094124 B-163074

UNITED STATES GENERAL ACCOUNTING OFFICE

REPORT TO THE CONGRESS

Advantages And Limitations Of Computer Simulation In Decisionmaking

B 163074

Department of Defense

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

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MAY 3, 1973

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON D C 20548

B-163074

To the President of the Senate and the
Speaker of the House of Representatives

This is our report on the advantages and limitations of computer simulation in decisionmaking in the Department of Defense This effort was one of a number of reviews undertaken at the suggestion of the Chairman of the House Appropriations Committee

Our review was made pursuant to the Budget and Accounting Act, 1921 (31 U.S C 53), and the Accounting and Auditing Act of 1950 (31 U S C. 67)

Copies of this report are being sent to the Director, Office of Management and Budget, the Secretary of Defense, and the Secretaries of the Army, Navy, and Air Force

Comptroller General
of the United States

Contents

ABBREVIATIONS

ABM	Antiballistic missile
DOD	Department of Defense
GAO	General Accounting Office

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

ADVANTAGES AND LIMITATIONS OF COMPUTER SIMULATION IN DECISIONMAKING
Department of Defense B-163074

D I G E S T

WHY THE REVIEW WAS MADE

At the request of the Chairman, Committee on Appropriations, House of Representatives, the General Accounting Office (GAO) inquired into selected aspects of computer-oriented war gaming, computer simulations, and contract studies sponsored by the Department of Defense (DOD) The resulting report, "Computer Simulations, War Gaming, and Contract Studies" (B-163074, Feb 23, 1971), discussed various aspects of the three areas and indicated that GAO intended to initiate further inquiries into selected subjects

Since the development and operation of models represent a substantial cost of conducting computer simulations, war games, and contract studies and since the computer model is the basic tool in many DOD operations research and systems analysis study efforts, GAO reviewed the development and use of computer models in DOD The review was made

--To provide the Congress with information concerning the characteristics and the use of computer models in the gaming and simulation activities of DOD

--To apprise the Congress of certain limitations that GAO believes are inherent in the application of operations research and systems analysis techniques to defense decisionmaking

Because of the widespread use and multiplicity of models, GAO used a questionnaire to obtain information on model characteristics, costs, uses, strengths, and weaknesses Initially, GAO indentified about 450 active models within DOD and circulated the questionnaire on 135 of these models.

FINDINGS AND CONCLUSIONS

Numerous models have been developed in DOD over the last 10 years to cover a broad spectrum of simulated war, defense, and military problems GAO obtained data on 132 models which represent a fairly complete picture of the modeling activity throughout DOD Some observations derived from GAO's analysis (see pp 9 to 18) were

--Development of models was about equally divided between contractor and in-house activities

--Reported costs of building 104 models totaled $28,805,500, and the average model cost was about $276,900 The cost of individual models ranged from about $1,200 to $3 million

MAY 3, 1973

Tear Sheet

--Building a model is generally a lengthy undertaking The average reported development time was 18 months, some models were under development for as long as 7 years

--Many models were related to previously developed ones and formed the basis for follow-on models

--Independent checks were not made to insure the accuracy, timeliness, consistency, and overall quality of the data used in about one-third of the models

--Technical, doctrinal, and force-structure evaluations were the principal stated purposes for building models, models were then used to answer specific questions and to study operational problems in five major areas logistics operations, ground combat, nuclear exchange, air warfare, and naval warfare

Models are used in studies that address many high-level defense matters and produce quantitative measurement of the effectiveness of weapons, forces, and policies and, as such, provide the decisionmakers with analyses that can influence resulting decisions (See pp 19 and 20.)

An Army review of selected models identified several types of shortcomings in most of the models reviewed. The results of the GAO review indicate that the conclusions and recommendations resulting from the Army's review may be applicable to a majority of DOD models (See pp 28 to 31)

There are indications that the uncertainties may not be adequately considered in the studies employing a computer model and that DOD decisionmakers frequently may not be made aware of the uncertainties inherent in the study results GAO believes that the proper use of study results requires that the relevant qualifications reflecting the inherent uncertainty be presented to the decisionmaker along with the results It is apparent that, if a decisionmaker is to be enlightened and is to receive full benefit from a study, he should be fully informed of the limitations and uncertainties and how they were treated, the range of assumptions that were made, as well as other qualifying factors that influenced the study results and conclusions (See pp 19 to 27)

Following the highly publicized debate over the antiballistic missile system, the Operations Research Society of America developed and published guidelines for the professional practice of operations research and for the reporting of study results Operations research and systems analysis provide DOD with quantitative evaluations that, in our opinion, are an important ingredient in its decisionmaking processes We believe that DOD's adoption of reporting guidelines similar to those published by the Operations Research Society of

America could lead to significant improvement in the utilization of these evaluations (See pp 25 to 27.)

RECOMMENDATIONS

GAO recognizes the ongoing efforts of defense and military activities to govern and improve the use of computer modeling and simulation techniques in their studies and analyses programs GAO's review indicated that additional emphasis was needed in this area

Specifically, GAO recommends that the Secretary of Defense

- --Formally adopt, as Department of Defense policy, guidelines for reporting of study results similar to those of the Operations Research Society of America
- --Establish a requirement for periodic, independent technical reviews of computer models to insure continued improvement in their development and employment as well as in the studies in which they are used

AGENCY ACTIONS AND UNRESOLVED ISSUES

DOD endorsed the general concepts indicated in GAO's report, namely, that the use of large-scale computer modeling to assist decisionmaking must be accompanied by continued review of these models and that principles, such as those outlined by the Operations Research Society of America, should be followed

As for the establishment of more formal guidelines, DOD was of the opinion that adequate guidelines are present in existing directives and manuals, and that extension of reporting requirements was unnecessary

MATTERS FOR CONSIDERATION BY THE CONGRESS

Weapon systems costing hundreds of millions or even billions of dollars, composition of future force mixes, and other defense planning and decisionmaking are often justified, in part, or supported by studies based on operations research or systems analysis techniques In considering Department of Defense proposals, the Congress may wish to inquire into the studies supporting the proposals and the assumptions and uncertainties inherent in these studies

CHAPTER 1

INTRODUCTION

In a prior report "Computer Simulations, War Gaming, and Contract Studies" (B-163074, Feb. 23, 1971), issued in response to a request from the Chairman, Committee on Appropriations, House of Representatives, we indicated that over $250 million had been expended annually in those three areas and that we intended to examine other selected areas. A substantial part of the cost of conducting computer simulations, war games, and analytical studies was represented by the development and operation of models used in these activities.

A model is a documented set of rules, methodologies, techniques, procedures, mathematical formulas, and logic designed to simulate or approximate selected elements and/or functions of reality that are deemed essential to the particular situation or system being studied. Modeling is one of the principal tools the operations research and systems analysis community uses to simulate, "game," or study complex problems or situations involving (1) technical performance of equipment or systems, (2) policies, strategies, and tactics, and (3) force structures, including the determination of optimum size and appropriate mixes of personnel and weapons. Its purpose is to provide decisionmakers with results that should present objective and statistically reliable bases for decisions in these areas.

The Operations Research Society of America describes operations research as "a science that is devoted to describing, understanding, and predicting the behavior of man-machine systems operating in organizational environments," the practice of which, while carried out in a scientific spirit, is applied science, art, or engineering

It is important to recognize that the tools and techniques used are scientific, generally mathematics and logic, whereas their application to particular problems or situations can be an art.

The essence of operations research analysis is the construction of a model to study and make predictions about the real world. A model abstracts the relevant features of the situation by means that may vary from a set of mathematical equations or a computer program to a purely verbal description of the situation in which intuition alone is used to predict the consequences of various choices.

The model furnishes a logical structure or framework for the data involved. Once operational, it provides a means for obtaining a better understanding of a proposed course of action and for making and correcting errors without incurring the costs or risks of application in the real world.

The model can be manipulated either manually or mechanically to obtain output results. The mechanical operation of a model is frequently handled by computer. The computer has made feasible the application of ideas and techniques that involve numerous variables and many mathematical computations as well as numerous reiterations using varying assumptions.

Computer model simulations are used to study problems of the Department of Defense (DOD) by illuminating the quantitative aspects and the logical structure of the problem area under study. Rapidly changing technology, the changing international situation, and changing national objectives create an environment that requires defense planning to anticipate and plan far into the future.

In this complex environment, involving a variety of uncertainties, the planning process must continue and vital decisions with far-reaching implications must be made. The techniques of operations research and systems analysis provide a systematic method of dealing with these issues. Indeed, experts in this area generally feel that the quantitative evaluation of such subjects as the potential effectiveness of new weapon systems and new force structures, as well as new tactics to employ these forces, in many instances, can be reasonably attempted only through the use of operations research techniques.

USE OF QUESTIONNAIRE

Because of the widespread use of models, games, and simulations by a number of DOD activities and the technical complexity of these techniques, we used a questionnaire to obtain information regarding a relatively large number of models. The questionnaire was designed to assist in describing, characterizing, and analyzing individual games, models, and simulations. Responses were obtained from the sponsors, builders, and users who, for the most part, were active members of the defense operations research and systems analysis community having special knowledge of individual models.

The questionnaire was developed and published by an authority in the field of simulation and gaming. He also assisted in compiling and collating the responses.

Initially we identified about 450 active models, simulations, and games on hand within major activities of DOD. We subsequently selected and circulated the questionnaire on 135 of these, and 132 completed questionnaires were returned to us. Appendix I identifies these models and the principal DOD users. Our sample was selected judgmentally, because we intentionally wanted to include more of the larger and frequently used models, games, or simulations. As a result the sample included 59 Army, 36 Navy, 26 Air Force, and 11 other DOD activities' models.

Our work disclosed a lack of unanimity among the professionals over the use of terms. The initial question, therefore, asked the respondent whether his response concerned a model, simulation, game, analysis, study, or other. Most of them (81%) were identified as models (46%) or simulations (35%). In this report we use the term "model" when referring to results obtained from the questionnaire.

Analysis

We tabulated and examined results of the questionnaire to determine critical areas and to examine trends. We researched available catalogs of models, interviewed professionals within DOD, made inquiries concerning individual models, and reviewed much of the published literature. Analytic effort was devoted to a review of the objectives and cost of modeling along with review of recognized limitations. By these means, we were able to investigate the role and value of models/simulations in decisionmaking.

CHAPTER 2

COMPUTER MODELS

IN THE DEPARTMENT OF DEFENSE

AN OVERVIEW

Numerous models have been developed in DOD over the last 10 years to cover a broad spectrum of simulated war, defense, and military problems. We obtained descriptive data on 132 of the models which, we believe, represent a fairly complete portrayal of modeling activity throughout DOD

From our analysis of these data, we have developed an overview of model uses, costs, and characteristics which is presented in this chapter Subsequent chapters discuss some of the problems of using models in decisionmaking and the improvements needed to enhance the use of the technique in DOD study efforts

MODEL BUILDERS

Of the models included in our review, 45 percent were developed in-house and 55 percent were developed by contractors In-house builders included such activities as the National Military Command System Support Center, U S Army Strategy and Tactics Analysis Group, Naval Weapons Laboratory; and the Air Force's Assistant Chief of Staff, Studies and Analyses

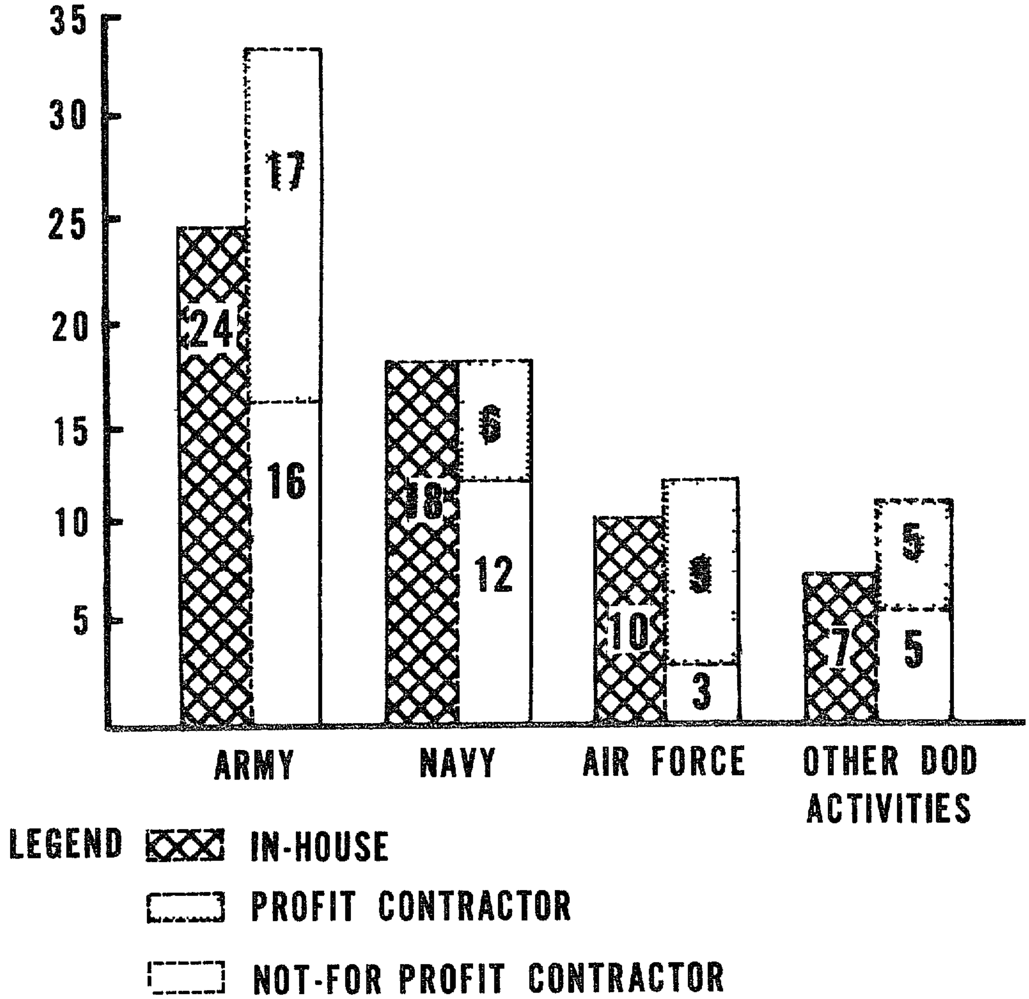
Contractor builders included such for-profit firms as Planning Research Corporation, Boeing Company, and Booz Allen Applied Research, Inc., and such not-for-profit firms as the RAND Corporation, the Research Analysis Corporation, and the Center for Naval Analyses.

COST OF MODELS

The reported costs of building 104 individual models totaled $28,805,500 This represents an average cost per model of about $276,900 The cost of individual models ranged from about $1,200 to $3 million

CHART 1

EXTENT OF CONTRACTOR AND IN-HOUSE MODEL DEVELOPMENT



Total Cost of Model Development

Military department	Number of models	Total costs: Total development cost	Total costs: Average cost of development
Air Force	18	$ 2,586,000	$143,700
Army	42	15,023,000	357,700
Navy	33	8,091,500	242,200
Other DOD	11	3,105,000	282,300
Total	104	$28,805,500	

Range of Model Development Cost

Military department	Range of model costs in sample (000 omitted): 0 to $49	$50 to $99	$100 to $249	$250 to $499	$500 to $3,000	Total
Air Force	9	4	3	1	1	18
Army	13	6	7	6	10	42
Navy	5	6	10	8	4	33
Other DOD	2	2	2	3	2	11
Total	29	18	22	18	17	104
Cumulative	29	47	69	87	104	-
Percent	27 9	17 3	21 2	17 3	16 3	100
Cumulative percentage	27 9	45 2	66 4	83 7	100 0	-

Although the potential costs of the equipment and operations involved in the models were not specified, it appears that, overall, the cost of modeling is small compared with the cost of the alternatives being examined

To maintain their currency and utility, models are usually updated annually. Fifty percent of the models were updated at costs of less than $9,000. Thirty-eight percent had estimated update costs ranging from $10,000 to $50,000.

LENGTH OF TIME TO BUILD A MODEL

Building a model is generally a lengthy undertaking The average reported development time was 18 months This represents the elapsed calendar time between the decision to construct the model and the date of the first use There were 11 models that took over 3 years to build and one model, LEGION, that had a development time of over 7 years

Another measurement of development time concerns the total man-years required to develop a model In this regard, 30 percent of the models required no more than 1 man-year of effort to develop and 35 percent required between 2 and 5 man-years of effort.

PROGRAM SIZE

Models vary in content and complexity. The number of programing instructions needed for each of the models ranged from less than 1,000 to more than 10,000; the greatest number of models (over 27%) required the latter. The Navy had more models in the over-10,000 category (33%) than the Army (28%) or the Air Force (19%)

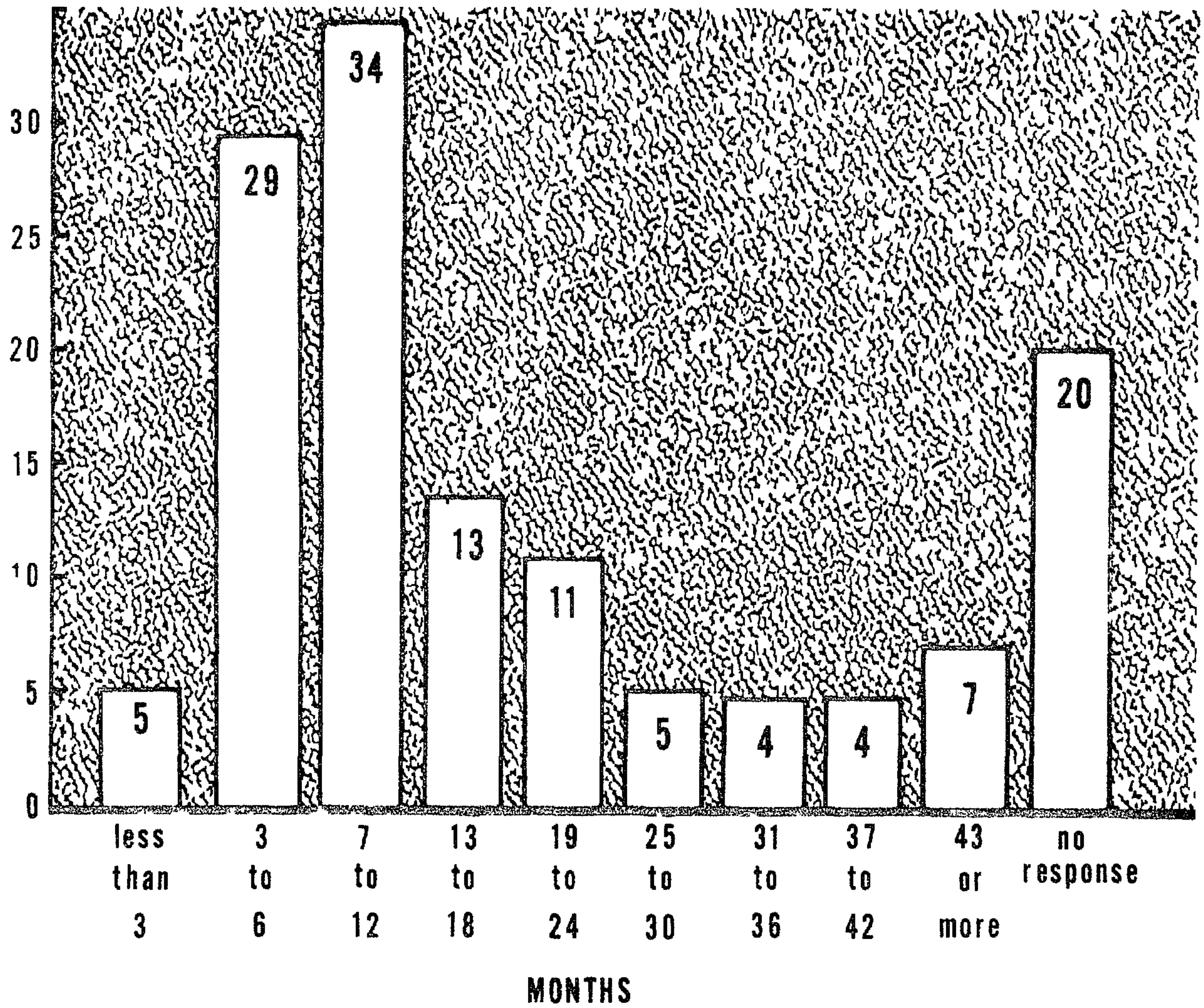
PARENTS AND ANTECEDENTS

Many models were related to previously developed models and formed the basis for follow-on models. A follow-on model may be the refinement of a previous effort having, for example, reduced computer time or expanded capabilities. About 60 percent of the models in our sample were reported to have one or more direct parents or antecedents Over 30 percent were the parents of one or more models.

MODEL TRANSFERABILITY

About 18 percent of the models were generally considered transferable for use by another person or at another site. Seventy-one percent had varying degrees of difficulty of transferability ranging from moderate to extremely difficult About 11 percent of the models were considered nontransferable Some of the reasons for this were that the model was classified, depended on specific facilities or experienced individuals, or was very large in computational size

CHART 2
LENGTH OF TIME NEEDED TO DEVELOP MODEL



DATA SOURCES

Input data for a model can come from many sources Data require updating, may change, and are subject to error. Independent checks generally should be performed to insure the accuracy, timeliness, consistency, and overall quality of the data, unless the data sources are field exercises or actual experience. Rather than these sources, in about 85 percent of the cases the DOD activities used data obtained, in whole or in part, from other sources. Furthermore, the input data used in about one-third of the models were not checked independently.

PURPOSES FOR WHICH MODELS ARE BUILT

Technical, doctrinal, and force structure evaluation were the principal stated purposes for building the model (See chart 3.)

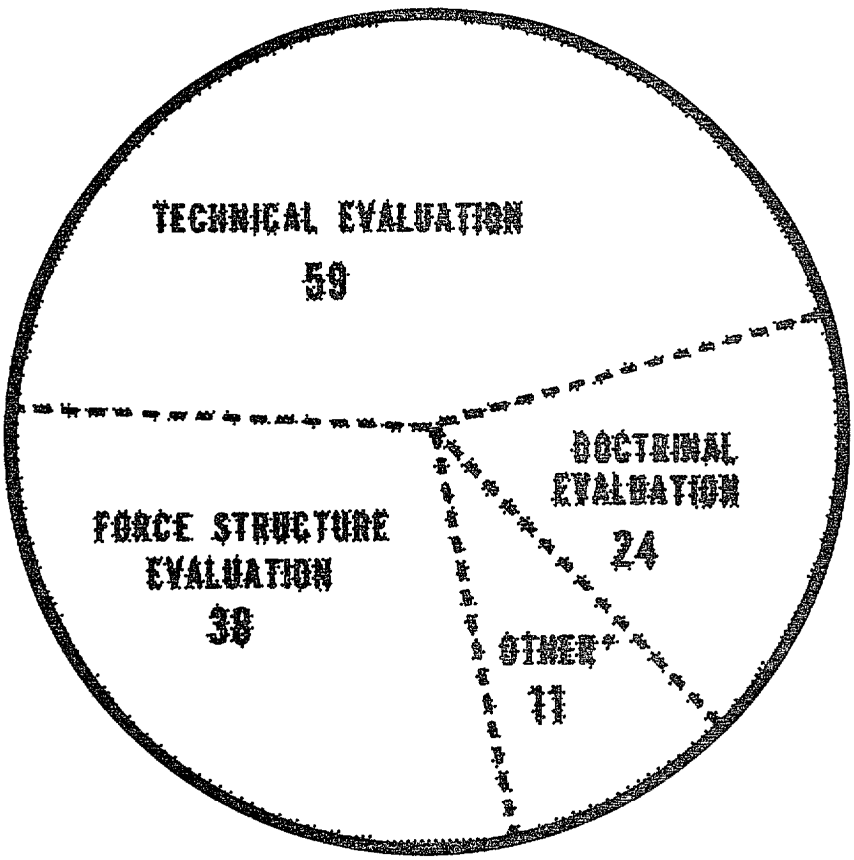
Technical evaluation concerns the simulation of equipment systems to evaluate the technical aspects of the system's operation. Some specific instances of technical evaluation are comparisons of alternative systems, the simulation of a system to evaluate its effectiveness in a specified environment, and the study and evaluation of a proposed system's characteristics and its ability to satisfy its mission objectives Examples include the use of a model to evaluate the effectiveness of several alternative radar systems in support of one or more maneuvering aircraft, the effectiveness of bomber penetration devices against selected defensive environments, and the preproduction design changes in a new fire control system

Doctrinal evaluation includes the study and evaluation of policies, strategies, and tactics Examples include the study of the merits of a damage-limiting first-strike nuclear attack and the evaluation of operational plans

Force structure evaluation involves determination of the optimum size and appropriate mix of personnel and weapons required under various conditions of threat and environment. Furthermore, alternatives for various combat functions and tactics can be compared and evaluated Specific models in the sample assist in evaluating specified strategic forces or in designing force mixes to accomplish specified strategic tasks Other models consider the capability in a rapid deployment situation of an airlift fleet to move troops and cargo or the effectiveness of various air defense forces against a specified threat.

CHART 3

STATED PURPOSES FOR BUILDING MODELS



SAMPLE OF 132

* TRAINING, RESEARCH, METHODOLOGY, MILITARY-DIPLOMATIC ANALYSIS

SPECIFIC USES OF MODELS

Models were used in simulations in five major subject areas logistics operations, ground combat, nuclear exchange, air warfare, and naval warfare. Following are specific questions or operational problems that the models were used to answer.

Logistics operations

Models concerned with logistics operations considered primarily the transporting of troops and equipment, the provisioning (supply and resupply) of troops, and the development of plans of operation for cargo loading and unloading. For example, specific models used to study logistics problems calculated the number of aircraft sorties needed to transport a given cargo, evaluated the capability of a transportation system to meet a required delivery schedule, and determined the most efficient operation of an aircargo terminal.

Ground combat

Most ground combat models simulated combat between opposing ground forces to evaluate the effectiveness of specified force and weapon structures, tactics, and environment or to assess the results from a change in one or more of these factors. The combat simulations are conducted in limited or general war environments.

Examples of questions addressed by models in this category included What influence will changes in combat communications have upon the tactical outcome? Operating in conjunction with ground elements, what is the value of the armed helicopter in a fire support role? and What will be the impact on force effectiveness by changing the mixes of major weapons or other systems?

Nuclear exchange

Nuclear exchange models simulate the offensive and defensive aspects of nuclear exchanges primarily to assess personnel casualties, damage to physical structures, and radiation intensities; to measure offensive and defensive capabilities; and to evaluate the effectiveness of selected nuclear weapons or mix of weapons against specified targets.

Examples of problems nuclear exchange models have been used to study include the profitability of building more defensive missiles versus building more offensive missiles or the coverage provided by an antiballistic missile site against a particular reentry vehicle.

Air warfare

Generally, models studying air warfare depicted different aircraft in attacking and defending modes involving air-to-ground and air-to-air combat situations. The models provided a vehicle for studying desired aircraft capabilities to penetrate a target and for assessing target damage. One model, for example, compares two opposing aircraft and evaluates their respective capabilities in a close-in air duel. In another model, the effects of aerial interdiction upon a logistical network are studied. Other models study the effectiveness of employing bombers against the complete spectrum of environments of enemy targets and defenses.

Naval warfare

Models used to study aspects of naval warfare include primarily the simulation of aircraft or submarines against target submarines. Specific examples of matters studied include the effect an antisubmarine warfare aircraft has upon a single submarine target or the antisubmarine warfare design features desired in a submarine. Another model simulated the operation of two helicopters and two destroyers through searching, localization tracking, and attacking a single submarine.

CHAPTER 3

REPORTING OF STUDY RESULTS

IMPACT ON DECISIONS

The model is the basic tool for conducting a simulation. Simulation is accomplished by exercising the model which employs a specific set of data appropriate to the matter under study. The simulation produces quantitative results which must be subjected to detailed analyses. The results of the analyses are generally reflected in the study's conclusions and recommendations.

Model results can affect DOD's decisionmaking in either a direct or an indirect manner. Directly, the model results may provide the quantitative values or evaluations that are the determining elements in deciding, for example, to pursue the development of a particular weapon system. Indirectly, model results can impact upon decisions by providing the data to develop an improved model and/or results that become part of a larger study.

The impact of the simulation results on a decision and the analyses of these results are extremely difficult to determine. Respondents to our questionnaire, however, indicated that models had been used in studies that addressed such important matters as:

--Force levels for the Joint Strategic Objectives Plan.

--Antisubmarine force structure for 1980.

--Force structure evaluation for the Strategic Arms Limitations Talks (SALT).

--Performance and survivability of the strategic communication network.

--Vulnerability of strategic missile forces.

--Comparison of weapons and weapon systems to satisfy an identified requirement.

Models produce quantitative measurements of the effectiveness of weapons, forces, and policies and, as such, provide the decisionmaker with analyses that influence resulting decisions.

According to the questionnaire responses, almost 50 percent of the studies in which models were used resulted in briefings at various military and civilian organizational levels. In most cases these briefings were part of the decisionmaking process. In addition, respondents indicated that in a number of instances the study results were influential in the subsequent decision. Comments on the importance of the model to the decision included: decision on missile system changes was made as a result of a briefing using this model; design features for an aircraft were based on this model; weapons recommended for a ship were based on the output of the model; and the model narrowed the number of alternatives and identified the most cost effective alternative for a future Army aircraft system.

LIMITATIONS IN THE OPERATIONS RESEARCH APPROACH

The purpose of the operations research approach is to provide quantified results over a spectrum of situations to minimize dependence upon intuition. Nevertheless, the choices of the scenarios, equipment performance, and personnel operations are based somewhat upon unknowns and uncertainties. The extent that the model reflects the real-world situation depends on the accuracy of the model builders' judgment. The degree that model results simulate real-world behavior is best determined by actual comparison of the outcome derived by exercising the model with real-world occurrences.

Of necessity, many of DOD's modeling efforts involve events or objects that have not occurred, do not exist; or, for various reasons, preclude experimentation. Examples include a simulation of a global nuclear war or a simulation of a planned but nonexistent weapon system to study its effectiveness. In such cases, the model results often cannot be compared with real-world occurrences and, consequently, the model's predictions of real-world behavior remain essentially unverifiable.

In this situation it is apparent that, if a decisionmaker is to be enlightened and aided by these efforts, he must be advised of important qualifying factors, such as assumptions and uncertainties, reflected in the results. Unless the decisionmaker is aware of the assumptions made and of the way the uncertainties were treated, the benefits to him will be substantially diminished.

Additionally, because human judgment has an important role in these efforts, disagreement over assumptions and uncertainties, as well as conclusions and recommendations, can be expected. To facilitate constructive debate, it is imperative that the qualifying factors reflected in the results be clearly identified.

Example of types of qualifying factors in a computer simulation study

The following example shows some of the types of inherent limitations that the decisionmaker should be advised of when considering the conclusions and recommendations of an operations research study employing a computer model.

The study is intended to provide input to a decision regarding the types and mixes of weapons with which to equip U.S. Forces in Europe during the 1973-78 time frame. The study's objective is to determine the most effective force by examining the combat effectiveness of selected equal-cost forces of approximate division size. These forces differ in their mix of direct aerial fire support, tanks, antitank weapons, and artillery. The model used in the study simulates ground combat between U.S. and enemy units, and verification of model results with real-world occurrences is not possible. Consequently, the model's predictive capability is uncertain.

Discussed below are some of the more important qualifying factors which will affect the study results. At the time of our review, this study had not been completed.

Model weaknesses

A recent Army technical review identified weaknesses in the way the model being used in the study treats important real-world factors, such as terrain, target detection, probability of kill, command and control, and communications.

Uncertainties in input data

One of the force mixes being considered in the study employs the helicopter in an antitank role. Army representatives conducting the study acknowledge that data on helicopter vulnerability are uncertain; yet, the comparison of force mixes' effectiveness is dependent on assumptions regarding helicopter vulnerability.

In addition, the model is highly influenced by factors--such as neutralization and suppression, recognition of a kill, and erroneous pinpointing of a target--even though few data based on combat experience are available for these factors. Neutralization and suppression refer to the probability of performing various activities--such as firing, moving, and observing--while being fired upon and also the extent to which these activities are degraded when experiencing varying degrees of incoming fire.

Limitations in the study effort

Because of time constraints and the model's inability to simulate varying visibility conditions, all simulations are conducted under good visibility conditions. This constraint significantly impacts upon study results. The effectiveness of each of the weapon systems under study varies according to changes in visibility; some weapon systems are affected more than others. Consequently the relative effectiveness among alternative force mixes under clear visibility conditions could conceivably be substantially different from that under poor visibility conditions.

These and other factors affect the quantitative results of the simulation (i.e., force A consistently outperforms forces B and C in terms of mission accomplishment, casualties induced, and casualties sustained) The exact effect of individual factors and their cumulative effect on the simulation results cannot be specifically determined. If the decisionmaker is aware of, and understands, these factors, he should be better able to assess the simulation results.

INDICATIONS THAT UNCERTAINTIES, ASSUMPTIONS, AND LIMITATIONS MAY NOT BE CONSIDERED

Previous General Accounting Office reports

In previous reports to the Congress, the General Accounting Office (GAO) noted instances where study results in the form of quantitative evaluations produced by computer models were used to support a specific alternative when, in fact, the studies were heavily influenced by assumptions and study limitations which favored the chosen alternative.

In one recent report, "Preliminary Report on the Army Tactical Fire Direction System (TACFIRE)" (B-163074, May 5, 1970), GAO noted that the study being used to support the development of a new fire control system had not considered all the factors which could have adversely affected the performance of the system The GAO report noted that, although the study showed an increase in capabilities by using the proposed new system, the study failed to consider certain factors that could have offset the small margin of advantages that the simulation showed for the new system.

This GAO report showed that the Office of the Secretary of Defense, upon review of the study, requested the Army to reconsider and reverify certain assumptions and costs that were used in the study. In addition, the Army was advised that specific uncertainties in the proposed new system should be resolved in the study and that the Army should recognize that study results should show differences large enough to overcome the inherent lack of precision in simulations of the kind used in the study.

Another GAO report to the Congress, "Analysis and Alternatives: The AGM-53A Condor Program" (B-160212-2, Dec. 31, 1970), examined two studies that employed computer models. These studies compared the cost and effectiveness of two competing weapon systems to satisfy a mission requirement. One of the competing systems was already operational, and the second was under development. One of the studies was conducted by the Navy, and the other was conducted by the contractor that developed part of the operational system. Both studies, which used the same basic input data, were conducted in a similar manner The two studies resulted in opposite conclusions because of the differences in assumptions made regarding specific combat environments that would be encountered and the tactics that would be employed The major assumptions which affected the conclusion reached in DOD's and the contractor's studies were

1 The targets to be attacked
2 The enemy defenses to be encountered.
3 The number and type of aircraft in the strike force.
4 The tactics to be used by the attack force

Although identical data and simulating techniques were used to study the same problems, completely different results were obtained as a result of the different assumptions used.

Other indications exist that DOD decisionmakers frequently may not be made aware of the uncertainties inherent in the study's results In a keynote speech to the 25th Military Operations Research Symposium in June 1970, the then-president of the Military Operations Research Society expressed a viewpoint that the decisionmakers often receive highly summarized, quantitatively supported proposals resulting from studies employing unverified models with limited information regarding the many uncertainties and risks associated with the underlying data

In addition, an Army ad hoc committee in its May 1971 report entitled "Review of Selected Army Models" made the following observation

> "In sum, the Army's gaming and simulation capability has grown, in the short span of about 20 years, from a narrow military and mostly training procedure to a varied, scattered, and almost routine study methodology, applied to a wide range of problems from counter-insurgency to nuclear war and from the M-16 to the C-5A. <u>More significantly, it has changed from a relatively simple and visible aid to judgment, to an esoteric and frequently unquestioned producer of battle outcomes</u> " (Emphasis added.)

IMPORTANCE OF IDENTIFYING ASSUMPTIONS, UNCERTAINTIES, AND LIMITATIONS-- THE ANTIBALLISTIC MISSILE DEBATE

The difficulties that can arise when operations research studies are used to support a position without making a full disclosure of the inherent assumptions to the decisionmakers are illustrated by the following example.

In 1969 a public debate occurred over conflicting analyses presented to the Senate Armed Services Committee concerning the need for the antiballistic missile (ABM) program. During the debate, eminently renowned experts using operations research techniques reached contradictory conclusions about the need for, and expected effectiveness of, the proposed system.

A subsequent analysis of the debate by an ad hoc committee on professional standards of the Operations Research Society of America, a professional society of operations research analysts, identified what it considered the primary reasons for the contradictory conclusions. The different conclusions were attributed to differences in assumptions about enemy capabilities and value estimates for weapon yields and target vulnerabilities used by the opposing analysts. The committee indicated that during the debate these differences were not evident.

The viewpoint of the Operations Research Society of America's committee concerning the effect of contradictory conclusions by operations research practitioners is stated in the following statement from its report.

> "When public debate is joined by eminent practitioners of operations research, advocating opposing positions on important issues and offering apparently contradictory testimony (all based, in part, on operations research methods), the confidence of the public in this approach may be undermined, and the decision makers to whom the testimony is being offered may become confused rather than enlightened."

As a result of this inquiry, the Operations Research Society of America's committee formulated guidelines for professional practices of operations research, which are included as appendix II. One area addressed by the committee's guidelines concerned reporting study results and included, among other things, the following guidance for operations research analysts.

--Report clearly the problem formulation finally adopted, the key assumptions used, the major alternatives considered, the essentials of the input information (and inaccuracies therein), the criteria employed, the findings (including their sensitivity to realistic changes in assumptions or the uncertainty in data), and their implications for policy and action.

--Delineate conscientiously what was accomplished by the study and, perhaps even more important, what was not considered or accomplished.

--Specify the limitations on methodology or conclusions that should be observed and specify with candor instances where definitive results are not provided by the analysis.

The ABM debate is a good example of the confusion that can result when inherent assumptions, assigned values, and other important factors and/or qualifications are not clearly presented with the study results.

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At all levels in the defense establishment, difficult decisions must be made on important and complex matters. Often alternatives presented to the decisionmaker are supported, in part, by studies based upon operations research techniques. Since these studies rely, in large measure, upon computer simulations which have certain fundamental limitations, a precise presentation of these limitations to the decisionmaker is required to realize the full contribution that operations research can make to problem solution.

Adoption by DOD, in its studies and analyses program, of the Operations Research Society of America's guidelines concerning the reporting of study results could lead to significant improvement in the use and understanding of operations research and systems analysis in defense planning and decisionmaking.

CHAPTER 4

IMPROVEMENTS NEEDED IN MANY MODELS

The development of models having maximum utility in studying the many complex problems facing defense decisionmakers requires careful attention to both the technical aspects of model development and the accumulation of various types of data to be used

After the start of our initial efforts in this area, the Army reviewed a number of important models which considered problems concerning the composition and size of ground combat forces and related support requirements The results of this review were presented in a May 1971 publication entitled "Review of Selected Army Models " The review was conducted by an ad hoc committee of professionals assisted by several consultants

In discussing the need for a review of models, the committee recognized the recent increase in the number of models--many with similar functions--and the problem of deciding when the development of additional models is required The committee also commented on the time and cost required to develop and operate models and on the serious questioning of model credibility by decisionmakers

The Army report identifies a number of problem areas and makes recommendations concerning the development and use of models which, based upon our review, may also be characteristic of modeling efforts within other DOD activities

TECHNICAL ASPECTS OF MODELS

The Army identified serious weaknesses in all the models reviewed and recommended that.

--Some models not be used any longer because of their limitations

--Certain models be used for studying certain types of problems

--Specific improvements be made in certain models

--Research be undertaken to improve modeling capabilities

Our review indicated that 45 percent of the models we surveyed had not been independently reviewed by professionals in operations research It seems likely, therefore, that similar shortcomings may be found in DOD models that have not been reviewed Review of these models could provide a basis for substantial improvements in the models as well as in the studies employing them

QUALITY, AVAILABILITY, AND SENSITIVITY OF DATA

For selected models, the Army committee reviewed the data requirements, the source and rationale for the data being used, and the sensitivity of the model to the data

With respect to the source and rationale for data used, a number of factors were identified in the models for which little real-world data exists but to which the models are highly sensitive The Army identified this situation as a serious problem which requires the initiation of a research program to develop a better understanding of these factors and better data for use in the models

Our review indicated that most DOD models used some uncertain data or data based on subjective and intuitive judgments According to respondents 81 percent of the models used data characterized as of considerable uncertainty

The process of determining the extent that model results are dependent upon certain data or combinations of data is known as sensitivity analysis More specifically, sensitivity analysis determines the extent the output of a computer model will be influenced by changing the values of the various factors being considered

We found that 49 percent of the models sampled had not had sensitivity analysis performed It is especially important to investigate the sensitivity of the model's results to changes in the various factors when they are represented by an estimate or assumption Moreover, professionals in the operations research field generally agree on the worth and importance of sensitivity analysis to a modeling effort

We learned that adequate sensitivity analysis is frequently not performed and that this is a serious shortcoming Given the reliance of most DOD models on uncertain data and the extent to which sensitivity analysis has not been performed, it seems likely that the significance of the data problem, the need for a research program, and greater use of sensitivity analysis may be applicable to modeling efforts throughout DOD

Additionally, the Army recommended that sensitivity analysis be performed whenever possible As part of its general conclusion, the Army report stated that

> "In many cases models are not subjected to detailed technical review and are not validated in any other way Some of the complex simulations contain many implicit inputs such as detection factors, decision factors, transition probabilities The rationale for such inputs in most cases is not documented and they have never been reviewed, improved, or updated There is rarely enough funding for sensitivity analysis and, if performed, they are not documented
>
> "The lack of continuity of personnel and the great complexity of the models often have resulted in models being used like 'black boxes' with neither the modeling group nor the sponsor subjecting the model to careful review to make sure that the model is really valid for the purpose employed "

The ad hoc committee recommended that a scientific advisor organization be formed to develop an Army model development program Such a program would include identifying data and research requirements, coordinating technical reviews of models, and analyzing proposals for new models

CONCLUSION

The results of the Army's review of its models, the extent to which shortcomings were identified, and the lack of reviews of a substantial portion of DOD models raise the question of whether similar shortcomings may be found in other DOD models.

The Army has taken a needed step to improve the quality of the models used to address important Army problems. We believe that substantial improvements in the models, as well as the studies in which they are employed, could result if the Office of the Secretary of Defense required the other defense and military activities to undertake periodic, independent reviews of their models similar to those accomplished by the Army.

CHAPTER 5

AGENCY COMMENTS AND OUR EVALUATION

DOD officials endorsed the general concepts indicated in the report, namely, that the use of large-scale computer modeling to assist decisionmaking must be accompanied by continued review of these models and that principles, such as those outlined by the Operations Research Society of America, should be followed. They indicated that the fundamental theme of these guidelines was that computer modeling should be used in a professional manner and that DOD was aware of the need to follow these practices.

Concerning our recommendation to establish more formal guidelines, DOD officials expressed the opinion that adequate guidelines are present in existing directives and manuals, and that the extension of reporting requirements was unnecessary.

We fully agree that the fundamental theme of the Society's guidelines is that computer modeling should be used in a professional manner. We also acknowledge that the Office of the Secretary of Defense and the military departments have made considerable effort to ensure that computer modeling is conducted in a professional manner.

This report is not intended to detract from this effort but rather to encourage increased effort. Continuing emphasis is necessary because:

1. Computer modeling and simulation continues to play a significant role in the DOD decisionmaking process.

2. Many decisionmakers who are exposed to study results based on these techniques are not analysts; therefore, it is important that they be made aware of the limitations inherent in these study results.

3. Our questionnaire responses indicated that, in a significant number of the models surveyed, certain actions, such as independent technical review and sensitivity analysis which are critical to the identification of model limitations, had not been done.

4. Prior GAO reviews and statements of professionals and professional organizations have indicated that study assumptions and limitations inherent in the model and in the underlying data have not always been fully disclosed.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Systems costing hundreds of millions or even billions of dollars, composition of future force mixes, and other defense planning and decisionmaking are often justified and/or supported by studies based on operations research and systems analysis techniques. Computer models are used frequently to process the data and produce the quantitative evaluations that influence the studies and the resulting decisions.

As indicated in this report, computer models have certain fundamental limitations and these, along with such other qualifying factors as assumptions and uncertainties, are reflected in study conclusions. In order for a decisionmaker to realize the extent of the contribution that operations research can make, and has made, to problem solution, he should be aware of all the qualifying factors which influenced a study's conclusion.

RECOMMENDATIONS

We recognize the ongoing efforts of defense and military activities to govern and improve the use of computer modeling and simulation techniques in their studies and analyses programs. As a result of our review and after analysis of the comments received, however, it is our opinion that additional emphasis is needed in this area. Specifically we recommend that the Secretary of Defense:

--Formally adopt as DOD policy, guidelines for the reporting of study results similar to those of the Operations Research Society of America.

--Establish a requirement for periodic, independent technical reviews of computer models to insure continued improvement in their development and employment as well as in the studies in which they are used.

MODELS INCLUDED IN THE QUESTIONNAIRE SURVEY

Sponsoring activity	Model name
DEPARTMENT OF THE ARMY	
Combat Developments Command (CDC)	Stano system assessment model (Stano Phase I SAM)
	Trans hydro craft
	Seaniteops aggregate cost
	Dynamic tactical simulator X (DYNTACS X)
	New unit cost model modification
	Dynamic tactical simulator (DYNTACS) (Tank weapon system)
	Evaluate (VALUAT V)
	War game B with offset (WAGMBO)
	Nomographs-(NOMGS)
	Effect 3 + 4
	Atomic demolition munition (ADM)
	Deterministic mix evaluation worldwide (DMEW)
	Tactical air defense computer simulation (TACOS II)
	Graphics
	HOVARM
	Target acquisition model (TAM)
	Tank antitank air cavalry simulation (GLOBAL I)
	HOVER
	Theater battle model (TBM)
	Information flow and combat effectiveness (ADVICE II)
	Corps battle model (CBM)
	Division battle model (DBM)
	Computerized tacspiel
	Theaterspiel
	Vehicle mission processor based on least times (VEMPBOLT III)
	Individual unit action (ATMIX IUA)
	Small infantry unit simulation (SINUS)
	Synthetic tactics (SYNTAC)
	Division through Army group war game (DIVTAG II)
	DIVWAG
	Combined arms combat limitations (MOD-FILTER)
	Ground combat communications simulation system (COMMEL)
	Artillery evaluation model (LEGAL MIX IV)
	Effects of varying evacuation policies upon the U S Army (Evacuation Policy)
	FLAME I
	Individual unit action simulation (TATAWS III)
Office of the Deputy Chief of Staff for Military Operations (DCSOPS)	Target acquisition routine III (TAR III)
	Survival probability hazard in a nuclear exchange (SPHINX II)
	A tactical, logistical and air simulation (ATLAS)
	LEGION
	Objective force designer (OFD)
	TARTARUS IV n/COCO
	ORION
	FORECAST II
	Global distance routine (GDR)
	Preliminary force designer (PFD3)
	NEWCON
	OPSTRA
	Preliminary force designer inter-theater movements simulation (PFD SAM)
Office of the Assistant Vice Chief of Staff Army (AVCSA)	An improved technique for evaluating the structure of U S Army forces in an area domination role (AREA DOMINATION II)
Office of the Assistant Chief of Staff for Force Development (ACSFOR)	Force analysis of theater administration and logistics support (FASTALS)
	The candidate families methodology
Computer Systems Command (CSC)	Cost effectiveness model
	TACFIRE effectiveness evaluation model (TEEM)
	Information flow and combat effectiveness model (ADVICE II)
Office of the Deputy Under Secretary for Operations Research (ODUSA (OR))	Strategic weapons exchange models (SWEM)
Office of the Assistant Chief of Staff for Intelligence (ACSI)	Soviet capabilities - Army (SOVCA)
Anti-ballistic Missile Development Agency (ABMDA)	Strategic attack and response (STAR III)

Sponsoring activity	Model name
DEPARTMENT OF THE NAVY Systems Analysis and Long-Range Objectives Division of the Program Planning Office (OP 96)	Detailed ship loading (DSL) Sustained attrition mine-field evaluation (SAMEN) Vehicle and equipment requirements simulation (VERS) ASW air systems (ASWAS) Fleet anti-ship missile engagement (FAME) Nuclear exchange model (NEMO III) ASW graphical resource allocation model (ASGRAM) Continuous fleet operations/tactical operations (CFOAM/TACOPS) Campaign execution model (CEM) SUBDUEL I Countering the anti-ship missile (CAM-SAM) Simulation of air-to-air battles (SAAB) Nuclear exchange (CODE 50) ASW programs surveillance engagement model (APSURV MOD-1) Air ASW model (ASWASP) Minefield analysis with hunting evaluation (MAYHEM) Submarine ASW engagement model (SASWEM-1) Network simulator Ship-to-shore (STS-2) Submarine barrier (SUBBAR) Shore party operations and logistics (SPOL) Submarine trailing evaluation model (STEM) Sea warfare integrated model (SWIM II) ASW localization, track and kill (LOTRAK II)
Fire Support Study Group of the Amphibious, Mine and Special Warfare Division, Deputy Chief of Naval Operations (Fleet Operations and Readiness OP-37D)	Fire Support simulations (FSS)
Office of Strategic Offensive and Defensive Systems (OP-97)	Strategic force mix Strategic international relations nuclear exchange (SIRNEM)
Office of Antisubmarine Warfare Programs (OP-95)	APAIR Surface ship (APSURF-MOD-1) Submarine (APSUB MOD O-1) ASW program campaign model (APCAMP)
Anti-Submarine Warfare Systems Project Office Naval Material Command (PM-4)	ASW escort engineering (ASESEM)
Advanced Systems Division, Material Acquisition Directorate, Naval Air Systems Command (NAVAIR 503)	Localization and systems characteristics analysis (LASCAR)
Naval Ordnance Systems Command	Anti-air warfare system effectiveness model (AAWSEM)
Naval Undersea Research and Development Center	Multi-ship ASW simulation
U S Marine Corps Landing Force Development Center	Marine amphibious deployment simulation (MARADS)

Sponsoring activity	Model name
DEPARTMENT OF THE AIR FORCE	
Office of Assistant Chief of Staff for Studies and Analysis	Tactical air capabilities avionics energy maneuverability evaluation and research (TACAVENGER)
	Bombing simulation (BOMBSIM)
	Saber infantry (INFANTRY)
	TACAIR
	Penetration evaluation gaming analysis strategic offensive studies (PEGASOS)
	Fighter aircraft penetration assessment (FAIRPASS)
	Simulation of utilization resources, cost and efficiency (SOURCE)
	Tactical fighter weapon effectiveness model (WEAPON)
	Combat bombing weapon firing program (COMBO)
	Advanced penetration model (APM)
	Surface-to-air missile (SAM)
	ENDO I
	Multiple penetration and site simulator (MPASS)
	EXO atmospheric (EXO I)
	Air contingency terminal simulator (ACTER)
	Strategic assured destruction and damage limiting evaluation (SADDLE)
	Geometric interceptor analysis technique (GIANT)
	Air tactial operations model (ATOM)
Deputy Chief of Staff, Plans and Operations	Operational analysis strategic interaction simulation (OASIS 71)
Headquarters Aerospace Defense Command Ent AFB Colorado	Space Defense planning simulator (SDPS)
Air Force, Director of Operational Requirements and Development Plans	TAFCOM
	UNCLE
OTHER DOD	
National Military Command System Support Center (NMCSSC)	Comprehensive blast and radiation assessment system (COBRA)
	Arsenal exchange model (AEM)
	Aircraft loader (LOADER)
	Simulation of contingency air terminal (SIMCAT)
	VALIMAR
	Gross feasibility estimator (GFE III)
	Strike planning aircraft requirements evaluation (SPARE)
	Deployment logistics requirements (DELOG REQ)
Joint Staff Logistics Directorate	Simulation of airlift resources (SOAR)
	Transportation requirements and capabilities simulator (TRACS)
	Posture system
	European theater network analysis model (ETNAM)
	Military airlift capability estimator (MACE)
	Movement requirements generator (MORG)
	Transportation movement planning system (TRAMPS)
	To help evaluate feasible transportation (THEFT)

INTRODUCTION

Since its inception in 1952, the *Operations Research Society of America* (ORSA) has had as its purpose (as stated in its Constitution)

> the advancement of operations research through exchange of information, the establishment and maintenance of professional standards of competence for work known as operations research, the improvement of the methods and techniques of operations research, and the encouragement and development of students of operations research

It has served these four main areas of purpose in a variety of ways However, the second one—"the establishment and maintenance of professional standards of competence for work known as operations research"—has been largely accomplished by holding up examples of excellent work, and by the efforts of individual ORSA members, using the tools of interaction and exchange that ORSA has helped to provide

In recent years, operations research has been employed increasingly as an aid to highly placed decision makers both in private industry and in government With the aid of operations research, decisions are being made on major policy issues that can affect the well being of everyone It is, therefore, more important now than in the past for the practice of operations research to be undertaken with the highest professional standards

When public debate is joined by eminent practitioners of operations research, advocating opposing positions on important issues and offering apparently contradictory testimony (all based, in part, on operations research methods), the confidence of the public in this approach may be undermined, and the decision makers to whom the testimony is being offered may become confused rather than enlightened

Clearly, it is important for ORSA to attempt a forthright statement on the professional practice of operations research

The ORSA Council, being cognizant of its responsibilities, established a Committee to prepare such a statement This document is the product of that Committee's endeavor and has been approved by the Council for widespread dissemination

GUIDELINES FOR PROFESSIONAL PRACTICE

Operations research (OR) is a science that is devoted to describing, understanding, and predicting the behavior of man machine systems operating in organizational environments.* However, the practice of operations research, while carried out in a scientific spirit,[1] is applied science, art, or engineering.

We will present guidelines for professional practice delineated as General, Beginning a Study, Conducting a Study, Reporting a Study, Reviewing a Study, Following Up Studies.

General

In dealing with a problem posed by an operating organization, an operations analyst should:

- Apply the scientific spirit (open, explicit, and objective) to his work.
- Take a broad and disinterested view, free of parochialism, inflexibility, or prior prejudice, that includes a lively sense of the public interest, as well as of the narrower interests of the organization involved.
- Become thoroughly familiar with all aspects of the organization's operations relevant to the problem, as well as forces outside the organization that can impact on it.
- Be responsive to the evidence adduced either as inputs or outputs of the study.
- Be equipped to bring to bear on the problem the most modern knowledge, approach, and techniques of analysis, while avoiding known pitfalls.
- Consider alternative approaches to the problem.
- Obtain access to all information that can reasonably be thought to be needed for the problem's solution, or to have a possibly significant bearing on it.
- Scrupulously observe any ground rules about confidentiality laid down by the organization being served.
- Report the study's results only to the organizational elements sponsoring the study, unless specifically directed by them to report to a wider audience.
- Keep the sponsoring elements as fully involved and informed on the work throughout its duration as is reasonable and feasible.
- Be aware of the fact that in many complex situations the study may illuminate only a portion (albeit a significant one) of the total problem.

* Related terms such as management science, systems analysis, and economic analyses are sometimes used to describe operations research. A more complete discussion of OR is given in Appendix I.

[1] A discussion of some of the aspects of the scientific spirit is given in Appendix I.

In Beginning a Study

Experience has shown that establishing an adequate initial framework for a study is a key step that frequently plays a decisive role in its ultimate success Therefore, *in close cooperation with the client throughout this step*, analysts should

- Collect information and data adequate to provide the initial framework for the study
- Take great care in formulating the problem or issue to be addressed, keeping in mind the client's needs
- Use both imagination and meticulous attention to detail in designing alternatives for examination in the study
- Recognize explicitly the uncertainties associated with the problem
- Understand the subjective, as well as objective, aspects of the problem
- Evolve appropriate criteria on the basis of which the study's results can be evaluated
- Describe the limits of the proposed study, so that both analyst and client have a clear idea of what will *not* be done, as well as what *will* be done
- Recognize that many of the elements involved in this step may have to be revised as the study proceeds, in the light of the knowledge the enquiry generates

In Conducting a Study

In this step, whose activities center largely in the analytical staff, the analysts should

- Assemble relevant information and data of verified reliability, or if not available, inputs of judiciously and suitably estimated unreliability, so that the impacts of uncertainty can be assessed in the results
- Use (develop or choose) the best relevant models and technical tools and use them with a rigor appropriate to the problem in hand, while at the same time achieving a reasonable balance between the demands of the problem and a reasonable economy of effort
- Employ appropriate accuracy checks, wherever possible
- Check the sensitivity of the results to variations in assumptions and inputs, and especially to uncertainties identified in the formulation, or the input data
- Keep in mind the need for a continuing reassessment, throughout this step, of the formulations and assumptions with which the

analysis began, and of changing them and recycling the analysis when this appears to be needed

In Reporting a Study

Recognizing that the ultimate effectiveness of a study critically depends on how well its findings are communicated, understood, and then acted upon, the analyst should

- Insofar as possible, use the vocabulary of his client, introducing only such new concepts and terminology as are essential to understanding the findings (the jargon and technicalities of operations research should be avoided to the greatest extent possible)
- Report clearly the problem formulation finally adopted (perhaps changed from the one with which the study began), the key assumptions used, the major alternatives considered, the essentials of the input information (and inaccuracies therein), the criteria employed (also perhaps changed from the ones with which the study began), the findings (including their sensitivity to realistic changes in assumptions, or the uncertainty in data), and their implications for policy and action
- Delineate conscientiously what was accomplished by the study, and perhaps even more important, what was not considered or accomplished
- Specify the limitations on methodology or conclusions that should be observed, and spell out with candor instances where definitive results are not provided by the analysis
- Set the study in the larger context appropriate for it
- Prepare a written report on at least two levels one for the client following the precepts outlined above (both a short and long form of this report are frequently useful), and another fully technical report that can be examined by operations and systems-research scientists
- Be prepared to participate in any follow up or implementation activities, both to assist with them and to evaluate their results

In Reviewing a Study

In reviewing studies arising from OR practice, either one's own or someone else's, it is particularly important to keep in mind that this practice is performed in a scientific spirit Therefore, in this role the analyst should

- Test the work against the guidelines presented above
- Be rigorous but fair in his thought

APPENDIX II

- Be candid about the basis for his statements
- Be realistic about his demands in the light of the context and scope of the study being examined
- **Avoid *ad hominem* attacks, either veiled or overt.**

Source of appendix II.
Operations Research Society of America Journal, September 1971

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D C 20301

COMPTROLLER

20 MAR 1973

Mr. James H. Hammond
Deputy Director, Procurement & Systems
Acquisition Division
General Accounting Office

Dear Mr. Hammond

As requested by your letter of January 15, 1973, the GAO draft report, "Advantages and Limitations of Computer Simulation in Decision Making" (OSD Case #3568) has been reviewed by those components of the Department of Defense who make wide use of simulation techniques.

The Department of Defense endorses the general concepts indicated by the GAO, namely, that the use of large scale computer modeling to assist decision-making must be accompanied by continued review of these models and in addition that principles such as those outlined by ORSA should be followed. The DoD has been aware of the need to follow these practices, as was referenced in the GAO report (page 22). In fact, the fundamental theme of the ORSA report, from which the GAO report quotes, is that computer modeling should be used in a professional manner.

As to the recommendation for establishment of more formal guidelines, it is the opinion of the DoD that adequate guidelines are present in existing directives and manuals, and that extension of reporting requirements is unnecessary.

Enclosed for your information are the comments of the DoD Components which address the specifics of the report.

The opportunity to review and comment on this draft report is appreciated.

Sincerely,

Don R. Brazier
Acting Assistant Secretary of Defense
(Comptroller)

Enclosures (4)