn. No discussion occurs, although the leader may ask for a show of hands on how many participants had a similar idea. (This is noted next to the item on the list.) Those responding then eliminate that idea from their respective lists. The process may continue in a circular fashion until all participants' lists are exhausted.

REQUIRED INPUTS

The nominal group generally includes five to nine members. Less than five members may not allow for the quality and diversity of opinions required. Large groups produce more interpersonal differences, which lengthens the process without a substantial increase in the quality of output. If more than ten persons must participate, it is better to divide the group for the round-robin and combine them for final discussion and voting.

The group leader may be directly involved in generating and discussing ideas. The composition of the group may be homogeneous or heterogeneous. Studies have shown that heterogeneous groups exhibit more creativity (Delbecq, 1975). But interpersonal differences and communication problems may increase for such groups.

The NGT question provides the basis for generating the ideas. It should be worded to prevent misunderstanding and should be stated as objectively as possible.

TOOL OUTPUT

The NGT produces a list of ideas and a rank-ordering of their importance. The group leader may wish to combine overlapping ideas under a common heading.

METHOD OF USE

GENERAL PROCEDURE

The general procedure for the Nominal Group Technique is straightforward. But because it runs counter to

the experience of most people in leading groups or participating in committee work, the steps must be followed closely. With this in mind, the guidelines prescribed by the originators of the Nominal Group Technique have been reproduced below (Delbecq, et al., 1975, figure 3-7, page 67-69):*

1. Silent generation of ideas in writing.
   - 1.1 Present the nominal question to the group in writing.
   - 1.2 Verbally read the question.
   - 1.3 Illustrate level of abstraction and scope desired with example which does not distort (lead) group responses.
   - 1.4 Avoid other requests for clarification.
   - 1.5 Charge the group to write ideas in brief phrases or statements.
   - 1.6 Ask group members to work silently and independently.
   - 1.7 Model good group behavior.
   - 1.8 Sanction disruption of the silent, independent activity by comments addressed to group as a whole.

Benefits:

1) Provides adequate time for thinking.
2) Facilitates hard work by the model of other group members reflecting and writing.
3) Avoids interruption of each other's thinking.
4) Avoids premature focusing on single ideas.
5) Eliminates dominance by high-status or aggressive members in idea generation.
6) Keeps the group problem-centered.

2. Round-robin recording of ideas on a flip pad.
   - 2.1 Indicate objective of the step is to map the group's thinking.
   - 2.2 Explain need to present ideas in brief words or phrases.
   - 2.3 Explain process of taking one idea serially from each member.
   - 2.4 Explain group members must decide if items are duplicates.
   - 2.5 Explain that an individual may "pass" when he has no further items, but may "re-enter" later.
   - 2.6 Express the desirability of hitchhiking and adding new ideas even if they are not on individual nominal worksheets.
   - 2.7 Explain inappropriateness of discussion prior to completion of listing.
   - 2.8 Record ideas as rapidly as possible.
   - 2.9 Record ideas in the words used by group members.
   - 2.10 Provide assistance in abbreviating only in special situations.
   - 2.11 Make the entire list visible by tearing off completed sheets and taping them on an area visible to all group members.
   - 2.12 Sanction group as a whole if individuals engage in side conversations or attempt to discuss items prior to completing the listing.

Benefits:

1) Equalizes opportunity to present ideas.
2) Assists in separating ideas from personalities.
3) Provides a written record and guide:
   a) Increases group's ability to deal with a larger number of ideas.
   b) Avoids loss of ideas.
   c) Confronts the group with an array of clues.
   d) Encourages hitchhiking.
4) Places conflicting ideas comfortably in front of group.
5) Forces the group to fully explore the problem.

3. Serial discussion for clarification.
   - 3.1 Verbally define the purpose of the step:
     - a) To clarify the meaning of items.
     - b) To explain reasons for agreement or disagreement.
   - 3.2 Indicate that final judgments will be expressed by voting, so arguments are unnecessary.
   - 3.3 Pace the group so that all ideas receive sufficient time for clarification.
   - 3.4 Avoid forcing the member who originally lists the idea to be solely responsible for clarifying the item.

Benefits:

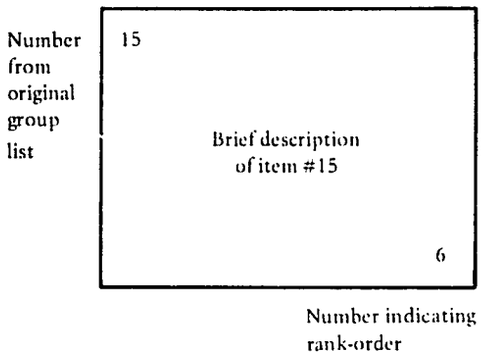
1) Avoids having discussion focus unduly on any particular idea or subset of ideas.
2) Helps eliminate misunderstanding.
3) Provides opportunity to express the logic behind items.
4) Allows members to disagree without argumentation.

4. Preliminary vote on item importance.
   - 4.1 Ask the group to select from the entire list a specific number (7 ± 2) of priority (important) items.*

*From *Group Techniques for Program Planning* by André L. Delbecq, Andrew Van de Ven and David H. Gustafson. Copyright (c) 1975 by Scott, Foresman and Company. Reprinted by permission.

*Five to nine items are all that can be effectively ranked on one dimension of discrimination (see Rating Scales, RTS, page 29).

FIGURE 1
Index Card Illustrating Rank-Order Voting Process



4.2 Place each priority item on a separate 3 x 5 card or rating form [see figure 1].
4.3 Rank-order or rate the selected priority items.
4.4 Collect the cards or rating forms and shuffle them to retain anonymity.
4.5 Tally the vote and record the results on the flip chart in front of the group.

Benefits:

1) Obtaining independent judgments in writing helps eliminate social pressures.

2) Expressing judgments mathematically by rank-ordering or rating increases accuracy of judgments.

3) Displaying the array of individual votes clearly highlights areas needing further clarification or discussion.

5. **Discussion of the preliminary vote.**
   5.1 Define the role of the step as clarification, not pressure toward artificial consensus.
   5.2 Keep the discussion brief.
   5.3 Caution group members to think carefully about any changes they make in their voting.

Benefits:

1) Provides group members a final opportunity to clarify their positions.

2) Ensures that "spread" votes really reflected differences in judgment, not unequal information or misunderstanding.

6. **Final vote.**
   6.1 Repeat step 4.
   6.2 Closure to the meeting.

Benefits:

Accurate aggregation of group judgments and error reduction.

EXAMPLE

The steps of the Nominal Group Technique have been presented in a straightforward procedure which reflects a structured group process. The following example highlights some of the key points in this process and illustrates typical intermediate products generated by the technique.*

The Ministry of Health for the government of Temasek wanted to analyze the state of the health delivery service. The evaluation staff elected to use the Nominal Group Technique and brought together a diverse group of physicians, rural health technicians, public health personnel, field personnel, and a cross-section of clients (from different income and social classes).

Silent Generation of Ideas in Writing

The assembled participants were broken into groups of nine by randomly selecting participants representing relevant occupations.

After the opening welcome and a brief explanation of the Nominal Group Technique and the objectives for the afternoon, each participant was given a single sheet headed with the following question:

WHAT ARE THE BARRIERS TO RECEIVING ADEQUATE HEALTH CARE IN OUR COUNTRY?

The participants were allowed 15 minutes to list responses from their own viewpoints.

Recording of Ideas on a Flip Pad

The leader for each group (a member of the evaluation staff trained in NGT) acted as the recorder to serially list the ideas. Some of the ideas generated by one group included:

1) No money to pay for services
2) Lack of adequate facilities
3) Too many doctors in the cities
4) Not enough trained personnel
5) Over reliance on traditional remedies
6) Not enough doctors

Note that this list contains some contradictions. The leader deferred discussion until the next step. However, when item 6 was voiced, someone asked whether this was the same as item 4 since doctors are included in trained personnel. The leader asked the participant if he thought item 6 should be dropped. The reply was negative, and the round-robin recording continued. All of the groups generated 15 or more items.

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*This example is adapted from an exercise conducted by one of the authors at a workshop to enable county health agencies to plan for the treatment of alcoholics.

Serial Discussion for Clarification

During the discussion of each item, the participants clarified their responses, e.g., since trained personnel can replace many functions of the physician, items 4 and 6 deserved separate consideration. Item 5 included going to a traditional village healer instead of the nearest clinic.

Preliminary Vote on Item Importance

Each participant was asked to rank (from the list) the five most significant barriers to receiving adequate health care. The tally of the vote was recorded on the flip chart, using the numbers from the items. A vote of five meant that the participant viewed that item as the most significant barrier. The votes for the first six items were:

Item Number	Votes	Total
1)	4, 1	5
2)	5, 4	9
3)	2, 2, 4	8
4)	3, 5, 3	11
5)	1	1
6)	3, 5	8

Discussion and Final Vote

During the discussion following the first vote, the participant who had presented item 5 expressed his amazement that the other members had not found the interference of superstitions and traditional healers to be a barrier. Other participants were not swayed by his arguments, and the final vote on the item was unchanged. Totaling the individual rankings for each of the above items gave item 4 the most weight (11) followed by item 2 (9) and item 6 (8). Note that this example is incomplete since the rest of the list has not been presented, but the essential idea remains the same. A group with rather large status differences was able to use the Nominal Group Technique to identify and rank problems in receiving health care.

THEORY

The Nominal Group Technique is the result of analysis and experimentation with group processes for effective planning and decision making, and is credited to Van de Ven and Delbecq (Delbecq, et al., 1975). The creativity of a group is an important determinant of its success. Types of group processes and leadership techniques for allowing creativity have been discussed widely (Maier, 1970; Osborn, 1957; Collins and Guetzkow, 1964).

The Nominal Group Technique utilizes the mathematical aggregation of group judgments to come to a group decision. The theory is discussed by Huber and Delbecq (1972). The advantages over conventional means for coming to a group decision (e.g., consensus or majority rule) are described by Delbecq, et al. (1975).

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Questionnaires

PREREQUISITE TOOLS

None.

USAGE

PURPOSE

Questionnaires generate ideas, opinions, or information from a selected target population.

USES

Questionnaires are used to:

1) Structure the content of an interview (Interviews, IVW, page 23).

2) Obtain responses for a sample survey (Surveys, SVY, page 36).

3) Provide the format for communicating with Delphi participants (Delphi, DLP, page 168).

KEY DEFINITIONS

1) *Open questions* permit the respondent to answer as he or she chooses.

2) *Closed questions* require the respondent to limit responses to prespecified categories, e.g., Yes/No, Option A, B.

3) *Frequency distributions*, or histograms, plot the frequency of different categories of response (see Histograms, HIS, page 131).

SHORT DESCRIPTION

Questionnaire design is an art with scientific elements determined by the purpose of the questionnaire, the type of responses desired, the characteristics of the respondent, and the method of distribution. Questionnaires may be distributed by mail, by phone, or directly. The responses may be obtained from a direct interview or by a self-administered questionnaire which is then collected (e.g., by return mail). The length and format of the questionnaire are crucial factors affecting the return rate, the validity of responses, and unintentional biases or distortion.

ADVANTAGES

1) Self-administered questionnaires allow the participant time to ponder the questions.

2) Mailed questionnaires may be distributed to a population at less cost than interviews.

3) Phone questionnaires involve minimum cost and maximum speed of response.

4) The anonymity of the respondents may be ensured.

LIMITATIONS

1) The return rate for mailed questionnaires is usually very low.

2) Those who do return the questionnaire may share a common interest that biases the sample.

3) Distribution by mail is often impractical because of reliability and time constraints.

4) Self-administered questionnaires are rigid and inflexible - confusion and ambiguities cannot be clarified by an interviewer.

5) Self-administered questionnaires can't be employed for illiterate or semi-literate populations, and may lead to erroneous responses for literate but mixed-culture target groups.

REQUIRED RESOURCES

LEVEL OF EFFORT

By far the greatest effort must go into designing and testing the format of the questionnaire. Other tasks, such as distribution and analysis, are proportional to the number of respondents, the number of open-ended questions, and the length of the questionnaire.

SKILL LEVEL

Questionnaire design requires skills which are only gained by experience. It is impossible to anticipate the misinterpretations and personal logic in responses; therefore, pretesting the questionnaire is important to success.

TIME REQUIRED

A comprehensive questionnaire design might take several days. Time must be allowed for pretesting, distributing the questionnaires (or interviewing), and analyzing results. Allowing time to encourage returns of mailed questionnaires is essential if the return rate is to be reasonably high.

SPECIAL REQUIREMENTS

The necessity to duplicate and assemble the questionnaire copies must not be ignored. Manual analysis of responses can be tedious, and electronic computation equipment (including specially programmed digital computers) is a great relief. Where such means are cost-effective, the response format should be designed with computer coding in mind.

DESCRIPTION OF TOOL

REQUIRED INPUTS

Questionnaire design begins with the purpose and target population clearly identified (see Surveys, SVY, page 36).

Mail facilities and self-addressed stamped envelopes are essential for mailed questionnaires. Include a cover letter describing the purpose and details of the questionnaire, even if the target population has been previously informed. For example, Delphi participants are involved in a series of questionnaires which are returned in a two-way communication (see Delphi, DLP, page 168).

TOOL OUTPUT

Individual questionnaires are not the end product of questionnaire design—the aggregated responses of the participants is desired. Consequently, an incomplete or mutilated questionnaire that is returned is valid information for the analyst.

Decision makers demand information in an easily digested form. This includes summaries of typical responses as well as indications of the pattern of responses, e.g., a graph of the frequency of categorical responses (see Histograms, HIS, page 131).

Usually the questionnaire results will be an intermediate product in further analysis which may or may not be transmitted to decision makers. But most of the time it will be appended to a final report (see Surveys, SVY, page 36, and Delphi, DLP, page 168).

IMPORTANT ASSUMPTIONS

A questionnaire is a measuring instrument. It is a transmitter of information from a selected individual to an analyst. The responses must be accepted at face value in the absence of any other information. Therefore, the analyst assumes that responses were given by the selected individual, that the responses were freely given, that the respondent was not just trying to please him, etc. Some of these necessary assumptions may be validated by randomly spot-checking returned questionnaires, e.g., by direct interview or phone.

METHOD OF USE

GENERAL PROCEDURE

1. **Specify the purpose of the questionnaire.**
   - 1.1 Identify the topics to be covered—keep the number to a minimum.
   - 1.2 Identify the target population and any special cultural or educational characteristics it might have.
   - 1.3 Determine the means of distribution and collection of the questionnaire.
   - 1.4 Specify an acceptable return rate and adjust the sample number of questionnaires accordingly. A

return rate for mailed questionnaires may be anywhere from 15% to 90%, depending on the motivation of the respondents and the topics selected.

2. **Design the questionnaire (Phillips, 1966).**
   2.1 Start with basic information about the respondent; consider only that information essential for analyzing the results. Ensure anonymity if desired.
   2.2 On any topic, begin with general questions. Then get more specific.
   2.3 Arrange the questions logically and avoid abrupt transitions.
   2.4 Examine the order for questions which may exert an undesired influence on the response to subsequent questions, e.g., a question which is likely to antagonize the respondent should be placed near the end of the questionnaire.
   2.5 If necessary, code the questionnaire so that responses and participants may be correlated, e.g., arrange questions in different sequences.

3. **Edit each question after completing the list.**
   3.1 Avoid long questions.
   3.2 Eliminate ambiguities and double entendres by incorporating examples or by setting the question in context.
   3.3 Determine if an open-ended question can be rewritten as a closed question.
   3.4 Make certain that the categories of response for closed questions are sufficiently comprehensive, e.g., by including a "none of the above" category.
   3.5 Eliminate emotionally charged words and leading or loaded questions.

4. **Design validating questions into the survey.**
   4.1 Repeat the same question (rephrased) at a later point in the questionnaire.
   4.2 Include collaborating questions where memory or personal biases are likely to influence the response, e.g., "How many bushels per acre did your last crop yield?" may be followed by a question "What was the tax on your harvest?"

5. **Pretest the questionnaire.**
   5.1 Try the questionnaire out on fellow staffers and analyze the results to see whether the desired information has been elicited.
   5.2 Administer the questionnaire to one or more members of the target population, checking particularly for cultural or educational anomalies.

6. **Distribute the questionnaire.**
   6.1 Include a cover letter in a mailed questionnaire.
   6.2 Include a self-addressed stamped envelope.
   6.3 Arrange for collection points for self-administered questionnaires and pick them up on schedule.
   6.4 Provide transportation for direct interviews (see Interviewing, IVW, page 23).

7. **Analyze the results.**
   7.1 Begin the analysis as soon as the first questionnaire is returned.
   7.2 Summarize the answers to open questions by listing the main points and the similarities or differences in responses.
   7.3 Aggregate the responses to closed questions and tabulate the frequencies in order to prepare a histogram (Histogram, HIS, page 131).
   7.4 Prepare a final report for transmission, including the original questionnaire as an appendix.

EXAMPLE

The following questions were taken from a questionnaire designed to elicit basic data on farm wages as part of a cost-benefit analysis (CBA, page 212). The target population is the farmers along the Mai River in the country of Temasek.

1. Name (optional) _____
2. Address (optional) _____
3. General location of farm (check one):

   ☐ north of Mai River
   ☐ south of river
   ☐ north of village
   ☐ south of village

4. Size of farm:

   ☐ smaller than one hectare
   ☐ between one hectare and two hectares
   ☐ larger than two hectares

5. Number of farm workers (including members of family) _____
   Available at harvest time? _____

6. Did you hire farm labor this year?
   Yes _____ No _____

7. If yes, how much did you pay?
   per hour? _____ per day? _____

8. How many did you hire? _____

The questionnaire begins with general (neutral) questions. Question 3 is a closed question whereas question 5 is open (but quantified).

If the number of farm workers needs to be cross checked, the questions on members of the family available for farm work can be used. However, even such relatively straightforward questions can lead to unreliable responses. How does the farmer define "family"? Is the extended family included? A careful pretest would probably result in a better specification of these questions.

THEORY

The theory of questionnaire design is documented in a number of texts addressed to survey research (Festinger and Katz, 1953; Warwick and Lininger, 1975). The theory is based on numerous empirical studies including the effects on the return rate of factors such as different questionnaire layouts, the color of paper, or the length of the questionnaire. However, there is no substitute for experience (including pre-testing): each situation is unique.

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Interviews

PREREQUISITE TOOLS

Questionnaires (QTN, page 19).

USAGE

PURPOSE

An interview generates ideas and gathers information by posing relevant questions to the respondent(s).

USES

Interviewing is useful for:

1) Obtaining background information about a problem situation.

2) Collecting information and ideas from a selected sample within a target population (see Surveys, SVY, page 36).

3) Eliciting information and ideas from experts or professionals, e.g., agency representatives.

KEY DEFINITION

An *interview schedule* is the plan for conducting an interview. It includes the questions to be posed.

SHORT DESCRIPTION

Interviews involve interpersonal transactions. The preparation, conduct, and results of the interview are determined largely by the participants. The interviewer may be specially trained. The *interview schedule* may be structured (*closed questions*) or unstructured (*open questions* and discussion). The respondent may be a professional, a project participant, or a randomly selected member of a target population. The combination of these factors is dictated by the purpose of the interview and the topic of inquiry.

ADVANTAGES

1) An interview provides a degree of flexibility in obtaining information and generating ideas that is not likely to occur in impersonal transactions, e.g., a mailed questionnaire.

2) The questions may be adapted during the course of the interview in response to immediate feedback from the respondent.

3) Face-to-face interaction tends to heighten the respondent's interest in participation and forces him or her to consider the questions immediately.

4) Where information must be gathered from an illiterate or semi-literate population, interviews may be the only effective instrument.

5) The interviewer can use cues other than the content of responses to assess their validity.

LIMITATIONS

1) When several people have to be interviewed on similar topics, or where a wide range of issues has to be

covered, the necessary resources may be cost-prohibitive when compared to using questionnaires (QTN, page 19).

2) An interviewer without the necessary skills may alienate the respondents or allow him or her to dominate the exchange.

3) Where the respondent is not motivated, the answers are likely to be inadequate.

4) If creativity or the discussion and evaluation of ideas are required, group processes such as Nominal Group Technique (NGT, page 14) or Brainstorming (BSG, page 3) may be more appropriate.

5) The anonymity of respondents (and thus their candor) cannot be ensured.

REQUIRED RESOURCES

LEVEL OF EFFORT

Gathering information by direct interviews can be a major effort bounded by the amount of information sought and the number of interviews desired. A follow-up interview may be necessary. Special training is required for interviewers.

SKILL LEVEL

An interviewer must have certain skills to ensure proper and effective interaction (Bocchino, 1972):

1) Training to recognize his/her own prejudices in order to maintain an open mind.

2) Giving credit wherever due and publicly acknowledging help.

3) Emphasizing courtesy and respect.

4) Respecting the skills of the respondent.

5) Listening more than talking.

TIME REQUIRED

Preparing for an interview takes about a day. An interview lasting longer than an hour usually results in diminishing returns. Time must be budgeted to write the interview report.

SPECIAL REQUIREMENTS

Electronic recording (audio or video) of questions and responses can be a great time-saver and can allow the interviewer to give full attention to the responses. However, there are some costs, such as transcription expenses and the possible loss of candor by the respondent. If electronic equipment is to be used, the respondent's prior permission is essential.

Ideally, the interview should take place in a location free from distraction (noises, telephone calls, children or other onlookers, etc.). One technique used in a village household survey in India was to provide a highly visible distraction in the center of the village while the interview team discretely circulated among the houses.

DESCRIPTION OF TOOL

REQUIRED INPUTS

The purpose of the interview must be established and should guide subsequent decisions. If the interview is the measuring instrument for a sample survey (SVY, page 36), the target population will have been selected and a questionnaire designed (QTN, page 19).

If the interview seeks ideas and information from experts in different fields, the preparations and the training of the interviewer will differ. In all cases, however, the purposes must be established in advance.

TOOL OUTPUT

An interview usually results in a report or tabulated responses which may be analyzed and transmitted to decision makers. The data may be in the form of a histogram (HIS, page 131), a statement of preferences, etc. Often, the report will be strengthened by including illustrative responses to key questions, but unprocessed responses are seldom useful.

IMPORTANT ASSUMPTIONS

The interviewer is assumed to be an unbiased, noninteractive transmitter of information and ideas. Where this is not the case (either by design or circumstance), the information must be appropriately interpreted. For example, the manner and style of the interviewer may trigger more negative (or positive) responses than expected for a neutral reporting instrument (e.g., a self-administered questionnaire).

METHOD OF USE

GENERAL PROCEDURE

The following steps are useful guidelines for planning and conducting an interview.

1. **Specify the purpose of the interview.**

2. **Determine who is to be interviewed.**

3. **Prepare an interview schedule.**
   3.1 Design the questionnaire and determine the type of responses to be allowed (Questionnaires, QTN, page 19).
   3.2 Determine how the responses are to be recorded and, if necessary, develop a coded form.
   3.3 Make provisions for transcribing electronically recorded interviews (optional).

4. **Select and train interviewers (optional).**
   4.1 Select interviewers based on the types of respondents.
   4.2 Train interviewers to eliminate biases and provide for uniform reporting.
   4.3 Pretest all questions and anticipate ambiguities.

5. **Conduct the interviews.**
   5.1 Arrange for transportation.
   5.2 Notify respondents in advance (optional).
   5.3 Arrange for immediate collection of reports.

6. **Synthesize and analyze the responses.**
   6.1 Begin immediately to eliminate ambiguous responses in case corrections are necessary.
   6.2 Report the overall results in a form suitable for transmission to others (e.g., consider such factors as anonymity of respondents, biases of interviewers, and systematic distortions in responses).

EXAMPLES

Rather than present the protocol of an interview, the following examples describe recommended procedures for conducting two very different kinds of interviews.

Interviewing a Peasant Population for an Aid Project

The following considerations were recommended by a colleague with extensive field experiences in data gathering (Ingersoll, 1976).

1. **Entry**

If the interview is not simply an academic pursuit of knowledge but project centered, the participant will have a much greater incentive to participate. Factors to consider in planning the interview include: cultural values, the influence of the extended family, outsiders sitting in on the interview, and differences in perceptions of space, time, and quantity.

2. **Respondent in center**

Make the respondent the center of attention during the interview. Be sensitive to participants who need cues to continue. Pay attention to answers. Don't divert attention to the mechanics of filling out forms.

3. **The interviewer's posture**

The ideal is neutrality, although it may be necessary to be positive to the respondent's views in order for the interview to proceed. Receive all replies with interest. Avoid body English, e.g., nodding. Engage in active listening, e.g., repeating exactly what the person says. Decide how to handle confusion over a question, e.g., rephrasing a question or giving an example. Note any further probe into a question for inclusion in the report of the interview.

4. **Departure**

Make sure that the respondent is not left with false impressions, e.g., that a new road *will be built* as an immediate result of his participation. Give some praise if new information and ideas have been volunteered. Signal the end of the formal interview, e.g., closing up the clipboard. Observe the social amenities upon departure, e.g., small talk. One may have to come back with more questions.

Interviewing a Professional or a Decision Maker

The situation is far different when the respondent occupies a status position in an academic, business, or governmental organization. Hartman (1968) recommends the following steps for a successful interview:

1. **Prepare for the interview.**
   1.1 Research the background of the respondent to become familiar with any special terminology or jargon.
   1.2 Schedule the interview well in advance to allow the respondent time to prepare.
   1.3 Arrange the interview through the respondent's immediate superior (where this is feasible) to assure the respondent that his participation is important and approved.
   1.4 Get the respondent's correct name and title in advance.
   1.5 Avoid scheduling interviews for late in the day, just after mealtime, or just before a weekend.

2. **Conduct the interview.**
   2.1 Introduce yourself and clarify the purpose of the interview even if there has been prior notification.
   2.2 Keep the interview to the subject - respect the demands on each other's time.
   2.3 Start the interview with broad questions.
   2.4 If the responses are not satisfactory, emphasize the importance of the respondent's views for the decision-making process.

2.5 Allow the respondent to think during occasional periods of silence.
2.6 When a reply is unclear, ask the respondent to separate opinions from facts.
2.7 Don't let note-taking interrupt the normal flow of discussion; use abbreviations and symbols or electronic recording (with prior permission).
2.8 Conclude the interview by allowing a few minutes for informal conversation and summation. Often these comments may divulge useful information and may give an indication of the validity or sincerity of the previous responses.

3. Follow up the interview.
3.1 Prepare the report of the interview immediately.
3.2 If a follow-up interview is necessary, send the report (or a digest of the first interview) to the respondent in advance.
3.3 In all cases, send a formal thank you to the respondent and his supervisor acknowledging their cooperation.

THEORY

There is no theory of interviewing in the sense of general laws or "truths." Each interview is different. However, there is some merit to taking a systems approach to the design of an interview, particularly when used as the measuring instrument for sample surveys (Surveys, SVY, page 36).

An interview is analogous to a communication system having four principal components (Warwick and Lininger, 1975, p. 184):

The interviewer
The respondent
The study content or topic
The interview situation

Each of these factors interact to determine the efficiency and effectiveness of the interview. The efficiency concerns the amount of information gathered per unit of time and cost. The effectiveness relates to the usefulness of the ideas or information gathered. For example, the interviewer and/or the respondent can introduce both biases and distortion into the information gathered. Consequently, if interviewing is to be an effective technique, the specification of any one of the components must take into account the interaction with the other factors, i.e., designed as an information-gathering system (Hartman, et al., 1968).

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List of Cross-References

Benefit-Cost Ratio
CBA, CFA, DIS, IPX, IRR, NPW, SVY
Brainstorming
CBA, DTR, NGT
Cash Flow Analysis
BCR, CBA, CEA, DIS, IPX, IRR, NPW, SVY
Computer Simulation Models
DTB, FLW, GAM, IMD, OVD, QTN, SVY
Contingency Analysis
CBA, CEA, DTR, IDL, MCU, PPM, SCN, SPA
Cost-Benefit Analysis
BCR, CEA, CFA, DIS, IMD, IPX, IRR, MPA, NPW, OBT, OVD, PPB, RTS, SDM, SVY
Cost-Effectiveness Analysis
BCR, CBA, CFA, CGA, CSM, DIS, DLP, IRR, OBT, RTS
Critical Path Method
CGA, GNT, SVY
Decision Tables
CSM, FLW, IRR
Decision Trees
CGA, MCU, SPA, SVY, TRD
Delphi
HIS, NGT, QTN
Discounting
BCR, CFA, IRR, NPW
Exponential Smoothing Forecasts
RGF
Flowcharts
DTB, IMD, SCN, SDM
Function Expansion
BSG, IDL, NGT, SDM
Gaming
CGA, CSM, IMD, OVD, SCN, TRD
Gantt Charts
CPM, SVY
Histograms
DLP, RTS, SPA, SVY
IDEALS Strategy
BSG, CBA, FEX, NGT, SDM
Impact-Incidence Matrix
BCR, FEX, INS, MCU, OVD, SVY
Intent Structures
BSG, DLP, FEX, IMD, NGT, OBT, TRD
Interaction Matrix Diagramming
BSG, DLP, NGT, OVD, RTS, TRD
Internal Rate of Return
BCR, CBA, CFA, DIS, DTB, IPX, NPW
Interviews
BSG, HIS, NGT, QTN, SVY
Logical Framework
IMD, OBT, OBD, SDM
Morphological Analysis
CGA, DLP, IMD, NGT, SCN, SDM, TRD
Multiple Criteria Utility Assessment
CEA, CGA, DTR, OBT, RGF, RTS
Net Present Worth
CBA, CFA, DIS, IRR
Nominal Group Technique
BSG, DLP, RTS
Objective Trees
IMD, INS, IVW, LGF, NGT, PPB, RTS, SVY, TRD
Organizational Climate Analysis
IVW, OBT, QTN, RGF, RTS
Oval Diagramming
CSM, FEX, IMD, LGF, SCN, SDM, TRD
Planning, Programming, and Budgeting
BCR, CBA, CEA, DIS, DLP, FEX, INS, LGF, MPA, OBT
Program Planning Method
NGT
Questionnaires
CBA, DLP, HIS, IVW, SVY
Rating Scales
CBA, CGA, DLP, DTR, MCU, NGT, SPA
Regression Forecasting
OVD, SVY
Scenarios
DLP, GAM, OVD
Subjective Probability Assessment
DLP, DTR, IVW, RTS
Surveys
CBA, CEA, DLP, GNT, HIS, IVW, QTN, RGF, RTS
Synectics
NGT, RTS
System Definition Matrix
BSG, CBA, CSM, FEX, GAM, IDL, LGF, NGT, SCN
Tree Diagrams
DTR, IMD, OBT, OVD

Glossary

ACTION STUB. That portion of a decision table which lists the actions or decisions to be taken if a particular combination of circumstances occurs (DTB).

ACTION-EVENT PATH. The sequence of alternative actions and relevant events represented by the branches in a decision tree (DTR).

ACTIVITY. An operation with a well-defined beginning and end and a specific purpose (CPM).

AND LOGIC ELEMENT. Links sub-objectives to objectives where all sub-objectives must be achieved in order to attain the higher level objective(s) (INS).

ANNUAL CASH FLOW. The net incremental benefits for each year of a project and the difference between the incremental benefits and costs (CFA).

ASSESSOR. A person who estimates the probability distribution of a set of events (SPA).

ATTRIBUTE. The elements or components of the system and the interrelationships among them (MPA, SCN).

AXIOLOGICAL MEASUREMENT. Involves value judgments, where the data necessary to determine accomplishment of an objective are gathered via subjective methods (OBT).

BASE SYSTEM STATE. The set of current conditions which describes the essential characteristics of the scenario (SCN).

BINARY-EVENT OBJECTIVE. An objective that either clearly occurs or does not occur (OBT).

BRANCHING RULE. A rule that governs the construction of relationships in a tree diagram (TRD).

CAUSAL CHAIN. A sequence of cause and effect relationships between variables (OVD).

CAUSAL LOOP. A causal chain which is connected so that a change in any variable eventually feeds back through the chain to affect this variable (OVD).

CENSUS. A survey of all members of a subject population (SVY).

CENTRAL TENDENCY. The most likely, or average value of the variable (HIS).

CHECKLIST. Used in design or analysis where items are marked or otherwise noted item by item (SDM).

CLASS INTERVAL. A uniform division of the variable range (HIS).

CLOSED QUESTIONS. Questions which require the respondent to limit responses to prespecified categories (QTN).

CLUSTER SAMPLE. The process of randomly selecting several clusters of subgroups from the total population and surveying all members of the selected subgroups (SVY).

CLUSTERED DATA. Used to aggregate the data into fewer points for analysis and plotting (HIS).

COMPONENTS. An entity in a system which may be elemental, or it may be a subsystem having distinct components (SDM, TRD).

CONDITION ENTRIES. The conditions of each factor (or question) listed in the condition stub (DTB).

CONDITION STUB. That portion of a decision table which lists the factors to be considered when making decisions in a given situation. Each factor is written in the form of a question (DTB).

CONTINGENCY. A particular combination of factors that describes a future environment (CGA).

CONTINUOUS MODEL. A model which treats variables that change continuously over time (CSM).

CONTINUOUS VARIABLE. Takes on an infinite number of values over some range of possible values (HIS).

CONTROL DIMENSION. Evaluates and regulates any element's specification. This dimension measures each element as the system operates, compares the measure to what is designed or desired, and takes action if the difference is greater than desired (SDM).

CORRELATION. An observed relationship between two or more variables in which the changes in one variable may be associated with predictable changes in another; the relationship, however, is not necessarily cause-effect (OVD).

CORRELATIVE BEHAVIOR. An assumed relationship between two or more variables in which the changes in one variable may be associated with predictable changes in the others (RGF).

CRITICAL ACTIVITY. An activity which, if not completed on time, will delay the entire project (CPM).

CRITICAL PATH. The sequence of critical activities from project start to project finish that determine the shortest project duration (CPM).

CROSS-INTERACTION MATRIX. A representation of relationships between dissimilar sets of variables (IMD).

DECISION RULES. The action entries of a decision table which link a particular combination of condition entries to specified actions (DTB).

DECISION SYMBOL. Represents a step in a process where there is a choice among two or more alternative actions (FLW).

DEPENDENT VARIABLE. The variable being forecast (RGF).

DESCRIPTIVE MODEL. A representation or imaginary entity containing information in a predefined form, intended to be interpreted by its user rules (SDM).

DETERMINISTIC MEASUREMENT. Where the realization of the objective is unequivocally determined from numerical data (OBT).

DIMENSION. Collections of attributes of the system, where each collection represents a major aspect of the system (SCN).

DIRECT ANALOGY. Compares the problem being faced to a parallel situation in another field, technology, or discipline (SCN).

DIRECT ANALOGY METHOD. Used in Synectics sessions when members compare the problem being faced to a parallel situation in another field, technology, or discipline (SYN).

DIRECT EFFECT. An interaction between two variables so that a change in one results in a similar change in the other (OVD).

DIRECT MARKET VALUES. Measures of project costs or benefits which are assessed from equivalent market prices (IPX).

DIRECTED LINE. Links two symbols together with an arrowhead indicating the sequence (FLW).

DIRECTED RELATIONSHIP. Specifies that the existence of the relationship is dependent on the order in which the two elements are considered (IMD).

DISCOUNT FACTOR. A fraction between 0 and 1 which gives the present worth of one monetary unit spent or received (DIS).

DISCOUNT RATE. A percentage rate (usually annual) which equates the present and the future worth of a payment (DIS).

DISCOUNTED CASH FLOW. A single value which represents the present worth of the net incremental benefits estimated for each project year (NPW).

DISCRETE STOCHASTIC MODEL. A model which describes the changes in variables at definite points in time (CSM).

DISCRETE VARIABLE. A variable with only a finite number of values which are multiples of a basic unit (HIS).

DRIVING FORCE. An attribute of a system which causes changes in the system state over time (SCN).

DUNNING. The process for recontacting participants who have failed to return their questionnaires (DLP).

DURATION. The estimated time needed to perform the activity (CPM).

DYNAMIC BEHAVIOR. A consequence of delayed interactions among system variables. The dynamic state of a system depends on the prior values of state variables (OBT, RTS).

EARLIEST FINISH (EF). The sum of an activity's earliest start time and its duration (CPM).

EARLIEST START (ES). The earliest time (measured from the start of the project) when an activity may begin, assuming all immediate predecessors are completed (CPM).

ECONOMIC ANALYSIS. Analysis from the viewpoint of the national government and the economy (CFA).

EFFECTIVENESS. The degree to which the project or system design objectives are achieved (CEA).

ELEMENT. Part of a problem situation which can be described by all its elements (MPA).

ELSE RULE. A column in a decision table which applies when no other decision rules may be added to cover the case or where no combination of conditions applies (DTB).

ENVIRONMENT. The set of all factors which are salient to the understanding of systems relationships, but which are outside the influence of the system variables (OBT, SDM).

EVENT. A future outcome, the occurrence of which is uncertain (SPA).

EXTERNAL CONTEXT. Represents the constraints on the base system (SCN).

FANTASY ANALOGY. The participant's wishful thinking that the problem may solve itself or cease to exist (SYN).

FEEDBACK STRUCTURE. The set of relationships describing a system that involves one or more interlocking causal loops (OVD).

FINANCIAL ANALYSIS. Analysis from the viewpoint of the individual, group, or business which will directly gain or lose because of the project (CFA).

FREQUENCY DISTRIBUTION. Plots the frequency of different categories of response (QTN).

FUNCTION. The primary concern of the system. It is the fundamental dimension of purpose (FEX, IDL, SDM).

FUNCTION HIERARCHY. An ordering of system functions from the most specific to the broadest (FEX).

FUNDAMENTAL DIMENSION. The basic characteristic of the eight system elements (SDM).

GOAL. A value judgment which satisfies one or more needs (FEX, LGF, SCN).

GOVERNING RULES. Describe the relationship between decisions made by the participants in a game and the resulting changes in the simulated environment (GAM).

HIERARCHY. An ordered structure illustrating which factors are subordinate to others (TRD).

HUMAN AGENTS. The personnel who may be necessary for the system to achieve its function, yet are not themselves inputs or outputs of the system (SDM).

IDEAL SYSTEM. A system that achieves the function in the best possible manner as judged by the criteria for evaluating the system. Such systems typically require the least possible cost, the least amount of human resources, and the least time while providing maximum benefits (IDL).

IMMEDIATE PREDECESSOR. Any activity which immediately precedes an activity and which must be completed before the activity can start (CPM).

IMMEDIATE SUCCESSOR. Any activity which immediately follows an activity and which may not start until completion of the activity (CPM).

IMPORTANT ASSUMPTIONS. The factors which affect the success of a project and which are beyond the influence of the decision maker (LGF).

INCREMENTAL COSTS AND BENEFITS. Computed by subtracting the "without project" values from the "with project" values (CFA).

INDEPENDENT VARIABLE. The non-random variable which is used for forecasting other variables using regression (RGF).

INFLUENCE RELATIONSHIP. When one variable's change in value influences change in another variable (TRD).

INFLUENCE TREE. A tree that diagrams the variables which influence other variables which are higher in the tree (TRD).

INFORMATION CATALYSTS. The communication (written or verbal) and the knowledge which enable the system process to occur, yet which are not inputs or outputs of the system (SDM).

INPUTS. The people, information, and/or physical items which enter the system to be transformed by a sequence into outputs of the system (LGF, SDM).

INTERACTING GROUP. A process that permits discussion among participants (NGT).

INTERFACE DIMENSION. The relation to other systems or elements—a linking entry to related system definition matrices (SDM).

INTERMEDIATE IMAGE. An intermediate image describes the state of the system after a time interval *n* (SCN).

INTERNAL ECONOMIC RETURN. The rate of return derived from an economic analysis of the benefits and costs to the society or economy of the country (IRR).

INTERNAL FINANCIAL RETURN. The rate of return derived from a financial analysis of the project cash flow (IRR).

INTERVAL SCALES. Scales that reflect not only the rank of one factor over another, but the degree to which one exceeds the other. The difference between them corresponds to a length of scale interval (RTS).

INTERVIEW SCHEDULE. The plan for conducting an interview. It includes the questions to be asked (IVW).

INVERTED EFFECT. An interaction between two variables so that a change in one results in an opposite change in the other (OVD).

IRREVERSIBLE VARIABLE INTERACTION. When the variable only increases or only decreases (OVD).

LATEST FINISH (LF). The latest time (measured from the start of the project) when an activity may be completed without delaying any immediate successor(s), thereby delaying completion of the project (CPM).

LATEST START (LS). An activity's latest finish time minus its duration (CPM).

LIMITED ENTRY. A type of decision table which permits only a limited set of condition and action entries in the decision rule columns (DTB).

LINEARLY LINKED MATRICES. Matrices with a common set of rows or columns (IMD).

LOGIC ELEMENT. A symbol indicating the nature of the relationship between two or more objectives at adjacent levels in a hierarchy (INS).

LOGICAL INCONSISTENCIES. When hypothesized relationships among variables are inconsistent (OVD).

LOGICAL MEASUREMENT. Determines whether a binary-event objective has or has not occurred (OBT).

MATRIX. A mathematical and graphical representation in two dimensions (IMD).

MATRIX ENTRY. The symbol used to indicate the existence or absence of a relationship between the element in the row and the element in the column (which together define the entry) (IMD).

MEAN. The average value or central tendency of the data (HIS).

MEANS OF VERIFICATION. The specific mechanisms by which quantitative indications of the accomplishment of a project may be observed (LGF).

MEANS-ENDS ANALYSIS. The identification of alternative actions to achieve specified ends (OBT, TRD).

MEASURING INSTRUMENT. A technique for eliciting and measuring responses from a subject (OCA, SVY).

MEDIAN. The value corresponding to the midpoint of the data points (HIS).

MILESTONE. A point in time (specific date) which marks the completion of a sequence of activities or the beginning date for subsequent activities (CPM).

MIXED ENTRY. A type of decision table which permits extended entries such as a range of values for a question in the condition stub (DTB).

MODE. The value or class interval which occurs most frequently (HIS).

MODEL. A representation of an imaginary entity that contains information in a certain predefined form and has specified rules for interpretation (TRD).

MULTIPLIER EFFECT. Occurs when a project impact on one aspect of an economic system generates a stimulating effect on other aspects (IPX).

MULTI-STAGE SAMPLING. Draws random samples in stages (SVY).

MUTUALLY-CAUSAL VARIABLES. Variables that occur when a change in one variable causes a change in another which is fed back to affect the first (OVD).

MUTUALLY-EXCLUSIVE PROJECTS. Incompatible alternatives where implementing one precludes implementing the others (NPW).

NOMINAL GROUP. A group process in which the members work independently but in each other's presence (NGT).

NOMINAL SCALES. Scales that categorize different factors (RTS).

OBJECTIVE. A specific statement of purpose expressing a desired end (INS, OBT).

OBJECTIVELY VERIFIABLE INDICATORS. Indicators that demonstrate that certain desired results are being accomplished (LGF).

OPEN QUESTIONS. Questions which permit the respondent to answer as he or she chooses (QTN).

OPPORTUNITY COST. The cost of committing resources to a particular use as measured by the highest return that could have been obtained by committing the same resources to an alternative use (DIS).

OR LOGIC ELEMENT. Links objectives where the attainment of any one or a combination of sub-objectives will achieve the higher level objective (INS).

ORDINAL SCALES. Scales used to rank-order a set of similar objects along a criterion dimension which reflects a basis for comparison, but not the degree of difference (RTS).

ORGANIZATIONAL ATTRIBUTES. The elements or components of an organizational system and the interrelationships among them (OCA).

ORGANIZATIONAL CLIMATE. The relatively enduring quality of the internal environment of an organization that (a) is experienced by its members, (b) influences their behavior, and (c) can be described in terms of the values of a particular set of characteristics (OCA).

ORTHOGONALLY LINKED MATRICES. Matrices with the same set of elements in the rows of one matrix and the columns of the other matrix (IMD).

OUTPUT. The desired and the undesired results of the transformation process of a system (FEX, LGF, SDM).

OWNER. An organization or person who possesses intent for, or has a vested interest in, a project (INS).

PARAMETER. A quantity with only one value over the entire range of the system behavior being simulated (CSM).

PARTICIPANT OBSERVATION. The gathering of information about and impressions of a selected group by direct interaction over an extended period of time (SVY).

PAYOFF VALUES. Represent the gain resulting from the occurrence of a particular action-event path (DTR).

PERIOD. The time interval between successive observations of the underlying process (EXF).

PERSONAL ANALOGY METHOD. Used in Synectics sessions where a group member identifies with an element of the problem and looks at it as though he were that element (SYN).

PHYSICAL CATALYSTS. The equipment, facilities, etc. which are necessary for the inputs to be transformed into outputs, but which are not themselves inputs or outputs of the system (SDM).

POLICY. Long-range decisions which influence a large number of diversified groups with different values. Policy made at one level of an institution forms the guiding criteria for shorter-range decisions at a lower level (INS).

PREDECESSOR ACTIVITY. An activity that must be completed before another activity can start (CPM).

PRESENT WORTH. The value today of a future payment (DIS).

PROBABILISTIC MEASUREMENT. Occurs when the attainment of the objective may not be determined with certainty (OBT).

PROBABILITY DENSITY FUNCTION. Represents the probability distribution of a set of continuous events (SPA).

PROBABILITY DISTRIBUTION. Associates each event in the set with its probability of occurrence (SPA).

PROBLEM ENVIRONMENT. The set of variables and relationships which are germaine to the decision process under study (GAM).

PROCESS SYMBOL. Represents an action which takes place over time (FLW).

PRODUCER-PRODUCT RELATIONSHIP. When one variable is a product of the other (TRD).

PROGRAM CATEGORY. A system category under which specific projects, or program subcategories, are developed (PPB).

PROGRAM ELEMENTS. The resources or inputs needed to carry on a project (PPB).

PROGRAM SUB-CATEGORY. Refers to the specific projects considered under a program category (PPB).

PROJECT EFFICIENCY. The ratio of project outputs to inputs (BCR, CEA).

PURPOSE. A project's primary intention or aim (LGF).

QUALITATIVE OBJECTIVE. Objectives that are judged subjectively to determine if they have been accomplished (OBT).

QUANTITATIVE OBJECTIVE. An objective that represents a quantifiably verifiable end or result (OBT).

RANK-ORDERING. The process of weighing one item against others and then ordering the items by weight on a scale such as importance or priority (BCR, NGT, NPW, PPM).

RATE DIMENSION. The performance measure for a system element (SDM).

RATIO METHOD. Estimates probabilities for a set of events by first obtaining the relative chance of pairs of events for all possible pairs (SPA).

RATIO SCALE. An interval scale for which the dimension of comparison has a natural zero point (RTS).

REDUCED MATRIX. A matrix formed by omitting one or more rows or columns from the original matrix (IMD).

REFLEXIVE RELATIONSHIP. Occurs when the variable interacts with itself (IMD).

REGRESSED VARIABLE. A variable is regressed on another when the former is dependent on the latter (RGF).

REGRESSION COEFFICIENT. The coefficient of the independent variable in a regression equation (RGF).

REGULARITY. The most frequent or dominant (and occasionally the most important) condition of concern to the project design (IDL, FEX).

RELATIVE CHANCE. Reflects whether one event will occur rather than another (SPA).

RELEVANCE TREE. A tree that diagrams the relationships among different sets of factors at each level of a hierarchy (TRD).

ROUND-ROBIN. A process for serially recording ideas where each participant provides an idea in turn. No discussion occurs, although the leader may ask for a show of hands on how many participants had a similar idea. Those responding then eliminate that idea from their respective lists. The process may continue in a circular fashion until all participants' lists are exhausted (NGT).

SAMPLE. A subset selected from a subject population, the attributes of which are assumed to hold true for the total population (SVY).

SAMPLE STATISTIC. A quantitative parameter which characterizes some aspect of the population from which a set of data are drawn (HIS).

SCORING. Used in games as feedback to the participants to reflect the effectiveness of their decisions (GAM).

SECTOR. The larger system of which a project is part (LGF).

SELF-INTERACTION MATRIX. A representation of relationships within a single set of variables (IMD).

SEQUENCE. The process by which the inputs are worked on, transformed, or processed into outputs, usually with the aid of catalysts (SDM).

SET. A collection of elements having some common property (IMD).

SET OF CONTINUOUS EVENTS. Consists of an infinite number of events (SPA).

SET OF DISCRETE EVENTS. Consists of a finite number of mutually-exclusive events (SPA).

SHADOW PRICES. Adjusted market prices which reflect the true benefit or cost to the economy (CFA).

SIMPLE RANDOM SAMPLE. A sample made so that every member of the target population has an equal probability of selection (SVY).

SLACK. The amount of leeway allowed in either starting or completing an activity (CPM).

SMOOTHED VALUE. An estimate of the average value of the variable being forecast (EXF).

SMOOTHING CONSTANT. A fraction between 0 and 1 that indicates the degree of confidence placed on the most recent datum (EXF).

SOLUTION COMPONENT. The part of a program that is proposed as the solution (PPM).

STANDARD DEVIATION. The measure of the dispersion of the data values about the mean (HIS).

STATE DIMENSION. A specification of anticipated changes and plans in specific time horizons for each of the four dimensions (SDM).

STATE SCENARIO. Describes conditions and events (the state of the system and the external context) at a single future point in time (SCN).

STATE SYMBOL. Represents a tangible product, requirement, or specific condition associated with a process sequence (FLW).

STOPPING RULE. A rule that determines when any branch of the tree diagram should end (TRD).

STRATEFIED SAMPLE. A sample that selects a proportional sample at random from each of the groups in a stratification of the total population (SVY).

SUBJECT POPULATION. The set of all events or entities which possesses certain specified characteristics (SVY).

SUBJECTIVE PROBABILITY. A quantified judgment of the chance of an event occurring (SPA).

SYMBOLIC ANALOGY METHOD. Describes the problem by objective and impersonal titles. These titles are used to identify other problems which may be described by the same title. They are generally expressed in two words, usually describing two conflicting attributes of the problem (SYN).

SYMMETRICAL RELATIONSHIP. Occurs when the relationship between two elements is non-directed (IMD).

SYSTEM. A collection of components which interact to achieve a common function (CEA, CSM, FEX, IDL, SCN, SDM, TRD).

TARGET GROUP. A set of persons with certain common characteristics (DLP, OCA).

THRESHOLD EFFECT. When one variable does not change until the other variable changes significantly (OVD).

TIME PREFERENCE. The general preference of individuals for present over future receipts and for future over present expenditures (DIS).

TOTAL CASH FLOW. The sum of all annual cash flows for the life of the project; an undiscounted measure of the aggregate change expected from implementing a project (CFA).

TRANSIENT SCENARIO. Forecasts changes in and the alternative actions on a system at various stages in the evolution of the system (SCN).

TRANSITIVE RELATIONSHIP. Requires that a directed relationship among three or more elements be consistent (IMD).

TREE GRAPH. A set of linked elements where only one exists between any two factors (OBT, TRD).

TUNING. The process of making changes in the parameters and initial values for variables in order to minimize the errors between expected and actual simulation output or between observed or simulated data (CSM).

UTILITY. A quantitative expression of the worth or satisfaction associated with an outcome (DTR, MCU).

UTILITY FUNCTION. Associates the possible levels a criterion may take with the utilities for those levels (MCU).

UTILITY MATRIX. Presents the elements of a decision under certainty (MCU).

VALIDATION. Testing whether a computer simulation program simulates the observed system behavior. It is a process of simulating the past and checking the simulated data against actual data (CSM).

VARIABLE. A factor used to describe a system which may change value as a function of time (CSM, OVD).

VERIFICATION. Testing a computer simulation program to see that the program functions as intended. It is a process of eliminating logical errors in the program (CSM).

XOR LOGIC ELEMENT. Links mutually exclusive sub-objectives to the higher level objective(s). The achievement of one sub-objective alone achieves the higher level objective (INS).

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