# VI.E. Architecting the Future: A DelphiBased Paradigm for Normative System-Building

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## I. Prelude

The purpose of this brief paper is to present some essentially tentative steps toward the development of a system-based "technology" for policymaking. This technology would take the form of a procedural paradigm which, it is hoped, would assist in accomplishing the following:

(a) Removing policymaking from the realm of rhetoric to which it has been historically condemned --- by introducing instruments to lead to a consensus of opinion and value on "objectified" issues (whereas existing policies often reflect only casual, suboptimal compromises among competitive a prioristic or "irrational" positions).

(b) Removing, to the extent possible, the ad hoc character of many existing policy-setting processes, by offering a system-based alternative to the "management by crisis" administrative modality under which most social, political, and economic systems are currently administered (which so often causes policies to become temporal panacea, producing surprises and embarrassment more frequently than structural cures).

(c) Substituting the "hit or miss" character of many existing policy-setting, processes with a disciplined "learning" attribute --- one in which all policies are viewed as hypotheses which subsequent experience and experiment must validate, invalidate, or modify. That is, the analytical procedures in establishing policies are now complemented by a monitoring-feedback system which constantly evaluates their impact relative to expectations, and which constantly audits the validity and rectitude of the premises from which the policies were derived. Thus, policymaking becomes an exercise in action-research.

From the standpoint of the system theorist, the process of rationalizing policy decisions may best be approached within the context of a somewhat immature but rapidly emerging discipline-normative system design. For policies are generally broad, usually long-range, formulation-based constraints on action. In effect, then, they represent a restraint on the action-space available to individuals or systems, or in some way serve to limit the repertoire of desired behavior. In operation, policies serve as a broad strategic envelope within which decisions are made, and, in effect, provide certain a priori premises for the normal decisionmaker. Thus, for example, a state or nation may have an environmental policy that demands conservation; the existence of this policy then constrains the decision-space available to individual businessmen, government agents, etc., or anyone else dealing with any aspect of the environment. It thus serves to limit the prerogatives available to systems which might have an impact on the environment. Without going into great detail, most proper policies would be of this sort, and all have a very special property as a class of phenomena: all policies reflect assertions about desirable system properties and, one hopes, serve the cause of transition from less favorable to more favorable system states. In short, policies are *normative* in nature, and always involve a preference given to one state alternative at the expense of all others which might have been elected as most desirable. Thus, *normative systems* may be thought of as ends (systems states) which policies are designed to obtain, and thus reflect "ordered" sets of "utopian" attributes pertinent to some future point in time. To this extent, policy-setting becomes the rational activity associated with the isolation of those "actions" which should prove most effective and efficient in causing a transition from less favorable to more favorable system states through some bounded interval in time.

The rationality involved in systematic normative future-building suggests that we employ some "scientific" method which, while offering procedural discipline; does not a priori constrain the substance of the future. This, basically, is the problem with schemes predicated on crude extrapolation, historical projection, or analogy-building-where we run the risk of restricting the *results* of our analysis by the *instruments* of our analysis. This is not acceptable. What would be acceptable, however, is a method which is Janusfaced, with one face turned toward imagination, evaluation, and axiological inputs, while the other face scans the empirical domain for relevant facts, experiences or objective "data" [1]. Our speculative flights might thus set the initial and tentative investigatory trajectories, whereas the objective information which emerges would serve the cause of validation, invalidation, or modification. Thus, the method appropriate for normative system-building would rest somewhere between the abject intuition of the science fiction writer, and that empiricist-positivist platform which dominates modern science and which knows only, facts and figures. It is in the interstice between imagination' and observation-between concept and percept-that the "science" of policy-' setting, future-building, and normative system-building seems to rest. Specifically, the methodology might well take the form of a procedural paradigm like that shown in Fig. 1.

## II. The Scenario-Building Logic

Our methodology must, in the first instance, generate a *syncretic scenario* which will, as nearly as possible, accommodate a diversity of needs or desires. This scenario should serve to emphasis similarities in axiological or affective predicates, not merely explicate differences. This means that it

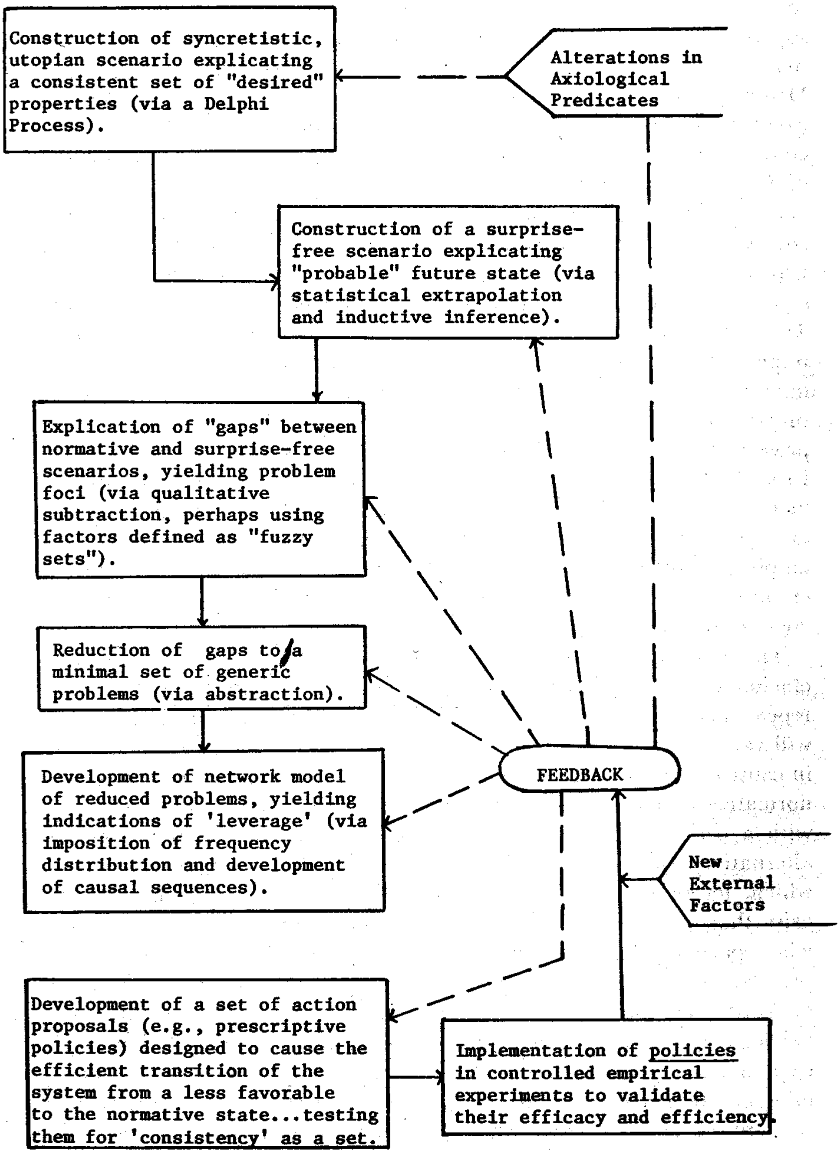


**Fig. 1.** Normative system-building paradigm.

should be constructed at a level of abstraction which, as nearly as possible, works backward from superficial positions to fundamental societal attributes. The device by which we may do this would be a simple variation on the basic theme of this book, the Delphi process.[1] Here, rather than searching for opinions or for probabilistic expectations about events, we would try to structure a set of properties which could be integrated into a normative future --- properties based on the criterion of desirability rather than likelihood, for example.

Given this set of utopian or normative future properties, we might set about convening a set of expectations about, the future independent of any action which we might take. This might be the development of a "business as usual" scenario, or the type which Harold Linstone has referred to as *surprise-free [2].* The normative and the surprise-free scenario would differ in an important respect: the former would be predicated largely on hypothetico-deductive instruments (e.g., defactualized or idiographic "information"), whereas the surprise-free scenario might legitimately be based on largely extrapolative or projective instruments such as those used to generate the "limits of growth," etc. In sum, the normative scenario would be a product of intellect and discernment, whereas the latter would be largely a mechanical exercise in statistical analysis coupled with limited uses of ampliative inductive inference (given that ampliative inductive inference simply extends the properties inherent in some empirical or experiential data base, introducing changes which are matters of *degree* rather than of quality).

The papers preceding this, and some which will follow, provide ample elucidation of the procedures and promise of the Delphi process, so I need not repeat them here. I simply want to note that while the normal Delphi process will value any divergence of opinion which emerges, that which we must seek in constructing these scenarios is a *consensus;* hence the syncretistic aspect of the normative scenario. In any exercise of any significance we must expect to begin with a considerable divergence of opinion about the relative desirability of alternatives. In most cases, these divergences will arise from axiological biases which, for many participants, may be empirically inaccessible. When these exist, there will generally be several uniquely different scenarios which emerge when participants are asked about a normative future through the Delphi process. The points of divergence among the various scenarios should enable us to locate the major axes of recrimination and, in the process, make the axiological predicates of the scenarios visible and manipulable. This is the first step in gaining a consensus where divergences are a matter of values and idiosyncratic perceptions rather than matters of objective disagreement. For in the process of explicating what are otherwise tacit assumptions underlying desired events, there is the opportunity for generating syncretic models at a next level of abstraction, that is, one step removed from the level at which the axiological arguments hold sway. This would be a process

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[1] For a discussion of some precedents for the use of Delphi processes in scenario-building exercises, see Chapter III, of this volume.

similar to that described by Ackoff, and extended by Mitroff and Turoff, concerned with "measuring the effect of background assumptions" [3].

Where divergences are a matter of objective argument-such that the engines of differentiation are explicable in universalistic rather than idiosyncratic terms --- then a syncretic solution can usually be generated by exchange and modification of causal expectations rather than by the indirect exchange of assumptions associated with cases of axiological argumentation. Here, again, the Delphi process could be used to generate these adverse scenarios, with these subsequently becoming the target for consensus operations:

Thus, in sum, a consensus as to the normative scenario will generally involve several interactions of the Delphi process, with the rate at which a consensus is achieved (or the rate at which we are converging on a syncretic scenario) being measured by the rate at which the raw variance in responses declines. Thus it becomes important to introduce questions into the Delphi process which are susceptible to some sort of ordered response (e.g., asking questions which permit the respondent to answer in terms of a probability of likelihood or degree of desirability). Thus, for example, we may pose questions where the response is to be made as follows:

100 75 25 Ø (*Probability / Desirability Index*)

Each respondent, pertinent to each question, is asked to place a check mark at the point on the continuum which best describes his expectations about probability or desirability of the event (or item) in question. The aggregate of all such responses, for each iteration of the Delphi process, will thus represent a frequency distribution with proper statistical properties, proper in the sense that it will yield a formal measure of variance. The questions should be phrased in such a way that affective or objective origins of disputation may be isolated (e.g., asking "leading" questions or questions with a strong but subtle valuational bias). When essentially the same issues are raised, perhaps, however, in different form, on subsequent iterations of the Delphi process, a measure of the decrease (one hopes) in variance can be obtained, which should enable 'us to evaluate roughly the effectiveness of the strategy or tactics by which we are trying to establish a consensus. Thus, through the course of a scenario-building exercise, it is the variance of responses with which we shall be concerned, for this is the best guide we have as to the means by which a consensus might be obtained. I shall not specify any of these means here, except to 'note that behavioral scientists concerned with consensus and conflict elimination have methods which are at our disposal, and the comparative effectiveness of these methods can be audited by the above procedure. Thus, the consensus-seeking process might be viewed as an action-research experiment in its own right, shifting instruments in response to empirically derived variance estimates.

It should be mentioned here that the response-by-continuum (e.g., asking for responses in the form illustrated above) lends us another capability which is extremely important, and which I have introduced in greater detail elsewhere [4]. Specifically, the frequency distributions which emerge from the successive iterations of Delphi processes aimed at securing indices of desirability pertinent to future properties may be thought of as subjective (a priori) probabilities, and may be treated as such. In short, in operational terms, expectations about the likelihood of an event occurring, and estimations of the desirability of events, become intelligible in exactly the same terms. In fact, we may usually expect to generate fairly accurate surrogates for desirability of events by asking about their probability of occurrence, this in the sense that respondents are often likely to assign the highest likelihood estimates to events which they themselves value.[2] There is some advantage in this surrogation approach especially where social conventions might act to impede true responses (e.g., a respondent might really prefer that his future minimize contact with members of minority groups, but would be reluctant to be tied to such a statement; asked, however, about the likelihood of homogeneous communities, we may get a reasonable basis for inference about desirability). Naturally, some local testing would have to be done to determine the extent to which expectations about probability of occurrence and estimations of desirability are truly correlated, with the reliability of inferences being adjusted accordingly. As a general rule, however, there should be some opportunity during the course of the Delphi process to gain indices of both likelihood and desirability.

The net result of this process will be a scenario which, at each point, may be thought of as involving a selection from among all alternatives which might have been included. In this sense, a scenario emerges as a proper model, with each of its components being assigned some index of either desirability (in the case of the normative scenario) or probability of occurrence (in the case of the extrapolative or surprise-free scenario). In graphic terms, we may think of each component of the scenarios as being represented by an event-probability distribution, as shown in Fig. 2. In the left-hand illustration, the events on which the probability distribution is, imposed may represent anything we wish pertinent to some scenario under construction (that is, the $e_i$'s may be variables, relationships, functions, complex events, parameter values, etc., or any other component). Of the two curves drawn there, the a priori (presumed to be that which exists after the first Delphi iteration and prior to the first attempt at consensus) is less favorable in terms of variance than the a posteriori (which is presumed to exist after some n iterations of the Delphi and consensus-seeking process). The transformation from the a priori to the a posteriori curve as a result of our polling and consensus-seeking operations results in the favorable learning curve at the right. We may now interpret these constructs in the following two ways:

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[2] For a discussion of this phenomenon, see J. R. Salancik's "Assimilation of Aggregated Inputs into Delphi Forecasts: A Regression Analysis," Technological Forecasting and Social Change 5, No. 3 (1973), pp. 243-47.

1) *For the* Normative Scenario: Suppose that the event set [E] is an array of mutually exclusive attributes pertinent to some aspect of the future, such that the two curves should be read as products of respondents' estimations of the desirability of these alternatives. In the a priori state there is a considerably greater divergence than in the a posteriori, with the numerically calculated variance acting as an imputed measure of the degree of consensus obtained. The "learning curve" on the right-hand diagram thus reflects the rate at which this consensus has been gained, such that the curve in that diagram may now be thought to represent the variance in estimations of desirability among those contributing to the scenario-building exercise.
2) *For the* Extrapolative Scenario: Here the a priori and a posteriori curves represent expectations about the likelihood of occurrence of the events constituting set [E], such that the a posteriori curve assigns respectively higher probabilities of occurrence to a sharply decreased set of alternatives. Thus the "learning curve" in the right-hand diagram may be read as written: measuring the probability of expected error associated with the aggregation of predictions. In short, we have converged gradually on a consensus of opinion about what will occur, whereas in the normative exercise we converged on a set of opinions about what is desirable.

In both of the above cases, we have used a statistical surrogation process to discipline the inputs from Delphi participants, and to gain an empirical appreciation of the *efficiency* of our model-building and consensus-seeking process. The normative scenario will, then, constitute a *complex model* which at all points has been assigned specific indices of consensus *as* to the desirability of the components entered; for the extrapolative or surprise-free

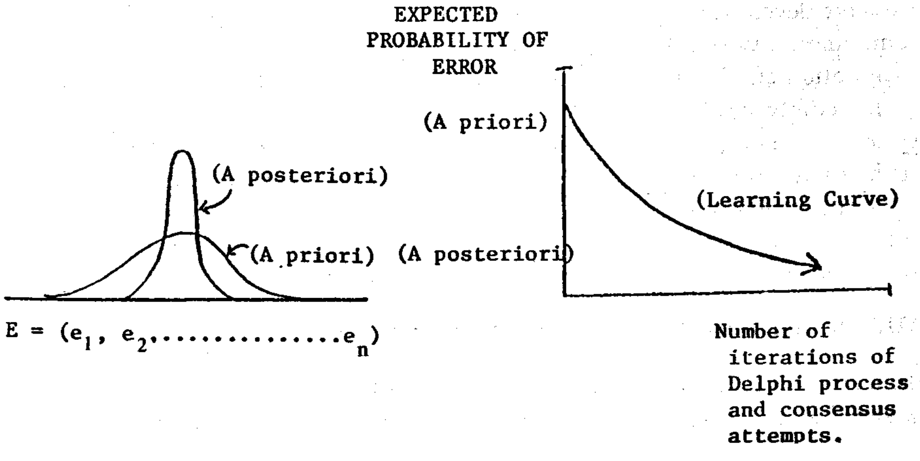


Fig. 2. Event-probability distribution and associated learning curve.

scenario, we have a model which, at all points, contains those components which have been assigned the highest probabilities of occurrence by the participants. The net result should be a normative scenario with the highest logical probability of accurately encompassing the desires of participants, and an extrapolative scenario which, relative to all others we might have built, has the highest probability of accurately reflecting the future *in the absence of any therapeutic or directional actions we might take.* In other words, this latter scenario represents what we think will happen if we do not interfere, or if we abrogate our opportunity to create the future.

There are two other aspects of the scenario-building process which we should note here. The first is that the normative and extrapolative scenarios should represent logically consistent models. Thus, as Joseph Martino suggests [5]:

> A scenario is more than just a set of forecasts about some future time. It is a picture of an internally consistent situation, which, in turn, is the plausible outcome of a sequence of events. Naturally there is no rigorous test for plausibility.... The scenario thus occupies a position somewhere between a collection of forecasts whose interrelationships have not been examined, and a mathematical model whose internal consistency is rigorously demonstrable.

While there are no hard and fast rules for establishing consistency, it is nevertheless useful to have at hand some sort of instrument for examining the nature of the interaction between system components, an exercise which is naturally aided by having an interdisciplinary flavor to the scenario-building team and concentrating some attention on the interfaces which emerge among components of the emerging models.

Second, the utility of this normative scenario-building process stems from a simple realization: if we were able to start from scratch, very few systems which we have developed would be designed the way they have evolved. Therefore, it sometimes pays simply to ignore what exists and turn instead to a disciplined exploration of what should exist. Little has been gained from the large number of incredibly costly studies which aimed at "finding out what's wrong with system x." The response which the normative system-builder might make to such an assignment is this: "Compared to what?" Without that normative reference, studies of existing systems lack reference and therefore can accomplish little (yet empirical science's domination of research technology has lent such studies a patina of legitimacy despite their long record of sterility).

## III. An Amplification of the Scenario-Building Technology

In terms of an amplification of the procedural logic we have developed, we first asked that a Delphi process be inaugurated which will gradually converge on a set of attributes deemed, by consensus, to be most desirable at some future point for the system in question. That is, we are searching for a set of state-variables, $X=(x_1 \ldots\ldots x_n\}$, which as a set exhaust the desires of the model-building participants. Now, associated with this set will be an event-probability distribution[3] derived from a frequency distribution (histogram) reflecting the number of mentions each factor received, should we have provided a facility for participants to give a numerical priority expressing the importance of the particular factors. At any rate, through the first iteration, we will emerge with an event-probability distribution where, instead of probabilities, per se, we are using *indices* of *desirability*. This first distribution will normally be a highvariance one, which successive iterations of the Delphi process must attempt to reduce to a low-variance one. The degree to which the variance declines is an estimate, at all points, of the efficiency of the Delphi process in its role as a syncretic instrument, as Fig. 2 indicated.

At any rate, the output from this first Delphi process should be some set of n attributes which, as a set, contains both a manageable number of elements and, for that n, maximizes the aggregate desirability. In short, the n --- factors selected are those which have been assigned the individually highest indices of desirability (as computed either by number of mentions or by some weighted measurement including a ranking variable). This set of $x_i$'s (attributes) now becomes the universe of properties available to us for the second of our analytical exercises --- scenario-building. The construction of a proper scenario becomes intelligible in two steps: (a) A selection, from among the universe of $x_i$'s, of some consistent subset of attributes (consistency meaning that all are mutually compatible or "synergistic") and (b) The imposition of an "order" of some sort on the attributes selected, which in effect means that we establish some functional structural relationship among them [6]. When these two tasks have been completed, we will emerge with a proper normative system model'-where the attributes included represent state-variables, and the "ordering", represents the necessary interaction conditions among them.

There may be several scenarios, each representing specific interests or ambitions or desires, and these may differ either in terms of the specific subset of attributes elected for inclusion, or in terms of the functional relationship imposed on the elected subset. Thus we might emerge with something like this:

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[3] We will continue to use this term, even though we are here concerned about desirability rather than probability-and we will continue to use continuous rather than dis crete formulations for these distributions, even *though* in most cases a discrete form would be more appropriate. The logic, in either case, remains the same.

*ALTERNATIVE SCENARIOS:*

$$A = f_a[X_a]$$
$$B = f_b[X_b] \qquad \textit{Where: } X_a, X_b \text{ and } X_m \subset X \text{ (the universe)}$$
$$\vdots \qquad \text{and where } f_a \neq f_b \neq f_m.$$
$$M = f_m[X_m];$$

Alternative scenarios are thus those where either the subset of attributes considered is different than that considered in other scenarios, or where the relationship (the f) among those state attributes is unique. In either case, scenarios represent normative system models defined at the state-variable and relational levels, and hence represent qualitatively unique system states. Associated with each of these scenarios will thus be some index of desirability, which will be computed by the' number of responses which favor a particular formulation (or, again, by some scheme which incorporates a ranking function).

This aggregate desirability index is really a product of indices of desirability (and feasibility) generated at lower levels -pertinent to the individual structural or functional components which are to be entered into the emerging scenarios. For example, some components (e.g., normative attributes) will receive a high consensus; given the other components: of the scenario under construction, while others will receive barely enough "votes" to get them included. The same will be true of the functional relationships which are imposed on the elected attributes, causing the generation of a "system" model, per se.

Thus, for each element in the alternative scenarios, there will be an event-probability distribution which reflects the desirability of that attribute and ideally one also reflecting its "feasibility." These individual component indices may be formulated as follows:

$$(a) \textbf{ DESIRABILITY } \quad [x_i | x_i^c], \text{for } \forall x_i \in X_a (\& X_b \ldots X_m);$$
$$(b) \textbf{ FEASIBILITY } \quad [x_i | x_i^c], \text{ for } \forall x_i \in X_a \ (\& X_b \cdots X_m).$$

The first formulation simply asks about the desirability of some attribute $x_i$ in company with all other attributes constituting the set $X_a$ (this being a measure of the conditional desirability of the factor). The feasibility formulation then asks about the "consistency" of having $x_i$ appear in concert with the other attributes constituting the set $X_a$ (e.g., the set of attributes *qua* state-variables for the A-scenario). The same task would be performed by each of the clusters, ultimating in scenarios where each of the $x_i$ 's has been assigned some index of desirability and feasibility. Essentially the same logic would hold for the derivation of the functional relationship among the $x_i$ 's pertinent to each scenario. In this sense, each pair of interacting attributes *(qua* state-variables) will have to have an assertion made about the nature of the influence or interface conditions. That is, we have to set the conditions for the following:

$$f_{i,j}[x_i | x_j], \quad \text{for all interacting pairs of attributes or state variables in } A, B \ldots M, \text{ where all } f_{i,j} \in f_a.$$

Thus, when $f_a$ (the functional relationship imposed on the set $X_a$, constituting the elements of A) is finally evolved, there will be possibly some, divergence of opinion about the validity of each of the individual $f_{i,j}$'s of which $f_a$ is , comprised. And, if we are to be strictly formal in our approach to the problem of establishing a relationship function, we would again have to consider the. relationships among successively more encompassing sets of variables, eventually emerging at the point where relationships are considered simultaneously among all variables (factors) connected even indirectly. Only in rare occasions, however, will we resort to this depth of analysis (except when the system at hand is an effectively "mechanical" one, permitting these relationships to be set, empirically through controlled manipulation of successively larger subsystems, etc.).

In general, however, a *clustering* effect will emerge in most scenario-building operations. This will tend to find individuals with like interests, ambitions, backgrounds, or axiological predicates forming subgroups which have homogeneous concepts of what he future should look like. As a result,; there, is, a natural tendency to emerge with scenarios which have a high degree of consensus as to the desirability or feasibility of their components (and which„as a result, are constructs exhibiting little internal variance of opinion). To a limited extent, we can counteract this clustering effect by *stratifying panels* (where we put individuals with substantially different backgrounds, interests, skills, or axiological positions together into scenario-building teams). Nevertheless, the alternative scenarios will usually result from the fact that there will not be unanimity among panel members as whole, and that there will usually be divergences of opinion about the rectitude of model components within strata or clusters.[4] But the clustering and stratification schemes differ in important respects, as follows:

| | WITHIN SCENARIO VARIANCE | BETWEEN SCENARIO VARIANCE |
|---|---|---|
| Clustering: | LOW | HIGH |
| Stratification: | HIGH | LOW |

That is, under a clustering scheme, we tend to put , similar panel members together into a model-building team (e.g., all economists or all sociologists or all environmentalists); under the stratification scheme, we tend to, form teams . of opposites. The net result is that the models built by clustered teams will vary greatly in aggregate, but will have high degrees of consensus (e.g., low variance) internally ... for the premises under which clustered teams operate vary greatly *between* the teams, but little if at all *within* the teams. Just the opposite is true of the stratification effect. There we will have a high degree of divergence within teams, and a low degree of divergence among teams, with the net result that the alternative scenarios will vary little between each other, but have high degrees of internal variance.

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[4] Nevertheless, we assume that when it comes to “voting” for one or another of the alternative normative scenarios, there will be unanimity among cluster members in preferring their own to any other.

As a general rule, clusters will tend to form naturally, whereas strata have to be deliberately invoked ... something which may prove to be *dysfunctional* if recrimination and acrimony occurs within groups.

For the sake of "efficiency" in the normative scenario-building process, it is a usually better strategy to permit the formation of these spontaneous clusters explicitly, and then concentrate on the elimination of the clear-cut differences between constructs as wholes at some later point. For the models which are built by clustered teams will be internally consistent and carry a high degree of consensus as to desirability, even though their conclusions may be hotly disputed by members of other clusters. Thus we have reasonably disciplined, "finished" products on which objective argument may be directed, whereas groups containing acrimonious components will have severe difficulty in actually completing anything substantial. To make this point somewhat clearer, consider Fig. 3. What we tend to find, then, is that the aggregate probability distribution functions for alternative normative scenarios (viewed as heuristics) tend to be products of the means of the event-probability distributions reflecting the degree of consensus among members of a cluster as to the desirability (or feasibility) of their construct.

Thus, for clusters, we have a situation where a larger number of alternative scenarios are proposed (such that the aggregate distribution is greater for the "flatter" clustered case), but where the consensus as to the individual desirability of these alternatives is strong (which means that each of the alternatives in the clustered case will have a narrow, peaked, internal variance). Just the opposite situation prevails with respect to the stratified distribution: there we have fewer "events"[5] assigned significant probabilities-with less variance in the aggregate distribution due to their tendency to be redundant with one another due to the stratification process-but each of the alternatives carries with it a much higher internal variance, and consequently shows less consensus) than do the alternatives in the clustered case. That neither of these situations is really satisfactory may be seen by calculating the overall variance associated with the constructs (e.g., computing variance as the product of the internal and external variance) [7]. The net result is that both cases would carry about the same total variance, with the lower internal variance associated with the clustered case (indicated by the fact that [b-a]<[d-c]) being offset by the lower aggregate index of desirability (or feasibility) associated with any single alternative-as is indicated by the "flatter" aggregate distribution.

What we eventually want to emerge with is, of course, an aggregate event-probability distribution like that shown in Fig. 4. We could achieve this distribution in either of two ways, relative to the distributions of Fig, 3: (a) We could inaugurate Delphi processes which will reduce the *within-scenario* variance associated with each of the few alternatives remaining in the stratified distribution (by forcing a consensus within the scenario-building groups). This, in effect, means forcing the marginal

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[5] Alternative scenarios.

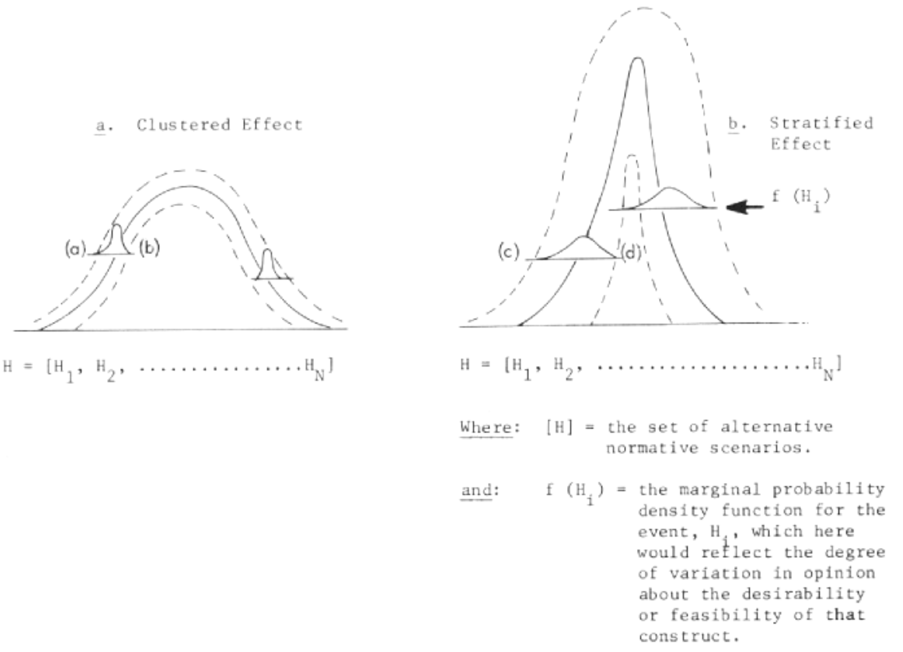


**Fig. 3. (*a*,*b*).** Results of clustered as opposed to stratified model-building structures.

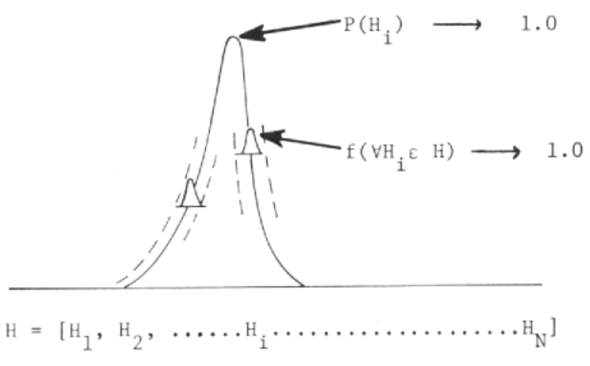


**Fig. 4.** The idealized event probability distribution.

desirability/feasibility density functions for all remaining $H_i$'s to converge toward 1.0 (which reduces the expected dysfunctionality/infeasibility associated with each alternative, and hence results in more "peaked" superimpositional probability functions). (b) We could take the low "internal variance" alternatives of the clustered distribution and inaugurate Delphi processes which cause the aggregate desirability density function to "peak," thereby eliminating some of the less expectedly desirable/ feasible alternatives and correspondingly increasing the relative desirability/ feasibility of those remaining. The new result, in either case, is the same: we have reduced a high-variance situation to a lower-variance' situation, with the end result that a single, most expectedly desirable and feasible normative system model is gradually converged on. Thus, in the above figure, both the aggregate and marginal density functions reflect an improvement over the cases illustrated in Fig. 3 *a* and *b,* respectively.

In many cases, and we shall not belabor the point here, the ultimate construct (e.g., the $H_i$ which is finally agreed to be the most desirable and feasible system state) might emerge as some sort of compromisive "hybrid," where agreement is obtained at the expense of either precision or actionability. The result of *democratic* model-building processes is often a construct which, while it has very little probability of proving absolutely wrong as a representation of some phenomenon, also has almost no probability of being "optimal." And where such constructs are to become premises for decision or policy action, the fact of a subjective convergence or consensus will have little bearing on the actual rectitude of the model, and hence may be cases where science disserves its larger community. A very important distinction, then, would be between models which obtain a convergence through compromise, and those which are truly *syncretic* or rationally (and sapiently) discerning. These strictly compromise hybrids, like so many essentially political formulations, will generally trade-off ultimate rectitude against short-run procedural expedience. And there is really no defense against this except for the fundamental integrity of the team leaders, so we can offer no "technology" for escaping these degenerative Delphi processes-just a caution to be alert for their presence. Thus it is important not to force an artificial or fabricated convergence where there is no natural basis for syncretistic accommodations, it is better to let the normative model-building process proceed along two or more parallel trajectories. The advantage of using the paradigm presented here will then be simply the fact that all parties have employed basically the same methodology, and this, in itself, may eventually provide some accommodative basis which might otherwise elude us.

At any rate, essentially the same logic would hold for the construction of the extrapolative scenario-that system model which simply projects existing system properties into the statistical future. We would largely just replace indices of desirability/feasibility with indices of likelihood (e.g., probabilities of occurrence), but would still have to go through a consensus-seeking process of the type imposed on the normative scenarios. Here, however, use of "stratified" as opposed to clustered panels would probably be indicated, as there will be greater reliance on experience and factual knowledge (objective "data"), and "differences" could, it is hoped, be resolved "rationally." That is, where divergence is more likely to be a matter of fact rather than a matter of value, accuracy of forecasts should increase to the extent that extrapolative teams are drawn from broadly different experiential and professional sectors.

## IV. Constructing the Problem Network

The completion of the normative and extrapolative scenarios now allows us to concentrate on the differences between what we want to occur and what we expect will occur in the absence of action on our part. These differences thus represent "gaps" which must gradually be closed if the properties of the normative scenario are to be realized, It is important, therefore, that the normative and extrapolative scenarios be built on exactly the same dimensions, such that they represent essentially different states for the same essential system In short, expectations and estimations of. desirability should be general only in pairs with respect to a set of system components which remain constant through both exercises.

Thus, for each aspect of the future, there will be a set of ordered pairs' of properties, with the first element in the pair representing the .desired property, and the second representing the property expected to obtain given inaction. I won't go into detail here, but it should be obvious to systems scientists that defining properties in terms of ordered pairs lends us some valuable mathematical capabilities and allows us to treat the two scenarios as formal-'- state alternatives for a formally defined system [8]. Where the elements of each pair are essentially similar, the "gap" will be negligible and this particular system aspect may thus be removed from immediate attention. However, before we finalize our action proposals, we must again review these- cases held in abeyance, for new conditions might be introduced which will prevent the extrapolative value from converging on the desired The logic here is simple but critical: in interfering with those aspects of the system deemed to be dysfunctional, we might very well introduce changes which prevent desired events taking place through the extrapolative mechanism. In short, when we change any aspect of the system, we must reassess the impact these changes might have on aspects of the system with which we did not wish to interfere.

At any rate, the generation of the "gaps" which do exist might be viewed as a problem in *qualitative subtraction,* where we are basically interested in isolating that set of properties which are *not shared by* the two scenarios (relative to each of the dimensions of the scenarios or to each system component being considered). As far as formal procedures for this exercise, there is an increasing literature on what is known as "fuzzy" set theory, which is the attempt to deal mathematically with qualitative variables [9]. The serious student of scenario-building will find some guidance here, though recourse to such discipline will hardly be necessary in most cases. The result of this subtractive exercise should, then, be a set of ordered differences which now may be thought to represent problems, per se, toward which the remainder of our work will be directed.

But for a scenario of any significant size, much less for those directed at large-scale systems such as regional socioeconomic systems or urban areas, etc., the number of problems cum gaps will be enormous. True, we have eliminated for the moment those aspects of the system where desired and extrapolated ends were the same (e.g., where the trend is adequately favorable or where a favorable system aspect is expected to remain secularly stable), but we must now perform a further reduction.

We want, in effect, to arrive at an array of problems which exhausts the "gaps" isolated above, but which contains the fewest possible elements or entries. We do this by looking for ways to phrase problems such that all those which we arrive at will be mutually exclusive and pertain to the largest possible number of specific instances (e.g., gaps). In a sense, then, the problem definitions which are sought here will be arrived at by a process of successive *abstraction.* Under this process, we are constructing generic problem referents which perform much the same function as theories or laws: they introduce efficiency into our explanatory process by allowing us to account for the largest number of specific (unreduced) phenomena with the fewest possible unique formulations. In operational terms, this successive abstraction process would be conducted by searching the several "gaps" for elements of *isomorphy* or attributal similarities. The search for, and exploitation of, instances of isomorphy is one of the best described procedures of systems science, so there are ample references to which the reader may turn for specific guidance [10]. The general strategy, however, relies mainly on the intellectual tenacity and sensitivity of the participants, and on the ability to absolve the problems cum "gaps" of their contextual or superficial properties so that instances of isomorphism maybe uncovered. In short, the method here would be to take the "gaps" previously isolated and gradually strip away as many *modifiers* as possible. The result should be the fewest number of mutually exclusive generic problem definitions which, in substance, exhaust as fully as possible the "gaps" used to generate them.

The next step is the analysis of these generic problem referents, and the imposition of some sort of *causal order.* This may be done in two steps. The first move would be to calculate the number of specific "gaps" (e.g., unreduced problems) to which each of the generic problems refers, thus giving us a rough measure of the degree of abstraction associated with each element of the reduced problem array. When this is done for all generic problems, we may develop a simple frequency distribution which will often have a valuable property for us. For when the various generic problems are arrayed as the event-set in the frequency distribution, the amplitude of the resultant curves imposed on each element in that set (each generic problem) gives us a measure of the relative system leverage it exerts. That is, the frequency distribution will point out those problems which, when operated on or treated, are likely to have the greatest overall therapeutic effect on the system as a whole. In short, the measure of abstraction associated with each of the generic problem referents is also a measure of its influence on the state of the system, with those generic problems encompassing the largest number of specific "gaps" being those which carry the greatest expected leverage. Hence, in the histogram below, Problem [$p_2$] carries imputedly greater leverage than any of the others, being the generic referent for the largest number of unreduced problems (or having appeared as a factor in the largest number of specific "gaps").

The second move is to search for some sort of causal order among the various generic problems we have defined. All must be directly or indirectly related, else the system' with which we re working is not a proper system. The task for us now is to allegorize the nature of these relationships, and these will generally fall into one of two broad categories: hierarchical or reticulated networks. If the ordering of influences

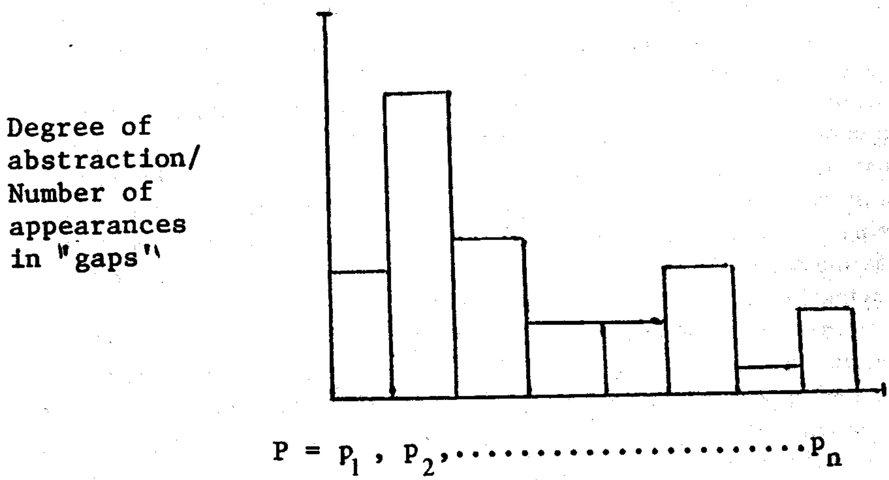


Fig. 5. Sample histogram.

among problems is of the former type, then we will be able to develop a causal tree (e.g., a partially ordered set) where problems may be ;arrayed on levels such that :problems on a lower level are deemed to be "causes" of problems on the next level, and so forth. The net result of such a structure is a rather neatly linear relationship among the various problems, with micro-problems gradually giving way to intermediate level problems which finally merge into a macro-problem. In order to be a true hierarchy, we might impose a constraint that prohibits higher-order problems from affecting lower-order, or perhaps a constraint which acts against reflexivity among the various problems (as reflexivity would abrogate the linearity and unidirectional causality we like to see in proper hierarchies). At any rate, there are many sources of information about the properties of hierarchies, properties which must be met by the generic problems if the hierarchical modality is to be employed to lend them an ordering [12].

The reticulated case represents a more complex set of relationships, one where the various problems are equipotential (i.e., all may affect each other). A reticulated network thus does not possess the neatly algorithmic properties of proper hierarchical structures, and so becomes very much more difficult to model. For, here, problems maybe related reflexively, recursively, and with omni-directional potential trajectories of influence. Under this structure, one must conceive of our problems being related in a network fashion where each of the various problems represents a *node*, from which many different paths of interaction may radiate. As the reader might rightly expect, then, problems related in reticular form generally arise from systems which are more inherently complex than are systems which enable us to impose a hierarchical ordering on the generic problems. That this is so may easily be verified by; comparing some of the formulations of modern network theory against their hierarchical counterparts [13].

With the completion of these causal orderings, the results from the frequency distribution should be reexamined. The problems which received the greatest number of appearances in the histogram of the first step should be those with the greatest number of connections in the reticular model (or, where the hierarchical structure is imposed, should be at the lowest levels of causality, i.e., influencing the greatest number of other problems). In this way we have a check on our derivation of problems from "gaps" and an additional verification of the consistency of our reduction logic.

**V. Generation of Action Proposals (Prescriptive Policies)**

The models just generated will serve as an input to. the next phase of the policy-setting/future-building process-the generation of an array of action proposals which, as a set, have the highest a posteriori probability of causing the transformation of a less favorable to a "normative" system state over some interval. These action proposals will generally take the form of prescriptive policies (strategic instruments) which are expected to achieve the effect of narrowing the gap between existent (or extrapolative) system properties *and* those that are deemed desirable, for each of the several problems comprising the reduced problem network just developed. There is no easy algorithm for the generation of strategic decisions-this depends on the wit and sensitivity *and* assiduity of the systems analysts and. policymakers-but we can say something about the order in which action proposals should be generated and the analytical setting in which they should be evaluated.

Obviously, those problems shown to exert the greatest leverage (e.g., those with the highest number of appearances in the histogram, those representing most "highly connected" nodes in the reticular formulation, or those at the lowest causal levels *in* the hierarchical structure) should be the first *attacked,* Thus, with respect to the frequency distribution just set out, problem [$p_2$] would be the first for which an action proposal (solution strategy) would be developed. The causal ordering model-in either the reticular or hierarchical form, whichever was deemed most appropriate-would then be used as the basis for a simulation of the effects of the solution strategy on the system as a whole. The results of this first iteration of the simulation model would then be to isolate any redefinitions in the other problems associated with the simulated . implementation of the solution to the first problem. In short, we want to know what effects our action with respect to problem [ $p_2$] would have on the other problems, so that, for each of them, a solution strategy could be devised in' light of the solution to the prior problem. We would then have to iterate die simulation until we were able to incorporate the entire array of problems to be solved, together with the parameters of their solution strategies. This is simply to be certain that, in solving one problem, we make every feasible effort to we that we do not create others or exacerbate the system situation in someway (in short, that we act to minimize the probability of occurrence of unexpected consequences or adverse second-order effects).

In the beginning, with that problem deemed to exert the greatest leverage *on* the system, we may emerge with an aggregate solution strategy (pertinent to the simultaneous solution of all problems) which promises to be most effective and efficient in making the desired system transition. In some case, however, particularly where a hierarchical problem structure was uncovered, we may think about introducing solutions sequentially-implementing them in a sequence which, at each step, isolates that problem which at that point in time promises to exert the greatest therapeutic leverage when solved. In either case, iterations of the simulation model should give us a logical pointer to the. necessary conditions for each solution step, and the indication as to which particular problem will emerge as the best target for attack at that iteration. Thus, the causal orderings on the problems give us the basis to make a most efficient transition, such that expenditures of developmental resources will produce an expectedly "optimal" effect, both in aggregate and at each point in the solution process.

## VI. The "Learning" Aspect

It should now be mentioned, again, that all the work we have done thus far results in constructs which are just hypothetical in nature, and which have generally only "subjective" indices of accuracy assigned them. Nothing, at this point, is fixed. The "hypothetical" character of these components simply reflects the system dictate that, in the face of a complex environment, linear procedures (those that anticipate a direct drive toward some invariant objective) are to be avoided with assiduity. Rather, our analytical behavior must be heuristic in nature, denying the impulse prematurely to stop analyzing and start acting, and denying the impulse to use what are essentially unvalidated constructs as action premises, So the policies qua action proposals which we now must generate themselves become hypotheses, and serve basically as "manageable" units of analysis for the empirical learning loops which will lend some "objective" discipline to what until now have been largely speculative exercises. It is here, then, that we make the switch from the hypothetico-deductive modality to the empirical modality.

The empirical "learning loops" which we now inaugurate will have basically two foci. First, there is the matter of validating - in the immediate short-run - the rectitude of the hypothetico-deductive components constituting the scenarios, and their problem and policy derivatives. Second, there is the long-range aspect to the learning context - that which finds even those constructs validated in the short-run being constantly monitored and evaluated in the long-run. The net result is a totally heuristic process, one where as little as possible is taken for granted, including not only the analytical constructs themselves but the basic "values" and axiological premises that existed at the time of the initial analysis. There is a distinct advantage here, for in the world of the future, approached heuristically rather than algorithmically: "... one may solve one's problems not only by getting what one wants, but by wanting what one gets."[6] In a world where we know only how to seek goals, and have not the capability to adjust them constantly, the actual future will hold only frustration and suboptimality. Thus, while the forecaster or traditional predictor of futures may bemoan the fact that there is

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[6] W. R. Reitman, "Heuristic Decision Procedures, Open Constraints and the Structure of Ill-Defined Problems," in *Human Judgments and Optimality,* Shelly and Bryan (eds.), Wiley, New York, 1964.

no determinism out there, the "rational" system will recognize that where there is no determinism, there is also no lack of opportunity.

At any rate, we begin the empirical learning loops by recognizing that our normative scenario is simply a "metahypothesis," a product of many different hypothetico-deductive elements linked together in a consistent system of concepts (where the consistency here may be considered to mean that the laws of deductive inference were followed more or less closely in relating the various components). In a similar way, the extrapolative (surprise-free) scenario is also a metahypothesis, though it is not strictly a hypothetico-deductive one because at least some of its substance is owing to the projection of empirical data and experiential bases. Now, the problem network models were evolved directly from these two scenarios through the processes of qualitative subtraction and successive abstraction (described earlier). Thus, in the strictest sense, the problem network model may be thought of as a *surrogate* for the normative scenario, for it simply has caused a reordering and redefinition of elements which were not found in the union between the normative and extrapolative constructs (e.g., those properties associated with the normative scenario which were not present in the extrapolative) [14]. Thus, our manipulation of the problem network model in the face of simulated solutions is roughly the equivalent of operating on the normative scenario itself, though the number of factors associated with the former are vastly greater than those comprising *the* reduced network model. In this way, very large scale systems may usually be reduced to more manageable entities without too much loss in rectitude -providing that the normative scenario can ultimately be *resynthesized* from. the problem network models to which it was reduced. This can be done, for our reduction procedure was a fairly algorithmic one, bearing not only replication but retroconstruction. Hence, the reduction process we went through not only allowed us to isolate those aspects of a potentially very large -system which demand treatment if some normative system state is to be realized, but has enabled us to develop a considerably simplified surrogate on which we can perform analytical operations such as simulation, thus allowing us to economize greatly on the costs of analysis.

The added attraction of this reduction process is that we have a unit of analysis (e.g., the network model) which is highly amenable as -a referent for empirical experiments aimed at validating (in surrogate form) the hypothetico-deductive components of the scenario and our expectations about therapeutic actions we might take. In this sense, the strategies we evolve in the form of action proposals now become hypotheses, per se, and the process of their implementation now becomes intelligible in terms of a reasonably well controlled *experiment. The* results of these empirical trials will then be fed back to the network model, and if our expectations were in error, appropriate modifications must be made in that model. And because the reduced network' model can be resynthesized into the normative scenario, we are able to allow our experiments on solution strategies to have a direct bearing on our normative construct way up the line, allowing modifications necessary in the network model to resonate back toward their origin in the much larger, less empirically tractable construct. The result of the hypothesis -experimentation-feedback process is what we have sought all along: the gradual transformation of initially hypothetical constructs into empirically validated ones, which in effect means that gradual transformation of the subjective probabilities associated with the normative scenario into objective probabilities.

It is this latter property which lends the paradigm outlined here its status as an *action research* platform, one which enables us to learn, in a disciplined way, while still having a hopefully positive effect in the world at large.

## VII. Summary

The process we have gone through should be that which assures that the policies. which we finally implement are those which have the highest a posteriori (.e., objective) probability of proving both effective and efficient in causing desired system transformations. The logic of the process, is summarized in Fig. 6.

In short, we have gone through this rather demanding exercise to make sure that the actions we initiate are those which are the very "best" we can arrive at, and not simply expedient products of casual or strictly opportunistic policy-setting procedures. And, finally, because the normative system design paradigm., is essentially an exercise in *action-research,* our most logically probable policy prescriptions will be tested within an empirical envelope, using structured (and, one hopes, reasonably well-controlled) experiments designed to lend some empirical validation to the essentially hypothetico-deductive constructs from which the action proposals (or prescriptive policies) were derived. The results of these empirical experiments will then be fed back, to the hypothetical constructs, either modifying, invalidating, or reinforcing them. In any case, a Bayesian transformation system will allow us to make a priori indices of desirability, feasibility, or likelihood responsive to a posteriori, objectively predicated "data," thus allowing us gradually to metamorphosize our deductive constructs into positivistic ones (at least to the extent that the nature of the system and its operational context permits). And it need hardly be mentioned that even those empirically validated aspects of the normative, extrapolative, or prescriptive, constructs must simply remain hypotheses against which emerging realities are constantly compared-especially those "realities" relevant to the operational effects of the prescriptive policies we implement and whose effects may be far spread and resonate very widely throughout a range much broader than that occupied by the system of primary interest itself.

In summary, this normative system-building process-and this system-based approach to policy-setting-is a very demanding and somewhat "idealistic" construct in its own right - much like the scenarios it is intended to help generate. Thus, it may represent more what could or should be done than what is immediately feasible or immediately likely, And at least it represents a .start toward a methodology useful for those who believe that we control the future and are responsible for it, a position which, thankfully, seems to be taken more and more often (especially as regards environmental issues).

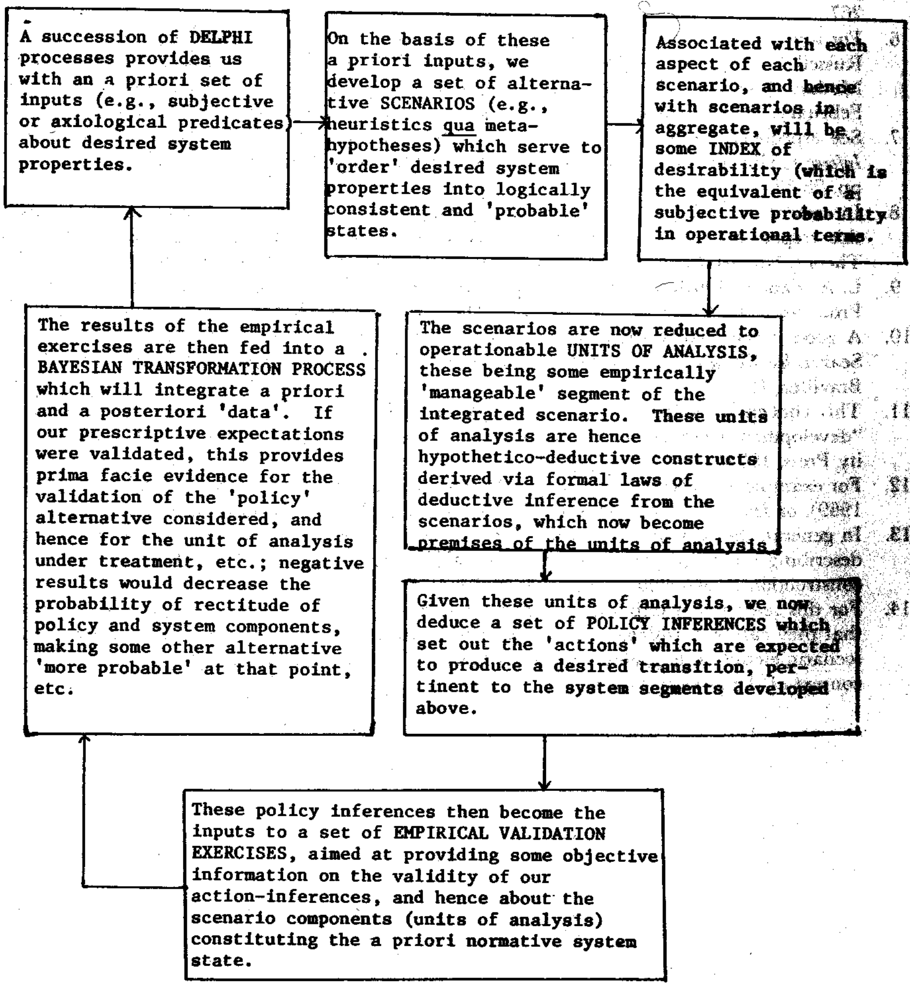


**Fig. 6.** The normative system architecture process.

**Notes and References**

1. For some indication of the importance of Janus-faced models in the social and behavioral and political sciences, see Chapter 2 of my *A General Systems Philosophy for the Social and Behavioral Sciences* (New York: George Braziller, 1973).
2. Harold Linstone, "Four American Futures: Reflections on the Role of Planning," *Technological Forecasting and Social Change* 4, No. 1 (1972).
3. Cf., Mitroff and Turoff's "On Measuring Conceptual Errors in Large-Scale Social Experiments: The Future as Decision," *Technological Forecasting and Social Change, Vol.* 6 (1974) pp. 389-402.
4. "Beyond Systems Engineering: The General System Theory Potential For Social Science System Analysis," *General System Yearbook* XVIII (1973).
5. Joseph P. Martino, *Technological Forecasting for Decision Making* (New York: Elsevier, 1972), p. 267.
6. For some illustration of the techniques available, for generating."consistency" in scenarios, see Russell F. Rhyne's *Projecting Whole-Body Future atterns-The Field Anomaly Relaxation* (FAR) Method (Stanford Research Institute Project 6747, Research Memorandum #6747-10; February, 1971). Also *Technological Forecasting and Social Change,* Vol. 6 (1974), p. 133.
7. See especially Jamison's excellent paper, "Bayesian Information Usage," in *Information and Inference,* Hintikka and Suppes (eds.), (Dordrecht, Holland: D. Reidel Publishing Co., 1970), pp. 28-57.
8. In essence, formal systems are treated as giving rise to ordered sets of inputs and outputs. In this respect see L. A. Zadeh's "The Concepts of System, Aggregate, and State in System Theory," *System Theory,* Zadeh and Polak (eds.), (New York: McGraw-Hill, 1969).
9. L. A. Zadeh, "Outline of a New Approach to the Analysis of Complex Systems and Decision Processes," *IEEE Transactions on Systems, Man and Cybernetics* SMC-3, No. 1, (January 1973).
10. A good conceptual introduction to this area of systems is given in Anatol Rapoport's "The Search for Simplicity," *The Relevance of General 7heory,* Ervin Laszlo (ed.), (New York: George Braziller, 1972).
11. This concept of system leverage was developed from Albert O. Hirschman's discussion of "development leverage" in his *The Strategy of Economic Development* (New Haven: Yale University Press, 1958).
12. For example, see *Hierarchical Structures,* Whyte, Wilson and Wilson (eds.), (New York: Elsevier, 1969), or *Hierarchy Theory,* Howard H. Pattee (ed.), (New York: George Braziller, 1973).
13. In general, the type of network which would evolve from the reduction process we have been describing could be portrayed in terms of graphs, the theory of which is essential to the construction of switched or reticular models.
14. For this reason, it is important to try to construct normative scenarios in positive terms, such that they can be translated eventually into structural-functional properties In short, negative scenario elements (e.g., elimination of prejudice; less unemployment) are to be avoided in the context of the present paradigm.