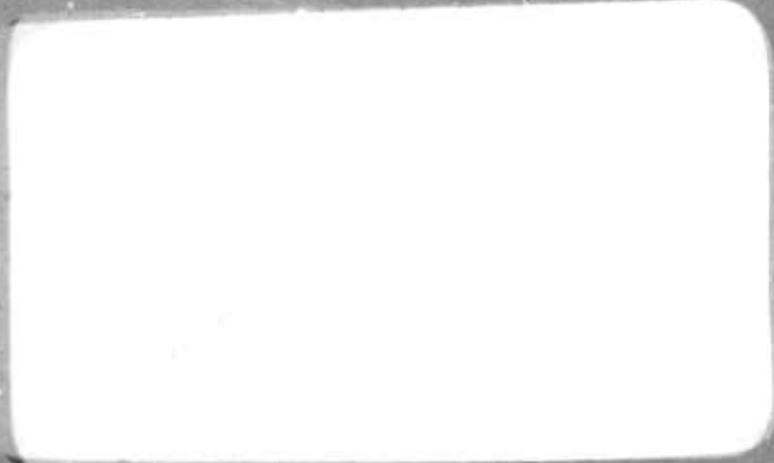


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of forecasting equations, and the construction of the three region-specific forecasting models.

Guidelines for generating forecasts and simulations are also presented in the Technical Appendix to enable Department of Defense personnel to become better acquainted with the approaches to generating meaningful, interesting, alternative futures for comparing the strategic implications of contrasting developments. Finally, the Appendix contains several annexes that identify the nations used in the study, the years and sources of all data, the model parameters, the computer forecasting program and data, the results of a standard forecast, and a sample simulation.

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FINAL TECHNICAL REPORT

STOCHASTIC SIMULATIONS OF
LONG-RANGE FORECASTING MODELS

VOLUME I

Executive Summary

October 31, 1975

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PREFACE

This report describes the development of long-range forecasting models for the Middle East, Latin America, and Africa. The research was supported by the Defense Advanced Research Projects Agency, Contract No. MDA903-75-C-0179.

For the past three years CACI has been engaged in an effort to enhance forecasting capabilities within the Department of Defense. In particular, that effort has sought to apply social science research methodologies to the problem of projecting important economic, political, military, and social variables over a 5- to 20-year range. The forecasts produced so far have been directed toward the Joint Long-Range Strategic Study (JLRSS), prepared by JCS/J-5. During the first phase of this effort, CACI developed a few very simple models to forecast key concepts (international conflict, international alignment, and domestic stability) for 20 Indian Ocean countries and demonstrated the potential utility of combining substantive expertise with quantitative methods. This combination was the basis for later efforts. As a result of this study, a second phase was planned and completed. A more complex model (12 interrelated equations rather than the 3 independent equations developed the previous year) was constructed for Europe to forecast five central environmental descriptors (international conflict, international alignment, international trade, internal instability, and national power base) over the long range.

The primary goal of the current project is to enhance long-range forecasting capability in the defense community by developing and introducing new methodologies that add a simulation capability. A second, but no less important, purpose is to provide the defense community with high quality forecasting models for the Middle East, Latin America, and Africa in support of the JLRSS. In this connection, JCS/J-5 has operational current models for the Middle East, Latin America, and Africa that can be

used to generate alternative futures and to manipulate policy-sensitive variables. Changes in these variables can be considered representative of policy shifts by the United States and the Soviet Union.

The current innovations are designed to handle the highly volatile situations found in the developing world and to produce usable forecasts on the basis of the imperfect data available for these regions. The models include stochastic (probabilistic) elements to project events like irregular governmental transfers (coups) which are probabilistic by nature. The most important new element in the regional models is the simulation capability which will permit hypothetical policy choices by the United States and the Soviet Union to be evaluated in an experimental setting by giving the analyst the capability to examine the impact of alternative U.S. and Soviet behavior toward the Third World regions. Hence, the project provides JCS/J-5 with a specific forecasting capability tailored to the development of long-range estimates of strategic plans and requirements.

This final report is presented in three volumes. Volume I, the Executive Summary, summarizes the work on all tasks in non-technical language. Volume II, Research Findings, describes the long-range forecasts and simulations and their implications for strategic policy and planning. Volume III, the Technical Appendix, describes in detail all phases of the study. These include the identification of key concepts and their operational referents, the specification of forecasting equations, and the construction of the three region-specific forecasting models.

Guidelines for generating forecasts and simulations are also presented in the Technical Appendix to enable Department of Defense personnel to become better acquainted with the approaches to generating meaningful, interesting, alternative futures for comparing the strategic implications of contrasting developments. Finally, the Appendix contains several annexes that identify the nations used in the study, the years and sources of all data, the model parameters, the computer forecasting program and data, the results of a standard forecast, and a simple simulation.

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The authors would like thank Dr. Janice Fain for her assistance in computer programming. The study team would also like to acknowledge the contributions and guidance of Dr. Robert A. Young of the Defense Advanced Research Projects Agency, and Dr. Richard Hayes and Dr. Warren R. Phillips of CACI. Finally, the authors would like to thank Colonel William McDowell, USA, and Major Michael Harley, USMC, for their valuable comments and assistance during the course of the project. We are also indebted to Ms. Carol Franco for editing these volumes and to Ms. Ann Yamat for typing them.

SCOPE OF THE REPORT

This effort represents something of a watershed in the development of long-range environmental forecasting capabilities for Department of Defense policy and planning. Two years of work preceded this project. The first demonstrated the usefulness of applying substantive area expertise and powerful quantitative tools to specific Department of Defense forecasting needs. The second advanced this combined methodology and demonstrated the utility of an integrated, multi-equation model for forecasting the European environment over the 5- to 20-year range. Europe was selected because of its substantial economic and political stability and abundant, high-quality data. The purpose of this year's work was to advance the methodologies already developed, particularly by tailoring them more specifically to JCS/J-5 planning needs, and to apply them to volatile, unstable, developing regions of the world.

A number of specific requirements were involved in successfully meeting these two purposes, including:

- Identifying key concepts for inclusion in the forecasting models that are functionally equivalent across regions and that can be used for comparing various world regions;
- Developing operational measures for those concepts that take into account the substantive peculiarities of each region and yet are comparable across regions;
- Identifying relationships among these operational measures that could be used to forecast the value of these measures for one or more regions;
- Identifying exogenous predictors of the operational measures of the key concepts that are useful in one or more of the regional models;
- Estimating the parameters for each regional model so as to represent realistically the similarities across

regions and the unique relationships among variables in each region that characterize one region from another; and

- Developing mechanisms for generating stochastic simulations of the regional forecasting models and for making the models sensitive to the inputs of user analysts.

Each of these six requirements has been fully met and most have been exceeded. Five key concepts -- national power base, international transactions, internal instability, international alignment, and international conflict -- were identified. These concepts are not only equivalent across the three regions examined in this effort -- the Middle East, Latin America, and Africa -- but are also equivalent to the five key concepts employed in the European forecasting model. Operational measures for these concepts were developed which are either identical to or conceptually equivalent across the three regions and identical or conceptually equivalent to those employed in the European study. At the same time, the operational measures capture the unique characteristics that differentiate the regions from one another.

The models developed in this effort combine the advantages of theoretically based, multi-region models with models that reflect the relationships among variables that are peculiar to a single region or two regions. This combination was accomplished by initially specifying the relationships among the operational measures of key concepts and between those measures and exogenous predictors on a generalized, multi-region basis. Then, empirical verification of the equations focused on each region specifically and, in some cases, on individual countries. The result was a set of forecasting equations that include different combinations of predictor variables and different parameter values for each region and/or country but identical or conceptually equivalent measures of the five key concepts.

In identifying exogenous predictors, capabilities have been included in the model for assessing the impact of American and Soviet behavior in the three regions and for simulating the effects of alternative U.S. and Soviet policies, a capability that far exceeds the contract statement of work. This capability was developed and included to meet JCS/J-5 planning requirements better by permitting analysts to examine the effectiveness of various strategies for reducing projected threats to U.S. interests.

Finally, a second form of simulation capability was included in the models to represent the political instability and tendency for policy fluctuation by the developing countries under study. One factor found to affect several aspects of nations' behavior is government type. Using a new coup propensity measure and government type transition matrices, capabilities were included in the models to simulate governmental changes stochastically that could be entered into the regional forecasts.

Thus, the models developed for the Middle East, Latin America, and Africa meet and/or exceed every requirement contained in the statement of work for Contract No. MDA903-75-C-0179. Moreover, the models have been installed and are fully operational on computers at the National Military Command System Support Center (NMCSSC).

IMPORTANT SUBSTANTIVE FINDINGS

In addition to enhancing long-range forecasting capabilities within the Department of Defense generally, and the JCS/J-5 in particular, this project has produced a number of substantive findings with important implications for U.S. defense planning. In this section, a few of the most significant of these findings are presented for each of the three regions for which models were developed -- the Middle East, Latin America, and Africa.

THE MIDDLE EAST

Four specific substantive findings concerning the Middle Eastern region are central to the forecasting model developed for those nations.

- On the basis of population and economic growth projections, Egypt is the only Israeli adversary that, on a sustained basis, has the capability to defeat Israel. Thus, it is particularly important to settle Egyptian-Israeli disputes to resolve the Middle Eastern conflict and insure the survival of Israel.
- The Israeli economy is likely to become and remain quite fragile during the next 20 years should the conflict between Israel and the Arab states remain unresolved. It is likely that the survival of the Israeli economy will require either a substantial dampening of that conflict, substantial levels of aid from the United States or other powers, or very large capital inflows.
- There seems to be a very great capacity for economic growth for Iran and Saudi Arabia. These countries are likely to become and remain the major regional economic and military powers during the next 20 years. Hence, much of the success of American diplomatic and military policy in the Middle East will depend on the support of these two countries.
- Experimental simulation shows that while military aid can exacerbate the escalatory potentials extant in the

Middle East, reductions in aid and/or arms sales alone bring about only limited reductions in Middle Eastern conflict. A more basic reduction of tensions and settlement of disputes are required for tensions and settlement of conflict potentials in the region. Moreover, substantial aid reductions without accompanying reductions in tensions are likely to depress the Israeli economy severely.

LATIN AMERICA

Although Latin America has traditionally been dominated by the United States and has not presented the kinds of widespread threats to world peace found today in the Middle East, a number of substantive findings result from this effort that bear upon U.S. policies and plans in the region.

- Cuba appears to be cross-pressured in its alignment posture. While Cuba is likely to remain closely tied to the Soviet Union in political and military arenas, it will require some rapprochement with the United States, at least enough to permit trade between the countries. Opening and strengthening economic links between Cuba and the United States, moreover, is likely to create dissonance in Cuban alignment behavior.
- Although recently regarded as "left-leaning" by a number of observers, Peru seems to be drifting more steadily toward the Soviet Union, possibly to counter-balance the overwhelming American influence in Latin America. It appears, in fact, that Peru will become more aligned, economically as well as politically and militarily, with the Soviet Union and less aligned with the United States.
- The Panamanian economy appears to be unable to sustain itself, much less expect substantial growth. Panama is likely to experience severe economic difficulties even if it obtains control of the Panama Canal. This finding, of course, does not mean that U.S. retention of the Canal control will assist the Panamanian economy.
- Arms competition in Latin America appears to exist independently of any real conflict. Nonetheless, arms

racess, even devoid of actual conflict, are a self-sustaining system in Latin America.

- There is a strong tendency for the Latin American nations to act more independently of the United States in formulating their foreign policy. While Peru is the extreme case, many other Latin American nations are likely to move away from American positions, though not necessarily toward the Soviets.
- Experimental simulation shows that, all things being equal, there is little potential for Soviet influence and penetration into Latin America, even with increases in Soviet military and developmental assistance. Thus the tendency for Latin American nations to act more independently of the United States in formulating foreign policy does not present the Soviets with much, if any, opportunity to penetrate the region.

AFRICA

Of the three regions examined in this effort, Africa is today the least important as far as American strategic interests are concerned. This situation may change drastically during the next 20 years, however, as African nations exploit strategic materials and become more involved in international political affairs. Thus, the following substantive findings regarding the African environment may become significant for U.S. defense policy planning.

- Military aid tends to supplant indigenous defense spending and thus release resources for development efforts. Over the short term, then, military aid may be a mechanism whereby major powers can genuinely assist in the development of the African region.
- Over the long term, however, the effects of military aid to African nations may be more malignant. Massive aid may create severe economic disequilibrium, strain, and thus internal instability in African countries. Substantial internal instability, in turn, could lead to alignment shifts among these nations. Finally, massive aid could break loose the resource constraints that presently dampen conflict propensities in the region and thus result in substantially higher conflict levels among the African countries.

- The alignment postures of the African nations are susceptible to influence by the superpowers, but only with the application of very extensive military and developmental aid. As noted above, however, massive aid levels can have a number of other, and perhaps undesirable, influences.
- Only with extremely effective planning can Nigeria depend on petroleum export revenues for consistent economic development. Present tendencies show Nigeria devoting resources to areas that do not promote development.
- Experimental simulation suggests that the Horn of Africa is particularly susceptible to increased conflict levels should superpower involvement in that area rise substantially. The Horn of Africa (Ethiopia and Somalia) has the potential to become a focal point in U.S.-Soviet rivalries.

PROGRAM ACCOMPLISHMENTS AND REMAINING NEEDS

This report has discussed the third project in a multi-year program to enhance forecasting capabilities within the Department of Defense in general, and for the JCS/J-5 in particular. A number of specific important technical accomplishments and significant defense-relevant substantive findings resulting from the work have been described. But the program as a whole has had impacts that extend beyond this specific project, impacts that have enhanced the state-of-the-art in forecasting within the Department. These accomplishments are briefly summarized as follows:

- The program has developed an interface between qualitative and quantitative techniques and the projects have produced some extremely interesting substantive results by employing very powerful analytic techniques.
- The program has revealed that region-specific, and sometimes country-specific, model parameters are required to capture the dynamics of rapidly changing regions.
- The program work has suggested that the components of the central environmental descriptors are different in various regions, but that conceptually equivalent measures of those descriptors can be developed and forecast for various regions using general comparative politics theories.
- In the course of work, the program has demonstrated an ability to integrate a number of traditional academic disciplines and focus them on a specific Department of Defense need.
- The projects have produced some of the largest and most complex economic, political, and military forecasting models in existence and have developed capabilities for defense planners to assess the impact of potential American policies on projected threats to U.S. interests.
- Finally, the projects have highlighted a number of potential long-term threats to U.S. interests in the various regions and, through the simulation capability, have examined the impact of selected U.S. responses to these threats.

These accomplishments more than met the original objectives established for the program: (1) to determine the utility of combining qualitative and quantitative methods for long-range environmental forecasting, (2) to determine how best to integrate these diverse technologies, and (3) to develop generalizable techniques for forecasting important economic, political, and military variables over the long-range. The program has also resulted in a forecasting capability for the Department of Defense, installed on DoD computers, that is relevant to Department of Defense planning requirements, timely, accurate, reliable, and capable of being updated, of evaluating alternative American policies, and of generating a range of multiple futures.

The accomplishments are about as far as we can go in developing strictly regional forecasts. Yet a number of unmet Department of Defense planning requirements remain. In many cases, the state-of-the-art in analysis is advancing to the point where substantially more can now or soon be done. For example,

- Forecasting still depends upon the past for the relationships used to depict the future environment. Some capacity to deal with watersheds and other discontinuous kinds of changes and relate them specifically to the linkages among important environmental variables is required. Simulation, first employed in this project, is a first cut at examining watersheds, but primarily focuses on the parameters of relationships and not on the structure of relationships themselves.
- While the inclusion of superpower influences is a substantial step forward, to date only the independent effects of the superpowers have been included in the models. What is required is an understanding of superpower interactions and how they can influence regional environments. For example, how the United States, the Soviet Union and the People's Republic of China react to one another's initiatives in Africa and how those interactions, themselves, affect the African environment is important if the Department of Defense is to understand how best to promote U.S. interests in that region.

- While separate regional models can be useful for projecting independent regional environments, a technology for linking regional models with different representations of central environmental descriptors is not yet available. Such a technology is required if the Department is to understand how a Middle Eastern conflict can affect U.S.-Organization of Arab Oil Producing Countries (OAPEC) relations and relations between the United States and other parties such as the European Economic Community and Japan.
- Additional modules should be developed for the existing regional models to focus on the availability of critical materials for Department of Defense projects. Contrasted with the existing analyses of critical materials, incorporation of this capability into the regional models will permit Department of Defense analysts to examine the impact of differing policies, regimes, and alignment configurations on critical resource availability. With this information, a more complete assessment can be made of the politico-military impacts of threatened production cutbacks, price manipulations, and other activities by current or planned raw materials cartels.
- Finally, a model has not yet been developed for Asia. Yet, with China growing in economic and military power and expanding its influence, particularly in Asia, it may be wise to develop some capability to understand alternative futures in that region. The experience gained in the three projects suggests that a model should be constructed specifically for Asia, and that an attempt to use another regional model in the Asian context cannot represent the dynamics of that region, particularly given the importance the People's Republic of China is likely to assume in the long-term future.

Thus, the program as a whole, and this project in particular, have gone a long way toward developing the kinds of projection capabilities needed within the Department of Defense. Several methodologies have been integrated in new ways and new methodologies have been developed and applied to forecasting needs in diverse world regions. Four regional forecasting models have been installed and made operational on the NMCSSC computer system and are being used in preparing the Joint Long-Range Strategic Study (JLRSS). Finally, a number of findings directly relevant to long-range U.S. defense planning have been uncovered in the course of the work. As noted, however, there are still a number of areas where basic research

and development on forecasting and planning technologies is likely to be of substantial value to the Defense Department, particularly in the effort to draw requirements implications from environmental projections. These include assessing the impact of watersheds or other discontinuous changes in the environments, assessing the interactive effects of superpower competition in regional environments, linking several regional models to capture inter-regional interactions, and providing theoretically based and comparable models for regions not yet investigated. Accomplishment of these objectives will round out what is already a substantial enhancement of the Department's long-range environmental forecasting capabilities and provide the kind of basis upon which to evaluate alternative defense plans and policies in the context of multiple world futures.

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