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REPORT TO THE CONGRESS

Impartial Cost-Effectiveness Studies Found Essential To Selecting New Weapons B-163058

Department of Defense

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON D C 20548

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

This is our report regarding the need for impartial cost-effectiveness studies by the Department of Defense in selecting new weapons

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

Elmer B. Staats
Comptroller General
of the United States

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ABBREVIATIONS

ASW	antisubmarine warfare
DCP	Development Concept Paper
DOD	Department of Defense
GAO	General Accounting Office
OSD	Office of the Secretary of Defense

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

IMPARTIAL COST-EFFECTIVENESS STUDIES FOUND ESSENTIAL TO SELECTING NEW WEAPONS
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D I G E S T

WHY THE REVIEW WAS MADE

In the past decade the Department of Defense (DOD) has relied greatly on cost-effectiveness studies in selecting and acquiring new weapon systems costing billions of dollars

DOD has used these studies to analyze the cost and effectiveness of weapons proposed to satisfy a predetermined military requirement by providing alternatives in order that the most suitable weapon might be chosen from competing weapons

Meanwhile, in the absence of completely reliable data on cost or effectiveness projections, questions have been asked concerning the value of these cost-effectiveness studies

The General Accounting Office (GAO), in a 1971 report to the Congress, recommended more stringent application of the cost-effectiveness technique GAO has now made a detailed review of cost-effectiveness studies on 16 major weapon systems--five Department of the Army systems, six Department of the Navy systems, and five Department of the Air Force systems

Examples of these weapons include the Army's TOW, a surface-to-surface guided missile, and its HLH, or heavy-lift helicopter, the Navy's F-14, an all-weather fighter aircraft, and its DD-963 fleet escort destroyer, and the Air Force's B-1 strategic bomber or MAVERICK, an air-to-surface missile For a complete list and description see appendix I

FINDINGS AND CONCLUSIONS

The cost-effectiveness technique is of great value

--It forces advocates of a proposed weapon system to examine and record the real need, the alternatives, the related costs, and the assumptions considered in making a proposal

--It provides the DOD decisionmaker with a substantial amount of information which is helpful in reaching a decision at a very early phase of the acquisition process

GAO's review of cost-effectiveness studies on the 16 weapons showed that, notwithstanding weaknesses found in many of these studies, the technique was essential to decisionmaking Examples of adequate and inadequate studies will be found in chapter 2

Like all methods of analyzing data, cost-effectiveness studies are subject to abuse or misuse The limitations of such studies may not be realized or undue reliance may be placed on the technique since the studies are paper analyses In some instances limitations or questions may be resolved only through such procedures as prototyping or parallel weapons development These procedures currently are being advanced by DOD

But regardless of the acquisition procedures selected, cost-effectiveness studies can be useful as aids in the decisionmaking process Procedures now being advanced by DOD provide a basis for adding needed realism to cost-effectiveness studies at each phase of the acquisition process

Under the directives in force when the cost-effectiveness studies were prepared for the 16 weapon systems, the studies were required just once, in the early conceptual phase Some of the studies were updated, but it was not the normal practice

There is a definite need for conducting cost-effectiveness-type studies as early in the acquisition process as practical and for updating these studies as important developments occur Studies for some weapons were not updated to consider changes, such as

--Availability of actual performance data which varied with predicted performance data

--Major cost or quantity changes

--Important changes in initial study assumptions

Examples of the need for updating studies will be found in chapter 3

Cost-effectiveness studies can be strengthened by insuring greater objectivity by the military services in analyses presented Strengthening could occur if an impartial party could participate in the study, which would insure, as a minimum, an element of independence Having an impartial party participate is particularly necessary when common mission areas generate excessive interservice rivalry which, if unchecked, could result in costly duplication of weapons

Many of the cost-effectiveness studies in the 16 weapon systems appeared to be designed to support the position of the advocating service in that

--Known alternatives were excluded

--Stated assumptions were too restrictive or were not completely valid

--Available data on alternatives were not considered, and, as a result, incomplete studies amounting to misleading information were furnished for decisionmaking purposes

BEST DOCUMENT AVAILABLE

ECOMMENDATIONS OR SUGGESTIONS

The Secretary of Defense should

1 Emphasize the need for cost-effectiveness studies He should also clarify the studies' roles as formal documents which support Development Concept Papers at each stage of the decisionmaking process

2 Take actions to attain objectivity in cost-effectiveness determinations, particularly in mission areas in which two or more services are competing for a weapon system This could require that the Secretary of Defense arrange for independent cost-effectiveness studies or identify an impartial party to review service studies In particular mission areas it may require joint participation with the service in planning and/or conducting the study

3 Make sure that the services, in implementing DOD Directive 5000 1, direct that cost-effectiveness studies be made at the earliest practical point and be updated throughout the acquisition process as major changes occur

.GENCY ACTIONS AND UNRESOLVED ISSUES

DOD provided the following information

--Guidance would be issued which would require cost-effectiveness analyses to be available to support the findings summarized in Development Concept Papers and for presentation to the Defense Systems Acquisition Review Council

--DOD agreed that there was a need to achieve objectivity in cost-effectiveness determinations, particularly in mission areas in which two or more services were competing for a weapon system DOD planned to insure that, when such a situation arose, an impartial cost-effectiveness study would be prepared and reviewed by either (1) the Office of the Secretary of Defense, (2) a multiservice review group, or (3) a Federal contract research center

--Concerning updating studies, the procedures established by the Development Concept Papers and the Defense Systems Acquisition Review Council and those needed to support the objectives of DOD Directive 5000 1, dated July 1971, necessitated the preparation of cost-effectiveness studies to support the three major decision milestones (1) program initiation, (2) full-scale development, and (3) full-scale production, as well as when any major program threshold might be exceeded

ATTERS FOR CONSIDERATION BY THE CONGRESS

This report apprises the Congress of the necessity for the three military services to apply cost-effectiveness studies in procuring new weapon systems, offers suggestions for improving the technique, and reports on progress made toward this end by DOD

CHAPTER I

INTRODUCTION

The General Accounting Office (GAO) reviewed cost-effectiveness studies for the acquisition of major weapon systems by the Department of Defense (DOD) The policy of DOD, as established in DOD Directive 3200 9, required that the cost effectiveness of a proposed weapon system be determined favorable in relation to the cost effectiveness of competing items on a DOD-wide basis The requirement of cost effectiveness was one of six prerequisites for approval to proceed from the weapon system conceptual phase to a more advanced phase

In September 1970 DOD canceled Directive 3200 9, however, it issued DOD Directive 5000 1, dated July 13, 1971, which indicated that costs and benefits were two factors of major concern in the acquisition of weapon systems

NATURE OF COST-EFFECTIVENESS STUDIES

The nature of cost-effectiveness studies can be described by citing the objective found in the studies we examined That objective, in general, was to analyze the cost versus effectiveness of specific alternative systems in achieving a predetermined mission goal The competing systems cited in the studies usually were of the same type, e g , aircraft versus aircraft As a rule the cost-effectiveness studies made no attempt to consider or propose radically different approaches to achieve the mission goal or to question whether that goal should be sought at all

The overall goal of a cost-effectiveness study should be to assist a decisionmaker by arraying significant factors so as to aid in identifying a preferred system from among the alternatives

Following are the major factors considered necessary for cost-effectiveness studies to become useful tools for the decisionmaker.

1. Statement of the mission(s) to be performed

2 Inclusion of alternative weapon systems

3 Disclosure of estimated costs of each alternative

4 Logical presentation of relationships--including costs, predicted effectiveness and assumptions

PREPARATION OF COST-EFFECTIVENESS STUDIES

The basic responsibility for preparing the individual weapon system cost-effectiveness studies we examined rested with the military services. The Army's Combat Developments Command prepared many of the Army studies we examined Such organizations as the Cornell Aeronautical Laboratory and the Battelle Memorial Institute also prepared some of the Army studies

The pattern was the same for each service In the Navy some studies were prepared in-house and some were prepared by organizations outside the Government, such as the Center for Naval Analyses Air Force studies were prepared in-house and by organizations outside the Government, such as the Analytic Services, Inc

At the Office of the Secretary of Defense (OSD) level, the Systems Analysis Directorate was involved in a review of a number of service studies and also in the preparation of independent cost-effectiveness studies for some of the systems included in our review

CONCEPT AND SCOPE OF OUR REVIEW

Our review was designed to determine

--Whether cost-effectiveness studies were required and made before the Government became committed to a particular weapon system in a substantial way and whether the studies were updated periodically when basic changes in the assumptions used in an earlier study occurred

--Whether basic elements of the studies--such as the need the system under study was supposed to fill, the alternative technical solutions that were available to meet that need, the cost associated with each possible solution and the models--were fully documented and considered

--Whether the studies highlighted significant issues so as to assist decisionmakers in selecting from among alternative systems within the same general class of equipment.

We selected for review a number of systems in each of the services which were in various phases of the acquisition process. Systems were examined not only for cost-effectiveness analyses which were or should have been made in concept formulation but for any such analyses which should have been made at critical decision points. A total of 16 major weapon systems--five Army systems, six Navy systems, and five Air Force systems--were covered in this review. (See app. I for mission of each.)

Army	Navy	Air Force
IOW missile	A-7E aircraft	MAVERICK missile
SAM-D missile	P-3C aircraft	B-1 aircraft
BUSHMASTER automatic weapon	S-3A aircraft	A-X aircraft
MBT-70 tank	F-14 aircraft	A-7D aircraft
HLH helicopter	AEGIS missile system	F-15 aircraft
	DD-963 destroyers	

In our review we did not attempt to determine the validity of cost estimates used in the studies but, rather, to ascertain whether cost estimates used were reasonably complete in identifying elements of cost for consideration and whether cost-effectiveness studies were updated to reflect changes in original estimates

CURRENT DOD POLICY

As previously indicated DOD canceled Directive 3200 9 which specifically required, among other things, that

cost-effectiveness studies be made on major weapon systems and issued on July 13, 1971, a new policy DOD Directive 5000 1, on acquisition of major weapon systems This new directive placed emphasis on the utilization of Development Concept Papers (DCPs) and the Defense Systems Acquisition Review Council (DSARC) for support of decisions made by the Secretary of Defense It emphasized that estimates of development costs and preliminary estimates of life-cycle costs and of potential benefits would be among the factors considered prior to authorizing full-scale development and production In addition, the directive also placed emphasis on practical trade-offs among system capability, cost, and schedule throughout the acquisition process

DCPs should document the full military and economic consequences and the risks involved in each new major research and development program DCPs describe the authority and responsibility in a program It is intended to document the considerations which support the determination of the need for that program DCPs define program issues, program objectives, program plans, performance parameters, major risk areas, system alternatives, and acquisition strategy

DOD has had in effect DOD Instruction 7041.3, "Economic Analysis of Proposed Department of Defense Investments," which requires the use of cost-benefit or cost-effectiveness analyses in the making of DOD investment decisions However, at the time of our review, this directive was not being applied in weapon systems acquisitions.

RECOGNITION OF INHERENT LIMITATIONS

Aside from the correctable shortcomings found in the individual studies we examined (see ch 2), there were inherent limitations in all cost-effectiveness studies These limitations make cost-effectiveness determinations an aid to the decisionmaker rather than a document that indicates which weapon should be developed.

Cost-effectiveness analysis requires a reliance upon various assumptions, some quantifiable, others not quantifiable, and still others in between these extremes Experience plays a major role in assigning values, and subjective judgment may be used to quantify factors.

Quantifying such things as future mission objectives and enemy strategy with a relative degree of certainty is difficult The value of human life, the impact of the human element, the combat effectiveness under extremely adverse conditions, and service bias in projecting cost, availability, maintainability, and reliability are some of the other considerations which require judgment in allowing them to bear on decisionmaking

In chapter 2 the basic elements or criteria for cost-effectiveness studies are described in some detail and are followed by examples of adequate and inadequate application of these criteria Comments received from the services indicating a disagreement with data in these examples have been incorporated into the examples

In chapter 3 the timeliness and the need for updating these studies are discussed Comments received from the services indicating a disagreement with data in these examples have been incorporated

Chapter 4 contains our observations, conclusions, and recommendations

CHAPTER 2

ASSESSMENT OF THE ADEQUACY OF COST-EFFECTIVENESS STUDIES

This chapter describes the basic elements or criteria for cost-effectiveness studies and gives examples of adequate and inadequate application of such criteria in specific weapon system cost-effectiveness studies The examples relating to each basic element mainly are illustrative and deal only with the adequacy or inadequacy of that particular aspect of the study, such as alternatives analyzed or costs considered They should not be construed as being representative of the adequacy or inadequacy of the total study

BASIC ELEMENTS OF COST-EFFECTIVENESS STUDIES

The criteria or basic elements of a study as described in this section are a consolidation of factors considered in specific studies we examined and of general guidance[1] published by lower level commands within the services Neither DOD nor the services have issued firm criteria or standards for the preparation of cost-effectiveness studies In varying degrees each of the following items were considered by the service involved in studies we examined

--Statements of the mission(s) to be performed

--Inclusion of alternative weapon systems

--Disclosure of estimated costs of each alternative

--Logical presentation of relationships, including costs, predicted effectiveness, and assumptions.

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[1]Army Materiel Command Pamphlet 706-191, dated April 1971, includes a comprehensive treatment of cost effectiveness

STATEMENT OF MISSION TO BE PERFORMED

The key element of any cost-effectiveness study should be a proper statement of the mission to be accomplished by the weapon system Once the mission is clearly defined, the cost-effectiveness technique can be used to aid in evaluating the alternatives The impact of shortcomings in defining the mission is obvious If wrongly made, the analyses--selection of alternatives, development of their costs, and the presentation of representative assumptions and variables--are addressed to the wrong question

The following sections of this chapter deal with alternatives, costs; and the presentation of relationships of costs, effectiveness, and assumptions and show that factors which would lead to questioning were frequently omitted from service-conducted cost-effectiveness studies

INCLUSION OF WEAPON SYSTEM ALTERNATIVES IN COST-EFFECTIVENESS STUDIES

In order to decide upon the best weapon system to counter the projected threat, competing alternatives must be recognized and appropriate alternatives must be included in the cost-effectiveness study Alternative systems can take the form of existing systems in inventory or operational modifications of these systems and of systems in the conceptual phase All comparable equipment in each service should be considered to preclude duplication

Following are some specific examples in which criteria for selecting alternatives were adequately applied and some in which they were not

Adequate application of criteria--alternatives

B-1 bomber

The B-1 was compared to a number of strategic offensive weapon systems in the cost-effectiveness studies Aircraft, missiles, and combinations of aircraft and missiles were included in comparisons for both general (nuclear) and limited (nonnuclear) wars

The aircraft compared with the B-1 for the general war mission ranged from small fighter bombers to large bomber-configured transports A total of eight different aircraft, other than the B-1, were used in these comparisons In addition, five variations of the B-1 were considered

BUSHMASTER automatic weapon

Several cost-effectiveness and related studies have been performed on BUSHMASTER, an automatic weapon which is intended to defeat lightly armored vehicles, unarmored material, dismounted personnel and which provides defensive fire against aircraft and infantry BUSHMASTER also provides primary armament for the mechanized infantry combat vehicle and the armored reconnaissance scout vehicle

In determining BUSHMASTER's cost effectiveness in 1965, 12 existing, and 84 parametrically generated concepts of, weapons and ammunitions were studied The study results showed 16 candidates to be within the selection constraints, but only six were within the state of the art The six candidates recommended for BUSHMASTER consideration had caliber ranges of 15 2 millimeters to 38 1 millimeters BUSHMASTER was studied in 1967 for analyzing new concepts and for determining whether prior studies were adequate The ranges of BUSHMASTER candidates evaluated in previous studies were satisfactory In addition, nine hypothetical candidates having caliber ranges of 20 millimeters to 30 millimeters were recommended for BUSHMASTER consideration In a 1970 study a conceptual BUSHMASTER was compared to existing guns having standard and improved ammunition

Inadequate application of criteria--alternatives

A-X aircraft

Only Air Force fixed-wing aircraft, such as the A-1J, A-7D, A-37B and F-4C/D, were included in the Air Force A-X cost-effectiveness study, although other systems in, or proposed for, the DOD inventory at the time of the study were capable of providing close air support Such aircraft included the Navy's A-4 and its A-6 attack aircraft, the Army's AH-56 CHEYENNE attack helicopter, and the Marine Corps' HARRIER aircraft

According to Air Force officials, interservice comparisons of competing systems normally are accomplished through a DCP prepared by OSD The Air Force therefore did not make comparisons of the other aircraft The DCP for the A-X aircraft included only a summary of the A-X cost-effectiveness study made by the Air Force and did not include a comparison of the aircraft of the other services

As a result of congressional interest, a special review group was formed within DOD to examine the issue of close air support, including the Marine Corps' HARRIER, the Army's CHEYENNE, and the Air Force's A-X aircraft A report issued by the review group in June 1971 recommended continued development and testing of each aircraft so that necessary information for making decisions on production of CHEYENNE and A-X and further procurement of HARRIER would be available

In commenting on this matter, the Air Force indicated that it would be desirable if cost-effectiveness studies conducted by each service were to include comparisons of all competing systems, including systems of other services if appropriate The Air Force indicated that it was attempting to accomplish this in ongoing studies of the A-X and other close-air-support weapon systems Studies of other services' systems normally are not provided formally to OSD because it is commonly accepted that OSD has the prerogative and responsibility for making the interservice comparisons The Air Force indicated that it did provide evaluations of the AH-56 and AH-1G to the special review group

TOW missile

The cost-effectiveness study did not show how TOW was determined to be the only technical solution available to meet the need The study concluded that TOW, an antitank missile, represented a significant improvement in performance and that the costs were expected to be as low as or lower than the 106-millimeter recoilless rifle and ENTAC combination which TOW was expected to replace However, the study did not consider other weapons, such as DRAGON and SHILLELAGH Both of these alternatives are in competition with TOW in the antitank role

In commenting on a draft of this report, the Army indicated that DRAGON and SHILLELAGH were not considered as alternatives in the study because these weapons were complementary to TOW and were not in competition with it

Cost-effectiveness studies on any system, in our opinion, should set forth data on potential alternatives having similar mission capabilities The decisionmaker can then examine these alternatives to determine whether they are in competition with the proposed system

F-14 aircraft

The cost-effectiveness study showed the F-14 to be superior to the F-111B in the evaluation of aircraft maneuverability for close-in, air-to-air combat engagements This conclusion was based on the results of the air-to-air combat simulations However, the study did not consider the F-4J, the aircraft which the F-14 was intended to replace The cost-effectiveness study showed that simulations comparing the F-4J with the F-14 had not been conducted because of lack of time and pilot availability

The Navy agrees that this role was not completely treated in this study It stated that work had been done subsequent to the issuance of the study and that the results showed an overwhelming superiority of the F-14A or B over the F-4J The Navy stated also that, with regard to maneuverability, the F-14 had subsequently been shown to be far superior to the F-4J

DISCLOSURE OF ESTIMATED COSTS OF EACH ALTERNATIVE

Costs used in comparing alternative weapons system candidates should include estimates of development, investment, and operating costs related to the total operation. Related costs--such as those for spares, logistic support facilities, personnel, training, and maintenance--should also be considered to permit evaluation of a weapon's cost effectiveness. Cost estimates should be correlated with effectiveness predictions in analyzing and comparing alternatives, otherwise the entire analysis loses its usefulness as a decisionmaking tool. The decisionmaker must be provided with data indicating when a system may become too costly to procure.

Costs used in the original cost-effectiveness study are estimated very early in the acquisition process when a system is under design. There will be uncertainties upon which these cost estimates are based The degree of uncertainty will vary from system to system and may be such that reliable estimates cannot be produced. It therefore becomes necessary that areas of potential uncertainties be disclosed in the cost estimates. Failure to identify major uncertainties may lead the decisionmaker to consider estimates as firm when, in fact, they contain potential for major variations. (The need for continually updating estimates is discussed in ch. 3.)

Quantity is another factor which has an impact on cost estimates. Considering the expected threat(s) to be encountered, varying quantities can be presented in a cost-effectiveness study to reflect total costs of minimum and maximum protection. Also quantities need to be analyzed to provide the decisionmaker with information on how costs could change as a result of quantity changes.

Following are some specific examples of adequate and inadequate application of the criteria.

Adequate application of criteria--estimating costs

SAM-D missile

The most recently updated cost-effectiveness study for the SAM-D, an Army surface-to-air missile, contained detailed

costs for candidate weapon system families. Each weapon system family cost included development, investment, and operating costs for each individual system in the family, the development, investment, and operating costs for predecessor systems, the development, investment, and operating costs for command, control, and communication systems, both present and future, and the phaseout costs of existing weapon systems.

Computer simulations were used to determine the force levels to be used in the costing. The force levels were established as those necessary to provide a predetermined degree of air defense. In the final analyses the force levels of selected families were adjusted to meet established thresholds.

In addition, various assumptions were specified in the formulation of weapon costs. For example, the study indicated that (1) fiscal year 1971 and prior year costs were considered sunk, (2) all costs were quoted in constant fiscal year 1971 dollars with no allowance for subsequent inflation, and (3) all families were costed for the period fiscal years 1972 through 1995, the last year being determined by allowing 10 years of full deployment for the latest SAM-D variant.

In preparing the SAM-D missile life-cycle cost estimates, the Army provided for technical uncertainties in the program and developed an allowance for their cost impact. This was done primarily by a statistical estimating method which computed the research, development, test, and evaluation costs for the system based on historical costs of other systems. This estimating method, termed "study of trends and escalation of costs," assumed that the SAM-D missile would follow the trend of previous systems and that a median level of past problems, e.g., schedule slippages and unforeseen technical problems, would persist in the future

AEGIS--surface-to-air missile system

The AEGIS cost-effectiveness study contained the following types of cost groupings (1) weapon system costs, (2) force costs, and (3) program costs

Weapon system costs included the projected weapon system procurement, development, and operating costs over a 5-year period. Ship costs were excluded in this costing method. Force cost represented the annual costs of a basic task force. Included were allocated weapon system development costs, ship and weapon system procurement costs, and annual operating costs of the ship and the weapon system. Program costs represented the total amount to develop, procure, and operate the total number of ships, weapon systems, and aircraft needed for a task group of specified size and composition at a certain future point in time.

The cost-effectiveness study contained estimates of annual force costs, together with the number of replacement ships needed at designated threat levels. The study disclosed that only advanced systems could provide the acceptable level of defense against the estimated raid size

Inadequate application of criteria--
estimating costs

S-3A aircraft

The cost-effectiveness studies conducted on the S-3A were based on the assumption that a definite need existed for a sea-based antisubmarine warfare (ASW) aircraft. In justifying the S-3A, the studies emphasized increased ASW effectiveness with much less emphasis on comparative costs.

Subsequent to the completion of the S-3A cost-effectiveness studies, significant changes occurred in planned procurement quantities and estimated costs for avionics. As a result the estimated S-3A development and production costs were increased by about $1.1 billion during the early validation phase of the acquisition cycle.

In commenting on this matter, the Navy explained that the $1.1 billion increase resulted from three factors (1) increases in aircraft quantities, (2) inclusion of escalation factors, and (3) increased ASW system capabilities. The Navy did not disagree that the S-3A cost-effectiveness studies failed to emphasize comparative costs.

LOGICAL PRESENTATION OF RELATIONSHIPS--INCLUDING COSTS, PREDICTED EFFECTIVENESS, AND ASSUMPTIONS

Cost-effectiveness studies express relationships among costs, effectiveness, and environmental factors to predict future outcomes of a course of action. These relationships consider important assumptions and variables and can become part of a computerized model, a simulation, or a war game. The process of identifying significant assumptions and variables is designed to simplify the task for the decision-maker in selecting the most appropriate alternative weapon system.

The consideration of assumptions and variables should be a logical presentation of real-world situations which a weapon system can be expected to encounter. For example, combat conditions should be realistic projections based on such things as previous history of similar combat engagements and environmental conditions. The assumptions and variables should consider a broad range of combat conditions which the weapon systems reasonably could expect to encounter. If the presentation of combat conditions is too restrictive, the results of the studies could inappropriately favor one particular system over others.

Following are examples where the criteria were adequately and inadequately applied.

Adequate application of criteria--assumptions

AEGIS--surface-to-air missile system

In the AEGIS study various enemy-attack vehicles and weather conditions were considered in evaluating the effectiveness of competing systems. Expected threats were defined and grouped into different categories. System effectiveness was expressed as the number of total kills to total targets in each category. Scenarios used to simulate actual war conditions contained descriptions of the geographic location of the battles, weather conditions, enemy-attack strategy and tactics, and the number and type of attacking units

Inadequate application of criteria--
assumptions

A-X aircraft

The initial A-X cost-effectiveness study prepared during 1968 was based on the assumption that all candidate aircraft would be compared under weather conditions permitting visual target identification The A-7D, an alternative aircraft considered in the study, was to be equipped with avionics to aid the identification of targets and delivery of weapons However, comparisons were not made of the A-7D and A-X under adverse weather conditions where such avionics would be needed to identify targets and to deliver weapons

In commenting on this matter, the Air Force said that, since the A-7D close-air-support capability was primarily in the visual operating regime, it was appropriate for comparisons between the A-X and the A-7D to be made primarily under visual conditions

Although the A-7D close-air-support capability was primarily in the visual operating regime, it had significant capability under adverse weather conditions In our opinion, all weather conditions in which the aircraft are expected to operate and all capabilities of the various aircraft to deliver weapons should be included when determining and comparing the cost effectiveness of the various close-air-support aircraft.

CONDOR missile

In a report on the CONDOR missile, we stated that the Navy had conducted two cost-effectiveness studies which compared the competing CONDOR and WALLEYE II air-to-ground missile systems Certain assumptions in the studies regarding attack tactics, target arrays, and enemy dispersal of defense stressed the advantages of CONDOR and led to the conclusions that CONDOR should be preferred

The studies considered a target distribution that would not allow an efficient expenditure of the WALLEYE II missile The WALLEYE II force would use more sorties and missiles than necessary to destroy the same targets than the CONDOR

force would. The assumptions portrayed a specific hypothetical combat environment rather than a broad range of conditions which would represent various types of environments that the systems could expect to encounter

CHAPTER 3

TIMELINESS AND UPDATING OF COST-EFFECTIVENESS STUDIES

The only formal requirement for a cost-effectiveness study has been that it be done early in the concept formulation phase of system acquisition Most of the weapon systems we examined had some form of a cost-effectiveness-study to support their selection to fill a particular need These studies were, as required, made very early in the concept formulation phase--a point of considerable uncertainty since the system description was not firm, technical performance was a long-range projection, and cost estimates were recognized as "ball park" type of estimates.

AVAILABILITY OF RELIABLE DATA

It is only near the end of the concept formulation phase that reliable information on cost and performance begins to become available As the system progresses through the acquisition cycle, this information becomes increasingly more reliable. Continual updating of these studies is necessary and is the only way to insure that the most cost-effective system will be developed The availability of new data or changes, such as those noted below, are reasons why continual updating is necessary.

--New competing alternative weapon systems/concepts are introduced into or are about to enter the acquisition cycle.

--Actual performance data, through testing, becomes available.

--New intelligence data are available that cause significant changes to meet the postulated threat

--Estimated system performance capabilities either increase or decrease and thus cause major configuration changes

--Major changes are made in cost, schedule, quantity, or any other assumption used in the earlier study

Following are examples where criteria for updating initial cost-effectiveness studies were adequately and inadequately applied

Adequate application of criteria

MAVERICK air-to-surface missile

In 1965 the initial cost-effectiveness study was made on the MAVERICK The objective of the study made during the conceptual phase was to determine whether resources required to add a new proposed family of missiles to the inventory were warranted in view of tactical missions of weapons then proposed or in the inventory

In May 1968 an updated cost-effectiveness study was completed The purpose of this updated study was to reexamine the basic requirement and the support rationale to develop the MAVERICK This study recognized that the basic cost-effectiveness methodology and inputs of the initial study were still valid This updated study was completed just prior to the award of the development contract in June 1968 and thus was available to OSD to assist in making the decision to enter full-scale development

The purpose of the second updated study, completed in June 1970, was to confirm the cost effectiveness of the MAVERICK in view of currently available cost, accuracy, and reliability data on guided bombs and to confirm anticipated increased unit production costs for the MAVERICK This increased unit production cost was due to cancellation of planned use of two types of aircraft as carriers for the missile and a corresponding reduction in planned production

BUSHMASTER automatic weapon

In 1965 parametric design/cost-effectiveness studies were done to establish the military characteristics of a BUSHMASTER weapon system for a new class of armored vehicles Several existing and parametrically generated hypothetical weapons and ammunitions were studied On the basis of cost-effectiveness results, six candidates were determined to be within the state of the art and were recommended for BUSHMASTER consideration

In 1967 the BUSHMASTER project manager, shortly after his appointment, determined that there was a need for additional assurance that the proposed system was cost effective in comparison with competing systems on a DOD-wide basis. Therefore a study was conducted to analyze the previous parametric design/cost-effectiveness studies and also to analyze new concepts to determine if prior studies were incomplete or incompatible. It was concluded that the range of BUSHMASTER candidates evaluated in previous studies was satisfactory. It was concluded also that there was sufficient basis to support a decision to initiate BUSHMASTER engineering development.

In addition, an updated study, which was made by the Army in August 1970, also concluded that the BUSHMASTER program should be pursued.

SAM-D missile

During 1967 the Army issued a report on its study of the SAM-D weapons family cost effectiveness Each family included variations of the SAM-D missile combined with variations of short-range air defense systems. The objectives of the study were, in part, to define the role and contribution of the SAM-D missile, considering the air defense requirements of the mid-1970s, and to develop the most cost-effective Army air defense weapons family It was concluded that development of the SAM-D missile and short-range air defense systems provided the best plan for Army air defense

The Air Defense Evaluation Board made a study covering the period March through October 1970 to determine, among other things, the most cost-effective means of providing air defense against a projected air-supported threat The study concluded that the SAM-D missile would provide the most cost-effective defense against the stated threat A recommendation made was that the SAM-D missile, then in advanced development, proceed into engineering development

Inadequate application of criteria

A-7D aircraft

Subsequent to a 1965 joint Air Force-OSD cost-effectiveness study and the approval by the Secretary of Defense of the A-7D procurement based on this study, major configuration changes in the system occurred which significantly increased its cost over that shown in the cost-effectiveness study

The change in capability which should have caused the study to be reevaluated or updated was that resulting from a new avionics system This new system increased the aircraft's ability to navigate accurately and its capability to deliver weapons on target Weapons delivery and navigation accuracy were increased significantly over the predecessor aircraft, the A-7A Terrain-following and all-weather capabilities were also provided in the new system Also, many tasks normally performed by the pilot were automated and self-testing features were built into the new system These avionics configuration changes contributed to the unit cost increase from $1 5 million when the procurement was approved by the Secretary of Defense to the estimated unit cost of $3 2 million as of December 31, 1972

In commenting on this matter, the Air Force said that our statement implying the A-7D program's cost effectiveness, as presented in a joint Air Force-OSD cost-effectiveness study made in 1965, had not been reevaluated after the decision was made to procure was misleading

In the consideration phases of incorporating these changes, mission and cost were the principal factors Several agencies within the Air Force reviewed and evaluated the weapon system changes All the major improvements to the A-7D were separately reviewed and evaluated by this process and were recommended as mission-effective changes to OSD for consideration Therefore, although there were no cost-effectiveness studies per se, this aspect was accomplished and all management levels within DOD were accorded the opportunity to apply the same basic decisionmaking process as used in the initial plan

As we have recommended in this report, cost-effectiveness studies should be prepared as formal documents at each stage of the decisionmaking process In this way the decisionmaker could be assured of the continuing cost-effectiveness of the system in relation to alternatives This assurance is necessary because, as a system progresses in acquisition cycle, there may be a tendency to exclude alternatives and to concentrate only on the cost and performance of the subject system

TOW missile

Between 1965, when the initial TOW cost-effectiveness study was prepared, and 1968, when TOW was approved for limited production, significant changes in the system occurred These changes should have necessitated an updated cost-effectiveness analysis Examples of these changes appear below.

1 An increase in research, development, test, and evaluation costs from $64 million to $102 million.

2 An increase in procurement costs from $267 million to $387 million.

3 A decrease in procurement quantities.

4. A decrease in launchers from nine to six in each mechanized infantry battalion.

The potential effect these changes could have on the TOW production program was not evaluated in an updated, formal cost-effectiveness study.

In commenting on a draft of this report, the Army stated that, although an update of the 1965 study was never made, it did accomplish certain studies and reviews prior to making production decisions. For example, prior to full-scale production, two separate studies examined TOW in relation to the performance and costs of other systems. One study was the congressionally directed TOW-SHILLELAGH comparative evaluation for the heavy antitank weapon role.

As indicated on page 25, cost-effectiveness studies should be prepared as formal documents at each stage of the decisionmaking process.

A-X aircraft

The initial A-X cost-effectiveness study prepared during 1968 was not updated, although changes in the program resulted in a later operational date and in higher estimated costs. Considerable controversy still exists as to whether night and all-weather weapon delivery capability should be installed in the A-X; however, a study was not made at the time of our review to determine whether the A-X with such capability would be more cost effective than that of other close-air-support aircraft.

The Air Force initiated a study in September 1971 to propose and evaluate candidate avionics systems for possible inclusion in the A-X. A major objective of this study was to perform cost-effectiveness comparisons on a constant budget basis to determine how many, if any, A-X aircraft should be equipped with an all-weather weapon delivery capability. The result will depend to a large degree on the level of improved capability that is technically feasible and on the costs of improvements.

The Air Force believed that this study was initiated at the proper sequence in the A-X program and that results would be available in sufficient time to allow avionics acquisition to be phased into the airframe acquisition as desired.

New cost estimates and capability changes, we feel, are two of the factors which necessitate continual updating of cost-effectiveness studies. Further, questions, such as the need for a certain capability and estimates of its cost, should have been included and discussed in the original study.

In our March 1972 staff study on the A-X, we recommended that, if additional avionics are determined to be necessary for any portion of the A-X force, a full justification be provided and evaluated in terms of the increased overall effectiveness in relation to the increased costs of the

additional avionics We recommended also that, before making any decision regarding the procurement of close-air-support aircraft, the Secretary of Defense conduct a cost-effectiveness study which would include all aircraft with close-air-support capabilities currently in or proposed for the DOD inventory; the latest information regarding costs, weather restrictions in areas of operation, enemy defenses, aircraft weapons delivery and evasion capabilities, and a comparison of the effectiveness of various combinations of close-air-support aircraft

CHAPTER 4

OBSERVATIONS, CONCLUSIONS, AND RECOMMENDATIONS

As a result of our review of cost-effectiveness studies on 16 different weapon systems, we are convinced of the definite usefulness of this technique. In some cases cost-effectiveness studies were comprehensive and provided the type of information on the cost-effectiveness aspects of systems which would be needed for important program decisions, would help insure that consideration was given to all important factors, and would aid in resolving program disputes--all in a logical, systematic way.

In other cases studies did not include all essential elements and therefore did not highlight the significant issues to the decisionmaker. It seemed that these elements were simply disregarded by the system advocates. The omission of these elements is not indicative of flaws in the technique. In such cases it would have been desirable for the service to inform the decisionmaker of a study's limitation, such as the nonavailability of data on the threat, alternatives, assumptions, or costs.

We believe that the greatest advantage of the cost-effectiveness technique is that it forces advocates of a weapon system to examine and record the real need, the alternatives, the related costs, and the assumptions considered. This serves to provide the decisionmaker with information which is helpful in making a decision at a very early phase in the system acquisition process. Continual updating at major decision points would help to confirm the development of the most cost-effective weapon.

We believe also that the cost-effectiveness technique in the military services can be strengthened by insuring greater objectivity in the studies. This could occur if an impartial party could participate in the study. This participation could be in the form of making joint studies, approving service study plans, or making independent studies. As a minimum this element of independence should be required when requirements in common mission areas generate an excess of interservice rivalry which, if unchecked, could result in costly duplication of equipment.

Recent policy guidance issued by DOD, while not identifying the cost-effectiveness technique as such, emphasizes that costs and benefits will be two of the factors considered and documented in DCPs prior to authorization for full-scale development of a system and prior to production and deployment We believe that the roles of cost-effectiveness studies and requirements for their use in support of DCPs need to be clarified

The recommendations listed below are designed to correct these shortcomings and to make the technique a useful tool in insuring not only the selection but also the development and procurement of the most cost-effective weapon needed to accomplish a specific mission.

RECOMMENDATIONS

The Secretary of Defense should·

1. Emphasize the need for cost-effectiveness studies. He should clarify the studies' roles as formal documents which support DCPs at each stage of the decisionmaking process.

2. Take actions to attain objectivity in cost-effectiveness determinations, particularly in mission areas in which two or more services are competing for a weapon system. This would require that OSD arrange for independent cost-effectiveness studies or identify an impartial party to review service studies. In particular mission areas it may require joint participation with the service in planning and/or conducting the study.

3. Make sure that the services, in implementing DOD Directive 5000.1, direct that cost-effectiveness studies be made at the earliest practical point and be updated throughout the acquisition process as major changes occur.

In its reply to the recommendations contained in a draft of this report, DOD provided the following information.

--Guidance would be issued which would require cost-effectiveness analyses to be available to support the findings summarized in DCPs and for presentation to DSARC.

--DOD agreed that there was a need to insure objectivity in cost-effectiveness determinations, particularly in mission areas in which two or more services were competing for a weapon system. DOD planned to insure that, when such a situation arose, an impartial cost-effectiveness study would be prepared and reviewed by either (1) OSD, (2) a multiservice review group, or (3) a Federal contract research center.

--Concerning updating of studies, the procedures established by the DCP-DSARC 5000.1, dated July 1971, necessitated the preparation of cost-effectiveness studies to support the three major decision milestones (1) program initiation, (2) full-scale development, and (3) full-scale production, as well as when any major program threshold might be exceeded.

MISSION OF 16 MAJOR WEAPON SYSTEMS SELECTED FOR REVIEW

SYSTEM	MISSION
DEPARTMENT OF THE ARMY	
TOW	Destruction of armored and field fortifications--surface-to-surface, air-to-surface guided missile
SAM-D	Surface-to-air missile--field army air defense system
BUSHMASTER	Primary armament for the mechanized infantry combat vehicle and armored reconnaissance scout vehicle
MBT-70	Main battle tank
HLH	Heavy-lift helicopter
DEPARTMENT OF THE NAVY	
A-7E	Light attack aircraft
P-3C	Land-based, antisubmarine warfare patrol aircraft
S-3A	Carrier-based, antisubmarine warfare aircraft
F-14	All-weather fighter
AEGIS	Surface-to-air missile system
DD-963	Fleet escort destroyer

APPENDIX I

SYSTEM	MISSION
DEPARTMENT OF THE AIR FORCE	
MAVERICK	Air-to-surface missile used to destroy tactical ground targets
B-1	Strategic bomber
A-X	Specialized close-air-support aircraft
A-7D	Fixed-wing, subsonic, light attack aircraft
F-15	Air superiority fighter

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON D C 20301

29 MAR 1972

SYSTEMS ANALYSIS

Mr Richard W Gutmann
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Dear Mr Gutmann

We have reviewed your Draft Report on "Review of Cost Effectiveness Studies for Acquisition of Major Weapon Systems" of November 26, 1971 This report concerns itself with the importance of, and need to perform, better cost-effectiveness studies in the Department of Defense and their usefulness as an aid in the decision-making process This study while recognizing that cost-effectiveness studies are subject to abuse and misuse, states that GAO's "review of cost-effectiveness studies on 16 major weapon systems disclosed the essentiality of the cost-effectiveness technique as an aid to decision making " The study further states that "such studies are paper analyses and, in some instances, limitations or problems may be resolved only through procedures such as prototyping, parallel development and stretchout of development "

It also notes that the new DoD Directive 5000 1 on "Acquisition of Major Defense Systems" while not identifying the cost-effectiveness techniques as such, emphasizes that costs and benefits will be two of the factors considered and documented in a DCP The study also notes that this "guidance appears to de-emphasize the role of formal cost-effectiveness studies as an aid in selecting a preferred weapon system."

The study also states that GAO's review showed·

" that there is a definite need for the conduct of cost-effectiveness type studies as early in the acquisition process as practical and for updating these studies as major developments occur We found that studies were not updated to consider changes such as.

" availability of actual performance data at variance with predicted performance data

" major cost or quantity changes

" major changes in initial study assumptions "

The study further states

" that many of the cost-effectiveness studies lacked objectivity and appeared to be designed to support the position of the advocating Service in that

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" known alternatives were excluded from the study,

" stated assumptions were too restrictive or not completely valid,

" available data on alternatives was not considered, and as a result, incomplete studies amounting to misleading information were furnished for decision-making purposes "

Based on these findings, the GAO report concludes that, "The Secretary of Defense should

"1) Emphasize the need for cost-effectiveness studies and clarify their role as formal documents supporting Development Concept Papers at each stage of decision making in the selection of specific weapon systems

"2) Initiate actions to ensure objectivity in cost-effectiveness determinations, particularly in mission areas where two or more Services are competing for a weapon system This could require that OSD arrange for independent cost-effectiveness studies or identify an impartial party to review Service studies In particular mission areas it may require joint participation with the Service in planning and/or conducting the study

"3) Ensure that the Services in implementing DoD Directive 5000.1 direct that cost-effectiveness studies be made at the earliest practical point and be updated throughout the acquisition process as major changes occur "

We are appreciative of your interest in the importance of cost-effectiveness studies and are in agreement with your conclusions that cost-effectiveness studies provide a useful and necessary input for making decisions concerning major weapon systems acquisitions

In reviewing your draft, we believe that you have incorrectly concluded that the new DoD Directive 5000 1 was intended to, or will lead to, the deemphasis of the importance of cost-effectiveness studies as a decision criteria in the DoD weapon system acquisition process In particular we feel the criteria established in Section III C of this Directive on Program Considerations clearly requires the use of the standards for good cost-effectiveness studies, as discussed in your draft report In addition, the increased emphasis that we are placing on the use of prototyping and operational test and evaluation is intended to help strengthen the quality of data used in cost-effectiveness, thereby increasing the confidence that can be placed on the findings of such studies In fact the assertion that DoD Directive 5000 1 involves a deemphasis of cost-effectiveness analysis is clearly at variance with your own description of 5000 1 on pages 7 and 8 of your report

As far as the GAO recommendation that cost-effectiveness studies should be available as formal documents to support DCPs, guidance will be issued which will require analyses to be available to support the findings summarized in DCP papers and for presentation to the DSARC In addition, these studies would be available for review by members of the DSARC and their staffs

It should also be noted that both the procedures established by the DCP/DSARC and those needed to support the objectives of DoD Directive 5000 1 necessitate the preparation of cost-effectiveness studies to support the three major decision milestones (1) Program Initiation, (2) Full-Scale Development, and (3) Full-Scale Production as well as when any major program threshold might have been exceeded We believe this approach is compatible with your recommendation that "cost-effectiveness studies be made at the earliest practical point and be updated throughout the acquisition process as major changes occur " In contrast, the former DoD Directive 3200 9, which is also discussed in your draft report, only emphasized the need to use cost-effectiveness analysis through the concept formulation and contract definition phases of the acquisition process

The GAO report asserts that DoD, when it cancelled DoD Directive 3200 9, had no policy in force requiring cost-effectiveness studies to be performed However, the "DSARC Checklist" has provided guidance on the items that must be considered and evaluated as part of the DSARC review to determine whether a specific weapon system should move to a subsequent phase of the acquisition process This checklist has also assured that studies are updated at subsequent milestones to consider major changes in assumptions

The draft report also fails to recognize that DoD Instruction 7041 3, "Economic Analysis of Proposed Department of Defense Investments," requires the use of cost-benefit or cost-effectiveness analysis in the making of DoD investment decisions This DoD Instruction has been implemented by all the DoD components

It is also the purpose of the coordination process on Development Concept Papers and convening of the DSARC to assure that (1) known alternatives are not excluded from the study, (2) stated assumptions are not too restrictive, and (3) all available data is considered We feel this assures, as suggested in your report, that studies are properly updated when major assumptions or conditions change

The Department agrees with the draft report recommendation that there is a need " to ensure objectivity in cost-effectiveness determinations, particularly in mission areas where two or more Services are competing for a weapon system " Toward this end, we plan to assure that when such a situation arises, that an impartial cost-effectiveness study is prepared and reviewed by either the (1) Office of the Secretary of Defense, (2) a multi-Service review group, or (3) a Federal Contract Research Center

Specific comments from the Military Departments on the inadequate application of the recommended criteria to specific weapon systems are attached for your consideration in preparation of the final report

John D Christie
Acting Principal Deputy Assistant
Secretary of Defense

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