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THE UTILIZATION OF THE BEHAVIORAL SCIENCES
IN LONG RANGE FORECASTING AND POLICY
PLANNING

Warren R. Phillips, et al

Ohio State University

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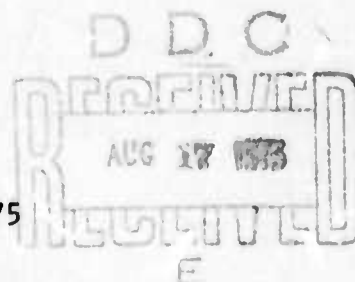
THE UTILIZATION OF THE BEHAVIORAL SCIENCES
IN LONG RANGE FORECASTING AND POLICY PLANNING

Semi-Annual Technical Report No. 1

W.R. Phillips and S.J. Thorson

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TABLE OF CONTENTS

	<u>page</u>
INTRODUCTION	3
1. ANALYSIS	
1.1 Report on the Oil Production Model	4
1.2 Agriculture Sector Sub-Model	4
1.3 The Preference Structures of U.S. and Host Country Decision-Makers	5
1.4 Country by Country Government Simulation Modules	6
1.5 Analysis of U.S. Goals and Preferences vis-a-vis Project Countries	6
2. METHODOLOGY AND PROGRAMS	
2.1 Computer Terminals	8
2.2 Simulation Programs	8
2.3 Methods of Interaction with Policy Planners	8
3. DATA	
3.1 Data Acquisition	8
4. PERSONNEL	
4.1 Principal Investigators	8
5. PUBLICATIONS AND PAPERS	
5.1 Papers	9
5.2 Publications	10
6. BUDGET	
6.1 Amount currently provided for contract	10
6.2 Expenditures and commitments to date	10
6.3 Estimated funds required to complete the work	10
6.4 Estimated date of completion of work	10

Quarterly Technical Report No. 1

INTRODUCTION

The advanced Research Projects Agency grant to The Project for Theoretical Politics began January 1, 1973. The first semi-annual technical report is being submitted to cover the beginning date of the grant to June 30, 1973.

The organization of the report will set the style for subsequent reports. The report will be divided into six major sections. The first will describe the analysis initiated and completed during the half year. Results of special significance will be highlighted. Methodological problems that have arisen during the analysis will be discussed in the second section and the computer programs that have been written or revised will be described. In this and the previous sections, technical terms and discussion will be avoided where possible.

The third section of this report will describe the data collection obtained during the period and their disposition in data archives. Current personnel on the project, personal commitments made and consultation will be noted in the fourth section. Project publications, research reports, monographs and preparation completed during the quarter will be listed in the fifth section. The sixth section will delineate changes necessitated in the budget, status of sub-contracts, and total versus expected expenditures to date. For ease in locating sections, all quarterly reports will be prefaced by a table of contents.

1. ANALYSIS

The goals of the project have been the development of forecasting techniques to the point where alternative U.S. policies towards specific countries can be unambiguously ordered with respect to their utility in light of certain foreign policy objectives. As a way of achieving this goal, the project envisions the development of a complex mathematical system for forecasting the effects of U.S. policy in various nations. In doing this, assumptions about the relations between U.S. policies and country and region specific indicators of stability in foreign behavior are to be expressed in a mathematical language. Results from current ARPA supported basic research efforts would be used to provide a basis for defining and testing the relations between these indicators. Mathematical control theory and dynamic programming, integrated with the user stated objectives in each country would then be applied to identify optimal mixes of policies toward each country.

As a substantive target, U.S. relations with Middle-Eastern oil producing countries was chosen. Specifically, Iraq, Iran, Saudi Arabia, Libya, and Algeria are the nations to be analyzed. With this in mind, several module simulations are being developed to portray the dynamics within each country that might either affect or be affected by U.S. policy actions. The modules are being developed keeping in mind two sets of criteria: The first is that

we want to specify those areas that policy planners feel are significantly affected by U.S. actions. The second goal is to insure that indicators are included in the simulations, changes in which are likely to affect U.S. policy preferences in this region.

In order to accomplish these goals, the modules are being developed in interaction with policy planners and in the Defense Department and the State Department. Those people who have been willing to discuss the development of such models with us will be reviewed in section 4.1.

1.1: Report on the Oil Production Model. The oil industry is important in the nations to be studied because it provides a key connection between their domestic and foreign political decisions. First, the income from oil operations (production and sales) provides a very large proportion of the national income, and thus becomes the foundation for many domestic programs. Second, because the oil income is both liquid and in hard foreign currencies it provides considerable freedom of maneuver in foreign policy. Third, because the oil income is not raised through taxation of the populace there are relatively fewer domestic constraints on its use, although loss of oil revenue could have (and has had) very severe domestic political consequences. Finally, development of the oil industry can have a powerful influence upon the emergency of an economic infrastructure so important in developing nations.

Accordingly, we are developing a computer simulation module for the oil industry as it appears to a policy maker within each of the producing countries. A copy of the current draft of the flowchart for that module is attached (Figure 1), along with a brief description of the salient variables. Presently we are engaged in programming and testing this module.

The next steps to be taken with regard to the oil sector will be in two main areas. First, the basic simulation module will be revised to take account of recent changes in the agreements between producing countries and the international majors. Those countries will receive revenues from direct sales of crude oil from the stocks they accumulate as part of their ownership equities. We wish to treat such revenue separately from income generated by the producing country's tax on oil produced. Second, we will be developing in more detail the linkages between oil income and both foreign and domestic political decisions in the producing countries. Eventually, such linkages will be part of an overlaid "decision-making" module within the simulation.

1.2: Agriculture Sector Sub-model. Oil production has clearly been a dominating force in these countries of the Middle East. But to focus solely on the oil sector is to present a rather incomplete picture of these countries. Other sectors of their respective economies are crucial to the understanding of these countries and as such must be incorporated in our models. Chief among these other sectors is the agricultural sector. While the major source of revenue in these countries has been the oil sector, perhaps the major recipient of this revenue has been the agricultural sector. This sector, in contrast

4-a

OIL MODULE
Figure 1

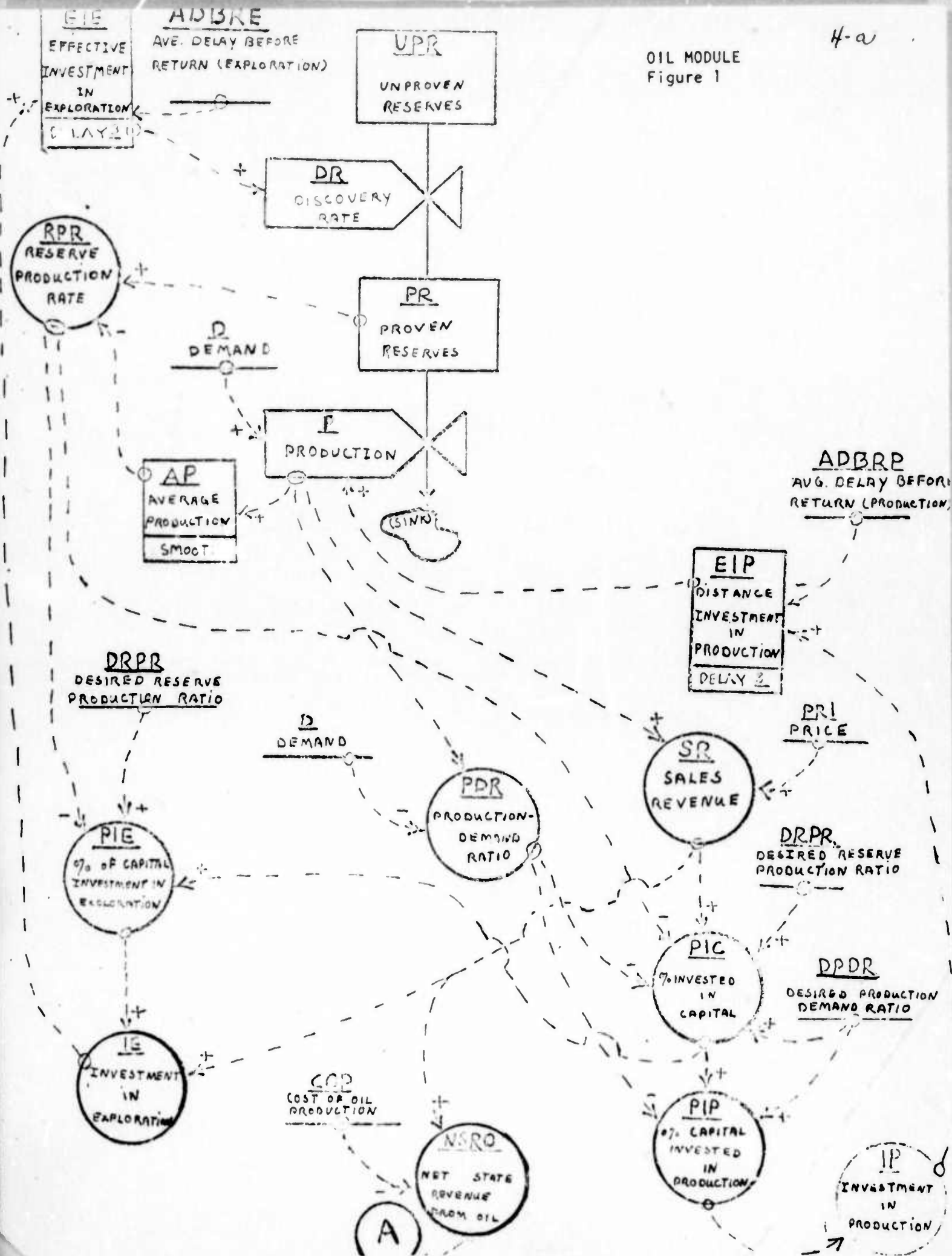
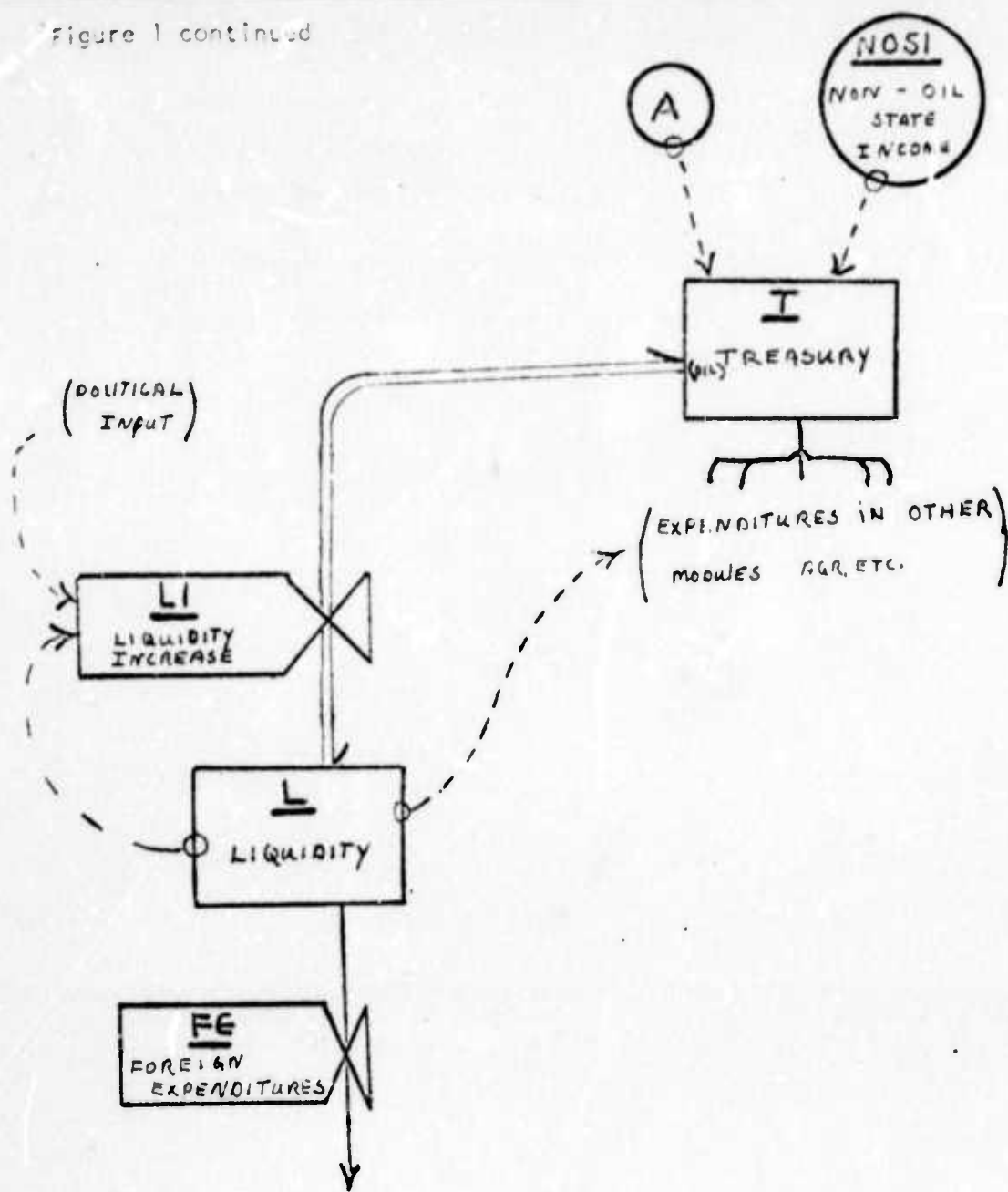


Figure 1 continued

46



VARIABLE LIST

ADDENDUM 2 TO PRELIMINARY DRAFT OF OIL MODULE
PROJECT FOR THEORETICAL POLITICS
JULY 1973

ADBRE	Average Delay Before Return (Exploration) [Months]: typical number of years before a given amount of capital invested in exploration begins to produce new discoveries
ADBRP	Average Delay Before Return (Production) [Months]: typical number of years before a given amount of capital invested in production facilities begins to increase production
AP	Average Production [Barrels/Day or Barrels/Month]: a smoothed production figure which will reduce the effect of large but brief increases or decreases in production
COP	Cost of Production [Dollars/BBL]: actual cost of production exclusive of taxes
D	Demand [BBLs/YR or BBLs/Month]: average level of demand for crude
DPDR	Desired Reserve-Production Ratio [YRS]: ratio of proven reserves to current demand
DR	Discovery Rate [BBLs/YR]: average rate of discovery of proven reserves
DRPR	Desired Reserve-Production Ratio [YRS]: desired ration of proven reserves to current demand
EIE	Effective Investment in Exploration [Dollars]: current amount of capital which was invested ADBRE months ago.
EIP	Effective Investment in Production [Dollars]: current amount of capital which was invested ADBRP months ago.
FE	Foreign Expenditures [Dollars/Month]: current level of foreign expenditures of all types by the producing country
IE	Investment in Exploration [Dollars/Month]: amount of capital invested in new exploration during current month

IP	Investment in Production [Dollars/Month]: amount of capital invested in new production facilities during current month
L	Liquidity [Dollars]: current holdings, of the producing country, of "hard" foreign exchange
LI	Liquidity Increase [Dollars/Month]: current month's increase or decrease in holdings of "hard" foreign exchange
NOSI	Non-Oil State Income [Dollars/Yr]: annual gross national receipts of producing country exclusive of oil revenues
NSRO	Net State Revenue from Oil [Dollars/Yr]: annual net oil revenue of producing country
P	Production [BBLs/Month]: current level of crude oil production
PDR	Production-Demand Ratio [dimensionless]: ratio of current production level to current demand level
PIC	Percent Invested in Capital [dimensionless]: percent of current sales revenue devoted to capital investment
PIE	Percent of capital Invested in Exploration [dimensionless]: percent of PIC which is to be invested in exploration activity
PIP	Percent of capital Invested in Production [dimensionless]: percent of PIC which is to be invested in additional production facilities
PR	Proven Reserves [BBLs]: current level of known reserves of crude oil
PRI	Price [Dollars/BBL]: current average price paid by international majors for each barrel of crude exported
RPR	Reserve-Production Ratio [YRS]: ratio of current level of proven reserves (PR) to current level of production.
SR	Sales Revenue [Dollars/Yr]: total annual revenue produced from sales of crude oil

T	Treasury [Dollars]: current balance of producing country's treasury
UPR	Unproven Reserves [BBLS]: estimated total of undiscovered reserves in producing country

to the oil sector, has generally been characterized by very slow growth, if any at all. As a result, these countries do not presently appear able to meet on their own the ever-increasing food needs of their populations. The decision-makers in these countries have thus had to divert more and more of their attention to their countries' resources to overcoming this situation. A number of crucial decisions confront these countries then concerning how to best meet these food needs given the limited nature of much of the resources.

It is in the context of these decisions that we have constructed our preliminary sub-model of the agricultural sector (Figure 2). Basically, the sub-model identifies the principal considerations which affect the choices of the decision-makers in dealing with this sector. As such, the sub-model is comprised largely of information flows; these are only three material flows (capital, water, land). A preliminary "decision-stratum" accompanies the sub-model (Figure 3) which when superimposed over the sub-model shows more clearly the relationships between these information flows and the decisions facing these countries.

To this point in the development of this sub-model, we have only identified the essential components of the sub-model and the direction of the relationships between them. The task facing us now is to specify the precise nature of these relationships. Additionally we need to further refine the sub-model so as to establish where exogenous inputs would feed into the sub-model.

[A final note: The sub-model has purposely been constructed so as to be general enough to apply equally well to the consideration of any commodity, or to any one of the countries in this study. Put more simply, the sub-model is neither country-specific nor commodity-specific. It is designed to be applicable to the general situation facing these countries as they seek to develop their agricultural sectors.]

1.3: The Preference Structures of U.S. and Host Country Decision-makers.

Another line of research which has been going on under the contract involves representing the preference structures of actions at various levels of analysis and identifying decision mechanisms for mapping preferences into higher level decisions. The approach which has been used is to locate policy possibilities in an n -dimensional "issue space". Each dimension or axis of the space corresponds to an "issue" or "aspect" of an issue. The ideal location of any decision unit (actor) can thus be described by an n -component vector of ideal locations on each dimension. Next each actor is given a utility function defined over the points in the issue space. By knowing an actor's location and his utility function, it is possible to look at the impacts of various sorts of decision mechanisms in aggregating these preferences into group decisions.

This "spatial" approach should be especially useful in looking at foreign policy behavior since it provides a way of representing the "multiple dimensionality" inherent in most foreign policy decision situations. It is further

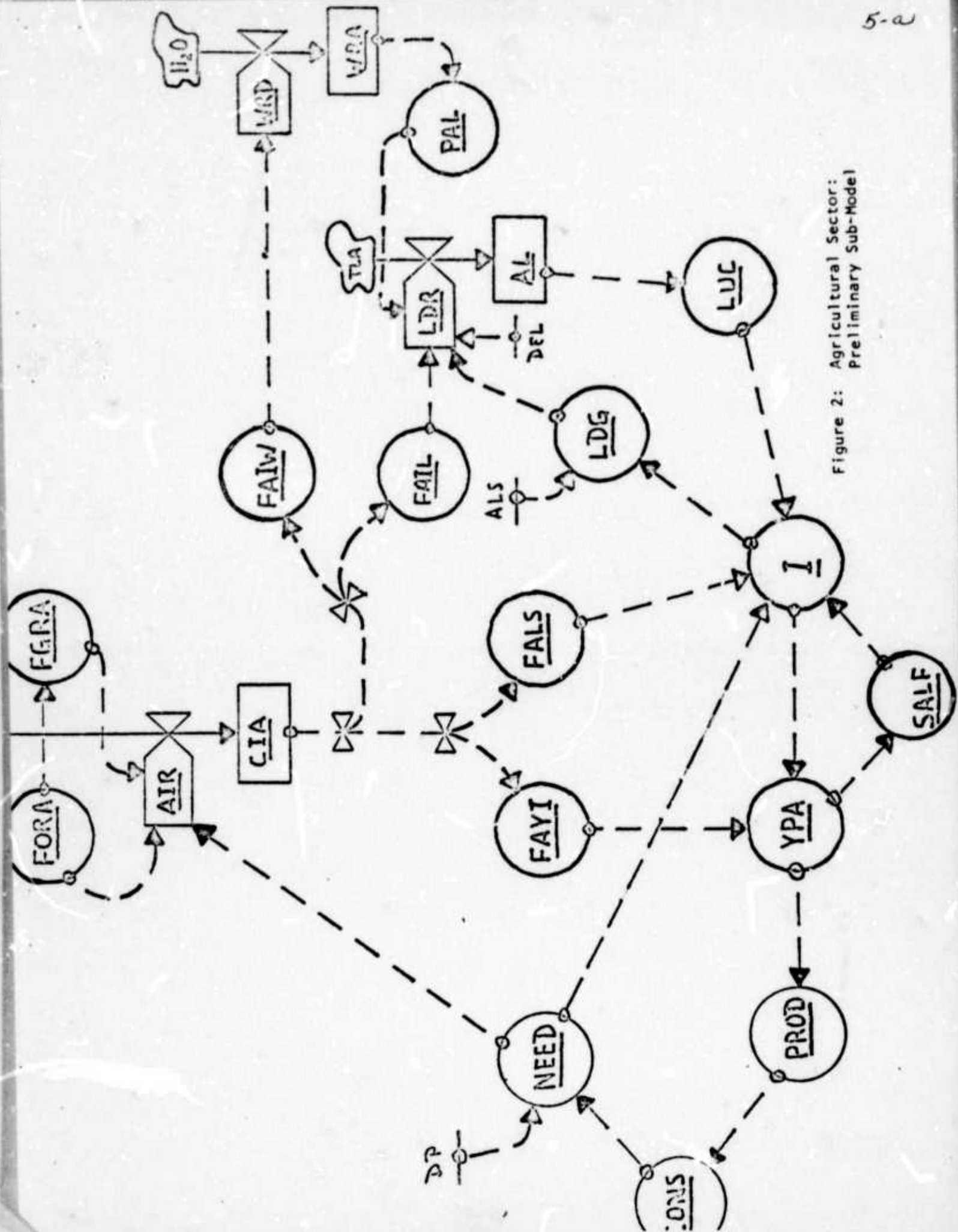


Figure 2: Agricultural Sector:
Preliminary Sub-Model

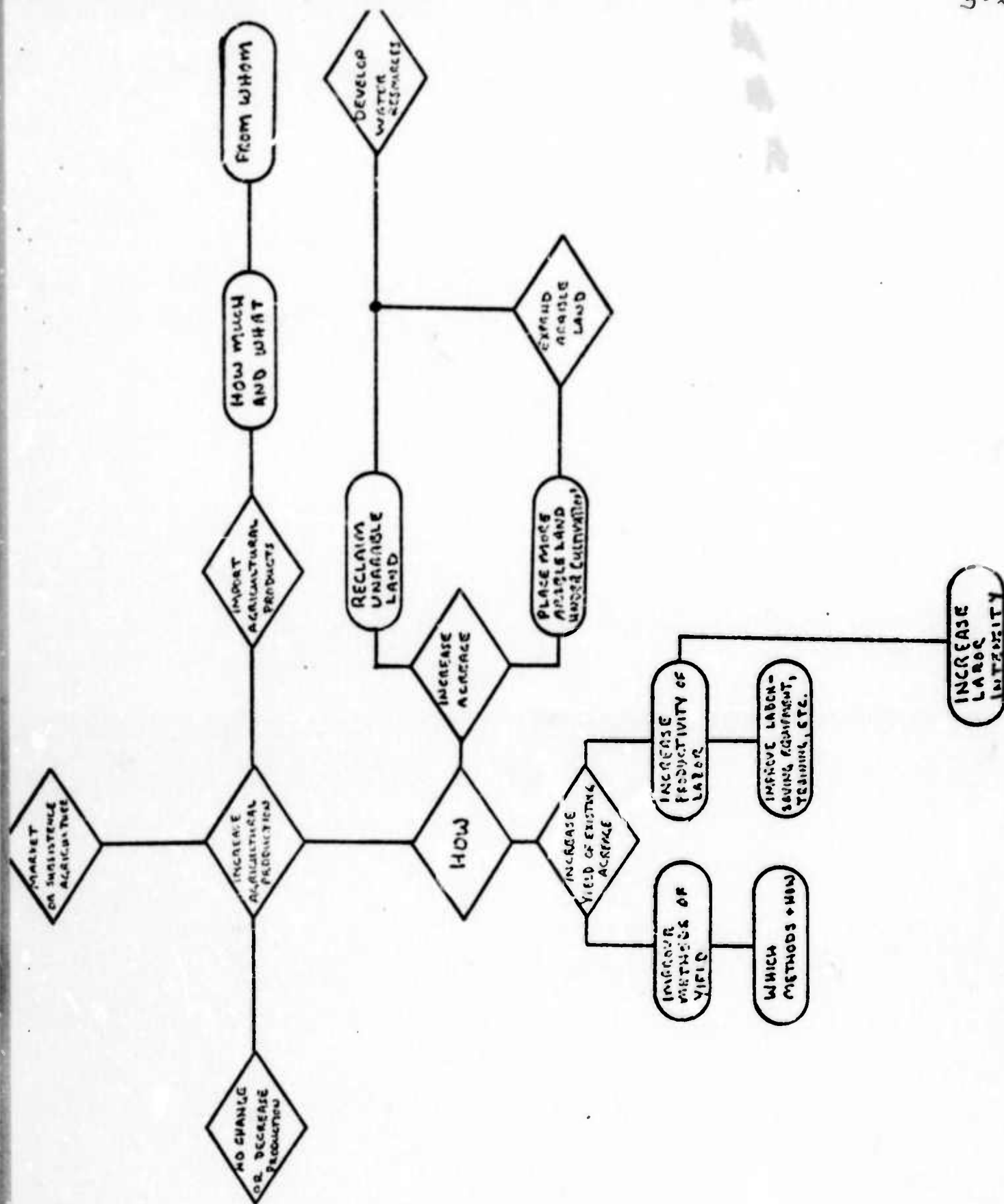


Figure 3: Agricultural Sector: Preliminary "Decision Strata"

Variables in the Agricultural Sector "Model":

1. FORA - fraction of oil revenues allocated to agriculture (dimensionless)
2. FGRA - fraction of government revenues (other than from oil) allocated to agriculture (dimensionless)
3. AIR - agricultural investment rate (dollars/time)
 $AIR = f(\text{Need}, \text{FORA}, \text{FGRA}, \text{Available Capital}, \text{AIR.JK})$
4. CIA - capital investment in agriculture (dollars)
 $CIA = f(\text{CIA.J}, \text{AIR.JK})$
5. FAIW - fraction of agricultural investment allocated to water resource development. (dimensionless)
6. FAIL - fraction of agricultural investment allocated to land development (dimensionless)
7. FALS - fraction of agricultural investment allocated to development of labor saving techniques, equipment, etc. (dimensionless)
8. FAYI - fraction of agricultural investment allocated to development of yield increasing methods. (dimensionless)
9. WRD - water resource development rate (million cubic meters/time)
 $WRD = f(\text{FAIW}, \text{WRA}, \text{JK})$
10. WRA - water resources available (million cubic meters)
 $WRA = f(\text{WRA.J}, \text{WRD.JK})$
11. PAL - potentially arable land (acres/million cubic meters)
12. LDR - land development rate (acres/time)
 $LDR = f(\text{PAL}, \text{FAIL}, \text{LDG}, \text{DEL})$
13. AL - arable land (acres)
 $AL = f(\text{AL.J}, \text{LDR.JK})$

13.5 LDG - average land degeneration rate (time) $LDG = f(I, ALS)$

14. LUC - land under cultivation (acres)

15. I - intensity (agricultural workers/acre)
 $I = f(FALS, Need, SALF, LUC,)$

16. YPA - yield per acre (quantity/acre)
 $YPA = f(I, FAYI)$

17. PROD- total production (quantity)

18. CONS- consumption (quantity)
 $CONS = f(PROD, NEED.J)$

19. NEED- production needed (quantity)
 $NEED = f(CONS, DP, PROD,)$

CONSTANTS -

DEL - DELAY

ALS - AVERAGE LIFETIME OF SOIL (TIME)

DP - DESIRED PRODUCTION (QUANTITY)

hoped that the spatial approach will prove to be applicable to the structural sorts of constraints imposed by the different bureaucratic organizations of the five oil producing countries being looked at.

The theoretical efforts carried out this far have been done primarily by Stuart Thorson and Richard Wendell (a mathematical programmer and optimization theorist) and are reported in research reports specified in section 5. The next phase of this effort will be to integrate the existing theoretical work with the empirical country by country analysis being carried out by Pat Callahan and reported in section 1.4. This will then form the basis for each country's government simulation module. In developing these modules, we will be working with Dr. R.A. Miller, a control theory scientist in Ohio State University's Department of Industrial and Systems Engineering. Professor Miller is an expert on multi-level systems control and has studied with Professor M. Mesarovic at Case.

1.4: Country by Country Government Simulation Modules. The research to be carried out this summer on specifying the government simulation modules is accomplishing three things. First, it will generate some estimates of the preference orderings of the leadership of five oil producing nations: Algeria, Iran, Iraq, Libya and Saudi Arabia. Three different approaches are being taken to develop these orderings. One will be to examine public statements of leaders, categorize the themes of these statements and derive some quantitative estimate of the relative importance of the themes. The second approach will be to categorize the budgetary allotments of the governments in terms of the priorities they reflect. The third approach will be to categorize the tenders which governments put out for the supply of various goods and services.

The second goal to be accomplished will be to arrive at some assessment of the options available to the leadership in each nation in the pursuit of its goals. Essentially, this will first require an exercise in deductive powers so that a more or less complete specification of the logically possible options can be derived. Then, through a survey of background material those options which are closed for any reason can be eliminated.

Finally, given a set of preference orderings and a set of options available to them, an attempt will be made to guess the probable future behavior of these five states in terms of their allocation of scarce resources in pursuit of goals.

1.5: Analysis of U.S. Goals and Preferences vis-a-vis Project Countries.

The initial pass at delineating U.S. goals and preferences has begun with the review of the hearings before the Senate Foreign Relations Committee and the House Foreign Affairs Committee. To date, all testimony reviewed has been by Curtis Tar and Joseph Cisco from the State Department and Vice-Admiral Peet from the Defense Department. There is a discernable difference in character between statements of the Under-Secretary of State for Security Systems and those of the Department of Defense representative. The former couches his presentations and responses in terms of political considerations. The DOD

representative sticks essentially to mechanical matters, e.g., what funds are necessary to preclude price increases due to delays in ongoing programs (production interruptions), to insure continuity of resupply (given the alternative sources of supply are not available to foreign countries), or to insure that sufficient lead time is available to select foreign military personnel for training and transport to the U.S. There appears to be a sharp functional division between the Defense Department and the State Department. The whether questions have been relegated to State, and the how questions to DOD. It is further obvious that if there is a debate the differences are resolved before the program goes to congress. But how it is resolved and who resolved it is not evident from the hearings, even under responses to direct questions on these points. Certain patterns do begin to emerge, however.

The first of these is a trend away from grants to aid in outright sales, or the substitution of "excess" material. A second is a concern for competitiveness in the arms market. Although the State repeatedly denies that the benefits to the U.S. economy are a factor in determining the character of military aid, they just as frequently admonish that if they don't buy from us, they'll buy from someone else. And, "in the long run, this helps our balance of payments." The third pattern relates to the so called "Nixon doctrine" of shared responsibility outlined in the second inaugural address. State quotes in a letter to Senator Pearson:

" . . . we shall do our share in defending peace and freedom in the world. But we shall expect others to do their share. Our material assistance, hence, is intended to be supplemental, and to ease the transition of recipient countries to full self-reliance.

In determining how our military assistance should be allocated we also should take into consideration treaty relationships, our military posture abroad, U.S. economic interest, and the extent to which our assistance can provide the foundation for political stability and economic progress in the recipient countries. Thus in responding to your request for rank-ordering of importance, you will appreciate that our priorities with respect to the request for FY73 funds have been based on the situation in Southeast Asia, the need to maintain the balance of forces in the Middle East, and to modernize the forces of countries such as Korea, as the U.S. military sale program is shaped by these same considerations, but in addition, FMS is used to facilitate the transition of grant recipients to increase reliance on their own resources."

It appears then that the most interesting substantive questions from the United States point of view is in dealing with just where outside of Southeast Asia the application of the Nixon doctrine will become important and the problem of how one reduces and phases out commitments while trying to achieve a balance of forces. These questions are being discussed with policy planners involved in the Middle East in both the Defense Department and the State Department.

2. METHODOLOGY AND PROGRAMS

2.1: Computer Terminals. The Ohio State University's simulation capabilities are strongly facilitated by TSO (Time Sharing Option) terminal capability. In order to make the most use out of this capability the Project has rented 3 computer terminals. One Execuport produces a standard 80 column hard copy and can be easily transported to and from Washington in demonstrating the modular simulations being produced on the project. Two other terminals are CRT's. These are excellent for debugging simulation programs and running the simulations when volumes of hard copy are not essential. Of course, separate commands for producing hard copy at the computer terminal for any run on the CRTs is available. Primary responsibility for developing and maintaining our computer system is provided by Polimetrics Laboratory at Ohio State University.

2.2: Simulation Programs. Of primary importance to the project is the ability to write simulation programs such that each of the modules developed in analysis can be packaged into a major simulation. The language most suitable for writing these programs is PLI. The work in constructing the simulation modules is being carried out by Robert Crain, a graduate assistant on the project, and James Ludwig, a systems programmer for the Department of Political Science.

2.3. Methods of Interaction with Policy Planners. Professors Stuart Thorson and Warren Phillips have been interviewing representatives of the Defense Department and State Department in an attempt to derive information from these planners on their perceptions of the operations of the U.S. activities in each of the countries being studied. Substantial assistance has been provided by Major General Brett and his staff and country desk officers in that section for Iran, Iraq, and Saudi Arabia have provided a good deal of their time and information. In addition, the State Department's Intelligence and Research Section on the Near East and Africa have provided substantial assistance as well. Professors Phillips and Thorson are currently developing questionnaires to illicit more systematic information from both branches of the government.

3. DATA

3.1: Data Acquisition. In an attempt to have on hand a complete file on national accounts data and national attributes the project has acquired the Minnesota Data Set and Retrieval Program. This data is collected under the auspices of MUCIA

4. PERSONNEL

4.1: Principal Investigators. Professor Phillips has been active coordinating the efforts to build the computer simulations modules. He has represented the project at the ISA meetings in New York presenting two papers. The first was on Forecasting for Planning and the second was on the Theoretical Underpinnings of the Events Data Movement. He also presented a paper at the

Midwest Political Science Association meetings in Chicago. He has also been active in the Military Operations Research Society's Working Group on Forecasting for Planning as its chairman for the June meetings. Those sessions provided ample opportunity to present the goals of the project to interested representatives from several branches of the Defense community.

Both Professor Phillips and Professor Thorson have been to Washington to interview several people responsible for U.S. policy with the five project nations. Those interviewed included the following:

1. Major General Duval Brett
ASD/ISA/NE & SA
2. Colonel James A. Briggs
ASD/ISA/AF
3. George Bader
ASD/ISA/AF
4. Colonel James St. Clin
JCS/Long Range Forecasting
5. Bob Dowell
State/INR/REC
6. Tom McAndrews
State/INR/NEA

Working relationships have been developed with all those interviewed and the next round of meetings will take place in late August. At that time interaction on the simulation modules will begin.

Professor Thorson has been active in developing the decision-making algorithms which will be employed in the command modules for specifying useful U.S. strategies in light of likely host country actions. He has represented the project at the International Studies Association as a critic of the use of simulation in international relations. He presented papers on spatial theory at the Symposium on Non Linear Programming in Washington, D.C., the Operations Research Society of America meetings and the Midwest Political Science Association meetings in Chicago, and attended the Ojai Conference on the Future of the Study of Comparative Foreign Policy. In addition he has consulted with the Club of Rome Project II at Case as well as Robert Holt and John Stiever at Minnesota who have a grant from NSF which has some similar goals as this contract.

5. PUBLICATIONS AND PAPERS

5.1: Papers

- No. 1. Phillips, W.R., "Theoretical Underpinnings of the Event Data Movement"
- No. 2. Phillips, W.R., "Forecasting for Planning"
- No. 3. Phillips, W.R., "Dynamic Foreign Policy Interactions"
- No. 4. Phillips, W.R. and P. Callahan, "Dynamic Foreign Policy Interactions: Some Implications for a Non-Dyadic World"

- No. 5. Phillips, W.R. and M. Hainline, "Major Power Conflict Exchanges in the Sixties: A Triadic Analysis of the U.S., Soviet, and Chinese Sub-System From a Comparative Foreign Policy View"
- No. 6. Thorson, S. and R.E. Wendell, "Location Theory and the Social Sciences"
- No. 7. Thorson, S. and J. Stever, "Classes of Models for Selected Axiomatic Theories of Choice"
- No. 8. Thorson, S. and R.E. Wendell, "Some Generalizations of Social Decisions Under Majority Rule"
- No. 9. Thorson, S. and R.E. Wendell, "A Mathematical Study of Decisions in a Dictatorship"
- No. 10. Thorson, S. "National Political Adaptation in a World Environment"
- No. 11. Thorson, S. "Comments on Some Problems in Constructing Descriptive, Policy and Design Theories of Foreign Policy"

5.2: Publications

- No. 1. Phillips, W.R. and T. Lorimor, "The Effect of Crisis Upon the Stability of the International System," to appear in Multivariate Behavioral Research.
- No. 2. Phillips, W.R. and R.C. Crain, "Dynamic Foreign Policy Interactions: Reciprocity and Uncertainty in Foreign Policy," to appear in McGowan (Ed.) The Sage International Yearbook of Foreign Policy Studies, Vol. II.
- No. 3. Phillips, W.R., "Where Have All the Theories Gone?" to appear in World Politics.
- No. 4. Phillips, W.R. "Theoretical Approaches in the Events Data Movement" to appear in C. Kegley, G. Raymond, R.M. Rood and R. Skinner's (Eds.) International Events and the Comparative Analysis of Foreign Policy.
- No. 5. Phillips, W.R., "Forecasting for Planning," to appear in Hilliker (Ed.) Knowledge and Diplomacy: The Interaction of Research and Foreign Policy.
- No. 6. Thorson, S. and J. Stever, "Classes of Models for Selected Axiomatic Theories of Choice," forthcoming, Journal of Mathematical Psychology.
- No. 7. Thorson, S. "National Political Adaptation in a World Environment," forthcoming in J. Rosenau (Ed.) Comparing Foreign Policies (Sage).

6. BUDGET

6.1: Amount currently provided for contract	\$ 65,914
6.2: Expenditures and commitments to date	\$ 19,631
6.3: Estimated funds required to complete the work	\$ 292,497
6.4: Estimated date of completion of work	Dec. 30, 1975