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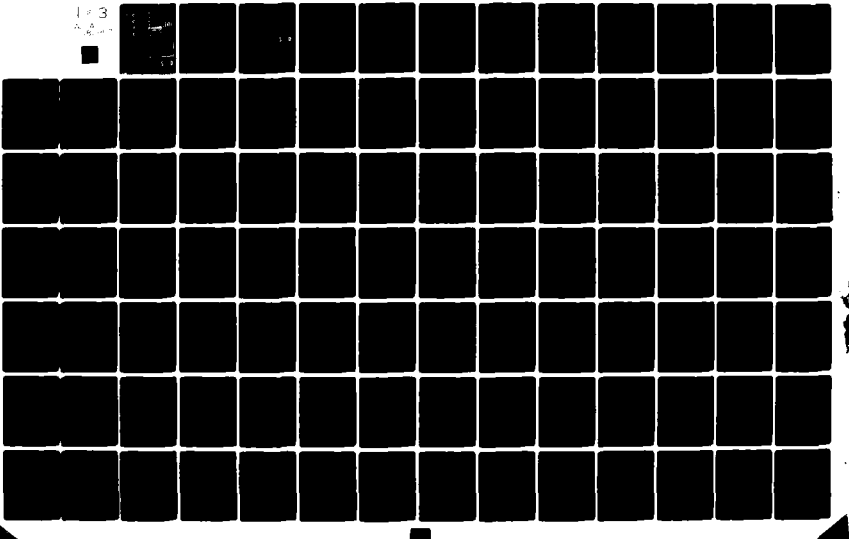

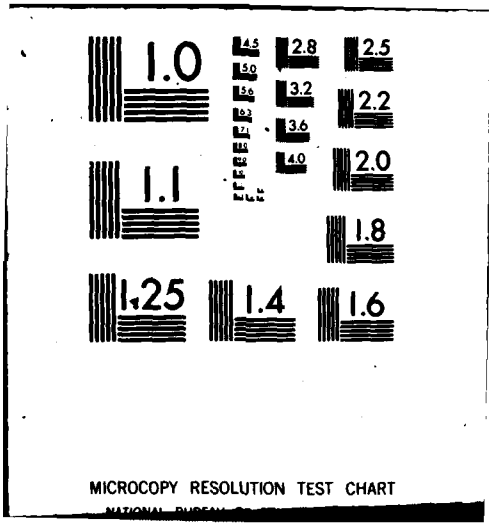
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TECHNICAL REPORT
TR 127-79
8 AUGUST 1979

LEVEL III

COMMAND & CONTROL TECHNICAL CENTER

A SURVEY OF LONG-RANGE FORECASTING MODELS AND DATA RESOURCES: A METHOD FOR THEIR APPLICATION AT THE DEPARTMENT OF DEFENSE

DEFENSE COMMUNICATIONS AGENCY

RECORD OF CHANGES

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COMMAND AND CONTROL TECHNICAL CENTER

Technical Report TR 127-79

8 August 1979

A SURVEY OF LONG-RANGE FORECASTING MODELS AND DATA RESOURCES: A METHOD FOR THEIR APPLICATION AT THE DEPARTMENT OF DEFENSE

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PREFACE

The current attention being given to the issues of available energy and mineral resources, food production, population growth, and disparities in economic development has led to an increased awareness of the need for planning on a long-term basis. However, the assertion has been made that while we generally recognize that today's decisions will shape our future, we do not have an adequate governmental capacity to assess the future implications of present trends systematically or to design and evaluate alternative courses of long-range policy action.* In a recent interview, President Carter expressed his concern for this matter, stating that he "...will press every Government agency to pursue futures research and technology assessment to help them make wiser decisions."**

This is a matter of obvious importance to the Department of Defense (DOD) since decisions are being made that will have an impact on the shape of the Armed Forces for 10 to 20 years in the future. As stated in one analysis:

> The weapons system acquisition process is by its very nature a form of long-range planning. The Department of Defense, unlike the Department of State or the CIA, does have programs that extend out to the long-range and therefore some form of long-range planning is required.***

The Joint Long-Range Strategic Study (JLRSS) document**** has historically provided a basic source for that effort. Published by the Office of the Joint Chiefs of Staff (JCS),

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*Congressional Research Service, Long-Range Planning, Serial No. BB prepared for the Subcommittee on Science and Technology, U.S. House of Representatives, Ninety-Fourth Congress, Second Session, May 1976, p. 3.

**"What's Next?", Congressional Clearinghouse on the Future, January 1977, No. 7, p. 1.

***Robert Gilmer and Leonard Wainstein, An Evaluation of the Joint Long-Range Strategic Study (U), Institute for Defense Analyses, Arlington, Virginia, 1974, p. 45.

****Note: The JLRSS and a comparable report, the Joint Long Range Estimate Intelligence Document (JLREID) are planned, as of this writing, to be combined as a single report entitled, "The Joint Long Range Strategic Appraisal (JLRSA)."

it addresses the strategic implications of worldwide and national economic, political, social, technical, and military trends. It deals with national objectives, policies, and military constraints and relates these to world and regional trends. This is a large task and the support requirements for its accomplishment are imposing. The purpose of this report is to provide a review of the approach, methodologies, and potential resources that can be used in support of DOD long-range planning.

ACKNOWLEDGMENT

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ABSTRACT

This Technical Report presents the results of a review of forecasting methods, computer programs, environmental indicators, and data sources of potential use in the preparation of long-range (10 to 20 years) planning documents at the Department of Defense.

This report recommends that DOD long-range planning be conducted on a general probabilistic basis, identifying the factors of national power, forecasting their most likely status on a national and regional basis, and assessing the political implications of these future power relationships accordingly. It suggests Ray Cline's Perceived Power equation as the vehicle for such an approach and recommends a "family" of forecasting models using Mesarovic's "APT" interactive software (developed by Systems Applications Company, Incorporated) to provide needed inputs to the equation. It identifies 18 forecasting models and 59 data resources as meriting further investigation for their potential use in such an effort.

SECTION 1. EXECUTIVE SUMMARY

This report presents the results of a study of forecasting methods, computer programs, environmental indicators, and data sources of potential use in the preparation of long-range planning documents. An interim report* provided a broader review of forecasting methodologies and modeling efforts whereas the principal focus of this document is the applicability of certain significant models and data sources to long-range planning concerns. The appendixes provide a review of alternative methodologies, organizations and individuals contacted, the user-interactive Assessment of Policies Tool (APT), and a bibliography of sources used for this report.

In order to accomplish its primary purpose, this study has also addressed the more fundamental concerns of the concept of the Joint Long-Range Strategic Study (JLRSS) and the proper approach to its preparation. To this end, the critique of the JLRSS prepared by the Institute for Defense Analyses (IDA)** received strong attention.

The IDA critique raised a number of serious questions, the most basic of which concerns the very nature and feasibility of forecasting in the field of global environments. The critique also questioned the role, utility, and consistency of the JLRSS and strongly criticized the validity of the quantitative methods used in its preparation.

This report disagrees with certain primary criticisms submitted by that critique, and takes a more positive view towards both the potential applications of quantitative methods and the necessity and feasibility of forecasting if done on a probabilistic basis. This study has based its assessment of the feasibility of forecasting on a probabilistic and conditional concept of prediction which is consistent with that employed by science in general.

Obviously, the nature of any forecasting effort requires provisions for substantial margins of error. However, the difficult and unsatisfactory nature of long-range forecasts cannot be used as grounds for abandoning the attempt to formulate long-range plans.

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*Computer Sciences Corporation Letter Report, "Current Research in Long-Range Forecasting," 30 September 1976.

**Robert Gilmer and Leonard Wainstein, An Evaluation of the Joint Long-Range Strategic Study (U), Institute for Defense Analyses, Arlington, Virginia, 1974.

The idea of intelligent planning requires strong efforts to assess future developments as far as current techniques permit. With or without long-range planning, expectations about the future will be formulated. In the absence of perfect knowledge and foresight, decisions that must be made will in fact be made on the basis of the most general, vague, and incomplete expectations. The present study contends that anything done to structure, quantify, and focus these expectations about the future is of direct service to decisionmakers.

In the meantime, the correct technique of forecasting in a world of uncertainty is not necessarily the one that accurately predicts events, but rather the technique that properly assesses probability. A good forecast minimizes the error, or minimizes the cost of error. To that end, this report recommends the adoption of an Army War College approach by seeking a forecast of the most probable alternative environments and a core environment common to each.

The foundation for the best forecast should be a reliable explanation of why events occur. If, as the status of current international relations theory suggests, such a total explanation does not exist, realist theory does partially fulfill that need on a relatively broad basis (that is, all nations are influenced by considerations of national power). Since the realist concern with national power is consistent with a primary concern of the Department of Defense (DOD), a profitable adaptation of realist theory to long-range planning could be accomplished by assessing the factors of national power, forecasting their likely future status on a national and regional basis, and then evaluating the likely political impacts of that future environment. This approach, deriving forecasts from projected "levels of threat," is a direct application of the method used and recommended by personnel at the Army War College.

The vehicle for this approach appears to be available in Ray Cline's method* of identifying and quantifying the measures of national power. This study has compared the subjects addressed by 18 forecasting models and 59 data resources against the factors that comprise the Cline equation: critical mass (population and territory), economic capability (GNP,

*Ray S. Cline, World Power Assessment: A Calculus of Strategic Drift, Georgetown University, Washington, D.C., 1975.

trade, energy, minerals, steel, and food), military capability (strategic and conventional), strategic purpose, and national will.

Thus, although in most cases they were not originally designed for strategic forecasting, the surveyed global and regional models attempt to cover significant sectors applicable to a strategic forecast. Additional models addressed are also potentially applicable but are considered partial either on a geographic or sectoral basis. The coverage by this group is restricted either to single nations or to specific sectors (e.g., energy, international trade, population, and food).

It is the view of the authors that certain existing simulation models, particularly the Mesarovic World Integrated Model (WIM) using the APT interactive software, can provide needed inputs to the Cline equation on both a national and regional basis. These inputs would be combined, where necessary or preferable, with qualitative appraisals to provide a more structured basis for an assessment of the international political implications of future power relationships. An example of such an approach would be to adapt the national power projections to Organski's power transition theory.* That is, a forecast of drastic changes in relative power capabilities could suggest future instability in the international environment and be an important factor for long-range defense planning considerations. Cline's equation could thus be used in a forecast of broad trends in national alignments and behavior as a function of the power configuration among nations.

Consequently, this study recommends the development of a set of coordinated models as the basic means of supporting DOD long-range planning. This system could afford a means of organizing data and substantive expertise to generate maximum information focused on specific issues or areas of concern in strategic forecasting.

The principal part of the system would be a multimodel array, to include models surveyed in this report with the addition

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*A.F.K. Organski, World Politics, New York: Alfred A. Knopf, 1968.

of any others that further search and study reveal to be appropriate or superior. The multimodel array would have two primary functions: quantitative projections and the formulation of scenarios of significant events.

With regard to quantitative projections, the model array would have the capability of making long-range projections of economic and social indicators associated with established areas of strategic concern. Using the array, these forecasts could be made at three levels of aggregation:

a. Global with regional interaction

b. Regional or national specific

c. Sector specific.

For forecasts at the first and second levels, this study strongly recommends the use of the Mesarovic World Integrated Model with its Assessment of Policies Tool (APT) interactive software. APT combines the advantages of a high degree of flexibility linked to the most highly developed and impressively conceived model currently available at this time. For detailed forecasts at the second and third levels, partial models such as Link for world and national level trade forecasts or the Houtakker-Petroleum model could be used. For key countries such as the Soviet Union and China, the available country-specific models could be employed.

The handbook concept proposed by the IDA critique* is a promising suggestion that could then be adapted to the planning process. In addition to the description of long-range problems and strategic concerns, the handbook should include descriptions of the recommended multimodel array and available data resources. The latter elements of the handbook would incorporate both the general documentation and a users guide for the multimodel array as well as data bases for use in the models and other applications. In the form of a handbook, such a long-range planning guide would encourage the use of the interactive simulation capability and better fulfill its function as a source document.

This report therefore submits the following recommendations for further action in support of the preparation of the JLRSS:

- Adopt a forecasting approach oriented to projecting the most probable alternative environments and a core environment common to each.

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*Gilmer and Wainstein, op. cit., p. 92.

- Use simulation models as necessary to provide inputs to a forecast of future power relationships among nations from the interactive model simulations.

- Conduct a more in-depth evaluation of the structure and assumptions of the surveyed models (particularly that of WIM and APT) to assess the feasibility of their use.

- Evaluate and identify potential data sources best suited to meeting the DOD long-range forecasting requirements suggested on the basis of the needs of the recommended models.

- Review the feasibility of developing a handbook of long-range problems and data as recommended in the IDA critique as a principal DOD long-range planning source document.

- Continue to maintain contact with other long-range forecasting organizations and to monitor the applicable literature on new forecasting developments.

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SECTION 2. JOINT LONG-RANGE STRATEGIC STUDY (JLRSS) DOCUMENT

2.1 Purpose

The purpose of long-range strategic forecasting at the Department of Defense should be identified first in light of the overall national security goals of the United States:*

- To maintain a worldwide military balance, in conjunction with our allies, and thus reduce the threat of war
- To deter any attack against the United States, its allies, and other nations vital to United States security, and, if deterrence fails, to ensure an outcome favorable to the United States
- To ensure the flow of ocean-going trade and supplies by protecting the sealanes that are vital to the national security and economic well-being of the United States, its allies, and its trading partners.

The JLRSS has been designed to support planning for the capabilities to meet these goals during the time frame from 10 to 20 years in the future. It has been published periodically by the Office of the Joint Chiefs of Staff (OJCS) and has been described as follows:**

> The JLRSS is designed primarily as a source document that addresses the strategic implications of worldwide and national economic, political, social, technical, and military trends. It deals with national objectives, policies, and military constraints and relates these to world and regional trends. As a source document, it is intended to stimulate more sharply focused strategic studies and to be useful in developing military policies, plans, and programs having long-range implications.

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*House Document No. 94-343, "The Budget of the United States Government, Fiscal Year 1977."

**Gilmer and Wainstein, op. cit., p. 7.

2.2 Institute for Defense Analyses Critique of JLRSS

Following the publication of the last JLRSS in 1974, IDA was contracted to review the document's utility and submitted the following principal findings.

2.2.1 Role. The IDA study found the JLRSS lacked a clearly defined and accepted role, citing a lack of consistency in previous versions of the study. Part of this problem, the critique suggests, may derive from a perceived lack of interest and lack of consensus as to what a useful JLRSS should contain. The critique suggests that the document should provide support to middle range planners in the development of the Joint Strategic Objectives Plan (JSOP).*

2.2.2 Utility. According to IDA, neither the JLRSS nor any other formal long-range planning and environmental forecasting document has much utility within DOD. The critique suggests that the JLRSS plays only a minor role in those branches of the Government concerned with national security. For example, the document carries little weight in the actual long-range weapons or force structure planning process and seems to be produced more as a "ritual drill." In a sense, the weapons acquisition process is a form of long-range planning, but it is carried on by the individual services more on an ad hoc basis, ignoring the formal long-range planning documents produced by JCS and the Services.**

2.2.3 Consistency. The IDA report criticizes the three DOD long-range forecasting documents, the JLRSS, the Joint Research and Development Objectives Document, and the Joint Long-Range Estimative Intelligence Document, for being inconsistent in their respective forecasts.***

2.2.4 Forecasting Method. Most important from the standpoint of this study, the IDA critique strongly questions the methods used in the preparation of the JLRSS forecasts. The ultimate foundation for the IDA findings is an argument in principle concerning the nature, method, and feasibility of forecasting in the fields addressed by the JLRSS.

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*Ibid., p. ix.
**Ibid., p. x.
***Ibid., p. xi.

The main points in this regard can be summarized as follows:

a. The upper limit of what the JLRSS can do is determined by the "correct" method of forecasting.

b. The correct technique of forecasting is determined by the nature of the subject matter which, in the case of the JLRSS, is essentially that of international power and politics.

c. The nature of the subject matter of international political relations is such that the future is not predictable since events are too numerous, too complex, and are essentially random in character. According to the IDA report:

> The essence of the problem is that the future does not lie in the present nor did the present lie in the past. The roots are there indeed but how they will develop is neither preordained nor traceable in advance.*

The proof of the unpredictable nature of the future in international relations is found in the fact that predictions are not precise and often are wrong. The fact that only the passing of time indicates whether or not a prediction is correct is also taken as evidence that the future cannot be predicted. According to the position taken in the IDA evaluation:

> ...one cannot defend a projection in the traditional sense since it is unsupported --and essentially unsupportable-- speculation ±0-20 years ahead. One estimate is almost as good as another.**

To paraphrase the IDA position, the future is any expert's guess.

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*Ibid., p. 56
**Ibid., p. 52.

d. IDA claims that, because of the subject matter, long-range forecasts of sociopolitical developments on an international scale can only speculate about the future.

e. Although the future cannot be forecast or predicted, IDA states that, "Speculation over time and imaginative scenarios derived through historical analogy can generally sketch out alternative futures."* To the extent that the JLRSS is valid, "...it will be as a set of speculations on possible futures."** IDA rejects all other methods, especially rigorous quantitative techniques of dealing with the future. With regard to quantitative methods, IDA claims that "these methods simply cannot address the problems raised by the long run,"*** and furthermore, "no rigorous models or quantitative analysis are needed, since there is no apparent need for them."****

f. IDA concludes that the JLRSS cannot be a forecast and should not attempt to predict. Rather,

> The JLRSS...is an overview. It does not have to trace the impact of changes made today into the future with any precision, nor does it make any force proposals. Thus, if any modeling <u>should</u> be required in preparing JLRSS, the rule of thumb should be to adopt the least structured approach possible. International relations remains a discipline in which skilled judgment is superior to any available set of deductive principles.*****

On the basis of these considerations, the IDA critique finds that the JLRSS has been overambitious, misconceived, based on inappropriate techniques, and of little value or use in military planning.

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*Ibid., p. 83.
**Ibid., p. 60.
***Ibid., p. 59.
****Ibid., p. 83.
*****Ibid., p. 82-83.

SECTION 3. THE USE OF MODELS AS FORECASTING TOOLS

3.1 General

The IDA criticism of the JLRSS raises deep philosophical, conceptual, and methodological problems. It wrestles with the fundamental question of the sense in which planners can know the future. The IDA treatment of this question is unsatisfactory because of its polar absolutist approach. The authors constantly pose the proposition that the future can either be known or not be known; it is either certain or not certain. From this point of view, a forecast is an unconditional prediction held with perfect certitude. To forecast is to have prescience; in fact, subjective processes (judgment) and intuition are the IDA recommended methods of forecasting.

The authors of this report view the IDA position to be an extreme one. Having set an impossible standard, their conclusion that the future cannot be predicted is understandable. Although the IDA argument is developed in terms of long-range forecasting of future sociopolitical developments, it is in fact general and can be applied to any attempt to predict, i.e., to the scientific method in general. The flaw in the IDA position is its inability or unwillingness to appreciate the role of probability in understanding the future. The future is uncertain to be sure, but this fact does not preclude knowing or making useful predictions. Certainly the business world, which deals heavily in risk and uncertainty, finds prediction unavoidable. Long-range business forecasting is an established practice and is necessary for rational investment policy.

The correct technique of forecasting in a world of uncertainty is not necessarily the one that accurately predicts events, but rather the technique that properly assesses probability. A good forecast minimizes the error, or minimizes the cost of error. To use the words of one prominent futurist, Dr. George Chacko,

> In dealing with the future, there is no certainty, only probability. Therefore, it is necessary to spell out the nature of probability which underlies the technological feasibility forecasts, to assess the risks.*

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*Chacko, George, Technological Forecontrol, North Holland Publishing Company, Amsterdam, 1975, p. 146.

However, extensive disagreement about techniques of forecasting should be avoided. Intellectual history shows that extended debates of methodological issues are extremely unproductive exercises. Although the difference between the present study and the IDA critique seems to involve the use of models, this impression may be erroneous. Relevant literature contains several distinctive definitions of the term model, including the following:

> A model is anything that illuminates and clarifies the interrelations of component parts, of action and reaction, and of cause and effect.*
>
> Models are intellectual tools . . . . In the broadest sense, a model must be able to help us distinguish what is possible from what is impossible, and from the realm of the possible to distinguish the better from the worse. In other words, a model should be used for defining our options.**
>
> The model is a vehicle for arriving at a well-structured view of reality. A model may be a substitute representation of reality . . . (a) model may be some sort of idealization.***
>
> Models are analogies. Scientific or engineering models are representations, or likenesses, of certain aspects of complex events, structures, or systems, made by using symbols or objects which in some way resemble the thing being modeled.****

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*Horton, Forest W., Jr., Reference Guide to Advanced Management Methods, New York American Management Association, Inc., 1972, p. 182.

**Henize, John, A Framework for the Evaluation of Large-Scale Social System Models, Brookings Institution, Washington, D.C., February 10-12, 1975 (Paper presented at the workshop on modeling large-scale systems at regional and national levels).

***Wagner, Harvey, M., Principles of Operations Research With Application to Managerial Decision, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1971, pp. 10-11.

****Chapanis, Alphonse, "Men, Machines and Models," American Psychologist, v. 16, March 1961, p. 115.

Despite their individual differences, these definitions generally support the proposition that models as mental constructs are necessary for any systematic thinking.

The issue in the discussion of forecasting technique is essentially this: what type of model should be employed? The division is centered on the merits of mental models versus symbolic models. Mental models are formed through experience, knowledge, and intuition, and they are used to understand and interpret the world around us. Mental models can be used as the IDA critique advocates to speculate about the future. However, this study favors the use of symbolic models - rigorous mathematical models - for the study of complex systems. As Forrester says:

> The mind is excellent at manipulating models that associate words and ideas. But the unaided human mind, when confronted with modern social and technological systems, is not adequate for constructing and interpreting dynamic models that represent changes through time in complex systems . . . . Our mental models are ill-defined . . . assumptions are not clearly identified in the mental model . . . . The mental model is not easy to communicate to others.*

3.2 Application of Forecasting Models

Obviously, the longer the time period being considered, the weaker the structural stability of the model sociopolitical and economic systems being forecast. Also, the more complex the system being forecast, the weaker its stability. Thus there is a relatively higher level of uncertainty for long-range global forecasting of international political developments. In general, the problems associated with any effort to model a large scale socioeconomic system can be summarized as follows:

- The complex and abstract nature of socioeconomic systems often makes it difficult to identify the important variables.

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*Forrester, Jay W., Principles of Systems, Wright-Allen Press, Inc., Cambridge, Mass., 1968, p. 3-1.

- Relationships between variables are generally not well defined.
- Most social parameters are difficult to quantify.
- Many of the variables are difficult to measure, resulting in the lack of a good data base.
- The range of available data on the measurable variables is often limited.
- Socioeconomic systems are generally not amenable to experimental action.

The scale and complexity of the model magnifies these modeling problems. For example, some highly ambitious, global scale, all inclusive, deterministic models, such as Forrester and Meadows'"World 2"and"World 3"models, can be seriously undermined by these factors. One can easily find, as the IDA critique did,* examples of machine simulation models such as TEMPER that are overstructured, rigid, arbitrary, and mechanistic. Thus the IDA critique opts for subjective, nonrigorous constructs (theories) to be used in speculating about the global political future.

The problems faced in modeling political, economic, and social developments at the international level are indeed serious. Although these problems reduce, they do not eliminate the value of the technique (essentially that of the scientific method). A rigorous approach does not, as IDA infers, preclude qualitative factors or human judgment. IDA seems unaware of the details of the techniques of model use. In using a simulation model for projective analysis, it is important to differentiate between the factors which contribute to a projective solution and the various modes of projection.

First, computing a model projection involves the following major elements:

- The speculation and estimation of the model itself, particularly the implicit assumptions concerning future technology and behavior

*Gilmer and Wainstein, op. cit., pp. 78-79.

- The assumptions made concerning the future of exogenous variables (those not determined in the model solution)

- The intervention of the analyst to compensate for deficiencies of the model and to improve additional information on model solutions.

Second, with these distinctions in mind, one can define a hierarchy of projective exercises:

- A solution of the model, which might not involve user intervention beyond the specification of the model and the solution of assumptions for exogenous variables

- A central solution which indicates a judgment of conditional plausibility and internal consistency by the analyst

- A forecast which represents further discrimination among plausible central solutions, i.e., the selection of the solution which appears most likely, given available information and expert opinion.

As this discussion suggests, good forecasting procedure usually involves extensive discussion of alternative assumptions and alternative central solutions by experts both involved in and independent of the project.

The conclusion of the present study is that, given a reasonable definition and standard of forecasting and prediction, there is no a priori reason for excluding any existing forecasting technique from use in support of JCS long-range planning documents. The restriction that the subject matter places on the ability to make predictions is that a forecast must be of a conditional and probabilistic nature.

3.3 Nature and Purpose of the Forecast

Contrary to IDA's suggestion, planners should not have to recognize all possible events in the process of making a prediction. What is necessary is that they recognize the general situation with the highest probability of occurrence. The analogy to this approach might be considered on a more mundane level in terms of a family's budgeting for a vacation

trip overseas. Given the goal (the nature of the vacation) and the family's anticipated financial resources, it must try to project its probable expenses. Due to the factor of uncertainty, it cannot specifically forecast, itemize, and allocate money for each and every vacation expense that will actually occur. It would also be unlikely that the family could list all expenses that might possibly occur. Instead, the family would forecast and budget its money on a broader basis for a general expected level of expense, using the most known major factors (i.e., cost of plane tickets) as its base and making general allowances for probable expenses such as meals, entertainment, and purchases. If it is judicious, the family would also allow for a backup capability to anticipate unexpected contingencies. This family's forecast for its expected general level of vacation expenses would thus consist of three parts: the most known, the most probable, and the uncertain contingencies. Such a forecasting and planning method is comparable to that used by a recent Army War College study to address a far larger problem.

3.3.1 Army Memorandum: An Approach to Long-Range Strategic Forecasting. This U.S. Army War College Strategic Studies Institute report* describes the methodology that was used to address a task directly comparable to the development of JCS long-range plans. In their case, the War College study team was faced with the problem of developing a postulation of U.S. strategy for the Pacific/Asian region for the 1980s. To accomplish this effort, the report authors initially sought to adapt approaches presently used at Government agencies and academies. However, they found that the common methods used for short-range planning do not adapt readily to long-range problems and that there is no generally accepted method for long-range planning. Consequently, the authors found it necessary to develop a general approach to long-range strategic planning as a prerequisite for the completion of their specific planning mission. The approach that was developed is a major contribution to the existing body of thought concerning long-range strategic forecasting.

3.3.1.1 Problem Definition. The Army War College report identifies three problems critical to the long-range planning process:

- Uncertainty - The uncertainty resulting from inadequate knowledge and excessive complexity

*U.S. Army War College, "An Approach to Long-Range Strategic Planning," Military Issues Research Memorandum (MIRM 73-3), AD 914437, Strategic Studies Institute, Carlisle Barracks, Pennsylvania, October 1973.

- Self-Fulfilling and Self-Defeating Prophecies - The fact that conditions are not fixed externally, but are strongly affected by national decisions and policies

- Fragmentation - The fragmentation of the policy planning process into isolated regional and functional groups.

3.3.1.2 Proposed Forecast Method. To meet these problems, the authors began with the basic planning method of identifying a set of fixed goals, placing them within an anticipated environment, and then creating a strategy for attaining the goals within the constraints imposed by that environment. Unfortunately for a long-range forecast of the future environment, the uncertainty factor increases according to the length of the projection. The authors thus chose first to project several alternative environments, sufficiently few to be manageable but sufficiently numerous to display most of the likely important outcomes of the trends in the world. These alternative environments, however, usually overlap considerably, and this fact can be diagrammed by showing the environments together as possessing a common core, as in figure 1.

In addition, the report incorporates the fact that, although the alternative environments cover as many of the important contingencies as possible, some contingencies never totally fit any of the environments constructed. These few "exogenous contingencies" are graphically portrayed by an exterior ring around the environments, as in figure 2.

3.3.1.3 Proposed Planning Strategy. Using this forecasting concept, the study now found it possible to design an overall planning strategy, composed of multiple parts, to cope with their complex situation. Quoting from the report:

> First, overall strategic problems can be simplified by designing a core strategy to deal solely with the core environment common to all of the projected environments. Interests, together with this core part of the environments, are relatively constant and can, therefore, be employed to generate a specific set of recommendations to policymakers.
>
> The core strategy is supplemented by a basic strategy, the dual purpose of which is to move toward the preferred environment (hereafter called

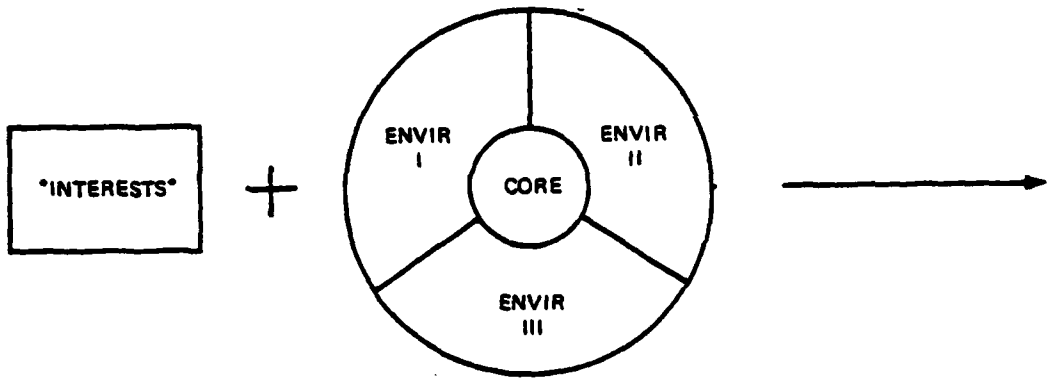

Figure 1. Core Plus Most Probable Alternative Environments*

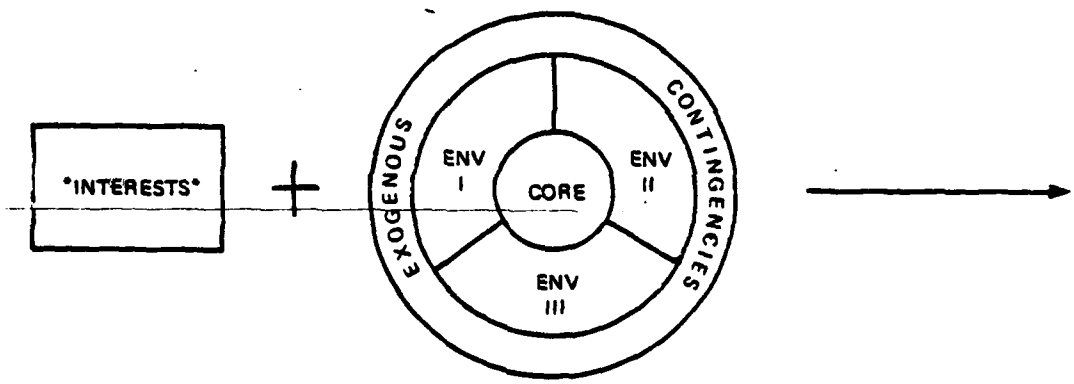

Figure 2. Core Plus Alternative Environments With "Exogenous Contingencies"*

*Source: U.S. Army War College, "An Approach to Long-Range Strategic Planning."

the basic environment) and to create the conditions necessary for success within that environment. Whereas the core strategy deals with the constants of the environments, the basic strategy copes with the variable features.

But the basic strategy is not by itself sufficient for coping with the variable parts of the environments. What if the basic strategy fails to create the preferred environment? And, supposing the preferred environment is achieved, what if surprises should occur which are not explicit features of that environment? For these contingencies, the basic strategy must be supplemented by a hedging strategy.*

The core, basic, and hedging strategies are diagramed in figure 3, where a second circle has been added to incorporate the preferred or basic environment. The core strategy now lies at the center, corresponding to the core environment. The basic strategy derives from an arrow aimed to result in, and act within the basic environment. The hedging strategy is a set of measures coping with the possibility that one of the other alternative environments, or exogenous contingencies may arise. To continue with the author's description, figure 3

...distorts the relationship among the strategies somewhat, because if the core and basic strategies are thoughtfully designed, the hedging strategy will consist of a few measures of diminutive importance by comparison with the core and basic strategies. As figure 3 shows, the hedging strategy copes with the exogeneous contingencies and with contingencies arising from the other environments--insofar as the basic strategy cannot cope with them. But invariably, a carefully designed basic strategy will be able to deal with many of these contingencies.**

3.3.1.4 Level of Threat. With respect to this basic strategy, the authors felt that, due to the complexities and uncertainties of any projected world environment, it would be foolish

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*Ibid., pp. 6-7.
**Ibid., p. 7.

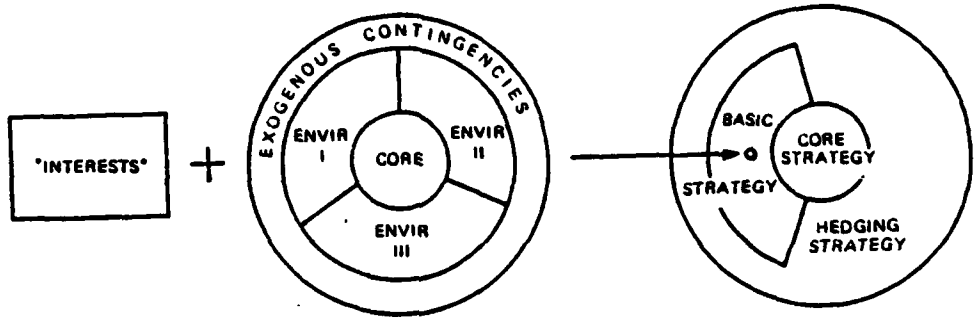

Figure 3. Application of Forecast to Strategic Planning*

*Source: U.S. Army War College, "An Approach to Long-Range Strategic Planning."

to attempt to design forces to meet a specific list of projected likely threats. Again, to quote their report:*

> So many possible contingencies and threats exist, to which no confident assignment of probabilities can be made, that designing counter-forces in this fashion would have to be either: (1) quite arbitrary in choosing likely threats, or (2) extremely wasteful because it was patterned to meet a very long list of threats, only a few of which would ever occur.
>
> Instead of planning forces around attempts to meet individual threats, one by one, it is therefore preferable to design a force structure and strategy which can clearly operate in the projected environment and which is clearly within U.S. economic and other capabilities, and which clearly has the capability to meet most low-level and moderate-level threats which might arise in the environment.
>
> This may not sound very different from standard conceptions, but there are crucial differences. In short-run planning for Asia, the United States faces half a dozen or a dozen important contingencies and can carefully calculate the likelihood of each one, the likelihood that two or more would occur simultaneously, and the specific forces required to meet all the likely combinations. In long-run planning, there are hundreds of contingencies and combinations of contingencies whose likelihoods are not calculable within reasonable limits. So instead of picking a <u>specific set of threats</u> and designing forces to meet them, it is more desirable to choose a level of threat for which constant readiness and forces in-being are required. A mobilization strategy can then be patterned for higher levels of threats.*

3.3.2 <u>Assessment</u>. The basic objective for a forecast should be to identify a general level of environment or, as in the case of the defense planner, a level of threat. This objective is crucial since it is only in light of its environment

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*Ibid., p. 11.

that the impact of an event can be judged. A significant future event, political or otherwise, will be defined in terms of the future environment in which it will occur (e.g., drop a lit match in water or drop it in gas). Obviously, events both foreseen and unforeseen influence the evolution of that environment, so the forecaster must make his three-tiered projections, as in the Army study, on a broad scale probabilistic basis. Such projections require a model of the evolving environment or system, i.e., a rigorous, formal, and, wherever possible, quantitative statement of how things work. For strategic forecasts, such a model would have to derive from the modeler's perspective on international relations theory.

3.4 Theoretical Foundation

As suggested in the previous section, in order to project a future environment, we must assess the regularities or pattern-relations of the present evolving environment, i.e., develop a theory. A valid theory is one that tests against present and past facts. This "goodness of the fit" test establishes the probability of the future state. To the extent that a theory (model) tells us how a system works in general, we are able to predict the effect of an event or class of events. Of course, the validity of this prediction depends on the accuracy and structural stability of our model. Hence, in order to build or evaluate a model, the forecaster must begin with a general understanding of the strengths and deficiencies of current international relations theory.

A definite and sometimes overlapping link exists between the concerns of the forecaster seeking to predict a future environment for planning purposes and those of the scholar seeking to understand why events occur. For this reason, some effort must be made to inventory and match the concepts, assumptions, interests, and other attributes of policy analysis with the similarly identified attributes found in the theories and hypotheses formulated, researched, and tested by social scientists. These attributes include, for example, theories about national power, threats, deterrence national aspirations, crisis behavior, and internal stability, all of which are concerns for strategic analysis within the DOD. In addition, for at least the past decade, interest has grown among international theorists in the development of conceptual and methodological tools to anticipate changes in the global environment. Unfortunately, most of this knowledge has remained confined to the social science community itself.

Only limited efforts have been made by this community to show how such knowledge might usefully be introduced into the policymaking process. Considering the increased requirement for accurate forecasting the limitations of the present means to meet that requirement, a closer link must be established between the planner and the theorist.

3.4.1 Survey of International Relations Theory*. Unfortunately, as with the other social sciences, the numerous theory building efforts over the past generation have not yielded a general theory of international behavior. Instead, multiple schools of thought have developed, differing in goals, approaches, levels of analysis, and concepts. This review emphasizes those perspectives most applicable to forecasting. Normative theories, which are more goal oriented, are therefore not discussed.

3.4.1.1 Approaches. Two primary perspectives have become important in the field of international relations since World War II, these being realist and behavioralist theory. As opposed to normative theory, their purpose is more to explain world trends and events than to establish and evaluate foreign policy against normative standards.

3.4.1.1.1 Realist Theory. Realist theory was developed as an effort to both describe interstate behavior and to provide a framework for the use of policymakers. Through the analysis of history, realist theory has sought to demonstrate recurring patterns in international behavior by isolating the factor of national power as the key explanatory variable requiring intensive analysis. For example, in Hans Morgenthau's words, "international politics, like all politics, is a struggle for power."** Primary exponents of this view have included Morgenthau, A.F.K. Organski, George Kennan, Robert Strausz-Hupe, and Henry Kissinger. Relying principally on historical experience for validation, the realists purport

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*This discussion is derived from Robert Pfaltzgraff's article, "International Relations Theory: Retrospect and Prospect," International Affairs, Vol. 50, No. 1, January 1974, pp. 28-48.

**Morgenthau, Hans J., Politics Among Nations, Knopf, Inc., New York, 1972, p. 27.

to furnish a description of the political behavior of rational actors. Although the assumption itself is the subject of controversy, the concept of rationality has provided a core concept for other theories, including game theory and deterrence theory, as well as certain types of decisionmaking theory. The view has been faulted for an alleged excessive preoccupation with power as a central element in international relations and its alleged lack of precision in defining and analyzing such concepts as national interest and balance of power. However, the focus of its concern coincides directly with that of the DOD planner.

3.4.1.1.2 Behavioralist Theory. Increasingly popular during the 1960s, behavioralist theory, like realist theory, seeks to provide a perspective which is both explanatory and predictive. However, it criticizes the earlier nonquantitative or traditionalist scholars for not being concerned explicitly with the formulation and testing of hypotheses and the construction of models or theories based on logically interlinked hypotheses. The view holds that international relations theory can be defined as a symbolic construction, a series of interrelated constructs or concepts, together with definitions, laws, theorems, and axioms. The behavioralists heavily emphasize quantification as a basis for precision, and thus place a great deal of reliance on methodologies based on statistics and mathematics. Mortan Kaplan has been a primary exponent of this approach, setting forth in elaborate form a set of interrelated laws deductively connected on a range of alternative international systems (including, for example, tight and loose bipolar systems, balance of power, and fully multipolar systems with all actors possessing nuclear weapons).* However, the behavioralists have been criticized for attempting an allegedly impossible task in that the factors sustaining international life are so numerous and complex and vary so greatly according to circumstances. For example, deficiencies in systems analysis have been cited in behavioralisms dealing with such irrational and uncertain forces as charisma and ideology, or the propensity of some individual actors to adopt high risk and others low risk strategies. Also, according to the critics, a better effort is necessary to explain the value assumptions of systems analysis.

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*Mortan A. Kaplan, System and Process in International Politics, Wiley, Inc., New York, 1958.

Finally, behavioralism is said to place too great a trust in inadequate or unreliable data resources to allow confident analysis or prediction. Still, the behavioralist models do provide a basis for comparison and analysis of real world environments. In addition, realist theory combined with certain systems approaches, by their reference to power and national interest as the key explanatory variables, represent probably the most ambitious effort yet to develop a grand theory of international behavior.

3.4.1.2 Levels of Analysis. Especially in the past decade, scholars have tried to delineate the following levels of analysis in international relations, and develop theories addressed to each: the international system, the national unit, and the individual. There has been much theorizing in recent years that can be categorized within one, and in some cases more than one, of these levels.

3.4.1.2.1 International System (Macrolevel). International relations theorists of the realist school, and more recently the behavioralists, have stressed the importance of the structure or power relationships within the international system as the primary motivating factor for national behavior. Three primary conditions for power relationships within the international system have been identified: balance of power, bipolarity, and multipolarity. Conflict or cooperation among states is considered largely as a function of the nature of the international system and, in particular, of the number of actors and the distribution of power among them. In recent years, the international system has been perceived as shifting from one of bipolarity to multipolarity. Recent American foreign policy has been based on this perception. Current questions raised in this context ask how the nature of the international system affects the range of foreign policy choices available to nations and what is the implication of multipolarity as it pertains to the frequency and intensity of war. Thus far, the answers to these questions have been inconclusive. In addition, with the advent of modern technology (particularly in transportation and mass communications), nations have been perceived as becoming more permeable to outside influences. Thus scholars have begun to describe linkages between the international system and domestic political systems and subsystems. Linkage theory has led to other questions, such as whether or not larger, more stable, homogeneous states are better able to ward off foreign influences. These questions also remain unanswered.

3.4.1.2.2 National Unit Level. Linkage theory might be considered as dealing with both the international system and the national unit levels of analysis. At the national unit level, authors have attempted to examine in detail the nature of differences as well as similarities among nation states. Recently, much attention has been focused on establishing common conceptual frameworks among several nations. For example, what similarities can be found in the foreign policies of great powers, small powers, democracies, and/or of authoritarian states?

3.4.1.2.3 Individual Unit Level. Theories at the individual level are oriented to sociopsychological analysis. Questions at this level relate to the perceptions of leaders and elite classes that help shape a country's foreign policy. These perceptions include their view of the world around them, their "psycho-milieu", how their perceptions affect the foreign policy choices made, and whether or not the differences in patterns of foreign policy decisionmaking depend on whether or not they are made during a crisis. Some writers have attempted to analyze the behavior of larger groups by reference to individual behavior, using frustration aggression hypotheses, animal instinct theories, and image theories (national images are said to reflect a process of selective perception).

3.4.1.3 Middle Range Concepts. Middle range theories are intended to explain more limited, yet important, phenomena such as international conflict, regional integration, foreign policy decisionmaking, and (at an even more limited level) transaction patterns among national units during crises or the relationships between patterns of domestic violence and a nation's propensity for international conflict. In general, these theories could be considered "islands" which one day may be linked into a more comprehensive theory of international relations. Two such middle range theories are those of international conflict and integration.

3.4.1.3.1 International Conflict. Theories of international conflict abound at each level of analysis, but unfortunately no single general view can explain the full varieties of possible conflict. If it could be developed, such a theory would require contributions from many disciplines and would combine insights from each of the levels of analysis discussed earlier in this subsection.

3.4.1.3.2 Integration. Integration theorists have developed a variety of models and drawn upon several disciplines for concepts and hypotheses. Their writings address such subjects as the extent and conditions under which integration in one sector leads to integration in others, and whether or not the integration of certain technical and economic sectors (such as trade or monetary policy) lead to "spillover" to other economic sectors. The European Economic Community experience has provided an important source of data for integration studies. However, current integration models have been faulted for not taking sufficient consideration of the role of conflict in increasing the cohesiveness of groups (this is perhaps due to a certain normative bias among integration theorists). Integration as a concept needs to be broken down into economic, political, and social components in order to address such subjects as mass public opinion support, elite support, the volume of transactions such as trade and communications, the nature of intergovernmental cooperation, and the building of political institutions at the international level.

3.4.1.4 Assessment. As has been suggested in this discussion, the numerous theory building efforts in the field of international relations have not yielded a general theory of international behavior, nor have they produced a widely accepted middle range theory. The gap between the qualitative and quantitative approaches and their practitioners remains great, and theorists disagree about the relative importance of deduction as opposed to induction in building theory. The field of international relations has been accused of consisting simply of a variety of theories, paradigms, and methodologies in search of a replicator (and also compared to the proverbial blind men describing an elephant).* It is a situation that should give the forecaster a healthy sense of caution.

However, the various approaches and methods in international relations theory are in many cases mutually reinforcing. Realist theory has come closest to meeting the requirement for a general theory of international relations. Its aim is to provide a framework for the use of policymakers, and in many cases the perceived factors of national power may be quantifiable. Consequently, if the forecaster cannot predict likely events in the future, he may be able to assess likely

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*Pfaltzgraff, op. cit., pp. 44-45.

future power relationships among nations that will influence those events. Thus, Ray Cline's methodology for quantifying factors of national power is of strong interest to this study.

3.4.2 World Power Assessment. The IDA critique pointed out a crucial concern between the role of long-range forecasting and the decisionmaker. The decisionmaker must identify what he wants, what he can have, and what he needs. However, as IDA cautions:

> ...the decisionmaker probably cannot tell what he wants from the long range, nor does he know how it will affect his plans or decisions. Given the opportunity to be explicit, the decisionmaker probably would not take it, preferring maximum flexibility.*

A survey of existing models for their applicability to the support of the JCS long range planning must be conducted on the basis of somewhat arbitrarily established guidelines. This consideration is also necessary since, with limited exceptions, none of the available forecasting models reviewed was identified as oriented to military concerns.

Three goals were identified at the beginning of section 2 as providing the overall direction for planning for U.S. national security. From the standpoint of JCS long range planners, each goal directly relates to the need for a relatively accurate forecast of any future potential military threat to the United States. Thus, the primary concern of the JLRSS must relate to perceived trends in the world balance of power. In addition, as the previous review of the current status of international relations theory has suggested, realist theory, with its concerns related to national power as the primary motivator for international behavior, comes closest to meeting the requirement for a general theory of international relations. Consequently, a forecast of the future balance of power will provide both a picture of the world in which the United States will have to operate and a basis for assessing future potential alliances and sources of instability. A means must therefore be established by

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*Gilmer and Wainstein, op. cit., p. 48.

which to assess the factors of national power and then forecast their likely status on a national and regional basis for the future.

Ray Cline at Georgetown University's Center for Strategic and International Studies has recently developed a novel approach to the assessment of the elements of power in international politics.* His purpose is to develop a "...simpler, more realistic model for analyzing today's power balance."** Cline defines power in the international arena as the ability of one state to cause the government of another state to do something which it would otherwise not do, whether by persuasion, coercion, or outright military force. Thus, "perceived power" is the decisive factor and Cline defines an equation for it as follows:***

$$P_p = (C + E + M) \times (S + W)$$

where

P_p = Perceived Power

C = Critical Mass (Population + Territory)

E = Economic Capability

M = Military Capability

S = Strategic Purpose

W = Will to Pursue National Strategy

As he says, the equation is not a "magic measuring rod" since the variables are not truly quantifiable. However, it does provide a shorthand notation or indexing system to replace words and judgments. Cline restricts his discussion to present power relationships, but from the standpoint of this review, such an equation may also provide a useful framework for structuring a forecast of future international power relationships.

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*Ray S. Cline, World Power Assessment: A Calculus of Strategic Drift, Georgetown University, Washington, D.C., 1975.

**Ibid., p. 4.

***Ibid., p. 11.

3.4.2.1 Factors of Perceived Power. The factors incorporated in Cline's equation are quantified on the basis of arbitrarily assigned rank list weights. This procedure is felt to be necessary for the sake of simplicity and due to the frequent lack of reliable data available for the factors considered. Still, as he suggests, gross orders of magnitude are nonetheless significant in weighting power relationships. The factors of perceived power are critical mass, economic capability, military capability, total macrometric power pattern, and national will and national strategy.

3.4.2.1.1 Critical Mass. A nation's size provides a large psychological influence on general perceptions of its power. The judgment of the size of a nation incorporates population and geographic area with each factor accorded a numeric weight of from 0 to 5 in Cline's grading scale (see tables 1 and 2). For example, the United States and the Soviet Union are each given power weights of 5 for the size of their population and 5 for the size of their territory.

3.4.2.1.2 Economic Capability. What a nation has accomplished with its available land and natural resources is a critical factor in its own and other nations' perceptions of its power. In addition, a nation's economy is important as a basis on which it can build organized military capabilities, manufacture arms, and provide the logistic and technical support needed for modern armies, navies, and air forces. However, in addition to the size of a nation's GNP (for which he assigns weighted grades of from 0 to 10), Cline has selected five factors for which reasonably good data are available and which are recognized as highly visible elements of a nation's economic capability. These factors are as follows: energy, critical nonfuel minerals, steel production, food, and foreign trade (see table 3). Weighted grades of from 0 to 2 are assigned for each factor. However, in assigning values for GNP, Cline considers the fact that autocratic economies can allocate their efforts to military and industrial products more easily than consumer oriented economies. Thus, although the size of the Soviet Union's GNP is half that of the U.S., it is accorded a perceived power weight of 8 as opposed to 10 for the U.S.

3.4.2.1.3 Military Capability. Perceptions of military capability are highly subjective, but they should consider two crucial elements: nuclear deterrence capability (if any) and conventional nonnuclear forces. The latter element can be assessed on the basis of three factors: scale of military

Table 1. Critical Mass: Major Countries Weighted for Population and Territory*

	Country	Perceived Power Weight: Population	Territory
1	China (PRC)	5	5
2	India	5	4
3	USSR	5	5
4	United States	5	5
5	Indonesia	5	3
6	Japan	5	1
7	Brazil	5	4
8	Bangladesh	4	0
9	Pakistan	4	2
10	West Germany (FRG)	4	1
11	Nigeria	4	2
12	Mexico	4	3
13	United Kingdom	4	1
14	Italy	4	1
15	France	4	1
16	Philippines	3	1
17	Thailand	3	1
18	Turkey	3	2
19	Egypt	3	2
20	Spain	3	1
21	Poland	3	1
22	South Korea	3	0
23	Iran	3	3
24	Burma	3	2
25	Ethiopia	3	2
26	Colombia	3	2
27	Argentina	3	4
28	South Africa	3	2
29	Zaire	3	3
30	North Vietnam (Indochina)	3	0
31	Canada	3	5
32	Yugoslavia	3	1
33	Rumania	3	0
34	South Vietnam	3	0
35	Afghanistan	2	2
36	Sudan	2	3
37	Morocco	2	1
38	East Germany (DRG)	2	0
39	Sri Lanka	2	0
40	Algeria	2	3
41	North Korea	2	0
42	China/Taiwan	2	0
43	Tanzania	1	2
44	Czechoslovakia	1	0
45	Peru	1	2
46	Netherlands	1	0
47	Australia	1	4
48	Kenya	1	1
49	Nepal	1	0
50	Venezuela	1	2
51	Libya	0	3
52	Saudi Arabia	0	3
53	Mongolia	0	3

*Source: Ray S. Cline, World Power Assessment.

Table 2. Critical Mass: Population Plus Territory*

Country	Weight	Country	Weight	Country	Weight
1 China (PRC)	10	19 Turkey	5	37 Rumania	3
2 USSR	10	20 Egypt	5	38 South Vietnam	3
3 United States	10	21 Burma	5	39 Morocco	3
4 India	9	22 Ethiopia	5	40 Tanzania	3
5 Brazil	9	23 South Africa	5	41 Peru	3
6 Indonesia	8	24 Sudan	5	42 Venezuela	3
7 Canada	8	25 Algeria	5	43 Libya	3
8 Mexico	7	26 Australia	5	44 Saudi Arabia	3
9 Argentina	7	27 Colombia	5	45 Mongolia	3
10 Japan	6	28 Bangladesh	4	46 East Germany (DRG)	2
11 Pakistan	6	29 Philippines	4	47 Sri Lanka	2
12 Nigeria	6	30 Thailand	4	48 North Korea	2
13 Iran	6	31 Spain	4	49 China/Taiwan	2
14 Zaire	6	32 Poland	4	50 Kenya	2
15 West Germany (FRG)	5	33 Yugoslavia	4	51 Czechoslovakia	1
16 United Kingdom	5	34 Afghanistan	4	52 Netherlands	1
17 Italy	5	35 South Korea	3	53 Nepal	1
18 France	5	36 North Vietnam (Indochina)	3		

*Source: Ray S. Cline, World Power Assessment.

Table 3. Economic Strengths: Consolidated Rank List With Bonus Values* (Part 1 of 2)

Country	Critical Mass	GNP	Energy	Minerals	Food	Steel	Trade	Econ. Total	Total
1 United States	10	10	2	2	2	2	2	20	30
2 USSR	10	8	2	2	—	2	2	16	26
3 Canada	8	4	1	2	2	—	2	11	19
4 China (PRC)	10	4	1	—	—	1	1	7	17
5 Japan	6	6	—	—	—	2	2	10	16
6 France	5	4	1	1	1	1	2	10	15
7 West Germany (FRG)	5	5	1	—	—	2	2	10	15
8 Brazil	9	3	—	1	—	—	1	5	14
9 India	9	3	1	—	—	—	—	4	13
10 United Kingdom	5	4	1	—	—	1	2	8	13
11 Australia	5	3	1	1	1	—	1	7	12
12 Italy	5	4	—	—	—	1	2	7	12
13 Iran	6	3	1	—	—	—	1	5	11
14 Mexico	7	3	1	—	—	—	—	4	11
15 South Africa	5	2	1	1	1	—	1	6	11
16 Indonesia	8	1	1	—	—	—	—	2	10
17 Argentina	7	2	—	—	1	—	—	3	10
18 Poland	4	3	1	—	—	—	1	5	9
19 Nigeria	6	1	1	—	—	—	—	2	8
20 Spain	4	3	—	—	—	—	1	4	8
21 Pakistan	6	1	—	—	—	—	—	1	7
22 Turkey	5	2	—	—	—	—	—	2	7
23 Netherlands	1	3	1	—	—	—	2	6	7
24 East Germany (DRG)	2	3	1	—	—	—	1	5	7
25 Zaire	6	—	—	—	—	—	—	0	6
26 Egypt	5	1	—	—	—	—	—	1	6
27 Yugoslavia	4	2	—	—	—	—	—	2	6
28 Algeria	5	—	1	—	—	—	—	1	6
29 Rumania	3	2	1	—	—	—	—	3	6
30 Venezuela	3	1	1	—	—	—	1	3	6
31 Colombia	5	1	—	—	—	—	—	1	6
32 Burma	5	—	—	—	—	—	—	—	5
33 Ethiopia	5	—	—	—	—	—	—	—	5
34 Sudan	5	—	—	—	—	—	—	—	5
35 Philippines	4	1	—	—	—	—	—	1	5
36 Thailand	4	1	—	—	—	—	—	1	5
37 Saudi Arabia	3	1	1	—	—	—	—	2	5
38 Czechoslovakia	1	2	1	—	—	—	1	4	5
39 Belgium	—	3	—	—	—	—	2	5	5
40 Sweden	1	3	—	—	—	—	1	4	5
41 Bangladesh	4	—	—	—	—	—	—	—	4

*Source: Ray S. Cline, World Power Assessment.

Table 3. (Part 2 of 2)

	Country	Critical Mass	GNP	Energy	Minerals	Food	Steel	Trade	Econ. Total	Total
42	Afghanistan	4	—	—	—	—	—	—	—	4
43	South Korea	3	1	—	—	—	—	—	1	4
44	Peru	3	1	—	—	—	—	—	1	4
45	Libya	3	—	1	—	—	—	—	1	4
46	China/Taiwan	2	1	—	—	—	—	1	2	4
47	North Vietnam	3	—	—	—	—	—	—	—	3
48	South Vietnam	3	—	—	—	—	—	—	—	3
49	Morocco	3	—	—	—	—	—	—	—	3
50	Tanzania	3	—	—	—	—	—	—	—	3
51	Mongolia	3	—	—	—	—	—	—	—	3
52	Switzerland	—	2	—	—	—	—	1	3	3
53	Austria	—	2	—	—	—	—	1	3	3
54	Denmark	—	2	—	—	—	—	1	3	3
55	Finland	1	1	—	—	—	—	1	2	3
56	Chile	2	1	—	—	—	—	—	1	3
57	Norway	1	1	—	—	—	—	1	2	3
58	Hungary	—	1	—	—	—	—	1	2	2
59	Sri Lanka	2	—	—	—	—	—	—	—	2
60	North Korea	2	—	—	—	—	—	—	—	2
61	Kenya	2	—	—	—	—	—	—	—	2
62	New Zealand	1	1	—	—	—	—	—	1	2
63	Iraq	1	—	1	—	—	—	—	1	2
64	Nepal	1	—	—	—	—	—	—	—	1
65	Bulgaria	—	1	—	—	—	—	—	1	1
66	Greece	—	1	—	—	—	—	—	1	1
67	Portugal	—	1	—	—	—	—	—	1	1
68	Israel	—	1	—	—	—	—	—	1	1
69	Kuwait	—	—	1	—	—	—	—	1	1
70	United Arab Emirates	—	—	1	—	—	—	—	1	1

expenditures (level of effort), size of armed forces, and global deployability or sea control potential (see table 4). A nation's nuclear deterrence strength factor is given a weight of from 0 to 15 (see table 5) while conventional strength is assessed on a scale of from 0 to 5 (see table 4).

3.4.2.1.4 Total Macrometric Power Pattern. Table 6 demonstrates the total combined values assigned for critical mass, national economy, and military power.

3.4.2.1.5 National Will and National Strategy. The most subjective and, in Cline's view, one of the most important factors in the equation is the assessments of national will and national strategy. That is, a nation may be efficient or inept in carrying out its policies, depending on the strength of the political will of the people as expressed in their national decisionmaking. As Cline suggests, the degree of energy and coherent behavior in a nation is the main source of its success or failure.* As to national strategy, powerful nations need a global strategy by which to focus their attentions. Secondary or tertiary powers fashion policies on a more regional basis and more in accordance with associations formed with powerful nations. Cline assigns a total possible index weight of 1 for national will and strategic purpose combined (0.5 + 0.5), but for larger nations with clear cut plans for international aggrandizement, he assigns a maximum value of 1 for strategic purpose alone. Also, he assigns a maximum value of 1 for national will if a nation is socially, psychologically, and politically unified. The striking fact emerging from this entire method of analysis is that national purpose and national will critically affect the relative power of nations (see table 7).

3.4.2.2 Power Groupings. In addition to individual nations, Cline addresses the subject of international power relationships on a group basis. In this case, he coins the word "politectonics" to denote the gradual formation and breakup of power groupings (mainly regional in makeup) that he feels determine the real balance of influence and force in international affairs. He identifies 11 groups of nations:

a. North America

b. USSR and the Eurasian heartland

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*Ibid., p. 97.

Table 4. Conventional Military Capability: Perceived Power* (Part 1 of 2)

Country	Level of Effort	Armed Forces	Global Reach	Total
1 United States	2	2	1	5
2 USSR	2	2	0	4
3 China (PRC)	2	2	0	4
4 North Vietnam (Indochina)	2	2	0	4
5 China/Taiwan	2	2	0	4
6 North Korea	2	2	0	4
7 Pakistan	2	2	0	4
8 United Kingdom	2	2	0	4
9 India	1	2	0	3
10 South Korea	1	2	0	3
11 France	1	2	0	3
12 West Germany (FRG)	1	2	0	3
13 Turkey	1	2	0	3
14 Italy	1	2	0	3
15 Egypt	2	1	0	3
16 Portugal	2	1	0	3
17 Iran	2	1	0	3
18 Nigeria	2	1	0	3
19 East Germany (DRG)	2	1	0	3
20 Israel	2	1	0	3
21 Poland	1	1	0	2
22 Spain	1	1	0	2
23 Indonesia	1	1	0	2
24 Yugoslavia	1	1	0	2
25 Brazil	1	1	0	2
26 Czechoslovakia	1	1	0	2
27 Syria	2	0	0	2
28 Jordan	2	0	0	2
29 Saudi Arabia	2	0	0	2
30 Iraq	2	0	0	2
31 Yemen (Aden)	2	0	0	2
32 United Arab Emirates	2	0	0	2
33 Qatar	2	0	0	2
34 Somalia	2	0	0	2
35 Sudan	2	0	0	2
36 Albania	2	0	0	2
37 Cuba	2	0	0	2
38 Burma	2	0	0	2

*Source: Ray S. Cline, World Power Assessment.

Table 4. (Part 2 of 2)

	Country	Level of Effort	Armed Forces	Global Reach	Total
39	Singapore	2	0	0	2
40	Mongolia	2	0	0	2
41	Japan	0	1	0	1
42	Canada	1	0	0	1
43	Greece	1	0	0	1
44	Netherlands	1	0	0	1
45	Belgium	1	0	0	1
46	Norway	1	0	0	1
47	Denmark	1	0	0	1
48	Hungary	0	1	0	1
49	Rumania	0	1	0	1
50	Bulgaria	0	1	0	1

Table 5. Nuclear Deterrence Strength*

Country	*Nuclear Deterrence and War Fighting*
USSR	15
United States	15
United Kingdom	2
France	2
China (PRC)	2

*Source: Ray S. Cline, World Power Assessment.

Table 6. Total Macrometric Power Pattern ($P_p = C + E + M$)* (Part 1 of 2)

	Country	Critical Mass	Capability		
			Economic	Military	Total
1	United States	10	20	20	50
2	USSR	10	16	19	45
3	China (PRC)	10	7	6	23
4	Canada	8	11	1	20
5	France	5	10	5	20
6	United Kingdom	5	8	6	19
7	West Germany (FRG)	5	10	3	18
8	Japan	6	10	1	17
9	Brazil	9	5	2	16
10	India	9	4	3	16
11	Italy	5	7	3	15
12	Iran	6	5	3	14
13	Australia	5	7	0	12
14	Indonesia	8	2	2	12
15	Nigeria	6	2	3	11
16	Mexico	7	4	0	11
17	South Africa	5	6	0	11
18	Poland	4	5	2	11
19	Pakistan	6	1	4	11
20	Argentina	7	3	0	10
21	Spain	4	4	2	10
22	Turkey	5	2	3	10
23	East Germany (DRG)	2	5	3	10
24	Egypt	5	1	3	9
25	Netherlands	1	6	1	8
26	Yugoslavia	4	2	2	8
27	China/Taiwan	2	2	4	8
28	Rumania	3	3	1	7
29	Burma	5	0	2	7
30	Sudan	5	0	2	7
31	Saudi Arabia	3	2	2	7
32	Czechoslovakia	1	4	2	7
33	South Korea	3	1	3	7
34	North Vietnam (Indochina)	3	0	4	7
35	Zaire	6	0	0	6
36	Algeria	5	1	0	6
37	Venezuela	3	3	0	6
38	Colombia	5	1	0	6
39	Belgium	0	5	1	6
40	North Korea	2	0	4	6

*Source: Ray S. Cline, World Power Assessment.

Table 6. (Part 2 of 2)

Country	Critical Mass	Capability: Economic	Capability: Military	Total
41 Ethiopia	5	0	0	5
42 Philippines	4	1	0	5
43 Thailand	4	1	0	5
44 Sweden	1	4	0	5
45 Mongolia	3	0	2	5
46 Portugal	0	1	3	4
47 Bangladesh	4	0	0	4
48 Afghanistan	4	0	0	4
49 Peru	3	1	0	4
50 Libya	3	1	0	4
51 Denmark	0	3	1	4
52 Israel	0	1	3	4
53 Norway	1	2	1	4
54 Iraq	1	1	2	4
55 Morocco	3	0	0	3
56 South Vietnam	3	0	0	3
57 Tanzania	3	0	0	3
58 Switzerland	0	3	0	3
59 Austria	0	3	0	3
60 Chile	2	1	0	3
61 Finland	1	2	0	3
62 United Arab Emirates	0	1	2	3
63 Somalia	1	0	2	3
64 Hungary	0	2	1	3
65 Greece	0	1	1	2
66 Bulgaria	0	1	1	2
67 Sri Lanka	2	0	0	2
68 Kenya	2	0	0	2
69 Syria	0	0	2	2
70 Jordan	0	0	2	2
71 Yemen (Aden)	0	0	2	2
72 Qatar	0	0	2	2
73 Albania	0	0	2	2
74 Cuba	0	0	2	2
75 Singapore	0	0	2	2
76 New Zealand	1	1	0	2
77 Nepal	1	0	0	1
78 Kuwait	0	1	0	1
				Total 627

Table 7. Final Assessment, Perceived Power Among Individual Nations and Politectonic Zones*

Zone	Country	Elements of Perceived Power	Coefficient for National Strategy and Will	Total Weighted Units of Perceived Power	Politectonic Zone Totals
I	United States	50	0.7	35	
	Canada	20	0.9	18	
	Mexico	11	0.9	9.9	
	Subtotal	81			62.9
II	USSR	45	1.5	67.5	
	Poland	11	1.0	11	
	East Germany (DRG)	10	1.0	10	
	Czechoslovakia	7	1.0	7	
	Rumania	7	1.0	7	
	Cuba	2	1.6	3.2	
	Subtotal	82			105.7
III	China (PRC)	23	1.0	23	
	North Vietnam (Indochina) (with South Vietnam)	10	1.4	14	
	North Korea	6	1.6	9.6	
	Subtotal	39			46.6
IV	West Germany (FRG)	18	1.5	27	
	France	20	1.2	24	
	United Kingdom	19	1.0	19	
	Italy	15	0.8	12	
	Netherlands	8	1.5	12	
	Spain	10	0.8	8	
	Yugoslavia	8	0.7	5.6	
	Portugal	4	0.3	1.2	
	Subtotal	102			108.8
V	Iran	14	1.4	19.6	
	Egypt	9	1.1	9.9	
	Saudi Arabia	7	1.4	9.8	
	Turkey	10	0.8	8	
	Israel	4	1.8	7.2	
	Subtotal	44			54.5
VI	India	16	0.8	12.8	
	Pakistan	11	1.0	11	
	Subtotal	27			23.8
VII	Indonesia	12	1.0	12	
	Singapore	2	1.5	3	
	Subtotal	14			15
VIII	Japan	17	1.0	17	
	China/Taiwan	8	1.5	12	
	South Korea	7	1.3	9.1	
	Subtotal	32			38.1
IX	Brazil	16	1.3	20.8	
	Venezuela	6	1.5	9	
	Argentina	10	0.5	5	
	Subtotal	32			34.8
X	Nigeria	11	1.0	11	
	South Africa	11	1.0	11	
	Zaire	6	1.0	6	
	Subtotal	28			28
XI	Australia	12	1.1	13.2	
	New Zealand	2	1.5	3	
	Subtotal	14			16.2
	Totals	498		351.7	351.7

*Source: Ray S. Cline, World Power Assessment.

c. China, North Korea, and Indochina

d. Western Europe

e. Middle East

f. South Asia

g. Southeast Asia excluding Indochina

h. Northeast Asia (Japan, South Korea, and Taiwan)

i. South America

j. Central and South Africa

k. Australia and New Zealand.

3.4.2.3 Results. Table 7 shows the final results of the application of Cline's complete equation using his input values for the 11 identified power groupings. Obviously, the final results reflect both the importance of the roles of National Strategy and National Will in the Perceived Power Equation and also the time period (1973) in which the values were assessed. For example, based on those computations, the perceived power and influence of the Soviet Union is considered to be nearly twice (67.5 versus 35) that of the United States.

3.4.2.4 Assessment. Considering its ambitious purpose and the very pessimistic results derived from its application, it should hardly be surprising that Cline's equation has been subject to criticism. The question of the significance of various factors that might constitute a nation's power and influence in the international environment is not one for easy resolution. Thus, an effort to define and grade such factors with some degree of specificity tends to be an open target for criticism, particularly once values are assigned to each variable. Then too, the highly subjective bases for Cline's computations are particularly apparent in the factors of National Will and Strategic Purpose since, whatever the validity of their assigned significance, that significance is so large that it overshadows the importance of more quantifiable variables such as military spending, natural resources, and population.

However, the very basis for much criticism of the equation, the fact Cline is willing to try to give some structure and specificity to an assessment of rational power, is what makes his equation attractive to this review. The equation remains broad enough to provide a general structure for an assessment of long range trends in rational power relationships. Unfortunately, as in Cline's application to the present world, the development of a reliable and stable measure of National Will and Strategic Purpose for a long term forecast remains problematic and may not be feasible. This concern must be addressed further in the future.

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SECTION 4. AVAILABLE MODELS, DATA RESOURCES, AND THEIR APPLICABILITY TO LONG-RANGE PLANNING

This study has suggested that rigorous mathematical models offer the best means by which to develop a forecast projection of quantifiable strategic indicators. Which factors are quantifiable is problematic and might better be answered upon a closer evaluation of the candidate models and data resources. In the meantime, this study has conducted a general survey and identified 18 forecasting models and 59 automated and hard copy data resources as potential vehicles by which to input data values to the Cline equation. A number of the surveyed models, most notably Forrester's and Meadow's "World 2" and "World 3," were reviewed in the interim report* but are no longer being considered at this time. In the case of World 2/3, the reasons for their exclusion are discussed in section 5.3.1 of this report.

It should also be emphasized that the following survey is merely a preliminary identification of candidate vehicles and resources since, within the constraints of this study, there was neither sufficient time nor adequate documentation available to conduct a more in-depth assessment of candidate models. Certain models, such as General Electric's TEMPO, the Census Bureau's LRPM and the Federal Energy Administration's IEES models also require a review which is not provided by this report.

4.1 Model Comparison

Table 8 provides a comparison of the components of the Cline perceived power equation versus the sectors addressed in the surveyed models. The identified strategic concerns also listed were compiled by the study group in consultation with CCTC in order to make the potentially quantifiable factors in the Cline equation more specific. They are also a preliminary list subject to further review and refinement.

Table 8 addresses global, regional, and partial forecasting models. A number of potentially valuable partial models focus on only a limited number of variables (i.e., energy, trade, population, etc.). This report includes these models

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*CSC Letter Report, op. cit., Section 3.2.3.

Table 8. Model Comparison (Part 1 of 2)

PERCEIVED POWER COMPONENT	GLOBAL: GLOBE 6	GLOBAL: CYBERNETIC WORLD MODEL	GLOBAL: WORLD INTEGRATED MODEL	REGIONAL: LONG RANGE REGIONALIZED FORECASTING MODELS	REGIONAL: CHINA I	REGIONAL: [illegible]	PARTIAL MODELS – ENERGY: SYSTEMS MAN ENERGY ENVIRONMENT	ENERGY: ALLOCATION OF ENERGY RESOURCES	ENERGY: WORLD PETROLEUM MODEL	ENERGY: ENERGY MODEL OF WORLD INTEGRATED MODEL	INTERNATIONAL TRADE: EXPLOR MULTITRADE	INTERNATIONAL TRADE: PROJECT LINK	INTERNATIONAL INTERACTION: UN PEACEKEEPING MODEL	INTERNATIONAL INTERACTION: DIMENSIONALITY OF NATIONS	INTERNATIONAL INTERACTION: [illegible]	POPULATION: INTERNATIONAL LABOR OFFICE (BACHUE)	POPULATION: POPULATION MODEL OF WORLD INTEGRATED MODEL	FOOD: FOOD MODEL OF THE WORLD INTEGRATED MODEL
CRITICAL MASS																		
TERRITORY																		
SIZE			X															
LOCATION																		
ACCESS TO SEA																		
INTERNAL TRANSPORTATION ARTERIES						X												
CLIMATE	X	X	X				X											
WATER RESOURCES			X															
POPULATION																		
SIZE	X	X	X	X	X		X									X	X	X
GROWTH RATE	X		X				X									X	X	X
AGE DISTRIBUTION			X													X	X	
DEMOGRAPHICS			X													X	X	
HEALTH STATISTICS			X														X	
MIGRATION																	X	
ECONOMIC CAPABILITY																		
GNP																		
GNP, ABSOLUTE & RELATIVE	X		X	X	X	X	X	X	X		X	X				X		
GNP GROWTH RATES	X	X	X	X		X		X	X		X	X				X		
INVESTMENT LEVEL		X	X	X							X	X						
TECHNOLOGY		X	X			X		X			X							
R&D INVESTMENT		X																
LEVEL & RATE OF DEVELOPMENT						X												
AREAS OF DEVELOPMENT			X			X		X										
NET EXPORTER/IMPORTER POSITION											X	X				X		
POPULATION EDUCATION LEVELS		X																
ENERGY																		
INTERNAL RESOURCES' TYPE & SIZE		X	X		X		X	X	X	X								
DEMAND			X				X	X		X								
SIZE			X				X	X	X	X								
TYPE			X				X	X	X	X								
GROWTH RATES			X				X	X	X	X								
DEPENDENCE ON EXTERNAL SOURCES			X					X	X	X	X	X						
INVESTMENT			X							X								
FOOD																		
FOOD PRODUCTION/GROWTH RATES	X	X	X		X	X												X
LEVEL OF PERSONAL CONSUMPTION/ TRENDS			X															X
ARABLE/NONARABLE LAND RATIO			X															X
LAND PRODUCTIVITY			X															X
CULTIVATED/NONCULTIVATED ARABLE LAND RATIO			X		X													X
NONFUEL MINERALS																		
INTERNAL RESOURCES	X	X	X				X											
DEMAND	X		X															
STEEL																		
PRODUCTION																		
DEMAND																		
INVESTMENT																		
TRADE																		
EXPORTS/IMPORTS	X		X	X		X					X	X						
TRADE GNP	X										X	X						
POLICIES												X						
NET DEBTOR POSITION											X	X						

Table 8. (Part 2 of 2)

PERCEIVED POWER COMPONENT	GLOBAL			REGIONAL			PARTIAL MODELS													
											INTERNATIONAL TRADE		INTERNATIONAL INTERACTION			POPULATION		FOOD
	CLOSS 6	CYBERNETIC WORLD MODEL	WORLD INTEGRATED MODEL	LONG RANGE REGIONALIZED FORECASTING MODELS	CHINA I	RUSSIA B	SYSTEMS MAN ENERGY ENVIRONMENT	ATTACHMENT OF ENERGY RESOURCES	WORLD PETROLEUM MODEL	ENERGY MODEL OF WORLD INTEGRATED MODEL	EXPLOR MULTITRADE	PROJECT LINK	UN PEACEKEEPING MODEL	UNRESPONSIVITY OF NATIONS	CLASSIFICATION	INTERNATIONAL LABOR (OPEC) (BACHER)	POPULATION MODEL OF WORLD INTEGRATED MODEL	FOOD MODEL OF THE WORLD INTEGRATED MODEL
MILITARY CAPABILITY																		
STRATEGIC																		
INTERCONTINENTAL BALLISTIC MISSILES				X*														
SUBMARINE-BORNE BALLISTIC MISSILES				X*														
SUBMARINES				X*														
NUCLEAR WEAPONS/WARHEADS				X*														
MANNED LONG RANGE BOMBERS				X*														
INTERREGIONAL BALLISTIC MISSILES				X*														
DEFENSE NETWORKS																		
R&D SPENDING																		
SPACE																		
CONVENTIONAL																		
LEVEL OF EFFORT																		
SCALE & NATURE OF EXPENDITURES				X*														
R&D SPENDING																		
SIZE OF ARMED FORCES																		
COMPOSITION OF ARMED FORCES																		
QUALITY/RELIABILITY OF FORCES AND LEADERSHIP																		
ARMAMENT				X*														
SUPPORT CAPABILITIES																		
GLOBAL DEPLOYABILITY																		
NAVAL SHIPS				X*														
NAVAL SHIP CONSTRUCTION																		
TACTICAL AND SUPPORT AIRCRAFT																		
ALLIANCE AGREEMENTS/DEPENDENCE																		
STRATEGIC PURPOSE																		
IDENTIFIED NATIONAL GOALS			X**															
CURRENT ALIGNMENTS				X									X		X			
FORMAL AGREEMENTS & TREATIES																		
ECONOMIC DEPENDENCE/ASSISTANCE																		
TRADE ALIGNMENTS/DEPENDENCE				X							X	X						
HISTORIC ALIGNMENTS/CONFLICTS				X										X	X			
NATIONAL WILL																		
NATURE OF GOVERNMENT																		
POLITICAL TRADITIONS		X			X													
CULTURAL PRIDE/UNITY/NAT'L MORALE																		
ELITE INSTABILITY				X									X		X			
HISTORIC PATTERNS		X		X														
MILITARY ROLE		X																
COMMUNAL INSTABILITY		X																
STUDENT ACTIVISM		X																
INSURGENT ACTIVITY																		
SOCIAL, ETHNIC, RELIGIOUS, LANGUAGE, AND ECONOMIC POLARIZATION		X														X		
RURAL/URBAN DISTRIBUTION/TRENDS	X													X				
NATIONALISM/IDEOLOGICAL COHESIVENESS																		
XENOPHOBIC ATTITUDES																		

* SOVIET UNION
** INPUT BY ANALYST

in addition to the more comprehensive global and regional models because of their potential value in constructing a multimodel forecasting system structured on the basis of the Cline equation. For future reference, this multimodel system is titled the MAFIAS system. Each of the surveyed models is described in section 5.

Table 8 demonstrates that a number of factors that should be of concern to OJCS long-range planning are not addressed by currently available models. Among these factors, the size and location of each country's territory can be considered a relative constant. However, certain other concerns, such as military capability, strategic purpose, and national will, might be better forecast through means such as those discussed in appendix A. The forecasts for these areas should obviously take into consideration the quantitative forecasts in other sectors (i.e., the forecast of a country's economic prospects affecting its prospective ability or necessity to maintain a larger or smaller military capability).

4.2 Data Resource Comparison

The adequacy of available data resources has been an important consideration in terms of the design, level of aggregation, and validity of simulation models. Data have yet to be collected specifically for world models, so it seems inevitable that some compromises will be necessary in such model development.* It has been noted that in the model design process, the choice of subsystem boundaries and levels of aggregation is often a matter of convenience dictated in part by the available data resources.** In addition, as Marvin Cetron of Forecasting International suggests, insufficient historical data frequently precludes the use of more sophisticated modeling techniques.*** However, as Cetron

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*Clark, John and Cole, Sam, Global Simulation Models: A Comparative Study, New York, John Wiley and Sons, 1975, p. 59.

**Ibid., p. 60.

***Cetron, J. Marvin, Technological Forecasting for Industry and Government, (James Bright, editor), Prentice-Hall, Inc., Englewood Cliffs, N.J., 1968, p. 151.

further notes, "substantial quantities of reliable data are available to forecasting models but have not been used."* It is therefore mandatory that a review of potential data resources be comprehensive and be conducted in a carefully systematic manner.

This study has identified 59 automated and hard copy data bases that appear to warrant further evaluation. Descriptions of 23 automated sources are available in section 6. Table 9 provides a matrix comparison of the subjects addressed by each of these resources against the factors identified in the Cline equation. Further evaluation will be required to assess the adequacy of these resources in light of their quality, the time spans addressed, the Cline equation, and the preferred model requirements.

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*Ibid., p. 151.

Table 9. Data Resources Comparison (Part 1 of 2)

PERCEIVED POWER COMPONENT	POTENTIAL DATA RESOURCES	
	AUTOMATED	NONAUTOMATED
CRITICAL MASS		
TERRITORY		
SIZE		NATIONAL BASIC INTELLIGENCE FACTBOOK
LOCATION		
ACCESS TO SEA		
INTERNAL TRANSPORTATION ARTERIES	CROSS NATIONAL TIME SERIES FILE	
CLIMATE		
WATER RESOURCES		
POPULATION		
SIZE	CROSS NATIONAL TIME SERIES FILE	NATIONAL BASIC INTELLIGENCE FACTBOOK
GROWTH RATE	UN DEMOGRAPHIC STATISTICS	
AGE DISTRIBUTION	COUNTRY DEMOGRAPHIC PROFILES	
DEMOGRAPHICS	DEMOGRAPHIC DATA RETRIEVAL SYSTEM	
HEALTH STATISTICS	SOCIOECONOMIC DATA BANK	WORLD HEALTH ORGANIZATION TECHNICAL REPORT 522
	SRI DATA BASES	
	SPECIAL APPLICATIONS FILE	
	FATHOM SYSTEM	
	CONFLICT AND PEACE DATA BANK	
ECONOMIC CAPABILITY		
GNP		
GNP, ABSOLUTE AND RELATIVE	UN DEMOGRAPHIC STATISTICS	NATIONAL BASIC INTELLIGENCE FACTBOOK
GNP GROWTH RATE	DATA RESOURCES, INC., DATA BANK	HANDBOOK OF ECONOMIC STATISTICS
INVESTMENT LEVEL	SPECIAL APPLICATIONS FILE	SURVEY OF CURRENT BUSINESS
	GENERAL INDUSTRIAL STATISTICS	INDUSTRIAL COMMODITY PRODUCTION
	FATHOM SYSTEM	
	CONFLICT AND PEACE DATA BANK	
TECHNOLOGY		
R&D INVESTMENT		SCIENCE CITATION INDEX
LEVEL & RATE OF DEVELOPMENT	CONFLICT AND PEACE DATA BANK	TECHNOLOGICAL INNOVATION INDEX
AREAS OF DEVELOPMENT		BATTELLE FOREIGN SCIENCE AND TECHNOLOGY LIBRARY
NET EXPORTER/IMPORTER POSITION	DATA FUND	GOVERNMENT R&D INVESTMENT
POPULATION EDUCATION LEVELS	CROSS NATIONAL TIME SERIES FILE	INTERNATIONAL TRADE STATISTICS
	COUNTRY DEMOGRAPHIC PROFILES	DYADIC TRADE DATA
	DEMOGRAPHIC DATA RETRIEVAL SYSTEM	
ENERGY		
INTERNAL RESOURCES, TYPE & SIZE	CHARACTERISTICS OF NATIONS	
DEMAND	WORLD ENERGY SUPPLIES	
SIZE		
TYPE		
GROWTH RATES		
DEPENDENCE ON EXTERNAL SOURCES	DATA FUND	BALANCE OF PAYMENTS YEARBOOK
INVESTMENT	CONFLICT AND PEACE DATA BANK	YEARBOOK OF NATIONAL ACCOUNT STATISTICS
		DYADIC TRADE DATA
		WORLD DEBT TABLES
FOOD		
FOOD PRODUCTION/GROWTH RATES	THREAT ANALYSIS RESEARCH PROJECT	NATIONAL BASIC INTELLIGENCE FACTBOOK
LEVEL OF PERSONAL CONSUMPTION/ TRENDS	COMMODITY DATA SUMMARIES	HANDBOOK OF ECONOMIC STATISTICS
ARABLE/NONARABLE LAND RATIO	WORLD CROP STATISTICS	PRODUCTION YEARBOOK
LAND PRODUCTIVITY	FOOD BALANCE SHEETS	FISHERIES YEARBOOK
CULTIVATED/NONCULTIVATED ARABLE LAND RATIO		
NONFUEL MINERALS		
INTERNAL RESOURCES	CHARACTERISTICS OF NATIONS	NATIONAL BASIC INTELLIGENCE FACTBOOK
DEMAND	COMMODITY DATA SUMMARIES	NON-FERROUS METAL. A SURVEY OF THEIR PRODUCTION AND POTENTIAL DEVELOPING COUNTRIES
		YEARBOOK ON METAL STATISTICS
STEEL		
PRODUCTION	GENERAL INDUSTRIAL STATISTICS	HANDBOOK OF ECONOMIC STATISTICS
DEMAND	UN INDUSTRIAL COMMODITY PRODUCTION STATISTICS	INDUSTRIAL COMMODITY PRODUCTION
INVESTMENT	COMMODITY DATA SUMMARIES	YEARBOOK ON METAL STATISTICS
TRADE		
EXPORTS/IMPORTS	CROSS NATIONAL TIME SERIES FILE	NATIONAL BASIC INTELLIGENCE FACTBOOK
TRADE GNP	UN INTERNATIONAL TRADE STATISTICS	HANDBOOK OF ECONOMIC STATISTICS
POLICIES	UN NATIONAL ACCOUNTS STATISTICS	DYADIC TRADE DATA
NET DEBTOR POSITION	CHARACTERISTICS OF NATIONS	BALANCE OF PAYMENTS YEARBOOK
	EXTERNAL DEBT SYSTEM	YEARBOOK OF NATIONAL ACCOUNT STATISTICS
	DATA FUND	INTERNATIONAL TRADE STATISTICS
	FATHOM SYSTEM	WORLD DEBT TABLES
	GENERAL INDUSTRIAL STATISTICS	

Table 9. (Part 2 of 2)

PERCIEVED POWER COMPONENT	POTENTIAL DATA RESOURCES	
	AUTOMATED	NONAUTOMATED
MILITARY CAPABILITY		
STRATEGIC		
INTERCONTINENTAL BALLISTIC MISSILES	JOINT RESOURCE ASSESSMENT DATA BASE	NATIONAL BASIC INTELLIGENCE FACTBOOK
SUBMARINE-BORNE BALLISTIC MISSILES	J-5 FORCE STRUCTURE INFORMATION DISPLAY SYSTEM (JFIDS)	DOD ANNUAL REPORT, FY 1976
SUBMARINES		
NUCLEAR WEAPONS/WARHEADS		
MANNED LONG-RANGE BOMBERS	AERIAL PORTS AND AIR OPERATING BASES (APORTS)	
INTERREGIONAL BALLISTIC MISSILES		
DEFENSE NETWORKS		
R&D SPENDING	WORLD MILITARY EXPENDITURES	GOVERNMENT R&D INVESTMENT
SPACE		
GENERAL PURPOSE	J-5 FORCE STRUCTURE INFORMATION DISPLAY SYSTEM (JFIDS)	
LEVEL OF EFFORT		
SCALE & NATURE OF EXPENDITURES	JOINT RESOURCE ASSESSMENT DATA BASE	NATIONAL BASIC INTELLIGENCE FACTBOOK
R&D SPENDING	CONFLICT AND PEACE DATA BANK WORLD MILITARY EXPENDITURES	GOVERNMENT R&D INVESTMENT
SIZE OF ARMED FORCES		
COMPOSITION OF ARMED FORCES	FORCE STATUS AND IDENTITY REPORT (FORSTAT)	YEARBOOK OF WORLD ARMAMENTS AND DISARMAMENTS
QUALITY/RELIABILITY OF FORCES AND LEADERSHIP		
ARMAMENT		
SUPPORT CAPABILITIES		
GLOBAL DEPLOYABILITY		
NAVAL SHIPS		
NAVAL SHIP CONSTRUCTION	PORT CHARACTERISTICS (PORTS)	
TACTICAL AND SUPPORT AIRCRAFT	AERIAL PORTS AND AIR OPERATING BASES (APORTS)	
ALLIANCE AGREEMENTS/DEPENDENCE	EXTERNAL DEBT SYSTEM WORLD TREATY INDEX U.S. - CANADA DEFENSE TREATIES	WORLD DEBT TABLES DYADIC TRADE DATA
STRATEGIC PURPOSE		
IDENTIFIED NATIONAL GOALS	CONFLICT AND PEACE DATA BANK	YEARBOOK OF NATIONAL ACCOUNT STATISTICS
CURRENT ALIGNMENTS	*ARCHIVES OF POLITICAL ELITES IN EASTERN EUROPE*	COMMUNIST AID AND TRADE AND DEVELOPING COUNTRIES
FORMAL AGREEMENTS AND TREATIES	WORLD TREATY INDEX	U.S. OVERSEAS LOANS AND GRANTS
ECONOMIC AND MILITARY DEPENDENCE/ASSISTANCE	UN NATIONAL ACCOUNTS STATISTICS	BALANCE OF PAYMENTS YEARBOOK HANDBOOK OF ECONOMIC STATISTICS YEARBOOK OF NATIONAL ACCOUNT STATISTICS WORLD DEBT TABLES
TRADE ALIGNMENTS/DEPENDENCE	UN NATIONAL ACCOUNTS STATISTICS DATA FUND EXTERNAL DEBT SYSTEM CONFLICT AND PEACE DATA BANK ICPR DATA BANK DIMENSIONALITY OF NATIONS	
HISTORIC ALIGNMENTS/CONFLICTS	CHARACTERISTICS OF NATIONS FATHOM STUDY *WORLD TREATY INDEX* CONFLICT AND PEACE DATA BANK COMPUTER BASED BEHAVIORAL STUDIES ROPER CENTER FOR PUBLIC OPINION DIMENSIONALITY OF NATIONS WORLD EVENT/INTERACTION SURVEY	
NATIONAL WILL		
NATURE OF GOVERNMENT	CROSS NATIONAL TIME SERIES FILE	NATIONAL BASIC INTELLIGENCE FACTBOOK
POLITICAL TRADITIONS		
CULTURAL PRIDE, UNITY/NAT'L MORALE		
ELITE INSTABILITY	CHARACTERISTICS OF NATIONS	
HISTORIC PATTERNS	CONFLICT AND PEACE DATA BANK	
MILITARY ROLE	THREAT ANALYSIS RESEARCH PROJECT	
COMMUNAL INSTABILITY		
STUDENT ACTIVISM	DIMENSIONALITY ON NATIONS	
INSURGENT ACTIVITY	*COUNTERINSURGENCY DATA FILES*	
SOCIAL, ETHNIC, RELIGIOUS, LANGUAGE, & ECONOMIC POLARIZATION	TACTICAL TECHNOLOGY INFORMATION CENTER (BATTELLE) WORLD EVENT/INTERACTION SURVEY	
RURAL/URBAN DISTRIBUTION/ TRENDS	SOCIOECONOMIC DATA BANK ICPR DATA BANK ROPER CENTER FOR PUBLIC OPINION COUNTRY DEMOGRAPHIC PROFILES SPECIAL APPLICATIONS FILE COMPUTER BASED BEHAVIORAL STUDIES	
NATIONALISM/IDEOLOGICAL COHESIVENESS	DIMENSIONALITY OF NATIONS	
XENOPHOBIC ATTITUDES		

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SECTION 5. DESCRIPTION OF MODELS SURVEYED

5.1 Introduction

In section 4, the models identified in the literature search are explicitly related to strategic concerns and a general theoretical framework for international political analysis and forecasting. These relevant models can potentially make up an important element in the general type of support system for long range strategic studies that this study will recommend. Therefore, in this section the relevant models are described in greater detail with regard to such matters as the individual model's subject and goals, structure, modeling technique, and output data. Some of the technical aspects and problems of socioeconomic modeling that are related to the use of models in any long range strategic study will also be discussed. The potential applications of the relevant models surveyed and others to be identified in a further search of the literature are discussed in section 6.

5.2 The Modeling Process and Problems

The current literature on the techniques of model building and problems encountered in constructing large-scale socio-economic models reveals a number of considerations that are important in terms of evaluating and adopting the surveyed models for use in a strategic forecast.

One objection to the use of rigorous models in long-range forecasting is that the models tend to be overly mechanistic and static. A further objection is that the models, with their stress on quantitative elements, do not adequately represent qualitative factors such as those identified in subsection 3.3.1. However, a review of the process of modeling reveals that there is no inherent reason why these faults would be present in all modeling projects.

The three phases of a model building process are conceptualization, implementation, and analysis of output. In keeping with the iterative nature of models themselves, the building process is also repetitive. The first phase includes the initial analysis, system structuring, data collection, formulation of mathematical equations, testing, and general documentation. Since the modeling team is new and perhaps the effort itself has few precedents, the initial

attempt at building the model is tenuous. During the testing phase especially, certain conceptual constructs are shown to be either irrelevant or quantitatively unsupportable. Moving into the implementation and analysis phase, inconsistencies are noted and the model is respecified. Additionally, the conceptual design of a long-range simulation must undergo periodic modifications to allow for changing trends and unexpected events. Figure 4 is a good representation of the feedback mechanisms within the model building process. Each level of development is examined in light of the previous phases as a validation of the structure consistency and verification of the data output with the real world situation. Figure 4 traces the process of constructing a computer model. Although analysts quickly realize that the process is not simply a step-by-step procedure, the process follows this flow in an iterative manner. Later stages may require modifications of earlier procedures.

The process of model construction reviewed above suggests that the structure of rigorous models need not be static, that there is ample scope for modification in use as a normal part of the construction and application, and that there is abundant opportunity - indeed a requirement - for expert opinion concerning qualitative considerations. One of the most important constraints on a modeler is that much data and many theories needed for the model have been gathered or derived for other purposes. It can be said with a fair level of certainty that data have yet to be collected specifically for world models. This fact is probably closely linked to the unavailability of funds for global modeling in general. Large amounts of money and skilled personnel would be required to build a comprehensive model, notwithstanding the equally substantial funding needed to support a data collection and validation effort (a case in point is the Mesarovic effort which lists 45 full and part-time project employees who maintain and continually test the Strategy for Survival model).

In discussing the aspects of a valid simulation model, it is necessary to have a substantial understanding of intended use of the model. If one contends that the primary reason for building a model is to assist policymaking, then the model user is looking for an assessment of the future, both in terms of the expected effect of policy and in terms of the probabilistic environment in which decisions will be made. The success of a model in any given policymaking

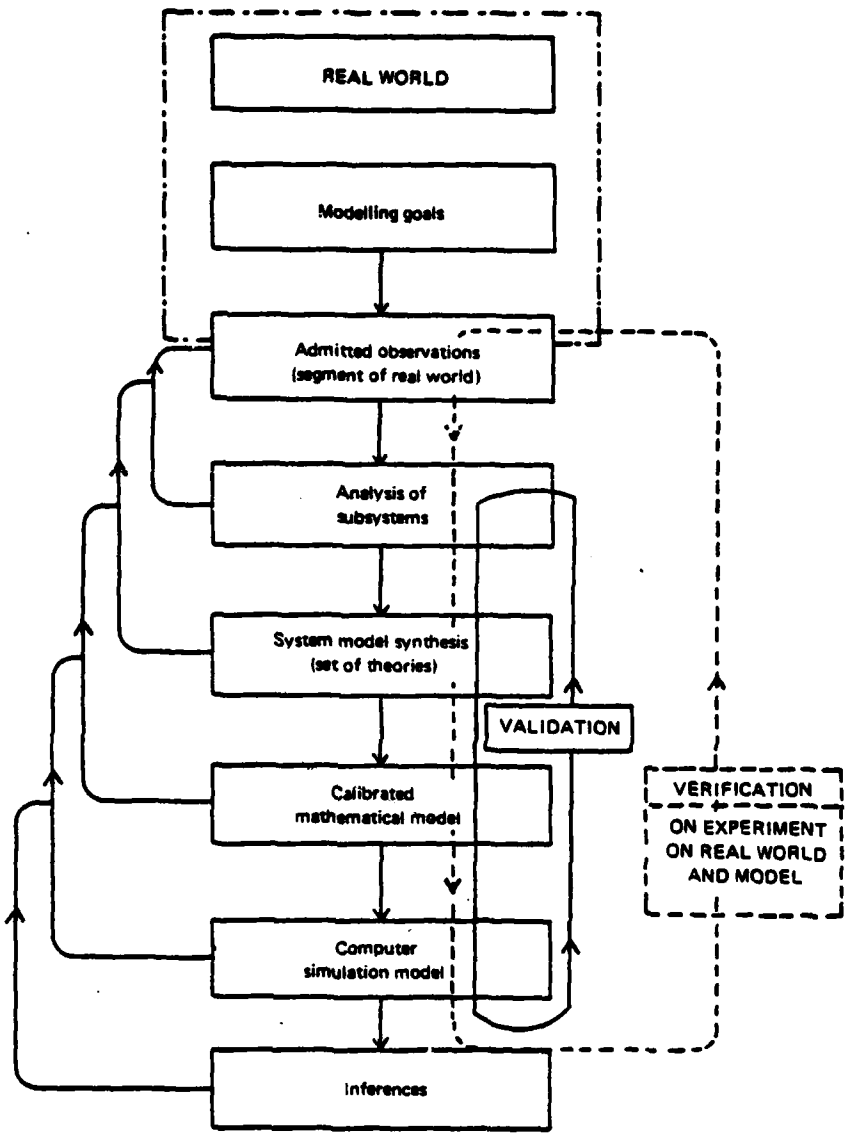

Figure 4. Model Building as an Iterative Process*

*Source: John Clark, Global Simulation Models.

situation depends on whether it provides the right kind of information and that the information is supported by a level of confidence. Little has been written about the applicability of world models to policy, but available literature* stresses the twofold criteria for model acceptability:

a. Model implications must be perceived as feasible by those in command prior to its application.

b. The model must address problems perceived to be relevant by the policymakers and analysts themselves.

However, models meeting these criteria are not necessarily the most accurate since a perceived notion of model implications might be contrary to the real situation. Thus, there is a struggle between building perceived notions into the model structure to prove a point and the quest for model objectivity within the realm of feasibility.

One of the major problems confronting the model builder is linking together quite complex submodels of very different levels of aggregation. It might appear that a highly detailed description in some of the submodels is superfluous to the comprehensive global model unless other subsystems are brought up to a corresponding level of detail. However, a case could be made in some instances that detail is relevant to the discussion of particular issues. The optimum utility of a model design is reached if the model is not less or not more complicated than is necessary to provide a relatively accurate reflection of the actual system. Sir Maurice Kendall, in a lecture on model building, stressed the notion that a complicated system does not necessarily require a complicated model.**

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*Raymond Tanter, "The Policy Relevance of Models in World Politics," Journal of Conflict Resolution, Vol. 16, No. 4, 1972.

**Maurice Kendall, seminar on "Model Building in the Social Sciences," sponsored by the Institute for Professional Education, Arlington, Virginia, 1 November 1976.

5.3 Model Descriptions

The following subsections present the essential details of the various models surveyed in the literature search and selected as potentially useful to long-range planning because of their relation to strategic concerns and feasible forecasting methods.

The wide array of models has been classified in the following manner. The first major division is between global and partial models. The global model class includes those models which are worldwide in scope and general in their inclusion of variables. The models in this group were developed for use in the study of what has been called the Problematique Humaine, i.e., the long-range survival of humanity. The partial model class is more heterogenous in content. At one extreme are models which are worldwide in scope but deal with only one variable, e.g., energy, trade, food. At the opposite pole are models of a single nation's economy or region which is of critical worldwide importance, e.g., the Soviet Union, China, and less developed nations. These models are classified as partial since, as a group, they were not developed for the study of any single common problem.

5.3.1 Global Models. Subsection 3.2 of the interim report for this study provided a broad review of past and present global simulation modeling efforts.*

It should be noted that World 2 and World 3, perhaps the most widely known and discussed examples of global modeling in recent times, are not included in our list of relevant models. This exclusion is based on the judgment, supported by the extensive critical literature on World 2 and World 3, that the models have potential use in an OJCS long-range planning system.**

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*CSC Letter Report, "Current Research in Long-Range Forecasting," Task Order 356, 30 September 1976 (Contract Number DCA 100-74-C-0002).

**For a review of some of the literature in this regard, see: James Burns and David Malone, "Optimization Techniques Applied to the Forrester Model of the World," Systems, Man and Cybernetics (March 1974); James Burns, "Error Analysis of Nonlinear Simulations, Applications to World Dynamics: Measurement Without Data," The Economic Journal (December 1973): C.J. Bottcher, "The Club of Rome and MIT Report: Challenge and Response in the Netherlands," Simulation (June 1973), pp. 207-209; Robert Boyd, "World Dynamics: A Note," Science (August 1972), pp. 516-519.

As the interim report stated, the Massachusetts Institute of Technology models have been criticized for their overly mechanistic character, their basic assumptions, and the highly aggregated nature of their world system concept. Critics have felt that the models overemphasize the physical aspects of world problems without consideration of the technological, sociological, political, and psychological changes during the span of time being considered. Thus, certain assumptions concerning such factors as the level of available nonrenewable energy resources may be invalid due to probable policy actions and technological advances in the creation of new energy resources. A Club of Rome response to that view suggests that the critics misunderstand the purpose of the MIT models, which is not to provide a prediction so much as a warning of a currently impending crisis which requires recognition and a major response. Thus, the critics are in a position of saying that "your warning is invalid because we will probably respond to your warning." However, from the standpoint of DOD forecasting requirements, there is an important distinction here. Any proper forecasting methodology must try to take into consideration the probable actions of all major actors in a scenario. Therefore, forecasting models must incorporate an interim feedback and response capability adaptable as a policy analysis tool. In the case of the MIT models, their mechanistic character fails to take account of inevitable modifications in structural relationships within a global system. The relationships are fixed in the MIT models so that the results of computer runs are determined only by the initial or intermediate choice of scenario conditions.

The present discussion will be restricted to three potentially available global models that appear most applicable to OJCS requirements.

5.3.1.1 Mesarovic World Integrated Model (WIM). The WIM was developed by Mihajlo Mesarovic and Edward Pestel with two major purposes:*

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*Library of Congress Futures Research Group, Computer Simulation Methods to Aid National Growth Policy (this report was prepared for the Subcommittee on Fisheries and Wildlife Conservation and the Environment of the Committee on Merchant Marine and Fisheries, U.S. House of Representatives), Serial No. 94-B, Washington, D.C., July 1975.

a. To develop a computer model to be used as a decision tool to study the increasing interdependence among different nations and societies and among various aspects of a given society, such as economic development, ecological changes, resources depletion, population growth, and institutional and social actions.

b. To provide a model for policy analysis to evaluate policy choices while simultaneously inserting various political and social values interactively into the computer.

Given those purposes, Mesarovic's and Pestel's work has resulted in a model with strong potential applicability to strategic considerations. The WIM is the most comprehensive global model to be developed so far (some 200 times bigger than the World 2 and World 3 MIT models discussed in the interim report) and has been designed as an alternative approach to that of the more mechanistic models at MIT (e.g., World 3).

In the initial version of the model*, the world system is represented in terms of 10 interacting regions with provisions made to allow the investigation of any individual country or subregion in terms of individual or global development. The 10 regions are: North America, Latin America, Western Europe, Eastern Europe, Japan, Australia and South Africa, Middle East and North Africa, rest of Africa, South and Southeast Asia, and China. This representation is flexible; its extension to a country level of description has been contemplated, although for some purposes fewer than 10 regions have been used. Each region contains countries grouped according to their shared tradition, history, and life style, their stage of economic development, sociopolitical arrangements, and the commonality of the major problems that will be encountered in these regions.

Each of these 10 regional models is structured and described in terms of interconnected levels or strata, each representing a distinct aspect of the world system (see figure 5). These strata are:

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*Ibid., p. 71-74.

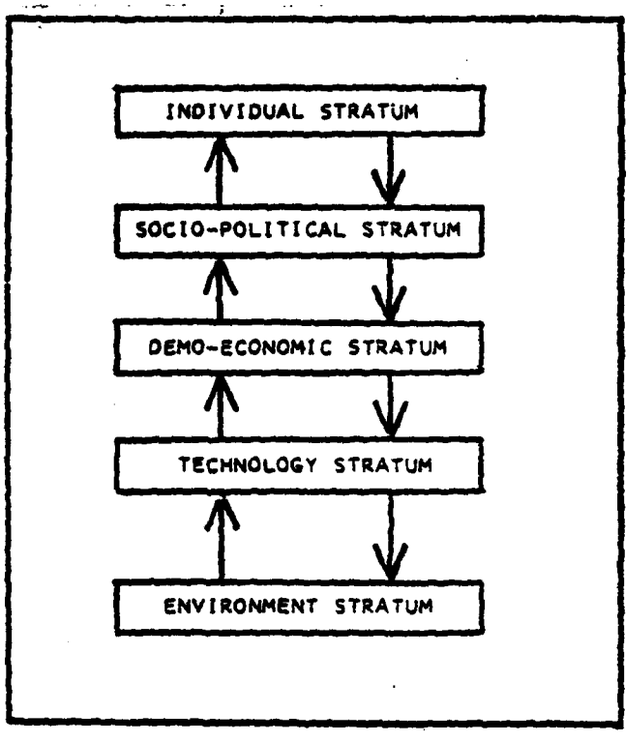

Figure 5. World Integrated Model Strata*

*Source: Highland et al (editors), Proceedings for 1976 Simulation Conference, p. 136.

- Environmental - the lowest level and encompasses man's physical environment (climate, land, water, air, and physical resources); also includes the ecological processes on whose existence man depends (the plant and animal kingdoms)

- Technological - embraces all man-created systems and human activities

- Demo-economic - includes all the procedures and concepts man uses to keep track of his demographic and economic processes

- Sociopolitical - concerned with formal organizations (such as governments and industries), informal organizations (such as religious and ideological movements), and societal processes with which man must associate himself

- Individual - the highest level and reflects man's psychological and biological make up.

Of these five levels, most of the environmental, technological, and demo-economic strata relationships and processes are represented by a causal model, the WIM based on cause-effect types of linkages or equations. The behavior of the causal model is thus fully determined by internal factors and relationships.

Meanwhile, the last two levels, the individual and group strata, are managed by a decisionmaking model and a set of scenarios. Each region has a decisionmaking model, the Assessment of Policies Tool (APT) which consists of a decision process layer reflecting choices among alternatives and a norms layer reflecting the norms and conditions influencing the choices. A policymaker (called the interactor) uses the APT to select from among any of the following given sets of items:

- Relevant goals which anticipate future needs

- Policies to achieve selected needs

- Strategies to implement selected policies

- Specific measures to implement selected strategies.

Initially, the interactor is permitted to select one of the scenarios associated with each region, and this determines the inputs to be applied to the causal model in time increments. He is then permitted to select from among the relevant goals, policies, strategies, and specific measures in the decisionmaking model, receive the likely consequences from the computer, and make new choices over subsequent time intervals.

The total model has been designed as a flexible decisionmaking tool rather than as a self-contained predictive model. A large number of scenarios have been analyzed and some 100,000 relationships stored for utilization.

5.3.1.1.1 Recent Revisions. The Mesarovic team from Case-Western Reserve University briefed U.S. Government officials at the General Accounting Office (GAO) in the summer of 1976.* Their primary emphasis was the assessment of global and United States long-range food policy alternatives. At that meeting, they also addressed the main differences of the second generation world model. Since documentation on the revised model has not been published, the following summary of revisions is provided:

- Some of the regions in the world system are further subregionalized to reflect national and regional constraints as well as climatic and ecological conditions.
- Additional specificity is added to a number of modules and subsystems from the first generation model to reflect the concern with more specific policies related to the food issue in different nations and regions of the world.
- New elements or submodels are added to the basic structure of the world system, especially those which relate to environmental constraints on food production such as weather variability, the impact of fertilizer use on the ozone layer, water resources, desertation, etc.

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*Mesarovic, M.D., "Assessment of Global and United States Long-Range Food Policy Alternatives," a report to the GAO, May 1976.

- More detailed models of the potential for food production in some key regions of the world (such as the Indian subcontinent, Indonesia, the Nile Valley, the United States and Latin America - especially Brazil) will be developed in reference to soil characteristics, weather variability, investment, educational, and social conditions. These detailed models will be in an offline connection with the control world model.

5.3.1.1.2 Applications. More recently, at the 1976 Winter Simulation Conference, Mesarovic's team gave a presentation on the use of their model as a policy analysis tool.* The interactive software developed by the Mesarovic team, APT, is an approach to coordinating the user's intuitive and logical aspects of evaluating the effects of various policy options. The analysts's intuitive inputs include perceived national or international goals and the interpretation of acquired experience, whereas the logical component in WIM concerns facts and data of traceable past and present events. The world model deals with the assessment of certain types of long term national and regional policies, but the tool is adaptable to a variety of additional concerns. APT can assist the decisionmaker in dealing with the complexity of the world system, the rate and magnitude of change, and the decreasing lead time from the policy decision to the effects of policy implementation. It attempts to structure thoughts and data on the dynamic world situation. The Mesarovic team has been and plans to continue presenting this model to technologists and decisionmakers around the world. Refer to the conference proceedings on the APT in appendix C for a detailed model description.

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*Highland, Schriber, and Sargent (Editors), Proceedings of the 1976 Bicentennial Winter Simulation Conference, Vol. II, p. 563-572.

5.3.1.2 Globe 6. The major objectives of the Globe 6 model are:

a. To identify and explore positive aspects of dynamic socioeconomic models and gain insights into the nature of the complex systems these models represent

b. To develop improved techniques for both socio-economic modeling and situation gaming (direct interactions with a simulation model).

The Globe 6 model is an update of a previous Battelle world model, Globe 5, which in turn was based on a flowchart for Forrester's World 2 (except that in World 2 the pollution factor was internally controlled). The Globe 6 model is a multiregion interactive model. The major elements of the model are resources, agriculture, population, industry, food, material wealth, and pollution.

The simulation operates in two modes: an interactive mode which allows a user to input data continually at the terminal and receive the results of these inputs back from the computer, and a repetitive mode, which allows the user to select any variable and receive a display of the changes to it over a specified time period. The user can also insert many types of changes and immediately observe the effects of these changes on the time histories of selected variables.

The respective two regions for developed and developing nations can each be represented by a policymaker who can review the status of this region as the simulation progresses and generate changing social, economic, and environmental conditions for it. The policymaker can then change the policies for his region during any time interval and can also change portions of the model with a few relatively simple commands.

The Battelle Memorial Institute conducted a research program entitled Decision Making Trial and Evaluation Laboratory (DEMATEL) to investigate the development of decisionmaking techniques for the "amelioration of problems of worldwide concern." The laboratory was developed to provide a focal point for scientists, students of world problems, business leaders, and government officials to participate in gaming and simulation exercises on the world problem. A part of

the DEMATEL program, the identification of world problems, is still taking place in Geneva, Switzerland. However, a major portion of DEMATEL and Globe 6 activities are no longer operating. The study group contacted Robert Burnett, who was a principal investigator on the Globe 6 modeling team. Burnett said that, due to funding problems, Battelle-Pacific Northwest discontinued the programs.

At this point, the major published criticisms* of the model are:

- Many of the technological factors such as agricultural, industrial, and pollution control technology remain constant over a period of time.
- Capital flows applicable to foreign investments and activities of the international monetary system are not modeled.
- The model provides little opportunity to invest capital for long term benefit and to sacrifice short term gain.
- GLOBE 6 does not provide for recycling resources.
- GLOBE 6 treats the population as a single group rather than placing it in such segments as urban and rural components.
- The model makes no provision for the exploration and discovery of new natural resources.

5.3.1.3 Cybernetic World Model. This model, unlike the others described in this section, is in a stage of conceptual development and is not fully operational. It is included here because of its importance as a methodological approach.

Dr. Rastogi is known for his contributions to the field of social cybernetics and computer simulation of complex social

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*Library of Congress Report, Computer Simulation Methods To Aid National Growth Policy, p. 78.

systems. His modeling approach relies upon cybernetics*, the scientific study of methods of control and communication which are common to machines and living organisms. Rastogi describes the course, the behavior, and the state of the world system as the outcome of internal processes and external impacts (see figure 6). Since the basic concept of cybernetics is control or regulation, the deviant behavior of any regulated variable results in a state of system disturbance. Under such conditions, changes in policy and structure may ensue in the system. Measurement of the regulatedness (λ) of the controlled variables provides a logical basis for evaluating the overall viability (Z) of a cybernetic system. Viable system performance implies the effective operation of its regulator. Consequently, the overall performance of a system may be evaluated in terms of the regulatedness (i.e., performance) of the variables controlled by the system regulator. Measurement of the viability of a societal system (Z) then simultaneously provides a measure of stability of its regulator (the computation of Z and of the value continuum is discussed in a following section).

The six loops can briefly be described as follows:

- Loop I shows the influence of politico-military pressure (PMP).
- Loop II shows that total pressure on government (TPG), which is determined by Public Unrest (PU), Ethnic Tension (ET), and PMP, determines government stability (GS).
- Loop III shows the mutually reinforcing relationship of government stability (GS), leadership factor (LDF), and the expectations of socii (ES).

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*Rastogi has used the terminology of cybernetics to examine similar relationships as were viewed in systems dynamics terms by Forrester and the multilevel hierarchy verbiage of Mesarovic and Pestel. Rastogi, having been a visiting post-doctoral fellow at MIT, based his early work on the feedback systems theory put forth in an early Forrester document entitled Industrial Dynamics.

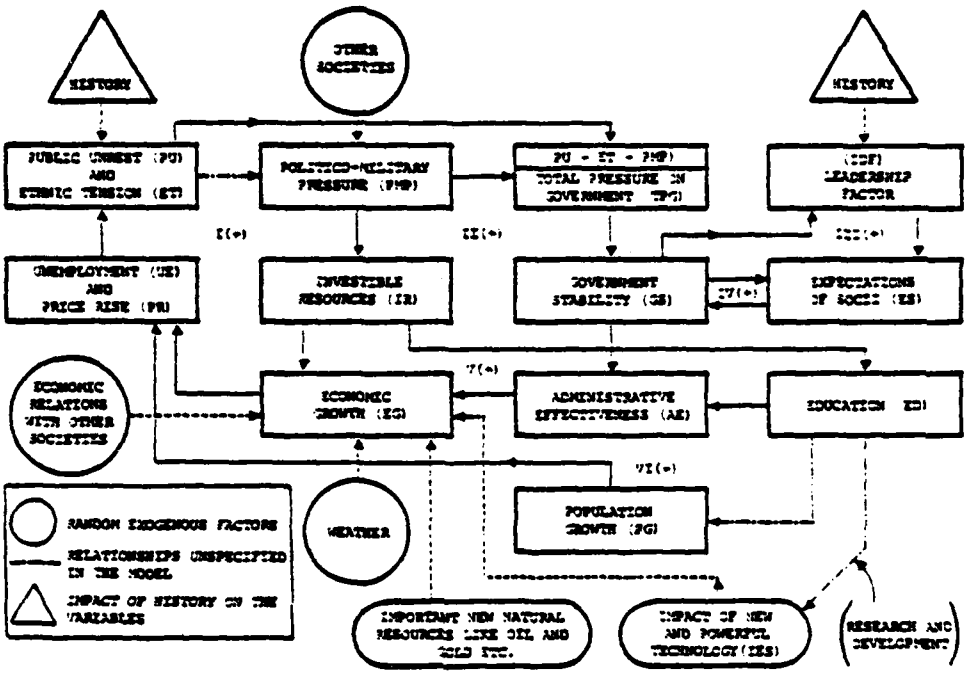

Figure 6. Dynamics of Societal System*

*Source: Dr. P.N. Rastogi, Cybernetic Analysis. Reprinted with permission from Simulation Councils, Inc.

- Loop IV shows a similar mutually reinforcing relationship between government stability (GS) and expectations of the socii (ES).

- Loop V shows that a higher level of investable resources (IR) for education (ED) serves to increase administrative effectiveness (AE).

- Loop VI shows that higher investable resources (IR) increase education (ED) which reduces population growth (PG).

The basic rationale of the cybernetic approach is provided by the complementary concepts of control and regulatedness. Government is the control subsystem of society. The whole pattern of societal operation is oriented around the processes that shape and are shaped by the stability (or viability) of the system regulator, i.e., the government. Figure 7 provides the overall logic of the cybernetic approach.

Rastogi presents the following three assumptions which are implicit to this approach:*

a. Peace and cooperation between the societies. A very low value of politico-military pressure is a very important factor, and its emergence would release rising levels of investment for productive growth. Increased resources and world peace would stimulate the development of appropriate scientific knowledge and technologies for the solution of population, pollution, productivity, and energy problems. Regenerative processes would become dominant in the behavior of societal systems, leading them toward higher trajectories of system viability.

b. Growth of science and technology proceeds at an exponential rate. Accumulation of scientific knowledge in the last 50 years has been greater than in the past 5 centuries. Innovative possibilities are almost boundless in view of the size and variety of the universe.

c. World peace and cooperation would help in a nonrestrictive dissemination of innovations and new technologies. They would also lead

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* Rastogi, P.N., "Cybernetic Analysis of Societal Systems and World Modeling, Part III", Simulation, Vol. 27, No. 4, October 1976, pp. 140-141.

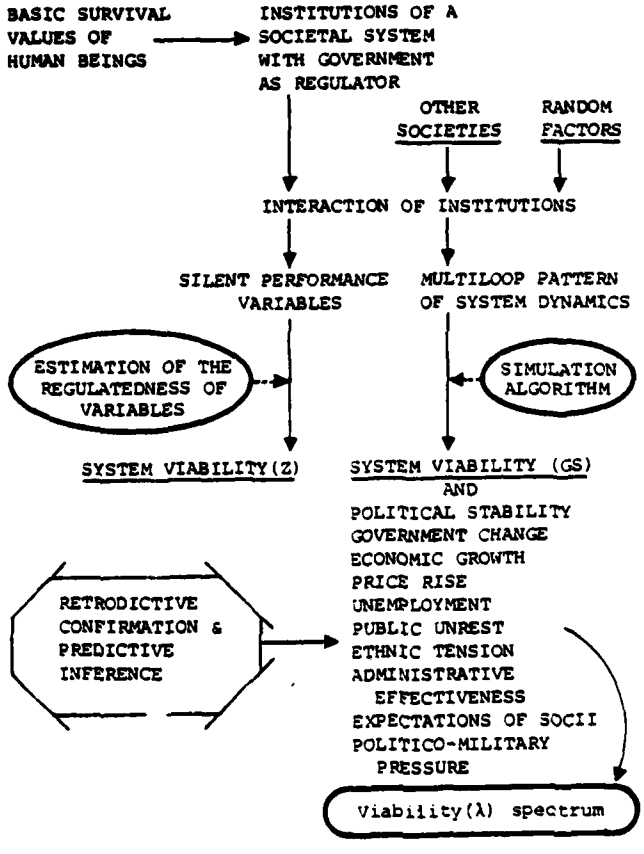

Figure 7. Logical Structure of Cybernetic Approach to the Study of Societies*

*Reprinted with permission from Simulation Councils, Inc.

to increasing transfers of economic and technical resources to the least developed societies since the better developed societies could discontinue preparations for war. Solution of the problems of war and poverty on the globe would open to mankind the opportunity for a Golden Age.

5.3.1.3.1 Computation of System Viability. The mathematical expression for the value of system viability (Z)* is

$$Z = \sum_{i=1}^{n} \lambda/N;\ i = 1,2,\ldots,n$$

where λ is the viability measure of the variable and N is the total number of variables regulated by system control. Figure 8 shows a sample mapping output of performance zones of system variables onto the zones of the λ continuum.

The process leading to this continuum includes the measurement of viability λ of system variables plus the estimation of the initial value for each variable. Each variable is mapped on a viability scale ranging from zero to one. Mapping is based on the modelers judgment, and as such the process is somewhat subjectively based, even though Rastogi uses a method of successive averages or maximum likelihood estimates to reduce some of the uncertainty of the estimate. This facet of the model should be critically evaluated but does not necessarily invalidate the model. Other forecasting techniques, (e.g., the Delphi) could be used to lend more credibility to the mapping process by tapping the knowledge base of several experts rather than the sole judgment of the modeler.

Rastogi defines the following steps to translate map values of the qualitative variables into corresponding λ values:

a. With reference to a given variable, hypothesize the extreme types of situations corresponding to the 0 and 1 extremities of the λ variable.

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*P.N. Rastogi, "Cybernetic Analysis of Societal Systems and World Modeling-Part II," Simulation, Volume 27, No. 3, September 1976.

Mapping of performance zones of system variables onto the zones of the λ continuum. The Roman numerals indicate the zones of the system variables. Thus high public unrest is mapped onto low viability (λ = 0.00 to λ = 0.25).

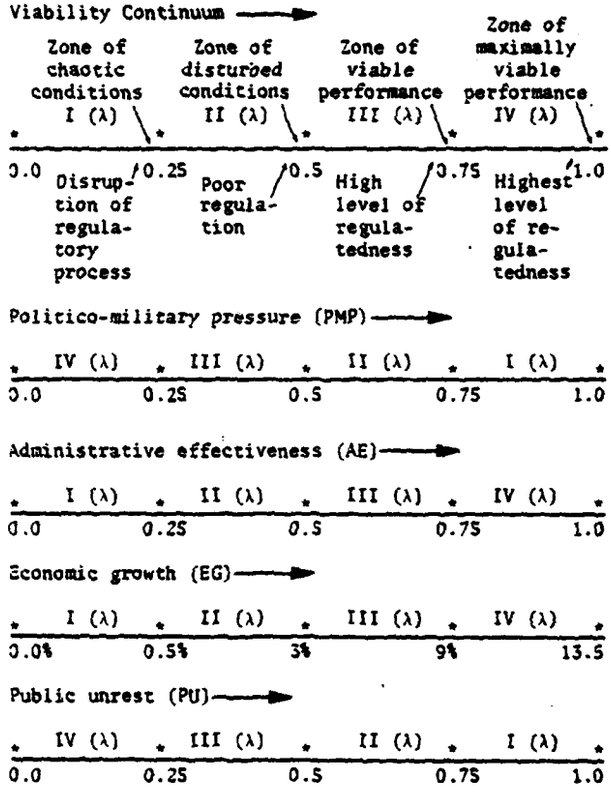

Figure 8. Sample Mapping Output of Performance Zones*

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b. Identify the relevant types of situations (in different societies across time and space) between the two hypothesized extremes.

c. Order these situations according to their increasing severity or intensity.

d. Arrange the situations so ordered in a set of four situation classes corresponding to the four segments of the λ continuum.

e. Define the terminal characteristics of each of these situation classes, i.e., where it begins and leaves off.

f. Map these situation classes into the four segments of the viability continuum.

g. Place a given situation under study within its situation class and locate it correspondingly within the appropriate λ segment.

This process establishes the continuum. The same process with two additional steps assists in the estimation of initial value. The two steps are:

h. After placing the situation within a λ zone or its corresponding performance zone, select a midpoint value between the segment boundaries as a tentative estimate.

i. Determine the final estimate according to a method of successive averages or maximum-likelihood estimates* in the light of the best available information to reduce the uncertainty in the estimate.

Referring back to figure 8, an initial value of $\lambda = 0.25$ indicates public unrest is high, whereas an initial value of $\lambda = 0.25$ for politico-military pressure is low.

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*For further explanation refer to: P.N. Rastogi, "Cybernetic Analysis of Societal Systems and World Modeling," Simulation, August, September, and October 1976.

5.3.1.3.2 System Simulation. Simulation of the system replicates the operation of the nature, direction, and pattern of internal processes and exogenous impacts on the system (refer to figure 6 for the system flow). The simulated course provides output that can be validated with data for the past and present for economic growth, price rise, unemployment, and change of government. Other variables such as politico-military pressure, public unrest, and ethnic tension can be indirectly confirmed by subjective analysis.*

5.3.2 Partial Models. Partial models addressed in this subsection incorporate the following subject areas: energy, international trade, population, food, and international interaction.

5.3.2.1 Energy. World modeling and forecasting projects have assigned key importance to the supplies of natural resources, especially those related to energy production in influencing the course of future global developments. Individual nation's supplies of critical resources and energy are also identified as important elements in determining the national power base and are therefore of special strategic significance. However, despite their importance, the energy sectors of available global models tend to be highly aggregated and cursory in character. Greater detail and flexibility would appear to be desirable in order to assess the long-range strategic significance of developments in this area.

5.3.2.1.1 Range of Models Available. In recent times intensive efforts have been devoted to energy modeling. The International Institute for Applied Systems Analysis (IIASA), in its attempt to catalog and review current energy modeling projects, has identified 145 models developed or being developed in some 20 countries.** These models, abstracts

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*P.N. Rastogi, "Protracted Military Conflict and Politico-Economic Stability," Simulation, January 1969.

**Jean-Pierre Charpentier (editor), A Review of Energy Models, Laxenburg, Austria, International Institute for Applied Systems Analysis, No. 1, RR-74-10, May 1974, No. 2, RR-75-35, July 1975.

of which are stored in the IIASA computer, exclude those dealing with the management of energy producing and distributing organizations. The models can be classified as to whether or not they are national or international in their coverage and as to whether or not they are applied to one or several energy sources. The models can also be further classified in terms of whether their principal area of application is to the energy system itself (energy is the main problem) or the application is to the linkage between energy and the general economy. The models of international coverage dealing with several energy sources and applicable to the analysis of the economic aspects of energy supplies are of the greatest importance from the point of view of long-range strategic forecasting. Unfortunately, the number of models in this category is relatively limited.

The projection of energy demand and supply is a gargantuan task, complicated by several aspects. First, the study involves several forms of energy each regarded as to production, demand, pricing, discovery of resources, and units of measure. Second, in addition to primary energy resources, there are secondary ones like electricity and petroleum products. Also the primary sources (coal, oil, gas, hydroelectricity, and nuclear power) can be used in the production of more than one type of secondary energy. Third, there is a debate regarding known reserves versus estimates of yet to be discovered reserves. These are considerations, although not covered in the following discussion of potentially applicable energy models, which should guide the further study team evaluation of energy models.

5.3.2.1.2 System Man-Energy-Environment.* With regard to subject and goal, this model is an approach to an overall analysis of the system man-energy-environment and considers economic, ecological, and technological aspects. It has been developed to show possibilities of a long term development of the world's energy system and aims at a quantitative description of alternative energy supply strategies by

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*A. Voss, "Ansatze zur Geramtanalyse des Systems Mench-Energie-Umwelt," Kernforschungsanlage Julich, Report Jul-982-RG, 1973.

evaluating the positive and negative effects of satisfying energy demand and providing its supply systems. The description of substitution mechanisms between primary energy sources is emphasized.

This is a world model with no regional disaggregation and is addressing a time horizon from 1900 to 2100. The model uses simulation techniques. The dynamic interactions and the feedback loops are described by the systems dynamic approach.

In this system the interaction between the energy system and the environment are described in five sectors: population, energy, nonrenewable resources, industrial production, and pollution. The development within the interactions between sectors determines the development of the overall systems and thus that of energy demand. Besides the effects of energy consumption and exploration of new energy resources, the energy sector of the model describes substitution among primary energy sources. The output data of the model is presented in terms of the development in time of variables such as population, energy consumption, energy reserves, share of individual energy carriers in the energy supply, industrial production environmental burden, and raw material consumption.

This model is a strategy rather than a forecast model. It shows a high degree of aggregation and uses global averages. It is reported that studies on the disaggregation in space and differentiation of the environment sector are currently underway.

5.3.2.1.3 Energy Simulation Model.* With regard to its subject and goal, this is a simulation model designed to study the impact of different supply strategies (nuclear, exploitation of home resources, etc.) and to develop energy demand and supply scenarios for the year 2000 and beyond. A special goal is the study of the impact of new technologies on the dependence of the European Economic Community (EEC) on primary sources imports.

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*W. Nordhaus, "The Allocation of Energy Resources," prepared for the Brookings Panel, November 1973.

This model has been actually applied to the nine nations of the EEC but it can be applied to any industrialized nation or world region. It incorporates a time horizon from 1860 to 2000. The code is written in Dynamo III. Time series are generated by a loop structure and time varying growth rates. Functional relationships are given in the form of tables (system dynamics approach).

This system is divided into four interconnected subsystems: demand, supply, conversion, and economy. Demand is subdivided into electricity and heat (fuel) for five economic sectors (industry, households, commerce, transportation, and energy). The demand subsystem is connected to the economy subsystem through the GNP growth rate by functional relationships. From the total electricity demand, the required primary energy (fossil, nuclear, hydroelectric) is calculated in the conversion subsystem and fed into the supply subsystem, which is structured into production, imports, and exports of different primary sources (coal, crude oil, natural gas, primary electricity, and primary heat). The costs of imported primary sources influence the GNP growth rate (feedback loop). The output data of the model is presented in terms of plotted curves from 1960 to 2000 for the following variables: GNP at fixed prices, GNP growth rates, total inland consumption of primary sources, production of primary sources (nuclear, hydroelectric power, natural gas, crude oil, lignite, and hard coal), imports of primary sources (oil, natural gas, and coal), sectorial consumption of primary sources, sectorial energy consumption per capita, sectorial share of primary sources consumptions, and share of different primary sources in total inland consumption. In addition, the time series projections of 70 parameters are printed.

This model is in the process of further development. The model's results have suffered from a poor knowledge of functional relationships. An effort is being made to extend the model by including other conversion processes besides electricity production and adding greater detail to the economy subsystem. An effort is also being made to develop more sophisticated linkages between the demand and economy subsystems.

5.3.2.1.4 World Petroleum Model. Two major efforts, one by R.J. Deam and the other by H. Houthakker and M. Kennedy, have been made in the development of international petroleum models. In both models, the world fuel oil market is divided into a number of regions whose production, transport,

and refining capabilities are taken into account. The Deam model uses linear programming to minimize the total expenditure for a given demand level. The Houthakker-Kennedy model simulates a market that the authors suppose to be optimal, described by equations that can be interpreted on first order conditions of a quadratic programming problem defining a competitive market. Both models are still being developed but can nevertheless be used now for studying different problems.

In a recently published report, Houthakker applied a reduced form of the model to the problem of international prices and trade in petroleum.* This version of the model divides the noncommunist world into six regions (the United States, Canada, Latin America, Europe, the Middle East together with Africa, and the rest of Asia together with Australia). It recognizes four products (gasoline, kerosene, distillate fuel oil, and residual fuel oil) but does not explicitly distinguish among different types of crude, although such a distinction is implicit in the refining coefficients employed.

The model takes 1972 data on production, trade, consumption, prices, and taxes as a starting point and then calculates the consequences of changing any of the many parameters that are used in describing the world petroleum market. This version of the model is designed primarily for policy simulations referring to any year between 1980 and 1985.

Each run of the model produces a solution describing production, trade, consumption, and the price of crude and products in each of the six regions. The principal number to be specified in the simulation is the export tax on crude from the Persian Gulf; however, in addition, any number of other parameters, such as the elasticities of demand with regard to prices or income and the regional economic growth rates, may also be specified. Specific assumptions are also made with regard to fixed supplies (from oil fields previously discovered but not being exploited in 1972).

Given alternative assumptions for the centrally important price of crude from the Persian Gulf, the model can be used

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*Hendrik S. Houthakker, "The World Price of Oil: A Medium-Term Analysis," National Energy Project, American Enterprise Institute for Policy Analysis, No. 13, 1976.

to predict certain prices, production and trade volumes, and revenues. The model can be elaborated to provide a rather complete description of all the critical variables in the world petroleum market.* The model can also be used to simulate the effect of nuclear energy on the world petroleum market.

5.3.2.1.5 Energy Models of the Multilevel World Model Project.** With regard to subject and goal, only the energy submodel of the multilevel world model is summarized here. It is divided into three submodels: the energy resource model, the demand model, and the energy supply model. These three submodels are to be connected with the submodels studying the population, economy, and environmental systems. The main goal of this model is not to forecast but to aid in decisionmaking and serve as a tool for building scenarios.

In this model the world is divided into 10 regions: North America, Western Europe, Japan, Rest of Developed Market Economies, Eastern Europe, Latin America, Middle East and North Africa, Main Africa, South East Asia, and China The time horizon is 2025 and the past data used are taken in the time period 1950-1965. The following discussion of model specifications was taken from a document produced by the World Modeling Project at Case-Western Reserve.***

Figure 9 shows the basic elements in the structure of the energy model. Energy demand is determined on the basis of values coming from the economic and population submodels.

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*M. Kennedy, "An Econometric Model of the World Oil Market," Bell Journal of Economics and Management Science, Vol. 5 (Fall, 1974) pp. 540-577. M. Kennedy, "Economic Model" in D.W. Jergenson, Econometric Studies of U.S. Energy Policy (New York, North Holland/American Elsevier, 1976).

**M. Mesarovic and E. Pestel, "Multilevel Computer Model of World Development System," Proceedings of the Symposium, International Institute for Applied Systems Analysis, Laxenburg, Austria, April 29-May 3, 1974, Volumes I-IV.

***Ram Dayal, Equation Specifications for the World Integrated Model (WIM), Case-Western Reserve University, Systems Research Center, Cleveland, Ohio, November 1976.

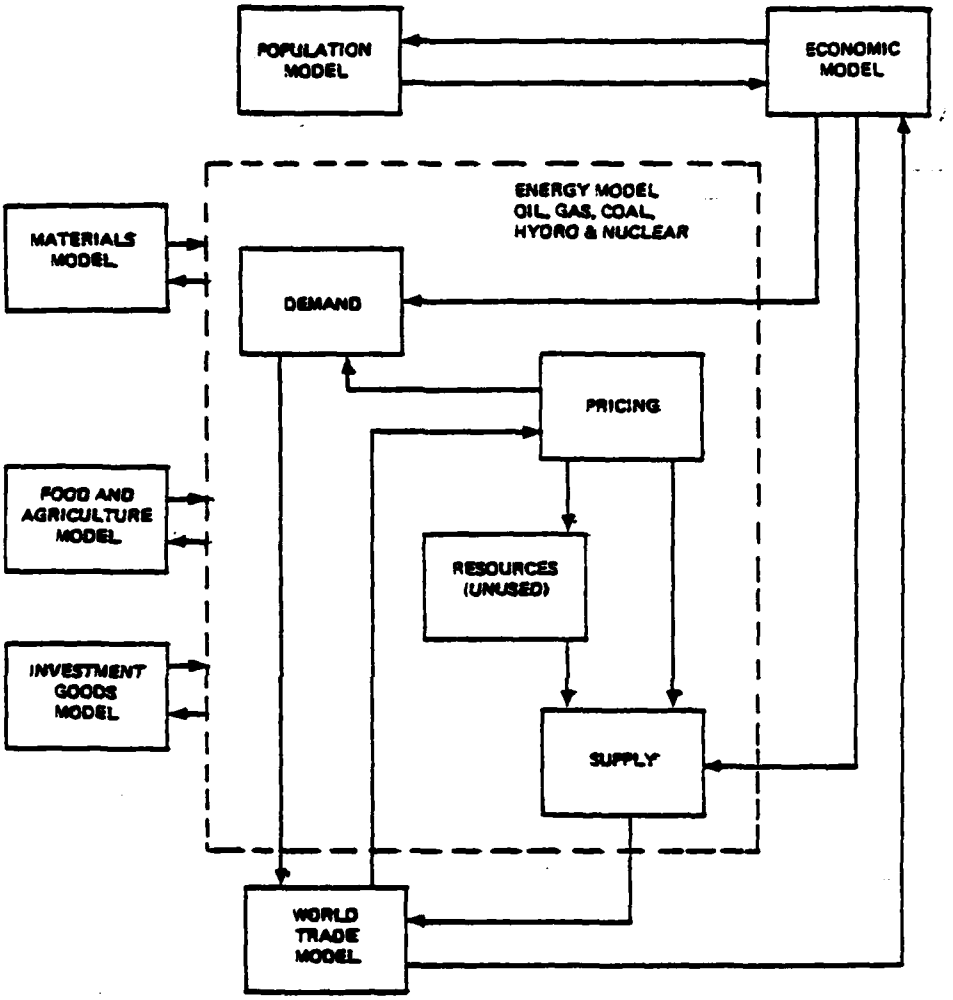

Figure 9. Simplified Block Diagram of Energy Model Linkages**

*Source: Ram Dayal, Educations Specifications for World Integrated Model (WIM), Case-Western Reserve University, November 1976.

It is also affected by the pricing of energy. Energy supply is a function of the economic model (specifically investment availability), energy pricing, and the energy resource picture. Energy demand and energy supply on a regional and on a global basis are reconciled in the world trade submodel. The reconciliation of energy demand and energy supply in the world trade submodel produces information about surplus capacity which has major impact on energy pricing and other components of the energy model. Energy pricing already affects the demand picture, supply picture, and the extraction or resource picture.

The following discussion covers energy demand, energy supply, and energy trade and pricing. It should be noted that all other submodels, specifically food and agriculture, materials, and investment goods, also have important implications for the energy model.

Figure 10 is a flowchart showing the principle variables in the energy demand submodel. At the upper left hand corner are variables which determine the total energy demand. Specifically, total energy demand is produced by an energy demand function in which the principal elements are gross national product, gross national product per capita, energy demand elasticity, and the price of energy. Energy demand is a function of the gross national product and energy demand per unit of the gross national product. Energy demand per unit of the gross national product is in turn a function of the level of economic development of a region represented by the gross national product per capita. The basic energy demand per unit of gross national product is influenced by the price of energy and the elasticity of demand with the price of energy. Once total energy demand for the region is specified, the demand for the various energy types within the model structure is determined. At the current time the model specifies demand, supply, trade, and consumption in five energy types: oil, natural gas, coal, hydroelectric power, and nuclear power. The basic mechanism for dividing total energy demanded among the various primary energy types is through the use of the demand vector. The demand vector represents basic consumer preferences for energy types and is modified or adjusted by the price of the various energy types and cross demand elasticities. The results of the calculated demand for energy types is translated into a derived demand for the various primary fuels in the energy model.

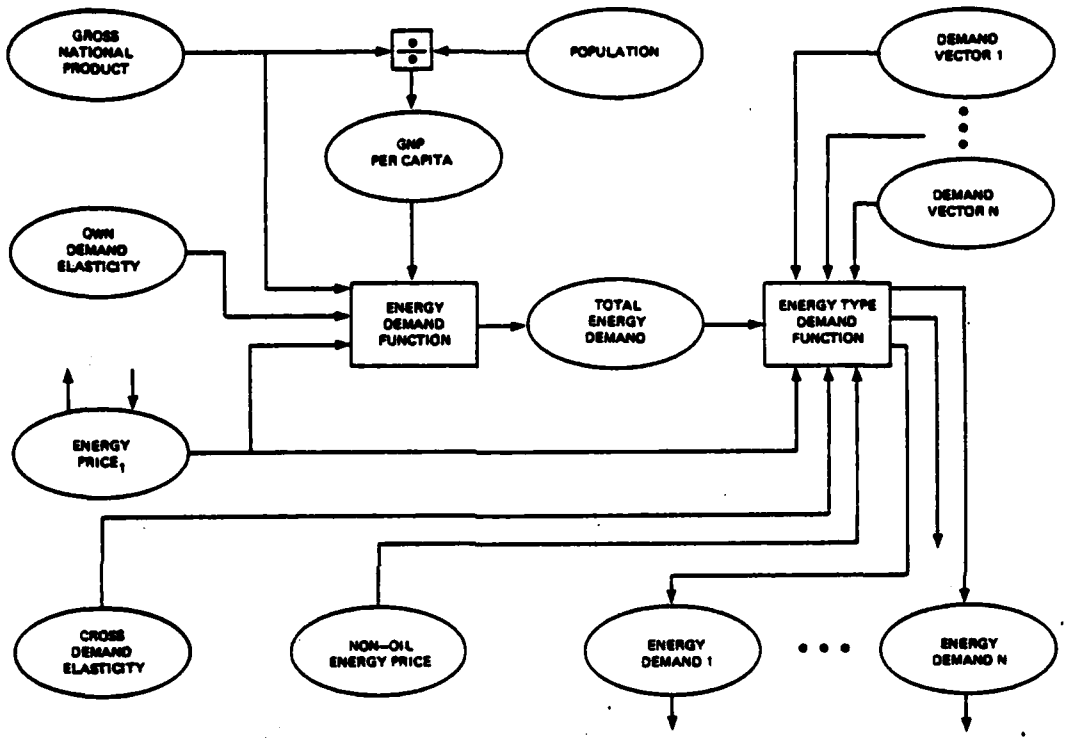

Figure 10. Energy Demand*

*Source: Ram Dayal, Equations Specifications For World Integrated Model (WIM), Case-Western Reserve University, November 1976.

These are represented at the bottom right hand side of the flowchart as energy demand for type 1 through energy demand for type n. Energy demands are taken to the World Trade Model and final energy consumption is computed there.

Figure 11 shows the flowchart for the energy supply submodel. In the energy supply submodel the critical variable production capacity is made a function of the capital stock available and the capital energy output coefficient for each energy type. Special attention is given in the energy investment function to the determination of the rate of investment for each energy type. Energy investment is dependent upon the total investment available in the economy, the price change in the energy type and elasticity of energy investment with regard to price changes, and the reserves of the energy type which serve as a restraint on the investment pattern. The reserve figures employed in the model are calculated on the basis of discoveries which increment reserves and production which decrements reserves in the reserve update function. Discoveries, in turn, are a function of the undiscovered resources which are represented in the model as being the difference between ultimate discoverable resources and reserves, and resources and reserves which are recoverable at current prices.

The program provides for 19 pages of output data. The main outputs are: net primary input energies, number of plants of each input kind, secondary energy by user sector, global annual expenditures of the system, and capital investment per year.

5.3.2.2 International Trade. In the analysis of national power, the volume and composition of international trade is generally assigned an important role. International trade is the vehicle for foreign military aid programs and is an important indicator of international political alignment. For the Lesser Developed Countries (LDCs) foreign trade is often the critical factor in efforts to achieve a rapid rate of economic growth. Although existing global forecasting models invariably deal with foreign trade, the treatment is quite unsophisticated and as a rule tends to ignore the financial aspects of international economic relations.

5.3.2.2.1 Range of Models Available. There are currently only two major models available that have international economic relations as their principal concern.* These are the Battelle Institute's Explor-Multitrade model and the

*For a review of other models, see Grant B. Taplin, "Models of World Trade," International Monetary Fund Staff Papers, Vol. XIV, Nov, No. 3, pp. 433-453.

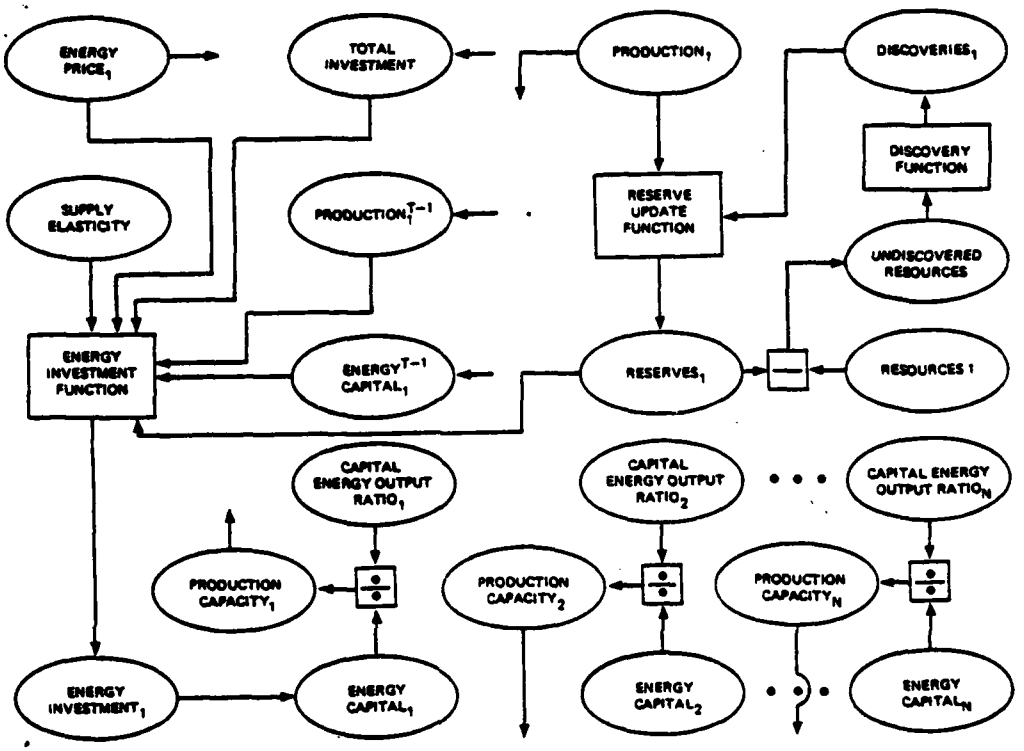

Figure 11. Energy Supply*

*Source: Ram Dayal, Equations Specifications For World Integrated Model (WIM), Case-Western Reserve University, November 1976.

Wharton/SSRC Link model. Both models are operational but remain in a developmental stage. The significant difference between these two models will be indicated below in the course of a survey of the structure and function of the models.

5.3.2.2.2 Explor-Multitrade. This model is the outgrowth of the Battelle Institute's experiments with the application of input/output accounting techniques on an international basis.* The Multitrade model, although it predates it in conception, may be considered a complement and extension of Battelle's Globe modeling projects.

With regard to its subject and goals, Phase I of the model's construction was aimed at the development of a multisector static equilibrium growth model for medium and long term forecasting. Phase I of the model was designed as a national econometric forecasting model. On the other hand, the goal of Phase II of the project, which is not yet completed, is the introduction of a detailed analysis of international commodity flows and the further development of the model as an international trade model.

Multitrade is a world model with national and regional disaggregation. The model recognizes 10 nations and accounts for the rest of the world in terms of five other "nation groups." The time horizon of the model is mid- to long-term. That is, employing a 1970 base year, the model has been used to make forecasts for 1975, 1980, and 1985. However, the model has also been used to make projections to the year 2000. The principal technique employed in making these forecasts is the input/output matrix.

The structure of the Explor-Multitrade model is illustrated in figure 12. The core of the model is used for making individual national forecasts in a commodity-by-commodity, input/output accounting system. As indicated in the diagram,

*Battelle Institute, Explor Multitrade: A Description of Methodology Used for Explor Multitrade-85, Phase I, Richland, Washington, Battelle Northwest, 1974.

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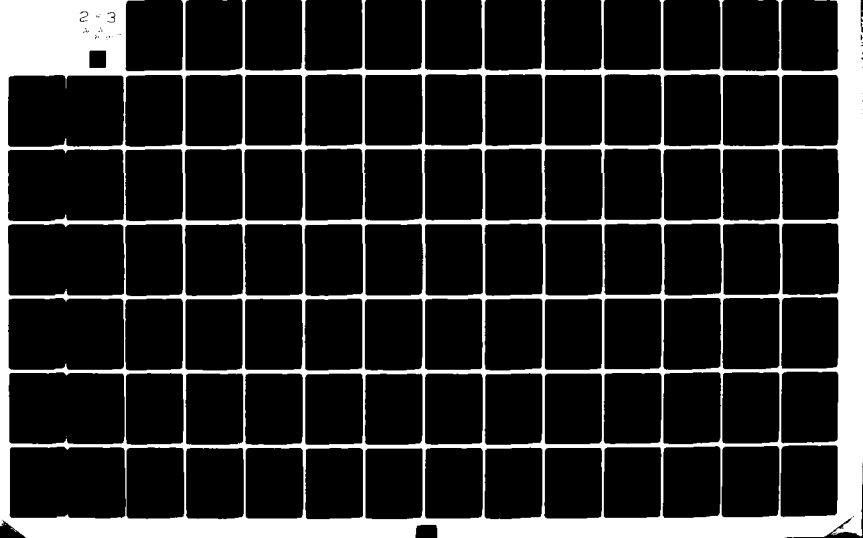

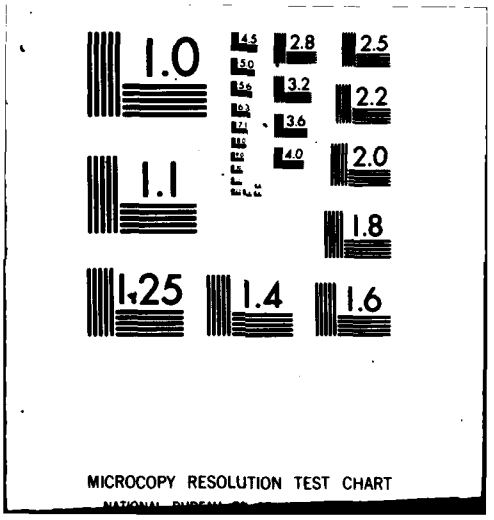
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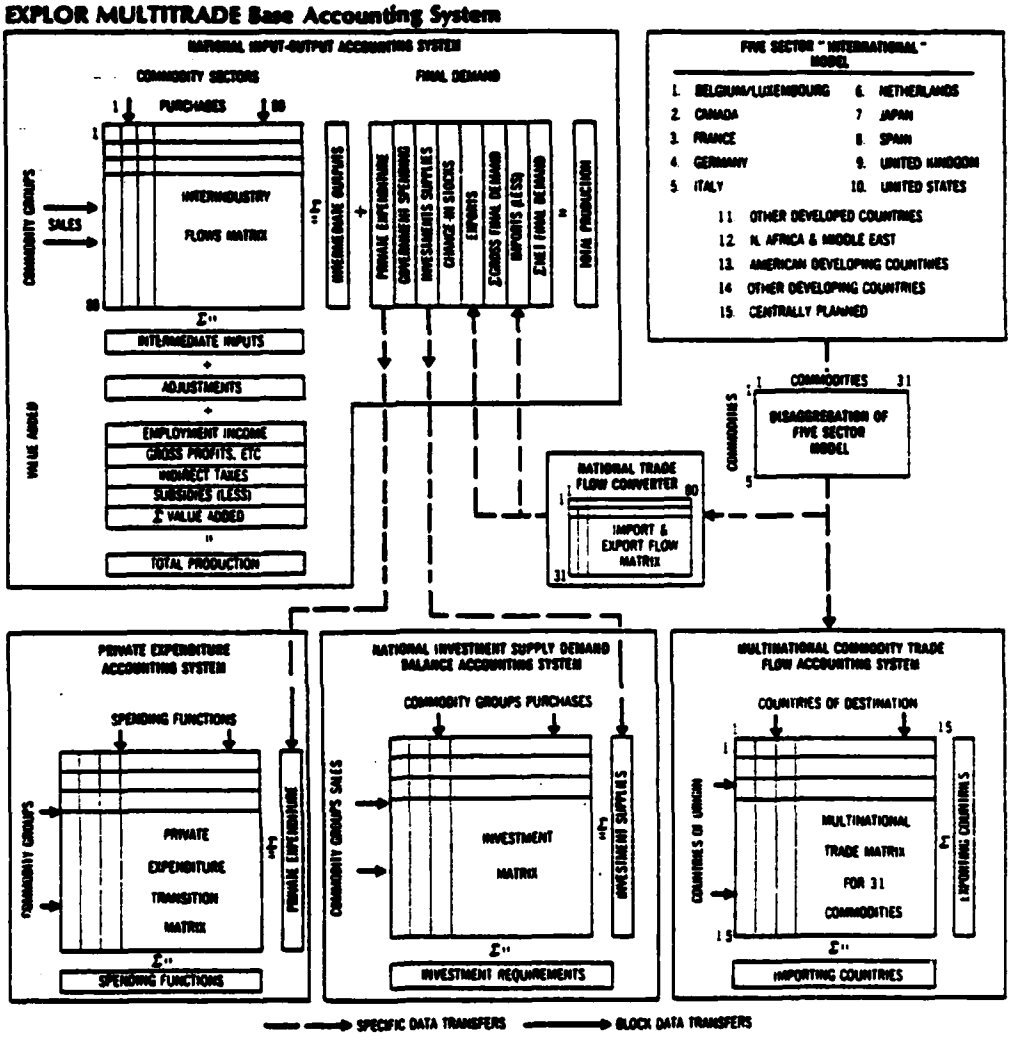

Figure 12. Explor-Multitrade Base Accounting System*

*Source: Battelle Northwest, 1975.

the analysis begins with an estimated interindustry flow matrix (upper left-hand corner). It identifies sales and purchases of the industries to each other. Production includes the total of these interindustry sales (intermediate outputs) and the additional elements of final demand (private and government purchases, exports, etc.). These are indicated to the right of the matrix. When imports are subtracted, the domestic output is obtained (total production).

Similarly, total production is equal to the commodities an industry purchases (intermediate inputs) plus the elements of value added which are contributions to individuals and society (in terms of wages, profits, indirect taxes, etc.). These are indicated below the matrix. The resultant input/output account is a picture of national economic activity. The matrices which give an account by commodity of private expenditures and investments add further detail to the national economic picture.

In addition to the input/output matrix, there are three other elements in the core of the Explor-Multitrade model that are required for its operation as a long term forecasting tool.

These additional elements are:

a. A system of demand functions estimating future demands at final and industrial levels and giving production levels

b. A system of production functions estimating investment and labor requirements

c. A system of cost functions estimating price formation resulting from costs of commodity purchases, wage rates, profit markups, indirect tax, and subsidy rates.

With these elements and the input/output matrix, the core model can be used to make forecasts of the level and composition of national economic activity.

The output data of the core model in Explor-Multitrade is reported in terms of forecasts for demand components in constant prices (intermediate output, private consumption, productive investment, public consumption, investment in dwellings, domestic market, changes in stocks, exports, imports, and gross domestic product), and cost components in

current prices (wage bill, prices, gross profit, value added, indirect taxes, subsidies, intermediate input, and domestic production). Reports for other important variables are also available. These forecasts can be made for each of the 70 commodity groups (sectors) of the input/output matrix as well as for national totals.

The core model and its national economic forecasting capability is the result of Phase I of the development of the Explor-Multitrade model and is currently fully operational. On the other hand, Phase II of the project, which involves the construction of an "international" model, is currently in the development stage.

In Phase II of the development of the Explor-Multitrade model, a five-sector model will be constructed for each of the 10 Explor nations and the rest of the world (in five regions). The five sector forecasts of trade flows for each of these 15 nations and regions will then be disaggregated, providing forecasts for 31 commodities. The disaggregated data are to be used as the basis for a multinational commodity trade flow accounting system (see figure 12, lower right hand) which will show trade by countries of origin and countries of destination for each of 31 commodities.

The Phase II "international" model of Explor-Multitrade offers a source of important detail in assessing the strategic importance of long-range developments in international trade. However, through its exclusion of international financial flows, the Explor-Multitrade model falls short of a comprehensive treatment of international economic relations, and in particular cannot be used to make long term forecasts of balance of payments developments.

5.3.2.2.3 Project LINK. This model is the product of the International Study Group on the LINK System which, under the auspices of the Social Science Research Council, has undertaken the construction of a system involving the linkage of national economic models.* The unique feature of the LINK

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*R.J. Ball, The International Linkage of National Economic Models, (Amsterdam: North Holland Publishing Co., 1973). J. Waelbroeck, The Models of Project Link, (Amsterdam: North Holland Publishing Co., 1976).

System is that it provides the means of utilizing the national economic models that have been independently constructed in various countries in recent years.

With regard to its subjects and goals, the LINK System was developed for forecasting and policy analysis in world trade. The principal focus to date has been on defining the trade/transmission problem, specifying the statistical systems, and obtaining meaningful simulation solutions for the economy. However, current development efforts are being directed toward the inclusion of capital flows and international financial relationships. The system, which is fully operational, has been used to estimate international trade multipliers, to study alternative national policies, and to simulate various exchange rate fluctuations. The LINK Study Group is an ongoing project and is currently actively involved in the expansion and refinement of the LINK System. The ultimate goal of the group is a model that can be used in forecasting and policy analysis of the international system of balances of payments.

Project LINK is a world model based on the country prices and a world trade matrix. The LINK System consists of separate national econometric models for 13 developed and developing countries, regional models for four developing areas, and some equations in reduced form for 12 developing countries. It is noteworthy that one of the regional models is a statistical model of trade for the Communist Block countries (Soviet Union, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania). Trade is analyzed in terms of five commodity groups.

The time horizon of LINK simulations is short term (1 to 3 years). Despite the inherent limitations due to the fact that the national econometric models, which are the base of the LINK System, are essentially short term forecasting models, efforts are underway to extend the horizon to 10 years.

The LINK algorithm works through the following steps:

Step 1: Each national model makes a best estimate of local inputs and submits that for a control solution to LINK Control.

Step 2: All national models with the inputs needed for solution are loaded in the LINK computer file.

Step 3: Import and export prices of products for each national model are converted to merchandise only, FOB valuation, into current U.S. dollars.

Step 4: Exports are computed from a trade share matrix multiplied into the computed vector and adjusted for price effects as in the equation below:

$$X\ 73\ \$ = A \cdot M\ 73\ \$$$

where: X 73 $ is exports in 1973 U.S. dollars
M 73 $ is imports in 1973 U.S. dollars
A is the trade share matrix.

Step 5: Import prices of each country are reevaluated from column weighted sums of changes in computed export prices of the other countries.

Step 6: National models are successively resolved with new input values for export and import prices determined in steps 4 and 5.

Step 7: Steps 3-6 are repeated with new solution values and reiterated until the total volume of world imports in current dollars no longer changes on successive iterations.

The output data of LINK are reported in terms of inflation rates, growth rates, export bills, and import bills for each country or region in the LINK System.

With the extension of its time horizon, the addition of financial flows, and further disaggregation of commodity trade, the LINK System promises to become the most effective model available for forecasting and simulating international economic developments.

5.3.2.3 Population. Various population studies emphasize the problems associated with increasing growth. One such study stated that it took more than 16 centuries after Christ's birth for the world's population to double in size, yet from 1930 to 1975 the population grew from 2 to 5 billion. At the current rate of growth, population could reach 8 billion by the year 2000. The consistently high global food

production of the 1950s and 1960s declined in the early 1970s due to inclement weather in Africa, Asia, Australia, and the U.S.S.R. In addition, uncontrolled population growth and other factors produced widespread food shortages with famine and starvation. It is important to consider the dynamics of population growth to better grasp the resultant competition for resources.

5.3.2.3.1 Range of Models Available. In the last decade, growing interest in anthropology, demography, and human population genetics has produced efforts to simulate the study of population. Although such models are developed and used for different purposes, certain common social and demographic characteristics and their interactions are evident. A collection of readings on population modeling noted that "no matter what the purpose of the simulation, there is a remarkable similarity in the computer programs and basic decision techniques involved."*

5.3.2.3.2 International Labor Office (ILO) BACHUE Model **. A group at the United Nations International Labor Office has been developing a population and employment model, entitled BACHUE, as part of the Population and Employment Project of the World Employment Program. In this model, population is divided into 5-year age groups except for the youngest and oldest groups, which are respectively considered in more and less detail. The model developers have used survey data to calibrate their first application and have succeeded in provoking a dialog of critical debate between themselves and the countries concerned. Other applications to Brazil, Kenya, and Yugoslavia are underway. The model is not intended to provide predictions of population growth, but to examine economic and demographic policies and their likely impacts. The model has been lauded as unusual in that it examines both the effects of population growth on economic factors and vice versa.

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*Dyke, Bennett and J.W. MacCluer, Computer Simulation in Human Population Studies, Academic Press, N.Y., 1974.

**Clark, John and Sam Cole, Global Simulation Models, New York: John Wiley and Sons, 1975.

5.3.2.3.3 Mesarovic-Pestel WIM Population Model. The WIM Population Model serves two main purposes:

a. To study the population growth in 10 regions under certain population policies and as influenced by other submodels

b. To investigate the influence of population development on important issues embodied in other submodels.

Population development is based on input represented by the population number living at the middle of year t, and by age-specific probabilities to bear a child (fertility) and to die (mortality) within the coming 12 months. The calculations are carried out separately for each of the 10 regions, and each is based on its own complete set of initial and other relevant data.* The level of the submodel detail is limited by the requirement that the coefficients and parameters must be available for all regions. The total population was divided into 86 age groups.

The demographic model uses the following time series and age distributions:

a. UN midyear population estimates from 1950 to 1970

b. Crude birth rates from 1950 to 1970

c. Death rates from 1950 to 1970

d. Population age distribution in 1950 or in the earliest available year

e. Birth distribution over mother age in 1970 or in the latest available year

f. Death distribution over age in 1970 or in latest available year

g. Population age distribution.

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*Data source: United Nations Demographic Yearbooks. Noted by M-P team: "not always reliable, but constitute practically the only data source."

Immigration rates were not available in sufficient detail and were treated in the model as the difference between total population as known and total population computed for a. through g. above. The M-P team compared available immigration data of the developed nations with the computed immigration rates and this comparison showed a rather good fit.

The M-P documentation* provides a discussion of data sources used on the basis of origin, reliability, mode of data preparation, a listing of data and of submodel programs, and missing data. This discussion is given for the following variables: estimates of midyear population from 1950 to 1970, crude birth and death rates, initial age distribution, and the development of 1-year age groups from 5-year age groups.**

5.3.2.3.4 Mesarovic-Pestel WIM Food Model. Mesarovic addresses the complexity of fool production and translates this concern into a detailed food model which draws upon the population and economic models. As a basis for this model, emphasis is given to the consideration of policies governing land use and applied technology within the spatial complexities of the historical development of man-land interactions. This same analysis calls for a consideration of the differing ecological potential of the land itself. This is further complicated by the social impact of the classical paradigm that the growth of agricultural technology spawns the reduction of farm laborers who perhaps are unable to cope with city life. Taking this factor into consideration requires an economic analysis.

The food model report is based on two postulates:

a. It is reasonable to review agriculture in an ecosystems framework

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*Mesarovic, M., and Pestel, E., Multilevel Computer Model of World Development System, (Proceedings of the Symposium, International Institute for Applied Systems Analysis, Laxenburg, Austria, April 29-May 3, 1974).

**Since the UN yearbooks supply data for 5-year age groups, the M-P team developed a special routine (SPLINE) to generate 1-year age group data for fertility and mortality computations.

b. Enough is known about agroecosystems to gauge their responses to specific stimuli.

The principal data sources for this model are statistical summaries from the Food and Agricultural Organization of the United Nations (FAO). The FAO publications used include Production Yearbooks of 1970, 1967, 1964, 1961, 1958, 1955, 1953, and 1951, the summary volume of World Crop Statistics for the years 1948-1966, the Fisheries Yearbook for 1970, and the Food Balance Sheets for the years 1964-1966.

Due to the detailed nature of the food model (which includes equations from other submodels in addition to variable specific equations and linkage equations with the other submodels), a listing of equations will not be given in this report. Figure 13 outlines a simplified block diagram of the food model.

The model is designed to be as complete as possible; it includes the production of foodstuffs and allocation of this production to various uses within a given region. Production is broken into three sectors: field crops, livestock, and fisheries. Land bases for field crops and livestock are calculated by a land use sector. The model is driven by the economic and population models which have been integrated into the food model. Gross production is expressed in terms of 26 foodstuffs (5 are cereal grains, 8 are noncereal crops, and the remaining 13 are various meat, fish, and dairy products). The food processing and allocation sector of the model allocates each foodstuff into its use as seedstock, livestock food, and food for human consumption. Per capita diet with regard to each foodstuff is calculated, and the results are summed into total calories, total protein, and animal protein.

The main contributions of this model are that enough different types of food have been considered to provide a feeling for the spectrum of food production in different regions, the different uses to which foodstuffs are put in different regions, and the nature of diets that are predictable for future consumption.

5.3.2.4 International Interaction. This subsection is provided to give the poetential relevance of forecasting probable conflict based upon the study of the patterns and characteristics of reported international events.

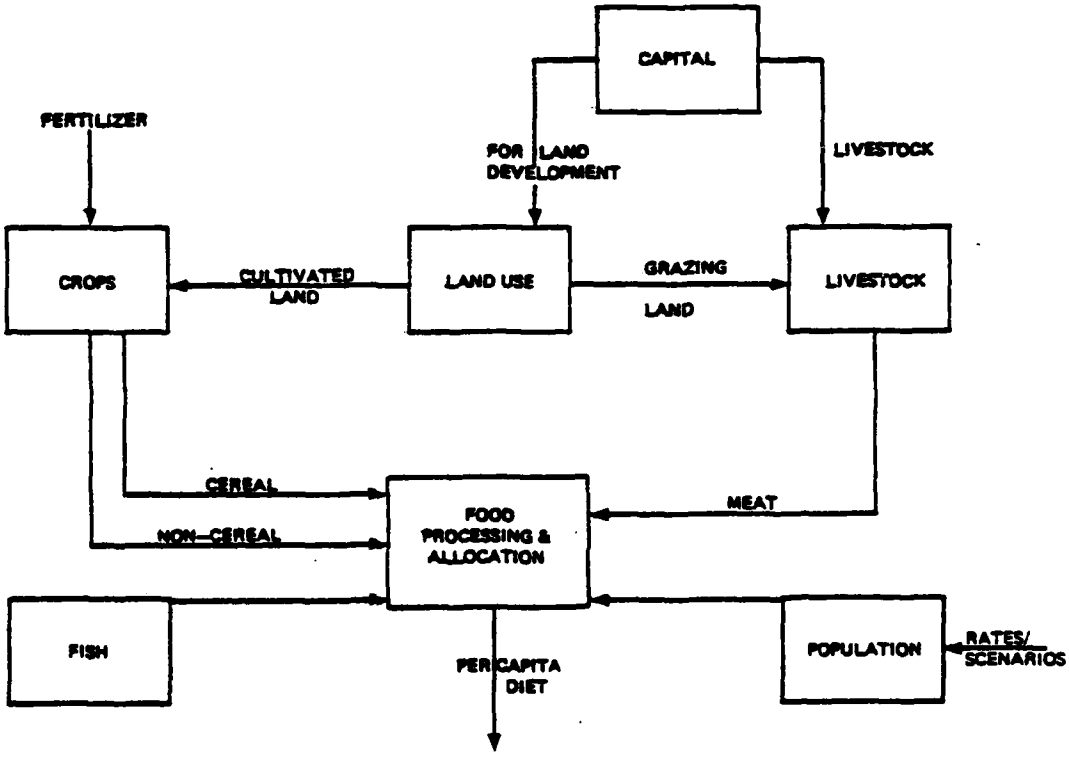

Figure 13. Simplified Block Diagram of Food Model*

*Source: Multilevel Computer Model III 3. A Regionalized Food Model for The Global System by Clapham, Shook & Warshaw IIASA, Austria 1974.

5.3.2.4.1 Range of Models. The following models could assist policy analysts in establishing and forecasting behavior by testing various outcomes based upon prior and simulated cases. Computer simulations and information systems which are presented score highly on the control aspect of policy relevance. The models which are presented allow interaction so as to assess interrelationships among policy options.* However, the overall impression is that such techniques should be further developed with an emphasis on reliability. The simulations described are only loosely tied to underlying models and are generally committed to one data type.

5.3.2.4.2 Alker and Christensen on UN Peacemaking**. This computer simulation model addresses the success and failure of UN peacemaking and consists of the following components:

a. A computer program that simulates the UN Charter to define UN involvement

b. A formal process model of a precedent logic decisionmaking procedure

c. A statistical model for explaining and predicting UN success and failure on the basis of actual or hypothetical involvement roles

d. A set of mechanisms for revising operational expectations, procedures, and system rules.

The model operates through precedent search. Precedents are found by matching on five characteristics of disputes: existence of hostilities, UN organization involved (determined by Charter), degree of major power involvement, type

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*For further information see Raymond Tanter, "The Policy Relevance of Models in World Politics, "The Journal of Conflict Resolution, Volume 16, No. 4, 1972.

of issue, and the general power configuration of the period. The two measures of success are the extent to which the UN settles or helps to settle the dispute and the extent to which it stops hostilities.

Currently available model documentation does not permit full evaluation of the model. One significant but unanswerable question concerns the weighting of exogenous variables which may also have an impact on the settlement of disputes. An assumption of the model is uncertainty of avoidance. The UN Charter is viewed as reducing uncertainty by specifying a behavioral series of coercive and noncoercive events. Charter-based expectations are modified by experience, and the user can vary the levels of involvement called for in the Charter as well as those actually found in historical cases.

The model could be used as a potential policy influence in calling for Charter reform if policy analysts concurred with output values which suggest that a more activist UN role would greatly improve its peacemaking ability. It is suggested that the model could assist the operator in problem solving or in case comparison analysis.

5.3.2.4.3 Computer Aided System for Handling Information on Local Conflicts (CASCON).* This model, developed by Bloomfield and Beattie, provides policy planners with a computerized mechanism to assist in the analysis of local conflict. The assumptions of this model are:

a. Local conflicts have a general common structure rather than being always unique and random phenomena.

b. All conflicts go through a preliminary dispute phase and one or more of five basic conflict phases:

(1) Phase I (dispute, prehostilities, premilitary)

(2) Phase II (prehostilities, but dispute seen in military terms)

(3) Phase III (hostilities)

*Ibid., pp. 576-580.

(4) Phase IV (posthostilities, but military option remains)

(5) Phase V (post conflict, but dispute remains, and settlement of dispute).

c. In each phase, factors can be identified that generate pressures tending to push the conflict across a threshold of transition into another phase. These factors may be countered by other factors that can be regarded as tending toward the prevention of that transition, or generally toward settlement.

d. Changes in the relationship among these specific factors will alter the likelihood of a conflict undergoing transition from one phase to another.

e. The course of local conflicts can be significantly altered by policy measures aimed at reinforcing violence-minimizing factors and offsetting violence-generating factors, on the basis of "conflict-specific" factors identified for the phase in question.

CASCON has been cited for its relevance to the criteria of the policy control analyst. Although policymakers may have little control over the factors of a local conflict (such as cases of historical hostility), they do have sizable control over the current policy process which could affect the outcome. CASCON assumes that any conflict passes through each phase outlined. An explicit formal model does not underlie CASCON. Basically, it is an information storage and retrieval system designed to assist the analyst in structuring his work. As of 1972, the data base consisted of 482 factors on 52 cases of local conflict which were coded by Government and area experts. Generally, CASCON permits a policy analyst to enter data into a computer terminal for a new conflict in phase. With its 52-case data base, the analyst meets the need for memory of actions and reactions of the foreign environment and can potentially identify new regional phases of conflict.

5.3.2.4.4 Computerized Conflict Information System (CASIS)*. At the University of Michigan, a team has developed an international version of CASCON and has expanded modeling capability. This system, entitled CASIS, also relies on the belief that a party in a conflict seeking a solution based on goals will search for historical precedents for policy guidance.

CASIS is concerned with the CASCON factors as well as conflict involving more than one major power. The model design consists of:

a. A memory module which stores information about prior conflicts

b. An experience module which stores evaluations on past strategies and outcomes

c. An involvement or stakes module which provides information about the type and intensity of interests an actor has in a specific conflict

d. An operational environment module which includes information on both the international environment and the internal domestic policymaking environment of the actors.

These modules could be useful in cataloging and analyzing events and trends which underlie regional, global, or domestic conflict.

5.3.2.5 The Dimensionaligy of Nations (DON) Project and Field Theory**. A forecasting model for dyadic foreign conflict is being developed based upon a combination of Rummel's field theory, the DON Project's attribute and Behavior Space Indicator variables, and the Choucri/North perspective on international violence.

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*Tanter, op. cit., p.577.

**George Omen, "A Forecasting Model of International Conflict," (a doctoral dissertation at the University of Hawaii, August 1975.)

R.J. Rummel, currently of the University of Hawaii, began the DON Project in 1961 at Northwestern University with the task of replicating an earlier study by Raymond Cattell.* The initial task had to do with applying factor analysis to a large amount of aggregate data for 236 attribute variables across 72 nations. The aim of the study was to quantitatively describe those particular attribute dimensions that were common to all nations and to see how closely the composition of these dimensions compared with the more traditional views of international relations.

Rummel developed a field theory which is, in part, a product of Rummel's attempt to link the attribute dimensions of nations that were the Project's first research interest and the behavioral dimensions that became of interest later on. These dimensions of international behavior were based upon studies of pairs of nations (called "dyads"), one operating as the actor and the other as the object: A→B. These nation-dyad studies were meant to complement the earlier cross national attribute studies and, through the same statistical techniques, to construct behavioral dimensions that were also common across all pairs of nations in the international system.

Since 1969, the linkages between the attribute and behavioral dimensions for 182 selected nation-dyads have been analyzed and refined.

The mathematical interpretation for the social field theory is

$$W_{A\rightarrow B,k} = \sum_{\ell=1}^{P} \alpha_{A\ell} d_{\ell,A-B} + u_{A\rightarrow B}$$

where

$W_{A\rightarrow B,k}$ = the behavior of the actor nation towards the object nation along a specified behavioral dimension k

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*Raymond Cattell, "The Dimensions of Culture Patterns by Factorization of National Characteristics," Journal of Abnormal and Social Psychology, XLIV (1949), pp. 443-469.

$d_{\ell,A-B}$ = the similarity/difference measure between the object and the actor nation along a specified attribute dimension

$\alpha_{A\ell}$ = the specified actor nation weighting which affects W

$u_{A \rightarrow B}$ = the residual containing those behaviors independent of attribute distances

The equation states that the behavior of any one nation towards another along certain specified behavioral dimensions is a function of the sum of the similarities and differences between the actor and the object nation as interpreted by the actor nation.

The notion of similarities and differences between nations is a distance measure computed by subtracting the object nation's value on a particular dimension ℓ from the actor nation's value. The equation for this computation is given below:

$$d_{\ell,A-B} = \ell_A - \ell_B$$

This interpretation contains two important assumptions. First, the construction of the distance measure is based upon the perception of similarities and differences by the actor nation with respect to the object nation. Therefore, the direction of the distance measure runs from the object towards the actor nation: $A \rightarrow B$. The actor nation's perception of its differences <u>from</u> the object nation determines the actor nation's behavior <u>towards</u> the object nation. Second, the distance measure not only shows the direction of the similarities and differences, but also measures the magnitude of the distance. As an example, assume that a 0 to 10 scale of national wealth has been constructed and the distances between Burma and the United States are to be calculated and compared. For this example assume that Burma has a score of 1 and the United States 9, and that Burma is the actor nation. Therefore,

$$d_{\ell,BUR-USA} = \ell_{BUR} - \ell_{USA}$$

$$d_{\ell,BUR-USA} = 1 - 9 = -8$$

or the distance from the USA to Burma on the national wealth measure is a -8. If the United States is then taken as the actor nation, the difference would be a +8.

BUR-USA = -8

USA-BUR = 8

A number of other intriguing implications for international relations result from the field theory perspective. While field theory provides a model with linking attribute distances and behaviors that can generally be applied to all countries in the international system, it does not go so far as to specify exactly which attribute distances relate to certain behaviors. To this extent it is not a general theory in the sense the term is used by some in the social sciences.* However, field theory does not exclude the possibility that some nations may display similar patterns in their attribute and behavior linkages.

The dynamic dimensions from the DON Project's analyses are:

Attribute Space	Behavior Space
1. Wealth	1. Transactions
2. Power	2. Alignment
3. Totalitarianism	3. Negative Communication
4. Authoritarianism	4. International Organizations
5. Population	5. Export Dependency
6. Diversity	6. Anti-Foreign Behavior
7. Density	7. Military Violence
8. Domestic Conflict	8. Aid
9. Relative Imports	
10. Catholic Culture	
11. Geographic Distance	

These dimensions represent the major criteria for classifying and understanding the structure of nations in the international system, and the principal types of interactions that take place between sovereign countries, at least for the post World War II international system from 1950 to 1965.

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*Kenneth Boulding, "General Systems Theory -- The Skeleton of Science," General Systems, I (1956), p. 11-17.

5.3.3 Critical National Models. Although the United States, Soviet Union, and China have been included in a number of world forecasting models as exogenous actors, there has been little effort, except in the case of the United States, to construct detailed econometric models of their economies and integrate them into a world forecasting system. This is a serious shortcoming since the economic developments and policy decisions of the superpowers is of utmost importance in long-range strategic forecasting. Utilization of such econometric models, even if not integrated into a world forecasting system, would be of importance as a means of providing a sound basis for assumptions used in scenario writing of long-range simulation exercises.

5.3.3.1 Range of Models Available. There is an abundance of detailed econometric models of the United States. Among the most widely accepted and used models are the Social Science Research Council (SSRC) Brookings Econometric Model, the MIT-Pennsylvania-SSRC or Wharton Model, and the University of Michigan-Stanford Research Center (SRC) model. It is with regard to China and the Soviet Union that there is a significant paucity of models. Only two examples of China models and one model of the Soviet Union have been identified.

5.3.3.1.1 China I.* This model was created by a group of undergraduate students at Dartmouth College under the direction of Donella H. Meadows.** In essence, China I is a modification of World 3 and, as such, is a systems dynamic model designed to simulate the major physical interacting factors of the human socioeconomic system in the twentieth and twenty-first centuries. Both models include four basic elements: population, industrial production, food production, and nonrenewable resources.

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*William Brinton, "China I: A Model of Growth for the People's Republic of China," Simulation, November 1974, pp. 133-141.

**Another China model is being developed by a Government agency but the study team has been unable to obtain model documentation.

In constructing the China I model, the World 3 model assumptions concerning a closed system were applied with some significant modifications to China. These modifications include changes in almost all the initial values, many parameters, and part of the World 3 model structure. The most significant changes are in the structure relating to the population submodel which is the special focus of attention in China I. An effort was made to model Chinese social and cultural norms in the determination of the rate of population growth. The model was used to simulate a number of scenarios with regard to the effect of different population policies on the sustainable rate of economic development.

5.3.3.1.2 SOVMOD II. This econometric model of the economy of the Soviet Union is the product of a joint research effort by the Stanford Research Institute and the Wharton Econometric Forecasting Associates, University of Pennsylvania. SOVMOD II is a medium scale econometric model which is similar in scope and potential application to models of Western market economies. The SOVMOD II model was explicitly designed to reflect Western understanding of Soviet economic institutions and bureaucratic behavior. The model has been intensively applied in the study of long-range political/strategic questions. In addition to recent applications to the analysis of alternative long-range Soviet growth strategies, studies of food and agricultural production, the energy situation, international trade relations, and other issues are planned.

The SOVMOD II model is an interdependent system of technical and behavioral relations. The system of equations has been fitted to the data for the actual behavior of the Soviet economy for the past 20 years and adapted to carry its existing trends into the future. The model computes consistent annual estimates for income and product in real and monetary terms, providing substantial detail as to sector of origin and final end uses. It covers industry (subdivided into 12 branches), agriculture, transportation, trade, and services (including government). The model uses Western, rather than Soviet, estimates of sector output and Soviet GNP so that the output measures are comparable to statistics constructed for Western market economies. The time horizon of the model is long run. Projections have been made for the 15-year period covering the years 1970-1985.

The SOVMOD II model serves as a framework for imposing regularities observed in the past upon the future and for

preserving a certain consistency. In using this model for forecasting the probable long term development of the Soviet economy and for evaluating official Soviet plans, the analyst is able to consider indirect effects as well as direct effects (i.e., total system impact) in quantitative terms. In developing simulation studies with a research instrument such as SOVMOD II, one can sketch not only the forward path of the Soviet economy under various assumed domestic and external conditions, but one can also test the impact of hypothetical changes in policy that might occur in response to specified surrounding conditions. These are not forecasts but answers to well-defined questions: what if ...? Thus the model can be used to construct a variety of alternative projections, encompassing total system effects based upon variations in Soviet policy, the world economy, and the weather.

Although fully operational and in current use, the SOVMOD II model is undergoing continuous development.* For example, one of the major objectives in the development of the Phase II version of the model that was recently introduced was the determination of a sequence of balanced input-output tables for the period 1959-1972 and the integration of such an I/O component to determine intersectorial deliveries, thereby determining a consistent vector of gross outputs by sector (10 sectors). This I/O component of the model is of critical importance in analyzing the materials balance aspect of Soviet planning procedures, and is to be used in the analysis of the impact of technological change on the operation of the Soviet economy.

5.3.4 Regional Models. The primary regional models of interest to this study are those produced by Consolidated Analysis Centers, Inc., (CACI) for the Defense Department

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*For two important recent applications of the SRI/WEFA SOVMOD model, see: Holland Hunter, M. Marke Earle, and Richard B. Foster, "Assessment of Alternative Long-Range Soviet Growth Strategies," and Donald W. Green, Gene D. Quill, Herbert S. Lavine, and Peter Miovic, "An Evaluation of the 10th Five-Year-Plan Using the SRI-WEFA, Econometric Model of the Soviet Union, in Joint Economic Committee of the Congress," Soviet Economy in a New Perspective: A Compendium of Papers, (Washington, D.C., U.S. Government Printing Office, October 1976).

and the Defense Intelligence Agency (DIA). The current Long-Range Regional Forecasting Models developed by CACI under contract to the Defense Advanced Research Projects Agency (DARPA) attempt to enhance the original modeling efforts acquired by the same agency for J-5. CACI has also designed a Soviet force effectiveness model. These new capabilities have been delivered to the Defense Intelligence Agency/Directorate for Estimates (DIA/DE) for installation on the Defense Intelligence Agency Online System (DIAOLS). Reference is made in the Executive Summary of the September 1976 deliverable* to the DIA/DE responsibility to supply military intelligence estimates to the Joint Strategic Planning System (JSPS). The two primary objectives of the regional long-range forecasting models developed by CACI are:

a. To improve the capability to forecast important factors that define the international military environment and have implications for long-range intelligence estimates

b. To apply social research methodologies to long-range forecasting of important economic, military, and political variables.

Model output is provided in four reports. The report title and data covered are:

a. Economic Report

(1) Year

(2) Investment (INV)

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*Consolidated Analysis Centers, Inc., Developmental Methodologies for Medium to Long-Range Estimates: Long-Range Regional Forecasting Models, Final Technical Report (September). Arlington, VA: CACI, Inc. See also: Consolidated Analysis Centers, Inc., Developmental Methodologies for Medium-to-Long-Range Estimates: User's Manual for Long-Range Regional Forecasting Models, Final Technical Report (September). Arlington, VA: CACI, Inc.

(3) Consumption (CNS)

(4) Total Exports (TEX)

(5) Total Imports (TIM)

(6) Gross Domestic Product (GDP) and Percent Change (PCC)*

(7) GDP Per Capita (GPOP) and Percent Change.

b. Military Report

(1) Year

(2) Defense Expenditure (DEX) and Percent Change

(3) Defense Expenditures as a Fraction of GDP (DEX/GDP) Percent Change

(4) Military Manpower Defense Expenditures as a Fraction of Population and Percent Change

(5) Defense Expenditures Per Capita and Percent Change.

c. Alignment Report

(1) Year

(2) Trade With the Superpowers as a Fraction of Total Trade and Percent Change

(3) Trade Alignment With United States, Soviet Union, and China

(4) Voting Intensity and Percent Change

(5) Voting Alignment With United States, Soviet Union, and China

(6) Total Alignment With United States, Soviet Union, and China.

*Percent change is the difference between the current year and the previous year divided by the previous year.

d. Conflict Report

(1) Year

(2) Arms Alignment With United States, Soviet Union, and China

(3) Turmoil and Percent Change

(4) Conflict and Percent Change

(5) Group Index (Revolt, for Europe) and Percent Change

(6) Tension Ratio and Percent Change.

Since major documents in the JSPS are likely to include input from DIA, an analysis of their current forecasting/ simulation methods would be of value. In general, CACI cites the following items as the significant accomplishments of model enhancements:

a. The regional forecasting models have been standardized at comparable complexity for Europe, the Middle East, Latin America, and sub-Saharan Africa, and China has been added to the superpower influence set.

b. The capability to influence forecasts by simulating regime changes was added and the models were made user-interactive.

c. Sensitivity tests and simulations have been performed with each of the models, and the three programs associated with the regional forecasting models (the preprocessor, forecasting program, and report generator) have been installed on DIAOLS.

d. The Soviet force effectiveness model has been developed using information available in the Defense Intelligence Projections for Planning (DIPP) on the number and characteristics of Soviet weapon systems.

e. An equation was developed that selectively aggregates weapon characteristics, interfaces them with DIPP force level information, and generates estimates of Soviet force effectiveness.

f. A program for the Soviet force effectiveness model that permits user interaction with the weapons system data and alternative assumptions about the growth and structure of Soviet forces has been implemented on DIAOLS and is presently available.

The CACI documentation debates the reliability of time-series versus cross-national estimates and the impact of the technique on the forecasts. However, until such time that the study team can run the revised model and conduct a series of sensitivity analyses, further detailed evaluation of the model structure is deferred. Instead, the following section cites a brief review of model parameters as found in the latest CACI documentation.

In addressing the significance of model parameters, the document compares the techniques used for the former world models, Europe (EUR) and Lesser Developed Countries (LDC), with the present efforts. The first generation Europe model was fundamentally cross-sectional, parameters were generated by time-series analysis, while parameters for the remaining sectors were cross-sectionally estimated.

The strategy used to estimate the LDC model parameters (economic sector parameters were generated by time-series analysis, while parameters for the remaining sectors were cross-sectionally estimated) was adopted for the updated regional models. Time-series data were collected for the economic sector of Europe, and a simplified model of that sector was specified for all regions. Country-specific growth parameters were then estimated if sufficient data were not available (primarily in Eastern Europe and the developing regions). The compound growth rate was used to identify country-specific parameters. Cross-sectional analysis was used to estimate the region-specific parameters.

Since the current model begins forecasting in 1971, the CACI analysts were able to compare forecasts for each sector with actual data for 1971-1975. They reported that the ability

of the models to project values very close to the recorded statistics was readily apparent. However, their report concedes that the great disparity among nations in all regions of the world poses particular problems in estimating the regional parameters. The use of regression analysis to estimate parameters will always underpredict some countries while overpredicting others, and the user must establish certain checks to keep the forecast output within realistic bounds. The user is also advised to first identify a relevant world political situation problem that he wishes to analyze, then operationalize the problem by identifying the appropriate superpower actions, national data, and parameters to be altered. This focused approach establishes a structure and area content knowledge which assists the user to pinpoint output errors that might be linked to faulty parameters. The user-interactive capability of the current CACI models gives the estimator a better grasp of the primary use of computer simulation as an aid to the analysis of alternative futures as opposed to a single decisive forecast. Table 10 lists the parameters that can be changed (i.e., country-specific, region-specific, and superpower) for the current combined model.

The study team is familiar with two critiques of the earlier model versions (i.e., LDC and EUR) of the long-range regionalized forecasting models. The author of one of the critiques is Ronald G. Sherwin, who is on the staff of the Naval Postgraduate School in Monterey, California. He questions the models' efficacy based upon concern over the significance of the reported regression equations, the computer programming codes, the model parameter estimates, and the relationships between certain empirical indicators and concepts.* The second critique addresses the LDC documentation and computer code.** This critique was the result of a term-by-term comparison in symbolic form of the coded equations for each submodel with the documented equations. Initial review of the

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*Ronald Sherwin, correspondence on the CACI documentation concerning the European and Lesser Developed Countries (LDC) environmental forecasting models, Monterey, California, 19 April 1976.

**Computer Sciences Corporation, Comparative Analysis of the Lesser Developed Countries Documentation and Computer Code, Letter Report, Washington, D.C., 15 June 1976.

Table 10. Dependent Variables Whose Parameters May Be Changed

Equations With Country-Specific Parameters

Variable Name	Parameters	Variable Definition
POP	B01	Population
CNS	B02	Consumption
INV	B03	Gross Fixed Capital Formation
TIM	B04	Imports
TEX	B05	Exports

Equations With Region-Specific Parameters

Variable Name	Parameters	Variable Definition
TUS	A17-A21	Trade With U.S.
TSU	A22-A26	Trade With U.S.S.R.
TCM	A27-A31	Trade With PRC
MLM	A08-A16, A36, A72	Military Manpower
CNF	A53-A58	International Conflict
DEX	A01-A07	Defense Spending
VUS	A38-A42	U.N. Voting Agreement With U.S.
VSU	A43-A47	U.N. Voting Agreement With U.S.S.R.
VCH	A48-A51	U.N. Voting Agreement With PRC
TML	A63-A66	Turmoil
RVL	A64-A69	Revolt (Europe Only)
COU	A64-A69	Coup d'Etat (LDCs Only)

Superpower Equation Parameters

Variable Name	Parameters	Variable Definition
USG	C01	U.S. Gross National Product
SUG	C02	U.S.S.R. Gross National Product
CHG	C03	PRC Gross National Product

*Source: Defense Advanced Research Projects Agency, Developmental Methodologies for Medium-to-Long-Range Estimates: Users Manual for Long-Range Regional Forecasting Models, Contract Number MDA 903-76-C-0255.

code revealed some discrepancies in the regressing models between the coded and the documented forms. Equation inconsistencies were noted for investment in the calculation of gross domestic product, defense spending, and various trade calculations. In light of these criticisms, the enhanced models should be carefully studied to ensure that these points have been resolved.

5.4 Assessment

The models described in this section represent a careful selection of those currently accessible in the literature. The list presented certainly does not exhaust those available. Although selected for their common potential use in long-range strategic studies, the models, as their descriptions clearly indicate, are a diverse and heterogenous group. There is a very wide range in terms of extent, coverage, number of variables, degree of complexity, and nature of output data. This diversity makes it difficult to summarize the models as a whole except in terms of their basic methodology of modeling. Yet, even in this regard, there is an element of diversity when one considers the work of Mesarovic or Rastogi. The diversity, however, is a strength rather than a weakness since it means that, when considered and used collectively, the models can provide a wealth of information in differing degrees of detail about the development of individual variables that can be of critical concern in formulating long-range forecasts. What is required to realize the potential usefulness of this array of models thus is an integrative framework as discussed in section 3 of this report.

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SECTION 6. DATA SOURCES

As the Battelle Institute pointed out in its discussion of the DEMATEL world modeling project,

> After reviewing several efforts to consider problems of the first type (i.e., those problems involving interaction among several regions and/or nations), we concluded that, before going further, we should examine the state-of-the-art of computer modeling and its potential, together with the quality and availability of the data essential to a responsible modeling effort.*

The study team, in addition to the literature search, has undertaken both a review of general data handling and collection problems and available data sources. These issues are discussed in this section.

6.1 Data Considerations

As noted in a National Science Foundation** study conducted in June 1974, the strong points of a model can be linked to methodology (the capacity to deal with complex systems, particularly in a comparative or predictive sense) and the forced expression of formerly unspecified goals and assumptions. The commonly noted weaknesses of a model, as cited in many studies, are set by the limitations of data and measurement. The limited amounts of data will continue to be a problem. One school of thought supports the idea that something quantifiable, in spite of the well-known problems, gives depth to the study of a complex environment and that the gross orders of magnitude are nonetheless significant in examining these complex environments. Recognizing the usefulness of data and empirical study, the user must be aware

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*Battelle Memorial Institute, "World Modeling - An Annotated Bibliography," Monograph Number 8, Richland, Washington, September 1974.

**National Science Foundation, "Federally Supported Mathematical Models: Survey and Analysis," Report Number NSF-RA-S-74-029, Washington, D.C., June 1975.

of several considerations. An earlier study of data bases conducted by Computer Sciences Corporation* itemized several of these considerations:

a. The variety of systems, access methods, and data structures is too complex to provide a quick and easy solution for data requirements.

b. The data must be evaluated by the user group for accuracy, completeness, and applicability, since the reliability of some of the data has not been established.

c. Some data bases are built to prove a particular theory or technique. The data base study group felt this to be the case with most data collection efforts in the universities and ARPA-sponsored projects. For instance, the Dimensionality of Nations project researchers at the University of Hawaii state that their data were collected for a particular theory and particular tests. This is a factor which deserves consideration but does not automatically invalidate the data.

d. Bias frequently exists when only a single systemic approach is used. When such a single approach deals with quantified data, there is bias of undeterminable amount in favor of that which is easily quantifiable.

The National Science Foundation study reference previously surveyed modeling efforts of nondefense Federal agencies. Over 650 models which deal with some aspect of social decisionmaking were identified. Reportedly, over 90 percent of these models were computer-based; the largest portion of the models addressed subjects involving economic impact and projections or policy options. Other models covered a wider range of problems from simulation of agricultural production to analyses of projected manpower requirements. The study participants noted that the lack of desired model comprehensiveness is a result of either the absence or high cost of

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*Computer Sciences Corporation, "Data Retrieval Systems/Data Banks Survey," Letter Report, Washington, D.C., 30 July 1973.

obtaining or processing "fine-grained," specialized information. Data for the survey models (in 76 percent of the cases) were drawn from published sources. The lack of appropriate data was noted as the most severe constraint on the modeling efforts and several respondents argued for Federal support to make more integrated socioeconomic data available to modelers.

In coping with the problems of missing data (of a complete set or single data points), the modeler has several possible courses of action. Depending on the significance of a certain indicator, the absence of a complete set of data could influence the modeler to restructure the conceptual model design. If the modeler notes the indicator as significant, a separate data collection effort could be undertaken or other approaches which are more qualitative could be chosen. Another choice, perhaps the most popular, is to supply data by using a mathematical or statistical method such as regression or trend extrapolation. In the Dimensionality of Nations Project which uses a large number of cross-national statistical data, missing data may cause severe problems. For this reason, the modeler developed a program to estimate certain data sets. Using this program, available data for each variable are regressed for the other variables. The number of regression equations equals the number of variables with missing data. A determination of the regression estimates for all missing data is made from the best fitted regression equations.

6.2 Survey of Data Sources

A review of data sources potentially applicable to the support of the types of models addressed in the MAFIAS framework has been conducted. More generally, the list of over 59 data bases represents a wide range of strategic environmental indicators. Table 11 lists these data sources, identifying the time span covered (if available) and sponsor, and stating whether they are presently retained in hardcopy or automated media. It should be noted that some of these sources coordinate rather than originate data. For example, the Data Resources, Inc., compiles the IMF Data Fund File, OECD Data File, and others.

This subsection also provides brief descriptions of 23 of the more widely distributed sources. The descriptions are

Table 11. Potential Data Resources

DATA RESOURCE	TIME SPAN (IF AVAILABLE)	SPONSOR	AUTOMATED	NONAUTOMATED
1. AERIAL PORTS AND AIR OPERATING BASES	——	U.S. DEPARTMENT OF DEFENSE	X	
2. ANNUAL BUDGET REPORT	ISSUED ANNUALLY	U.S. DEPARTMENT OF DEFENSE		X
3. ARCHIVES OF POLITICAL ELITES IN EASTERN EUROPE	——	UNIVERSITY CENTER FOR INTERNATIONAL STUDIES, UNIVERSITY OF PITTSBURGH	X	
4. BALANCE OF PAYMENTS YEARBOOK	ISSUED ANNUALLY	INTERNATIONAL MONETARY FUND		X
5. BATTELLE DATA BASES	——	BATTELLE MEMORIAL INSTITUTE	X	
6. CHARACTERISTICS OF NATIONS	1870–1914 1916–1935 (INCOMPLETE) 1935–PRESENT	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	X	
7. COMMODITY DATA SUMMARIES	——	U.S. BUREAU OF MINES	X	
8. COMMUNIST AID AND TRADE AND DEVELOPING COUNTRIES	——	U.S. DEPARTMENT OF STATE/BUREAU OF INTELLIGENCE		X
9. COMPUTER BASED BEHAVIORAL STUDIES (CCBS)	——	UNIVERSITY OF CALIFORNIA – LOS ANGELES	X	
10. CONFLICT AND PEACE DATA BANK	1966– *	UNIVERSITY OF NORTH CAROLINA	X	
11. CONTRY DEMOGRAPHIC PROFILES	——	U.S. DEPARTMENT OF COMMERCE	X	
12. CROSS ANTIGNAL DEMOGRAPHIC YEARBOOK	ISSUED ANNUALLY	UNITED NATIONS		X
13. CROSS NATIONAL TIME SERIES FILE (CNTS)	1815–1914 1918–1940 1945–PRESENT	STATE UNIVERSITY OF NEW YORK, CENTER FOR COMPARATIVE POLITICAL RESEARCH	X	
14. DATA FUND	——	INTERNATIONAL MONETARY FUND	X	
15. DEMOGRAPHIC DATA RETRIEVAL SYSTEM	——	U.S. DEPARTMENT OF COMMERCE	X	
16. DIMENSIONALITY OF NATIONS	——	UNIVERSITY OF HAWAII	X	
17. DRI DATA BANK	——	DATA RESOURCES, INC	X	
18. DYADIC TRADE DATA	1948–1975	INTERNATIONAL MONETARY FUND	X	
19. ENERGY AND PROTEIN REQUIREMENT TECHNICAL REPORT SERIES NO. 522	——	WORLD HEALTH ORGANIZATION		X
20. EXTERNAL DEBT SYSTEM	——	WORLD BANK	X	
21. FISHERIES YEARBOOK	——	UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION		X
22. FOOD BALANCE SHEETS	——	UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION	X	
23. FORCE STATUS AND IDENTITY REPROT (FORSTAT)	——	U.S. DEPARTMENT OF DEFENSE	X	
24. FOREIGN AFFAIRS THEORY, OPERATION, NAD MONITORING	1966–PRESENT	U.S. NAVAL ACADEMY	X	
25. GENERAL INDUSTRIAL STATISTICS	——	UNITED NATIONS STATISTICAL OFFICE (UNSO – *)	X	
26. GOVERNMENT R&D INVESTMENT	——	ORGANIZATION ECONOMIC COOPERATION AND DEVELOPMENT (OECD)		X
27. HANDBOOK OF ECONOMIC STATISTICS	——	CENTRAL INTELLIGENCE AGENCY		X
28. INDUSTRIAL COMMODITY PRODUCTION	——	UNITED NATIONS		X
29. INTERNATIONAL FINANCIAL STATISTICS	——	INTERNATIONAL MONETARY FUND	X	
30. INTERNATIONAL TRADE STATISTICS	——	UNITED NATIONS		X
31. INTER–UNIVERSITY CONSORTIUM FOR POLITICAL RESEARCH (ICPR)	——	UNIVERSITY OF MICHIGAN	X	
32. J–5 FORCE STRUCTURE INFORMATION DISPLAY SYSTEM	——	U.S. DEPARTMENT OF DEFENSE	X	
33. JOINT RESOURCE ASSESSMENT DATA BASE	——	U.S. DEPARTMENT OF DEFENSE	X	
34. NATIONAL BASIC INTELLIGENCE FACTBOOK	ISSUED ANNUALLY	CENTRAL INTELLIGENCE AGENCY		X
35. NON–FERROUS METAL, A SURVEY OF THEIR PRODUCTION AND POTENTIAL IN DEVELOPING COUNTRIES	——	UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION		X
36. PORT CHARACTERISTICS	——	U.S. DEPARTMENT OF DEFENSE	X	
37. PRODUCTION YEARBOOKS	ISSUED ANNUALLY	UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION		X
38. ROPER CENTER FOR PUBLIC OPINION	——	PUBLIC OPINION RESEARCH CENTER, WILLIAMS COLLEGE	X	
39. SCIENCE CITATION INDEX	——	NATIONAL SCIENCE BOARD		X
40. SOCIO–ECONOMIC DATA BANK	1950–PRESENT	WORLD BANK	X	
41. SPECIAL AFFLICATIONS FILE	——	U.S. DEPARTMENT OF DEFENSE	X	
42. SRI DATA BASES	1960–	STANFORD RESEARCH INSTITUTE	X	
43. SURVEY OF CURRENT BUSINESS	——	U.S. DEPARTMENT OF COMMERCE		X
44. TECHNOLOGICAL INNOVATION INDEX	——	GELLMAN RESEARCH ASSOCIATES		X
45. THREAT ANALYSIS RESEARCH PROJECT	——	UNIVERSITY OF SOUTHERN CALIFORNIA SCHOOL OF INTERNATIONAL RELATIONS	X	
46. UN DEMOGRAPHIC DATA BASE	——	UNITED NATIONS STATISTICAL OFFICE	X	
47. UNITED NATIONS ECONOMIC DATA	——	UNITED NATIONS STATISTICAL OFFICE	X	
48. UN VOTING RECORDS	1946–1975	UNITED NATIONS	X	
49. U.S. – CANADA DEFENSE TREATIES	UP TO 1975	NORTH AMERICAN BRANCH INFORMATION RETRIEVAL SYSTEM	X	
50. U.S. OVERSEAS LOANS AND GRANTS	1946–1975	U.S. DEPARTMENT OF STATE/BUREAU OF INTELLIGENCE		X
51. WORLD CROP STATISTICS	——	UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION	X	
52. WORLD DEBT TABLES	——	WORLD BANK		X
53. WORLD ENERGY SUPPLIES	——	UNITED NATIONS STATISTICAL OFFICE (USNO – 4	X	
54. WORLD EVENT/INTERACTION SURVEY	1966–1976	UNIVERSITY OF SOUTHERN CALIFORNIA	X	
55. WORLD MILITARY EXPENDITURES	——	ARMS CONTROL AND DISARMAMENT AGENCY	X	
56. WORLD TREATY INDEX	——	AMERICAN BIBLIOGRAPHIC CENTER	X	
57. YEARBOOK ON METAL STATISTICS	ISSUED ANNUALLY	AMERICAN BUREAU ON METAL STATISTICS		X
58. YEARBOOK OF NATIONAL ACCOUNT STATISTICS	ISSUED ANNUALLY	UNITED NATIONS		X
59. YEARBOOK OF WORLD ARMAMENTS AND DISARMAMENTS	ISSUED ANNUALLY	STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE		X

supplemented by a Computer Sciences Corporation Letter Report* completed under contract to the Studies, Analysis and Gaming Agency (SAGA) of the Organization of the Joint Chiefs of Staff (OJCS). Their report provides a data reference list which describes, catalogs, and indexes resources by type, currency, and update intervals. The subjects covered incorporate domestic politics, military capabilities, economic activities, and international relations.

6.2.1 Archives of Political Elites in Eastern Europe. This data source is maintained by the University Center for International Studies, University of Pittsburgh. In the Archives of Political Elites in Eastern Europe, data are presently maintained on national leadership for the countries of Bulgaria, Czechoslovakia, Hungary, Poland, and Romania and include various demographic and career-event characteristics. The leaders maintained in the files are, or have been, members of the Central Committee and/or Council of Ministers of their respective countries. The information is gathered from East European publications and then assimilated by the Archive. Since the files are updated on a regular basis, both the quantity and quality of information for individuals already in the files increase over time, as does the total number of persons within each country. Students acquire and code data from the Radio Free Europe files in Munich. Data are obtained from official government biographies, books, periodicals, and newspaper accounts. Data are converted into machine readable form at the Archive.

6.2.2 Battelle Data Bases (BAT). This data source is maintained by the Battelle Memorial Institute, Columbus Laboratories, Department for Information and Communications Systems. The Battelle Memorial Institute maintains a variety of data bases and information centers, of which the Tactical Technology Information Center and the Foreign Science and Technology Library are of potential interest.

The Tactical Technology Information Center, formerly the Remote Conflict Information Center, is ARPA sponsored. The Center contains counterinsurgency data pertaining to North Vietnam, Thailand, Iran, Malaya, and Indonesia. It offers DOD agencies analytical support on a quick-response basis.

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*Computer Sciences Corporation, Data Retrieval Systems/Data Banks Survey, Letter Report, Washington, D.C., 30 July 1973.

The holdings include approximately 42,000 selected tactical warfare documents dealing with incipient insurgency and low intensity conflict through the utilization of nuclear tactical weapons. Although much of the data is concerned with weaponry, the collection also contains data on the economic, social, and political aspects of counterinsurgency and tactical warfare. (See "TACTEC, Tactical Technology Center," brochure, published by Battelle, no date (FOUO).)

Battelle's Foreign Science and Technology Library contains selected publications and translations on Sino-Soviet Bloc technology. In addition, military publications are collected on a worldwide basis. The collection also contains political and economic data in support of research and development.

Data are acquired from brochures, original language publications for libraries, reports for TACTEC, occasional machine readable data files to support studies and analyses, foreign scientific and technical publications, reports by government and nongovernment organizations, and publicly available machine readable files.

6.2.3 Characteristics of Nations (CN). This data source is maintained by the Massachusetts Institute of Technology (MIT), Center for International Studies. Ms. Chouchri maintains a data base of "Characteristics of Nations" from 1870 through the present. This file is made up of economic indices, actions, events, resources, trade, etc. Information is complete for the period 1870-1914 and 1935 to present. Data for the 1914-1935 time period are less complete, but are updated continually. Data are acquired through standard library tape searches from newspapers, books, periodicals, and government published statistics.

6.2.4 Computer Based Behavioral Studies (CCBS). This data source is maintained by the University of California, Los Angeles (UCLA), Center for Computer Based Behavioral Studies (CCBS). This ARPA sponsored project is monitored by Ms. Pat Langendorf at Rome Air Development Center, Griffiss AFB, N.Y. The CCBS is an installation centered around a virtual memory PDP-10 computer with addressable peripherals. On 1 August 1973, a COMPUTEK terminal in SAGA, which is connected to the CCBS through the ARPA Network, was able to access, using near English language commands, the following data bases: World Handbook of Political and Social Indicators (Taylor), Wages of War, Diplomatic Missions and Diplomatic Exchange (Singer), International Subsystems (Hass), Political Conflicts (Cady),

Middle East Time Series (Milsten), and WEIS (McClelland). Data are acquired from any given machine readable data base that can be put into CCBS, depending upon the requirement. Additional source files may be selected by the user, depending upon the requirement. The user must know the substantive data in any file in order to have meaningful access.

6.2.5 Conflict and Peace Data Bank (COPDAB). This data source is maintained by the University of North Carolina, Department of Political Science, Studies of Conflict and Peace. The Conflict and Peace Data Bank (COPDAB) is an extensive, longitudinal collection of daily inter-nation and intra-nation analytic events, yearly inter-nation and intra-nation transactions, and yearly national attributes and capabilities. The first two types of data constitute the most comprehensive and up-to-date collection in COPDAB. COPDAB presently contains about 225,000 descriptive events gathered from a large set of sources and is continuously being updated and cleaned out. The analytic events are quantitative translations of these descriptive events.

COPDAB was started in 1968 with the intent of monitoring changes in the number of actions between and within certain international actors (both territorial and nonterritorial). COPDAB presently monitors 50 actors.

Dr. Azar's interest in and knowledge of North Africa, the Northern Tier states, and the Middle East gave him an advantage in evaluating data for these regions. He further argued that in order to understand international interactions of African and Asian states, one needs to monitor the major international actors, their interactions, and the way they influence the behavior of the states being studied. As a result, COPDAB's collection came to include data on 36 developing nations and 15 major actors such as the USA, USSR, PRC, Britain, and France.

COPDAB contains four types of data:

a. Events Data - The verbal and physical actions, reactions, and interactions which international actors direct toward their domestic and/or their international environments

b. Attribute Data - Population, gross national product, military budgets, development expenditures, and the like

c. Transactional Data - Such variables as trade and military-economic aid flows among international actors

d. Perceptual Data - Goals and preferences which key decisionmakers articulate.

Data are acquired from open publications. All prospective COPDAB coders are required to study COPDAB's Coding Manual (available on request) intensively. During the training period, which lasts a minimum of one week, individuals code data under the direct supervision of the project coordinator. When coders are judged to have attained the necessary expertise (a correlation over .95 with "standardized" coded events is required before a student is qualified), they are assigned a volume from one of COPDAB's sources. The project coordinator holds weekly meetings with each coder to review that week's work. About one fourth of all prospective coders are dismissed during the training period.

Several of the most experienced and capable coders are further trained as editors and scalers. These assistants review each event and edit it (i.e., correct mistakes, check the original source if necessary, and clarify penmanship as an aid to the keypunchers) in order to ensure that accurate and sufficient information is retained in COPDAB's events. When the events have been "edited," they are scaled by trained assistants according to the 13-Point Interval Scale. These editor-scalers also meet with the project coordinator on a weekly basis to study any problems which might arise. The coordinator, at this time, also checks on the editing and scaling as a review of the assistants' work.

Following scaling, data are keypunched, sorted by actor, listed, and inspected for keypunching errors. The data are then added to respective actor files where they are arranged chronologically by dyads. Events are coded daily, but the update of transactions to the data bank takes place on an average of three to four times a year. Updates can be made sooner, depending upon a particular project need.

Every 6 months COPDAB data are recalled, cleaned, and restored. "Cleaning" refers to the removal of duplicate events (the result of coding from such a large number of sources). This process ensures that the data which are made available to other users are complete and accurate.

6.2.6 Country Demographic Profiles (CDP). This data source is maintained by the U.S. Department of Commerce, Bureau of the Census, International Statistical Programs Center (ISPC). The CDP will present detailed data on individual countries for both a recent census year and the current period. The demographic data accessible include aggregates and other items such as composition of the labor force, school enrollment, migration, and rate of annual growth. Sixty country profiles are on disk, but user programs have not been written, nor have required data processing routines been fully developed. A complete profile for each country contains three arrays of data (base, intermediate, and current) which are presented side by side for ease of comparison. Data will be available to users through COMNET Corporation time sharing network. Primary data are acquired from sources indicated, and then evaluated, adjusted, and input to the CDP. Data for the profiles are compiled from various sources, including: censuses, surveys, statistical yearbooks, journals, special reports published by individual countries, special analytical reports issued by the United Nations (including unpublished results of population projections prepared by the Population Division), reports of specialized agencies of the United Nations, such as the Food and Agriculture Organization Production Yearbook, the International Labour Office Yearbook of Labour Statistics, and the UNESCO Statistical Yearbook, reports prepared by other international organizations such as the Centro Latinoamericano de Demograffa, and technical papers prepared for conferences and articles in demographic or statistical journals. Many of the items have been prepared by ISPC for use by the Agency for International Development in various issues of its publication, Population Program Assistance.

6.2.7 Cross-National Time-Series File (CNTS). This data source is maintained by the State University of New York (SUNY) Center for Comparative Political Research (CCPR). The Binghamton archive, as presently constituted, has 210 variable locations and contains data for 167 independent countries, with provision for entries from 1815 to 1973 (excluding the two major wartime periods, 1914-1918 and 1940-1945), on a wide variety of phenomena such as areas and population, revenue

and expenditure, trade, transport and communication, education, social welfare, and politics. Entries are made on an annual basis with estimated data provided where original data are lacking. Secondary indices are derived by mathematical manipulation of primary data, by reducing the latter to per capita or per square mile for internation comparability, or by recasting of data arrays on the basis of annual percentage change.

The archive uses data from published open source literature, selected in accordance with CCPR criteria, and input manually into the system.

6.2.8 Data Fund (DF). This data source is maintained by the International Monetary Fund (IMF). The Data Fund is an automated data base containing economic data for 200 countries. It is used as the basis for the publication of two monthly serials: "International Financial Statistics" (IFS) and "Direction of Trade" (DOT).

IFS contains a summary of every country's balance of payments, data on its principal components (trade and reserves), and data on the principal cause and effect elements of the balance of payments problem (monetary expansion and contraction, government surpluses and deficits, production, prices, and interest rates). DOT provides a detailed picture of that part of balance of payments transactions that can be classified by partner country.

The monthly issues of IFS and DOT serve the purpose of providing current data promptly; the annual Supplement to IFS serves the purpose of providing long strings of annual data, and the DOT Annual serves the dual purpose of providing strings of annual data and partner country estimates for countries whose data have not been reported, and of bringing the data together in area and world totals. For those who have access to a computer, two other provisions could be useful: data in machine readable form, and long strings of monthly and quarterly data.

The time series that constitute these two publications are compiled and maintained in the Data Fund computer system. The Data Fund contains, so far as available, all monthly, quarterly, and annual entries for each of the IFS and DOT country page series; i.e., all those that appear in current issues and those that, with the passage of time, have

disappeared from the pages. Each of the series is continuously updated and, when necessary, corrected and revised. Hence each new tape replaces its predecessor and makes unnecessary any updating or merging process.

Tapes are merged from machine readable data for developed countries. Cards are keypunched by IMF personnel from manual data supplied by emerging nations. IMF member countries' central banks and statistical offices provide data for the Data Fund.

6.2.9 Demographic Data Retrieval System (DDRS). This data source is maintained by the U.S. Department of Commerce, Bureau of the Census, International Statistical Programs Center (ISPC). The DDRS (previously known as International Demographic Data Directory (IDDD)) is a computerized bibliography of demographic and family planning data, supplemented by the data themselves. About 1,000 tables are referenced currently, and about 2,500 more will be added annually. The retrieval system associated with the directory enables the user to obtain references rapidly, either through the use of his own remote console or through submission of requests to the ISPC. User instructions are available via the terminal. There may be no data for some countries, little data for some, and incomplete data for all. Data are available to users through COMNET Corporation Time-Sharing Network.

The system covers information for the world, major areas of the world, component regions, countries, major subdivisions of countries such as states or provinces, the urban and rural parts of these areas and, where data are available, metropolitan areas, cities, towns, and villages. Primarily, emphasis has been placed on information relating to the countries of Africa, Asia, and Latin America. There are, however, two exceptions: data from the United Nations, which cover all countries of the world, and data from recent census reports as they become available from any country in the world.

Subject coverage of the system includes such demographic data as population characteristics and vital statistics; also included are statistics on family planning program activities, health programs, education, and demographic-related economic characteristics.

Information on two types of data is included: primary data and adjusted data. Primary data are acquired from such sources as census reports, vital statistics publications, and United Nations documents. The adjusted data referenced in the system are also from a variety of sources. A major source is the International Statistical Programs Center of the Bureau of the Census, which is engaged in evaluating and adjusting demographic data. Working papers and publications prepared in ISPC provide adjusted demographic data as well as projections of populations. Other sources of adjusted data include publications of the United Nations, articles from journals, and conference reports on population and family planning.

Primary data are acquired from the sources, evaluated, adjusted, and input to the DDRS. Data are acquired from the following sources:

Sources:

- Census Reports - Information on all characteristics of the population selected from both preliminary and final census reports are entered into the system. These tables vary from the most common subject of age and sex distributions to more specialized subjects such as economic status cross-classified by educational level. In addition, a limited number of tables on household subjects are included. Most frequently, these relate to number and size of households, usually distributed by type of household.

- Sample Surveys - These are often the only source for supplying data on population characteristics of a country when a census report is not available. The subject content of such surveys frequently includes familiar census-type information. However, special sample surveys also supply certain types of information which are not usually collected in a population census, such as vital events, movement of the population into and out of areas, etc.

- Offical Statistical Publications - Vital statistics are available in monthly, quarterly, and annual official publications of national governments. From these sources, references to current data on births, deaths, marriages, divorces, and migration are selected for inclusion in the system. Some official

publications provide data on public health statistics which include, among other subjects, the number of hospital facilities, personnel, cases of abortions, rural health clinics, dispensaries, and deaths by cause.

- United Nations - Every table contained in the Demographic Yearbook is referenced in the DDRS. In addition, reference is made to unpublished data contained on basic questionnaires collected by the U.N. directly from national statistical offices. The subject content of the U.N. tables is broad. Included are all subjects normally covered in a comprehensive population census as well as data on vital statistics. Some other U.N. publications screened and selectively referenced in this system include the Monthly Bulletin of Statistics, Working Papers of the Population Division, Population and Vital Statistics Report, and Compendium of Social Statistics.

- Other Sources - Professional journals are screened for data which have been adjusted according to sound methodological procedures. The International Statistical Programs Center's internal working papers and publications provide adjusted demographic data and projections of populations. These data relate to measures of fertility and mortality, and to projections of the population using different assumptions about future changes in fertility and mortality. The "Age-Parity Grid System" is another source for unpublished data tabulated by ISPC. Based primarily on the Demographic Yearbook, tables in the grid report births by age of mother and parity, median age, "excess" births by age group, and "excess" births by parity group. The grid system includes all countries of the world for which age-specific data are available. A publication series of ISPC is "Demographic Reports for Foreign Countries"; these reports are published irregularly. The main tables of data appearing in the series are projections of the population by sex and single years of age through age 29, and by 5-year age groups thereafter. Coverage is from the year of the latest census to about the year 2000. Also presented are the number of births and deaths which underlie these projections.

6.2.10 DRI Data Bank (DRI). This data source is maintained by Data Resources, Inc. (DRI). DRI provides a time shared service to customers requiring economic statistics, modeling, and trend analysis. Although its Economic Information System is primarily oriented toward U.S. data, it does maintain extensive International Financial Statistics tapes which DRI receives and processes into its Economic Information System. According to Dr. Ripley, DRI must reprocess the IMF data to eliminate errors and inconsistencies. DRI also maintains special files on Canada and Japan. The tapes are acquired from the IMF, the OECD, the U.S. Government, and from internally generated data. The DRI sources include IMF Data Fund File, OECD Data File, Department of Commerce and other U.S. Government Department/Agency publicly available economic data files, Canadian and Japanese Government statistical information, information from U.S. and foreign universities, and internal data research.

6.2.11 External Debt System (EDS). This data source is maintained by the International Bank for Reconstruction and Development (World Bank), Economic and Social Data Division (ESDD). The External Debt System (EDS) contains 35,000 items indicating obligations of debtor countries. Information contained is used for credit worth analysis and periodic credit reports. The data are original and are from reports obtained from foreign governments and central banks for the Bank's operation. Sources are official government statements, especially central bank reports. These data are developed from primary sources.

6.2.12 Foreign Affairs Theory, Operation and Monitoring (FATHOM). This data source is maintained by the U.S. Naval Academy, Department of Political Science. McClelland's WEIS data structure is the foundation of the FATHOM system. Attributes and relational data are described by families of data, for example, kind of data (GNP, Trade, Literacy Rate, Political Behavior, Area, Population, etc.), time domain of data, possessor of an attribute or originator of a relationship, measure of magnitude, recipient, and additional subclassifications and descriptions where needed. Over 50,000 events are stored for the period 1966 to the present.

Three data files of interest are the WEIS File, United Nations Voting Records File, and International Communications File. WEIS data edited by McClelland is provided by the Naval Postgraduate School in Monterey, California. The original data

set was developed by McClelland at the University of Southern California. Communications data are developed by the Naval Academy. UN voting data were acquired from the University of Michigan.

WEIS data are largely derived from the New York Times. International Communications data come from a variety of sources; i.e., International Mail Division of the U.S. Postal Service, Universal Postal Union, International Telecommunications Union, and COMSAT data. Research had to be done for telephone, telegraph, radio, etc. Ms. Suzan Tate at the Department of State is the contact for UN data.

6.2.13 ICPR Data Bank. This data source is maintained by the University of Michigan, Inter-University Consortium for Political Research (ICPR). The Inter-University Consortium for Political Research was founded in 1962 as a component of the Political Behavior Program of the Survey Research Center in the Institute for Social Research at the University of Michigan. The ICPR is now a partnership between the Center for Political Studies and the University of Michigan with over 170 member universities and colleges. The ICPR cooperates closely with such organizations as the European Consortium for Political Research and the International Social Science Council (UNESCO). The ICPR makes known to the research community its activities through annual meetings with representatives from member institutions, quarterly ICPR Council meetings, and through publication of its Guide (A Guide to Resources and Services of the Inter-University Consortium for Political Research 1972-1973). There are three ICPR archives: the Survey Research Archive, the Historical Archive, and the International Data Archive.

In response to a number of stimuli, not the least of which has been the shifting focus of scholarly activity, an increasing number of non-American, comparative studies are coming into the various archives. For example, surveys from several nations, many covering a significant span of time, are being regularly added. Subnational aggregate data on social structure and data holdings of the ICPR are likely to be the area of fastest growth in the coming years, although there will be no decline in the rate of expansion of the American holdings.

With the growth in both magnitude and substantive content of the data in each of the ICPR's three archives, it is important to be aware of the holdings of data in all three units. To

aid exploration of the whole range of data holdings, the various studies have been grouped by general categories, regardless of the particular archive which holds the data. Data should be ordered from the particular archive under which they are described. Data sets are acquired from member and nonmember institutions as well as individual contributors. Over 170 member institutions contribute data.

6.2.14 Joint Resource Assessment Data Base (JRAD). This data source is maintained by the U.S. Department of Defense, Command and Control Technical Center, Data Division. The JRAD bank is a listing of fixed resource installations, arranged by functional category. It consists of three subfiles extracted from the Defense Intelligence Agency Automated Intelligence File: Eurasian Target Data Inventory (ETDI), Anglo/North American (ANA), and Foreign Free World (FFW). The capacity and other DIA quantitative significance figures are converted into actual figures, and are retrievable from the JRAD without further interpretation. Files are maintained in current status and include projection data which are now manually extrapolated by the CCTC. Fixed resource data for economic, military, political, and social classifications are available for single nations or groups of nations. Tapes are obtained from the DIA and reformatted into the JRAD file format. Data are acquired from the Defense Intelligence Agency Automated Intelligence File and subfiles (ETDI, ANA, FEW), as well as the Consolidated Facilities Planning List (CFPL) data.

6.2.15 Roper Center for Public Opinion (ROPER). This data source is maintained by the Public Opinion Research Center, Williams College. The Roper Center contains approximately 10,000 data sets of cross-national, national, demographic, and opinion surveys. One-third of the surveys at the Roper Center were conducted in the U.S. by national, regional, and state organizations. The remaining two-thirds were carried out by survey research groups in 67 other countries. Over 80 percent of the studies are omnibus surveys containing questions on a variety of topics.

Proportionately, the subject areas are: 50 percent Public Affairs (other than domestic or political; e.g., race relations, juvenile delinquency, international relations, welfare, etc.), 20 percent Mass Media of Communications (e.g., attitudes toward, exposure to, etc.), 15 percent Domestic Political Behavior and Attitudes (e.g., vote intention and

recall, party preference, campaign issues, etc.), and 15 percent Market Research (e.g., consumer attitudes and behavior, product ownership and preference, etc.).

Because of the omnibus nature of most of its surveys, the Center uses the individual question as the basic indexing unit. Each question is assigned to one or more of the 70 major and 1,400 minor topical categories in the Center's indexing system.

Special files include U.S. Information Agency sponsored internation relations surveys.

Data are acquired from public opinion surveying organizations in the U.S. and abroad. There are over 60 overseas organizations contributing data. These sources are based in 45 countries. A complete list may be obtained from the Roper Opinion Research Center. Individual data sets are identified as to source in the Roper Center Newsletter.

6.2.16 Socio-Economic Data Bank (SEDB). This data source is maintained by the International Bank for Reconstruction and Development (World Bank), Economic and Social Data Division (ESDD). The SEDB contains approximately 183 macro social and economic indicators for 142 countries covering 23 years since 1950. SEDB provides a data base for projections and reports. Global projections are made 5, 10, and 20 years into the future to test the validity of assumptions made by the countries' economists. Data are acquired from public and secondary sources such as newspapers, books, periodicals, attache reports, and government statistics.

6.2.17 Special Applications File (SAF). This data source is maintained by the U.S. Department of Defense, Command and Control Technical Center. The SAF consists of worldwide population data and economic data for the 25 major industrial nations. Population is listed for all place names of 25,000 and over, plus "rural cells." New file will project population and economic current data from 1 to 11 years in the future. Tapes are from Department of Commerce and Defense Intelligence Agency for most data. Punched cards for data are created by the Data Division. Free world population data are supplied by the Foreign Demographic Analysis Division, Bureau of Economic Analysis, Department of Commerce. Population and economic data for the USSR and its satellites and the Peoples Republic of China and its satellites are supplied by the Defense Intelligence Agency. Reports of the Joint

Economic Committee of the Congress are also used for USSR and China. Department of Commerce obtains data from United Nations for both population and economic information.

6.2.18 SRI Data Bases (SRI). This data source is maintained by the Stanford Research Institute (SRI) Office of Strategic Studies. SRI has built data bases to support the studies and analyses it has performed for the U.S. Government and other clients on political, military, economic, and international relations subjects. These studies include "An Analysis of Soviet and East European Energy Programs" for a DOD client, published in the autumn of 1973. Other studies are retrievable through the Defense Documentation Center and the Army Library.

The SRI machine readable data base consists of current population and industrial economic data. The population data bases consist of U.S. population figures for 1960 and 1970 projected to 1990 for the 100 largest metropolitan areas. They also include the population of 12 Western European countries at approximately 34,000 population locations. Projection factors for subregions in each country are also available, based on 1960 and 1962 censuses. Population data for four West German states are also updated to 1970. The countries included in the Western European population data base are: Belgium, Denmark, Norway, Portugal, Turkey, and the United Kingdom. Other countries included in the population data base are Japan (1960), Canada (1961), East Germany (1961), Poland (1961), and Czechoslovakia (1961).

The industrial data base is for the U.S. only and includes: Value Added, 1961 projected to 1975; Petroleum Refining, 1969; Electric Generating Capacity, 1965; and Nonferrous Refining, 1967.

Researchers compile data from other data bases and from classified and unclassified literature. Some data elements from the U.S. Government and other automated files are extracted and placed in the SRI data base. Data are also acquired from open source and classified publications, and unclassified machine readable data files.

6.2.19 Threat Analysis Research Project (TARP). This data source is being developed by the University of Southern California (USC) School of International Relations. Dr. McClelland began work as principal investigator on the Threat Analysis Research Project under ARPA HRRD-ONR Sponsorship on 1 July 1973. TARP will go beyond the analysis of day-to-day

reporting from open sources of world events. It will attempt to develop techniques for picking out signs of impending unrest, famine, military action, and other threats, internal and external. Sources will be unclassified nongovernment publications. TARP will identify those factors not emphasized by official government public policy statements which are relevant to indications of impending threats. Graduate students read and code data from nongovernment open source literature (newspapers, magazines, etc.).

6.2.20 UN Demographic Statistics (UNDS). This data source is maintained by the United Nations (UN) Statistical Office. The UN maintains economic and demographic statistics (see paragraph 6.2.21 for economic data). Demographic statistics contain country-specific, aggregations, and raw data of economic, econometric, and demographic nature. All data are from official government statistics of UN member countries.

6.2.21 United Nations Economic Data (UNED). This data source is maintained by the United Nations (UN) Statistical Office. The UN maintains four computer based files, of which three are economic and one is demographic. They are: National Accounts Statistics, International Trade Statistics, Industrial Commodity Production, and Demographic Statistics. For the convenience of this report, the first three have been called *UN Economic Data (UNED)*. All data are from official government reports of the UN member nations.

6.2.22 World Event/Interaction Survey (WEIS). This data source is maintained by the University of California, Los Angeles. WEIS can be used in quantitative social science analysis called "event analysis." This analysis makes use of the "World Event/Interaction Survey" (WEIS) technique first developed by Charles McClelland, Dept. of International Relations, UCLA. An event is an action/interaction by and between nations. There is an "International and Domestic Event Coding System" (INDECS) for both inter- and intra-national affairs for nine items for each event: event class, event date, actor country, subnational actor, event type, target country, subnational target, general subject area, and news source. Most of the event analysis is based on the New York Times. Some work is also done using the FBIS Bulletins, London Times, and other sources. The event analysis technique can be used to calculate "relations" between nations, i.e., negative, neutral, and positive behavior. The WEIS files are maintained at the Naval Academy Computer Center.

6.2.23 World Treaty Index (WTI). This data source is maintained by the American Bibliographical Center. The WTI is a 5-volume computerized index which culminates a 10-year effort directed by Professor Rohn, Department of Political Science, University of Washington, Seattle, Washington. It includes the United Nations Treaty Series, League of Nations Treaty Series, and more than a dozen national treaty collections. Treaty Profiles, a companion volume to WTI, is a statistical analysis of world treaty patterns - national, regional, and global. Users can negotiate custom-made computer printouts for research in regional and global systems and interaction patterns. Each country and organization is "profiled" in a standard format, listing its top 30 treaty partners, plus regional groups, time trends, topical data, and various percentages to facilitate cross-national and cross-regional patterns. Printed copies of treaties are indexed, abstracted, and coded by graduate students at the University of Washington, and data are input via punched cards and terminals. Data are acquired from the United Nations Treaty Series, League of Nations Treaty Series, and National Treaty Series for more than 12 countries.

SECTION 7. CONCLUSIONS AND RECOMMENDATIONS

The principal focus of the study project on which this report is based is survey, review, and evaluation of the simulation models and data sources which an extensive literature search (see appendix A) revealed to be currently available. The models and data sources were considered and evaluated with regard to their potential applicability as forecasting tools in the preparation of the long-range planning documents at the Department of Defense.

7.1 Conclusions

This study was conducted with consideration of the fact that the last JLRSS published in 1974 was reviewed by IDA and was strongly criticized for its role, utility, consistency, and method of preparation. The IDA critique casts some doubt on the feasibility of any form of long-range forecasting and explicitly rejects any highly structured approach employing models, although it does recommend a more clearly defined role and a more qualitative approach to the endeavor. It also noted a lack of an authoritative statement of the strategic concern toward which military forecasting efforts must be directed.

These factors directly affected this study's requirements to survey and evaluate alternative forecasting methodologies, data sources, and simulation models for their applicability to the preparation of long-range planning documents. An evaluation requires a clear statement of standards and objectives that can be used as the basis for comparison and judgment. Therefore, this study considered the question of the nature of and alternative approaches to long-range planning as a necessary first subject for investigation.

After considering the arguments and recommendations of the IDA critique of the JLRSS, this study has endorsed a method of long-range strategic forecasting proposed by the Army War College report, to be used in conjunction with Cline's equation for perceived power. The study recommends that the equation be used as the basis for a family of integrated forecasting models. It also recommends an approach to long-range planning and a means of supporting the effort through the application of the IDA reports' suggested development of

a handbook of long-range problems and data.* Such a handbook could serve as a principal DOD long-range planning source document.

In arriving at these recommendations, the study addressed a number of fundamental questions. The most basic of these questions concerns the very nature and feasibility of forecasting and prediction in the field of global environments. This study based its assessment of the feasibility of forecasting on a probabilistic and conditional conception of prediction which is consistent with that employed by science in general.

The present study does not claim that long-range strategic studies are simple, straightforward exercises, nor does it view correct forecasting as a question of selecting the correct method. The nature of the subject is such that uncertainty and a substantial margin of error are always involved. However, the difficult and unsatisfactory nature of long-range forecasts cannot be used as grounds for abandoning the attempt to write any long-range planning document. The idea of intelligent planning requires strong efforts to assess future developments as far as current techniques permit. With or without a planning document, expectations about the future will be formulated. In the absence of perfect knowledge and foresight, decisions that must be made will in fact be made on the basis of the most general, vague, and incomplete expectations. The present study contends that anything done to objectify, quantify, and focus these expectations about the future is of direct service to decisionmakers.

The potential usefulness of the models identified in this study is also heavily dependent on the form and function of JCS planning documents. One of the principal conclusions of the IDA study is that if the JLRSS were to have been useful in planning, it would have had to have a different design. This study contends that if such a redesign attempted a fuller integration of the planning and forecasting functions, the usefulness of rigorous models would be substantially enhanced.

Although simulation models as a class offer the greatest potential for supporting suitable long-range planning concepts, the problem remains to determine the model or models that best fulfill this function. The large number of models surveyed

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*Gilmer and Wainstein, op. cit., p.92

in this study poses the problem of which should be selected as the correct and most useful. Closely associated with this problem is the question of whether a planning document is best supported by one or a number of models. A single, multipurpose supermodel capable of simulating global political-economic-social developments would be desirable, provided its aggregates could be broken down into regional and national data and forecasts. In practice, this type of model is probably not practical because of limits imposed by the state-of-the-art in global environment modeling techniques and because of budget restraints. On practical and technical grounds, then, a multimodel approach is the best alternative.

The array of models surveyed in this report may be the basis for this approach, if employed in a suitable framework. Such a system would afford a means of organizing data and substantive expertise to generate maximum information focused on specific issues or areas of concern in strategic forecasting.

The principal part of the system is the multimodel array, which would include models surveyed in this report with the addition of any others that further search and study reveal to be appropriate or superior. The multimodel array would have two primary functions: quantitative forecasting and formulating scenarios of significant events.

With regard to quantitative forecasting, the model array would have the capability of making long-range projections of economic and social indicators associated with areas of strategic concern. Using the array, these forecasts could be made at three levels of aggregation:

a. Global with regional interaction

b. Regional or national specific

c. Sector specific.

For forecasts at the first and second levels, this study strongly recommends the use of the Mesarovic World Model through the Assessment of Policies Tool (see subsection 5.3.1.1 and appendix C for a more detailed discussion of this model). The APT model combines the advantages of high degree of flexibility linked to the most highly developed and impressively conceived model in existence at this time.

For detailed forecasts at the second and third levels, partial models such as Link for world and national level trade forecasts or the Houtakker-Petroleum model would be used. For key countries such as the Soviet Union and China, the available country-specific models would be employed. The model sector forecast would then be used as input to establish forecast values for Cline's perceived power equation on a national and regional basis. Using the Cline equation, some assessment of the international political implications of future power relationships could be conducted on the basis of the broadest prevailing general theory of motivation for international behavior available today. For example, adopting the national power projections to Organski's power transition theory*, a forecast of drastic changes in relative power capabilities could suggest future instability in the international environment and be an important factor for long-range defense planning considerations. Cline's equation could be used to forecast broad trends in national alignment and behavior as a function of the power configuration among nations.

The handbook concept proposed by the IDA critique is, with appropriate modifications and additions, the most promising of the various suggestions that have been made. In addition to the description of long-range problems, data, and list of strategic concerns, the handbook should include the recommended multimodel array. An essential element in the handbook would also be the documentation and users guide to the multimodel array, as well as data bases for use in the models and other applications. In the form of a handbook, any long-range planning document would encourage the use of the interactive simulation capacity of the multimodel array and better fulfill its function as a source document. Obviously, this concept requires further refinement, but this study strongly endorses such an effort as the proper direction for future long-range forecasting by the DOD.

7.2 Recommendations

Based on the considerations identified in this report, the following are recommendations for further action in support of the preparation of DOD long-range planning documents:

a. Adopt a forecasting methodology oriented to the Army War College proposed most probable and core environment approach.

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*Gilmer and Wainstein, op. cit., p.92

**Organski, A.F.K., World Politics, New York: Alfred A. Knopf, 1968.

b. Use a structured set of simulation models, where feasible, to develop a forecast of future power relationships among nations.

c. Conduct a more in-depth evaluation of the structure and assumptions of the surveyed models (particularly that of Mesarovic) for possible inclusion in the set of simulation models.

d. Evaluate and identify potential data sources best suited to meeting the DOD long-range forecasting requirements suggested on the basis of the needs of the models recommended for adoption.

e. Review the feasibility of developing a handbook of long-range problems and data as recommended in the IDA critique to serve as a major DOD long-range planning document.

f. Continue to maintain contact with other long-range forecasting organizations and to monitor the applicable literature on new forecasting developments.

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APPENDIX A

GROUPS CONSULTED

This appendix provides a listing of the most relevant groups and individuals that have been contacted by the study group. The list of over 115 entries is divided into the following groups: government groups contacted, university groups contacted, and miscellaneous groups contacted.

UNIVERSITY GROUPS CONSULTED

Group	Contact Name	Contact Status: Response Received	Contact Status: Additional Contact Suggested	Comments
American University — Center for Technology Assessment	J. R. Richardson D. Malone	X	X	Dr. Richardson is a team member of Mesarovic Case-Western Group, specializing in the food sector analysis. He is currently director of the CTA and could be of potential value in acquiring contacts for subtask guidance. Dr. Malone is director of the Operations Research Program at CTA. He has been cooperative in sharing information, names and materials on global modeling perspectives.
Brandeis University	Ann Carter		X	Participated in development of Leontief's global model.
Case-Western Reserve University	M. Mesarovic C. Brewer E. Hughes T. Shouk	X	X	The world modeling group is involved in presenting their model capabilities to an international list of decisionmakers, scholars, and professional organizations. A continual effort is also undertaken to improve and expand the model. The Case team highlighted the 1976 Winter Simulation Conference at the National Bureau of Standards. The presentation included some general background information on the global model in addition to running several scenarios.
Columbia University; American Assembly	Clifford Nelson	X		This organization was established by Dwight Eisenhower in 1950. It holds nonpartisan assemblies and publishes authoritative books to illuminate issues of United States policy. At least two assemblies are held each year encompassing a range of topics.
Cornell University	Duane Chapman	X		Authored a paper on "Energy Conservation, Employment, and Income."
Dartmouth	Dennis Meadows	X	X	Dr. Meadows expressed an interest in our literature search and he hopes to ensure future contact. He will be working with the World Modeling Group of IIASA in 1977.
Delft University (Holland)	J. Tinbergen			To request information on the RIO project that is examining the international economic order; Tinbergen is being sponsored by the Club of Rome.
Emory — School of Theology	Carl Brewer	X		Organizing a conference on "Southeast 2001: The Next 25 Years"; not of immediate interest to the subtask.
George Washington	James Wertz	X		Currently teaching a class on the industrialization of space. He is also a full-time employee of Computer Sciences Corporation.
Georgetown — Center for Population Research	Conrad Taeuber	X		As a demographer, he provided some assistance on the fundamentals of population studies. However, he is not currently involved in long-range demographic forecasting.
Georgetown — Center for Strategic and International Studies	Ray Cline		X	This center supports an interdisciplinary approach to research political, economic, and strategic issues. Dr. Cline is of special interest to the subtask given his development of the world power assessment formula. Work in this areas is proceeding under a Ford Foundation grant.
Indian Institute of Technology — Department of Humanities	P. V. Rastogi			Contact was made to acquire a comprehensive listing of his publications and more detailed information on his current world modeling efforts.

Group	Contact Name	Contact Status		Comments
		Response Received	Additional Contact Suggested	
Massachusetts Institute of Technology	Ms. Weissner	X		After receiving an initial article, we requested a more comprehensive group of articles. MIT publishes the Technology Review Journal.
Michigan State University Agricultural Sector Analysis Program		X	X	Regarding Policy Analysis Language which was referred to in Simulation as a reputable simulation language.
University of North Carolina Population Center	P. Shipman			Conducting studies on population dynamics, demography, and population policy.
Political Science Department	Edward Azar		X	Needs Conflict and Peace Data Bank (COPDAB) Project, a compilation of some 280,000 inter and intraration events for some 50 international actors since 1945.
Northwestern Department of Political Science	T. R. Gurr	X	X	In a 1974 letter to CCTC, Gurr referenced a world event interaction survey which might have potential use for the current task. His original letter mentioned the unreliability of 'conflict' data due to underreporting for not only the Third World Countries but also the Communist States. He feels that the most useful collection of his data is available from the Consortium in Ann Arbor. If for some reason the data is not readily available from the Consortium, he is willing to provide us with particular data sets and documentation for the modest costs of tapes and mailing.
Pennsylvania Wharton School	L. R. Klein	X		To obtain information about LINK. This international system of economic models is in its seventh year of operation. Klein lectured for the Institute of Professional Education on "Model Building in the Social Sciences." He described the LINK model in addition to the Wharton Econometric Model. The possibility of using model components was examined briefly. Any further questions should be addressed to Professor Klein.

Group	Contact Name	Contact Status: Response Received	Contact Status: Additional Contact Suggested	Comments
Syracuse University Department of International Relations	Michael O'Leary	X		Developed a computer program which assesses political variables of the "limits to growth." We received the Users Manual for their Policy Research Observation and Evaluation (PROBE) model.
Tokyo University Facility of Engineering	Yorchi Kara			Developed "Design of the Future: Japan in the Changing World."
University of California at Los Angeles Sociology Department	David McFarland	X		Dr. McFarland addressed the Institute for Professional Education (IPE) seminar on "Model Building in the Social Sciences." He is well known for his work on demographic modeling.
University of California Political Science Department	J. Noel	X		Initiator of POLIS, which is a computer simulation model network used as a foreign policy teaching tool.
University of Illinois Population Dynamics Group	Paul Handler	X		Author of PLATO demonstration model addressing international demographic/economic trends.
University of Maryland Department of Government and Politics	Warren Phillips	X		Participated in SACI work on Europe, LDC, and combined models. Author of "Critique of Analysis and Planning at DOD."
University of The District of Columbia	Dr. Robert Jordan	X		Obtained information regarding data base suppliers and referrals to other potential contacts.
University of Michigan	Stuart Bremer		X	Developed a model of the international political system which was derived from the Inter-National Simulation Model created at Northwestern University. The model is called SIPER (Simulated International Processor).
Virginia Polytechnical Institute Economics Department	Melvin Hinich	X		Dr. Hinich addressed the Institute for Professional Education seminar on "Model Building in the Social Sciences." He is well-known for his work on the study of voting behavior.

GOVERNMENT GROUPS CONSULTED

Group	Contact Name	Contact Status: Response Received	Contact Status: Additional Contact Suggested	Comments
Agency for International Development	Jim Brashear Jerry Peterlin Elmer Slater	X		Provided some assistance in identifying population/demographic forecasting projects of potential interest to this research.
	Henry Szuppo	X		Was able to provide several contacts for information on AID data bases.
Army War College Strategic Studies Institute	William Kennedy	X		Chairman of most advocating approach to Long-Range Strategic Forecasting.
Central Intelligence Agency	Ray Shrecengost (Information Sciences Division) Donald Jones (Forecasting)	X	X	Contact was made with agency personnel. The Information Sciences Division conducts training sessions in management techniques and systems dynamics with an emphasis on macro and long-range applications of these techniques. Another office is concerned with the evaluation of forecasting methodologies. An effort has also been made to acquire more documentation on the China model which a group within the agency has developed.
Clearinghouse on the Future	Anne Chestnut	X	X	The function of the Clearinghouse is to keep Congress aware of the future research field; they publish a newsletter that highlights future in long-range planning meetings that are scheduled for the Hill.
Command and Control Technical Center	Peter Thrift	X	X	Information was acquired on the Joint Information and Retrieval System (JIRS) which is currently used to catalogue Joint Chief of Staff working papers. This system runs on the IBM 370 and a demonstration was provided in the CCTC terminal room.
Department of Commerce Bureau of Census	Martha Harvar	X	X	Had participated in the IBM Data Base study which was conducted for NASA in 1971. As a statistician, she is interested in the uses and abuses of data banking. Heads Long-Range Planning Unit. LRPU project addressing demographic/economic trends among nations. Models are a derivation of MIT's TEMPO work.
DOD ARPA	Jerry Wilson	X		Suggested that we contact ARPANET Information Branch at DCA (202-692-5[illegible]) says there is no central clearinghouse which catalogues all projects used on the net.

Group	Contact Name	Contact Status: Response Received	Contact Status: Additional Contact Suggested	Comments
Department of Defense OSD-Net Assessments	LTC Peter Bankson LTC Robert Gough	X	X	This office answers OSD research requests covering a range of topics. Two specifically identified areas of interest are Soviet defense and investment spending, and comparison of weapon characteristics.
Department of Interior	Signe Larson			Active in the area of data base user groups evaluations.
Department of State	George Vest Arch Turrentine	X		Met with Arch Turrentine of ACDA; advised us that very little modeling is ongoing at State. There is not enough widespread interest or funds for long-range research. Most research sponsored by State, Bureau of External Research, is of a regional or country specific nature.
	Lindsay Grant	X	X	As Deputy Assistant Secretary of State for Environmental and Population Affairs, he is leading a White House study that will use Mesarovic's World Integrated Model.
	Brent Olson			A foreign service officer who is interested in the potential of applying models to foreign affairs analysis.
	Robert Sarsfield	X	X	Familiar with availability of data tapes at State.
Department of Transportation	Robert Crosby	X	X	Is currently interested in establishing a government interagency long-range forecasting effort. This effort is envisioned as being supported by the National Science Foundation.
Federal Energy Administration International Analysis Office	John Pearson Calvin Kilgore	X	X	The FEA International Energy Evaluation System (IEES) has been developed by this office. As Government experts in the energy modeling field, they use the model in response to requests in support of Government studies.
General Accounting Office	J. Kinney	X		Involved in the coordination of Mesarovic briefing to the Government on the Uses of Simulation Modeling in the policymaking process.
	W. Zarth G. Ross			GAO is also in the process of reviewing agricultural simulation models.

Group	Contact Name	Contact Status		Comments
		Response Received	Additional Contact Suggested	
Interagency Committee	Dick Wakefield			This informal committee is open for membership of discussants on a variety of policy choices.
Library of Congress(LC) — Futures Group	Keith Rea Marvin Kornblith Dennis Little	X	X	This group is concerned with keeping Congress abreast of long-range planning projects, forecasting techniques, and the implication of current legislation on the future. The staff consists of five professionals who work in the Library of Congress. They maintain a reading corner that includes a wide range of future oriented books and documents. They are in the process of designing an information system to catalog futures oriented materials.
LC — Science and Technology Reading Room	Constance Carter			This person is of great assistance in identifying pertinent services in the area of science and technology. She is also very helpful in explaining the SCORPIO bibliographic storage and retrieval system.
LC — Deputy Librarian	Mr. Applebaum			Contact was made regarding the possible acquisition by CCTC of the SCORPIO system. As yet, it is only available to Congressional offices and the Library of Congress.
National Bureau of Standards	Carolyn Brown			She is currently on sabbatical and conducting a study on data bases.
National Energy Information Center(NEIC)	Larry Clinton			NEIC serves as an information gathering and disseminating center on energy. The center consolidates the information on the energy-related programs, models, and data bases which are currently operational.
National Institutes of Health — Demographics Office	J. Coons			A sociologist who has served as a contact monitor for several national modeling efforts. Referenced Nathan Keyfitz (Harvard) as a source of demographic information.
National Science Foundation — Special Studies	Ron Powell Dr. Newland	X X	X	Contact with this office provided us with a review of a draft SRI document on energy models and methodologies. Sponsors research to review alternative assumptions on new methodological ground. Some of the topics funded by the group have been energy R&D. costs associated with pollution, and econometric models.

Group	Contact Name	Contact Status		Comments
		Response Received	Additional Contact Suggested	
National War College	Lawrence Grinter	X		Developed a forecasting approach to "Alternative Asian Futures" which he presented at the 19th HSMS symposium.
Panel on Environmental Science and Technology	J. Culver M. Naylor	X	X	This panel, as initiated in 1971, is designed to be a study group on environmental issues and futures analysis. They are briefed by high-powered analysts well-known in futures research, but they do not have legislative power. They can only use the information they receive to introduce new legislation on the Senate floor.

MISCELLANEOUS GROUPS CONSULTED

MISCELLANEOUS GROUPS CONSULTED

Group	Contact Name	Contact Status		Comments
		Response Received	Additional Contact Suggested	
Abbott Associates	Paul Juriedini	X		Contact was made to discuss data sources as referenced by Professor Azzam of UNC on the world events survey. Abbott Associates is also in the business of environmental modeling and was not interested in any free exchange of information.
Aid Association for Lutherans	Frederick Kile	X		This group has developed a 30 region world focusing on social values of global models. He addressed the IEEE conference in Washington on November 1, 2, and 3, 1976.
Bariloche Fundacion	E. Herrera			Herrera has developed a normative approach to demonstrating physical and economic possibilities for the third world in the absence of certain global, political, and trade conditions.
Battelle-Pacific Northwest	Robert Burnett	X		Funding has been discontinued for DEMATEL and the GLOBE 6 project. Mr. Burnett programmed the GLOBE 6 model in 1974. The model source deck is still available.
	E. A. Eschbach	X	X	Mr. Eschbach continues to offer interesting insights into modeling; he forwarded two monographs: An Annotated Bibliography on World Modeling and the World Mineral and Energy Resources in addition to a number of personal notes on modeling. He plans to visit the study team during his next local visit in January. He believes that EMPLOY-MULTI TRADE could assist planners in evaluating the impacts of embargoes in the technological subsectors of the model.
Brookings Institute		X		Acquired publications catalog.
CACI	John Mellroy	X	X	Have discussed possible speakers to address the topic of long range forecasting at the Military Operations Research Symposium in December 1977. Briefly addressed CACI's LDC, Europe, and combined models.
Computer Sciences Corp. Infonet	George Bishop John Koval	X X		Received information on capabilities and costs for Infonet application of a bibliographic storage and retrieval system.
Control Data Corp. Service Bureau	Brad Curley	X		Information was acquired on CDC retrieval systems.

Group	Contact Name	Contact Status		Comments
		Response Received	Additional Contact Suggested	
Data Resources Inc. (DRI)	Stan Boulding Al Cook	X		A discussion of DRI projected and current energy forecasting capabilities was held with the study team and Al Cook, DRI Chief Energy Analyst and former Assistant FEA Deputy.
East-West Center	Miriam Gould	X	X	This national education center was established in Hawaii in 1960 to promote better relations and understanding between the U.S. and the nations of Asia and the Pacific through cooperative study, training, and research.
Econometric Society	Julie Gordon	X		Three main functions of this society are: (1) publication of the Econometrica, (2) organize semi-annual conferences to air economic research findings, and (3) recognize individual economists who become the governing body of the Society.
Futuremics	R. Maston	X	X	The group publishes monthly Futures Abstracts; currently on contract to the Clearinghouse on the Future to provide an index of the legislation that has implications for the future. This group is of potential use to the subtask.
Futures Group	T. Gordon	X	X	This group conducts futures analyses. They are credited with introducing the SCOUT forecasting retrieval system. The system draws upon the data coded from professional journals, books, and published and unpublished reports to forecast relevant technological, social, political, economic, and demographic developments.
General Electric General Electric Tempo	Bernard Albert	X X	 X	Author of "Long Range Strategies to Maintain Effective Strategic Competition with the USSR," prepared for OSD Net Assessments Office. This group has developed some of the most significant work in demographic econometric planning models available at the present time.
General Mills Public Relations				Recommended by M. Kornbluh, they have a corporate interest in futures research and have published several relevant publications.
	R. Hough	X		Developed ALCHEMIST, a global model encompassing 91 river basins, 65 nations and 115 cities focusing on retrospective and futures forecasting of behavior.

Group	Contact Name	Contact Status: Response Received	Contact Status: Additional Contact Suggested	Comments
Hudson Institute	B. Bruce Briggs Herman Kahn William Overholt	X	X	Acquired publications catalog; attended a briefing by a key Hudson researcher who addressed Quality of Life. They present the optimistic, more qualitative view of the future. Overholt is a coauthor of "Army War College Approach to Strategic Planning."
Institute for Defense Analyses	Leonard Wainstein	X	X	Author of "Critique of the Joint Strategic Planning System (JSPS)."
Institute for Life Insurance	E. Vest	X	X	Recommended by *H. Kornblum* for their comments on computer simulation success in business. Produce Trend Analysis Program reports.
Institute for the Future	R. Amara	X		The Institute publishes Futures journal in USA. Its primary research goals are: (1) to develop improved methods of scientific judgment to understanding social problems, and (2) to apply information technology to facilitate aware social choice based on improved methods and mechanisms for collection, processing and disseminating the best of society's collective wisdom.
Institute for World Order	Robert Johansen	X		The Institute is working on the analysis of the world *as* it is today, the world *as* it might be in the year 2000, and the means to get there. Twenty-eight staff workers and some 100 professional resource people make up the transnational group. The four world order values which form a basis for their work are: peace, social justice, ecological balance, and economic well-being.
International Business Machines		X		Information was obtained on new bibliographic retrieval system developments.
International Institute for Applied Systems Analysis	Michael Greene	X	X	IIASA is a newly formed nonprofit organization designed as a vehicle for channeling international *research as performed by an international body of* scholars. The 1974 proceedings on the Strategy for Survival model were received from IIASA. We were also given several valuable publications on the IIASA energy analysis approach: Water, Energy, Land, Materials and Manpower (WELMM).
International Labour Office (ILO)		X	X	Developed the BACHUE series of economic-demographic planning models, a derivation of TEMPO.

Group	Contact Name	Contact Status		Comments
		Response Received	Additional Contact Suggested	
International Monetary Fund	Rehnberg		X	The organization is currently using LINK. He suggested a book by R. J. Ball which explains the basis for the international linkage of economic models.
Johns-Manville	E. LiPuma	X		This corporation publishes a futures oriented magazine called Futures, which we now receive.
Lockheed		X	X	Information was obtained on their commercial data bases.
Mankind 2000	Guy Streatfeld			Organization is involved with global modeling with a particular emphasis on Europe.
OECD		X	X	Publications catalog received. Further contact could be helpful during a data base review phase.
Resources for the Future (RFF)	Ron Ridker			As a researcher, he is concentrating on applications of the Resources for the Future/Strategic Environmental Assessment System (RFF/SEAS).
Simulation in Service to Society	John McLeod	X		Requested additional information on articles published in Simulation.
Stanford Research Institute	Claire Starry		X	Econometrician who has worked with world modeling could assist in locating relevant work at SRI.
	Chic Peterson	X		As a marketing manager, she is quite knowledgeable in SRI activities and was able to provide information on the SRI World Energy Study.
	Jay Kopelman	X		As Chief Economist of the SRI World Energy Study, he provided valuable information even though it was not possible to obtain equations and documentation. The SRI international model was originally developed on contract to Gulf Oil, Inc.
Systems Development Corp.	Linda Rubens	X		Obtained information concerning three data bases of potential interest to CJIJ.
United Nations	Vera Gathright	X	X	Acquired publications catalog. It was also learned that certain U.N. data tapes are retained at the State Department.

Group	Contact Name	Contact Status		Comments
		Response Received	Additional Contact Suggested	
World Bank	Ilona Sebestian	X		Acquired publications catalog and ordered several documents. Referred to other offices for various information items on econometric models.
World Future Society	Sally Cornish	X	X	This society acts as an international clearinghouse of futures materials. They sponsored the World Congress in Washington, D.C. in 1975 that attracted many reputable futurists. The Society is not technically oriented.
World Fertility Survey	Sir Maurice Kendall	X		Kendall addressed the general model building session at the IIE Model Building Seminar. He is an accomplished statistician and Project Director of the World Fertility Survey.
World Institute Council	Julius Stulman	X		The organization publishes a journal called Fields within Fields, which focuses on the problems facing mankind. The group itself is rather loose and still evolving from the gestalt of one man into a fully recognized organization.
Worldwatch Institute	Lester Brown	X		This author and well-known analyst coordinates a research group specializing in international systems; especially concerned with food production and population policy.

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APPENDIX B

FORECASTING APPROACHES

The following discussion of alternative approaches is taken either directly from or paraphrases the review of the subject in the Library of Congress report, "Long-Range Planning," prepared for the Subcommittee on the Environment and the Atmosphere in May 1976. These approaches have been grouped in the Stanford Research Institute (SRI) categories indicated below.

Although it would be impossible for this report to identify all of the various forecasting methodologies, this appendix briefly describes several of the more commonly used techniques. A recent SRI study found some 100 such methods which were grouped under three broad categories: qualitative and quantitative techniques; methods using historical trend data and projections; and techniques based on models and simulations. This section will discuss five examples from these three categories, giving special attention to simulation modeling.

B.1 Qualitative and Quantitative Techniques

B.1.1 Delphi. This is a technique used to gather and process information and judgments from a group of individuals who are experts in a particular field or subject. In a typical policy oriented Delphi, a group of respondents (experts) is selected and a questionnaire is prepared (the "Round 1" questionnaire), which poses quantitative and qualitative questions about the future to be studied. Their answers are compiled in a statistical summary which is returned to the respondents to allow them to rank and evaluate each of the answers. This process may be repeated in another round, at which point the views of the respondents will have converged or the reasons why convergence is unlikely will have been documented.

There are a number of variations to the Delphi, but all share three basic characteristics: use of controlled feedback, use of sequential questionnaires, and preservation of the anonymity of the respondents. Anonymity exists at two levels.

Participants frequently are unknown to each other and in all cases the individual response is never attributed to particular individuals. In future research, the Delphi method is often used instead of the traditional conference method, because conferences can produce such undesirable side effects as specious persuasion, an unwillingness to abandon opinions once they are publicly expressed, and the bandwagon effect of majority opinion.

Delphi may be considered a useful instrument for forecasting as long as one understands that it is not really a scientific instrument. It is an empirical method of addressing the subjective views of a subjectively selected group of respondents. Thus, if the instrument appears scientific, in reality it is not, and its real value may be more in forcing the various parties involved with an issue to articulate and discuss their underlying assumptions.

Any evaluation of the Delphi process or of a particular Delphi must be made in light of the goals sought and the alternatives available to meet those goals. The analyst needs to address the questions "Who is it that should communicate about the problem, what alternative mechanisms are available for that communication, and what can we expect to obtain with these alternatives?"

B.1.1.1 Advantages. Some of the advantages of the Delphi are:

a. Allows for interdisciplinary communication of experts from remote geographical locations

b. Avoids the psychological problems of direct group interaction such as the bandwagon effect, specious persuasion, and domination by quantity or strength of personality

c. Focuses attention directly on the issue.

d. Lends itself to problems which require subjective judgments on a collective basis.

B.1.1.2 Disadvantages. Some of the problems or disadvantages of the Delphi are:

a. Lacks the stimulation of face-to-face confrontation

b. Subject to misinterpretation or manipulation by the Delphi investigator

c. Slow, time consuming, and expensive

d. Possible inability of panelist to communicate his views concisely

e. Emphasis on consensus tends to suppress extreme points of view

f. Defining and selecting the "expert" is currently a poorly understood and undefined process

g. Material is presented as the work of experts, but in many investigations it is the casual opinions of unexperienced persons with no expertise in the technical areas.

B.1.2 Cross-Impact Analysis. This method attempts to predict the effect that some specific event (or policy action) can have on the likelihood of occurrence of another event. It focuses on the relationship, if any, between any two individual events. It poses the question, "Does the occurrence of one event inhibit, enhance, or have no effect on the occurrence of another event in the future?" The answer may be expressed in qualitative or quantitative terms. All events are regarded as phenomena that may occur only once within a given time period. Like the Delphi method, cross-impact analysis relies on intuitive judgment combined with systematic analysis.

Combining two or more forecasts may be very helpful in providing decision information. If the forecasts are of the same events or environmental indicators, similarities between them will provide increased confidence with results, especially if the forecasts have been obtained by truly independent methods or groups. Identifying the differences between the forecasts may lead to significant questions as to why the differences exist. In turn, this can lead to

greater clarification of the issues, and better definition of the risks and uncertainties in the subject being forecast. If the forecasts are of different events or environmental indicators, the combination can provide a more complete and more consistent picture of some future time period, especially if the interactions between different events and environmental indicators are taken into account. Since one of the major sources of error in past forecasts has been failure to take into account the impact of events outside the field being forecast, combining forecasts of different events or environmental indicators should help considerably in improving the accuracy of and usefulness of forecasts.

These future histories can be used for the development of scenarios, for testing policies, and for identifying those events whose outcomes will have a significant impact on the subsequent course of events. When a large number of events must be analyzed, not even the cross-impact matrix makes the task easy. However, by using a systematic approach, the cross-impact matrix assures completeness and permits focusing on the events and not on the procedure of handling them. The cross-impact matrix can be computerized, allowing examination of a large number of future histories in a short time. These can be summarized to provide improved estimates of the probabilities of specific events, and to identify those events which seem to have a major impact on following events, and examining the interaction between discrete forecasts.

In examining the interaction of discrete forecasts it is necessary to consider the mode, force, and lag of the interaction. With regard to mode, one event may enhance or diminish the likelihood of the other event, it may advance or delay the other event; it may necessitate or obviate the other event; it may enable or prevent the other event. The force of the interaction is a question of whether the influence of the one event or the other is strong or weak. In considering the time lag of the influence, the question arises of whether one event influences other immediately or whether some time is required before the influence is felt and if the influence tends to die out after some length of time.

Cross-impact analysis generally involves at least the following steps:

a. Defining the issue being addressed and the time period of interest

b. Identifying the major events that are relevant and important to the issue at hand

c. Making estimates of the likelihood of each event occurring during the time period of interest

d. Constructing the cross-impact matrix by listing events as row and column headings of a table. The initial estimates of occurrence are shown in parentheses beside the events. Participants in the analysis are then asked to estimate how these estimates might change if each event in turn were to occur. These estimates are placed in the cells of the matrix (table)

e. Analyzing the interrelated sets of events to try to understand where the occurrence of one event may strongly influence the likelihood of the occurrence of other events

f. Experimenting with alternative actions and policy options to arrive at an overall assessment of the interrelationships among events and to determine how best to promote desired outcomes.

Computerized assistance appears to be necessary for analyzing and experimenting with large cross-impact matrices. Computerized runs can quickly spot inconsistent likelihood estimates, reduce the time and effort needed to perform experiments, and highlight significant interrelationships.

The technique of cross-impact analysis is often used with other futures research methods. For example, a technique known as "probabilistic system dynamics" combines cross-impact analysis with the system dynamics simulation modeling technique developed by Jay Forrester at Massachusetts Institute of Technology (MIT). The method not only describes the impact of a single event on other events but also describes the impact of events upon all elements of a simulation model. (Reference subsection B.1.4.4 for a further discussion of probabilistic system dynamics.)

The impact typically takes several forms. These include modifying the inherent structure of the simulation model, adding or deleting terms from the equations, or permitting the model to impact and change event likelihoods.

B.1.2.1 Advantages. Some of the advantages of this method are:

a. The approach rationale is very explicit and systematic. Interactions among events are clearly depicted. Counterintuitive results are always retraceable from the inputs and unintended consequences can quickly be spotted.

b. Experimentation with the consequences of various actions and policy options are facilitated and various trade-offs can be tested. Results can provide useful inputs for the development of different scenarios.

c. The likelihood estimates made by policymakers can easily be checked for logical consistency. Inconsistent estimates can be quickly revised, thereby increasing the reliability of the technique.

B.1.2.2 Disadvantages. Some of the major shortcomings of cross-impact technique analysis are:

a. Estimates of event likelihood are subjectively determined. This makes them vulnerable to uncertainty and arbitrariness.

b. The approach focuses on the interactions between only two events at a time. In reality, many events may be interrelated in an overlapping and integrative manner.

c. While the consequences of event interactions are clearly identified, the mechanisms causing these consequences are not logically and systematically deduced.

B.2 Methods Using Historical Trend Data and Projections

B.2.1 Trend Extrapolation. The process of projecting a historical trend line into the future is known as "trend extrapolation." Characteristic of this approach is the listing or plotting of the values of some factor of interest (called a variable) against specific intervals of time in the past and in the future.

The future or extrapolated values are the forecasted trend. The forecasted trend should extend into the future no more than the same number of time intervals for which there are past data. Thus, if the data base contained data for the past 15 years, extrapolating a trend line 30 years into the future would be highly questionable. The end product of a trend extrapolation can take the form of graphs, bar charts, and tables (which can easily be converted into the other forms, narratives, scenarios, etc.).

B.2.1.1 Advantages. Major advantages to forecasting the future with trend extrapolation are:

a. The progressive history of any selected variable is clearly displayed for subsequent subjective interpretation. Planners and policymakers can use and probably accept the general shape, direction, and slope of a trend without needing to understand its underlying assumptions.

b. The approach appears to have wide applicability to the significant variables in the physical, biological, behavioral, and social sciences.

c. A reasonably accurate trend can be formulated in relatively short time because visual judgment can be applied in many cases and computer programs for standard curves are available.

B.2.1.2 Disadvantages. Some problems mentioned in connection with trend extrapolation include:

a. The approach implicitly assumes that the factors that shaped the past will continue to hold true in the future.

b. An adequate data base having values for the required time intervals must be maintained in order to establish reliable trends. This can be time consuming and expensive, and in many cases it simply does not exist.

c. Discontinuities are not explicitly handled in trend extrapolation, yet discontinuous events such as fads, assassination attempts, and ghetto, college, and other kinds of riots can influence trends.

d. Data for different time intervals may not be parallel or compatible even though they may be presented as such. Definitions and standards of data acquisition and recording vary greatly from time to time.

B.2.2 Trend Impact Analysis. As indicated above, trend extrapolation involves the assumption that the social, economic, and other forces that have controlled the historic development of a trend will continue to control it through the indefinite future, an assumption that has to be wrong eventually due to the dynamic nature of interacting influences in world affairs. Trend Impact Analysis (TIA) was thus developed to include the effect of possible unexpected events that may change their historic paths of development. For example, given a particular trend, this method can be implemented through the following steps:

a. Identifying possible events which might cause some change in the path of the trend

b. Estimating the chances that each event will occur and estimating the impact of that event on the trend

c. Describing the effects of the impact, such as the extent, the timing, and the areas that are changed

d. Calculating the composite impact of all events by letting all events "happen" each year according to their respective chances of happening

e. Changing the extrapolated trend in each year by the total impacts calculated above to determine the new direction of the trend.

In addition to producing an event-impacted trend, TIA can demonstrate the trend's sensitivity to individual events and focus attention on those events which tend to produce the desired changes in the trend.

B.2.2.1 Advantages. The primary advantages of trend impact analysis are as follows:

a. Provides a systematic method of incorporating in trend analysis the outside events which might change the historic path of a trend.

b. Provides a method of assessing the sensitivity of a trend to those outside events.

c. Provides a framework for the policy analyst in the formation and evaluation of policies. This framework is a useful tool both as a process and for the product it provides. The process elucidates judgments, opinions, and expectations, both about the future of events, trends, and policies and about their interrelationships. The product is an event-impacted projection with an assessed measure of uncertainty.

Obviously, this framework and its results rest on judgmental estimates, and as such are limited to the accuracy of these estimates. Thus, in providing a detailed series of steps quantifying judgmental estimates and opinions, TIA highlights implicity assumptions about the future while serving to articulate the forecasting process and discussions of that future.

B.2.2.2 Disadvantages. Major limitations of trend impact analysis include the following:

a. TIA assumes that there are no other interactions among the events than their impacts and the single trend itself.

b. It puts heavy reliance on judgmental estimates and opinions.

c. It has an inability to consider the relationship between the impact of an event and the time of its occurrence, i.e., the impact of an event in 1985 may be different than its impact today.

d. It is complex and cumbersome in all but the most limited applications. The detailed description of the impact and timing of each event requires at least six separate estimates. A typical TIA includes, at a minimum, 6 events, and thus, 36 estimates.

B.3 Models and Simulations

The method of computer simulation modeling is based on two concepts: a system (parts operating interactively to achieve one or more purposes) and a mathematical model (a series of equations describing the system components or variables and their interrelationships within a system). A special class of mathematical models is referred to as simulation models, the basic premise for which being that the simulation model can serve as a surrogate for a system, allowing time to run faster than the actual time of the system's operation and providing the ability to forecast the future state of reality. Computer simulation modeling also provides the capability to estimate the effects of external forces on the system being simulated.

B.3.1 Required Characteristics. A simulation model is essentially dynamic, meaning that at least one of its properties is expected to change with time. Thus, it requires time as a variable. To be successful, it must also meet four requirements.

a. It should be consistent with the real world in its assumptions.

b. The variables used should be consistent with corresponding elements in the real world.

c. It should be sufficiently simple for easy comprehension.

d. Functional relationships among model variables should be demonstrable.

B.3.2 General Characteristics. A simulation model may be linear or nonlinear. If it is linear, then changes in values will produce proportionate changes in output. If it is nonlinear, then changes in values will produce disproportionate changes in output.

The model may also be essentially deterministic, probabilistic, or stochastic. A deterministic model will use exact values that can be computed and the values for all its parameters will be known. A probabilistic model will have at least some variables or parameters that have unpredictable randomness. In a stochastic model, different results will follow from the use of different sets of random numbers even

though no change is made to the model. A "Monte Carlo" procedure can be used with the model so that repeated runs will produce a distribution of output.

The system can also be addressed on a micro or macro level. On a micro level, it would deal with small units or variables; on a macro level, the small units would be grouped into larger components.

The level of aggregation in a model will depend on the degree to which it represents individual items as broader single entities. For example, a disaggregated model will represent each item on an individual basis whereas a largely aggregated model will be composed of large and fairly broad types of variables. Theoretically, in the interests of simplicity and manageability, a model's level of aggregation should be as high as possible consistent with its continuing to accurately simulate the real system. In practice, such decisions are often based more on the availability of data and their proposed application.

B.3.3 Phases in Model Building Process. Three general phases in the development of a simulation model can be categorized as conceptualization, implementation, and the analysis of simulation results.

B.3.3.1 Conceptualization. This phase incorporates the following: initial analysis, system structuring, data collection, review, mathematical equations, testing, and documentation.

B.3.3.1.1 Initial Analysis. This analysis activity must address the following considerations:

a. Critical system components and attributes

b. Principal decisions

c. Important relationships between components

d. Problems

e. Areas of limited knowledge

f. Uncontrollable variables

g. Environment

h. Constraints on system behavior

i. Random or uncertain elements in the system

j. Stability in system behavior

k. Trade-offs that a system usually makes with respect to such questions as level of aggregation and possible data sources

l. Means for measuring system effectiveness

m. Formulation of objectives.

B.3.3.1.2 System Structuring. With the initial analysis completed and the objectives established, the system is divided into sectors or subsystems, resulting in multiple submodels which can be studied and subsequently reintegrated into the total model. The major attributes of the system variables are deduced, the specific cause and effect interactions are identified, a modeling technique (such as systems dynamics or econometrics) is identified, and a time horizon and intervals are selected.

B.3.3.1.3 Data Collection. This activity may involve:

a. Statistical data on past behavior

b. Educated guesses from authoritative sources

c. Observations of system behavior

d. Measurements from samples and experiments.

B.3.3.1.4 Review. The system behavior assumptions formulated in the initial analysis are reviewed again.

B.3.3.1.5 Mathematical Equations. The mathematical equations which will comprise the model are then formulated.

B.3.3.1.6 Testing. The initial testing begins with the checking of numerical calculations and the verification of the model.

B.3.3.1.7 Documentation. Corrections to the model are made and the concept is documented with a description of the model rationale, its detailed structure and characteristics, and the test results.

B.3.3.2 Implementation. At this point, the model is still in its conceptual state. The implementation process now involves its translation into a computerized working model through the programming and testing process and the conduct of model runs which are also documented.

B.3.3.3 Analysis of Simulation Results. This activity involves the study and interpretation of run outputs and the concomitant drawing up of study conclusions.

B.3.3.3.1 Conclusions. Typically, the study conclusions will involve answers to the following types of questions:

a. What were the principal effects of system interactions under alternative conditions?

b. What are the likely trends in system behavior?

c. What alternative policies improve system behavior or adversely affect it?

d. What might happen to system behavior if certain variables assume particular values?

B.3.3.3.2 Recommendations. These may be policy and/or simulation method oriented. In the latter case, the recommendations may suggest a need for any or all of the following:

a. Insertion of new variables

b. Deletion of certain existing variables

c. Insertion of new relationships among variables

d. Deletion of some existing relationships

e. Further aggregation of some parts of the model

f. Disaggregation of some parts of the model

g. Modification of assumptions

h. Collection of actual or more realistic data for the variables

i. Introduction of new possible events on a probabilistic basis

j. Change of some variables into parameters (arbitrary constants).

B.3.3.3.3 Model Reruns. These may be conducted for a still larger number of alternatives.

B.3.4 Bases for Model Validation. These can be addressed through testing and qualitative evaluation.

B.3.4.1 Testing. The final testing should incorporate the following actions:

a. Running the model to detect "bugs"

b. Running the model using historical data to determine how closely the results approximate actual past performance

c. Running the model over future time periods to determine if the results seem logical and reasonable.

B.3.4.2 Qualitative Evaluation. In addition to formal testing, the model should be reviewed on the basis of the following:

a. The degree to which its behavior conforms to existing and relevant theory

b. The degree to which it forecasts the system future as the future unfolds

c. The degree to which it is found acceptable to accepted authorities in the subject area

d. The degree of its utility to and acceptance by the user, and how often it is used.

B.3.5 Techniques of Policy Oriented Simulation Models. Due to limited precedents and the complexity of socioeconomic systems, a large number of methods have been used to construct policy oriented simulation models. However, three approaches to the effort seem fairly prevalent: Input-Output Analysis,

Econometrics, and Systems Dynamics. These, along with one variation, Probabilistic Systems Dynamics, are reviewed in the following subsections.

B.3.5.1 Input-Output Analysis. The concept for this method reflects a general theory of production based on the economic interdependence of each producer.

B.3.5.1.1 Assumptions. Careful consideration of assumptions of Input-Output Analysis suggest the method's deficiencies as a simulator of any complex system. That is, regions are divided into a specified number of interdependent industries or sectors and addressed on the following three bases:

a. Total industrial output is consumed as input by all industries for the time period under consideration.

b. The inputs to each industry are dependent on the levels of industrial output rather than vice versa. For example, twice as much output will call for twice as much input.

c. Once the ratio of an industry's input to its output has been established, it is fixed. This ratio is known as the production coefficient or input-output number.

B.3.5.1.2 Usages. Given the nature of these assumptions, Input-Output Models should be used with careful consideration. However, they do have utility in addressing such questions as the level or nature of aggregate demand required for full employment and the effects of public programs on employment in industry.

B.3.5.1.3 Criticisms. Beyond the limitations of their assumptions, criticisms of these models relate to the fact that they are essentially static, linear, and incapable of being adapted to technological change.

B.3.5.2 Econometrics Models. The concept for these models is based on econometrics (or quantitative economics) techniques which rely heavily on empirical data. They incorporate a blend of economic theory, mathematics, and statistical analysis, and assume the following:

a. Formulated equations use historical data appropriately (econometricians can and do test this assumption by applying statistical techniques to determine the consistency of formulated equations with sets of observed data).

b. The future will behave in the manner depicted by the formulated equations.

B.3.5.3 System Dynamics Models. The concept for these models was developed by Jay W. Forrester at MIT and deals with deterministic, dynamic, nonlinear, and closed boundary systems. Based on engineering principles, it makes possible a representation of decision policies and information flow through such concepts as feedback loops. The system is then simulated under alternative policies (decision rules), levels, and environments and the resulting system behavior is described. Its great asset is that it forces a comprehensive consideration of a system rather than singling out a particular facet of the system and trying to understand it alone.

B.3.5.3.1 Assumptions. The following assumptions are made:

a. All systems that change through time can be represented by varying levels and rates. A level represents an accumulation within a system and also provides an indicator of the condition or state of that system. A rate is a flow from one area to another of what has been accumulated. Rates of flow cause and control changes to levels and need not be constant.

b. Decision rules (or policies) control system activities or rates of flow.

c. The external system environment is considered constant for a particular set of time periods being simulated.

B.3.5.3.2 Structure. Feedback loops provide the basic building blocks for the system model, connecting decision points, system levels, and environment. There are two types of feedback:

a. "Goal seeking" or negative feedback has a goal or desired value for a level. If the

level departs from its value, the rate of flow is modified to bring the level back to its desired value, as with a thermostat.

b. Positive feedback loops contribute to either persistent growth or continuous decline of levels.

A system dynamics model consists of multiple positive and negative feedback loops linked together. These may either dampen extreme fluctuations of variables or exhibit "exponential growth" according to which type of loop is dominant.

B.3.5.3.3 Criticisms. Many of the criticisms that have been directed at systems dynamics models could be leveled at simulation models in general. However, the most frequently noted objections may be stated as follows:

a. Values for many variables have been obtained from intuitive judgments and theoretical constructs.

b. The system dynamics model excludes unprecedented events such as scientific discoveries, revolutions, abrupt reversals of political policies, and technological advancements.

c. System dynamics models are more easily created than verified. The models can do little more than reflect the views and assessments of their builders.

d. The models tend to concentrate on a mechanistic view of socioeconomic systems. That is, they implicitly assume that people and institutions show little fundamental change in behavior with the passage of time.

e. The nature of their equations is such that the system dynamics models do not adequately handle events that occur at random.

B.3.5.4 Probabilistic System Dynamics. One method recently formulated may be an answer to some of the criticisms indicated above. Devised by the Futures Group of Glastonbury,

Connecticut, it tries to combine the strengths of system dynamics with those of the cross-impact analysis forecasting approach discussed earlier in this report. As indicated before, cross-impact analysis tries to predict the effect that some specific event (or policy action) can have on the likelihood of occurrence of another. Thus, the model's interactions are of two types:

a. The impact of events on the model itself (its structure, parameter values, etc.)

b. The impact of model variables on event probabilities.

This technique has been applied with an energy policy model used in a study of Japanese rational development policies.

APPENDIX C

INTRODUCTION TO
AN ASSESSMENT OF POLICY TOOLS (APT)

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INTRODUCTION TO APT: AN ASSESSMENT OF POLICIES TOOL

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CONCEPT OF AN ASSESSMENT OF POLICIES TOOL (APT)

An assessment of policies tool (APT) is envisioned as an instrument whose use can help in the assessment of likely consequences of proposed policies. It is not a substitute either for policy formulation or for the policy selection; rather, its role is to improve these processes in a practical manner by enabling formulation of broader and more comprehensive policies and by increasing the likelihood of success with the policy finally selected for implementation.

Any policy-making process has intuitive and logical components. Intuitive aspects include perceived goals, the interpretation of acquired experience, and learned knowledge, while the logical aspects have to do with the facts and data (numerical, quantitative information) and the logical sequences of events triggered by or affected by policy implementation. The role of APT is to add a new dimension to the second aspect and in so doing also to augment performance of the first.

The objective of this article is to provide enough *information for the general use of APT.* Like *any* sophisticated tool, APT can be used on a variety of levels from rather simple to quite intricate. The potential of a well designed tool should be discernible in some simple situations. Only after such potential has been established can one realistically expect that decision makers and policy analysts will invest the time and resources necessary for use of the tool and its possible adaptation for specific situations.

The model embedded in APT which will be described in this article is designed for the assessment of certain types of long term national and regional policies in the global, i.e. world, context. It should be emphasized that many other models, such as urban or subnational regional models, can and have been embedded in APT. In the second section of this report, the types of policies for which the global model has been designed are indicated, major components of the APT tool are specified, and the process of combined use is described. The third section contains a specific example of use in the consideration of certain types of energy policies, while the fourth section contains an example of use for food policy. The concluding section gives more information on a broader domain of applications, on the range of policies for which the tool can be used, and on its flexibility for further extension and adaptation. Further illustration of the use of the global model and APT can be found in the second report to The Club of Rome, published under the title Mankind At The Turning Point (E. P. Dutton, New York, 1974).

Some factors which provided motivation for the development of the APT concept and which guided its design and construction might be of interest here. National policy making has entered a new era of increased difficulties for many reasons, among which are the following:

(a) Complexity: National policy formulation and selection has become increasingly complex in the following two directions. First, interdependence between domestic politics and the foreign politics of bilateral, multi-lateral and global relationships. As Harmon Cleveland aptly put it recently, "every domestic issue is partly international and every international issue is partly domestic." The energy, food, population, development gap, trade, and monetary crises provide ample examples to illustrate the point. Second, interrelatedness between policies traditionally considered, at least in the practice of decision making, to lie in separate domains. To paraphrase Cleveland again, every foreign minister must be a little bit of an expert on energy and food, not to mention economics in general, while every minister of agriculture had better have a grasp of foreign affairs. While separation of policies into different domains was always a poor approximation of reality, it absolutely does not suffice any longer.

(b) Rate and Magnitude of Change: In the past, many (although by no means all) policies could be based on a somewhat experimental approach. By implementing some aspects of policies, one could assess from the resulting trends what the policy would produce if fully implemented over the entire period of time. Such an approach, frequently called incrementalism, or "muddling through," appears both practical and prudent as long as the penalties involved are not unduly high. The rate and the magnitude of changes associated with various current policies make the approach increasingly risky. Technically speaking, one cannot rely on the real world "feedback mechanism" for correction and adjustment, but must try in the best way possible to anticipate the consequences of intended options.

(c) Leadtime: The period between the time when the decision to implement a policy must be made and the time when its beneficial (or harmful) consequences become apparent has lengthened considerably, to the extent that in many vital areas it can be a decade or more. For example, the return on government and private investment in the nuclear energy area can be expected only in a decade or so and depends on both the prevailing conditions at completion time and the ability to sustain a continuous effort (i. e., investment) over a rather long time period with associated uncertainties and changing conditions. Leadtime concerns are related to the rate and magnitude of change concerns mentioned above, and together they indicate a need to take into account the "dynamics of the system in an anticipatory manner."

APT and the global model were constructed to assist decision-makers in meeting increasingly difficult decision situations. Some of the factors which have to be considered in the construction and application of APT and the model to assure their use in practice are the following:

(a) Reliability: The construction of the tool has to be based on as many facts and data as are available and to use as much relevant theoretical and practical knowledge as possible. An important decision should not be based on incomplete information.

(b) Comprehensiveness: A rather full spectrum of relevant factors must be covered. For example, there is no point in considering economic implications in minute details while overlooking technical feasibilities and constraints; nor is there much to be gained from analyzing extreme technical possibilities without taking into account the economic and human base and other support for such technology. The task is further complicated by the need for at least general comprehension of the complex set of interrelationships among the large set of factors which have to be considered. This requires a balance in the detail with which each of the related domains (economics, technology, resources, demography, etc.) has to be represented.

(c) Efficiency in Use: This is another point which is also quite readily overlooked. APT, in stressing anticipatory policy making, involves a certain amount of "ball-gazing" and "futures prediction." This is clearly a risky business and one must be especially careful as to what can be said about the future and what can not be said with any degree of certainty. To meet this challenge, APT is built on the concept of assessing the likely future if certain events and policies take place in a given sequence. It is in such an "if-then" context that credible and responsible use of APT takes place. In other words, although APT can become indispensible, its use should be to augment the power of reasoning as employed in present decision making, rather than as a substitute for that process.

APT AND THE PROCESS OF ITS USE

The concept of APT is based on the identification of three components in a policy assessment process:

(i) Explication of the policy in specific and explicit operational terms;

(ii) Selection of the factors in terms of which the success or failure of the policy will be assessed;

(iii) Identification of the relationship between the policy and the factors for assessment of policy success.

The first component becomes part of the APT process through scenario preparation. A scenario, in general, is defined as a feasible sequence of future events and choices (decisions) which could occur or would be made over the future time period of concern. A scenario contains, in essence, assumptions regarding the uncertain future conditions in which the system will operate and assumptions about poorly understood aspects of the system's behavior as well. A scenario is the "if" part of an "if-then" type of futures analysis. Using APT, the explication and specification of a scenario is frequently done by preparing a scenario sheet, i.e., by making choices or "guesses" as to the outcome of certain events and the values of certain variables. An example of a scenario sheet will be given in the next section.

The second component of the APT process is handled in a manner similar to the first, i.e., by a selection of an indicator or variable set in terms of which the response of the system will be judged as good or bad. In practice, it amounts to the selection of the evaluation set from a large set of indicators and variables which are envisioned, in the broadest sense, to be affected by the policy implementation. Examples of such a set will be given in the next section.

The third component of the APT process is materialized by means of a computer model which encodes the cause-effect relationships between the policy variables and evaluation variables. Such a model is nothing more than an "image" which the policy maker (or analyst) has about the outcomes of alternative policy implementations. It should be pointed out that it is the very nature of any decision-making or more general selection process that such an image must exist. It is only in reference to that image that the selection is made. A model, therefore, represents the understanding the decision-maker has (at least at the time when the choice is made) of the plausible outcome of alternative choices. It is to be hoped that the mental model will reflect as many relevant aspects of the real situation as possible and in as accurate a way as possible. When much of the information in the model is numerical and when the model involves a large number of interconnected relationships, it is only natural to use a computer to untangle the exact sequence of events and the flows of influence. Indeed, this is the only practical or even conceivable way in a situation of even moderate complexity.

The total process of policy assessment used in APT, which we refer to as scenario analysis, consists therefore of three steps:

(i) Scenario preparation;

(ii) implementation of the scenario on a computer model;

(iii) evaluation of the policy by the analysis of evaluation indicators.

Of course, the decision maker (analyst) may go through these steps many times in the process of investigating a variety of alternative scenarios (s)he has in mind initially, and/or to explore alternatives which are additionally suggested by the insights gained as the investigation proceeds.

The crucial importance of the utmost efficiency in scenario analysis should be stressed here. In practice, one has to consider a rather large number of alternatives. Thus, the consequences of implementing any one of these alternatives should be presented in a comprehensive manner and within a sufficiently short span of time so that the policy maker (or analyst) can compare the outcomes --- not only in specific numerical terms, but also by comparing the general behavior and response of the system. It is not unlikely that the final choice will be made on the basis of a feature whose importance becomes apparent only in the process of comparing the outcomes of alternative choices. Also, it is not uncommon that after the response of the system to a set of scenarios is analyzed, new scenarios are conceived or triggered by some features observed in the system's response. It is through such a process that the policy analyst really develops a "feel" for the dynamics of the real world system in question; such an improved understanding in itself can make a significant contribution not only to policy selection, but to the policy formulation process as well. To facilitate the process of scenario analysis, video display terminals are used in the practical implementation of APT.

Some comments on the second component, i.e., the computer model used with APT, are needed here. A full description of that model is clearly outside the scope of this article, but can be found elsewhere (see the Proceedings of the INternational Institute for Applied Systems Analysis Symposium on Multilevel Computer Model of World Development System, Austria, May, 1974). For our purposes here, a general understanding of the basic structure of the model should be adequate.

The computer model is a representation of the long term global world development process. Its principal components are: population development; the world economic system; man-made processes such as energy and materials processing and use, and agricultural processes, resource development, and exploitation, and their ecological impact. In addition, higher level socio-political and value factors are accounted for through scenario analysis (see Figure 1). All these components (which one also refers to as levels, strata, or spheres) are fully integrated as they most certainly are in reality. In order to be able to account for the most crucial problem of today, namely, disparity in developments in different parts of the world, the world system model is represented in terms of regions which again are fully integrated into the

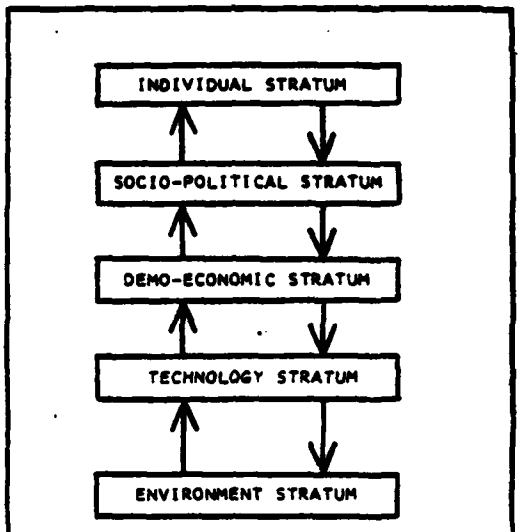

Figure 1.

world system. The first generation of the world model uses ten regions as shown in Figure 2 (given at the top of the next page). Any of these ten regions can be further subdivided into as many as seven subregional or national units for more detailed analysis.

The central role which the conception and construction of the model plays is evident. It must contain sufficient "input" or causal variables so that various policies can be translated into terms needed to influence the evolution of the system in time; it also has to contain a sufficient number of important evaluation or assessment indicators so that choice between alternatives can be made. Needless to say, these policies and indicators ought to be related in a manner fully consistent with all available facts and relevant information and knowledge.

USE OF APT FOR ANALYSIS OF OIL ISSUES

The use of APT and the global model will be described in this section by means of a specific example. A completely parallel presentation for the use of APT on food issues will then be given in the next section. Some indications of other uses and potentials for extension and adaptation are given in the concluding sections.

Scenario analysis using APT proceeds in the following steps:

Step 1: Selection of a scenario sheet, and its completion. A scenario sheet contains a list of choices for the analyst which reflect the alternative policies available. A simple form of a scenario sheet is shown in Figure 3 (shown two pages hence). A scenario sheet which facilitates a more detailed analysis of options and policies is too long to include here. Scenario sheets with differ-

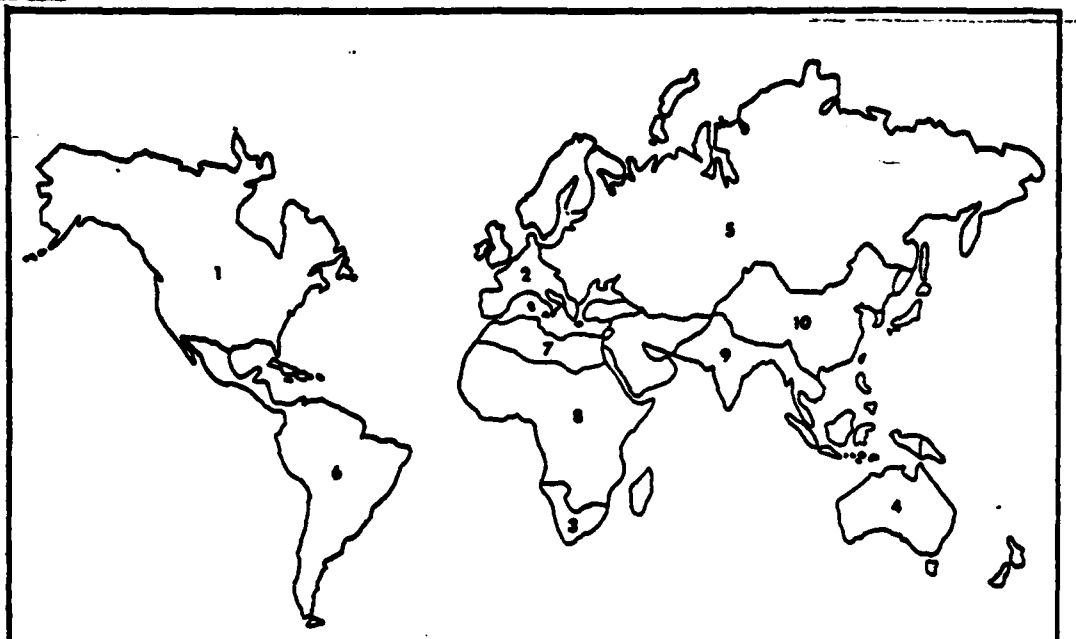

Figure 2.

ent levels of detail are provided. A participant with some experience using APT can design a scenario sheet of his or her own, as long as it is consistent with the set scenario variables (which in the case of analysis of the oil situation number in the hundreds). The scenario sheet of the type given in Figure 3 is completed simply by marking off the selected options with "x"'s. Completion of more detailed scenario sheets requires indication of numerical values or even a consistent sequence of values.

For the sake of illustration, the scenario sheet in Figure 3 is filled in in a manner reflecting somewhat optimistic assumptions about the oil situation.

Step 2: After the scenario sheet has been completed, it has to be "inputted" into the computer in order to provide the model with the assumptions made in policy selection and scenario preparation. One can turn this step over to a technical person. However, simple scenarios of the type given in Figure 3 are exceedingly easy to implement on the computer by using a typewriter console and following instructions that can be mastered in about ten minutes.

Step 3: Selection of the assessment indicators. The benefit from any given policy has to be assessed in terms of indicators which reflect the response of the system. For the sake of simplicity, "standard" sets of indicators are prepared so that one can indicate the set or combination about which one would like to get information. For example, they include an oil physical information set, an oil monetary information set, a basic economic indicators set, etc. The list of the simplest and most commonly used indicator sets for oil analysis is given below:

OILPRT	WORLD OIL DATA--PRINT
ODEPLT	WORLD OIL DEFICIT/SURPLUS--PLOT
MONPLT	MIDEST OIL MONEY--PLOT
SCEPRT	SCENARIO RESULTANT ECONOMIC DATA--PRINT
YPRT	GROSS REGIONAL PRODUCT (Y) -- PRINT
WECPLT	WORLD ECONOMIC SUMMARY--PLOT
POPPRT	POPULATION--PRINT
RYPRT	CHANGE IN GRP (Y) -- PRINT
RPOPRT	CHANGE IN POPULATION--PRINT
ODOPRT	OIL DOLLAR FLOWS--PRINT

In the examples provided here, the oil and economic indicators are selected in both graphical and numerical form. A participant with some experience using APT can select the indicators of his or her own from the truly large set available.

Step 4: Activation of the computer run. This step

POLICIES AND PARAMETERS				Code For Computer Implementation
1. Potential Resource Estimates	high	(3000 billion barrels)	( )	P11
	*medium	(2500 billion barrels)	(x)	P12
	low	(2000 billion barrels)	( )	P13
2. Oil Demand Reduction with Price Increase	high	(.4S)	( )	P21
	*medium	(.22S)	(x)	P22
	low	(.1S)	( )	P23
3. Oil Supply Increase with Price Increase	high	(1.0)	( )	P31
	*medium	(.7S)	(x)	P32
	low	(.S)	( )	P33
4. Annual Increase in Oil Prices	high	(S%)	( )	P41
	medium	(3%)	( )	P42
	*none		(x)	P43
	decrease	(-S)	( )	P44
	other	(exogenous)	( )	P45
5. Upper Limit on Oil Prices	high	($1b.SO)	( )	P51
	*medium	($13.SO)	(x)	P52
	low	($10.SO)	( )	P53
6. Oil Consumption Reduction	substantial	(15%)	( )	P61
	medium	(7.5%, 10%, MEUR)	( )	P62
	*none		(x)	P63
7. Relationship Between Oil Prices and Investment Good Cost	full	(1.0)	( )	P71
	partial	(.S)	( )	P72
	*none		(x)	P73
8. Desired Economic Growth	fast	(5%, 6%, LDC)	( )	P81
	*medium	(3%, 4%, LDC)	(x)	P82
	slow	(1%, 2%, LDC)	( )	P83
9. Population Policy	stringent	(20 Yr.)	( )	P91
	*medium	(35 Yr.)	(x)	P92
	none		( )	P93
10. Monetary Recycling	efficient		( )	P101
	*fair		(x)	P102
	poor		( )	P103

*Standard Values.

Figure 3.

simply involves typing in the word "RUN" at the typewriter console. The computer will respond by providing the results of the computer run in terms of sets of indicators as specified. The format of display, e.g., hardcopy printed version, TV tube display, or a combination thereof, can also be specified. As an illustration, some results of the computer run for the scenario sheet shown in Figure 3, using two of the sets of indicators shown under Step 3, are given in Figure 4 in graphical form, and in Figure 5 in numerical form. (The information shown in Figure 5 is normally shown on a year-by-year basis; for simplicity here, however, the information is shown on an every-five-years basis.)

In addition to these purely formal steps, which specify the "physical" use of APT, there are the steps of policy formulation and evaluation of the computer printouts or displays. These steps, however, require an intimate understanding of the specific issues at hand and, for the sake of brevity, will not be elaborated upon here.

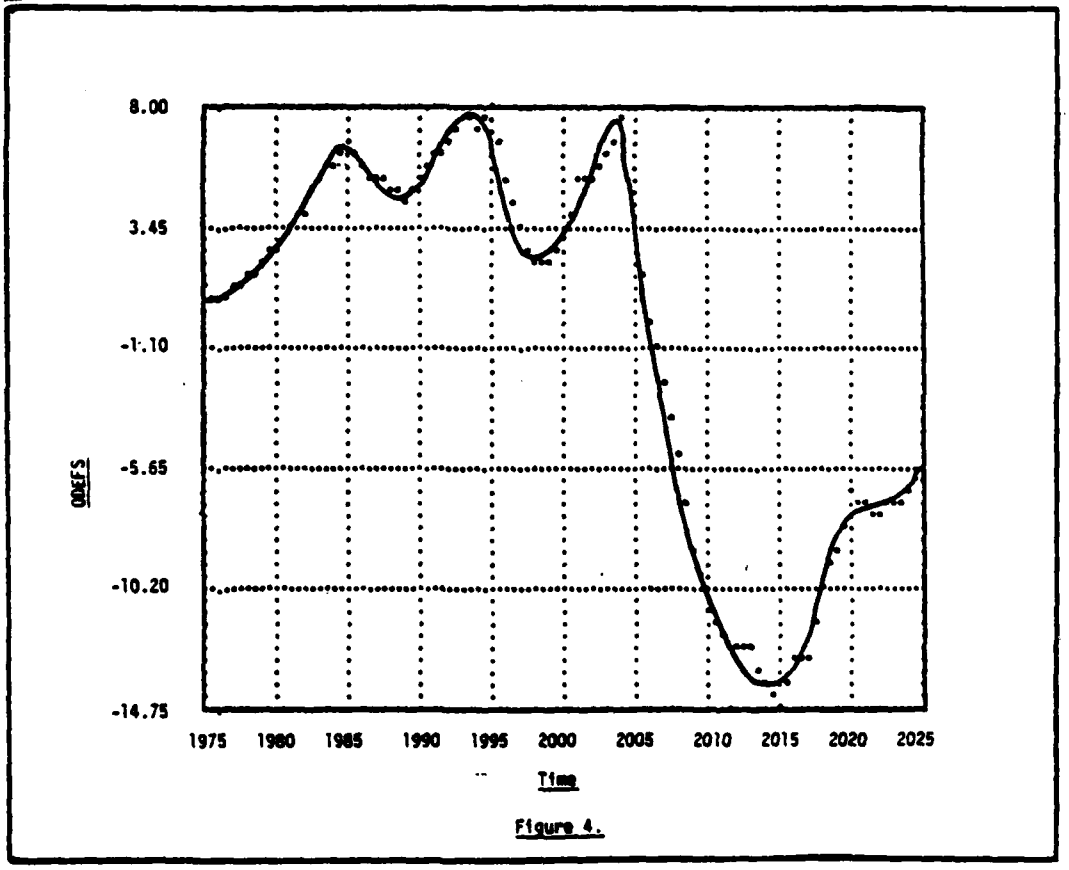

Figure 4.

	V NAM	V WEUR	V JAP	V ROEV	V EEUR	V LAM	V ME	V AFR	V SEA	V CHINA	V WORLD
1975	1030.74	1071.51	368.41	61.597	586.49	166.09	125.44	47.30	152.56	106.37	3706.5
1980	1214.14	1219.60	424.75	83.306	742.53	224.41	178.57	62.47	206.83	138.62	4512.3
1985	1419.18	1400.85	508.95	121.284	944.22	297.48	213.95	134.10	277.58	198.81	5614.2
1990	1637.41	1572.10	598.43	156.494	1206.47	393.60	308.68	195.39	378.81	312.23	6757.7
1995	1896.69	1734.11	704.90	190.908	1546.82	521.47	453.95	277.47	503.40	509.10	8336.7
2000	2186.60	1959.70	846.13	230.370	1896.14	700.84	732.10	386.64	641.91	667.12	10266.8
2005	2586.02	2271.57	1050.70	278.091	2267.71	932.96	1051.84	498.77	803.12	863.09	12573.9
2010	3089.41	2721.89	1368.57	321.404	2759.59	1205.98	1260.51	627.93	1019.19	1098.35	15470.8
2015	3697.95	3249.33	1789.21	382.197	3368.57	1530.77	1560.46	795.62	1296.72	1393.32	19064.1
2020	4397.35	3845.19	2519.12	452.571	4099.34	1951.00	2011.97	1006.02	1647.63	1780.31	23510.5
2025	5214.78	4554.94	3018.86	533.542	4979.72	2478.45	2632.39	1272.89	2094.09	2260.71	29038.4

Figure 5.

USE OF APT FOR ANALYSIS OF FOOD ISSUES

The use of APT and the global model will be described in this section by means of another specific example. This presentation is completely parallel to that given in the last section on the use of APT for analysis of oil issues.

Again, scenario analysis using APT proceeds in the following steps.

Step 1: Selection of a scenario sheet, and its completion. A simple form of a scenario sheet for food issues is shown in Figure 6. Scenario sheets which facilitate more detailed analysis of options and policies are too long to show here. The scenario sheet of the type given in Figure 6 is completed simply by marking off the selected options with "x"'s. Completion of more detailed scenario sheets requires indication of numerical values, and may even involve indicating a consistent sequence of values. For the sake of illustration, the scenario sheet in Figure 6 is filled in in a manner reflecting somewhat optimistic assumptions about the food situation.

Step 2: After the scenario sheet has been completed, it has to be "inputted" into the computer to provide the model with the assumptions made in policy selection and scenario preparation. Again, one can turn this step over to a technical person, but simple scenarios of the type given in Figure 6 can be introduced to the computer by any user after about ten minutes of training.

Step 3: Selection of the assessment indicators. The benefit from any given policy has to be assessed in terms of indicators which reflect the response of the system. For the sake of simplicity, some "standard" sets of indicators have been prepared for this purpose. The list of the simplest and most commonly used sets is given at the top of the next column. A participant with some experience using APT can select the indicators of his or her own choosing from the very large set available.

Step 4: Activation of the computer run. This step is accomplished simply by typing in "RUN" at the console. The computer then responds by providing the results of the computer run in terms of sets of indicators and their values. As an illustration, some results of the computer run for the scenario sheet shown in Figure 6, using two of the sets of indicators shown at the top of the next column, are given in Figure 7 (shown 3 pages hence) in graphical form, and in Figure 8 (also shown three pages hence) in numerical form. (As before, the information shown in Figure 8 is normally printed out on a year-by-year basis; for simplicity here, however, the information is shown on an every-five-years basis.)

In addition to these purely formal implementation steps, there are the much weightier steps of policy formulation on the one hand, and evaluation of the model-produced results on the other. Of course, these steps require understanding of specific issues; for brevity, they will not be explored here.

BASSCN	TABLE OF BASIC DATA FROM SEVERAL SELECTED DOMAINS
BASPLT	PLOT OF BASIC DATA
POPSCN	TABLE OF POPULATION DATA
POPPLT	PLOT OF POPULATION DATA
NUTSCN	TABLE OF NUTRITION
NUTPLT	PLOT OF NUTRITION DATA
ECOSCN	TABLE OF ECONOMIC DATA
ECOPLT	PLOT OF ECONOMIC DATA
AGESCN	TABLE OF AGRO-ECONOMIC DATA
AGEPLT	PLOT OF AGRO-ECONOMIC DATA
CROPSCN	TABLE OF CROP PRODUCTION DATA
CROPPLT	PLOT OF CROP DATA
LANDSCN	TABLE OF LAND-USE DATA
LANDPLT	PLOT OF LAND-USE DATA
POLSCN	TABLE OF SELECTED POLICY-RELEVANT DATA
BASPRT	TABULAR DATA, BASIC
CROPRT	TABULAR DATA, ECONOMIC
POPRT	TABULAR DATA, POPULATION
LANDPRT	TABULAR DATA, LAND

CONCLUDING REMARKS

The purpose of this article is to enable an interested person to use APT, or actively participate in a demonstration of its use. Needless to say, an application of APT aiming at actual implementation of the results requires a considerable investment in time and effort. The objective of the simple kind of use described here is merely to indicate the tool's potential and to trigger the imagination as to what really can be done when the instrument is used more fully. As an aid to the imagination, the following is a potpourri of thoughts on the subject.

(a) A sequence of increasingly intricate scenario sheets has been designed. The scenario sheets presented earlier are termed "qualitative," because the participants need not develop numerical values but simply indicate general preferences or expectations. A type of "quantitative" scenario sheet requiring specification of numerical values has been developed, as have still more detailed scenario sheets on which one indicates the entire pattern of assumed or selected policy changes over a period of time. Finally, there is the "design your own scenario" option which was mentioned earlier. In more aggregated scenarios, any variable or option which is not explicitly indicated takes on a "standard" value determined from the data and past trends.

(b) The period of time over which the implementation of a policy is to be analyzed can be selected by the user. Of course, with longer time spans, the associated uncertainties increase, and this has to be taken into account when analyzing results.

SELECT THE REGION(S) FOR WHICH THE INDICATORS ARE TO BE PRESENTED

North America	( )	Rest of Developed	( )	Latin America	( )
Western Europe	( )	Eastern Europe	( )	Africa	( )
Japan	( )	Middle East	( )	Southeast Asia	( )
				China	( )

				Code for Computer Implementation
I.	FOOD POLICIES AND PARAMETERS			
	1. Cultivable But Uncultivated Land	*high	(x)	F11
		medium	( )	F12
		none	( )	F13
	2. Price Increase for Fertilizer and Technical Inputs	high	( )	F21
		medium	( )	F22
		*none	(x)	F23
	3. Technology Advances Increasing Agricultural Productivity	high	( )	F31
		medium	( )	F32
		*none	(x)	F33
	4. *Receipts of Food Aid*	massive	( )	F41
		moderate	( )	F42
		*none	(x)	F43
II.	ECONOMICS			
	1. Desired Economic Growth Rate	fast	( )	E11
		*medium	(x)	E12
		slow	( )	E13
	2. *Shift of Investment from Non-Agriculture to Agriculture*	high	( )	E21
		medium	( )	E22
		*none	(x)	E23
	3. *Shift of Non-Agricultural Investment to Food Imports*	total	( )	E31
		medium	( )	E32
		*none	(x)	E33
	4. *Magnitude of Monetary Foreign Assistance (Recipient Region)*	massive	( )	E41
		moderate	( )	E42
		*none	(x)	E43
	5. *Usage of Foreign Assistance Funds (Recipient Region)*	agriculture	( )	E51
		*balanced	(x)	E52
		industry	( )	E53
	6. *Magnitude of Monetary Foreign Assistance (Donor Regions)*	massive	( )	E61
		moderate	( )	E62
		*none	(x)	E63
	7. *Source of Funds for Foreign Assistance (Donor Regions)*	investment	( )	E71
		*balanced	(x)	E72
		consumption	( )	E73
III.	POPULATION			
	1. *Improved Health Care and Medical Technology*	high	( )	P11
		medium	( )	P12
		*none	(x)	P13
	2. *Population Policy*	stringent	( )	P21
		moderate	( )	P22
		*none	(x)	P23

*standard values

Note: Parameters in roman letters refer to questions of uncertainty about the future; parameters in italicized letters refer to policy options

Figure 6.

AD-A082 857 COMMAND AND CONTROL TECHNICAL CENTER WASHINGTON DC F/G 15/7
A SURVEY OF LONG-RANGE FORECASTING MODELS AND DATA RESOURCES: A--ETC(U)
AUG 79 R MILLER, B MARSHALL, P KRAMER-DEBUCK

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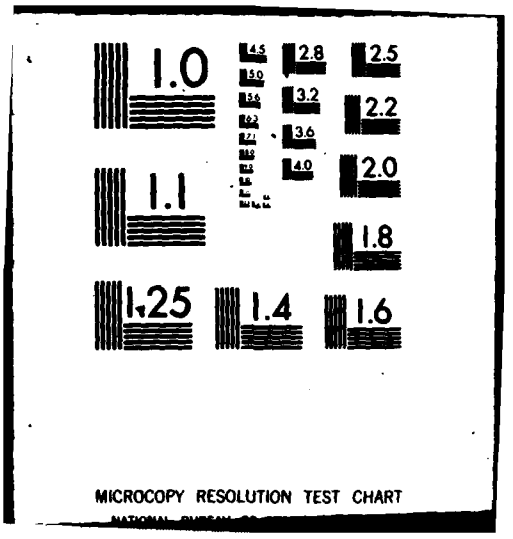
1.0
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2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3
7.1
MICROCOPY RESOLUTION TEST CHART

(c) A more demanding type of analyst-computer interaction is possible in which the analyst becomes de facto a part of the system's evolution, rather than a passive observer as (s)he is in the case of the scenario analysis presented here. In such a process - termed interactive or symbolic analysis - the policy choices are implemented only over a short initial period of time (whose length is free to be selected), and the response of the system is observed. The analyst then can either continue the application of the originally selected policy, or make modifications and changes in light of the way the system responded initially. In such a way, the analyst becomes a part of the overall system as it evolves in time, in the sense that his or her own judgments and values determine the ultimate evolution of the system. The policy which evolves from such a process is often composed of a combination of the policies originally conceived.

(d) APT can be used for numerous other issues and not only for energy and food; other possibilities using the global model in APT include the analysis of effects of the indexing of raw materials prices, reducing the world gap in economic development, and alternative proposals for a new world economic order.

(e) APT can and has been refined to be used on a national level, i.e., for the analysis of long term national development policies in the global context, both with the global model and with more detailed national models.

(f) APT can be of use not only to governmental decision-makers or policy analysts in international organizations, but also to other government branches, such as the legislature, and even to other elements of society, such as business and the public at large. This could, in principle, add a new dimension to "democratization and decentralization" of decision-making in modern, highly complex, post-industrial societies, and to public education. The well known information and expertise gap between bureaucracy and the people and their representatives could conceivably be somewhat reduced. For example, decision-makers could be asked to explicate proposed policy in a manner which would permit its evaluation by using APT and global or national models.

(g) Many contemporary international and global problems create conflicts, not only because of the diverging interests and goals, but also because of factual ignorance and reliance on "wishful thinking." The realities of the world situation are complex to comprehend, and in an atmosphere contaminated with suspicion, the facts, even when presented, are doubted. APT can provide a vehicle for arriving at a common denominator of facts regarding present and future, and in that way hopefully eliminate at least those conflicts which are demonstrably unnecessary.

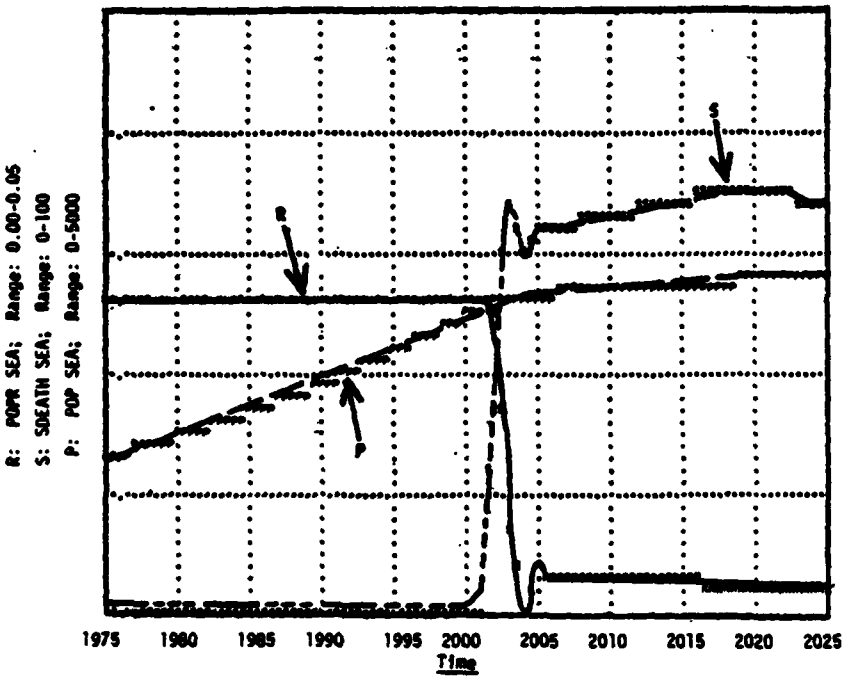

Figure 7.

	Y SEA	YA SEA	YNA SEA	I SEA	II SEA	INA SEA	KNA SEA
1975	145.430	53.9083	91.522	23.1234	3.3529	19.7705	210.50
1980	169.901	55.1984	116.654	27.0142	3.9171	23.6971	268.30
1985	200.427	59.5483	144.882	31.8679	4.6208	27.2471	333.23
1990	232.949	64.2913	176.474	37.0389	5.3706	31.6683	405.89
2000	305.481	73.5645	240.575	48.5683	7.0424	41.5259	574.02
2005	341.769	75.7185	291.131	54.8183	7.9487	46.6698	669.60
2010	398.397	76.1470	336.531	62.0731	9.2224	54.3804	774.02
2015	440.279	76.2515	386.569	70.0044	10.1506	59.8538	888.88
2020	495.100	76.1842	441.340	78.7210	11.4145	67.3084	1015.08
2025	555.457	76.8369	501.655	88.3176	12.8061	75.5116	1153.81

Figure 8.

APPENDIX D

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20. ABSTRACT (Continued)

This report recommends that DOD long-range planning be conducted on a general probabilistic basis, identifying the factors of national power, forecasting their most likely status on a national and regional basis, and assessing the political implications of these future power relationships accordingly. It suggests Ray Cline's Perceived Power equation as the vehicle for such an approach and recommends a "family" of forecasting models using Mesarovic's "APT" interactive software (developed by Systems Applications Company, Incorporated) to provide needed inputs to the equation. It identifies 18 forecasting models and 59 data resources as meriting futher investigation for their potential use in such an effort.