

# On the Human Aspects in Structural Modeling

GEORGE G. LENDARIS

## ABSTRACT

This article deals with two facets of structural modeling often ignored: a) the several human roles that effective participative modeling must encompass, and b) the group procedures developed to assist modelers in defining the elements of the system to be modeled. The roles are 1) the method technician, 2) the facilitator, and 3) the participant. Their recognition on the part of the technology assessment leader is vital to the successful conduct of participative modeling. The element-generating group procedures surveyed here are organized into two categories: those which emphasize an atmosphere for free-wheeling thinking, and those which emphasize structured guidance (either through use of words or geometric and analytic techniques).

## Introduction

The intent of this article is to illuminate two aspects of structural modeling often misjudged or overlooked entirely: the diverse roles which must be filled in participative structural modeling activities (see *The Three Human Roles*) and the definition or derivation of the "elements" which constitute the starting point of the structural modeling process (see *A Survey of Generating Processes*). The two aspects have in common the centrality of the human actors in contrast to the analytic focus of much of the rest of the structural modeling activities in contexts such as *Technology Assessment (TA)*.

## The Three Human Roles

The basic concepts in this section were formulated by the author some years ago based on a series of experiences involving the development and use of a computerized (pattern-recognition) facility [1, 2]. The ideas have proven very useful ever since; indeed, they have remained among those "obvious" premises the author has never felt the need to question. During a recent study [3], however, it became evident that these ideas are not after all so "obvious" to everyone—quite the contrary. Thus, this portion of the present article is an attempt to alert other (systems) practitioners to a strongly perceived fundamental requirement for successful participative modeling.<sup>1</sup>

The class of tools whose application is the subject of this discussion are those that deal with the stimulation, extraction, and/or representation of ideas/knowledge from the mind of a person or a group of persons. In the case of a group working together, the attendant activities are herein characterized as participative modeling. The structural modeling tools discussed in this issue, in particular, lend themselves to such an approach.

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GEORGE G. LENDARIS is a Professor of Systems Science in the Systems Science Ph.D. Program, Portland State University, Portland, Oregon.

<sup>1</sup>The idea that roles need to be recognized in certain interpersonal activities is not new with this article. Psychologists and social scientists have pointed this out in various contexts (e.g., see [4-8]). Some parallel considerations appear in [9]. The present development differs in the specifics of the role types defined and in the context to which such ideas are applied.

The key assumption underlying the present discussion—and this must be clearly understood—is that some sort of (experience-based) intuitive knowledge or understanding of a given problem context *exists* in the minds of certain individuals. Further, it is assumed that an effort is being made to elicit this knowledge or understanding, and to represent (or “model”) it in a way that is useful to the participants. (The specific representation, of course, is determined by the particular tool or methodology being used.) Generally, the aim of such an activity is to develop a shared understanding of the problem being studied, and to provide a means for further problem-solving activities. An alternative, or parallel, aim might be to communicate the shared understanding to persons outside the immediate group.

In general, the process addressed here is one of problem solving.<sup>2</sup> As is well known, the identification and definition of a “problem” simultaneously establish the context for what is to be done. Further, the environment within which the problem solving is carried out is characterized by a) the objectives to be met, b) the resources available, c) the constraints imposed, and d) the value system(s) selected for judging progress toward the “solution”. At various stages of the problem-solving process, it is presumed that the knowledge and/or skill required to effect the next step resides in certain identifiable people. The tools referenced herein serve as aids in applying this knowledge or skill to the problem being addressed.

The choice of a specific tool for each given use must be made on the basis of informed judgment by the Project Manager.<sup>3</sup> Such an informed choice requires that the Manager become familiar with the various tools available, the kinds of problems for which each is more or less suitable, and the kinds of understanding and/or insights each potentially affords. But quite apart from the choice itself, *once it is made*, attention must then be paid to the *mechanics* of the participative modeling process. The mechanics of this process is the subject of the present article.

In what follows, the term “exercise” or “session” is employed to represent the activities wherein a specific tool is being used by knowledgeable people toward the end of solving the problem at hand. In the conduct of any such session, it appears necessary (to the author) that at least three *roles*, defined as follows, must be represented.

Note: These roles may be filled by a single individual (e.g., a person conducting a session by himself while sitting at a computer terminal); by separate individuals for each role; or by several persons for one or more of the roles. The particular circumstances dictate which is appropriate.

#### ROLE 1: METHOD TECHNICIAN

Basically, this role requires an intimate, in-depth understanding of the chosen tool—an understanding essentially independent of the context of use. Such an understanding includes knowledge of all the basic principles, constraints, and limitations, as well as implications—often quite subtle—inferable from the tool’s output. It is important to know how to proceed *smoothly* during the exercises, e.g., how to handle problems as they arise.

<sup>2</sup> Using the terminology of [3], the participative modeling exercises discussed herein would occur within the context of solving “component problems” of the Technology Assessment.

<sup>3</sup> The participative modeling exercises considered here are assumed to be done within the context of larger projects (e.g., Technology Assessments). The person managing the larger project is herein called the Project Manager. At his own discretion, the Project Manager may or may not be directly involved in the participative modeling exercises. However, it is assumed that he selects the persons who will conduct or participate in them.

Care must be taken that the participants are not alienated or overwhelmed by the tool or by a lack of understanding of the tool's technical details. Also, the output must not be allowed to dominate, distort, or dictate the context of the problem solution. Finally, the tool should be kept in the background, in keeping with its function of *aiding* the process.

#### ROLE 2: FACILITATOR

The degree of success of a session is highly dependent upon the performance of this role. The Facilitator must be:

1. Knowledgeable in group dynamics and knowledgeable in individual and group creativity processes and the various means of stimulating them. Further, he/she must have whatever it takes—let us call it “charisma”—to guide a group of people through a creative process of the kind envisioned in these methods.
2. Knowledgeable enough about the problem area under consideration to be able to *guide* the Participants successfully in developing understanding, insights, and communication vehicles.
3. Knowledgeable enough about the tool to establish an effective communication channel between the Participants and the Technician. The Facilitator is no mere messenger of information here. Rather, he or she assumes a synthesizing or catalyzing function.

There is an important behavioral process going on, and it is the Facilitator's task to orchestrate it so that it leads to a successful conclusion, however defined.

#### ROLE 3: PARTICIPANTS

The problem-oriented knowledge or information underlying the very exercise resides, of course, in the Participants. The performers of this role are the beneficiaries of the session; it is their desire to share perspectives and learn from one another that gives rise to the entire effort. As the very name “participative modeling” suggests, an important expectation to be held open for the Participants is that by *participating*, i.e., cross-fertilizing, synthesizing, communicating ideas among themselves, they stand to gain a broader, more insightful understanding of the problem at hand. A parallel objective for the Participants is the development of a vehicle for communicating their shared understanding to others.

Selection (say, by the Project Manager) of the persons to fill this role must take into account the need for a “sufficient” data base relative to the problem under consideration. A question that may always cast its shadow over such sessions is, “Do the Participants really have sufficient data or knowledge to deal with the problem?” In some cases it does not matter, since learning is the prime objective. But in other cases it may be critical; in these cases, it should be clear that there are no guarantees that the synthetic collective perception is necessarily “correct.”

#### (POSSIBLE) ROLE 4: OBSERVER

The preceding three roles are considered by the author to be necessary for each session. A fourth role, that of Observer, though not necessary, might be useful for certain circumstances. Examples of such circumstances include the following.

1. The Project Manager wants to convene outside experts to work on a problem in a format consistent with the current discussion. He has a keen interest in the proceedings, but does not want to participate in any of the three roles defined above. Accordingly, he constitutes an interested Observer. (In general, any client vis-a-vis the larger project would be a candidate for the Observer role.)
2. There are too many Participants to run a session effectively. They are divided into smaller groups with each group preparing "positions." Each group then selects one or more representatives to serve as Role 3 Participants. In this instance, the rest become Observers, i.e., assume Role 4.

In considering the three (necessary) roles together, the Facilitator role may be seen to provide a sort of meta-level communication function (in the sense defined in [11]) between Role 1 and Role 3. The term *meta-level* is used here to suggest that the Facilitator may not be functioning *in* the realm of the *content*, per se, either of the tool being used (the domain of the Technician) or of the problem being solved (the domain of the Participants). Rather, the Facilitator is operating at a level which is concerned *about* each of the content areas and with *relations between* the content areas, for the purpose of guiding each of the participants to communicate within their respective domains, and further, to provide them with information concerning the opposite role's content, as needed, to effect the modeling process. Clearly, to provide this meta-level communication, the Facilitator needs to have a certain "sufficient" amount of familiarity about the content material of both Role 1 and Role 3.

A graphic representation of the relationships among the three necessary roles is given in Figure 1.

The model shown in Figure 1 may be modified in various ways to give insight into other aspects of the process—with respect, say, to the circumstances of a specific session. Two such possibilities are given in Figures 2 and 3. Please note, however, that although the same graphic symbols are being incorporated in Figures 1, 2, and 3, they should each be viewed from a different perspective.

Figure 1 deals with the Roles per se, and is meant specifically to show that Role 2 requires understanding of certain aspects of the content material of both Roles 1 and 3.

Figure 2 deals with the capabilities residing in some person A.

Figure 3 deals with the Role 3 participants' awareness of the tool being used.

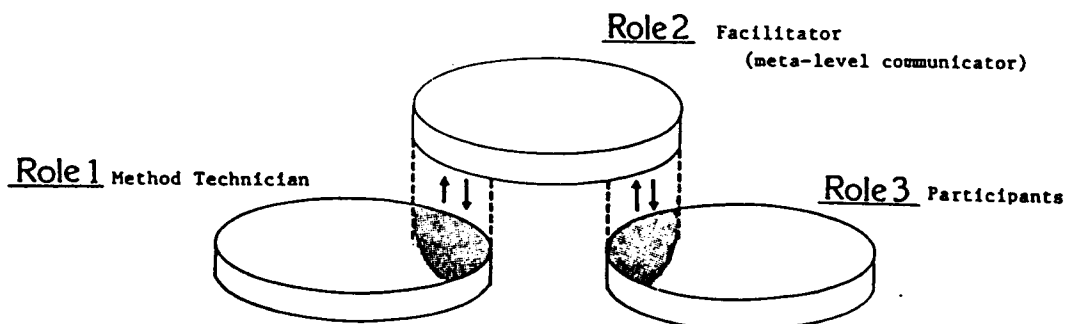


Fig. 1. Representation of the relationship among three necessary human roles for participative modeling sessions. Shaded areas in Role 1 and Role 3 serve to indicate the requirement for Facilitator to know something about the Role 1 and Role 3 content material—sufficient to effect the desired meta-level communication.

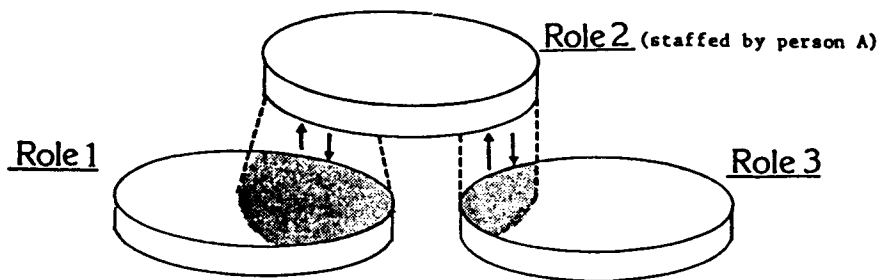


Fig. 2. Example wherein a person staffing Role 2 has a large understanding of Role 1 content material. Accordingly, this person is in a good position to staff both Role 1 and Role 2 if circumstances warrant.

The modified representation shown in Figure 2 suggests that person A could fill both Roles 1 and 2 (since person A is aware of a large portion of the Role 1 content material). A caveat is in order, however: In cases where there are numerous Participants (Role 3), it is advisable to have Roles 1 and 2 staffed by different individuals, so that the Role 2 function can be given the attention it warrants. For example, if the tool being used requires a computer terminal, a single individual could have difficulty trying to run the terminal and keep a group process going at the same time.

The other modified representation, shown in Figure 3, suggests that the Participants perceive themselves at a considerable "distance" from the methodology being used. This kind of situation would probably require even greater skill from the Facilitator than would a situation wherein the Participants are better versed in the methodology.

#### COMMENTS

It is important for the Project Manager to be explicitly aware of the three roles that must be staffed for each such exercise in the problem-solving process. Anecdotal experience confirms that modeling sessions of the kinds in question do not always prove successful. Analyzed in the context of the present discussion, such a lack of success invites speculation that the distinct roles were not recognized as such, and were not staffed properly. The more usual shortcoming relates to Role 2: The Facilitator. *The Facilitator role is extremely important.*

In many problem contexts, to repeat, a number of persons are involved in Role 3, so generally it will be preferable to plan on having one or more individuals involved in each

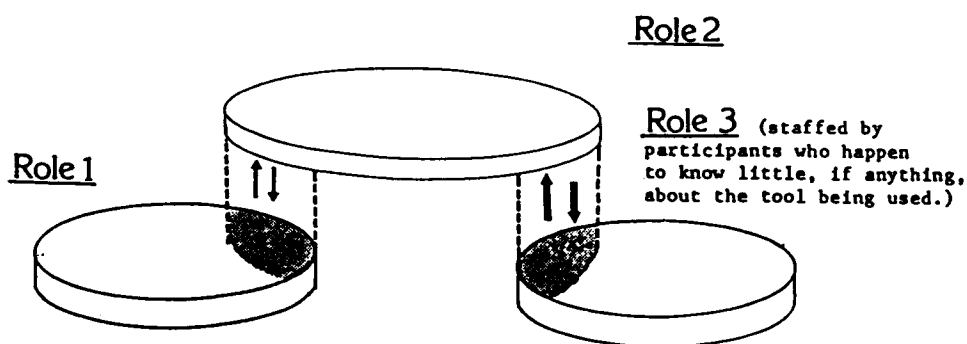


Fig. 3. Example wherein the persons staffing Role 3 have only a limited awareness of the tool being used. The "elongated" Role 2 is intended to indicate that the Facilitator needs to serve an even greater "bridging" function than would otherwise be necessary.

of Roles 1 and 2. Further, the Participants' willingness to share their various perspectives and to learn cannot always be taken for granted; individual participants may hold vested (perhaps even competitive) interests in the problem-solving outcome. The Facilitator will have to develop expertise to work in such situations, and to draw out the information pertinent to the problem being addressed.

Historically, tools of the type considered here were generally developed in an environment where there was a problem, or a specific class of problems, to be solved by the developers. Consequently, as the tool to accomplish this task developed, the same people were involved as developers of the tool and as Role 3 Participants. This overlap minimized the requirement for an explicit Facilitator (Role 2). However, as the tools became more and more developed and generalized—and hence more context free—the developers became removed from the knowledge base required of Role 3, so other persons were required to fill Role 3. The more successful uses of the various tools have been cases where one of the developers or one of the developers' "disciples" was running the session (i.e., competent Role 1), and fortuitously proved to be a good Facilitator. Not all tool developers are good Facilitators! On the other hand, there is also evidence that, even with a good Facilitator, the Participants tend to get impatient and/or disillusioned when Role 1 is not staffed competently, and the process breaks down. A clear lesson to be learned—and shared—is that, as a minimum, each role must be competently staffed for such exercises to accomplish objectives of the type outlined at the beginning of this section.

### **A Survey of Generating Processes**

In the course of the structural modeling study discussed elsewhere in this issue [3], the need to deal separately with the definition of the elements to be structured became evident. This survey constitutes an effort to bring to the attention of the analyst an array of element *generating procedures* which might prove useful in a frequently frustrating task.

In virtually any problem-solving context, and certainly those encountered in the technology assessment area, the definition of the problem and the way in which the problem is posed play a significant role in determining the "solution" to be generated. Common to most problem-solving approaches is to first build some kind of model (in the broadest meaning of this term) to represent in an organized way what is known about the situation. There is a very large literature on the model-building process; it is not our intent to present a review of that material here.

In building a model to represent a given technology context, we recognize that the model will never be "complete," i.e., there is always approximation and/or subjective bias involved. This comes about by the way certain variables and/or interactions are represented or by the fact that certain variables/interactions are left out (intentionally or by oversight). In judging the usefulness of a model, one crucial issue is whether the important variables and the important relationships among them are represented. *There is no constructive method for arriving at a list of even the "important" variables/interactions which can be guaranteed to be complete.* One can come close in those situations where a theory exists to describe the situation being considered, and the theory directs the investigation in an orderly manner. Alternatively, in certain cases where many similar situations have been done previously, a checklist of items may have been developed to guide the investigators. *Beyond this, one must depend on human creativity and intuition to provide judgment, ideas, and information.*

This begs the question: how do we best put human creativity and intuition to work on such problems? There are no definite answers to this question. However, there do exist methods or techniques that have been developed with the specific purpose of stimulating groups (and/or individuals) to improve what we might call creative functioning. A convenient label for this class of techniques is the term "creativity enhancement methods." In the present context, these methods stimulate groups in their *generation* of ideas, information, "elements," etc., during various aspects of the problem-solving process—thus we use the term "generating tools."<sup>4</sup>

For the purpose of this discussion, the types of tasks to be performed by the group will generally be related to:

1. "Problem" formulation, definition, and/or clarification, including a clear, definitive description of the *context* within which the problem is to be embedded (as this will provide the reference frame for all further work to be carried out); and/or
2. Generating a list of "elements" (variables) to represent the problem in the given context (clearly, this is intimately related to 1).

The size of projects normally encountered requires that teams of people be utilized in the design/solution process. There are times when the team must give concentrated attention to a specific problem as a group, and it will be useful for the leader (or designated Facilitator) to utilize one or more of the generating tools to guide the group in its task.

There will be occasions, especially at the beginning of the project while the whole context is being defined, when input or participation by outside groups will be sought. These situations can make particularly good use of the generating tools, because the group(s) will usually be available only a short time and it is desired to maximize the use of their time. The particular generating tool used will, of course, depend upon what specific function the group is to perform, and the type and/or background of the group itself. Project Manager will have to carefully select the Facilitator who will go out and interact with each outside group and select the generating tool(s) that is (are) most appropriate.

#### ORGANIZATION OF THE GENERATING TOOLS

In studying the methods selected for inclusion in this survey,<sup>5</sup> it was found that they can easily be grouped into two categories:

- I. Those which emphasize an atmosphere for "free-wheeling" thinking; and
- II. Those which emphasize structured guidance for carrying out the design/solution activities.

<sup>4</sup>It is interesting to note that at least two recent publications have incorporated a similar terminology [12, 13]. It is not known whether this is pure coincidence, or whether those authors saw our early reports and agreed with this designation, and therefore used it. In any case, there are at least three authors now using this terminology. Also, a view where this terminology would be fitting is developed in [3].

<sup>5</sup>This survey is by no means comprehensive. For example, the heuristic procedures for directing creative search discussed by Polya, Newell and Simon, and Wicklegren are not included.

**TABLE 1**  
**Emphasis I**

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Provide Atmosphere for "Free-Wheeling" Thinking

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1. Brainstorming
  2. Nominal Group Technique
  3. Brainwriting
  4. Synectics
  5. Generative Graphics
  6. Delphi
  7. Computerized Conferencing
  8. Clinical Interviewing
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**TABLE 2**  
**Emphasis IIA and IIB**

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Structured Guidance

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*Semantic*

1. Attribute Listing
2. Function Analysis
3. Morphological Analysis
4. Scenarios
5. Misfit Variable Concept
6. ISM
7. Checklists  
    Check Matrices
8. Theories

*Geometric*

1. Trees
  2. Networks
  3. GENESA
  4. Systematics
  5. Pattern Analysis/Recognition Methods
- 

The latter category is further subdivided into:

- IIA. Those methods which use words as the vehicle for the structured guidance, and  
IIB. Those methods which use a geometric figure and/or analysis techniques as the vehicle.

A listing of the selected methods is given in Tables 1 and 2, and certain of their interrelationships are shown in Figures 4 and 5. The tables are organized according to the categorization indicated above. After some general comments, a short description of each of the methods is given in the following subsections, in the same order as they appear in the tables.

The intention here is not to give a detailed explanation of each of the methods, but rather to give the reader a feeling for each of them, and a sense of how the selected methods relate to one another. The structure chosen for communicating the latter consists of the three categories (I, IIA, and IIB) cited above, and shown in Tables 1 and 2. References are cited for more detailed information concerning the individual methods.

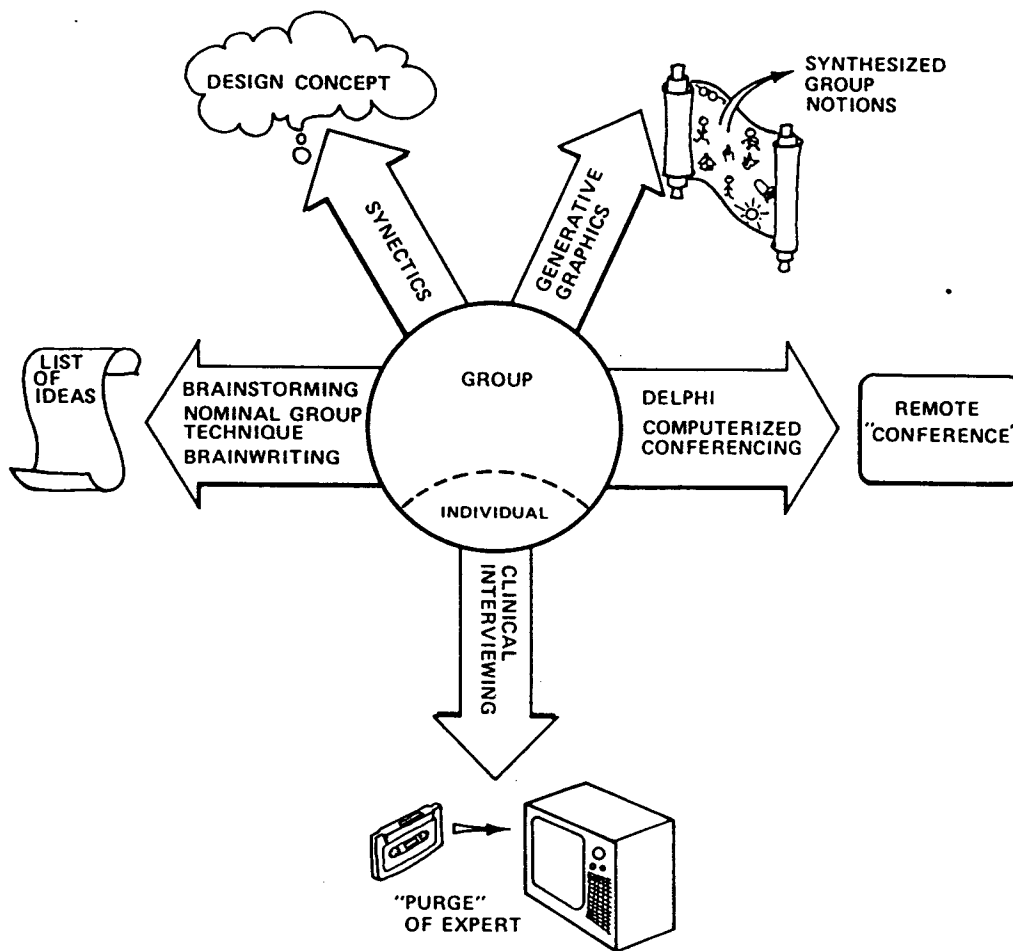


Fig. 4. Schematic overview of category I tools (those which emphasize an atmosphere for "free-wheeling" thinking).

#### GENERAL COMMENTS CONCERNING CATEGORY I TOOLS

The main attribute common to the methods in this category is that of creating a "nonthreatening" environment in which the participants are encouraged to contribute new, untested ideas without the usual fears of criticism and/or censorship. This is accomplished in different ways by the following various methods.

In Brainstorming, a definite operating principle of separating idea evaluation from idea generation is adopted.

In the Nominal Group Technique, and in the closely allied Brainwriting Technique, idea generation is done privately, in writing, in the presence of others; and idea sharing is done in such a way that evaluation is delayed and anonymity is fostered.

In Synectics, the group is trained to work together such that the unusual is expected, and everyone accepts this.

In Generative Graphics, the medium, per se, is nonthreatening; this is assured by expressing early ideas in soft colors and/or tones, and as the ideas become strengthened, more bold colors and tones are utilized.

In Delphi, anonymity and the "comforts of home" are contributing factors.

In Teleconferencing, anonymity (if desired), protection from interruption while making an input, and freedom from the constraint of sequential conversation common to group conferencing are contributing factors.

In Clinical Interviewing, the skill of the interviewer involves setting the interviewee at ease and gently soliciting the desired freewheeling thinking.

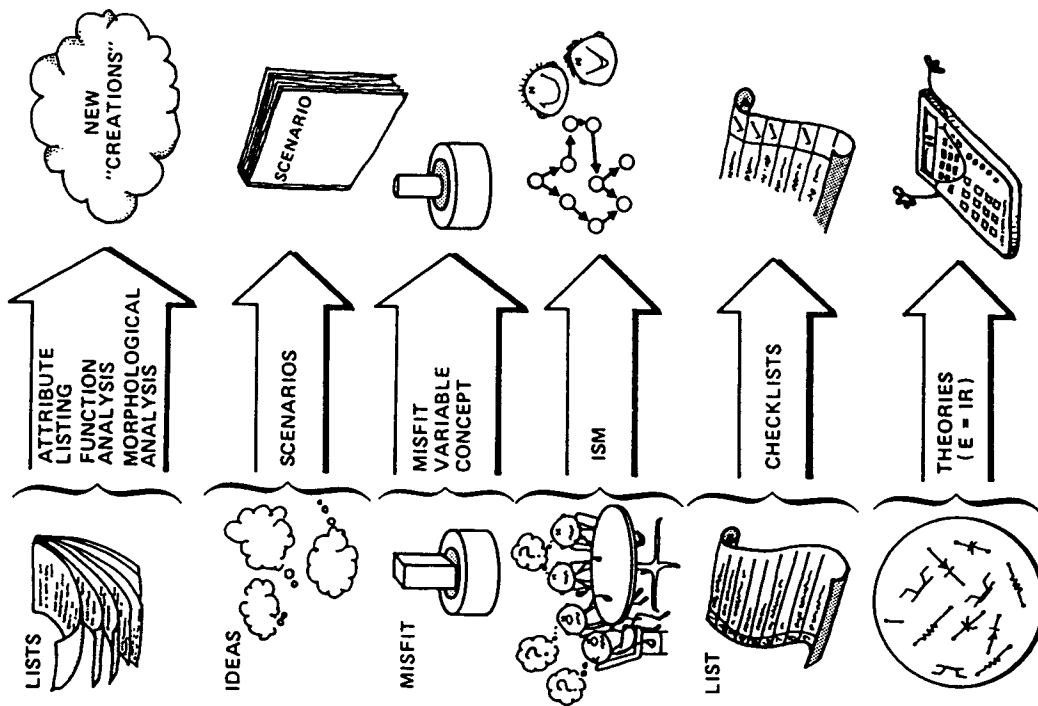


Fig. 5. (A) Schematic overview of Category IIA tools (those which emphasize structured guidance, and use words as the vehicle for this guidance).

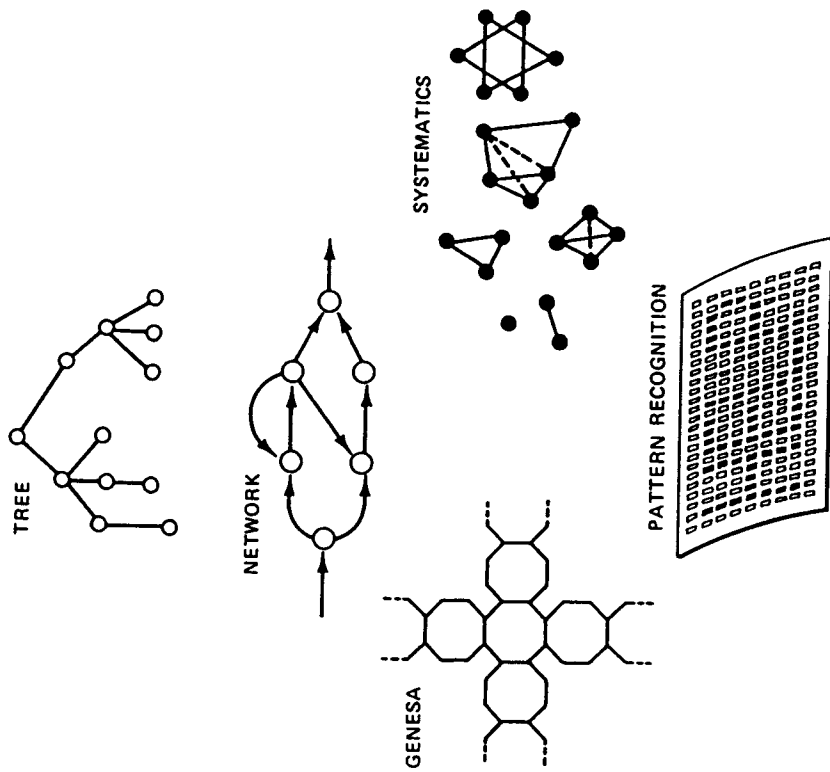


Fig. 5. (B) Schematic overview of Category IIB tools (those which emphasize structured guidance, and use a geometric figure and/or analysis technique as the vehicle).

When using any of the tools to be discussed here (except for Delphi and perhaps Computerized Conferencing), attention must be given to the composition of the group, as well as to the running of the session and the setting in which it is run. It is better if the members of the group know each other before undertaking such a session; if they do not know each other, then a "warm-up" session should be arranged prior to the actual session. The members of the group should be motivated to solve the given problem together. The members should be aware of the tool/method to be used; do not spring it on them cold. The group should be composed of resource experts of heterogeneous disciplines and backgrounds (or, represent different perspectives of the given problem), because cross-fertilization of ideas is what is being sought. It is usually not wise to include people from different levels of the same organization in the same group, unless a clear understanding is negotiated among them prior to the sessions. The number of members in the group should be limited to the now well-known "seven plus or minus two". If more than 10 members are present, then the leader should consider breaking the group into two (or more) subgroups with subsequent merging of their respective outputs. The participants should be given a clear statement of the problem (and the methodology to be used) ahead of time.

The efficacy of any of the methods will be enhanced by the employment of a skillful Facilitator (with perhaps the exception of computerized conferencing). In the terminology introduced earlier, the Facilitator for these methods could usually fill "Role 1" (Method Technician) and "Role 2" (Facilitator) simultaneously.

These tools can be applied to a broad range of problem types. Many of the tools can easily be used in connection with others, in particular those of Category I with those of Category II. The range of possibilities is large and basically is limited only by the imagination and experience of the user.

#### DESCRIPTION OF CATEGORY I TOOLS

The following is a brief description of the methods in Category I.<sup>6</sup>

*Brainstorming* The best known and probably most widely used procedure to stimulate creativity is Brainstorming. Basically, Brainstorming is a procedure for *idea generation*, and has the goal of producing a list of ideas which may *then* be evaluated, and which may *then* serve as a source for creative solutions.

Brainstorming is based on two major premises: 1) deferment of judgment; and 2) quantity breeds quality.<sup>7</sup> These are operationalized by the following rules: a) criticism is ruled out; b) free-wheeling is welcomed; c) quantity is wanted; and d) combination and improvement are sought.

Brainstorming is otherwise a relatively unstructured process. The participants are encouraged to introduce any and all ideas which occur to them relating to the subject at hand; follow-on ideas, or "hitch-hikes" are encouraged. The strength of this technique

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<sup>6</sup>While this manuscript was in preparation, a recent publication [13] came to our attention. This reference has a section entitled "Generating Ideas" which contains a 3- to 4-page formatted discussion of tool numbers 1, 2, 3, and 7 of the present category, and tool number 3 of Category IIA. This reference is recommended to the readers of this article.

<sup>7</sup>Although this premise is assumed for Brainstorming, there is evidence that the premise may not hold as a general principle. See [15] for discussion of this point and citation of appropriate references.

lies in the interacting group process (as in Synectics). Accordingly, the Facilitator plays a significant role in the success of this method.

Relative to the other methods, Brainstorming is more subject to domination by one or two members, with the attendant result of stifling participation of the others. Generally, the more recently developed Nominal Group Technique and the related Brainwriting method are to be preferred to Brainstorming because of the above-mentioned and other behavioral factors. Brainstorming is included here primarily for completeness (because it is so well known) and because there are times when the relatively unstructured format might be preferred. In the author's experience, it has been found useful to adopt the Brainstorming operational rules in the latter part of the Nominal Group Technique process (discussed shortly) to yield what is, in effect, a combined methodology.

As with any other application of tools, the Facilitator should be aware of a number of methods and select the appropriate one, or combination, for the given time and circumstances. (Principal reference sources were [14, 15].)

*Nominal Group Technique (NGT)* NGT is a structured group meeting which proceeds in the following, briefly summarized, manner:

0. A clear problem statement is presented to the group.
1. Initially, participants do not speak to each other. All of their ideas are generated in writing (15 min, typical).
2. After the generation period, and in a round-robin fashion, each participant presents one idea from his (her) list and a recorder writes the idea in a terse phrase on a flip chart in full view of the other members.
3. Round-robin listing continues until all members have exhausted their private lists. There is still no discussion at this point of the meeting.
4. Discussion of each recorded idea then takes place with the purpose of clarification and evaluation.
5. Independent voting then takes place. Each member, privately, and in writing, selects priorities by rank ordering or rating. The group decision is arrived at by mathematically pooling the individual votes.

A very detailed outline of the methodology, including time and cost factors, is presented in the developer's text [18].

Nominal (meaning silent and independent) generation of ideas can be contrasted with interacting-group-type methods in that it minimizes conforming influences and assures that minimal energy will be spent on maintaining social-emotional relationships. It provides for equality of participation and for all members to influence the group decision outcome through voting and ordering of priorities. On the other side of the coin, however, inflexibility of the structured NGT format makes it difficult to make adjustments or changes to topics in the middle of a meeting. NGT is generally limited, therefore, to a single-purpose single-topic meeting.

An in-depth comparison of Interacting Groups, NGT and the Delphi Technique (described later in this section) on several critical dimensions is given in [18] and [19].

*Brainwriting* Brainwriting is a method which is akin to the Nominal Group Technique. In this method, after a clear problem statement is presented to the group, individu-

als write their ideas on a piece of paper, and then, without talking, exchange the pieces of paper with other members. Each participant then adds comments and/or new ideas on the sheet of paper; this is continued until each piece of paper has been processed by each participant.

Two implementations of this method are given in [20]. These are as follows:

#### Method "635"

1. The number of participants is 6.
2. The problem is explained and discussed. No particular leadership qualifications are vital.
3. Each participant writes three relevant ideas on a piece of paper.
4. Each participant gives his or her page to his or her neighbor.
5. The original ideas are developed further on paper by those receiving the other's ideas; or new ideas are added.
6. Every 5 minutes the pages are passed on to the next person.
7. When each person has received the page he or she started with, the session is ended.
8. The pages are collected, and the ideas are evaluated later.
9. The meeting will take about 50-60 minutes.

and,

#### Brainwriting Pool

1. There are 4 to 8 participants.
2. At the beginning, some ideas previously developed are placed in a pool of pages.
3. Each participant starts with a blank sheet and puts his or her ideas on the sheet. When he or she finds that ideas no longer are coming, he or she puts the sheet in the pool and takes another sheet from the pool.
4. After 30 to 40 minutes, the exercise is terminated.
5. Evaluation is done later.

The elimination of talking in these methods allows for simultaneous participation by all the group members. Since papers are exchanged, each participant sees what others are contributing. Both of these attributes serve to minimize the problems associated with unequal verbal participation attendant with most group processes.

*Synectics* Synectics means "the joining together of different and apparently irrelevant elements." The Synectics method is based on the use of metaphors and analogies within a systematic framework to achieve creative results. In this method, the problem as it is initially stated has to be restated and looked at in various ways through the use of metaphors or analogies. During the course of this process the individual goes on what is called an "excursion" and in so doing is often able to attain creative solutions. Just how the different kinds of analogies and metaphors may be used, what the purpose and function of an excursion is, and related matters are all dealt with during Synectics training.

Synectics requires that the group be trained; the training may range from 1 week to 12 months.<sup>8</sup> Therefore in the usual TA problem-solving process, consideration might be

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<sup>8</sup>Training is available from Synectics Education Systems, Inc., and Synectics, Inc., both in Cambridge, Massachusetts 02138.

given to locating an existing Synectics group and presenting the desired subproblem to it for some creative input. In addition, the TA team itself (or some portion of it) might consider undergoing Synectics training, because, once it is so trained, the team may use this skill for attacking many new problems as they arise during the problem-solving process. (Principal reference sources were [21, 22, 15].)

*Generative Graphics* A technique called Generative Graphics has been developed<sup>9</sup> for enhancing group problem-solving efforts. This technique has been used to lead problem-solving sessions for such diverse kinds of groups as psychiatric researchers and city planners. Brunon describes the process as follows.<sup>10</sup>

Generative graphics is a discussion leadership technique characterized by simultaneous drawing and defining of images. It is applied to task-oriented conference settings in the following way: a large sheet of poster paper occupies one wall and holds the attention of the problem-solving group. As the discussion unfolds, the leader paraphrases spatially what is said, drawing with an array of colored, felt-tip markers on the sheet. There may appear sketches of persons or places, lists of phrases, areas of color to designate undefined content and bold titles summarizing conditions. Each isolated image represents a fragment of a message. The total message is represented by the mosaic that grows on the sheet as the session continues. Ultimately, there is the opportunity for a spontaneous grasp of pattern of this total message by the entire group. Information that has been established, the space for needed new information, and the relationships that indicate where decisions are to be made, all become apparent at a glance. With the completion of this mosaic, or graphic image-structure, the problem-solving group has a visible energy investment and sense of achievement which can underlie a new session, and further development of the subject matter.

Brunon distinguishes "reiterative graphics," wherein one has a thought and then creates a graphic to express it, and "generative graphics," wherein one makes graphics for the purpose of generating ideas, via feelings, awareness, etc., expressed in the group. While he has continued to apply Generative Graphics to task-oriented conference situations, Brunon is currently involved in preparing learning packages to enable others to master the technique, and in exploring its compatibility with film or television media. At present, if this technique is to be used, Brunon himself may have to be retained to assist in the process. (In the terminology presented above, he would staff Role 1: "Method Technician.")

This method promises to be very useful in situations where a group of people is assembled to discuss a not-yet well-defined problem area, and whose goal/task is to develop a better *concept* of the problem (or *design*, where appropriate) for guiding future activities.

*Delphi* The Delphi method is well known to the readers of this journal. Suffice it here to say that the Delphi method provides an alternative to assembling a group of experts in a conference. In this method, members of a panel are in remote communication through several rounds of questionnaires transmitted in writing or through a computer terminal. The results of each round are analyzed, integrated, and distributed to the panelists for their use in the next round.

There are several attributes of Delphi that are important to the present discussion. First, it preserves anonymity so that one of the problems of a conference is solved: the

<sup>9</sup>By Joseph Brunon, an architect now working at the Neuropsychiatric Institute at UCLA as a media design specialist.

<sup>10</sup>Private Communication.

dominant personality no longer can impose his ideas on the others. Second, the conference becomes much more structured: there are discrete steps, and changes can be tracked. Third, a large heterogeneous group can participate on an equal basis. Fourth, the panelists may use self-ratings to indicate their expertise on a given question and the responses may then be weighted on the basis of the self-ratings. (Principal reference source was [23].)

*Computerized Conferencing*<sup>11</sup> In its simplest form, computerized conferencing is a system in which a group of people who wish to communicate about a topic may go to computer terminals at their respective locations and engage in a discussion by typing and reading, as opposed to speaking and listening. The computer keeps track of the discussion comments and compiles statistics on each contributor's involvement. In effect, one may view this process as a written version of a conference telephone call. However, the use of the computer provides a number of advantages in the communication process compared to the use of telephones, teletype messages, letters, or face-to-face meetings. The key advantage deals with the fact that since all the individuals are operating asynchronously, more information can be exchanged within the group in a given length of time, as opposed to the verbal process where everyone must listen at the rate one person speaks. Furthermore, because the computer stores the discussion, the participants do not have to be involved concurrently. The discussion may take place over hours, days, weeks, or be continuous. Therefore, an individual can choose a time of convenience to him to go to the terminal, review the new material, and make his comments. The disadvantages that accrue to the computerized communication process vis-a-vis telephones and face-to-face meetings relate primarily to the absence of the nonverbal communication components (e.g., voice inflections, body language, moods, etc.) that are present in telephone and face-to-face communications.

In general, computerized conferencing appears to be a more attractive alternative than other forms of communication when any of the following conditions are met: 1) the group is spread out geographically; 2) a written record is desirable; 3) the individuals are busy and frequent meetings are difficult; 4) topics are complex and require reflection and contemplation from the conferees; 5) insufficient travel opportunity is available; 6) a large group is involved (15 to 50); 7) disagreements exist that require anonymity to promote the discussion (e.g., Delphi discussions) or free exchange of ideas.

It is easy to speculate that there will probably be situations during the execution of at least some of the component problems in a technology assessment wherein a number of the above conditions will hold. Accordingly, for those situations consideration should be given to using a computerized conferencing approach.<sup>12</sup> (Principal reference source was [24].)

*Clinical Interviewing* The clinical interview has its origins in psychiatry, and at this point in time, most experienced interviewers are psychiatrists, although the learning of interview skills is spreading into other areas. The clinical interview can be described as *creative listening*. It is based on the realization that, in "normal conversation," we do not communicate very much valid information. This form of communication (or miscom-

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<sup>11</sup>Other forms of teleconferencing (e.g. telephone and television conferencing) could also be considered in this context. This section borrows heavily from [23]. A more recent and complete reference, however, is [24].

<sup>12</sup> For example, EIES, developed at the New Jersey Institute of Technology under the direction of Murray Turoff.

munication) is exemplified by rationalization, one-upmanship, defensiveness, selective listening, etc. The practitioner of good communications/interviewing/listening skills first learns to omit these kinds of behaviors, usually referred to as "communications blockages," and to develop verbal and nonverbal behaviors that help the other persons to express themselves fully and to be understood at the highest level possible. More specifically, the interviewer learns to use various responses to an interviewee such as:

1. Following verbal leads—involves responding to a statement to encourage more communication about one or more parts of the message.
2. Exploratory questions (asking open-ended questions, or making statements that beg for a response).
3. Focusing selectively on either the content dimension of the message or the feeling dimension, or both.
4. Behavioral descriptions (which avoid labeling or judgment and simply describe what is seen and/or heard).
5. Paraphrasing (stating the gist of the sender's message briefly and vigorously as a test of the accuracy of the message).

The application of the clinical interview would relate primarily to those situations where certain overview information and insights are being sought from an expert, or various experts. The interviewer would be instructed ahead of time to elicit information/insights related to certain specific items appropriate to the context of the problem at hand. Video taping of the interviews is useful for subsequent (re)communication of the information gathered. (Principal reference sources were [25, 26].)

#### DESCRIPTION OF CATEGORY IIA TOOLS (STRUCTURED GUIDANCE—SEMANTIC)

The term "structured," employed in this article to describe the generating tools, is used with slightly different meaning for *each* of various subgroupings of the generating tools. These are as follows:

The methods in the previous section, though they were not labeled as such, may be said to be structured in the sense that the *process* within which the creative work is done proceeds along some set guidelines and/or according to certain principles. For Category IIA, we use the term structured guidance to refer to the fact that the generating methods use certain "devices" to prod or guide the creative thinking, and it is these *devices* that are structured. For tools 1 through 6 of this category, the structured device (primarily lists of various kinds) is developed during the early stages of the process to guide the remainder of it. For tools 7 and 8, the structured entity (checklist, theory, etc.) is available a priori and serves as a guide for carrying out the generation process.

For Category IIB, the term structured takes on a still different meaning: in the case of tools 1 to 4, the "structured" guidance is provided by a geometric form intended to prod the mind of the user to consider aspects of the problem it might otherwise overlook. In the case of item 5, reference is made to methods which attempt to determine a structuring of a geometrically represented measurement space.

*Attribute Listing* In this technique, a list of basic attributes of an item is presented to the group. Such a list, for example, may have been developed via a Brainstorming session. The group's instructions are to make a step-by-step change or modification to each of the attributes on the list, and the group's objective is to use this list of modifications as a basis for devising new and/or "better" products. This is one of the

simpler techniques; however, for appropriate problems, it is very effective. (Principal reference source was [27].)

*Function Analysis* Similar to attribute listing. In this case, attention is given to each of the functions being performed by a given device, or, required by a given application. The question asked is "How can this function be performed differently?" The answers to this question are then used as guides for the group's creative activities.

*Morphological Analysis* Morphological Analysis consists of describing the major variables of a problem and eventually placing them in a multidimensional matrix so that combinations can be examined systematically. Study of the various combinations revealed by the matrix can result in seeing possibilities that were not previously obvious to the observer(s).

The procedure is as follows:

Phase A

Start with a broad and general statement of the problem.

List the essential variables of the problem, also stated broadly.<sup>13</sup>

Develop a matrix using each of the variables as an axis.

Phase B

*Examine* each of the cells thus formed for possible new combinations that could lead to an invention or innovation.

The method is intended to stimulate cooperation between imagination and systematic research with a view to making technological innovations, creating original processes, and discovering new principles. Morphological Analysis is sometimes called "structured search." (Principal reference source was [28].)

*Scenarios* Although the readers of this journal are familiar with scenarios, the following discussion is included for completeness. The dictionary definition of scenario includes words like ". . . sketch of a plot or chief incidents of a play. . . ." In the present context, scenarios may be constructed for any of a variety of reasons, and one among these is to focus attention on and/or to describe the consequences of making certain choices appropriate to the problem context. Another reason is to describe the situation as it exists at present (or at some point in the future) in as many dimensions as is possible within the present (future) state of knowledge. Separate scenarios can be constructed to give alternative perspectives attendant with the same selection of problem variables. An example might be to describe the situation surrounding the alternative actions that a business or nation might take at each step to defend against threats or take advantage of opportunities, and to develop (sub)scenarios from the perspective of alternative major role players.

A key requirement in developing scenarios (for this application, at least) is that internal consistency be maintained. This means that all actions and consequences described and/or implicit in the scenario be consistent with all assumptions being made. One of the major benefits of the scenario (in the present context) accrues during the process of its development. The demand for internal consistency provides a stimulus to the mind(s)

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<sup>13</sup>A number of the tools in Category I would be useful during this step.

of the developer(s) to be as complete as possible in its considerations of the various aspects of the situation.

Some of the other advantages attendant with scenarios as an aid to thinking are [29]:

They force the analyst to deal with details and dynamics that might be overlooked if he/she were restricted to abstract considerations.

They illuminate the interaction of psychological, social, economic, cultural, political, and military forces on the situation.

They call attention to the large range of possibilities that must be considered in analysis of the future.

*Misfit Variable Concept* The misfit variable concept is based on the viewpoint that the process of design, analysis, or problem solving consists of achieving fitness between the form and the context. The "context" defines the problem; the "form" is a solution to the problem. The misfit variable process is thus one of identifying "misfits," and then proceeding to eliminate them [30].

This approach has been suggested for certain large-scale problem-solving contexts by Sharma, of the California Energy Resources Commission. He states [31]:

Although the concept of misfit variable may appear simplistic and perhaps primitive, its use has significant practical, philosophical and perceptive advantages, particularly when dealing with complex issues having "soft" underpinnings. These advantages stem from the fact that in many instances, better insights can be obtained by first identifying misfits (rather than "fits") and then developing strategies to eliminate or neutralize the misfits. For example, assessment studies with significant social or cultural implications can benefit by looking at the means to reduce cultural or social stresses instead of determining the means to satisfy a number of social or cultural requirements. This is so because in most instances the problem is first revealed by the presence of misfits in an ensemble. In addition, the list of requirements to be satisfied can become prohibitively long and perhaps endless.

The misfit notion derives its strength from the fact that ([30, p. 23]) "when we speak of a bad fit, we refer to a single identifiable property of an ensemble, which is immediate in experience. Whenever an instance of misfit occurs in an ensemble, we are able to point specifically at what fails and to describe it." Whereas, to speak of a good fit, "reference must be made to the simultaneous satisfaction of a number of requirements." Although the two are logically the same, the former process is in reality much more straightforward to implement, and thus offers a good operating procedure, at least as a starting point, in attacking complex problems.

The use of misfits, undecidabilities and gaps contributes a different (and fruitful) dimension to the process of generating a list of elements and their relationships in problem-solving (or problem-definition) applications. An interesting related concept recently applied to TA is Synoptic Operations Patterning Analysis (SOPA). It seeks points of mismatch between new technology and social institutions [3, 32]. (Principal reference source was [30].)

*Interpretive Structural Modeling (ISM)* In the context of "generating" versus "structuring" tools, ISM is principally a structuring tool. ISM is included in this list, however, because it may also be incorporated in a generating activity. An ISM session can be carried out using a preliminary set of elements and a variety of relations to attempt to

discover clumpings or characteristics that will lead to a modified set of elements that subsequently serve as input to structuring activities.

Note that the term "structural" in ISM applies to a different part of the process than for the above-described Category IIA tools. In the above cases, a list was derived for each problem context, and the list was used to structure or guide the remainder of the process. In the ISM case, however, it is assumed that a list of elements is available, and that a preliminary structuring of the list of elements is sought for the purpose of giving the participants additional insight for the subsequent parts of the process.

There is a relatively large literature developing on ISM. The principal reference is [33]. Reference [34] is recommended for the potential leader of the ISM process.

As mentioned at the beginning of this section, in contradistinction to the six tools discussed so far, wherein the structured "device" attendant with each tool is developed during the early stages of the process to guide the remainder of it, for the next two tools, the structured entity is available a priori and serves as a guide for carrying out the generation process.

*Checklists* A checklist is simply a listing of items one should take into account when carrying out a specific process. The lists generated in some of the above methods (e.g., attribute listing, morphological analysis, etc.) were, in this sense, checklists. In the present case, however, we refer to those situations wherein a problem type is understood well enough in *advance* that an experienced problem solver makes up a list of items or steps for subsequent problem solvers to follow. This method was first explicated as a procedure for enhancing problem-solving creativity by G. Polya [35]. Initially, Polya presented checklists for use in certain areas of mathematics, but the process has since been generalized to other problem-solving contexts.

One well-known example of a checklist is that used by NASA during their countdown procedures in launching the manned spacecraft.

Closely allied to these (one-dimensional) checklists are *check matrices*. These are simply two-dimensional checklists, put into the form of a matrix. In a certain sense, the morphological box cited earlier is a form of a check matrix (after it is developed). (Principal reference source was [35].)

*Theories* In general, a theory which pertains to a given problem situation can be considered a structured guide for the problem solver. For example, the laws of mechanics and dynamics provide guidance to an investigator when generating the list of elements (variables) necessary to model a given mechanical-dynamical system.

In such engineering-type applications, this notion is obvious because of the many existing theories that are routinely used for that kind of problem solving. In the context of more general TA-type problems, however, this notion might normally not be so obvious—hence inclusion of this item.

#### DESCRIPTION OF CATEGORY IIB TOOLS (STRUCTURED GUIDANCE—GEOMETRIC)

As mentioned at the beginning of the previous section, the term structured here takes on a still different meaning from that used before. In the case of tools 1 to 4 to be described below, the structured guidance is provided by a geometric form which is intended to prod the mind of the user to consider aspects of the problem it might otherwise

overlook. In the case of item 5, Pattern Analysis/Recognition methods, reference is made to methods which attempt to determine a structuring of a geometrically represented measurement space.

*Trees* A tree is an ubiquitous tool, and takes a variety of forms. In its primitive form, a tree is defined by the requirement that there be one and only one path between every pair of vertices. The utility of a tree rests upon its capacity to represent a hierarchy of things by means of levels, and upon the associations that can be made between ideas and specific elements of the tree.

In the tree's use as a generating tool, a level may be defined and certain relations posited for "growing" the tree to its next level. As the tree develops, the user is reminded by the presence of each branch to consider the possibility of "growing" other branches from it to satisfy the relations assigned to each level. The tree is very flexible in that by using different sequences or kinds of relations (e.g., for the entire tree or from level to level), different tree structures emerge—thus giving different "perspectives" for a given problem.

Well-known applications of trees include objective trees, activity trees, decision trees, and relevance trees (e.g., see [36]). The main point here, however is to use the tree *concept* in creative ways to make it useful as a generating tool.

*Networks* As in the case of trees, network concepts are well known and broadly applied. A network differs from a tree in that it does not represent hierarchies, but rather "process-type" interrelationships. In contrast to a tree, a network accommodates multiple paths and paths that loop back onto themselves. A network generally represents a *flow* of some kind, e.g., time, information, material, energy, etc. Well-known examples are block diagrams, PERT networks, transportation flow models, and mission flow charts.

Use of network concepts should prove very useful during the generating phase of large-scale technology assessments, in particular, when developing an understanding of the context and of the interactions of subcomponents of the system under consideration, and especially with reference to the "flows" involved.

*GENESA* GENESA is based upon "thinking in 13 dimensions" [37]. Various forms of geometric models have been built by the developer to facilitate this kind of unified but expanded thinking process. Some of these are paper-and-pencil-type models, but others are in three dimensions, requiring the participant to physically interact with the model to stimulate his/her integrated thinking about the desired subject.

In a radio interview in March 1975, [38], Langham said:

GENESA teaches three things: It teaches you the form—the 13-dimensional structure through which all things can be understood—and it teaches you the flow—the polarities, the positive and negative polarities, and their dynamics. Take this structure and these dynamics, the form and the flow, and apply them to any focus (the third factor) and situation you wish to understand and perceive in greater clarity. Through form, flow and focus you can immediately generate a 13-dimensional crystal through which all relationships, actual and potential, may be perceived.

The claims for success of this method by its developer are similar to those of Zwicky in the early days of Morphological Analysis [28]. To the author, this method appears to merit further investigation. (Principal reference source is the GENESA Foundation [38].)

*Systematics* Systematics, as defined by J. G. Bennett [39], is the study of structures as simplified totalities . . . "Systematics takes the connections as primary and elements as secondary." The approach in Systematics is to build up a set of primitive systems, consisting of "terms" and "connections" (or elements and relations), each with an increasing number of terms. The "order" of the system is given by the number of terms. A system of the first order is called a monad; second, third, fourth, . . . , order systems are called, respectively, dyads, triads, tetrads, . . . . Each order of system is said to be associated with a particular mode of "experiencing the world," called the *Systemic Attribute*. Each of the primitive system types, monad, dyad, . . . dodecad has been and continues to be studied in detail and its inherent properties catalogued. Then, the study of a "real structure" is carried out in terms of the component primitive systems, and all that is known about them.

This approach qualifies under our rubric Structured Guidance—Geometric by its modular reference to the component primitive systems, each being considered with the aid of a corresponding set of geometric figures. However, the method is too complex to describe adequately here. It is included in this listing because the author feels that it has a strong potential for the "generating" activities in the study of complex systems. (Principal reference source is [39].)

*Pattern Analysis/Recognition Methods* There will probably be situations in a TA when a lot of (measurement) data is available, but there is little understanding of the underlying structure of the phenomena measured. This is the situation that underlies the study of pattern recognition methods. The approach has been to study large amounts of data to determine (really to "discover") patterns among the data, which in turn can be used to characterize the data. A large repertoire of methods (primarily computerized ones) have been developed to assist in this process. The pattern-recognition literature is large, and the number of potentially applicable techniques correspondingly large. They will not be described here. This category is mentioned for the purpose of bringing this source of candidate tools to the awareness of the reader. Two well-known tools in this category that have been used by the social scientist are Factor Analysis [40] and Multidimensional Scaling [41].

*Comments* The purpose of this section has been to bring certain tools to the awareness of persons who are or who will be responsible for the early stages of problem definition and/or modeling in the TA process.

It is hoped that by virtue of presenting the above survey a step will have been made toward improving the quality of results obtained in the solution of problems encountered in large-scale technology assessments—ones that are of seemingly ever-increasing complexity and/or importance to society.

The tools surveyed herein primarily serve to enhance the "creativity" of the group process in the sense that (experience-based) intuitive or inner, personal knowledge or ideas are elicited from the members and in some cases combined to develop a group product of "higher quality" than otherwise usually available.

In the present context, the most appropriate application of these tools appears to occur during the deliberations in the early steps of problem definition and/or during the process of putting together in an organized way an understanding of the overall pattern of the situation—usually called modeling. This statement is a generalization, of course, and

the actual areas of fruitful use of these tools are limited only by the imagination and experience of the user.

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## References

1. Stanley, G. L., Nienow, W. C., and Lendaris, G. G., SARF: A Signature Analysis Research Facility, *Proceedings, Purdue Centennial Symposium on Information Processing*. Lafayette, Indiana, April 1969.
2. Lendaris, G. G. and Stanley, G. L., Diffraction Pattern Sampling for Automatic Pattern Recognition, *Proceedings IEEE*, 58 February (1970).
3. Linstone, H. A., Lendaris, G. G., Rogers, S., Wakeland, W., and Williams, M., The Use of Structural Modeling for Technology Assessment, *Technol Forecast. Soc. Change*, 14, 291-327 (1979).
4. Berne, E., *Games People Play, the Psychology of Human Relationships*. Grove Press, New York, 1974.
5. Flynn, E. W. and LaFaso, J. F., *Group Discussion as a Learning Process; A Sourcebook*. Paulist Press, New York, 1972.
6. Bales, R. F., et al., eds., *Small Groups: Studies in Social Interaction*, Knopf, New York, 1965.
7. Bales, R. F., Self Analysis in Groups, in *The Cutting Edge: Current Theory and Practice in Organizational Development*, ed., W. W. Burke, Univ. Assoc. Press, New York, 1978.
8. Klein, A. F., *Effective Groupwork. An Introduction to Principle and Method*. Association Press, New York, 1972.
9. Warfield, J. N., *Societal Systems*. Wiley, New York, 1976.
10. Linstone, H. A., et al., Alternative Models of the Decision Making Process and their Applications to Technology Assessment, project in progress for the National Science Foundation, Futures Research Institute, Portland State University, Portland, Oregon, 1979.
11. Watzlawick, P., Beavin, J. H., and Jackson, D. D., *Pragmatics of Human Communication*. Norton, New York, 1967.
12. Fitz, Raymond and Troha, Joanne, Interpretive Structural Modeling and Urban Planning, *Proceedings, 1977 International Conference on Cybernetics and Society*, IEEE-SMCS, October, 1977.
13. Delp, P., Thesen, A., Motiwalla J., and Seshadri, N., 1977, Systems Tools for Project Planning, Program of Advanced Studies in Institution Building and Technology Assistance Methodology, Indiana University, Bloomington, Indiana, 1977.
14. Osborn, A. F., *Applied Imagination*, 3rd ed. Scribner, New York, 1963.
15. Stein, M., *Stimulating Creativity*, vol. 2. Academic Press, New York, 1975.
16. Parnes, S. J., *Creative Behavior Guidebook*. Scribner, New York, 1967.
17. Parnes, S. and Harding, *A Source Book for Creative Thinking*. Scribner, New York, 1962.
18. Delbecq, A., Van de Ven, A. and Gustafson, *Group Techniques for Program Planning: A Guide to Nominal Group and Delphi Processes*. Scott, Foresman and Co., Glenview, Illinois, 1975.
19. Van de Ven, Andrew, *Group Decision Making and Effectiveness*. Kent State University Center for Business and Economic Research Press, Kent, Ohio, 1974.
20. Warfield, J., Geschra, H. and Hamilton, R., Approaches to Problem Solving Number 4: Methods of Idea Management, Joint Publication of Battelle Institute and the Academy of Contemporary Problems, Columbus, Ohio, August, 1975.
21. Gordon, W. J. J., *Synectics*. Harper, New York, 1961.
22. Prince, G. M., *The Practice of Creativity*. Harper, New York, 1970.
23. Linstone, H., and Turoff, M., *The Delphi Method, Techniques and Applications*. Addison-Wesley, Reading, Massachusetts, 1975.
24. Hiltz, S. R., and Turoff, M., *The Network Nation*. Addison-Wesley, Reading, Massachusetts, 1978.
25. Finesinger, J. E., Psychiatric Interviewing, *Am. J. Psychiatry* 187-195 (1948).
26. Ivey, A. E., *Microcounseling, Innovations in Interviewing Training*. Charles C. Thomas, Springfield, Illinois, 1971.
27. Crawford, R., *The Technique of Creative Thinking*. Frazer Co., Vermont, 1964.
28. Zwicky, F., *Discovery, Invention, Research through the Morphological Approach*. MacMillan, New York, 1969.
29. Stanford Research Institute Long Range Planning Service, Structured Approaches to Creativity, Report No. 385, SRI, Nov., 1969.

30. Alexander, C., *Notes on the Synthesis of Form*. Harvard Press, Cambridge, Massachusetts, 1964.
31. Sharma, K. J., Misfit Variable—A Useful and Efficient Concept for Technology Assessment Methodology. *Proceedings, IEEE/SMCS Annual Convention*, San Francisco, 1975.
32. Fried, J., and P. Molnar, *Technological and Social Change: A Trans-disciplinary Model*. Petrocelli Books, Inc., 1979.
33. Warfield, J., *Societal Systems—Planning, Policy and Complexity*. Wiley, New York, 1976.
34. Lendaris, G. G., Some Considerations in the Use of ISM, Portland State University, Portland, Oregon (1979), submitted for publication).
35. Polya, G., *How to Solve It*. Doubleday Anchor, New York, 1957.
36. Warfield, J., and Hill, J. D., A Unified Systems Engineering Concept, Battelle Monograph Series No. 1, 1972, Columbus, Ohio.
37. Langham, D. G., *GENESA, An Attempt to Develop a Conceptual Model to Synthesize, Synchronize, and Vitalize Man's Interpretation of Universal Phenomena*. Aero Publishers, Inc., Fallbrook, California, 1969.
38. GENESA, KPFK Radio Interview—March, 1975, GENESA Foundation, Fallbrook California (Note: a list of 10 GENESA Publications is available from the Foundation).
39. Bennett, J. G., *The Dramatic Universe*, vol 3. Hodder & Stoughton, London, 1966.
40. Harmon, H. H., *Modern Factor Analysis*. University of Chicago Press, Chicago Illinois, 1967.
41. Carroll, J. D., and Wish, M. Multidimensional Scaling: Models, Methods, and Relations to Delphi, in *The Delphi Method: Techniques and Applications*. H. A. Linstone and M. Turoff, eds., Addison-Wesley, Reading, Massachusetts, 1975.

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