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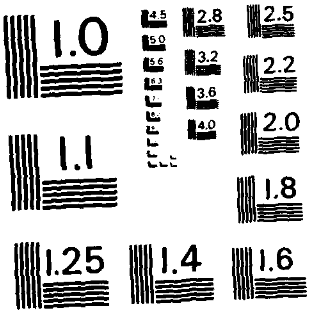

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The Rand Strategy Assessment Center

An Overview and Interim Conclusions about Utility and Development Options

Paul K. Davis, James A. Winnefeld

35th Year
Rand

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March 1983

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SANTA MONICA, CA. 90406

PREFACE

The Rand Strategy Assessment Center (RSAC) is an ambitious, multiyear research effort to improve methods of strategy analysis, using an approach based on automated war gaming and the multiscenario analysis it makes possible. The RSAC is supported by the Director of Net Assessment in the Office of the Secretary of Defense, and by the Defense Nuclear Agency, under Contract DNA001-80-C-0298. Work began in April 1980 and continued intensively through January 1981. A second phase of intensive research began late in 1981. This report provides an overview of the RSAC program at the end of the Phase Two work. Comments and inquiries are welcome and should be addressed to Dr. Paul K. Davis, Director of the Center.

SUMMARY

This report on the Rand Strategy Assessment Center (RSAC) is intended for diverse audiences. For those unfamiliar with the program, it provides an introduction to the RSAC's objectives, approach, and potential. In addition, for those following our work more closely, it provides a summary of recent conceptual and technical progress, our interim conclusions about the RSAC's utility, and a plan for future development with several options. Readers interested in more detail about RSAC operations should consult the Bibliography; nearly all of the RSAC documents referenced there will have been published by early 1983.

RSAC ORIGINS AND OBJECTIVES

The RSAC's origin stemmed from a conclusion by the Department of Defense that U.S. strategic-nuclear analysis has too often been shallow, in part because of the simplistic *methods* of analysis and related paradigms. In 1979, the DoD elicited ideas for a fundamentally new approach that led, ultimately, to the current RSAC program. Consistent with the original DoD request, our effort is an attempt to develop new methods for strategic analysis that *combine the best features of war gaming and analytic modeling*. War gaming, in the past accomplished with human teams, provides a rich context for analysis by imbedding events, such as a given strategic-nuclear exchange, in the framework of a larger war. War gaming also brings out clearly asymmetries between antagonists, the roles of nonsuperpowers, the shadow that nuclear forces cast over events below the nuclear threshold, and a wealth of phenomena and operational constraints often ignored by modelers. Such war games are also typically slow, narrow in scope (treating only one scenario), undisciplined, and unreproducible.

The RSAC seeks ways to make war gaming more efficent, rigorous, and analytical. Our approach involves the use of artificial intelligence techniques to produce computer models able to replace some or all of the human teams. This speeds game play, allows us to examine *many* scenarios, and—very importantly—imposes a rigorous discipline requiring statements of assumptions and rationale. It is still possible for human teams to play, all or part of the time, and at one or several positions, but the intention is to capture most of the human-expert contribution in background research reflected in the models.

The RSAC program has now completed a second phase corresponding to concept formulation and exploratory development. It has become apparent that the emerging methods are suitable not only for analyzing strategic and other nuclear forces (the project's principal focus) but also for addressing a broad range of national-level strategy issues. This result is an inevitable consequence of building the capability to work complex scenarios "from beginning to end," paying due account to the role of third countries and the full spectrum of military forces. At this point, then, we consider *RSAC objectives* to be quite general:

- To create an *integrating framework* for analyzing and discussing worldwide military strategy for conflicts up to and including general and prolonged war involving nuclear weapons.
- To create the capability for *multiscenario analysis* that would test sensitivities to key variables: Soviet and U.S. strategy and operational art; behavior patterns of the Soviet Union, United States, and relevant third countries; battle outcomes; and other factors.
- To increase *analysis realism* by treating many factors usually ignored: operational constraints; phenomena of war that are difficult or impossible to model quantitatively; asymmetries in U.S. and Soviet objectives, attitudes, and military styles; and the impact of third country decisions on military operations.
- To provide tools to improve our understanding of *strategic dynamics* involving decision points, interrelationships, and possible cascade effects.

THE RSAC'S TECHNICAL APPROACH

The new methodology we are developing should not really be characterized as "war gaming," although we expect to run war games for background research and to use the *structure* of war gaming (i.e., the concept of an adversary process in a complex setting) as an organizing principle. Our objectives are largely analytical and the nature of the work is quite different from war gaming activities conducted elsewhere because we have control over the variables rather than being subject to the vagaries and inconsistencies of human teams. In particular, we think in terms of *sets* of "exercises" or "experiments" in much the same way as a scientist organizes his experiments to permit systematic examination of several variables.

The approach has four major elements, all of which involve fundamental departures from traditional analysis. The first of these is the automated game-based simulations mentioned above. Using decision models in the form of computer automatons permits fast and reproducible results for a wide range of assumptions. That is, it permits *multiscenario analysis.* The other major elements are

- *Heuristic rule-based modeling*, which makes explicit in decision models the key assumptions on which outcomes depend.
- *Structured military campaign analysis*—the source of realistic military content, designed for the RSAC's automated system.
- *Interactive force-operations modeling*, which treats interrelationships among strategic and nonstrategic forces, cutting across boundaries of theaters, military Services, and types of warfare and reflects the effects of special phenomena usually ignored in models (e.g., unconventional warfare and failures of command and control).

The RSAC approach to automated war gaming has involved creation of a number of computer models, notably: Red Agent, Blue Agent, and Scenario Agent. These represent, respectively, the Soviet Union, United States, and nonsuperpowers. Two other models were also developed: Force Agent, which keeps track of forces worldwide and computes the results of combat and other operations, and Systems Monitor, which maintains game records and provides a variety of other service functions such as determining whose move it is and the amount of time since the last move.

Full development will require several more years of effort, but some of the basic ideas will remain constant. In particular, the RSAC system is focused on major confrontation or conflict between the United States and Soviet Union. Scenario Agent represents nonsuperpowers, but only enough to create a realistic context for the superpower conflict. For example, Scenario Agent determines whether third countries grant basing rights to superpowers, whether they ask for superpower assistance, and whether they commit forces to the conflict. The rules on which the decisions are made are relatively simple, although developing a rule set broad enough to cover many countries in a range of interesting situations is a difficult task. The Red and Blue Agents must have substantial capability. In particular, we require that they:

- Make basic decisions at the level of strategy and operational art—decisions that involve choosing among general war plans, allocating forces among theaters, deciding whether or not to employ high-risk high-payoff operations, etc.

- Base decisions not only on the current state of the world as they see it but also on projections or "look-aheads" using a game within a game to predict the political and military actions of the other superpower and the nonsuperpowers.
- Adjust the strategies and details of war plans as conflict continues and more information becomes available.
- Reflect in decisions not only such quantitative calculations as the projected rate of advance but also qualitative judgments about the opponent's will and intentions and about the cohesiveness of the opponent's alliance.

Technically, the Red and Blue Agents are essentially identical. They have drastically different behaviors, however, because of objective factors, differences in the strategies they have to choose from, and differences in the rules that establish their behavior patterns.

Although the decision models, or automatons, are sophisticated in some respects, they are by no means omniscient. Indeed, one of the most important features of the RSAC structure is that it allows the Red and Blue Agents to make realistic mistakes—mistakes based, for example, on Red making projections using an incorrect model of Blue. There are also provisions for Red and Blue to have different models for calculating combat outcomes, incomplete information about the state of the other side's forces, and delays in receiving intelligence information. Such mistakes and asymmetrics are crucial in understanding escalation.

Clearly, there are fundamental uncertainties about the likely behavior of the Soviet Union, nonsuperpowers, and even the United States. Thus, to conduct strategy analyses, we must work with *alternative behavior patterns*. We refer, then, to different models of the Soviet Union and the United States as Ivan 1, Ivan 2, . . . and Sam 1, Sam 2, ... Similarly, Scenario Agent distinguishes the behavior of "reliable and reluctant allies," etc. If an analyst is not satisfied with the behavior patterns he has available to work with, he can construct his own.

The Red and Blue Agents need a structure within which to work, since they cannot develop realistic military strategies from whole cloth. A unifying principle for RSAC work is the concept of "analytic war plans"—logic structures that attempt to describe with some rigor the many high-level decisions the United States and Soviet Union would need to make during conflict. The analytic war plans are abstract rule-based generalizations of decision-theory "trees." Because Red and Blue know each other's analytic war plans (but not each other's decisions), it is possible for them to "play chess." The analytic war plans (and more detailed descriptions of the campaigns corresponding to each war plan) are developed in campaign analysis by experts in military operations.

RECENT PROGRESS

Most of the RSAC's work in 1982 focused on ways to introduce military content (via the analytic war plans referred to above) and on conceptual design of the Red, Blue, and Scenario Agents. Lesser work has been devoted to Force Agent. The conceptual work dealt with advanced designs of a sort that will take some time to build. However, for a variety of reasons, including the need to have some concrete representations of our concepts and the desire to be able to work some strategy problems early rather than late in the development program, we constructed an interim system for automated war gaming that has incorporated some of the ideas intended for the advanced system. In addition to allowing us to test some of our concepts, the interim system permitted some *illustrative* experiments illuminating ways in which RSAC analysis could most readily be applied to important strategy problems. The experiments treated a U.S.-Soviet conflict beginning with Soviet invasion of Southwest Asia, escalating through war in Europe, and ending with intercontinental nuclear war. Most of the emphasis in 1982 was on the Southwest Asia portion of the conflict; we are now concentrating on the high end of the conflict, including prolonged nuclear war.

One of the major challenges of RSAC work will be to find ways to summarize the results of numerous exercises or experiments in a meaningful and digestible way. The report discusses some of our concepts for doing so—concepts that require new measures of effectiveness and sophisticated data retrieval systems. In RSAC work, the appropriate measures of effectiveness have much less to do with "beancounts" (i.e., static counts of remaining missiles and remaining divisions) than with war status as it might be viewed by a national- or theater-level military commander. The focus is on questions related to national objectives, such as who controls what, what military functions can still be performed, and what strategic options remain?

PLANS FOR THE FUTURE

From our recent conceptual efforts and illustrative experiments with the interim system, we conclude that it is now appropriate to begin the multiyear development anticipated in the original DoD problem statement. There is basis for confidence that the RSAC analytic methodology is both feasible and powerful. Although advanced development will involve state-of-the-art efforts in artificial intelligence and combat modeling, and a broad range of research in several disciplines, it now seems evident that progress can be *evolutionary* with even initial efforts proving valuable. This is an important conclusion because we were earlier concerned that success might be an all-or-nothing matter dependent on the success of largely abstract artificial intelligence techniques.

Success of the approach will require several years of development and extensive collaboration among military planners, Sovietologists, other regional experts, strategy analysts, and the computer scientists building the automated war gaming system. If DoD so chooses, the result can be an operational strategy assessment center (OPSAC) serving a variety of users within the offices of the Secretary of Defense and Joint Chiefs of Staff (and, through the Joint Chiefs, offices within the military Services and unified commands). We anticipate that RSAC techniques and models will also be adopted by some or all of the military Services and commands.

A final decision on an (OPSAC) could reasonably be made in about two years, after the RSAC completes a full-scale operational prototype system and applies it to some appropriate problems with participation of military officers and DoD civilians in a form of operational test and evaluation.

Assuming successful development of the techniques and an operational prototype, we conclude that the substantial and varied potential of the RSAC approach will allow:

- Testing strategies and war plans for nuclear and general-purpose forces under a wide range of assumptions.
- Testing the adequacy of programmed forces under a similar range of assumptions.
- Better assessing the circumstances under which new technologies would have a major effect on conflict.
- Examining the possible consequences of changes in doctrine.
- Complementing current command post exercises.
- Analyzing theories of escalation.

Finally, we foresee the RSAC's multiscenario approach as providing a new way to analyze and describe the intercontinental strategic, regional, and worldwide military balances. Such an approach would emphasize operational capabilities under a range of circumstances rather than weapon counts or likely outcomes in any one stylized scenario.

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The Rand Strategy Assessment Center (RSAC) is an ambitious multiyear effort to improve methods of strategy analysis by combining the best features of war gaming and analytic modeling. The approach is based on automated war gaming in which human teams are replaced by decision models (computer automatons) using heuristic behavior rules and by a force operations model treating: interrelationships among strategic and other forces, events in different theaters, and the operations of the several military services. The result is a capability for complex multiscenario analysis that has not previously existed. The power of the approach is due in large part to its emphasis on realism (relative to more standard approaches) and to the use of artificial-intelligence and force-modeling techniques that make behavior rules and other key assumptions both transparent and interactively variable. This report provides an introduction to RSAC work for those unfamiliar with it. It also provides, for those following the program more closely: a summary of recent conceptual and technical progress, interim conclusions about the utility of RSAC methodology, a plan for future development, and references to more detailed RSAC publications.

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ACKNOWLEDGMENTS

The Rand Strategy Assessment Center (RSAC) is a classic team effort that participants will probably look back upon with pleasure for years. Because so many people have contributed concepts, techniques, and effort, we hesitate to single out particular individuals. However, exceptions must be made for: Andrew Marshall and Fritz Ermarth, whose ideas played a large role in Rand's initial thinking about a center; Carl Builder, who structured and led the initial RSAC effort; and William Jones and James Gillogly, whose cross-discipline collaboration helped motivate the concepts of automated war gaming and a "Red Agent." To these, and to the members of the RSAC team listed below, we acknowledge our appreciation. In addition to the continuing support and guidance provided by Andrew Marshall, we wish to acknowledge the important contributions of Captain Charles Pease, USN, and the many members of the DoD working group. Finally, we appreciate review comments by Thomas Brown, John Clark, Peter deLeon, LTC Murphy Donovan, USAF, Michael Landi, Edward Scholz, and James Thomson.

In addition to those mentioned above, *major contributors to the RSAC program have been:* Roberta Allen, Bruce Bennett, Patricia Berger, Arthur Bullock, Theodore Connors, James Dewar, LTC Phillip Gardner, USAF, Charles Glaser, Rose Gottemoeller, Morlie Graubard, Robert Grotz, Herbert Hoover, Marcia Hunt, Lewis Jamison, LTC Donald Jensen, USAF, Jerry Koory, Jean LaCasse, Mark LaCasse, Ben Lambeth, Robert Levine, Mark Lorell, Christe McMenomy, Thomas McNaugher, Michael Mihalka, Larry Painter, Theodore Parker, Bruce Powers, William Schwabe, Norman Shapiro, Captain Sherry Sims, USAF, Peter Stan, Randall Steeb, David Stein, Mitchell Tuller, Bradford Veek, Sorrel Wildhorn, and Cindy Williams.

GLOSSARY OF RSAC TERMINOLOGY

Analytic War Plan (AWP): a decision network (in decision-tree or rule-based form) that represents an idealized start-to-finish strategic-level war plan with branches accounting for uncertainties in adversary behavior and other uncontrollables. Choosing strategy options is equivalent to choosing analytic war plans, and since strategy-level decisions must be made throughout the war game, the effect is that AWPs are imbedded within AWPs.

Branched Script: a higher-resolution view of a particular analytic war plan. Branched scripts specify alternative military and political actions at the strategic and operational levels over a period of time (e.g., timelines for mobilization, deployment, and employment). The actions to be taken are typically conditional, with final choices to be made or details to be adjusted according to circumstances.[1]

Campaign Analysis: the structured examination of possible military campaigns producing: (a) analytic war plans; (b) branched scripts; (c) decision criteria; (d) data bases; and (e) guidance to modelers.

Heuristic Rules: problem-solving rules that are good enough most of the time but may not always work and usually do not optimize (e.g., rules of thumb).

Operational Art: the art and science of force employment at the operational level.[2]

Operational Level (also, **Operational-Art Level**): intermediate between the strategic and tactical levels, the operational level attempts to achieve strategy-level objectives in a given theater or in intercontinental strategic-nuclear warfare. It is concerned, for example, with gaining advantage over the enemy through: large-scale maneuver, bold execution, and rapid exploitation of vulnerabilities. Examples might include corp-level maneuver; early seizure of ports

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[1]It is a matter of taste and context whether a particular decision is characterized as "strategic" and highlighted in simplified representations of analytic war plans, or characterized as "operational" and treated only at the branched-script level of resolution.

[2]See Scott and Scott (1982) for a summary of Soviet definitions. Until recently, the term operational art was not used by the U.S. military.

with high-risk deep insertion of airborne forces; and early attacks on strategic-nuclear command and control nodes.

Operations Plan (also, **Op Plan** or **Plan**): in RSAC usage, the path through a branched script on which actual planning is focused. The operations plan makes numerous assumptions about adversary actions, the results of individual operations, etc. It typically retains few decision nodes and branches, and deals largely with near-term operations.

Scenario Space: the union of all analytic war plans; also, the network defining the set of all scenarios permitted in the game.

Scripts: building block segments of branched scripts. Primary scripts set the basic war objectives with priorities among theaters and functions. They also describe the goals, objectives, general plan of action, and constraints for the highest-priority effort. Ancillary scripts chosen to support the primary script then describe appropriately constrained plans for the "other" efforts. Both primary and ancillary scripts have subordinate scripts (coded as subroutines) describing specific action packages (e.g., those for executing a particular type of attack or for accomplishing strategic airlift to some region).

Scripted Models: simple models prescribing events on the basis of history, expert judgment, or war gaming with human teams. Scripted models do not attempt to show cause-effect *mechanisms*.

Simulation Models: models incorporating to a significant degree the underlying *mechanisms* of cause and effect. Simulation models may be highly detailed (treating, for example, individual aircraft or ground units) or may be quite aggregated.

Strategic: of or pertaining to strategy (i.e., in this report, "strategic" does not necessarily mean "strategic nuclear"; nor does it necessarily connote a focus on the homeland's capacity for supporting war).

Strategic Level: usually associated with the national command authority, the strategic level sets goals, objectives, constraints, and the overall approach to war. Its perspective is global and long range, with a focus on establishing plans to "win." It is concerned with such high-level issues as the decision to establish tripwires or go to war, mobilization, escalation, nuclear employment, and the relative priorities of different theaters.

(Military) Strategy: the art and science of employing the armed forces of a nation to secure the objectives of national policy by the application of force or the threat thereof; e.g., the *large-scale* planning and directing of operations consistent with the combat area, possible enemy actions, political alignments, etc.

Tactical Level: the tactical level is concerned with the detailed execution of plans by specific actions (e.g., clearing an area, protecting a flank, assaulting a hill, destroying the adversary's ICBMs).

CONTENTS

FIGURES

TABLES

I. INTRODUCTION

OBJECTIVES

The purposes of this report on the Rand Strategy Assessment Center (RSAC) are (1) to review RSAC objectives, (2) to provide a technical overview of our approach, (3) to discuss the RSAC's potential utility in a range of applications, and (4) to suggest development options. We intend the report to be a useful introduction to RSAC work for those newly interested and a progress report for those who have been following it more closely. We do not provide many details on RSAC operation here, but have included extensive references to specialized RSAC documents.

The RSAC's charter is to develop methods for improving the quality of U.S. strategy analysis—methods that may lead to creation of a national operational strategy assessment center (an OPSAC).[1]

A mature center should be government controlled and comprehensive, examining the full range of factors affecting both peacetime and wartime strategy—not only at a given time in history but over a period of many years. In addition to studying military factors, the center would, for example, examine the economic and political aspects of long-range planning for superpower competition. Contributors might be drawn from a broad spectrum, ranging from academic consultants, to military officers on assignment to the center, to full-time system analysts.

The vision of a comprehensive and mature OPSAC will probably not be realized for several years, but as a critical first step the RSAC is developing new conceptual approaches to strategy analysis and new analytic tools focusing largely on military issues. The RSAC's original tasking was strongly oriented toward assessment of strategic-nuclear forces. However, emphasis was on the importance of examining those forces in a larger and richer context that would treat scenarios "from beginning to end" and would consider the roles of third (nonsuperpower) countries and forces of all types (Appendix A). As an inevitable consequence of building the capability to perform such analysis, we now have an approach suitable not only for strategic-nuclear prob-

[1]Appendix A, drawn from the government's original statement of objectives, explains the concerns leading to the program. For a discussion of those concerns and the notion that war gaming might contribute to improved analysis, see Marshall (1982).

lems but for the full range of issues involving national military strategy.[2] Thus, we consider our *general objectives* to be quite broad:

- To create an *integrating framework* for analyzing and discussing worldwide military strategy for conflicts up to and including general and prolonged war with nuclear weapons.
- To create the capability for *multiscenario analysis* that would test the sensitivities of outcomes to Soviet and U.S. strategies; Soviet, U.S., and third country behavior patterns; battle outcomes; and other factors.
- To increase *analysis realism* by treating explicitly many operational constraints; many phenomena of war that are difficult or impossible to model quantitatively; asymmetries in U.S. and Soviet objectives, attitudes, and military styles; and the impact of third country decisions on actual military operations.
- To provide tools to improve our understanding of *strategic dynamics* involving decision points, interrelationships, and possible cascade effects; and, thereby, to permit decisionmakers to anticipate and accommodate to events in crisis and conflict.

PRINCIPAL FEATURES OF THE RSAC APPROACH

As discussed in the Department of Defense's original statement of objectives in 1979, the basic idea has been to combine the best features of two very different assessment methods: political-military war gaming and analytic modeling. The Rand approach to this challenge is built around four activities:[3] automated war gaming; rule-based modeling; structured military campaign analysis; and interactive force-operations modeling. We discuss these separately in the following paragraphs.

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[2]We have changed the center's name to use the word "strategy" rather than "strategic" assessment center to emphasize that, while our highest priority efforts involve strategic-nuclear forces, we attempt to avoid compartmentalizing the phases of war and our scope is restricted neither to strategic-nuclear issues nor to warfare involving the homelands. With this caveat, we use the adjectives "strategic" and "strategy" interchangeably in the text.

[3]The first two were major elements of Rand's original proposal and Phase One effort (Graubard and Builder, 1980). The concepts for inserting military content with structured campaign analysis are new (Davis and Williams, 1982; and Davis, 1982b).

Automated War Gaming

Automated war gaming is an analytic approach with the same structure as classic political-military war games but with human players complemented by or largely replaced by computer models acting as automatons or "agents."[4] Thus, we refer to the Red, Blue, and Scenario Agents—the automatons representing the Soviet Union, United States, and other countries, respectively. RSAC exercises[5] employ human technicians and analysts who can intervene at any move in the game to correct glitches, overrule automatons, or provide unmodeled information. Usually, however, not much intervention is necessary; instead, the analysts explore issues by rerunning a game with different inputs. The result is a new scenario with new outcomes. By contrast with traditional analyses, *the scenario is an output rather than an input in RSAC war games:* analysts must confront explicitly the assumptions necessary to generate scenarios of interest prepared elsewhere (e.g., the Defense Guidance Scenarios used for programming and operational planning). For this reason, the RSAC system has sometimes been referred to as an "assumptions trap" (Graubard and Builder, 1980; Builder, 1982).

Rule-Based Models

The Rand approach to automated war games emphasizes heuristic rule-based modeling techniques developed in recent years by the artificial intelligence community.[6] In this approach, the rules governing national behaviors are the model's explicit variables. The rules reflect expert judgment; where experts disagree we carry along alternative rule *sets*—referring, for example, to the different rule sets for the Soviet and U.S. automatons as representing different "Ivans" and "Sams."

Campaign Analysis

The third element of the Rand approach is structured military campaign analysis designed to support automated war gaming. This en-

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[4]See Jones, LaCasse, and LaCasse (forthcoming), and Winnefeld (1982), for a description of the RSAC's interim version of automated war games.

[5]We use the term "exercise" in preference to "war game" when possible, to emphasize that RSAC activities are quite different from traditional war games.

[6]For examples of this approach, see Steeb and Gillogly (forthcoming); Schwabe and Jamison (1982); and Dewar, Schwabe, and McNaugher (1982). For a survey of artificial intelligence techniques, see Barr and Feigenbaum (1981).

tails experts gathering to consider, with the use of maps, terrain boards, order of battle data, intelligence assessments, and computer-assisted war games with human teams, the alternative paths that conflict might take in a given generally defined campaign (e.g., a Soviet invasion of the Persian Gulf region, a Soviet invasion of Western Europe, or a North Korean invasion of the South).[7]

Traditional campaign analysis has usually focused on "best estimate" enemy strategies and perhaps one or two excursions with alternative strategies. In the RSAC, the objective is to identify as many alternative campaign paths, decision points, and options as possible, and to identify criteria on which decisions would probably be based. Obviously, we need to "game out" such matters from both the U.S. and Soviet points of view. The products of such campaign analysis will be useful in themselves as well as being essential inputs to militarily substantive automated war games.

Interactive Force Operations Modeling

The RSAC's Force Agent is an omnibus model that keeps track of military forces worldwide and predicts the results of force operations as needed. Because of the complexity of a war game, Force Agent must deal with many force types and situations. Moreover, because of the RSAC's strategy-level orientation and emphasis on transparency, the on-line models used during exercises must be highly aggregated and able to use variables with which strategy-level analysts or other users would be comfortable. To assure realism, it is then necessary to relate the parameters of the on-line models to results from other work—work that may involve, at Rand or elsewhere, detailed simulation models, war games with human teams, historical research, or interviewing of experts. In some cases, no detailed simulation models exist—either because they have not been developed or because the phenomena of concern cannot easily be modeled (e.g. unconventional-warfare tactics or unanticipated attack mechanisms against command and control systems). In such cases, we attempt to reflect the *consequences* of the special phenomena with "scripted models"—models that claim no basis in microscopic analysis but that make the war game more realistic than if no model at all were used.[8] More generally, we attempt to avoid the frequent tendency to rely upon complex models even when they are known to give incorrect, and even

[7]See Davis and Williams (1982), Davis (1982b), and especially Levine and Winnefeld (forthcoming).

[8]See Davis (1982b) and Davis and Williams (1982).

silly, results. Instead, we attempt to prescribe (using scripted models) results thought to be more realistic. Our on-line models are interactive so that users can readily change the key parameters.

RESPONSE TO SKEPTICISM

Obviously the automatons (and the RSAC analyses) can be no better than the programmed rules. Skepticism is warranted for this new technique, which is interesting and complex but ultimately dependent on many assumptions ranging from national behaviors to military strategies and tactics. Indeed, many analysts will question the very desirability of the war gaming format—after all, good analysis often consists of reducing problems to bare essentials rather than considering the myriad of complications and interrelationships that always exist if one looks for them. The skeptic may also question whether the results of multiscenario analysis can be digested and used in the real world, especially given the usual preference of decisionmakers for simple explanations and options.

This report cannot resolve all of these concerns (which the authors share) and we do not claim that RSAC analysis will be an analytic panacea or useful on all problems. However, our experience to date is encouraging. On the one hand, we are convinced that *there is, in a sense, no choice*: There is simply no way to conceive, implement, and maintain sound national strategies without confronting—and explaining to a broad audience—the complications that the war games illuminate. Moreover, we are now persuaded that multiscenario analysis can be important and digestible (making that happen will be a major challenge in our 1983 work). Finally, we have confirmed our earlier suspicion that the discipline of preparing for automated war game experiments has a salutary effect on the structure and depth of our thinking. The concept of automated war games, coupled with structured campaign analyses to make them substantive, is an organizing principle with broad implications.

REPORT OUTLINE

The remainder of this report is organized as follows: Sec. II provides background and rationale for the RSAC approach. Section III gives a technical overview of the RSAC automated system and the activities necessary to support it. Section IV discusses possible applications of the RSAC approach, pointing out its strengths and weaknesses, noting ways it should and should not be used, and suggesting an approach to applications emphasizing the concept of structured "experiments." Finally, Sec. V presents a development plan and some options for a future operational center.

II. BACKGROUND

ORIGINS OF THE RSAC: STRATEGIC PROBLEMS

The RSAC's origin was widespread discontent among strategic-nuclear analysts concerning the inadequacies of U.S. work in their domain. This discontent broadened and intensified in the mid-to-late 1970s as the considerable asymmetries between Soviet and American strategic thinking became apparent, and as the military balance shifted substantially to the detriment of the United States. Out of this grew a more general recognition that U.S. (and Western) strategic thinking since World War II has often been shallow, myopic, and poorly suited to deterring the Soviets, who have very different concepts, objectives, doctrine, and capabilities. As demonstrated in Appendix B, the evolution in DoD thinking transcended politics.

It may be useful to summarize a few of the problems that so troubled analysts. Quoting from Ermarth (1978), an article based on work at Rand:[1]

> The essence of U.S. "doctrine" is to deter central nuclear war at relatively low levels of arms effort ("arms race stability") and strategic anxiety ("crisis stability") through the credible threat of catastrophic damage to the enemy should deterrence fail. . . .

By contrast:

> Soviet strategic doctrine stipulates that Soviet strategic forces and plans should strive in all available ways to enhance the prospect that the Soviet Union could survive as a nation and, in some politically and militarily meaningful way, defeat the main enemy should deterrence fail. . . .

With reference to the relationship among types of forces:

> The Soviets, on the other hand, appear to take a more comprehensive view of strategy and the strategic balance. Both in peacetime political competition and in the ultimate test of a central conflict, they tend to see all force elements as contributing to a unified strategic purpose, national survival and the elimination or containment of enemies on their periphery. The U.S.S.R. tends to see intercontinen-

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[1]Ermarth and others discussed these problems at a 1978 meeting of the Defense Science Board (DSB) at Woods Hole. The DSB later recommended a research program to develop new analytic methods. Andrew Marshall took the lead and a request for proposals was issued in 1979 (see Appendix A and Marshall, 1982).

> tal forces, and strategic forces more generally, as a means to help it win an all-out conflict in its most crucial theater, Europe. Both institutionally and operationally, Soviet intercontinental strike forces are an outgrowth and extension of forces initially developed to cover peripheral targets. Land combat forces, including conventional forces, are carefully trained and equipped to fight in nuclear conditions.
>
> Whatever the consequence of a central U.S.-Soviet nuclear conflict for their respective homelands, it could well have the effect of eliminating U.S. power and influence on the Eurasian landmass for a long time. If, by virtue of its active and passive damage-limitation measures, the Soviet Union suffered measurably less damage than did the United States, and it managed to intimidate China or destroy Chinese military power, the resultant domination of Eurasia could *represent a crucial element of "strategic victory" in* Soviet eyes. In any case, regional conflict outcomes seem not to lose their significance in Soviet strategy once strategic nuclear conflict begins.

Ermarth was by no means arguing that the Soviets would take nuclear war lightly, or fail to foresee its consequences—a destruction that would be appalling under the best of circumstances. He did, however, argue in the article that Soviet views about deterrence, escalation, war objectives should deterrence fail, and preparations for that war are fundamentally different from our own. This should be of considerable concern, since it is Soviet attitudes, not our own, that will determine the success of our deterrence.[2] In this connection, he deplored the current forms of U.S. strategic-nuclear analysis that emphasize stereotyped missile duels and the like. Not only are they dubious on their face, but "the Soviets do not appear to do their balance measuring in this manner." To the contrary:

> It appears that Soviet planners and force balance assessors are much more sensitive than we are to the subtleties and uncertainties—what we sometimes call "scenario dependencies"—of strategic conflict seen from a very operational perspective. The timing and scale of attack initiation, tactical deception and surprise, uncertainties about weapons effects, the actual character of operational plans and targeting, timely adjustment of plans to new information, and, most important, the continued viability of command and control—these factors appear to loom large in Soviet calculations of conflict outcomes.

This view of U.S. and Soviet strategy asymmetries could be summarized as follows: The United States thinks and analyzes in terms of a (single) crushing response, whereas the Soviets think and analyze in terms of the classic dynamics of war fighting—even in a nuclear era that guarantees high casualties.

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[2]*This seemingly obvious point was notably absent in* U.S. *official thinking until* rather recently (see then-Secretary Rumsfeld's 1976 comments in Appendix B).

Ermarth was concerned primarily about strategic-nuclear forces, as were the government sponsors who initiated the RSAC project. However, we can readily extend the list of concerns to include more general issues of military strategy. The same Western paradigm that has emphasized mutual assured destruction and stereotyped missile duels has also tended to emphasize what many observers have regarded as a static approach to conventional defense of Europe—an approach based largely on deterring the Soviets by promising them the potential of high attrition and of escalation to nuclear weapons. Indeed, until this year, it could be claimed that the United States (and NATO) did not even have a counterpart *concept* to what the Soviets refer to as operational art—the realm intermediate between strategy and tactics where maneuver, counteroffensives, "daring thrusts," and other actions highly characteristic of imaginative warfare reside. That claim was surely exaggerated (U.S. general officers may have been surprised to read that they were perceived not to be interested in maneuver), but it is nonetheless striking that no such level was separately identified in the U.S./NATO military lexicon.[3]

In a similar vein, U.S. studies of regional military balances have generally had the same flaws as those of strategic-nuclear issues: excessive emphasis on static weapons counts (beancounts) and division counts and on quasi-dynamic calculations ignoring some of the most important features of war. A particularly serious problem continues to be a focus on one or a very few planning scenarios, with minimal attention paid to capabilities required for other situations.

The implication of this is that *we have requirements for more complex analyses* that should

- Assess the performance of our forces and strategies should deterrence fail.
- Include the Soviet view.
- Consider the perceptions and roles of third countries.
- Treat all types of forces worldwide in one structure and reflect such operationally critical issues as command and control, intelligence, strategic mobility, and logistics more generally.

In addition, it is eminently clear from study of Soviet materials (and from the premise that we should assess our capabilities for the case in which deterrence fails) that *our analysis should emphasize*:

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[3]See Scott and Scott (1982), who summarize the Soviet concept and make the claim noted. In fact, the U.S. Army has recently begun to emphasize more strongly the operational level of conflict and has reflected that emphasis in the new version of their manual FM 100-5.

- Capabilities as a function of time.
- Capabilities in many different scenarios.
- The role of uncertainty in, for example, weapon capabilities, battle outcomes, adversary behavior, and acts of God.

Such requirements have not played a prominent role in U.S. or Western analysis in the postwar era. Although cause and effect are unclear, it is not surprising, then, that we find ourselves with a range of strategic problems, a sampling of which might include:

- Strategic-nuclear forces with minimal *operational* capability for other-than-spasm conflict (e.g., inadequate command, control, and communications; and targeting plans excessively concentrated on a single massive retaliation to a surprise Soviet first strike).
- The near-total absence of civil defenses.
- A worldwide lack of military leverage over the Soviets—a consequence of our manifest inability to respond to Soviet aggression in one region with *offensive* military actions elsewhere.
- The absence of forward-deployed land and air forces in the Persian Gulf region and currently inadequate capabilities for rapid deployment.[4]
- A military strategy in Europe that hinges on effective initial conventional defense (difficult to achieve in the past), on a short conflict, or on the increasingly less credible nuclear umbrella tied to Western concepts of nuclear deterrence.

Reasonable men can differ on how they view the seriousness of these problems and on how the United States and its allies should deal with them. Although at present we lack the analytic tools to investigate such matters in any depth, there seems to be a competition between comparably shallow debating arguments, pointing out again the need for new analytic tools. It is unclear in this case whether paradigms determine analysis methods or vice versa, but it *is* clear that we are limited by our methodology (see also Appendix A).

POTENTIAL SIGNIFICANCE OF A STRATEGY ASSESSMENT CENTER

The reader may have noted that the preceding list of problems did not go unnoticed all these many years; he may also have doubted that

[4]See Davis (1982a) for a discussion of how this problem arose and of programs under way to remedy it.

understanding them better by virtue of having a strategy assessment center would have made much difference. Indeed, there have been many efforts to solve most of them. For example, twenty years ago the Kennedy administration supported civil defense (briefly), a stronger conventional capability in Europe, and the capability to deploy contingency forces quickly. As discussed in Appendix B, there has been a slow and steady trend for about a decade in DoD thinking about requirements for nuclear deterrence, a trend that increasingly recognizes the importance of enduring capability. The success of the initiatives, both conventional and nuclear, has hardly been spectacular.

With some trepidation, we would argue that the approach under development in the RSAC *could* make a difference on such issues *in the long run*, especially if it were used in an OPSAC and became the standard by which analysis was conducted. We base this view on the observation that it is not enough that experts recognize and understand a problem. The United States is a pluralistic society in which every major national initiative is debated and passed upon by a variety of groups in the executive and legislative branches. In many cases, the debates lack quality because current analytic approaches lend themselves well to shallow debate and because each participant sees only a part of the whole. The result of this and other factors (such as the rapid turnover of our policymakers and the mobility of our analytic community) has been a painful and dangerous lack of continuity in U.S. strategy as it is practiced.[5] For example, new administrations on entering office have often reversed or slowed strategy initiatives, and then come to positions similar to those of their predecessors—but only after years of delay. One function of an OPSAC could be to provide an efficient and credible mechanism for passing strategic principles and realities from one administration to the next *and*, simultaneously, offering the new administration a mechanism to test proposed changes in strategy. In some respects, *this capability for credible and understandable integration may prove as important as the analysis itself*, especially for setting the structure of discussion.

Another OPSAC function would be to set a standard for analysis that would come to affect the thinking (i.e., paradigms) of the larger community concerned with strategy and defense issues (i.e., members of Congress and the academic community). To those who doubt the practicality or utility of such an ambitious vision, we can only point out that the alternative is to continue as we have or to develop an elite of strategists who talk only to themselves.

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[5]See Davis (1982b) and Wohlstetter (1980) for a related discussion of inconsistency and its effect on U.S. capabilities for non-NATO contingencies.

COMBINING WAR GAMING AND ANALYTIC MODELING: THE GRAND SYNTHESIS

It is against this backdrop of problems that the DoD set requirements for a new approach to strategic analysis. An essential part of any such capability will be its analytic framework: It is not enough to discuss strategic concepts in competing essays—it must be possible to analyze them with some rigor and realism. The RSAC's analytic approach is described in what follows. For reasons that will be discussed below, it seemed natural for the DoD to seek a synthesis of the techniques of war gaming and analytic modeling. For less obvious reasons, Rand concluded that it was possible and feasible to accomplish this with *automated* war gaming.

Why War Gaming?

The basic quarrel with current strategic analysis is that it is simplistic. By contrast, the classical political-military war game provides the very complexity and touches of reality so sorely missing in that analysis. In particular, *war games provide a framework* with

- Contextual richness.
- Interaction of political and military factors.
- Operational constraints.
- Asymmetries in national styles.
- Asymmetries in perceptions and objectives.
- Relatively realistic descriptions of military campaigns.
- Action and reaction among the nations involved in conflict.

Such war games played little role in U.S. analysis over the last decade. This is perhaps understandable since, given the emphasis on mutual assured destruction—and its more sophisticated descendent assured retaliation[6]—it was possible to do strategic analysis with simpler constructs such as missile duels and so-called assured destruction calculations. Moreover, as Rowen and Wohlstetter (1977) pointed out, that general climate for thinking about nuclear issues also had a damping effect on military thinking generally. Indeed, *the more general problem is that the study of war has been widely neglected in the United States.*

As recognized in the last few years, even our senior military officers have had much less education in the classical concepts of strategy and

[6]Assured retaliation includes massive attacks on military targets such as ports, airbases, command and control centers, and silos. Pure mutual assured destruction targeting is a strawman that has not existed for many years if at all.

tactics, or even in military history, than their Soviet counterparts.[7] In addition to being a consequence of the Western concept of deterrence, this is also part of a more general cultural tendency to assume that we will use our American ingenuity and initiative to cope with exigencies as they arise. Although development of war plans consumes thousands of man-hours, the prevailing view seems to be that these plans will become irrelevant as soon as the real war starts. However valid such views may be in a narrow sense, they discourage preparations and training for other than a few set-piece scenarios. They also discourage thinking through for multiple steps into the future the implications of initial actions. Our best general officers have an intuition for the chess-playing aspect of war, but what is sorely needed is to have the officer corps train at it systematically.

Given recent recognition of these problems, war gaming is being reinstituted throughout the U.S. military, with the strong leadership of the current and previous Chairman of the Joint Chiefs among others. It is worthwhile describing such games briefly, since their format is important to RSAC work.

Nature of Traditional War Games.[8] Procedurally, a typical political-military war game includes a Red Team, a Blue Team, and a Control Team. The Red and Blue Teams represent the Soviet Union and United States (or, sometimes, the Warsaw Pact and NATO). The Control Team represents other countries and provides information to Red and Blue about the state of the world, describes the results of battle, imposes constraints designed to account for the role of luck, weather, and happenstance, and rules on the validity of operations attempted by the Red and Blue Teams. The Control Team also perturbs standard operations, for example, by decreeing that at some point in the game Blue loses an important satellite, early-warning aircraft, or aircraft carrier.

The teams usually take their responsibilities seriously, with Red "thinking Red" and Blue "thinking Blue." The Control Team may perturb the situation to force the competing teams to confront new but realistic complications. The method is a good device for teaching officers to cope with both the surprise as well as the complications of war. It is also an excellent device for suggesting the operational consequences of the asymmetries alluded to above. This is important not only at the strategic level where one side's objectives are seldom merely the opposite of the other's, but also at the operational and

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[7]Recognition of these problems has led recently to greatly expanded war gaming activities at all of the Service war colleges. There is also revived interest in strategy.

[8]See Brewer and Shubik (1979) for a review of U.S. experience with political-military games. The most notable continuing games have been those of the Naval War College and the Studies, Analysis, and Gaming (SAGA) organization within the OJCS.

tactical levels[9] where each nation's military forces have their own styles and the side that understands the other's style best may exploit it to its advantage. Examples here are legion, ranging from the unwillingness of certain countries to fight at night to the use of particular aerial maneuvers in dogfights. Although it is more dangerous to speculate about style at the strategic level, it is nonetheless evident that national doctrines are different there also.[10]

The reason such gaming is important to strategy analysis is that the United States must deter the Soviet Union on its terms not ours, and this requires understanding how the Soviets think, what they wish to achieve, and what they fear. Moreover, should the United States and the Soviet Union again find themselves in crisis or conflict, U.S. decisionmakers will need to understand as much as possible about the Soviets if they are to obtain the best feasible outcomes while avoiding the escalation to a general nuclear war that everyone fears. It is probable that general nuclear war, if it should ever occur, will be due more to misunderstandings or miscalculations at lower levels of conflict than to one side's being sanguine about its ability to "win" the war.

War games also illuminate the many variables controlling deployment and employment of military forces. They bring out operational constraints stemming from such matters as the need for allied cooperation and the limitations of weapons and men in sustained combat. War games frequently can demonstrate dramatically to high-level officers and officials the existence of serious "horseshoe-nail" problems that must be solved before the potential of the overall force can be approached. One reason they can do so is that in war games it is not necessary to focus on standard scenarios or to work consistently at the same aggregated levels of description. For example, it is possible in a given war game (or RSAC exercise) to reflect specific known airlift logistics problems (e.g., shortages of a specific spare part limiting "outsize" airlift productivity) without necessarily reflecting other logistics problems in similar depth. Purists might argue that such inconsistency is objectionable, but others would claim that we must solve problems as we find them. There will never be a comprehensive and balanced view.

Useful as the war games have been over the years, they have had distinct limitations. The traditional war game has been an experiential opportunity rather than one for systematic analysis. Participants

[9]See the Glossary for definitions.

[10]See, for example, Ermarth (1978), Lambeth (1980), and Lambeth (forthcoming). Considerable related work is ongoing at Science Applications, Inc., by John Battilega and Associates.

are sensitized to the complexity of real war and learn particular lessons, but they can seldom emerge from the game with a new intellectual structure or a set of new principles. The problem, of course, is that a particular war game is cursed by the very details that make it interesting: The details make the particular war game unique but leave the participant unclear about what would happen under other circumstances.[11] Because the war games have been slow, repetitions to examine other circumstances have not been generally practical.

We do not intend to overstate the indictment here. Clearly, some war games have been more structured than others and very instructive. Admiral Chester Nimitz once said that none of the major events in the Pacific campaign of World War II was surprising to him because they had all been played out in a *series* of war games at Newport before the war.[12] He did not mean, of course, that the games foretold the future—some games were close to the mark and others were not—but rather that his considerable game experience acquainted him with the problems and strategic principles that dictated the Pacific campaign—principles based on geography and the objectives of the two sides, as well as the inherent limitations of particular forces.

More typically, war games do not have the systematic impact remarked upon by Nimitz. Because the games require so much time and so many people, and because they are training oriented, they are not used as systematic analysts might like. Instead, as noted above, they serve more to sensitize and train officers to cope with tactical complexity. They do not often serve the purposes of strategy analysis. Furthermore, it has been extremely unusual for war games to be adequately documented. As a result, they have not been reproducible, transparent, or rigorous. RSAC exercises are intended to remedy this. Although the RSAC's emphasis is on automated war gaming for analysis, it is also possible to use some human teams and computer-generated records.

Why Analytic Modeling?

Analytic modeling's forte is precisely what traditional war games have not been able to offer—a combination of (1) transparency (i.e., clarity of assumptions and causality), (2) reproducibility, (3) rigor, (4) efficiency (especially through use of computer models), and (5) a struc-

[11]See Brewer and Shubik (1979) for critiques of war gaming. See Brown (1982) and Martin (1982) for ways to improve manual gaming and computer-assisted war gaming.
[12]He acknowledged an exception in the Japanese employment of kamikazes.

ture that depersonalizes issues by laying them out on paper logically. Because of the structure and efficiency of good analytic models, sensitivity analysis is straightforward—indeed, the sensitivity analysis is often more important and more credible than the baseline calculations.

Unfortunately, traditional analytic models of warfare have been extremely simple by comparison with what would be necessary to model real war. There has been a natural tendency for modelers to focus on what they could measure or calculate, sweeping under the computational rug those variables that were inconvenient or impossible to model (e.g., the effects of leadership, morale, and tactical surprise). Although modelers have been willing to treat particular uncertainties that are mathematically tractable (e.g., the likelihood that a single SS-19 RV will destroy a Minuteman silo given uncertainties about Soviet accuracy and reliability), they seldom have tried to deal effectively with "the fog of war," except to the extent that such matters are reflected in such aggregated descriptions as the average rate of advance of large land armies in World War II, the Middle Eastern wars, etc.

Another feature of analytic modeling has been emphasis on one or a few scenarios that are relatively sterile with respect to operational art or strategy. The scenarios are typically highly stereotyped and suppress speculation about the effects of generalship, deception, etc. In rare instances when analyses claim to treat a large number of scenarios, they usually do so only within an artificially constructed set of boundaries. For example, even the most sophisticated of strategic-nuclear analyses treat their problem as separable from that of the theater war in Europe and elsewhere.

In summary, then, analytic modeling has a great deal to offer, but it has traditionally suppressed many aspects of war important to strategy in the event deterrence fails and has oversimplified requirements for deterrence by ignoring asymmetries.

The Concept of Automated War Gaming

In principle, it might be possible to run traditional political-military war games under highly structured circumstances, and to make an analytic tool of the the process (Martin, 1982; and Brown, 1982). For example, human players could record their reasoning and games could be replayed by directing a given team to change particular close-call decisions to see what would then happen. Computer assistance for documentation, instructions, constraints, etc., would help a great deal. Several fundamental problems loom large, however: (1)

the time required to conduct war games with human players; (2) the loss of interest humans display after a few iterations; (3) the distaste humans would show for having to operate under numerous constraints; and (4) the cost of maintaining an adequate cadre of human experts. Although attempts to make war games more structured and analytic are to be commended and should pay dividends, Rand's approach—initially quite controversial—has been along a different path made feasible by the last decade's developments in the realm of computer science known as artificial intelligence.

The basic idea is simple: We seek to maintain the basic structure of a political-military game while replacing some or all of the players with computer programs serving as automatons. This permits (but does not guarantee) efficient documentation, replicability, and transparency. It certainly has the virtues of depersonalizing issues and rendering them amenable to analysis. Note that the purpose is not to eliminate the role of expert judgment but rather to harness it through the building of models.[13]

Role of Modern Computer Science

It would not have been possible to develop a useful automated war game ten years ago because the necessary techniques had not been developed for writing sophisticated computer programs, and the computers themselves were inefficient and expensive. Today, however, we are seeing the emergence of computer capabilities only dimly imagined a decade or so ago. Although the field of artificial intelligence from which we draw many of our current ideas is new and highly specialized, progress has been impressive. At present, we are limited as much by our ability to get political scientists to spell out what they believe about the behavior of individual countries, and by our ability to encapsulate what we believe are the processes of war, as by our ability to represent this knowledge in computers.

So, for example, computer programs need no longer focus on quantitative criteria alone. It is now relatively easy to write programs emphasizing qualitative criteria identical to those that would be used by

[13]A useful definition for our purposes is that artificial intelligence is the science of using computer models to better understand the intelligence-related behavior of people and organizations. See also Boden (1978). Our definition has the advantage of emphasizing the role of artificial intelligence in improving *human* understanding and downplaying the image of omniscient robots. Artificial intelligence is also defined as the science of making machines do things which, if done by humans, would be regarded as evidence of intelligence. Readers interested in the subject may want to read the Compton lectures of Herbert Simon (Simon, 1969). For technical details, see Barr and Feigenbaum (1981).

experts. Moreover, as has long been recognized by experts in the field, computers are superb logic machines.

Some aspects of modern computer science are worth mentioning here because they play a major role in RSAC work. They include:

- *Rule-based programs* in which the cause-effect relationships are themselves key variables—i.e., the programs are written so that if, for example, a nation behaves in a way that seems peculiar, the user can (with interactive processing) interrogate the computer, discover the logic chain that led to the action, and then change either his intuition about what is sensible or the rule that led to the aberrant behavior. In earlier times, it would have been difficult to recover the rule because it would have been buried in the computer code. There is now developing a substantial literature on rule-based modeling and the related field of knowledge engineering. There have been successful applications to medical diagnosis (MYCIN), geological surveys (PROSPECTOR), surface naval warfare (TECA), and other fields.[14]
- *Pattern matching.* A nation's response to a new world state (as defined by such matters as who is fighting whom, who is mobilized, and who is allied) can be inferred by looking at its response to the "closest" world state in a data base developed by prior analysis.
- *English-like computer languages*, which are often useful because nonexperts can use the computer while focusing on the substantive issue rather than the intricacies of the program. Rand has developed several such languages, notably RITA, ROSIE, and ROSS[15] under the sponsorship of DARPA and the Air Force.
- *Chess-playing programs*, which have now reached a high degree of competence, reflect recent progress in developing programs that cannot only look ahead to see the possible consequences of alternative actions but can adjust "strategy" in response to additional information as it becomes available. Chess-playing programs are of obvious interest to the RSAC effort because they embody the concept of a competition between two intelligent, but not omniscient, entities.

With this background, then, let us now explore the structure of the Rand approach to automated war gaming.

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[14]See Steeb and Gillogly (forthcoming) for references to the recent literature; see also Barr and Feigenbaum (1981).

[15]See references in Steeb and Gillogly (forthcoming). ROSIE is a trademark of The Rand Corporation.

III. OVERVIEW OF THE TECHNICAL APPROACH

STRUCTURE OF THE RSAC AUTOMATED WAR GAME

The RSAC's technical approach is based on automating the major components of the traditional political-military game. The automatons are manifested in separate computer models linked together currently by a combination of electronic and manual processes. The most distinctive feature of this system is not the use of computers to *assist* in calculations or recordkeeping but rather the combination of computers and artificial intelligence techniques to replace human players making decisions. The elements of the RSAC system include a supervising analyst and:

RED AGENT	A computerized model of Soviet behavior.
BLUE AGENT	A computerized model of U.S. behavior.
SCENARIO AGENT	A computerized model of nonsuperpower behavior, as well as a "bookkeeping" model describing political aspects of the world situation.
FORCE AGENT	Computer models and data bases used to keep track of military forces worldwide and to determine the results of combat.
SYSTEMS MONITOR	Housekeeping programs determining the times of the various automaton moves, formatting information for use by the different agents, and compiling game records.

We will discuss the Red, Blue, and Scenario Agents separately later in this section. For now, however, note only that the RSAC focuses on U.S.-Soviet confrontations, with nonsuperpowers treated just enough to provide a realistic context. Thus, the Red and Blue Agents are more intelligent and more sophisticated than is Scenario Agent.

Figure 3.1 indicates the move sequence within a game and shows how information flows to Blue, Red, and Scenario (in the form of diplomatic messages only) and to Force (in the form of force deployment and employment directives). If, for example, Red invades country X, that fact would be reflected in updates to Force and Scenario data

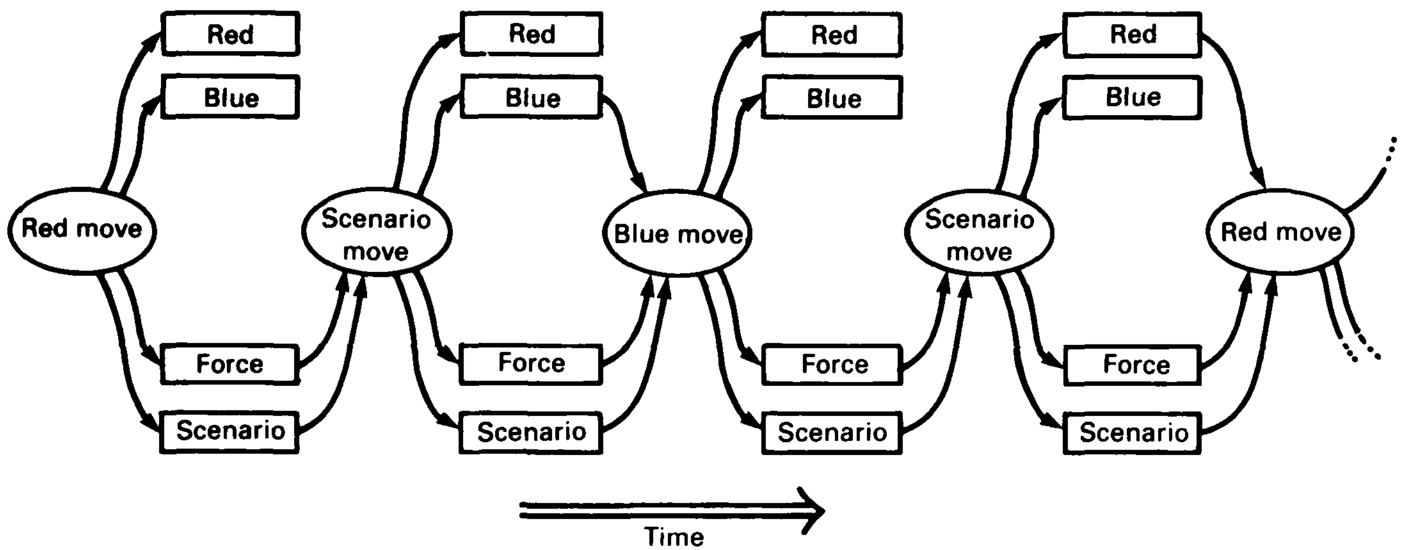

Fig. 3.1—Move sequence and information flow in RSAC automated war games

bases. Red may also have sent diplomatic messages to countries represented by Scenario.

Using information from Force (primarily to determine the threat to nonsuperpowers), Scenario makes decisions for all nonsuperpowers. These are usually stimulated by messages from the superpowers. Scenario decides when messages go to Red and Blue, and the information goes to Force Agent for a data base update (e.g., instructing Force to add French forces to those of NATO if Scenario Agent decides that France commits forces).

Blue then acts, using as inputs previous-move messages from Red, new messages from Scenario, and information as needed from the Scenario and Force Agents (e.g., status of forces and political alignments). The information received from Scenario and Force is correct but may not be complete, reflecting, for example, that we know Soviet force levels less well than our own.

The game continues in this ping-pong fashion, for perhaps 10 to 30 superpower moves.[1] The time between moves, and even the time between submoves, is determined by Systems Monitor (not shown in the figure) on the basis of the pace of events and recommendations in Red and Blue rules.

In summary, the RSAC employs a two-player event- and time-stepped game in which the usual Control Team functions are shared by Force, Scenario, and Systems Monitor. The game is much more complex than a usual two-player game because it captures some of the independence of the nonsuperpowers, which affects game dynamics.

ANALYTIC WAR PLANS AND CAMPAIGN ANALYSIS

RSAC war games deal with realistic campaigns rather than abstract situations. This implies the need for preparatory research ("campaign analysis") in which experts consider, with the use of maps, terrain boards, intelligence data, orders of battle, and computer-assisted games with human teams (e.g., using McClintic or IDA-GAM models), the alternative paths that conflict might take within a grossly defined "scenario" such as a Soviet invasion of the Persian Gulf region. The plausible paths are limited at the strategic and operational levels[2] by objectives, terrain, lines of communication, doctrine,

[1]Real-world confrontations are not ping-pong games, but some aspects of real-world confusion can be included in RSAC work by having both Red and Blue operate with data bases that differ from each other and the real-world and by reflecting intelligence cycle times and delays in decisionmaking.

[2]See the Glossary for definitions.

and other factors. These can be illuminated rather quickly by campaign analysis, although filling in details is complex and time consuming.

As discussed in Davis and Williams (1982) and Levine and Winnefeld (forthcoming), we use campaign analysis to construct logic structures called "analytic war plans" (AWPs), which attempt to capture the many high-level decisions and other branch points that would be faced by the United States and Soviet Union in conflict.[3] Although it is uncertain that either superpower currently uses such logic structures explicitly in their planning (hence the word "analytic" in "analytic war plans"), the issues they capture are real.[4] Developing AWPs, and the decision rules applicable to different Soviet behavior patterns (different "Ivans"), is valuable in itself. Also, using the AWPs allows us to limit the scope of our war games to militarily plausible events. This, in turn, makes it possible to develop Red and Blue Agents that can play chess—i.e., they can choose strategies in recognition of the adversary's posture and likely actions and can adjust the strategies in light of new information. The AWPs also make possible the use of a powerful artificial intelligence technique known as "scripts" (Steeb and Gillogly, forthcoming).

Purely to illustrate terminology, let us consider a highly simplified world consisting of three countries: Red, Blue, and X. *Suppose* that we have done a campaign analysis and concluded:

1. Red *may* invade X, by one of two strategic plans (fast or slow).
2. Blue *may* respond conventionally.
3. Red or Blue *will* win a decisive conventional victory.
4. The loser *may* escalate to a full-scale nuclear war, in which case the other *will* retaliate in kind.

Because this example suppresses so many complications of the real world, it is possible to construct simple decision trees as in Fig. 3.2.

[3]There are constructs in game theory corresponding to many of the ideas in this section (see, for example, Harsanji, 1977, for a readable and well-structured treatment). However, the problems we deal with are not those with general solutions.

[4]See, however, the 1949 article by Israeli General Yigael Yadin reproduced in Liddell Hart (1967) where Yadin argues: "A few more words on maintenance-of-aim. The aim must be single, but the method of achieving it, if we want to be sure of maintaining it, must comprise alternatives—for otherwise the failure of one method will immediately bring about failure in achieving the aim. A plan must be based upon: 'If . . . such and such will happen . . . then. . . ; if, on the other hand such will happen . . . then . . . .' See in this connection the very lucid considerations of Jacob in his preparations for battle with Esau in Genesis 32. Liddell Hart very aptly wrote: 'A plan, like a tree, must have branches if it is to bear fruit; a plan with a single aim is apt to prove a barren pole.'"

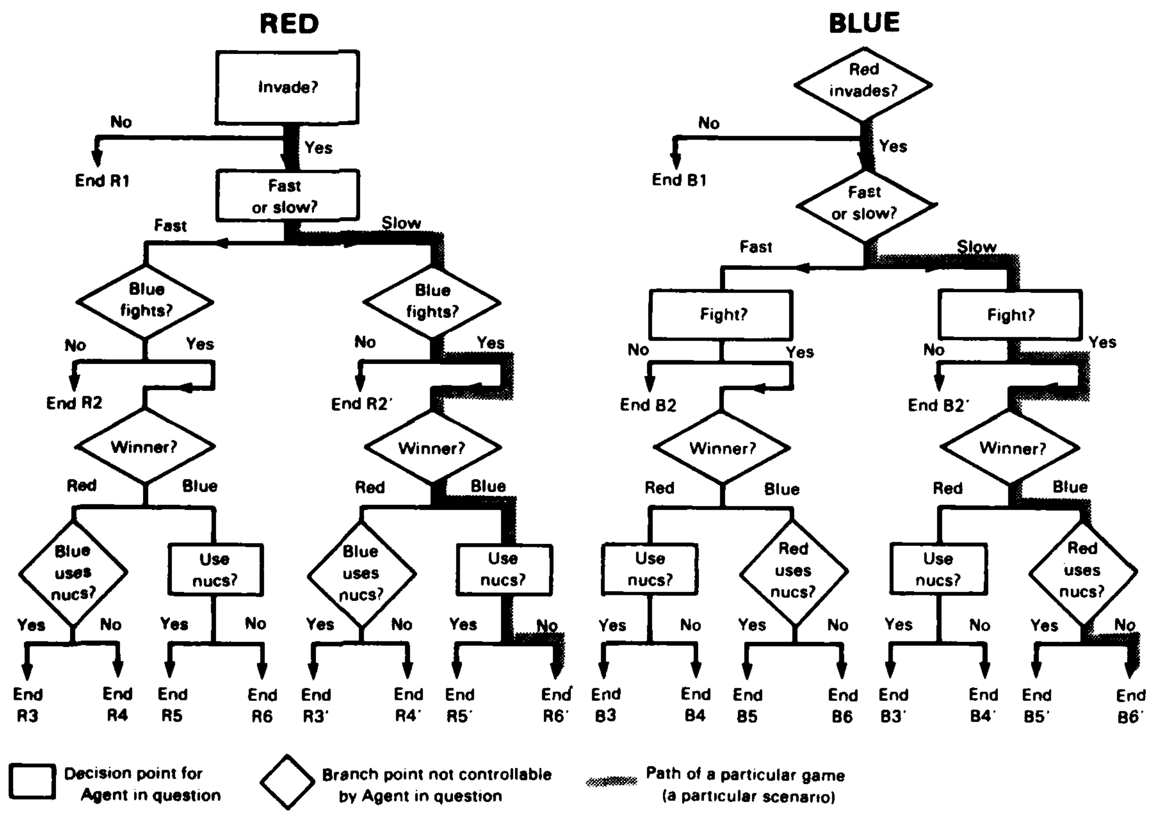

Fig. 3.2—Decision trees for a simple problem

Note that the Red and Blue trees are parallel. The dashed lines illustrate the path through the logic structure corresponding to a particular scenario. Which scenario would in fact unfold would depend on behavior rules of the Red and Blue Agents and force levels.

The set of all possible paths through the logic network defines the "Scenario Space" for this problem. Figure 3.3 divides the scenario space into subsections constituting the strategic options we call AWPs. As the figure illustrates, the Agents choose from among AWPs at the outset; even within an AWP, however, there may be subsequent decision points and branch points reflecting decisions of the other Agent, luck, or other factors. Everytime a *strategic*-level decision is made, the Agent is choosing among AWPs—i.e., AWPs are imbedded within AWPs.

Figures 3.2 and 3.3 deal largely with events at the strategic level. However, in implementing the strategies we have to make assumptions about operational details and tactics: What forces go where, when, to do what, and to whom? With what objectives and constraints? This kind of information comes from the campaign analysis in the form of "scripts." Scripts are the building blocks of war plans. The terminology in scripts is natural because they provide the outline for a set of actions intended to occur over time.

The scripts used to date in illustrative experiments in the RSAC have been simple campaign plans with specified decision points defined by events in the exercise. They have suffered from a lack of flexibility. The follow-on system provides for scripts with empty "slots," which are blanks in which later to specify information such as the number of divisions and the allocations of forces to different attack axes. The Red and Blue Agents fill in the slots as the exercise proceeds using rules and models to determine precisely how to do so.

Developing building block scripts and the algorithms by which to adapt them to a given exercise automatically is one of our major current efforts.[5]

Finally, we should emphasize that it is not generally possible to physically draw out the decision tree corresponding to an AWP or branched script or even to enumerate the branches. In the general case, the decision structure forms a continuum and simple decision trees can be used only to illustrate the underlying principles or for portions of the total problem. For this reason we say that our con-

[5]The interested reader should refer to Steeb and Gillogly (forthcoming) for a discussion of scripts from the artificial intelligence point of of view; and to Levine and Winnefeld (forthcoming) for a discussion of how a campaign analysis team attempts to provide information in the relevant form.

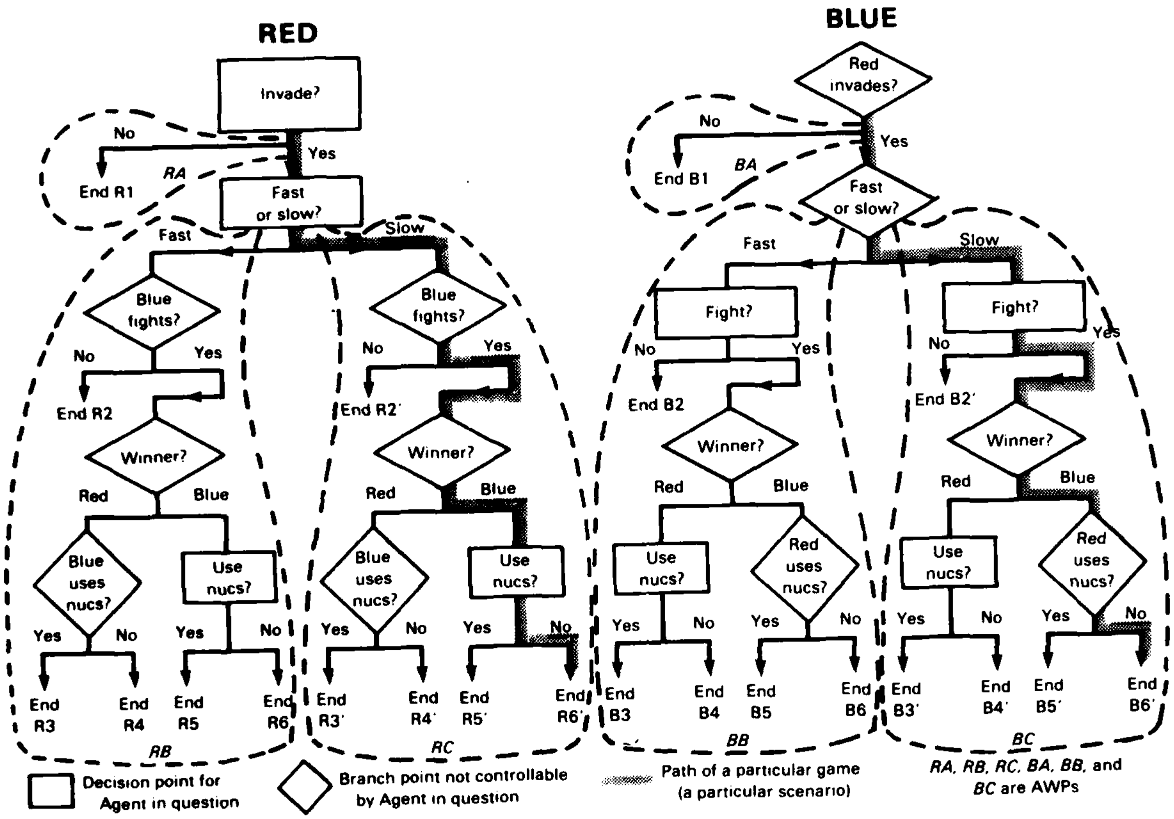

Fig. 3.3—Analytic war plans as portions of a scenario space

structs are rule-based generalizations of decision trees. In practice, we start a problem by sketching out decision trees to help us understand the principal issues in the campaign of interest. We then translate the trees into rules and the associated building block scripts. We then generalize those rules so that the resulting decision framework, if drawn out, would be an extremely complex "bushy tree" at best (Davis and Williams, 1982).

To summarize, then, Fig. 3.4 shows how campaign analysis and inputs from country specialists produce the principal components of RSAC war games. We should note in candor that our exploratory efforts in 1982 have not been so neatly structured in practice (Levine and Winnefeld, forthcoming).

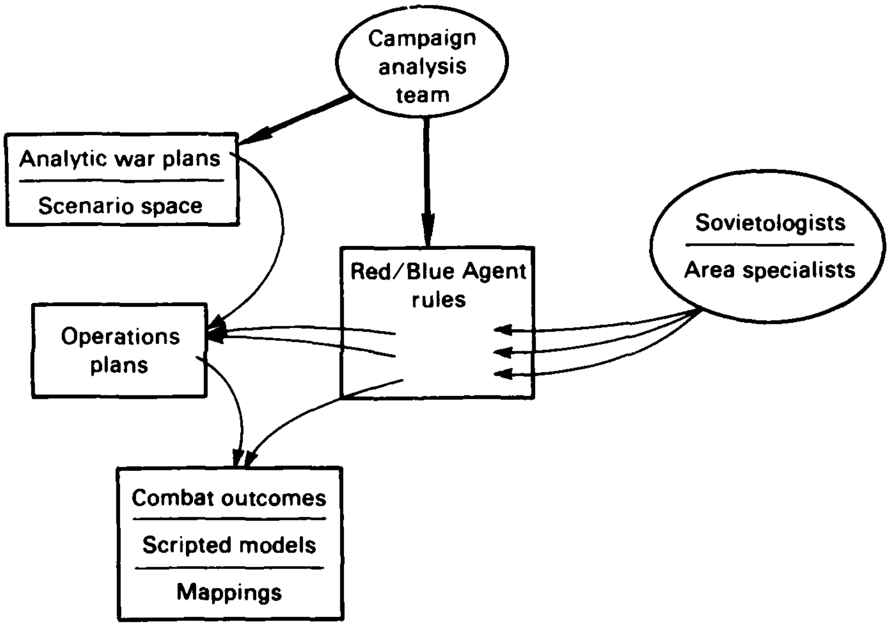

Fig. 3.4—The use of campaign analysis in developing analytic war plans and rules

STATUS AND EVOLUTION OF RSAC MODELS

In the following pages we discuss the Red, Blue, Scenario, and Force Agents individually, as well as Systems Monitor. However, since the

RSAC system is evolving, it is important to distinguish among the several versions. We refer to the first-, second-, and third-generation versions as Mark I, Mark II, and Mark III, respectively:

Mark I: A breadboard proof-of-principle system demonstrated in January 1981 (Graubard and Builder, 1980). It included simple automated Red and Scenario Agents but did not purport to have much military content.

Mark II: The current system, intended to support some illustrative experiments (Winnefeld, 1982) and to serve as a test bed for some of the concepts proposed for an advanced system (e.g., analytic war plans). Agents make decisions automatically, but extensive human participation is necessary for typing, correcting errors, performing calculations (or selecting combat models within the system), and adjusting or extending rules and strategies.

Mark III: The generic name used for advanced future systems suitable for serious applications in a research environment (an operational prototype). The Mark III system will develop by stages in FY83 and FY84, will undergo extensive testing, and will become the basis for operational systems. Human intervention will become increasingly unnecessary except at the analyst level and in exercises intended to have human teams at one or more positions.

Although the Mark I system was sufficient to suggest the value of the approach, there was no attempt to conduct serious analysis with it. The Mark II system is structurally similar in some respects but incorporates major changes in the Red, Blue, and Scenario Agents. To a large degree, the Mark II system was an attempt to skim off some of the ideas proposed for an advanced system and try them out on concrete problems to improve our understanding of the technical issues involved in building an advanced system. The Mark II system was not intended to be smooth, flexible, or fully automated. Nonetheless, we conclude that a version of the Mark II system could be used for serious applications, albeit not efficiently. This may prove quite useful in the next year since development of the Mark III system will take time and involve numerous development problems. The first version of Mark III may be an improved version of Mark II.

The Red and Blue Agents

The Mark II Red and Blue Agents. The program structures for the Red and Blue Agents are identical, with U.S.-Soviet asymmetries reflected in the different data bases that are inputs to the programs (i.e., the rules on the basis of which the Agents act). We refer to the general program as the Major Agent Control System, "major" emphasizing that it pertains to a superpower and "control system" emphasizing that the program is a device for storing, retrieving, displaying, and manipulating complex data—the substantive "content" of the Agents residing in the data bases. Figure 3.5 describes the Agent operations schematically.[6] Recall that we have alternative behavior models (Ivan 1 and 2 and Sam 1 and 2) because of fundamental uncertainties.

The Red or Blue Agent begins a move by examining the current political military situation as described by tableaus showing, for example, locations of conflict, belligerents, and states of mobilization. The Agent then compares this situation with a number of preanalyzed situations reflected in a data base of similar tableaus. To each such situation in the data base there corresponds a set of action instructions, and the Red or Blue Agent will implement the action instructions corresponding to the "closest" situation.[7] This procedure is similar to that used for the Mark I system, except that the situation descriptions and the action instructions are substantially more sophisticated and in effect support two levels of automated decisionmaking. A notable feature of this decisionmaking is the use of extended look-aheads (projections), in effect accomplished by a game within a game—to evaluate alternatives in the action instructions. The look-aheads include Force Agent projections of combat outcomes and other military operations and Scenario Agent projections of third-country behavior.

The situation-matching part of Red or Blue's move is a preliminary filter; it also has the effect of representing the view from the national command level. The form of the rules imbedded in the action instructions is usually more representative of what would concern theater commanders. The use of such rules and of distinguishing levels of command was an attempt to move part way toward the concepts for advanced Red and Blue Agents.

Another major improvement has been the incorporation of rules (and situation descriptions) reflecting some of the qualitative factors known to be important to real-world decisionmaking. So, for example, the Red Agent is sensitive (to greater or lesser degree depending on which Ivan is used) to indicators of U.S. will and intentions. Table 3.1 lists the descriptors we currently use in distinguishing among Ivans.

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[6]See Jones, LaCasse, and LaCasse (forthcoming) for details and documentation.

[7]Pattern-matching techniques used to find the "closest" situation were adapted to RSAC work by Norman Shapiro and William Jones.

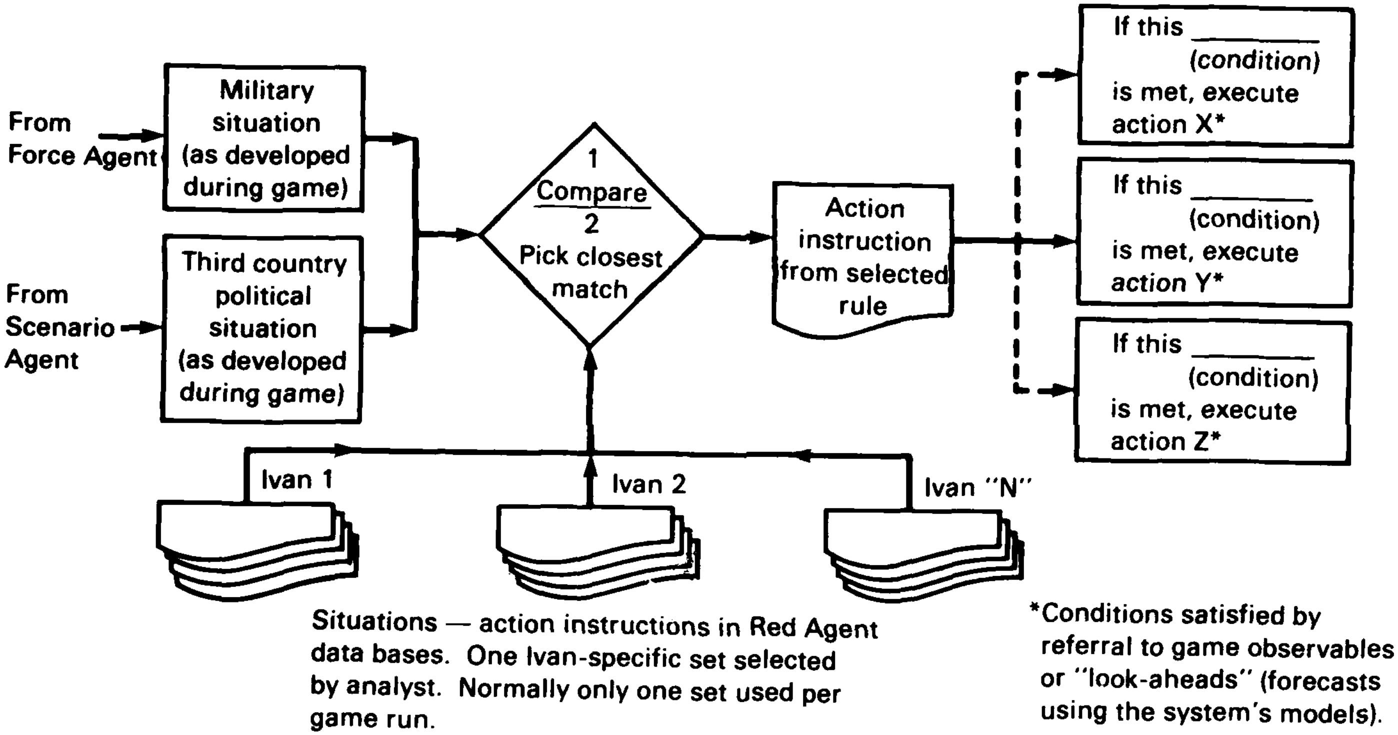

Fig. 3.5—Schematic of Mark II Red Agent operation

Table 3.1

DESCRIPTORS DEFINING ALTERNATIVE SOVIET BEHAVIORS

Descriptors	Possible "Values"
Expansionist ambitions.	Adventuristic, opportunistic, conservative.
Willingness to take risks.	Low, moderate, high.
Assessments of adversary will.	Conservative, neutral, contemptuous.
Assessments of adversary intentions.	Optimistic, neutral, alarmist.
Insistence on preserving imperial controls.	Moderate, adamant.
Patience and optimism about historical determinism.	Low, moderate, high.
Flexibility of objectives once committed.	Low, moderate, high.
Willingness to accept major losses to achieve objectives.	Low, moderate, high.
Look-ahead tendencies.	Simplistic one-move modeling, optimistic and narrow gaming, conservative and broad gaming.

Each descriptor can have several possible "values." We define an Ivan's character qualitatively by choosing those values for each descriptor.

Defining an Ivan using Table 3.1 does not, of course, determine all the detailed rules needed to run an RSAC exercise. However, it does give rule writers an image of the Ivan they are dealing with, and this tends to improve consistency. To illustrate how Ivan 1 (adventurous, risk taking, and contemptuous of the United States) might differ from Ivan 2, suppose that the United States had its forces on worldwide alert. Ivan 1 might regard that as a minimum measure, characteristic of timidity, and plunge forward with his plans. Ivan 2 might be alarmed and adjust his plans accordingly. If the United States had *deployed* forces to the region of confrontation, or was otherwise taking tangible preparations for battle, Ivan 1 would also be alarmed—or at least would take that objective evidence more seriously than mere alerts. The important point to note here is that it is quite feasible to include qualitative considerations in the RSAC war games, especially those we believe are important to escalation processes.[8]

The Mark III Red and Blue Agents. Our planned approach for the advanced agents centers around even more use of AWPs than in the Mark II system. Campaign analysts will prepare war plans for each major strategic option and area to be studied. The Red and Blue Agents will choose among strategic options (i.e., among AWPs) and then will follow the actions specified in the corresponding plan, filling in operational details and taking branches within the plan depending on conditions and their character. The plans will include military goals and timelines, which the Agents will use along with feedback mechanisms to modify planned actions until objectives are more nearly met. The approach will seldom be one of optimization but rather one of choosing the best of a range of operationally and doctrinally constrained options.[9]

The proposed Mark III Red and Blue Agents will distinguish explicitly among three different levels of command. As illustrated in Figure 3.6, the national command level (NCL) will examine the situation and select the best available AWP, given the situation and the particular Ivan's (or Sam's) objectives and character. The area or functional command level (ACL) will then translate the selected AWP into operations plans by assigning forces, selecting force employment options, and providing in-plan timetables. The tactical control level (TCL) will then test and execute the plan.

The Red and Blue Agents will be able to use look-aheads that attempt to predict adversary and nonsuperpower actions and combat prospects. The projections are accomplished by running a game within a game. Red has a model of Blue, assumptions about third-country behaviors, and his own combat models. Since all such projections will involve considerable uncertainty (e.g., Red's model of Blue may be wrong), the Agents will modify their plans as the game proceeds and they can see the reactions.

Red and Blue Agents will assign probabilities to alternative branches they do not control (reflecting their uncertainties about adversary and third-nation behavior, battle outcomes, etc.). In addition, building block scripts will be developed that are sufficiently flexible for a variety of circumstances, with appropriate situation-specific adjustment. This kind of flexibility was not even attempted in the Mark II system.

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[8]Experience to date with the Mark II system suggests that the RSAC will be very useful in examining the components and dynamics of escalation.

[9]See Steeb and Gillogly (forthcoming) for more detail on the concepts that will guide the development effort.

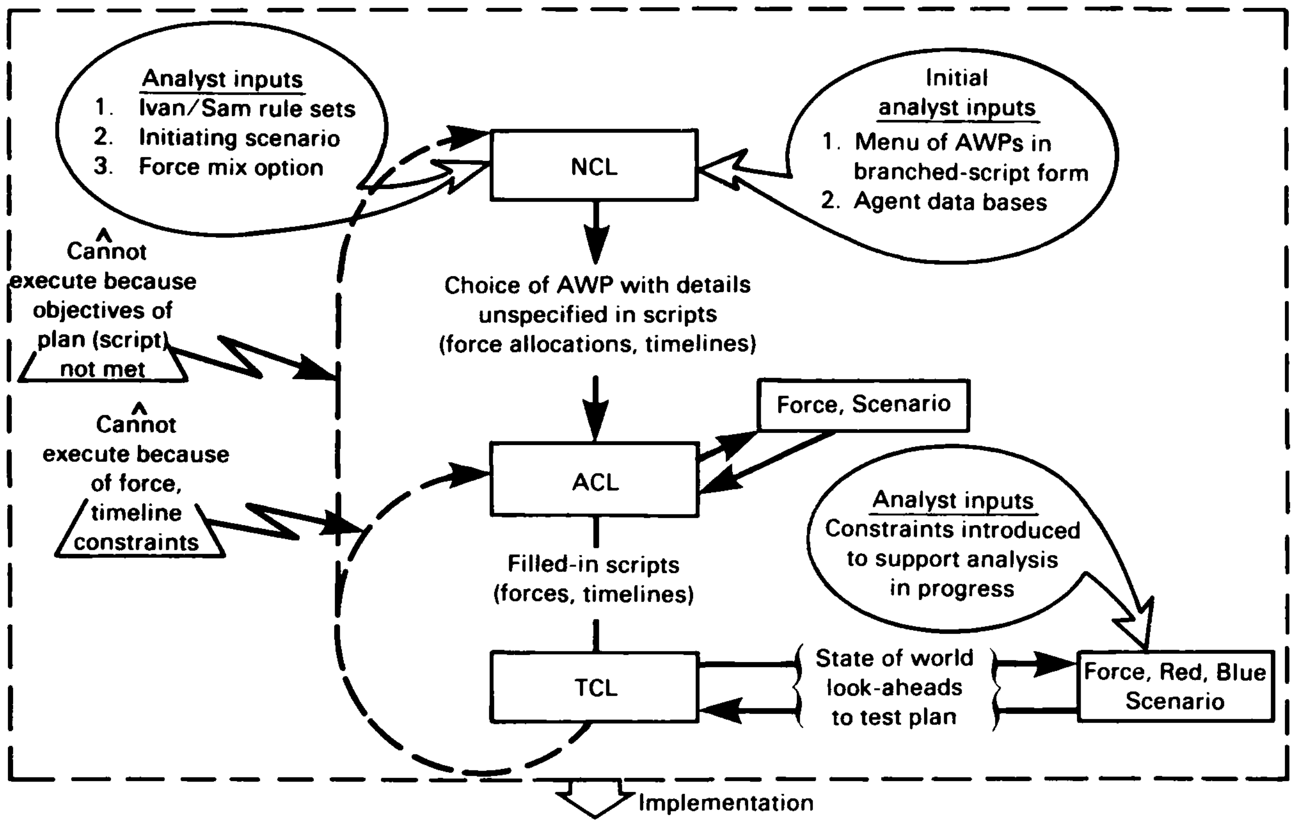

Fig. 3.6—Schematic of Mark III Red and Blue Agents: flow for a single game move

These plans for developing Mark III Red and Blue Agents are highly ambitious, in terms both of comparisons with other state-of-the-art applications of artificial intelligence and of requirements for ancillary efforts involving campaign analysis, research about Soviet military operations, and research on Soviet decisionmaking. It will, by necessity, be an evolutionary effort over a period of years, although the technical structure should be well in hand by the end of FY83.

Scenario Agent

As mentioned earlier, Scenario Agent is not intended to be as sophisticated as the Red and Blue Agents. It is expected to reflect the behavior of third countries well enough to create a realistic context for the superpower confrontation. It is not important how the nonsuperpowers reach their conclusions (for instance, we certainly do not wish to model the politics of the French cabinet), nor how well they achieve their independent objectives in the conflict. Rather, for the purposes of current RSAC work, we are concerned about such matters as whether Red and Blue allies grant basing rights, allow combat operations to be mounted from their soil, invite their superpower ally into their country, etc. And, of course, we are interested in whether invaded countries and their allies will join in combat.[10]

Given the purposes of Scenario Agent, it would have been inappropriate to tie our work to one or another of the various theories of international behavior, none of which is predictively satisfactory for the situations of interest to us.

As indicated by Figure 3.7, the Mark II Scenario Agent is a perception-response model of nonsuperpower political-military behavior.[11] By this we mean that the Scenario Agent views the world situation, infers the degree of threat or opportunity to each of the countries it represents, and then develops associated responses. Perception and responses are dictated by rules that attempt to capture the most important distinctions in national behaviors. Since the rules cannot possibly be definitive, even in principle, they are grouped by classes

[10]The starting philosophy has, therefore, been quite restrictive. In practice, however, Scenario Agent is becoming increasingly sophisticated. For example, a third country can join with a superpower in conflict with the other superpower and then, late in conflict, see an opportunity to achieve long-standing objectives by invading a neighbor. The RSAC would not treat the military details of this invasion, but its existence can substantially alter the final phases of conflict between the superpowers by drawing off forces and creating an additional problem area to worry Red and Blue national leaders. It is also possible for conflict to begin with actions by third countries.

[11]The original work on Scenario Agent is described in Dewar, Schwabe, and McNaugher (1982). For a more comprehensive description documenting the current model, see Schwabe and Jamison (1982).

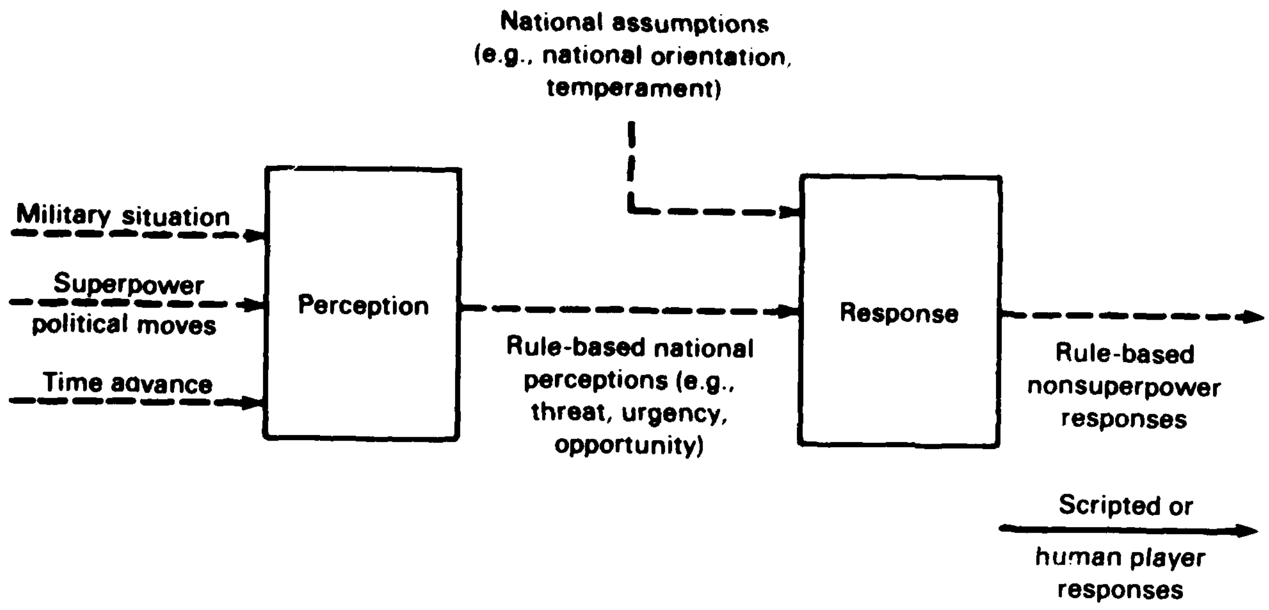

Fig. 3.7—Perception-response relationships in Mark II Scenario Agent

from among which the analyst can choose. The classes include, for example, "reluctant allies"—allies that drag their feet in response to superpower requests unless they see a commonality of interest that transcends mere friendship. The analyst can choose a behavior pattern for each exercise. By intention, then: *The Mark II Scenario Agent is the analogue to parametric models in physics and engineering.*

On the basis of review comments and the results of some small exercises with human teams, we conclude that the Scenario Agent model is sufficiently flexible to serve as the prototype for the Mark III system, although we anticipate substantial research over several years to establish adequate rule sets. Since the structure of the Mark II Scenario Agent appears to be adequate, we intend now to reprogram it from ROSIE into a C-based computer language comparable to that planned for the Mark III Red and Blue Agents. This will increase efficiency by an order of magnitude or more without losing many of the "user-friendly" features that have characterized Scenario Agent from its inception.[12]

The Force Agent

Force Agent design has hinged on major agent and system development decisions. Accordingly, in establishing priorities within project funding levels, Force Agent development was modest in 1982 and focused on conceptual design compatible with system requirements. With major agent and system design concepts well in hand, a major effort will be mounted in 1983 to build an advanced Force Agent.

The Mark II Force Agent. The Mark II Force Agent is very similar to the Mark I version, and is built around the highly aggregated Foment model.[13] Modest improvements have included treating air-ground warfare in Southwest Asia, developing a simple ballistic missile defense module, and designing a mobility model (a simple version of which should be complete by the end of FY82). In addition, we have made considerable use of off-line analysis to develop "scripted models" that compensate for the lack of adequate simulation models and permit us to enrich the treatment of operational art (Davis and Williams, 1982).

Figure 3.8 illustrates the components and data flow of the Mark II Force Agent. Currently, the Force Agent must orchestrate the flow of

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[12]As of December 1982, it appears that the reprogrammed Scenario Agent will be able to make its move in about a minute, including human-operator time.

[13]Unpublished material by Michael Mihalka and Arthur Bullock.

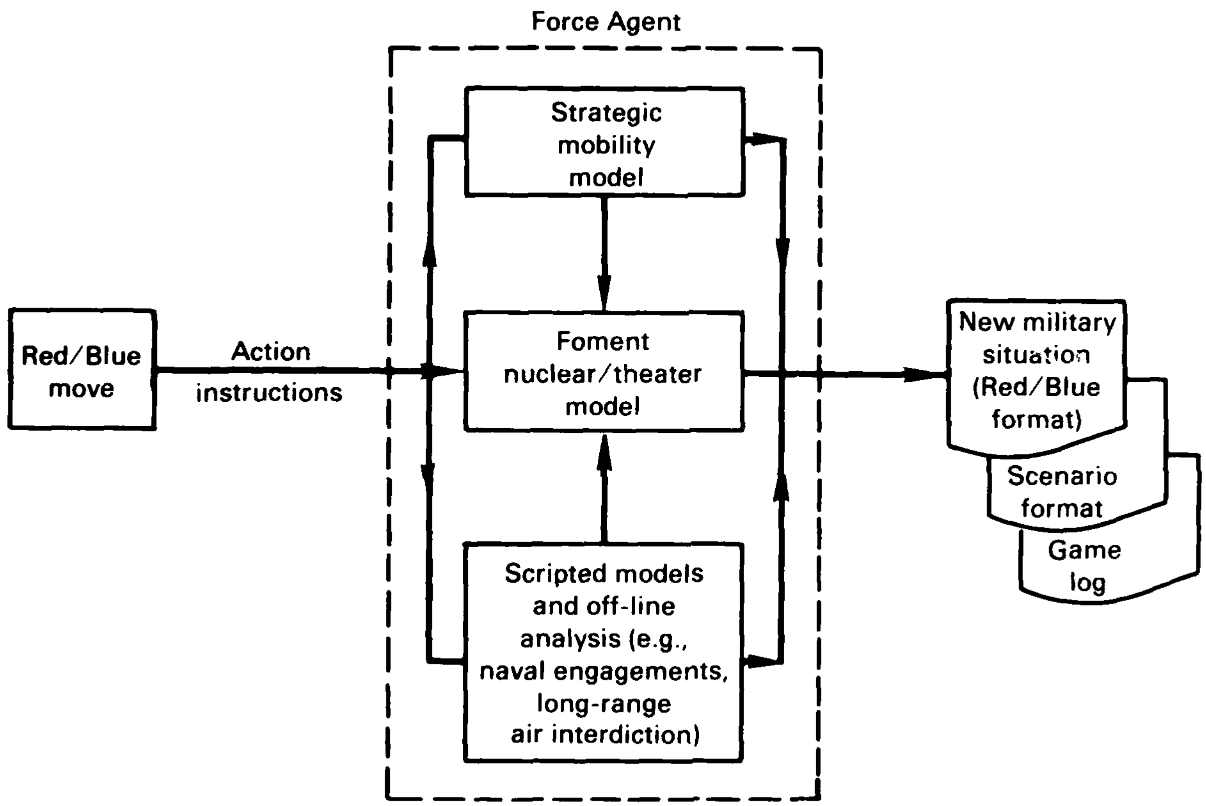

Fig. 3.8—Schematic of Mark II Force Agent operations

data between models and off-line analysis and fill in the output formats for use by other agents. The procedures are clumsy and will be corrected in the Mark III system.

The Mark III Force Agent. The core of the Mark III Force Agent will be a new force model called Campaign, which, like its predecessor Foment, will be an aggregated, dynamic model to keep track of military forces and operations worldwide.[14] It will incorporate some design concepts and calculational techniques from Foment but will be more sophisticated, flexible, comprehensive, transparent, and documented. Taken individually, the design requirements for Campaign may sound obvious or trite. Taken together, however, they constitute a highly demanding set of objectives that will take several years to satisfy. In particular, Campaign will have to:

1. Track force deployments.
2. Describe mobilization and mobility.
3. Determine outcomes of theater combat.
4. Determine outcomes of naval engagements.
5. Determine results of central nuclear conflict.
6. Support uncertainty analysis.
7. Read and respond to AWPs.
8. Permit model improvements to be implemented incrementally.
9. Handle suitable levels of aggregation.
10. Accept inputs based on off-line analysis using detailed simulation models and war games with human teams.

A *major* challenge here is to reflect the interrelationships among different theaters and different aspects of combat and related operations. Although, by preference, the Campaign model will be aggregated and parametric, it will be essential to capture these interrelationships if the RSAC is indeed to be an appropriate integrating framework for strategy analysis.[15]

Given the complexity of the challenges and the relatively poor state of current force modeling for our purposes, we anticipate that development of Campaign and associated supportive models will be a major effort over the next several years. We hope to tie this effort in with

[14]*Campaign*, as used in this report, includes planned Mark II on-line Force Agent programs, including the Campaign Force model and bookkeeping, force-tracking, and related housekeeping programs.

[15]Design plans for the Force Agent effort as a whole and the Campaign model in particular are not yet documented. Many of the important decisions, however, are described in Davis and Williams (1982) and in unpublished briefing material by Williams and Bennett. The reader should also see the IDA study by Schultis and Robinson (1981), which treats many of the issues.

complementary forms of modeling based on more microscopic analysis such as that of Blumenthal at Lawrence Livermore National Laboratory (the JANUS system). We do not, however, anticipate replacing aggregated RSAC force models with detailed simulation models; nor do we anticipate having such detailed models "plug in" directly except in special cases. We have concluded that doing so would create enormous integration problems and would obscure large and important uncertainties inherent in the detailed models.

OPERATIONAL MODES

Although our principal focus is analysis of a sort most convenient with automated[16] decisionmaking, the RSAC system can also be used with human teams. In the automated mode, the system develops event streams based solely on programmed rules contained in the several agents. In the human-team mode, one or more of the Agents are disconnected and the human players take on the corresponding role. Alternatively, those players can examine the proposed move of their automaton and override if necessary.

It is possible to interrupt automated-mode war games at critical move points to permit some higher-resolution analysis performed off-line. The game data can be adjusted appropriately and the game restarted. In the human-team mode, a single team can play against the system; or, several teams can play, with the system used as a semiautomated "control."[17]

We hope that it will prove feasible for individuals (or small analyst teams) to move from chair to chair readily, to better appreciate all sides of the game and that large numbers of people are not required.

Scenario Agent can operate in several different modes. When the purpose is to see the results of war games with programmed rules, Scenario is run in the "simulation mode." In other cases, the interactive nature of the system can be used to try out alternative rules for self consistency and potential implications. Here, or when the analyst is postulating rules of behavior other than those previously assumed, the analyst can override the programmed rules wholly or in part. In the limit, the Scenario Agent serves merely as an efficient bookkeeper

[16]Strictly speaking, the RSAC system is "semiautomated"; human technicians/analysts are always present to facilitate data transfer, correct glitches, and—when appropriate—override programmed behavior rules.

[17]Usually, human teams take on the Red or Blue roles, but we have experimented with human teams representing selected countries. The only special requirement associated with human teams is the need for additional information displays—a subject that will receive more emphasis in FY83.

and transmitter of information from one Agent to another. Similar flexibility appears possible with the Red and Blue Agents.

Choosing an Operational Mode To Fit the Application

The fully automated mode seems best suited to problems of the following types:

1. Comparing alternative projected force structures, while dealing with a range of Red and Blue characters and major uncertainties in scenario (see, for example, Winnefeld, 1982).
2. Examining alternative operational plans with fixed forces but with variable assumptions about Red, Blue, and Scenario Agent behaviors.

More generally, automated-mode operations appear well suited to help the analyst: explore a wide range of variations in key variables; identify sensitivities, at an aggregated level, to establish what studies should be made at a higher level of resolution; or to identify cases needing quick first-order results, even at the expense of some fidelity and precision.

The human-team mode is probably best suited for semiexperiential explorations of such issues as asymmetric perceptions and deterrence. It is also potentially valuable during the development of rules and campaign assumptions, because analysts can use the system to try out their intuitive ideas before committing them to paper. Unfortunately, there is currently no convenient way to record the "whys" of actions taken by a free-play team. We plan to examine options on this.

Elaborating a bit on human-team play, note that a number of free-play options exist:

1. By directing the Blue Agent, it should be possible to explore employment options for U.S. forces.
2. By directing the Force Agent, it should be possible to test different force structures and characteristics under controlled conditions.[18]
3. By directing the Red Agent, it should be possible to explore the robustness of U.S. forces and plans against a variety of Soviet perceptions and initiatives.
4. By manipulating the Scenario Agent, it should be possible to explore the impact of various political and military actions by nonsuperpowers.

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[18] In addition, alternative Force models could be used to test system outcomes for sensitivity to Force calculations.

Operational Requirements for the Mark II System

The Mark II system requires four to five operators and a supervisory analyst. A complete move cycle from one major agent to another takes up to 20 minutes unless it is necessary to write on-the-spot rules or conduct extended look-aheads to assist decisionmaking. The Mark III system will be no slower and may be faster in spite of its greater complexity.

ILLUSTRATIVE OUTPUTS OF RSAC WAR GAMES

Output Documents from a Game Run

1. The raw game log is compiled automatically and contains verbatim records of all automated transactions among the agents and the results of computations by the agents. It also provides a place for the supervisory analyst to record technical observations on the conduct of the game run.
2. The game move diagram is a log maintained by the Systems Monitor in an automated bookkeeping system. It provides a visual road map of the move sequence for easing use of the raw game log.
3. The analyst of record summary includes the analyst's notes on the initial run setup, interventions in automated operation, and a narrative summary.
4. The Scenario Agent log is compiled automatically and records changes in nonsuperpower descriptors, chronologically, over a succession of game moves.

Supportive Graphics

A range of graphics is needed by the supervisory analyst in setting up the experiment, guiding system operations, and assisting postrun analysis. The services available include:

1. *The Analytic War Plan Library*. Figure 3.9 illustrates, in abridged form, the family of war plans available in a particular experiment. Illustrations like this may contain more detail such as the conditions required to initiate mobilization or employment.
2. *Decision Trees*. Discussed in Sec. III, these are similar to but more complex than the hypothetical example in Fig. 3.2. As noted earlier, however, it is not generally possible to capture the full range of possibilities allowed by the programmed rules in a classical decision tree because some of the variables are continuous.

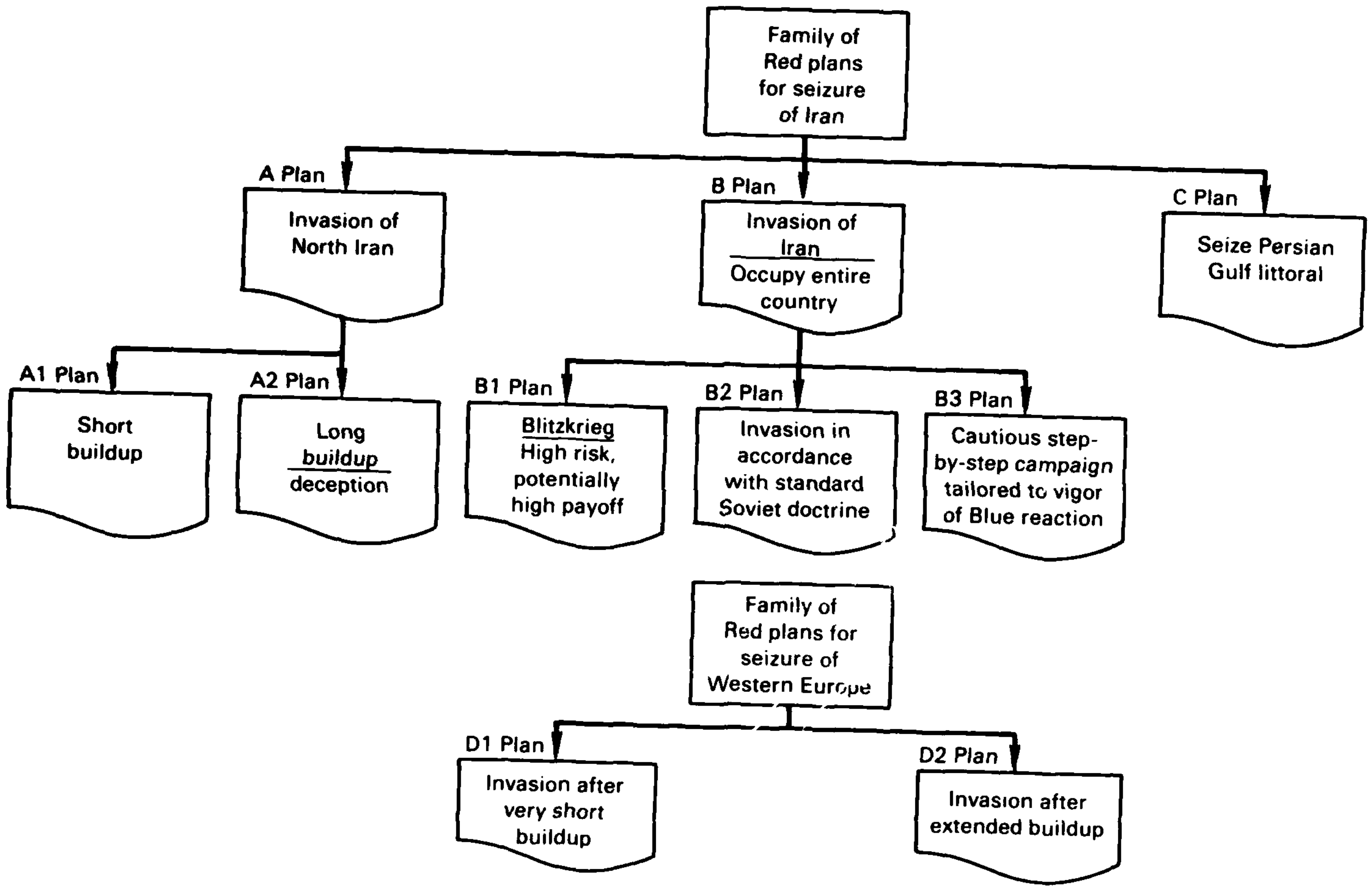
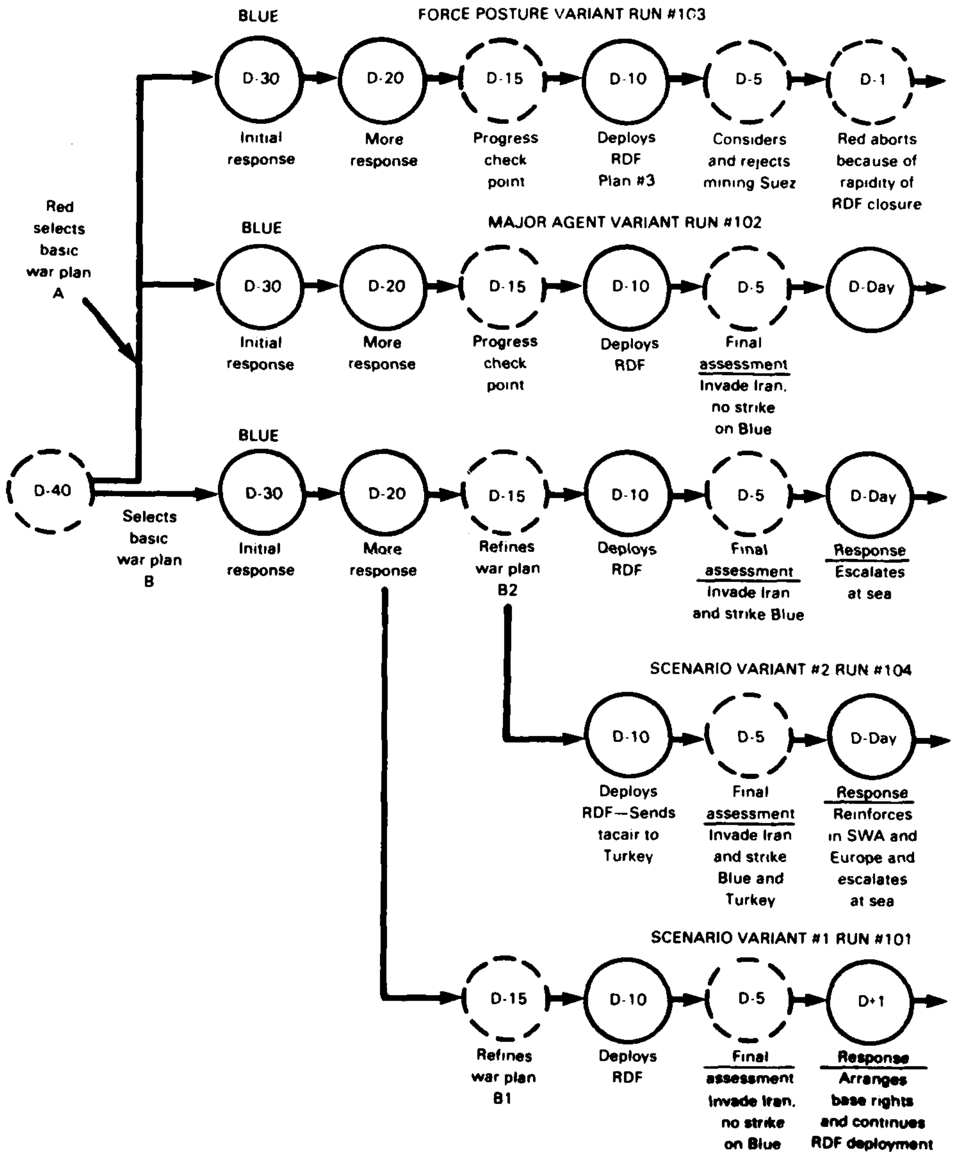


Fig. 3.9—Families of Red plans used in the experiments


BLUE
FORCE POSTURE VARIANT RUN #103
D-30
Initial response
D-20
More response
D-15
Progress check point
D-10
Deploys RDF Plan #3
D-5
Considers and rejects mining Suez
D-1
Red aborts because of rapidity of RDF closure
Red selects basic war plan A
BLUE
MAJOR AGENT VARIANT RUN #102
D-30
Initial response
D-20
More response
D-15
Progress check point
D-10
Deploys RDF
D-5
Final assessment
Invade Iran, no strike on Blue
D-Day
BLUE
D-40
Selects basic war plan B
D-30
Initial response
D-20
More response
D-15
Refines war plan B2
D-10
Deploys RDF
D-5
Final assessment
Invade Iran and strike Blue
D-Day
Response
Escalates at sea
SCENARIO VARIANT #2 RUN #104
D-10
Deploys RDF—Sends tacair to Turkey
D-5
Final assessment
Invade Iran and strike Blue and Turkey
D-Day
Response
Reinforces in SWA and Europe and escalates at sea
SCENARIO VARIANT #1 RUN #101
D-15
Refines war plan B1
D-10
Deploys RDF
D-5
Final assessment
Invade Iran, no strike on Blue
D+1
Response
Arranges base rights and continues RDF deployment

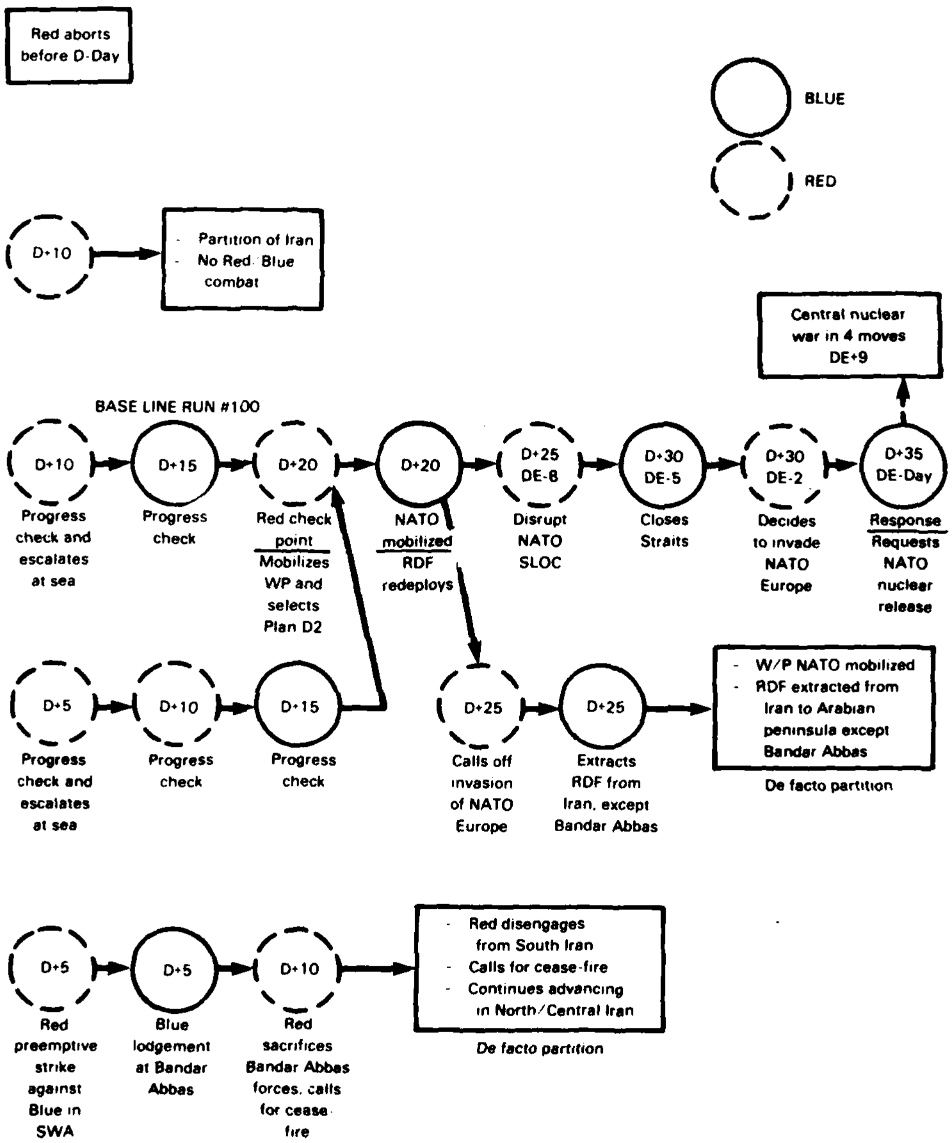


Fig. 3.10—Event stream development for five runs

3. *A Game Move Flow Chart.* Figure 3.10 shows a sample flow chart developed in recent RSAC experiments (Winnefeld, 1982). It is closely related to the game-move diagram but is more oriented to the needs of a high-level reader or viewer.

4. *Graphic Plots of Output Data.* We are beginning to explore ways to represent graphically experimental results—a major area of study in FY83. Section IV discusses analytically useful graphics in more detail (and provides one example); however, this is done at a level of speculation as to what will be useful.

TECHNICAL ISSUES, CHALLENGES, AND PROSPECTS

Issues and challenges for full-scale development fall roughly into four categories:

- Building the individual agents that capture the richness of military planning, decisionmaking, and operations, while avoiding complexity that impairs transparency and system speed.
- Integrating the system components.
- Performing the campaign analysis and research on Soviet decisionmaking necessary to exploit the technical potential of the Red Agent model.
- Expanding the scope of RSAC work to include some initial modeling of Soviet and nonsuperpower behavior over a period of years—i.e., making a start on the modeling of peacetime competition.

Section IV describes the range of applications we foresee, and Sec. V describes the development plan necessary to make the Mark III RSAC system a reality.

IV. POTENTIAL APPLICATIONS

INTRODUCTION

One of the RSAC's principal tasks in FY82 has been to illuminate the potential utility of an operational strategy assessment center (an OPSAC). Our tasking required: (1) a survey of potential users to develop a broad range of ideas and challenges; (2) thought experiments on applying the RSAC techniques to a number of such challenges; and (3) illustrative applications using interim capabilities supplemented by off-line analysis and gap-filling postulates to work through one or more problems "from beginning to end" in enough detail to illuminate the process of applying the methodology, the feasibility of doing so, agent requirements, and integration problems. As a group, these activities were to clarify what a mature center could be expected to accomplish—and what it could not.

As will become evident, one of our problems in exploring plausible applications for a mature center has been an embarrassment of riches. To avoid presenting what might appear to be a mere laundry list of applications, we have attempted to apply a number of criteria that would indicate which applications would be the most important and feasible. The criteria we have used are as follows:

- *Substantive content*: Could the same analysis be accomplished more easily in another way? Are we using a sledgehammer to crack peanuts?
- *Impact*: Could the same story be conveyed more effectively?
- *Feasibility*: Are the requisite models, data bases, and rules available or within reach?
- *Practicality*: Is it plausible that bureaucratic factors and human psychology will allow the RSAC techniques to be used in the way described?
- *Potential for troublemaking*: Could the analyses confuse, mislead, or build false confidence about the predictability of events? Is the approach more prone to such problems than other analytic techniques?

In the remainder of this section we shall first examine the range of possible applications, using the above criteria to do some subjective sorting; then we shall work through one illustrative class of applications in more detail, discussing in depth the effort required to turn the application concept into reality.

A TOUR OF THE HORIZON OF POSSIBLE APPLICATIONS

Many of the ideas on how to apply a strategy assessment center traced back to the early thinking that preceded the government's statement of objectives (Marshall, 1982) and the initial Rand proposal. However, during the first phase of the RSAC's program (the latter half of 1980 with some continuation into 1981), there was little opportunity to explore any of the ideas. The technical challenge of building a breadboard version of an automated war game more than fully occupied the energies and intellects of those concerned. Thus, work on applications did not begin seriously until the latter half of 1982. As a start, and consistent with explicit tasking, RSAC staff elicited suggestions about applications from about 50 civilian analysts, senior executives, middle grade officers, and general officers. Appendix C summarizes the results of these interviews, which were conducted in the summer and autumn of 1981.

The survey results were interesting and helpful; they also underlined the broad base for the view that the United States badly needs a better analytic framework for strategy analysis. Those surveyed appeared largely comfortable with the idea of war game techniques, although many were by no means certain the approach would work. The applications suggested were diverse, but similar suggestions often emerged, frequently reflecting the interests or experience of those interviewed more than their current responsibilities. Most potential users sought techniques that would help to answer the following types of questions:

- What difference would it make if... (in the context of capabilities or strategies)?
- What if... happened (i.e., what if the scenario variables change)?
- On what assumptions do conclusions about... depend (e.g., assumptions underlying planning scenarios)?

After combining survey results with additional suggestions from within Rand and a good deal of thought, we currently believe that the applications described in Table 4.1 are those most obviously appropriate for RSAC techniques. This important table summarizes considerable thought and debate and is more discriminating than might be immediately evident.

In a sense, Table 4.1 is troubling—the list of applications is so large and diverse as to suggest the selling of a panacea. In fact, we are very sensitive about the limitations of RSAC techniques and are by no means in the panacea business. Nonetheless, the length of the list in

Table 4.1

POTENTIAL APPLICATIONS OF RSAC TECHNIQUES

Function	Lead Users	Role of RSAC Techniques
Operational war planning (including contingency planning in crisis)	JCS, CINCs	Multiscenario tests of baseline plans. First-order planning for multiple scenarios. Testing plans developed during crisis. Acquainting new planners with previously learned lessons of strategic dynamics (with assumptions explicit and variations possible). Adjusting plans during conflict to incorporate new information. Anticipating decision points and keeping track of key indicators during conflict.
Policy-level strategy planning for: a. Potential conflicts b. On-going conflicts c. The long-term competition and related arms-control negotiations	SecDef, NSC, SecState	Policy-level analogues to the above items. Testing defense guidance scenarios and contingency planning guidance. Acquainting decisionmakers with possible strategic dynamics; identifying in advance key decision points and potential consequences of alternative decisions; emphasizing the importance of timely decisions. Identifying potential bonus opportunities and spelling out down-side risks. Acquainting officials with real-world constraints and horseshoe-nail problems. Depersonalizing strategy debates and testing alternative strategies.

Table 4.1 (continued)

Function	Lead Users	Role of RSAC Techniques
		Evaluating arms-control proposals' military implications. Evaluating implications of peacetime events and challenges for future conflicts. Identifying critical elements of alliance postures. Explaining strategy to Congress, bureaucracies, and lower levels of military Services.
Policy-level program planning	SecDef (DPA&E)	Testing programmed forces in multiple scenarios. Testing alternative figures of merit and system-analysis paradigms. Testing potential effect of new systems. Testing program balance.
Policy-level research planning	SecDef (USDRE)	Providing illustrative campaign-based frames of reference for potential applications of new technology. Multiscenario testing of concepts. Placing technology options in perspective; i.e., measuring relative importance of different shortfalls and fixes. Identifying current and future U.S. and Soviet vulnerabilities. Making quality-quantity tradeoffs.
Describing trends and balances, including net assessment	SecDef (DPA&E, DNA)	Complementing bean-count assessments by providing campaign-based analyses. Providing more realistic assessments of force postures by emphasizing multiple scenarios rather than programming scenarios; measuring robustness of U.S. and allied postures. Placing asymmetries in perspective.

Table 4.1 (continued)

Function	Lead Users	Role of RSAC Techniques
Joint-Service and joint-nation exercises	JCS	Complementing current command post exercises with multiscenario testing. Sensitizing policymakers, Congress, allies, and military Services to horseshoe-nail and coordination problems.
Developing and testing doctrine	Military Services	Testing Service doctrines in combined-arms context against enemy doctrine. Testing assumptions of doctrine in multiple scenario games emphasizing issues of time.
Training officers in strategy and grand tactics	War Colleges	As in much of above.
Developing and testing theories of deterrence, escalation, and termination	Multiple users	Providing an analytic framework within which to translate theoretical essays into assumptions and explicit value judgments. Testing alternative theories for self consistency and key points of disagreement. Illuminating the shortfalls of partial theories. Providing a display mechanism for phenomena identified in theoretical work. Providing a verisimilitudes testbed for "empirically" testing new strategic theory or concepts (e.g., strategic use of nonnuclear weapons).

Table 4.1 is justifiable and the particular items on the list highly defensible.[1] *In our view, the importance of applications such as those in Table 4.1 are now evident and the real question is whether we can make the RSAC "work."* The RSAC approach uses a framework that should be of interest to all serious students of strategy, be they civilian strategists, program analysts, or military war planners. The issue then becomes one of implementation: Can we solve the difficult technical problems? Can we incorporate an adequate level of detail? Can we comprehend the rules embedded in the games? And, can we absorb and use the large amount of information an RSAC system could generate? If the answers are yes, as we now believe, then it should not be surprising that the list of applications is long.

Even the list in Table 4.1 is incomplete—failing, for example, to point out that each of the military Services has an important role in most joint-staff activities such as war planning. If the conceptual framework and analytic techniques we are developing prove valuable, they will probably be broadly disseminated—not merely by an OPSAC serving multiple users but by the separate organizations creating their own mini-OPSACs.[2] It also seems likely that there will be spinoffs suited to the needs of the CIA, Department of State, and the planning agencies of multinational corporations.[3]

The substantial redundancy in the RSAC techniques listed in Table 4.1 reflects the view that U.S. strategy analysis should be increasingly consistent from organization to organization. The confusing era of the 1960s, in which declaratory, programming, and employment policies were all different, caused trouble that persists to this day. Although it is inappropriate for the civilian leadership to tinker with operational planning below a certain level of detail, it is highly desirable that top-level civilian and military planners have a shared concept of national objectives in the abstract, specific national objectives in a given conflict, the strategic-level options, and the risks associated with the various options. Similarly, it is highly desirable that those concerned with programming (in both the Office of the Secretary of Defense and the military Services) appreciate the full range of potential contingencies, the role of operational constraints, the special prob-

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[1]We do not attempt to explain or prove the applications here; we hope they are self-evident to most readers. If not, the reader will probably find that many of the assertions become more plausible on reading through the next subsection. See also Winnefeld (1982).

[2]An analogue here is the recent proliferation of training-oriented war-gaming facilities in each of the Service war colleges as well as at other locations.

[3]One problem with the spinoffs we foresee will be data bases: Without matched data bases, the different groups will not readily be able to exchange results or discuss issues. An OPSAC would solve this problem.

lems of combined-arms operations, and the danger of suboptimization or optimization for any size scenario.

Is the List Serious?

Given the length of Table 4.1, and the scope of the activities referred to, it is important both to consider whether the applications envisioned are important and to indicate where RSAC techniques might *not* be suitable—again, we wish to avoid the appearance of selling a panacea. Table 4.2 is a subjective attempt to apply the criteria referred to earlier. Table 4.3 attempts to put some of the claims in perspective by distinguishing between plausible and implausible, valid and improper, and reasonable and distorted applications of RSAC techniques.

There are some analogies that can be used in discussing what RSAC techniques can and cannot accomplish. One analogy is to rules of law: The RSAC approach can impose a framework to tighten the standards of evidence and the format of their presentation, but it can neither judge the truthfulness of values nor establish matters of fact. Another analogy is to the scientific method: The RSAC approach can provide a framework within which to state assumptions and test for consistency and logic; it can also encourage free and focused debate and establish standards about clarity and reproducibility; it can even provide a framework for "experiments" that may not predict what would happen in a real conflict, but can establish the implications of alternative assumptions in an orderly manner. To be successful, however, it will be necessary to develop a broad user community acquainted with the approach and its techniques and willing to use it for assessment. This will surely take time.

An obvious question here is whether "all we have is a methodology"—the question suggesting the common view that techniques and methodology are ultimately sterile. This is not the forum for an extended discussion of such issues, but a few observations are appropriate. First, the analogies of law and science immediately suggest the importance of technique and structures for both constrained and creative endeavors. Further, what we regard as "creativity" is closely related to: (1) the ability to correlate and synthesize stimuli from previously compartmentalized domains; and (2) the ability to change frames of reference while drawing partial analogies (a talent related to the first). Finally, recall that the origin of the RSAC was the widespread recognition that U.S. strategy analysis has been badly hampered by a narrowness (and apparent invalidity) of paradigms. Systems that force users to confront the implicit paradigms, to test them with evidence, and to change them as necessary must surely

Table 4.2

A SUBJECTIVE ASSESSMENT OF THE VALUE OF RSAC APPLICATIONS

	Substantive Content	Impact	Feasibility	Practicality	Potential for Troublemaking
War Planning	++	++	++(a)	++	-(b)
Policy-level strategy	++	++	++	?(c)	-(d)
Policy-level programming	+(e)	+(e)	?(f)	?(c)	?
Research planning	+(g)	+	+(h)	?(c)	--(i)
Trends and balances	++	++	+(h)	++	--(j)
Exercises	++	++	++	++	-(b)
Doctrine	++	++	+(k)	?(c)	-?
Training officers	++	++	++	++	-
Theory	++	++	++	?(c)	-

NOTE + = positive effect; - = negative effect; ? = uncertain effect. Example: RASC techniques could have a positive (+) "impact" on research planning and a highly positive impact on war planning. The potential for troublemaking exists for war planning and is high for research planning.

[a]Emphasis on *first-order* war plans.

[b]Danger exists that some users will regard systems as omniscient.

[c]Sensitively dependent upon leadership attitudes and interest in analytic problem solving.

[d]Danger exists if policymakers are shown only a few cases matching their biases. Some may see the system as a tool of advocacy rather than as an analytic tool.

[e]Indirect effects through changes in paradigm: new figures of merit, etc.

[f]Detailed tradeoffs are better studied with more focused models.

[g]Tension: researchers need to be aware of real-world problems but should also pursue subjects for which applications are not yet visible. RASC analyses could probably be very useful for OUSDRE and somewhat useful for DARPA.

[h]Model limitations are currently severe for this application.

[i]Direction of high-technology and basic research should not be finely tuned to *any* models of future conflict.

[j]Improper use of RSAC techniques could produce biased and misleading results. Serious difficulties exist in designing a balanced RSAC experiment and sampling therefrom. This, of course, is true to some extent of all methodologies.

Table 4.3

APPROPRIATE AND INAPPROPRIATE USES FOR RSAC TECHNIQUES

Appropriate Uses	Inappropriate Uses
Drawing out assumptions. Imposing a logical framework. Checking completeness. Checking self consistency and logic. Exploring implications of variations in many types of variable. Pointing out potential down-side risks (or possible bonus opportunities). Providing an integrated summary of strategy issues. Bringing out interrelationships and possible cascade effects. Developing ideas, theories, or plans efficiently, at least to first-order accuracy (by interactive use of RSAC tools).	Proving theories or proving that one strategy is superior to another (results depend on assumptions; techniques can improve quality of discussion, but not establish matters of fact). Predicting detailed flows of events as an answer machine. "Snowing" senior officials and officers (as system analysis did in the early 1960s). Detailed operational planning or tactical war planning. Dealing with peacetime "crises" in which national behaviors are often driven by considerations of short-term politics rather than security alone.[a] Automatically developing ideas, theories, or plans.

[a]The current RSAC is strongly oriented toward superpower confrontations in which issues would not be particularly subtle, however difficult. RSAC techniques could be used to develop decision aids for more typical crises.

have enormous potential for changing the very nature of U.S. strategic thought and debate.

Summary

In summary, then, our conclusions from a tour of the horizon are as follows:

- There are many potential RSAC applications—of use to all groups concerned with the theory or employment of strategy, and to the intellectual environment in which opinions are formed and propagated in a democratic society.
- The approach is by no means a panacea and will require a

level of intensive research and rigorous analysis for which there has recently been little market in the United States.

- There are natural tensions between appropriate and inappropriate uses of the technique. The complexity, facility, and productivity of automated war gaming can either be a boon or a curse depending on the quality of the people involved, the procedures developed for analysis, and *the ethics that emerge for its use* (more on this below).
- A large fraction of the approach's insights come from framing problems, identifying variables, and designing experiments that use the automated system.
- It will be essential to define professional ethics for those using the techniques, and to impose high standards in choosing people with whom they should be trusted. Otherwise, we may see an avalanche of self-serving war-game-based "analyses" that will deluge decisionmakers with incomprehensible contradictions and discredit the approach.

BACKGROUND FOR SOME PROTOTYPICAL APPLICATIONS

As mentioned at the outset of the section, one major objective in the RSAC's FY82 work has been to work through at least one illustrative problem "from beginning to end"—not for the purpose of solving that problem definitively but rather to add concreteness to what would otherwise be an abstract discussion with breadth and imagination but limited depth. The intention was to illuminate the detailed procedures necessary to make the concept work, the nature of the research inputs that would be demanded, and the requirements levied on agent design and system integration. A major issue from the beginning, in the minds of both friendly and hostile skeptics, has been whether it would be possible to handle and digest the massive information a multiscenario analysis could generate. Overall, of course, we hoped to provide ourselves and reviewers with a glimpse of the future—a richer and more substantive picture of what the RSAC program might hope to produce.

Managerial Approach

Designing a work program to accomplish the illustrative analysis while simultaneously developing improved agents, working on advanced designs, and conducting a survey of numerous applications has been a challenge, in part because of the practical tensions involved in moving on the parallel tracks below:

Track 1	Track 2
Build an operational Mark II system (implies making and rationalizing compromises).	Design an ambitious Mark III system (implies avoiding premature compromises).
Develop techniques and methodology (often at the expense of substance).	Define and better understand the actual strategy issues.
Work through specific problems in detail.	Conceptualize at a level of abstraction adequate to assure some generality and elegance.
Use expedients where good models do not exist.	Design better models.
Examine some potential applications in relative detail.	Examine a broad range of applications lightly.

Those familiar with large-scale research and development efforts will appreciate that such an ambitious set of parallel activities guarantees the existence of communication problems and the mixing up of objectives, especially since it has been necessary for most people to work on two or more aspects of the overall effort simultaneously.

Since we expected these problems to be troublesome, we tried to avoid further problems by narrowing the context of applications. We did so by using a modified version of the Defense Guidance Scenario as the baseline around which we would do excursions. Moreover, within that framework we focused largely on the conventional campaign in Southwest Asia and mechanisms for escalation up through general and prolonged war. Although we included war in Europe, various levels and types of nuclear war, and war at sea, we treated most of these at a more stylized level than that used for the Southwest Asia campaign and certain escalation decisions.

This focus is reflected in most of the RSAC documentation (see the Bibliography) and is directly addressed in Winnefeld (1982). Because of system limitations, the illustrative experiments conducted in 1982 were relatively simple and used crude assumptions about force performance, agent behavior, and the options available to the adversaries. Consequently, these experiments represented a period of development between the very modest substantive content in the Mark I prototype system and the high degree of substantive content and policy focus planned for the OPSAC. To illustrate this point, we will examine some illustrative tasking for a hypothetical OPSAC. This hypothetical tasking served (and will continue to serve in FY83) as an organizing principle for much of our thinking about applications.

ILLUSTRATIVE TASKING

MEMORANDUM: LIST (including CJCS, USDP, USDRE, DPA&E, etc., and also the Director of the OPSAC)

FROM: THE SECRETARY OF DEFENSE

SUBJECT: NATIONAL SECURITY PLANNING FOR POTENTIAL CONFLICT WITH THE SOVIET UNION IN THE PERIOD 1983-1990

PREFACE: In NSC XXX, which I have recently received, The President expressed his conclusion that this is an appropriate time for the Department of Defense to conduct a broad-reaching study on our overall military strategy with respect to overt conflicts with the Soviet Union (the problem of the long-term competition during peacetime will be dealt with elsewhere). He has requested a major study of the subject, a study that will focus on pragmatically rank-ordered corrective measures directly tied to operational needs should deterrence be tested or fail. Although nothing is ruled out a priori, NSC XXX reminds us that the study should recognize that it is current policy to address issues of strategy readiness, modernization, and joint actions with our allies before considering major expansions in U.S. force structure beyond those already planned. I have decided that the study will be conducted by a steering group under the joint direction of a representative of the Under Secretary for Policy and a representative of the Chairman, Joint Chiefs of Staff. All addressees should assign a representative with the rank of Lieutenant General or its equivalent. The study should make extensive use of the capability for multiscenario analysis possessed by the new Strategy Assessment Center, which, in turn, should give this study its top priority over the next year. The following terms of reference apply; major contributors are indicated in parentheses, with the first-named having lead responsibility.

1. Assume, for the sake of analysis, that at some point within the next five years, the Soviet Union seriously contemplates overt military aggression in Southwest Asia. Assume that the United States intends to protect vital interests of the Western Alliance in that region, notably assured access to Persian Gulf petroleum under noncoercive conditions.

2. Although emphasizing deterrent-related strategies, assume the potential exists for deterrence to fail, for regional conflict to spread (perhaps even by our own choice), and for the ultimate result to be general and prolonged nuclear war. Use the scenarios of Defense Guidance FY83-87, extended to include nuclear war, to formulate baseline scenarios from which to work excursions.

3. Conduct a range of campaign analyses to gain insight about probable and other plausible military strategies the Soviets might consider. These cam-

paigns should address the initial aggression in Southwest Asia, war with NATO, and prolonged war in which nuclear weapons are used.(OJCS)

4. For each Soviet campaign strategy so identified, develop illustrative first-order plans for U.S. and allied counterstrategies. These should be executable, but need not be efficient; they should include enough detail for policy analysis, but should typically deal with generic types of forces, aggregated measures of mobility, etc.; they should include more detail (e.g., on specialized support-force shortages) when doing so is necessary to illuminate a limiting factor on which action is desirable. (OJCS)

5. Extend the analysis to include, for both U.S. and Soviet strategies so identified, identifying predictable decision points regarding employment options, rules of engagement, escalation, and changes in military strategy (to exploit opportunities or to cope with setbacks). It is anticipated that the analysis should produce qualitatively perceptive information on such matters even though it will not be possible to predict timelines or sequences of events confidently except in special cases. The principal objective is to identify the range of contingencies with which the U.S. may have to deal, identify the types of decision that the President and senior civilian and military advisers may be asked to make, and to suggest ways of preparing that do not tie us to any one or a few detailed scenarios. (OJCS/PA&E)

6. Identify the key variables that would probably determine Soviet strategy, the U.S. response, and the resulting flow of events. These will include both political and military factors (e.g., timelines for access to bases and active cooperation by regional or out-of-region allies, performance of mobility and combat forces, mobilization rates, and the results of individual battles). The purpose here is to go beyond usual studies and to discuss the factors over which we have relatively little control or on which we have little information; these factors involve both "scenario variables" and technical issues. (OJCS/PA&E)

7. Subsequent to completing the above, recommend measures to improve the likelihood of U.S. success—in achieving deterrence if possible, and in achieving the best possible results should deterrence fail. The recommendations should address separately the following types of measures:

a. Near-Term Political Initiatives (OUSDP/OJCS)
b. Near-Term Operational or Program Measures (OJCS/PA&E/Comptroller)
c. Mid-Term Political Initiatives and Changes in Mid-Term Political-Military Strategy (OUSDP/OJCS)
d. Mid-Term Program Initiatives (PA&E/OJCS)
e. Fast-Track Research and Development Initiatives (OUSDRE/ OJCS)
f. Longer-Term Research and Development (OUSDRE)
g. Near- and Mid-Term Initiatives for Political Action (to include covert activities) and Intelligence Collection (OUSDP)

The initiative suggested should include, as appropriate, feasible actions by our allies—to include changes in NATO force levels and the allocation of efforts.

8. Prepare a report suitable for more general distribution on the results of the study expressed in terms of military balances and trends.

9. Given the breadth of the overall tasking, I anticipate that the study should require approximately one full year. However, I would like to receive a progress report, along with interim conclusions, options, and recommendations, in six months.

Such tasking would be difficult to imagine today, and even if it were issued, it would be difficult to respond to because of the many variables, the limitations of current analytic tools, and existing mindsets. Note particularly that the tasking *elicits* information about variables and decision points rather than specifying a long list of policy-planning assumptions (e.g., assume that our NATO allies will respond favorably to U.S. requests for. . .). Our hypothesis is that the tools under development in the RSAC would be very powerful in response to such tasking. In particular, they could make it possible to efficiently elicit and organize operations-oriented military judgments with major consequences for strategy and diplomacy.

RESPONSE OF OPSAC TO HYPOTHETICAL TASKING

Let us now consider the problems that would be seen by the postulated OPSAC as it prepared to respond to the Secretary's tasking under the guidance of the working group. It is essential to recognize that the OPSAC could not plug the problem into a black-box model and await printouts or video displays of wisdom. Instead, it would be necessary to go through a long sequence of staff efforts. Figure 4.1 illustrates the likely initial sequence, at least as best we can judge from our experience (see, for example, Winnefeld, 1982)

The flow chart has managerial and substantive significance, because in practice no one person or natural grouping of people can do the full range of research necessary to respond to the postulated tasking. A range of skilled people—from modelers and related programmers to highly specialized Sovietologists—would be required. The task of designing experiments to respond to the tasking must be accomplished by someone with an understanding of the whole: the policy issues, the technical capabilities (and limitations) of the assessment center, and the quality of the rules and specialized models developed for the particular problem.

In our illustrative application at Rand we did not adhere rigorously to the flow chart, partly because we were feeling our way, and partly because we do not currently have sufficient staff to separate out the

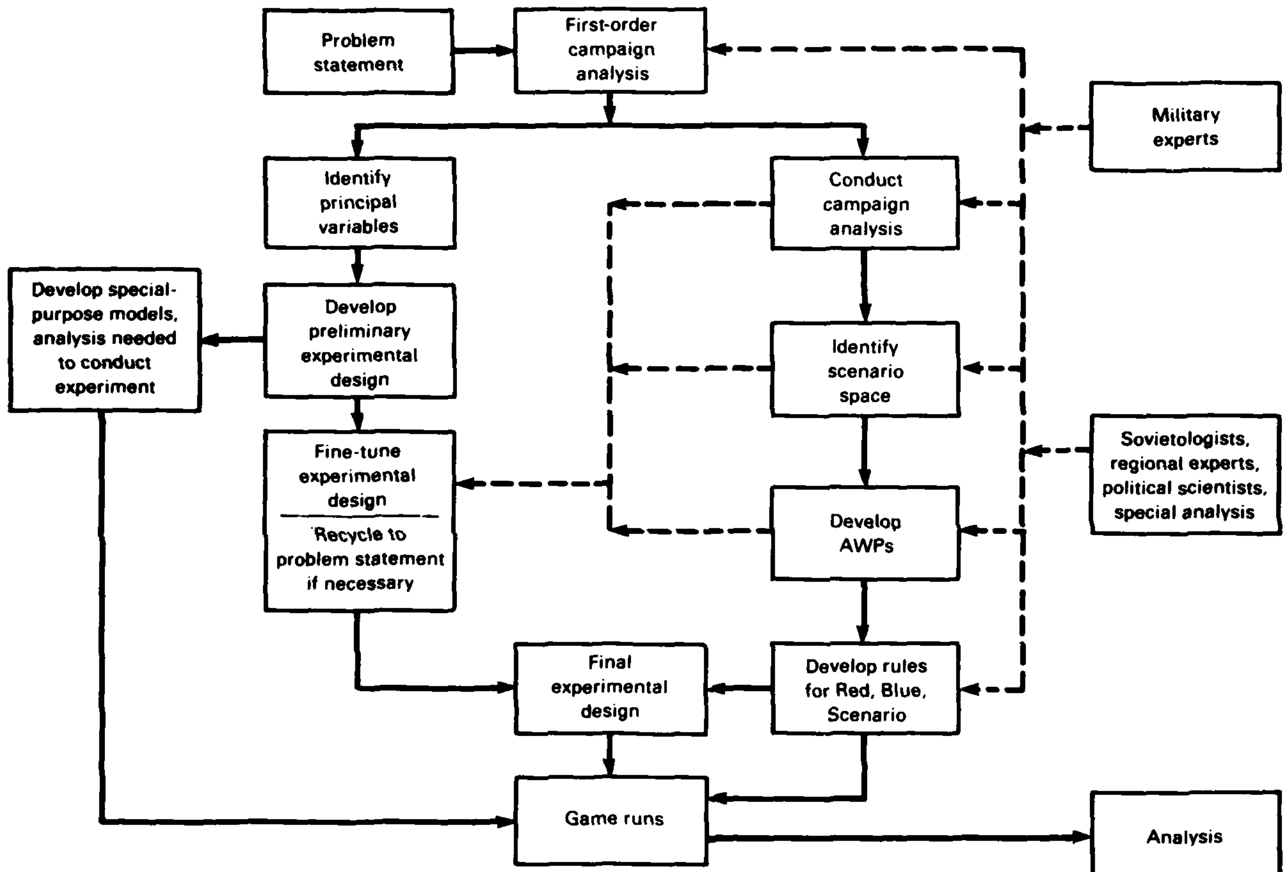

Fig. 4.1—OPSAC activities in response to postulated tasking

many functions. So, for example, one small team did a large fraction of the work on both campaign analysis and the development of AWPs, rules, and experimental design. Fortunately, however, we were able to draw upon a substantial literature that included intelligence-community judgments on Soviet doctrine and probable strategies.

The results of some of our illustrative experiments are described in Winnefeld (1982). We did not perform enough runs to develop finely tuned conclusions; nor did we use precise data or sophisticated models. The purpose was to provide an image of future capabilities and utility rather than to answer deep questions of strategy. We expect to address the substantive issues in more depth beginning in the fall of 1982, including strategic-nuclear issues.

PREPARATION FOR ANALYSIS

Our experience so far shows that there appears to be a good deal of commonality between RSAC experiments performed for different types of users. We anticipate that an OPSAC would require most of the same measures of effectiveness and variables treated below, possibly some additional ones.

Measures of Effectiveness

It is useful to distinguish explicitly among three generic measures of effectiveness suitable for analyzing results of RSAC war game experiments:

- Deterrence: Was the Soviet Union deterred from initiating the aggression or from pursuing its more ambitious objectives?[4]
- Escalation Control: Was the United States able to contain conflict to regions or levels desired and able to escalate effectively when circumstances demanded?
- War Fighting Effectiveness: How well do the United States and its allies come out, in terms both of static outcome (possession of territory, independence, relative military strength) and price (casualties, alliance cohesiveness, na-

[4]We emphasize that deterrence is not an all-or-nothing proposition. As the RSAC war games demonstrate, there are numerous opportunities for one side to deter the other from continuing or escalating the conflict. The success of deterrence depends on real and perceived capabilities and intentions, the position on the escalation ladder, and the history leading to that position.

tional cohesiveness, etc.)? In other words, did the United States achieve its objectives?

Note that there is in all of these measures of effectiveness some mention of dynamics—it is important not only to know where the war game ends but how the end result developed (in part because in some cases the war games are more reliable in providing insights about "strategic dynamics" than they are in their detailed predictions of outcomes).

The Variables for RSAC Experiments: Heading Off Combinatorial Explosion

In responding to the postulated tasking, the OPSAC director would be faced with a problem replete with variables of all types. Table 4.4 suggests the variables that might be insisted upon by the diverse working group assigned to the study.

All the numbers in Table 4.4 are subjective, but they are sufficient to illustrate the potential for combinatorial explosion. Indeed, without some restraint, analysts could demand even more variations in each category. Instead, we assume there would be a major effort to limit the variables. Given the hypothesized tasking that made no mention of tradeoffs between military Services (e.g., divisions versus aircraft carriers), it is not unreasonable to assume that the working group's approach to force-structure issues would be to tie them to budget levels and assume that higher budgets would allow proportional increases in all Service programs. Under this assumption, the minimum number of force variations might be as modest as shown; the working group would have to develop a programmed force and two larger forces reflecting higher budgets.

The fundamental question that arises with each set of variables is whether they must be varied independently or whether it is reasonable to assume correlations. As we mentioned above, in *some* studies it is reasonable to assume that force structures will merely be scaled up or down; in others it is most decidedly not appropriate. In considering possible Soviet behavior relevant to strategy-level issues, it is easy to identify about a dozen potentially important descriptors with values that could be varied independently. In Table 4.4 we have assumed, however, that for planning purposes it is possible to construct two to four Ivans that represent an adequately diverse but plausible set of behaviors. For example, we consider Ivan 1 to be somewhat adventurous, risk-taking, and contemptuous of the United States. We assume that Ivan 2 is generally more cautious, conservative, and wor-

Table 4.4

INDEPENDENT VARIABLES FOR THE OPSAC EXPERIMENTS

Variable	Approximate No. of Values: Minimum	Approximate No. of Values: Preferred
Initiating scenario	1	4+
Soviet behavior (Ivan)	2	4
U.S. behavior (Sam)	2	4
Allied behavior	2	8[a]
Regional-state behavior	4	8[a]
Force capabilities	3	100[b]
Battle outcomes	20	100[c]
Miscellaneous (weather, acts of God, etc.)	3	10
Total	5760	410,000,000
Total holding forces constant	1920	4,100,000
Total holding forces constant and using best estimate battle outcomes	96	41,000
Total using best estimate non-U.S. behaviors and battle outcomes	18	16,000

[a]Some distinctions must be made among countries, since they do not all act as blocks (e.g., not all NATO nations would be likely to respond equally fast or decisively to crisis).

[b]In principle, one would want to vary independently the levels and modernization of ground, air, sea and nuclear forces, and, within each class, to vary independently certain types of forces to establish tradeoffs (e.g., ratios of light to heavy divisions).

[c]For each type of critical engagement (e.g., air-to-air combat in the Central Front) there are major uncertainties about battle outcome—uncertainties involving weapon-system performance, details of the scenario, and human factors. These can be as important as the more obvious scenario variables.

ried about U.S. responses and capabilities. Obviously, there are many complex combinations not captured. The justification for the smaller set is twofold: The attributes are not in fact independent—adventurous people or nations often tend to be risk-taking as well, and to underrate, or otherwise misjudge, their adversaries. Also, we suspect (but cannot yet prove) that if we can choose a few appropriate Soviet behaviors, they will be sufficient for a much broader range of circumstances.[5]

From Table 4.4 it appears that some control over combinatorial explosion is possible for particular studies, although not all participants will be able to have all of their particular interests explored in the detail they would like. Even the "minimum" number of war game experiments appears large nonetheless. RSAC experience to date suggests that a typical war game may require ten moves and perhaps half a working day with the Mark II system; although the Mark III system will be far more efficient in many respects (e.g., possibly faster by a factor of ten in Scenario Agent decisions), it will also involve more sophisticated agents and contexts. Thus, it is premature to hope for game rates much greater than perhaps two to four per day.

This does not mean, however, that the time required for an OPSAC analysis would be the number in Table 4.4 divided by two to four. At least three factors will mitigate the problem, to a degree we cannot yet judge accurately:

- Excursions are faster than full game runs.
- Results of some war games can be written down by inspection—i.e., without running the games—after building up a set of actual game runs.
- It *should* be possible, for some purposes, to sample the variables.

We do not yet have enough experience to make reliable estimates on these matters, but it is surely not unreasonable to expect that the first two short-cut techniques could reduce total game requirements by a factor of three. The last item is more subtle. Suppose, for example, that the output of OPSAC war games is to approximate an overall net assessment of how the United States would probably fare in a real-world conflict comparable to that described in the terms of reference. For that purpose, it would be interesting, and perhaps not even wildly unrealistic, to assume that the various scenarios resulting from the experiments suggested by Table 4.4 would be more or less equally probable, and to construct bargraphs showing the distribution of likely outcomes. With sophistication, one could begin to weight some variable values more heavily than others (e.g., to place relatively more confidence in a best-estimate of allied behavior than in any of the various excursions). This, of course, would be dangerous and might end up eliminating information. On the evidence, it appears that ex-

[5]We do not merely use a worst-case Ivan because there is no single Soviet behavior that would be worst in all circumstances; furthermore, if we were forced to use a single behavior for the Soviet Union (as is often done implicitly in analyses), it is likely that subtle constraints or biases would make it a poor single choice—neither a best estimate nor a worst case, but some peculiar hybrid.

perts are not very good judges of the likelihood of events they consider to be relatively unlikely.

It is not necessary to resolve these difficult issues here, but it is worth noting that where the cases suggested in Table 4.4 can be treated as equally valid, then Monte Carlo sampling would also be feasible, in which case the number of necessary system runs could be cut by factors of three to ten. One type of output might be something like Fig. 4.2.

The implication of such an output would be that, in effect, the U.S. force posture is extremely tenuous. In more than 50 percent of the scenarios generated by the experiments, there was war between the United States and Soviet Union and an outcome that, from the U.S. perspective, could hardly be deemed good.

Next, suppose we considered the analogous results with one difference: a hypothetically altered force structure with a larger Rapid Deployment Joint Task force (RDJTF) or a greatly enhanced strategic mobility. The dashed line in Fig. 4.2 suggests enhanced deterrence and the probable outcome should deterrence fail.

There is no reason to expect a result like this to be predictively accurate, and it is unlikely there will ever be empirical data to test it. However, following time-honored tradition, it would still be possible to do useful sensitivity analysis—i.e., to develop a series of such plots under a range of assumptions. For example, if one were to generate the corresponding plot for the set of experiments in which the Soviet Union was represented by Ivan 2 (the more conservative Ivan), we would expect to see a dramatic shift—a much larger fraction of the scenarios ending up favorably for the United States, with the Soviets altogether deterred. On the other hand, if we generated the frequency chart for the set of scenarios in which Ivan 2 did cross the border into Iran, we might find that in a surprisingly large fraction of the cases war occurred and escalated in spite of Ivan 2's conservatism. A more discriminating analysis might show for example, that a combination of Ivan 2 and Sam 1 might produce a bimodal distribution of results: Either the Soviet Union would be deterred at the outset or would make a mistake and quickly become engaged in war because of Sam 1 pushing too hard and too quickly for Ivan 2 to draw back from the slippery slope of escalation.

Again, let us emphasize that we are not claiming that the RSAC is now or soon will be able to produce such graphical summaries in a predictively valid way. Indeed, misused, such plots could be quite dangerous—as can the results of most analysis. Nonetheless, we envision that such plots could be extremely useful for sensitivity analyses and for showing policymakers and senior military planners the potential

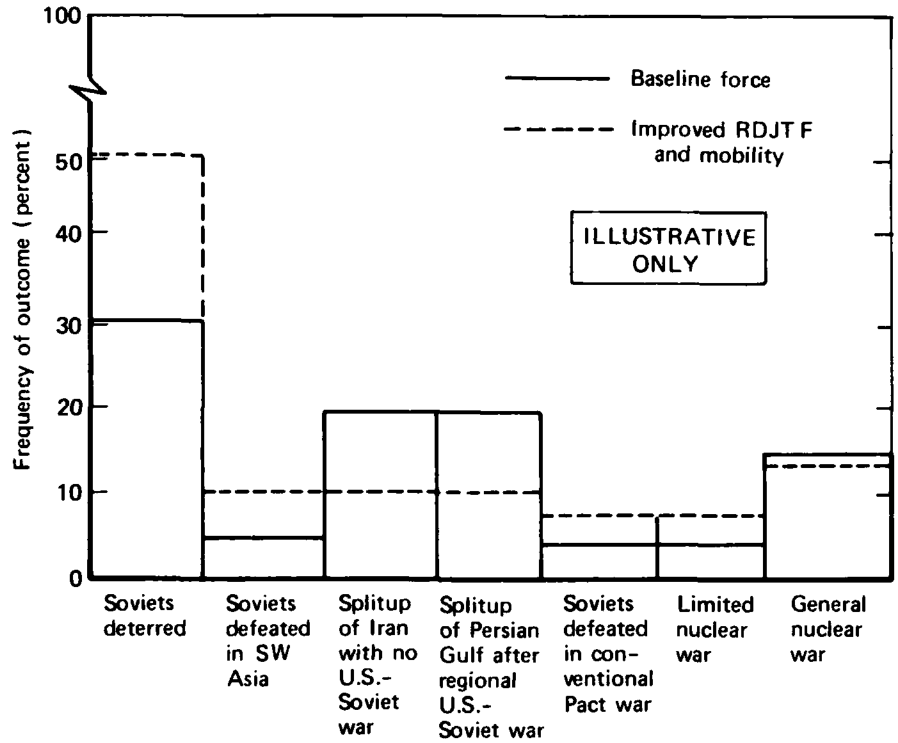

Fig. 4.2—Frequency analysis of multiscenario simulations

implications of decisions under a variety of assumptions.[6] Since any "statistical analysis" would be controversial, consider, briefly, the implication of eschewing such frequency plots because of the fear of criticism or the fear that the plots might be taken too literally. To describe results of analysis with, for example, an augmented RDJTF, it would then be necessary to write lengthy paragraphs saying: If... and... and..., then...; on the other hand, if... then...; and.... In effect, it would be necessary to trace through the same information as would be conveyed by the graphics but in an incomprehensible manner. Our conclusion, then, is that such plots will be essential to bring out results of multiscenario analysis.

[6]Such analysis could also shed light on the potential effect of inconsistent decision-making which, in some cases, could lead to errors and escalation, and which, in other cases, might confuse and stall the aggressor.

UNDERSTANDING STRATEGIC DYNAMICS

One of the most evident benefits of RSAC-style analysis is that it provides a framework for identifying, discussing, and learning to prepare for critical real-world decisions that could have important ramifications—e.g., decision points involving commitments of tripwire forces; forces with important missions in other regions; or operational reserves; or, in a different realm, decisions involving escalation. It forces the generalist to confront specific assumptions and critical details and the technician to confront the underlying context and relevance for his calculations.

As a practical matter, in developing the AWPs that are the building blocks of RSAC exercises, we construct heuristic escalation ladders and related ladders of time-ordered events allowed by the models. We find that the process of doing so is itself quite valuable in improving intuition about strategic dynamics,—primarily because it forces us to confront action-reaction phenomena—phenomena occurring not in a two-person game but in an n-person game (United States, Soviet Union, and third parties).

V. DEVELOPMENT OPTIONS

> The development contractor should keep in mind that military officers and DOD civilians will be eventual users of this new approach, not specialists in research organizations. The conception and development will be carried out...over a period of several years, but when the tools are ready, an appropriate government location will be designated to house and operate them for use by the government. The contractor will manage the transition of the developed capabilities back into the government and may be requested to continue development of any advanced analysis modules that are still required.
>
> —from a letter issued by the
> Defense Nuclear Agency
> dated 7 November 1979

IMAGES OF AN OPERATIONAL STRATEGY ASSESSMENT CENTER (OPSAC)

As the original statement of objectives made manifest, the DoD intended the work currently ongoing in the RSAC to culminate in an *operational* center—within the U.S. government and with access to information on forces, intelligence, and sensitive policy issues. The reasons for this are obvious, although as discussed below, it may or may not prove desirable to follow the original concept precisely. In particular, it may prove desirable instead to establish a new government-controlled contractor-operated facility or to constitute something analogous to the relationship of the old Weapon Systems Evaluation Group (WSEG) and the Institute for Defense Analyses (IDA) as it existed in the 1960s. If the OPSAC were a fully in-government operation, it might be attached to existing organizations such as the OJCS' Studies, Analysis, and Gaming Agency (SAGA) or the new groups under the National Defense University concerned with strategy analysis, war gaming, and logistics. However the issue of OPSAC location is resolved, the need for special "inside" access to issues, information, and decisionmakers is fundamental to the concept. Clearly, the OPSAC staff should work for OSD or OJCS, not individual Services and should be jointly controlled by the OSD and the OJCS (or possibly OSD and the Chairman, JCS).[1]

[1]As discussed in Sec. III, we anticipate separate use of RSAC techniques by staffs of the military Services, CINCs, and war colleges.

The issue of an OPSAC will become increasingly important as the RSAC's efforts begin the transition from conceptual work and exploratory development to the full-scale development intended for FY83. Although it is not necessary to define the location and composition of an OPSAC yet, it *is* necessary to think about generic OPSAC requirements, the scale of effort that will be involved in its operations, and the long-lead-time aspects of creating an OPSAC.

In this discussion we assume that the OPSAC's organizational location will allow it to be responsive to tasking by the Office of the Secretary of Defense and the Office of the Joint Chiefs of Staff. It might also be indirectly responsive to requests by the military Services and the Commanders of the unified and specified commands, but probably the requests would funnel through OSD and OJCS.[2] Figure 5.1 displays one possible set of organizational relationships between the OPSAC and other elements of the national security community. With details dependent on its degree of "in-houseness," the OPSAC would be assigned physical space, manpower spaces, equipment (primarily computers and display systems), staff, access to data bases, operational software, a tasking system, and housekeeping and budget support. We will examine these in turn. First, however, let us consider a conceptual architecture.

The OPSAC's business will be to examine national security problems such as those suggested in Sec. IV. Figure 5.2 illustrates schematically how a given problem might be addressed. The concept behind Fig. 5.2 focuses on three elements in the analytic process:

1. Preparatory activities including problem definition, choice of approach, experimental design, and gaming preparations.
2. Detailed research and data collection (i.e., campaign analysis, development of specialized models, preparatory war games with human teams, a review of the behavior rules and behavior patterns to be ascribed to the various countries, and the gathering of all source data relevant to the analysis).
3. Analysis of experimental results and other sources of relevant information (to include developing summaries appropriate for review by top-level civilians and military officers that might include the pros and cons of options, "net assessments," and rank-ordered action items).

[2] As mentioned in earlier sections, we hope that some of the RSAC's technology and conceptual approaches will be picked up separately by the Services and CINCs. Although we focus on the issue of an OPSAC here, it would be in everyone's interests if similar tools were more widely available.

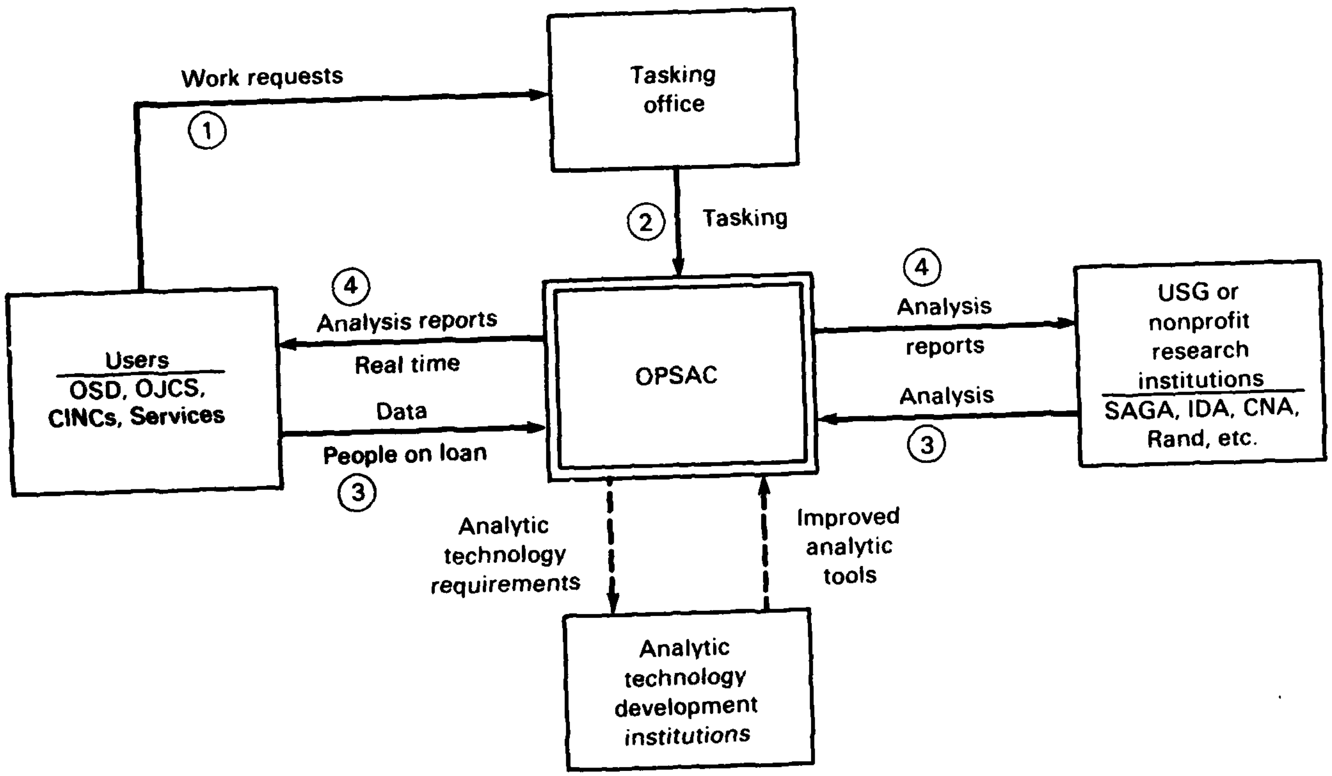

Fig. 5.1—Possible OPSAC organizational relationships

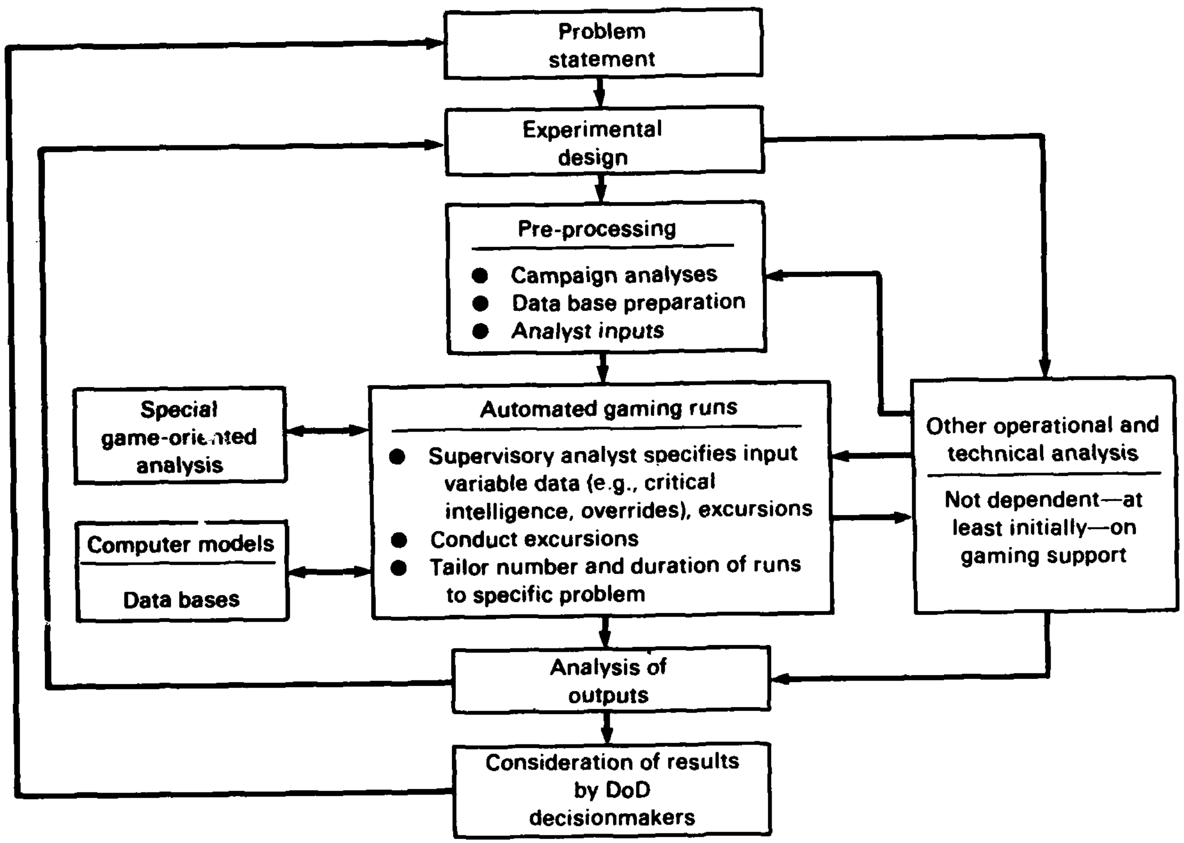

Fig. 5.2—Conceptual architecture of an OPSAC

It is especially important to note that we see automated center operation as an organizing principle for a broad range of research and analysis of which the actual RSAC or OPSAC exercises are merely one (albeit an important) element. If the OPSAC's character were merely that of a computer center, the concept would fail for lack of substance. If the reader envisions a hand-over of an answer-machine that could be used in isolation, let that vision be hereby dashed. Nearly every problem will be somewhat different from its predecessors, and nearly every analysis will require the assistance of experienced analysts to review behavior rules, force models, and the like. To be successful, the OPSAC will have to borrow freely from the best analysis available within the national security community; its principal and unique role will be that of providing an *integrating framework* with a broad view, "inside" position, and minimal parochialism.

STAFFING AND SUPPORT

Staffing

Staffing for the OPSAC will depend strongly on the OPSAC's relationship with other organizations, including research institutions. In our discussions we have found major disagreements about the extent to which the OPSAC could be self-contained within the U.S. government. One view holds that it would be better to have a government-controlled contractor-operated center that would improve prospects for continuity and the attraction of top-quality professional analysts (including, for example, visiting Sovietologists). Holders of this view doubt that the DoD will take the steps necessary to create a new organization with large numbers of top-quality staff and privileged access. They also argue that their version of an OPSAC might more easily be able to deal with existing line and staff organizations than would an OPSAC in potential competition with them. The other view (reflected in the original request for proposals) holds that the OPSAC should be self-contained except for "major" research efforts such as design of large models or large-scale specialized research. It argues that no nongovernment organization could have the necessary access to intelligence and other information; also, that to be effective, the OPSAC should be *tightly* coupled to military line organizations and top-level Secretary of Defense advisors. Holders of this view point out substantial related activities at the National Defense University and within the OJCS (i.e., the Total Force Capabilities Assessment).

With this background of disagreement, let us now consider requirements for a relatively self-contained government OPSAC. Whether or not these are the "right" choices, they set upper-bound requirements.

Figure 5.3 shows an illustrative organizational chart which, although sketchy, represents most of the necessary functions and manning levels for an in-government OPSAC. We envision a need for the following:

- *Directorate* consisting of about three senior personnel and some special assistants. To provide institutional weight, the Director should be at least a one- or two-star general officer if military, or a Senior Executive Service (SES) civilian with Deputy Assistant Secretary status. He might report to the Under Secretary of Defense for Policy (USDP); or jointly to the USDP and Chairman, Joint Chiefs of Staff; or through some other scheme. Although continuity would be highly desirable and partisan ideology lethal, it would be essential that top DoD leadership have full trust in this individual. The Deputy might also be Director for Research, and should be a career SES civilian or a general officer on long-term assignment.
- An *analysis staff* with six or more senior analysts with backgrounds in military operations, operations research, and strategic system analysis. Grade levels could vary from GS 12 to SES, and from O-3 to O-6, with emphasis on the GS 15 and O-5 level. We assume that the Director and Deputy Director for Research would be involved personally in the analysis.
- An *operations cadre* with five to eight junior or mid-level personnel with a mix of programming and support of military operations as background. They would operate the automated gaming system, maintain data bases, and perform simple data analysis and programming for the analysis staff. Typical grade levels might be GS 9-12.
- A *modeling and programming cadre* with four to eight mid-level personnel unless advanced modeling and programming were contracted out. This may be a minimum figure.
- A *special studies staff* would be essential if the OPSAC were to be largely self-contained. It might include, for example, two Sovietologists, two historians, and two experts researching possible changes in military operations. Some of these positions might be filled by Visiting Scholars—both military and civilian. It is also possible that additional visitors might be attached from CIA, DIA, one or more of the Service doc-

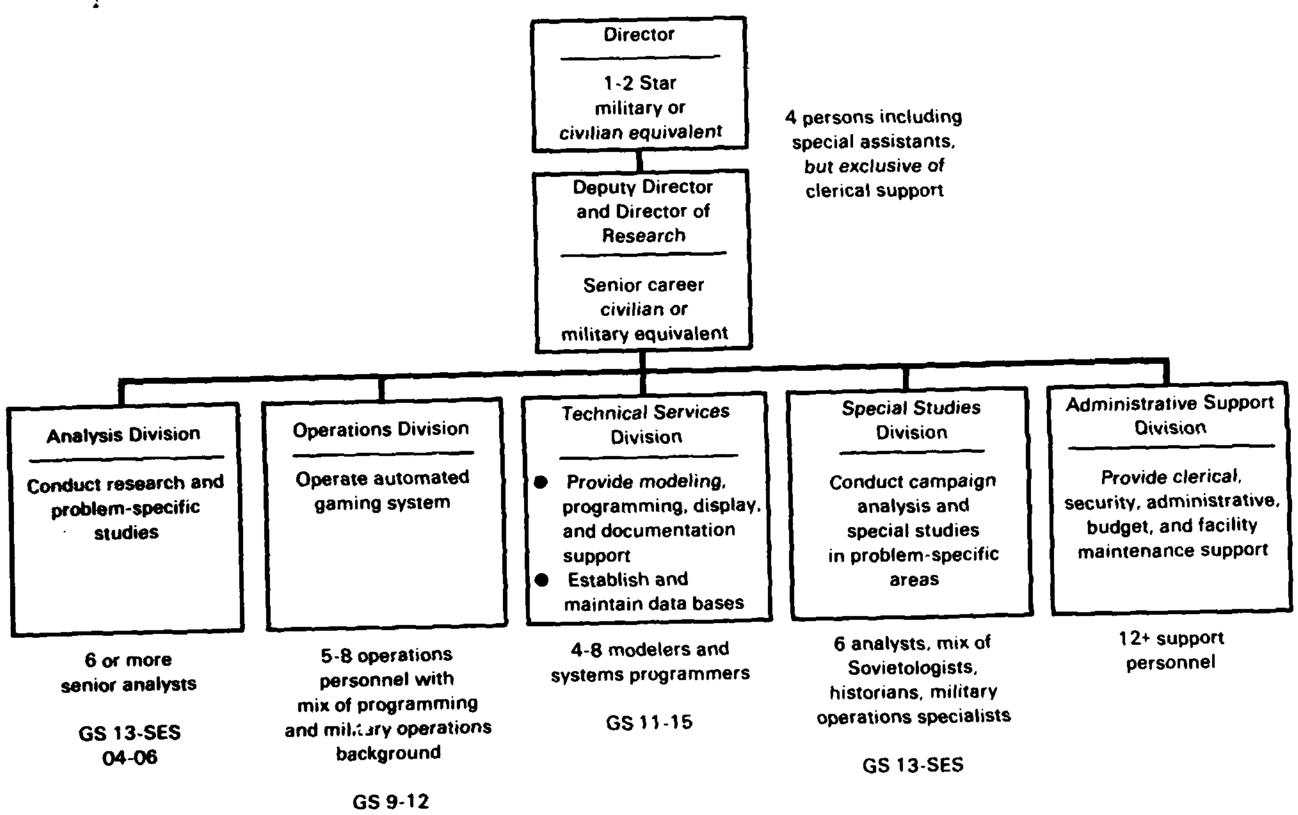

Fig. 5.3—Possible organizational chart for an OPSAC within the U.S. government

trine organizations, or close U.S. allies such as the United Kingdom. As a minimum, we would expect this staff to include about five top-quality personnel. Grade levels would vary from GS 14 up through SES. If the higher grades were not available, it is unlikely that appropriate people could be recruited.

- *Technical and administrative support* could easily involve about 12 personnel, even if the OPSAC were provided security and custodial services.

In summary, then, we estimate that a relatively self-contained OPSAC will need about 35-50 personnel with a possible breakdown by grade as follows:

- One to two flag-rank officers and four to six SES civilians.
- 15-25 mid-level civilians or officers (e.g., GS 15 or O 5-6).
- 13-25 clerical or junior personnel.[3]

These estimates are suggestions only; the real requirements for grade levels will depend strongly on market forces at the time.[4] Currently, however, we see little prospect for attracting and holding programmers and modelers of requisite talent if salaries and grade levels are low.

It is difficult to estimate personnel requirements for a less self-contained OPSAC, e.g., one consisting of a small government contingent at the top and a government-owned contractor-operated facility. Total numbers of people would, of course, be comparable. However, many of the contractor personnel might be jointly paid under the OPSAC and other research contracts, especially if the OPSAC's location and the contractor's total structure made it physically convenient to do so. The obvious models for such a government-contractor relationship include the old WSEG-IDA coupling, the numerous government and federal contract research center relationships, and other similar models in which the contracts are on a level-of-effort basis and the contractors are constrained from certain types of conflict of interest.

As noted earlier, there are several possible in-government alternatives to a self-contained OPSAC. In particular, it might be possible to attach the OPSAC to the SAGA in the OJCS or to the National Defense University, which is currently building separate groups for work on strategy, war gaming, and logistics. Whatever arrangements were developed, joint control by OSD and OJCS (or, perhaps, the

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[3]Our estimates do not include the additional civilian and military personnel from user offices that we would expect to participate on an ad hoc study-specific basis. It does assume, however, that most of the analysis would be done by the OPSAC staff with the additional personnel contributing but not leading.

[4]The staff requirements listed are roughly double Rand's current level of effort with the RSAC.

Chairman, JCS, if recommendations of retired Chairman General Jones were followed) seems likely.

Support Requirements

The OPSAC staff would require support from a highly capable computing system, perhaps built around one or two units such as the DEC Vax 11/780 or 11/790. The OPSAC facility would have a control room with an array of video displays (including electronic mapping) for the use of the supervisory analyst and the operations staff. It might have an observation booth with the necessary video repeaters and other displays for visitors. Two additional rooms with display equipment would serve the needs of human-player teams. Top-quality printing equipment would be essential in dealing with the masses of data and the need for specialized hard-copy displays of multivariable results.

Some or all of the facility would have to be able to process Top Secret and Sensitive Compartmented Information, including information currently withheld from contractors. It would also be important to have a secure link to key contractors if the OPSAC were not self-contained. Similar links could be provided to remote sites (e.g., the CINCs).

PLANNING FOR FUTURE DEVELOPMENT

Stepping back from this vision of the future, we need to assess where we are now (the subject of Secs. I-IV) and to outline options for development over the next several years. The principal tension in this planning effort is the desire, on the one hand, to promptly exploit the system's promise, and on the other hand, the desire to achieve, demonstrate, and test much of the system's technical potential before freezing the design and moving toward an operational configuration.

Fortunately, the Mark II system is now operational and appears adequate for analysis of some strategy issues in FY83. This suggests to us that it will not be too difficult to work simultaneously on selected strategy issues and advanced development of a Mark III experimental prototype system. Furthermore, there will be some distinct synergisms possible, since Mark II operations reveal many of the integration problems that must be resolved efficiently in the Mark III system and allow us to test out concepts as they arise. As discussed in Sec. IV, managing such parallel efforts is a challenge, but in this case we believe the advantages clearly outweigh the disadvantages.

Even though we feel that most of the concepts and general design requirements for Mark III will soon be in hand, it is less clear at what pace we should push the Mark III development and testing, or the subsequent phase in which we reprogram the Mark III system for smoothness, efficiency, user-friendly links, and refined displays. The initial version of the Mark III system will still have glitches, and it is difficult to predict how quickly we will converge to what appears to be an appropriate point for a design freeze. Prudence would seem to argue for a testing period of perhaps a year during which the Mark III prototype would be directly used for strategy problems. In a similar vein, it is unclear how quickly the government could arrange for the facility, personnel slots, funding, or contracts required for an OPSAC. Thus, on balance, *we conclude*:

- Advanced development should proceed at a measured pace such as that suggested in Fig. 5.4, with the Mark III prototype tested in applications during FY84. The OPSAC IOC would probably be in early FY86, by which time there would have been several years of applications work with interim systems and transitional organizational arrangements.

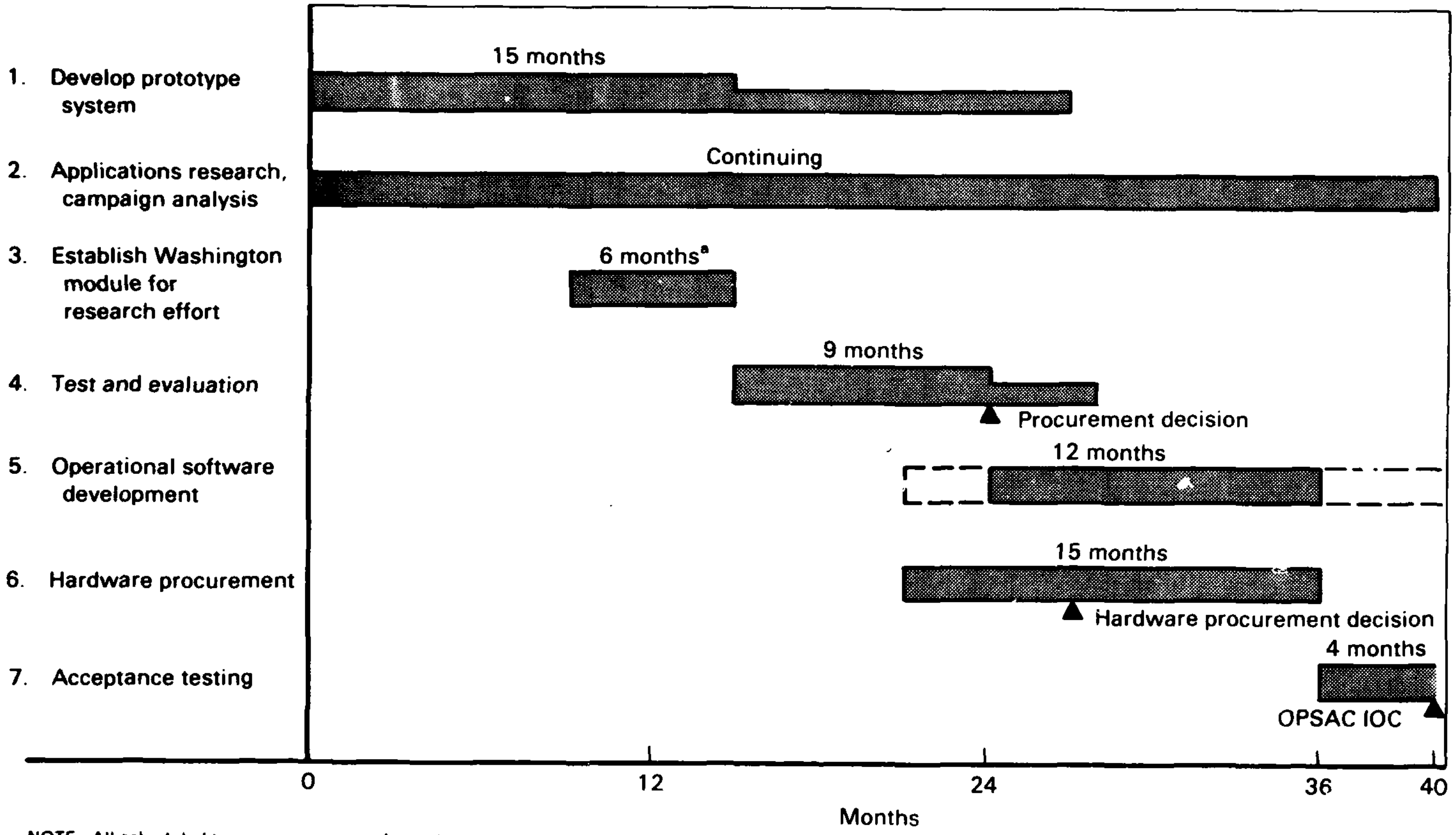
Mark III: An Experimental Prototype

The task here will be for Rand to build a functional Mark III system with research-quality models, programs, and documentation. By the end of the first year, we *estimate* that the Red and Blue Agents will be 80 to 90 percent complete, the Force Agent and Campaign model perhaps 70 percent complete, and the Scenario Agent essentially fully complete.[5] The system will be ready for operational testing, but some components will lack some modules and capabilities intended for the first OPSAC system. The Force Agent overall design should be complete, but there will still be numerous areas in which the quality of the force modeling will be lower than what could be achieved in time with additional research (including calibrations with more detailed models and human-intensive war games). In the early period, we expect the Force Agent to rely heavily on parametric models with little detailed simulation. Some advanced displays will have been demonstrated, but full development of displays will await the second year of development.

We can emphasize that estimates of development times for system software have been notoriously optimistic.[6] On the one hand, we

[5]The percentages deal with technical structure, research (not operational) software, and baseline rules and models. Obviously, there will be many opportunities for more detailed research on the rules and models in subsequent years.

[6]Brooks (1979).



NOTE All scheduled times represent prudent minimum.

[a]Shows establishment only. Washington module would be used to support applications and OT&E.

Fig. 5.4—OPSAC development schedule

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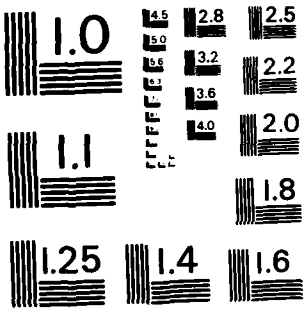
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estimate we can produce a useful experimental prototype as early as late FY83 or early FY84. On the other hand, we cannot be certain what fraction of the concept's potential will be captured in that system, nor whether the development period should be precisely that shown in Fig. 5.4.

Supporting Research

As repeatedly emphasized, the RSAC system is a framework within which to imbed the best information and models available, but it is not an autonomous answer-machine. Supporting research will be extremely important and should begin in earnest as soon as possible because of the time required to accomplish it. The majority of our effort will center on campaign analysis to develop:

- Analytic war plans and building block scripts.
- Decision rules for the Red, Blue, and Scenario Agents.
- Scripted models of combat (for situations in which existing models are inadequate and building simulation models quickly is infeasible).
- Calibration of existing models through use of detailed models and human-played war games run under controlled conditions. This may require collaborative efforts and subcontracting in some cases.

The other principal supportive research will be collaborative Sovietology, in which a major effort will be made through subcontracting and other mechanisms to make full use not only of Rand's considerable work in this area but of research efforts ongoing at other research locations.

Strategy Analysis

As should be clear from Sec. IV, there are more potential applications for the RSAC approach than we could possibly hope to address in any one year. To some extent, which applications we pursue seriously will depend on what opportunities arise for collaborating with groups in the DoD and other government organizations. At the writing of this report (December 1982), it seems particularly appropriate for the RSAC to focus during FY83 on a more detailed study of so-called Defense Guidance Issues (including strategic-nuclear issues). Our illustrative experiments in FY82 have laid considerable groundwork for doing so (see Sec. IV; also Winnefeld, 1982), and the requirements for information are relatively modest. In addition to Defense Guidance Issues, we hope to pursue applications to war planning, war-plan testing, or in-war plan adjusting, with one of the appropriate military organizations. Although we might then face a problem of access to information, a great deal could be accomplished if suitable military officers could be assigned directly to the project at Rand. Finally, we believe the RSAC techniques will make possible a new form of balance assessment that should be examined in much more detail during FY83.

SOME CONCLUSIONS

In summary, the RSAC's experience in FY82 leaves us confident that important applications are possible with techniques within reach. It is now evident (primarily by virtue of our experience with the Mark II system) that we need not await the ultimate OPSAC to begin serious analysis of strategy issues. The techniques involved can evolve gracefully over several years as decisions are made about the OPSAC and detailed requirements for the polished automated war gaming system.

In our view, it is now appropriate and important for the DoD to commit itself to the multiyear development effort envisioned in the original statement of objectives. The reasons for such a commitment include:

- Providing high-level legitimacy to an effort that will require active cooperation—and participation—by military and civilian organizations unable to squander high-quality talent on uncertain programs;
- Assuring continuity and the availability of top professional researchers; and
- Encouraging government organizations to begin long-lead-time preparations.

Appendix A

DEPARTMENT OF DEFENSE REQUIREMENTS FOR A NEW ANALYTIC METHODOLOGY

The material in this appendix is drawn verbatim from a letter issued by the Defense Nuclear Agency (DNA001-80-R-0002) on 7 November 1979.

IMPROVING METHODS OF ANALYSIS FOR STRATEGIC FORCES WORK STATEMENT

1. BACKGROUND

Our capabilities for analyzing and understanding the strategic balance and the roles and performance of strategic forces are limited by the kinds of analysis that can now be conducted. For over 30 years the United States has stated certain general goals for strategic forces:

> **— Deter nuclear attacks on the U.S., its forces, and its allies.**
> **— Prevent, along with other forces, coercion of the U.S. and its allies.**
> **— If deterrence fails, terminate the conflict on as favorable terms as possible.**

This is a broad and difficult set of goals, and their relation to the kinds of "strategic analysis" typically seen—damage expectancy against a fixed target set—is not clear. Ideally, one would:

> **— Examine a wide range of outcomes of situations from a Soviet perspective in order to obtain a basis for judgements about the adequacy of our posture as a deterrent.**
> **— Assess, by our own standards, the operational performance of our forces in a wide variety of situations in which we have failed to deter attack or coercion.**
> **— Assess the adequacy of the strategic balance from Allied and third party perspectives.**

The capability to do this is not available now. The lack is most apparent in analyses of deterrence, for there it is the Soviet assessment—not our own—that is important. Neither is the capability available to examine the behavior of forces in crisis, even though we recognize that misperceptions of intent as well as failure to prepare adequately during crisis can lead to catastrophic, although unanticipated and undesired, consequences.

Even in the analysis of the performance of forces in conflict we tend to seriously narrow our inquiry. By selecting a few measures of strategic force ability to destroy fixed, pretargeted installations we have no chance to examine and understand such things as the changes that are taking place in the time required for U.S. forces to retaliate, the increasing dependence on tactical warning, or the shift in U.S. retaliatory weapon mix and the interaction of those weapons with the evolving Soviet defenses.

Our methods of analysis limit our ability to study escalation—the varied ways in which conflict may evolve—and also the role of other forces. Regional, theater, and naval forces may significantly affect events both before and after central strategic forces are used. Further, in most analyses there is no attempt to reflect the substantial differences in Soviet and U.S. military strategy, tactical doctrine, etc., nor do the vital contributions that communications, intelligence, warning, and logistics make to strategic force effectiveness receive the attention that their importance in conflict demands.

2. PROBLEMS AND OBJECTIVES

Strategic analyses are fundamentally undertaken to gain a better understanding of the range of outcomes that may result from different situations, and to identify the variables, decisions, and factors that are important determinants of outcomes. The focus of strategic analysis may be on strategic, or intercontinental, forces, but in reality, other forces (naval, theater) are involved, and may affect the environment in which strategic forces operate and the outcomes. These forces must also be included in the analysis. Similarly, we rarely consider a complete scenario from start to finish. While many models and data bases are available in the analysis community, each is generally only suitable for examining a particular situation, and we have no means to integrate these separate tools into the exploration of a complete scenario, or to record the major decision points that led to particular branches.

Three principal sets of offices within the DoD perform strategic analyses for somewhat different purposes. Force designers are concerned with deriving information on suitable weapons and overall force characteristics. Analyses useful to them should treat a variety of force variants rapidly dealing with a range of adversary postures and major uncertainties at an aggregated level. Operations planners generally keep weapon and force parameters fixed, while varying tactics, commitment schedules, scenarios, and adversary responses over a wide range. Assessments of the strategic balance require that a number of different scenarios be looked at in some detail, including peacetime perceptions, crises, conflict in theaters and at sea, major exchanges, and the aftermath.

An improved capability to perform all of these types of analysis is required and it should be designed to permit inclusion and examination of certain significant areas. First, the real uncertainties that will confront decisionmakers and operational commanders should be present in the analysis. This would include such factors as imperfect information, variation in weapon performance, target hardness, damage effects, force readiness, etc.

Second, elements such as communication, command style, logistics and material support, and the availability, denial, or interference with intelligence must be capable of analysis. It is also important that we be able to stop the flow of events in a scenario so that a situation can be examined at the time in greater detail, or so that the situation can be recorded for later separate analysis, perhaps from the point of view of the Soviets, our Allies, or third parties.

The government is seeking a framework for analysis for the strategic forces that is sufficently flexible to accommodate the three types of user described above, and also sufficiently adaptable in design to permit improvement and evolution as experience is gained in its use. It appears to us that to permit the exploration of complex scenarios, a wargaming style of analysis which blends human judgement with computerbased models and bookkeeping routines will be required. But whatever approach is chosen, it must provide the opportunity to systematically work through many different branches of complex scenarios which involve the use of nuclear forces at levels of crisis and conflict ranging from peacetime to the aftermath of major nuclear conflict. The methods suggested by the contractor must be able to selectively examine and account for operational detail.

We do not believe that this capability can be obtained simply from a more complex set of computer models or simulations. Nor are we seeking a gaming facility which would simply train people or in which we could derive outcomes which were dependent on forces and decisions in some unrepeatable way. We need a comprehensive and far-sighted approach which will make the best use of people and computer-communications technology, and which seeks predictive validity at least equal to that we currently associate with our strategic models. Such an approach must be designed from the start so that its procedures and strategies for use can evolve and so that new models and special methods of analysis can be built later as the need for them is understood.

The development contractor should keep in mind that military officers and DOD civilians will be eventual users of this new approach, not specialists in research organizations. The conception and development will be carried out by contractor research organizations, probably over a period of several years, but when the tools are ready, an appropriate government location will be designated to house and operate them for use by the government. The contractor will manage the transition of the developed capabilities back into the government and may be requested to continue development of any advanced analysis modules that are still required.

Appendix B

EVOLUTION IN DOD STRATEGIC THINKING

The official and unofficial writings of national leaders shows clearly that there has been an evolution in U.S. strategic thinking since the 1960s. This evolution has been largely bipartisan, in spite of appearances to the contrary during political campaigns. What follows is a short selection of quotes from the DoD posture statements.

Robert S. McNamara (1969)

> In the case of the Soviet Union, I would judge that a capability to . . . destroy, say, one-fifth to one-fourth of her population and one-half of her industrial capacity would serve as an effective deterrent.

Clark M. Clifford (1970)

> Our strategic nuclear power is the foundation of deterrence. . . . I am confident that our existing and programmed . . . forces are adequate.
>
> Our calculations indicate that the U.S. strategic forces programmed over the next few years, even against the highest Soviet threat projected in the NIE, would be able to destroy in a second strike more than two-fifths of the Soviet population and about three-quarters of their industrial capacity. . . .
>
> Thus, by any definition of the term, our assured destruction capability . . . should be fully adequate.

James R. Schlesinger (1975)

> The principle that nuclear deterrence . . . must be based on a high-confidence capability for second-strike retaliation . . . is now well established. A number of other issues remain outstanding, however. . . .
>
> The [targeting] concept that has dominated our rhetoric . . . has been . . . assured destruction . . . there is a certain terrifying elegance in the simplicity of the concept. . . .
>
> I can say with confidence that in 1974, even after a . . . brilliantly executed . . . attack . . . the United States would retain the capability to kill more than 30 percent of the Soviet population and destroy more than 75 percent of Soviet industry. . . .
>
> Such reassurances may bring solace to those who enjoy the simpler but arcane calculations of assured destruction. But they are of no great comfort to policymakers who must face the actual decisions . . .

[and who must] consider the morality of threatening such retribution on the Soviet people for some ill-defined transgression by their leaders; in the most practical terms, they must also question the prudence and plausibility of such a response when the enemy is able . . . [to destroy our cities]. . . . The wisdom . . . of assured destruction [strikes] [is] even more in doubt when allies rather than the United States itself must face the threat of a nuclear war. . . .

[after discussions of counterforce and damage-limiting theories and their liabilities, and after discussions of the need for flexibility for relatively selective options, and other matters]. . . .

Accordingly, not only must our strategic force structure contain a reserve for threatening urban-industrial targets, the ability to execute a number of options, and the command-control necessary to evaluate attacks and order the appropriate responses, it must also exhibit sufficient and dynamic countervailing power so that no potential opponent or combination of opponents can labor under any illusion about the feasibility of gaining diplomatic or military advantage over the United States. Allied observers must be equally persuaded as well. . . .

Donald Rumsfeld (1978)

We could try to create the facade of a defense capability, a military house of cards, accompany it with threats of mutual disaster, and hope against hope that the deterrent would never be tested. This is the direction seemingly urged by those who believe there is a distinction between deterrence and defense.

The other direction—indeed the only sound direction—requires that we design . . . a posture . . . [of] serious fighting capability . . . we must assume for purposes of planning that deterrence has somehow failed. . . .

[Quoting from a CIA report] The Soviets are committed to the acquisition of war-fighting capabilities, a decision which reflects a consensus on the need to assure the survival of the Soviet Union as a national entity in case deterrence fails. It also accords with a long-standing tenet of Soviet military doctrine that a nuclear war could be fought and won. . . .

Harold Brown (1982)

Our basic strategy is deterrence, across the entire spectrum of conflict. Deterrence is a function of three factors: military capabilities, the will to use them, and a potential aggressor's perception of the first two. Thus, implicit in deterrence is the . . . ability . . . to deny an aggressor its objectives or to retaliate so as to prevent it from gaining more than it would lose. . . .

[The countervailing strategy of PD-59] *is designed* with the Soviets in mind . . . deterrence requires shaping Soviet assessments . . . that they will make using their models, not ours.

Several Soviet perspectives are relevant. . . . First, Soviet military

> doctrine appears to contemplate the possibility of a relatively prolonged nuclear war. Second, there is evidence that they regard military forces as the obvious first targets in a nuclear exchange, not general industrial and economic capacity. Third, the Soviet leadership clearly places high value on preservation of the regime and on the survival . . . of the instruments of state power. . . . Fourth, in some contexts, certain elements of Soviet leadership seem to consider victory in a nuclear war to be at least a theoretical possibility.

We see, then, that there has been a clear shift from a bipartisan assured destruction concept to one of requirements for "war fighting capabilities"—not in the stereotyped mold of a search for war winning capabilities but in terms of endurance, sustainability, and flexibility.

Appendix C

SELECTED NATIONAL SECURITY ISSUES REQUIRING IMPROVED METHODS OF ANALYSIS[1]

Commencing in late July 1981 and extending through the following September, members of the Rand staff canvassed selected members of the OSD, Joint, and Service staffs on the subject of national security issues requiring improved analysis. This survey was required by the Task One work statement that forms the basis of the body of this report. Those interviewed were, for the most part, members of a working group assigned to assist the DoD project sponsor in evaluating Rand's methodology and system development. Some senior members of the OSD, Joint, and Service staffs were also interviewed. The interviewers were five senior members of the Rand staff with extensive experience with issues of interest to the prospective DoD user communities.

Those interviewed were asked to identify both topics requiring better analytic techniques and the shortcomings of existing analytic tools. In most cases they were already familiar with the Rand methodology and where they were not special briefings were conducted. Although three classes of users had been identified (force structure planners, force employment planners, and net assessment planners), it quickly became apparent that the interests of the users overlapped to such a degree that categorization of issues by user type was impractical and perhaps unnecessary. In this appendix, the issues raised are presented as stated during the interviews—with editing only where required for clarity. To reflect the topical interests of the three user communities, the issues are presented under three headings: Service, Joint, and OSD.

THE SERVICES

1. Assess the impact of symmetrical and asymmetrical deployment of ABM systems by the United States and Soviet Union on:

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[1]This materi[illegible] was provid[illegible] to the sponsor in unpublished form by William Jones and James Win[illegible] in S[illegible]ber 1981.

a. escalation thresholds/stability/crisis management.

b. war fighting outcomes.

c. arms control options.

Note: This topic was cited by all four Services.

2. Assess the effect of alternative U.S./Soviet rules of engagement for conventional and nuclear forces under crisis conditions. Measure the effects of alternative rules on:

   a. escalation control.

   b. war-fighting outcomes.

   Note: Cited by two Services.

3. Assess alternative Navy conventional/nuclear munitions loads in a variety of scenarios across the spectrum of conflict. Navy munitions loads can be altered at sea but flexibility is limited by storage capacity, aircraft configuration, and the availability of ammunition ships.

4. Assess the defense guidance scenario for plausibility and develop alternative force planning scenarios that create conventional two-war situations:

   a. Replicate the defense guidance scenario in the RSAC (if possible) and set forth assumptions required of all agents to duplicate the event stream.

   b. Define alternative plausible scenarios that are suitable for force structure definition.

   Note: The respondents recognized that force structure scenarios probably must have some artificial elements, but that "testing" the scenario is important to "validate" the factors driving force requirements.

5. Assess the effectiveness of specified arms control alternatives in crisis management and deterrence as well as war fighting. (Assessment would be measured by the ranges of outcomes and their likelihood, by their contribution to stability, and by their impact on war fighting.)

   Note: Cited by three Services.

6. Assess the impact on crisis management/deterrence and war fighting by assigning U.S. SSBNs current Minuteman targeting:

   a. with the current programmed structure.

   b. with an increased force structure.

7. Assess the impact of alternative NATO LRTNF levels on deterrence/crisis management and war-fighting outcomes.

   Note: Cited by two Services.

8. Assess the impact of acquisition of significantly improved PRC nuclear weapons capabilities on deterrence and war fighting (assume major changes in Soviet withholds to cover increased PRC threat).

9. Define and assess the ranges of outcomes for both the FYDP and Air Force planning force for a variety of initiating scenarios.

10. Assess the effect on Soviet actions of their perceptions of the commitment of selected dual-committed U.S. forces (tankers, airlift, and possibly ASW). What perceptions most influence events?

11. Define the implications of defeat of either the United States or Soviet Union at a low level of conflict. What would be the effect on stability?

12. Assess the outcomes of alternative national strategies (e.g., launch on warning, use of tactical nuclear weapons in non-NATO conflict, and increased reliance on the PRC).

13. Assess the effects of force asymmetries:
    a. U.S. reliance on bombers and Soviet reliance on ICBMs.
    b. U.S. reliance on seapower projection and Soviet reliance on sea denial.
    c. U.S. reliance on tactical airpower and Soviet reliance on armored ground formations.

JOINT ACTIVITIES

The J-5 and SAGA interviewees cited some of the same issues identified by the Services but were more interested in the Command Post Exercise (CPX) utility of the Rand methodology than were the Services. In addition, they saw it as a "capstone" model that is needed to provide a contextual baseline for the large number of force models used in both program and force employment analysis.

OSD

1. Assess the effects of symmetrical/asymmetrical U.S./Soviet ABM deployment including silo defense, limited or light area defense, and city defense:
   a. Likely Soviet counters.
   b. ABM tradeoffs with other forces.
2. Assess the effects of other strategic defenses (air defense, civil defense, ASAT, and strategic ASW):
   a. Would air defense survive a missile attack?
   b. Implications for U.S. SSN program.
3. Assess the effects of U.S. deployment of C^3I systems that can survive an initial nuclear attack.
4. Assess the effects of alternative mixes of nuclear and conventional forces in a protracted conflict scenario. (This is a force balance issue.)
5. Determine the results of allocation and commitment of multimission assets (tankers, airlift) to conflict at various levels of conflict. Assess the effects of alternative commitment plans.
6. Assess the impact of commitment of Navy tactical air to conventional and theater nuclear conflict.
7. Assess the effects of conventional attacks on the Soviet Union during conventional war outside Europe.
8. Assess the offensive options, such as attacking Soviet energy production facilities, and their responses.
9. Assess the utility of prepositioning afloat.
10. Define the necessary characteristics of survivable reconnaissance capability.
11. Determine U.S. air defense requirements for protracted conflict.
12. Assess the impact of a Soviet anti-SLOC campaign for conventional war in Europe and other theaters.
13. Scenario "validation." Several interviewees cited the need for an assessment of the scenarios used in force exchange calculations. For example, most such analyses start with U.S. strategic forces in either a normal day-to-day or a fully

generated posture, with no prior conflict to affect force size or deployment. In "more realistic" situations, some theater conflict might be going on, such as conventional war in Europe. The initial conditions for an intercontinental strategic exchange might be quite different in that case. Several other examples were cited that challenged the relevance of customary initiating scenarios.

14. Systems characteristics assessments. Several interviewees pointed out that existing analyses can not assess important system characteristics such as flexibility, reaction time, and endurance. For example, missiles based deep underground can have long endurance but they cannot react very fast. Missiles in silos have the reverse characteristics. What is the proper mix of these and other systems? Canonical scenarios were criticized as giving "pure" solutions that did not adequately treat some important characteristics.

15. Assess alternative uses and deployments of the bomber force in protracted conflict. If a substantial portion of bomber force could be dispersed to survive initial missile exchange, what is the deterrence and war-fighting effect?

16. Identify protracted war capabilities needed in the CONUS and in overseas theaters. Identify the effects if capabilities are obtained.

17. Identify the conditions under which a theater nuclear war would not escalate to intercontinental exchange.

OTHER ISSUES

1. Define future modeling requirements and priorities based on sensitivities to outcomes in Rand's automated game. (The RSAC will probably identify requirements for force models that do not now exist.) Where should the development effort be placed?

2. Define tradeoffs in force structure for force employment alternatives across a range of initiating scenarios. In what situation can a smaller force be just as effective as a larger one, if the former is employed differently? (This type of cross functional analysis seems well suited to analysis using automated gaming techniques.)

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