REPORT TO THE CONGRESS

Acquisition Of Major Weapon Systems B-163058

Department of Defense

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

MARCH 18, 1971

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-163058

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

This is our report on the acquisition of major weapon systems by the Department of Defense. 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).

In addition, you will receive a classified supplement containing summaries of our evaluations of the individual weapon systems covered by our study. More detailed classified studies have been prepared on each weapon system. Copies of these studies will be provided on request.

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

Contents

ABBREVIATIONS

AMC	Army Materiel Command
CDC	Combat Development Command
CONARC	Continental Army Command
DA	Department of the Army
DOD	Department of Defense
GAO	General Accounting Office
OSD	Office of the Secretary of Defense
SAR	Selected Acquisition Reporting
SOR	Specific Operational Requirement

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

ACQUISITION OF MAJOR WEAPON SYSTEMS
Department of Defense B-163058

D I G E S T

WHY THE REVIEW WAS MADE

The large investment required in recent years for acquisition of major weapons has impacted heavily on the resources available for other national goals and priorities.

Acquiring these major weapons involves substantial long-range commitment of future expenditures. Because of deep concern in the Congress on these matters and because of evidence that the weapon systems acquisition process has serious weaknesses, the General Accounting Office (GAO) has undertaken to provide the Congress and the Department of Defense (DOD) with a continuing series of appraisals of those factors most closely related to effective performance in procuring major weapons. This report represents GAO's first such appraisal.

FINDINGS AND CONCLUSIONS

1. Concurrent with GAO's studies, over the last several months the Office of the Secretary of Defense (OSD) and the military services have been engaged in a substantial effort to identify and solve problems that have adversely affected the acquisition of major weapon systems in terms of compromised performance, delayed availability, and increased costs. GAO has found that generally the newer weapon procurements are following a slower development pace and procurement practices are more conservative than those of earlier periods. Because many of the current programs are in early states of acquisition, evidence of the results of the changed concepts is not yet available to adequately assess them, but the outlook is brighter.

2. The identification of need for a weapon system and the relative priority to be assigned its development is a fundamental problem in acquisition of weapon systems.

   Initial decisions as to which weapon system will be developed and the priority of its development is made by any one of the military services, but DOD has no organized method by which such proposals can be measured against its total needs. Such a method is now under development but it is in its infancy.

3. In recent months, the Office of the Secretary of Defense and the military services have paid extensive attention to the persistent problems of defining performance characteristics of weapon systems and

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of determining the technical feasibility of achieving that performance. There are many encouraging signs that these problems are being abated.

Extensive efforts are being applied--early in the weapon development process--to identifying areas with high design risks and to constructing and testing the hardware itself to demonstrate the feasibility of high-risk components before proceeding with further development.

4. In the preparation of and attention given to cost-effectiveness determinations, there was a wide range of quality. This variation has lessened the value of these studies to the entire acquisition process.

5. One of the most important unresolved problems in the management of major acquisitions is the problem of organization. The essence of the problem appears to be attempts to combine the specialized roles of major weapon systems acquisition management into more or less traditional military command structures. Because of this, there usually are a large number of organizations not directly involved which can only negatively influence the project.

   It occurs to GAO that ideally there should be a direct relationship between the missions for which weapon systems requirements are determined; e.g., strategic deterrent, land warfare, ocean control, etc., and the organizational structure needed to acquire them. Such an arrangement would facilitate grouping related weapon systems in packages of common mission and would permit putting together an acquisition organization of appropriate size and stature to handle these matters. Eventually, GAO believes, program management and organization will evolve along mission lines.

   There are other alternatives involved, but whichever is chosen must clearly provide for someone to be in charge, to have authority to make decisions and to have full responsibility for the results. The Deputy Secretary of Defense has recognized that the correction of this problem is fundamental to any real improvement and has stated that he plans to pursue it aggressively.

6. GAO found that, on 61 weapon systems where complete cost data were available, estimates to develop and produce the weapon system had increased some $33.4 billion. About one third of this increase, or $9.5 billion, represented the difference between the estimate prepared when the system was first approved for development (the planning estimate) and an updated estimate prepared when the system was about to be placed under a development contract. The remaining $23.9 billion increase was due to changes in quantities to be acquired and to a combination of such things as engineering changes, revisions to estimates, and provisions for increased cost due to economic inflation. (See p. 58.)

RECOMMENDATIONS OR SUGGESTIONS

The Secretary of Defense should:

1. Make every effort to develop and perfect a Department-wide method--now in its early stages of development--to be followed by all military services for determining two things: first, what weapon systems are needed in relation to the Department's missions; second, what the priority of each should be in relation to other systems and their missions.

2. Establish guidelines and standards for the preparation and utilization of cost-effectiveness studies. These guidelines should require that studies be updated and reviewed as part of the decision process when major changes in cost and/or performance require revised schedules for funding commitments.

3. Place greater decisionmaking authority for each major acquisition in a single organization within the service concerned, with more direct control over the operations of weapon systems programs and with sufficient status to overcome organizational conflict between weapon system managers and the traditional functional organization.

4. Ensure that each selected acquisition report (a) contain a summary statement regarding the overall acceptability of the weapon for its mission, (b) recognize the relationships of other weapon systems complementary to the subject systems, and (c) reflect the current status of program accomplishment.

AGENCY ACTIONS AND UNRESOLVED ISSUES

DOD has been actively pursuing a program to improve the management of the acquisition of major weapons. The Deputy Secretary of Defense has assumed a significant role in this improvement program. It is too early to say how effective many of these actions will be; but, if effectively pursued, they should result in better management. As GAO has noted previously, beneficial results of some of these actions have become apparent.

The comments by DOD on this report express only a general reaction due to the limited amount of time GAO was able to allow for DOD review. Because of the nature and importance of this subject, DOD wants to examine the final report further.

MATTERS FOR CONSIDERATION BY THE CONGRESS

This report provides the Congress with an independent appraisal of the complex problems associated with weapon systems development and procurement by DOD--a matter of serious concern in the Congress.

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

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DIGEST

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CHAPTER 1

INTRODUCTION

The investment to acquire major Department of Defense (DOD) weapons impacts heavily on allocation of the Nation's resources. Acquiring these major weapons involves substantial long-range commitment of future expenditures. Because of this and because evidence exists that the weapon systems acquisition process has not been conducted in an efficient manner, there has been considerable congressional and public attention focused upon improving the process for acquiring major weapon systems.

In the past year, several studies of the acquisition process for major weapon systems have been completed. These include studies by the Department of Defense Blue Ribbon Panel, the National Security Industrial Association, and the Defense Science Board Task Force on Research and Development Management. All these studies were critical of the systems acquisition process to some degree. More recently the Government Operations Committee, House of Representatives, held hearings on policy changes in weapon systems acquisition. The Committee report on this subject, dated December 10, 1970, contained recommendations for several improvements and the Commission on Government Procurement is including major acquisitions as one of the subjects in its study.

Recently, the Congress has called upon GAO to report periodically on the progress of various acquisition programs and to provide other forms of assistance that would make available to its committees and members more reliable information on which to base judgments concerning issues that involve its oversight, as well as its legislative function.

In order to effectively respond to the interest and needs of the Congress to obtain more timely and comprehensive data on which to base an evaluation of the management of ongoing procurements, the General Accounting Office has initiated a long-term program which will help provide data for continuing appraisal.

This report presents the basic format which GAO intends to use in its long-term evaluation. The GAO program is an effort to establish an approach conducive to nurturing greater agreement among the Congress, GAO, and DOD which will clarify facts and issues and result in improved management of the acquistion process. Our intent is to develop an orderly process which will lead to a constantly improving body of basic data to assist all participants in the making of critical weapon systems decisions.

Another objective of this GAO program is to provide a recurring series of evaluations of the weapon systems acquistion process. In these reiterations, GAO will (1) reexamine overall acquisition process efficiency and (2) make detailed and comprehensive examinations of the process followed in most, if not all, of the individual major acquisition programs. The consistency of format and the recurring nature of the evaluation program should aid in the annual review of these acquisitions by the Congress, as well as provide DOD with an independent assessment of the weapon acquisition process.

Finally, the GAO program is structured for recognition and appraisal of any improvement programs that DOD initiates for its acquisition process.

It is not the intention of GAO to judge the propriety of technical decisions made by DOD but rather to evaluate the efficiency of the management and decisionmaking processes applied.

THE DEVELOPMENT PROCESS FOR A MAJOR WEAPON SYSTEM

Developing major weapon systems is a primary function of DOD. The development process is highly structured and complex. The combined process involves close interactions between needs of the user and the ability of the developer to fulfill them.

A substantial portion of personnel of OSD and the military services are involved in the acquisition process. Costs of weapon development consume a large portion of the military budget each year. Large segments of industry are engaged in producing the needed weapons. More than

$150 billion is estimated to be necessary to acquire the weapon systems currently under development. Some $95 billion of that amount is yet to be appropriated by the Congress. An oversimplified representation of the manner in which weapon systems evolve from an idea to production is shown in the following chart. (See figure I.)

Conceptual phase--This is the initial phase in weapon acquisition. In this phase, need for new military capabilities is established, concepts are developed for a weapon system which will provide those capabilities, and technical feasibility is explored and determined. The objective of this phase is to provide the technical, economic, and military bases for initiating full-scale development of the weapon system. Advancement to the next phase, validation, is dependent upon satisfying criteria designed to measure achievement of the conceptual phase's objective.

There are six objectives which should be accomplished in the conceptual phase. First, mission and performance envelopes should be defined. Second, a thorough trade-off analysis must be made among the elements of cost, schedule, and performance to ensure that the most effective product is obtained when it is needed and at the most reasonable cost. Third, a military service must ensure that the best technical approaches have been selected for the new weapon system. Fourth, the service must provide assurance that engineering rather than experimental effort remains uppermost in the program and that the needed technology is available. Fifth, that the cost effectiveness of the proposed weapon must have been determined to be favorable in relation to the cost effectiveness of competing systems on a DOD-wide basis. Sixth and last, the service must ensure that, insofar as it can, the cost and schedule estimates are both credible and acceptable. When these prerequisite criteria have been fulfilled, the weapon program is ready to go into the validation phase. Secretary of Defense approval is required to authorize the program to move into the validation phase.

Validation phase--In this phase, the preliminary designs and engineering for the weapon system are verified or accomplished; management plans are made; proposals for engineering development are solicited and evaluated; and the

THE DEVELOPMENT PROCESS FOR A MAJOR WEAPON SYSTEM

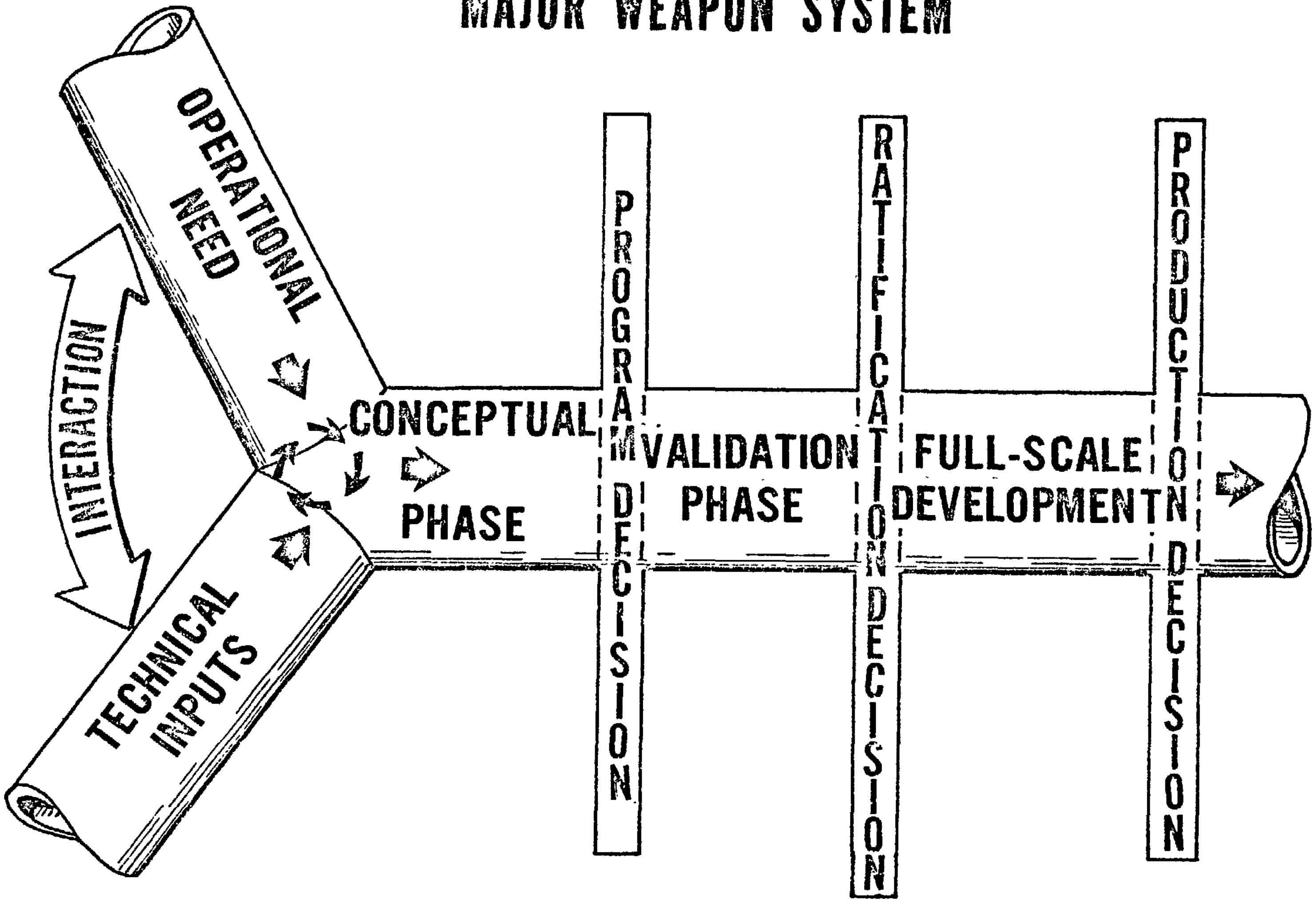


FIGURE I

development contractor selected. The objective of this phase is to verify that the technical and economic bases for initiating full-scale development of the weapon system are valid. Advancement to the next phase, full-scale development, depends upon establishment of achievable performance specifications for the weapon system that are supported by an acceptable proposal from the development contractor selected. Secretary of Defense approval is required for the program to move into the development phase.

Full-scale development--In this phase, the design and engineering of the weapon system is accomplished. The development contract is negotiated and awarded; the prototype of the weapon system is developed, produced, and tested; and the detailed specifications for manufacturing the weapon system are prepared. The objective of this phase is to develop a weapon system acceptable for production. Advancement to the production phase must be authorized by the Secretary of Defense.

The development phase overlaps the production phase since development is not considered complete until adequacy of the production model of the weapon system has been validated by a series of production acceptance tests.

Production--In this phase, the weapon system is produced in quantity for deployment. It begins when the production contract is negotiated and awarded. Production acceptance tests are conducted to validate the adequacy of the production model of the weapon system. Quantity production is initiated and the first operational unit is equipped with the weapon system and trained in its use. Advancement to the operational phase occurs when the first operational unit equipped with the weapon system is deployed. Production continues, however, until all required quantities of the weapon system are produced. The production phase includes production tests, service acceptance tests, and user acceptance tests.

Many potential weapon systems never progress beyond the early stages of consideration, e.g., conceptual phase. There are many reasons for this: unavailability of necessary technology, realization that a potential system may become too costly for its intended purpose, anticipated obsolescence in terms of threat that the system is intended to counter, or another system concept subsequently may compete more effectively. As a system passes through validation, however, the Government's commitment to it becomes firmer. By the time the system reaches full-scale development, the Government's commitment has become so great and the structure of the program so definite that major adjustments to the program are difficult because they almost always delay critical delivery dates and are costly. Few really acceptable options are available to the Government once the design is approved and a decision is made to begin production.

The pattern of deeper involvement and decreasing options is shown in the following chart (figure II). The greatest opportunity for broad decisions occurs during the early stages of acquisition.

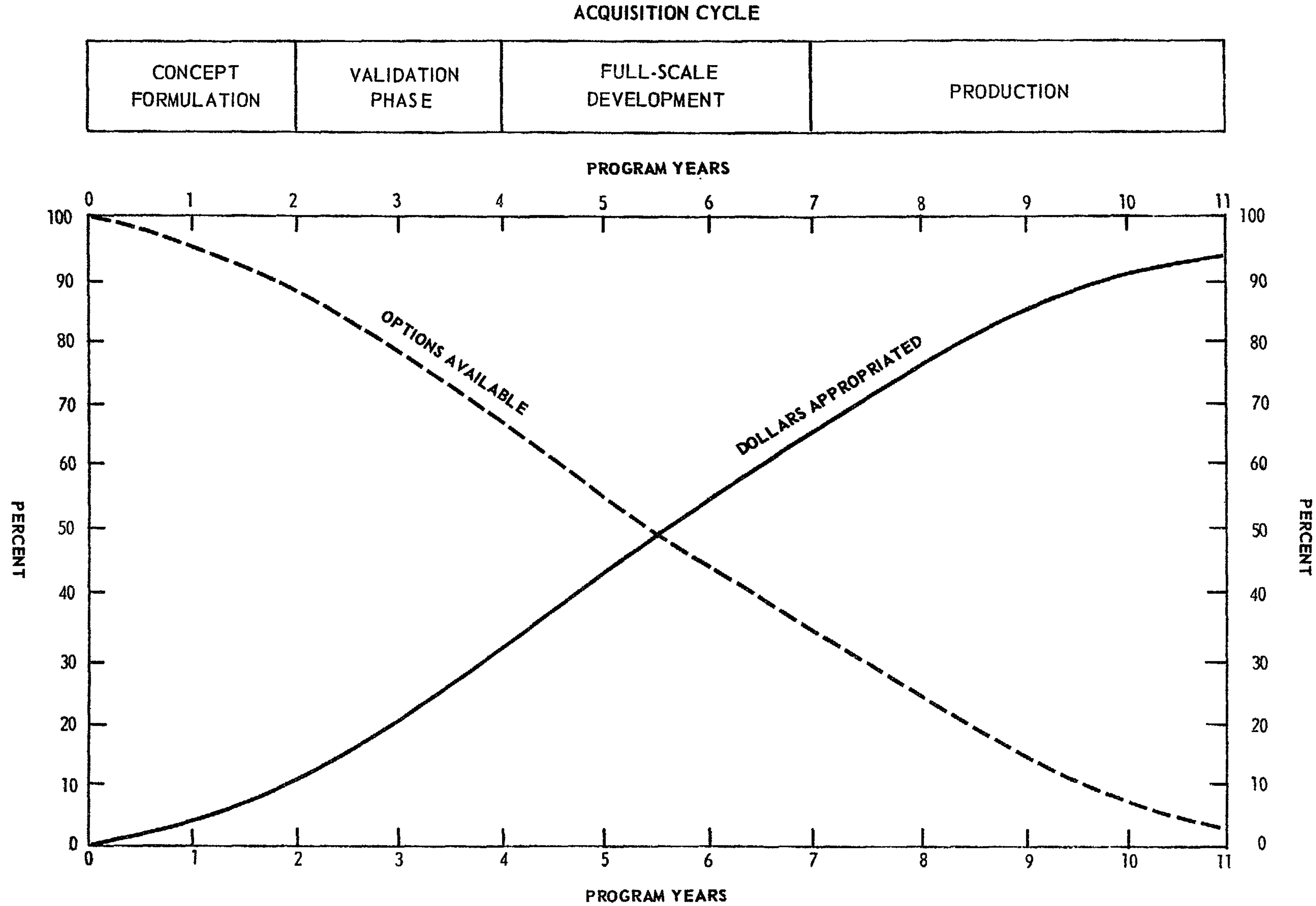

ACQUISITION CYCLE
CONCEPT FORMULATION
VALIDATION PHASE
FULL-SCALE DEVELOPMENT
PRODUCTION
PROGRAM YEARS
PERCENT
OPTIONS AVAILABLE
DOLLARS APPROPRIATED
0
1
2
3
4
5
6
7
8
9
10
11
100
90
80
70
60
50
40
30
20
10

FIGURE II

CONCEPTS OF THIS STUDY

It was clear to GAO, when this study began, that the underlying management difficulties, as well as the problems of actually executing sound day-to-day actions at all levels, were probably deep seated and could best be evaluated by a systematic review of the entire process by using specific systems and phases as a basis for case studies.

At the outset, critical major weapon acquisition management actions and decisions, which would occur in every acquisition, were outlined. In determining these critical actions, DOD's own criteria and objectives were used. The critical management activities examined pertain to

--requirements for systems,
--assessment of technical progress, and
--organization and procedures.

We selected specific weapon systems now being acquired on which to conduct reviews on the basis of the criteria which had been developed. Several factors influenced our selection of specific weapon systems. First, we selected some of the systems where the Congress or DOD would have future options regarding a further course of action. Second, we selected a number of weapon systems which recently proceeded into the early phase of the acquisition process. This factor is most important, because problems occurring in the earlier phases may plague the system for years and adversely affect the cost, schedule, and performance of the system at a point when adjustments are difficult to make. As was noted earlier, it is also the point in time when the greatest number of options are available to both DOD and the Congress. Relatively small sums of money are committed at this stage, and therefore it is easier to change the direction of a program. As the program progresses, however, choices will decrease and the responsible officials will tend to become committed to a particular course of action, until no options are left. Although there is little to be gained by dwelling on problems which have occurred in weapon systems where options were low, we have included a few such systems in our study since they provide the best means of assessing the full import of sound as well as unsound past actions.

To fulfill our task, 45 systems (14 Air Force, 14 Navy, 17 Army) were reviewed. In addition, we reviewed cost and schedule data from a number of other systems. Still other systems have been reviewed at the request of congressional committees. In all, the data in this report are distilled from studies of some aspect of 70 weapon systems.

In chapter 2, several of the management actions critical to weapon systems acquisition are described in some detail and are followed by examples of good and poor performance.

In chapters 3 and 4, information collected in this study on the costs and schedules of programs studied is presented in summary form to provide a useful basis for further analysis.

Chapter 5 contains our observations, conclusions, and recommendations.

Scope

In order to review current policies and practices, we examined weapon systems which were in various phases of acquisition--conceptual, validation, full-scale development, or production.

Information on these programs was obtained by reviewing plans, reports, correspondence, and other records and by interviewing officials at the system program office, intermediate and higher commands throughout the military departments, and the Office of the Secretary of Defense. We evaluated management policies and the procedures and controls related to the decisionmaking process, but we did not make detailed analyses or audits of the basic data supporting program documents. We made no attempts to (1) assess the military threat or the technology, (2) develop technological approaches, or (3) involve ourselves in decisions while they were being made.

CHAPTER 2

ASSESSMENT OF CRITICAL MANAGEMENT ACTIONS

In this chapter, several of the management actions critical to weapon systems acquisition are described and are followed by examples of adequate and inadequate application of criteria. Although each example is based on an evaluation of the management of the particular weapon system procurement which is cited, these examples are mainly illustrative. It is not the purpose of this report to focus on any particular acquisition.

REQUIREMENTS

Establishing requirements for weapon systems is an involved process. It is the basis for getting the system off on the right track and for controlling the development process. The process begins with identification of need for a specific capability and proceeds through such steps as defining performance characteristics, assessing the feasibility of achieving them, establishing some relative priority of need, and selecting the system that promises to be most cost effective. Once requirements have been firmly established, a basis for important actions during the development process exists. Such actions are controlling changes, continually making trade-offs between performance and cost, and controlling system phasing and interfaces. Requirements provide a yardstick against which action can be measured.

The following section outlines our understanding of general criteria to be followed in principal acquisition process steps and some illustrative examples where the performance in meeting the criteria has been both good and bad.

Identification of need for a system

The first step in weapon system acquisition includes (1) evaluating the products of documented military department threat studies, (2) projected enemy force structures, and (3) operating command statements of requirements and translating them into specific mission requirements and technology assessments.

The justification for selecting a particular major weapon system to fulfill the need includes analysis of concepts of existing and alternate capabilities, as well as the establishment of a relative priority of need. The clear identification of new mission requirements establishes a firm basis for initial and subsequent weapon systems and production.

Key considerations for establishing needs are:

Threat studies--Prepare future military risk positions and provide a justification of future needs.

Mission requirements--Define system capabilities in terms of specific objectives and tasks required of the potential system or systems, including operational and logistics concepts.

Current capabilities--Review abilities of existing systems or modifications to them in relation to defined mission requirements, and identify areas of required technological advances.

Technological advances required--Analyze alternate technical approaches and generally identify technical risk areas in relation to mission objectives.

Tactical concept of employment--Construct a detailed plan for the use of the weapon which sets the operational limits.

We have not attempted to pass judgment on military threat assessment; but we have examined methods that military services have followed to estimate current capability, to assess the potential for technological advancement, and to apply priority to a program relative to other weapon acquisitions.

Following are some examples of instances where criteria were adequately applied and some where they were not adequately applied in determining the need for the system.

The success which some of the weapon programs achieve in meeting their objectives for performance, schedule, and cost confirms the usefulness of DOD's own criteria for selecting the specific weapon system to be acquired.

A. Adequate application of criteria

S-3A

The S-3A need was identified and the decision to develop this weapon was made by a comprehensive analysis of future military requirements for carrier-based airborne antisubmarine warfare capability. In the analysis, the Navy and DOD considered mission requirements, technological advancements required to develop the S-3A, and possible alternative ways of satisfying the need. For example, the system that the S-3A is to replace was examined to determine whether it could meet the military requirement and whether it could possibly be modified to meet the requirement. Also considered was the feasibility of achieving technological advances needed to meet the performance planned for the S-3A program. (In addition to this early attention to ensure technical success, actual commencement of the development cycle of the S-3A aircraft was slowed considerably because of continuing reassessment of program priority with the land-based antisubmarine weapon system.)

B. Inadequate application of criteria

1. LAMPS

As early as 1957, the Navy stated a need to extend the weapon delivery range of destroyers to take advantage of improved submarine detection capability. The Drone Anti-Submarine Helicopter program was first developed to fill this need. (This program was canceled later due to limited capability and unreliability.)

The Navy then considered filling the need for an antisubmarine warfare (ASW) capability on destroyers with a manned helicopter, the Light Airborne ASW Vehicle (LAAV). Shortly after LAAV entered the conceptual phase, however, it was canceled, and effort was directed to development of the Light Airborne Multi-Purpose System (LAMPS).

This was done because it was felt within the Navy that OSD support for a strictly ASW system would be withheld. In order to "sell" the system, the mission profile was expanded to include an Anti-Ship Missile Defense (ASMD) capability. At this point ASMD was added to the LAMPS capabilities and was given priority over the ASW mission.

Thus, although need for an ASW helicopter had been clearly demonstrated for a number of years, the Navy decided to develop a multipurpose helicopter. This decision led to 2-1/2 years of debate on how these mission requirements were to be met within the weight restrictions that had been imposed on the helicopter because of anticipated interface problems with the ship.

2. Mechanized Infantry Combat Vehicle (MICV)

The MICV project began because of forecasts of threat to U.S. Forces and, in 1964, a change in Army mechanized infantry doctrine. From 1964 to 1966, the Army began a program to acquire an MICV for the 1960's--on an urgent basis. This effort was discontinued because the vehicles were too heavy, were not mobile enough, and were not cost effective. In the meantime, the Army embarked upon a second program, to acquire an MICV for the 1970's. This program had high priority, since the vehicle was scheduled for early deployment.

The schedule has not been met. The vehicle is still in the conceptual phase, and deployment is expected to be 5 years later than originally scheduled. The program has been drawn out for various reasons, including the priority for available funds.

The first major delay came in defining the vehicle's mission and characteristics. Approval of the definition was scheduled for March 1967 but was not made until October 1968. The delay occurred, in part, because certain studies were considered inadequate and additional work was required. An important factor was the complexity and resultant slowness of the Army's decisionmaking process.

The October 1968 vehicle definition assigned the MICV "Priority I" and called for development on an "urgent basis." In mid-1969, the project manager and higher commands sought, without success, Department of the Army (DA) approval to move the MICV out of the concept formulation phase. DA reviewed the program in the light of several factors including anticipated budget cuts, an increase in the MICV's estimated cost, and possible use of alternative vehicles which did not exist at the time of earlier studies. It considered several program alternatives, including (1) deferring the program a year, (2) deferring it a year and testing additional alternative vehicles, and (3) terminating the program and developing one of the alternative vehicles. DA decided to authorize a review of all feasible competing vehicle systems before deciding to move the MICV out of concept formulation.

During the new review, completed in April 1970, the project manager established the concept of an "austere" MICV, which would have a lower cost because of deletion of features that the Army earlier had termed "essential." In July 1970, he and higher commands recommended its adoption. At the time of our review, the DA decision was still pending.

3. SAM-D

Development of the SAM-D system began although there was uncertainty over the utility of the system, the character of the threat which was to be countered, and the capabilities of companion weapons with which the system would operate. Because of these uncertainties, in May 1967 the Secretary of Defense delayed the system's entry into full-scale development. Instead, the system was placed in an advanced development program to be conducted over a 3-year period. After 2-years in the advanced development phase, the system was studied in March 1969 to determine whether it should enter full-scale development. The Deputy Secretary of Defense directed that the system be continued in the advanced development phase through fiscal year 1970 and that the decision to place the system into full-scale development be deferred until fiscal year 1971. His position was that the system would not be needed until sometime later, the number of batteries needed and how the system would be deployed in the field was unknown, and the system was neither fully defined nor justified.

In March 1970, the Army subjected the system to review by the Air Defense Evaluation Board. The Board was directed to again analyze the threat that the system had to meet, to identify the air defense capabilities required to defend against this threat, and to identify existing air defense capabilities and deficiencies to meet the threat. The Board's report was approved by the Chief of Staff on November 19, 1970, and, in essence, confirmed the Army's position on the need for the SAM-D. As of December 1970, no action had been taken by OSD.

Definition of performance characteristics

Determination of weapon system operational requirements and performance characteristics (speed, range, accuracy, etc.) depends on well-defined mission statements. Performance characteristics are used to determine parameters of trade-off studies, performance feasibility studies, and phased system acquisition projection. Performance specifications prepared from these characteristics are the basis for initial design feasibility studies and validation efforts.

System design studies and development test programs derive from performance specifications. Absence of well-defined system specifications can cause underdesign or overdesign. Completion of the entire development process, without actual satisfaction of system mission requirements can result from this absence. Conversely, it is more likely that an explicit definition of system performance characteristics will result in an improved product. This is not to say, however, that system performance characteristics, once defined, must never be changed. This is an iterative process which becomes more firm as one approaches final design for production. Program management, to be effective, should allow for trade-offs as system development progresses and for unanticipated technical unknowns which are surfaced by detailed engineering design.

Following are some examples of instances where criteria for defining performance characteristics were adequately applied and some where they were not.

A. Adequate application of criteria

1. A-X

The definition of performance characteristics for the A-X weapon system flows from a clear, precise statement of the mission this weapon system is intended to perform in support of the Army mission.

The A-X mission is defined as close supporting fire for ground forces, armed escort, and armed reconnaissance in battle areas. It was determined, by contractor studies, that an aircraft with twin engines, capable of takeoff and landing at forward operating bases, surviving hits by light antiaircraft artillery projectiles, having a rapid-fire gun and carrying bombs or rockets; having high subsonic speeds and a range sufficient for effective close air support, is required.

A minimum of avionics for visual control is to be included initially with the weapon delivery. The aircraft, however, is to be designed with extra space and power so that more sophisticated avionics could bring its capability up to all-weather use, which the Army considers essential.

The Air Force awarded competitive prototype development contracts for the A-X close air support aircraft on December 30, 1970. This will give the Air Force actual hardware upon which to base a decision for further full-scale development and should provide a sound basis upon which to establish firm performance specifications.

2. Heavy Lift Helicopter (HLH)

The basic military mission for HLH was articulated by representatives of the operating command. Some objectives of the mission were revised, however, during early attempts to gain approval. One revision changed the mission emphasis from tactical to logistical. Another revision resulted from an Army/Navy compromise initiated by congressional interest in developing an HLH that would satisfy both the Army and Navy.

Basic mission requirements established by the representatives of operational commands were in clear and concise terms. The change in mission emphasis caused appropriate changes in the mission statements and subsequently in performance characteristics.

Performance characteristics, as well as all changes for the first two, were developed by study groups from various Army organizations. These study groups included representatives from the field, the project office, and engineers with various functional capabilities. The characteristics finally selected were considered the most desirable to achieve the established mission. Our review was completed before the Army/Navy compromise was approved, but preliminary studies were conducted individually by Army and Navy engineers who examined the compromise position. Their results indicated that a compromise on performance characteristics would limit some of the mission requirements of both the Army and Navy.

In September 1970, the Secretary of Defense approved a program to develop high-risk critical components for the HLH before full-scale development is approved, on the basis of performance requirements agreed to by the Army and Navy.

This approach assumes that advanced technological development of the critical components is necessary to (1) determine whether technology is available to build such an aircraft system and to identify the best technical approach offered by the helicopter industry and (2) establish realistic cost estimates. Related studies concerning further refinement of the mission, technology, and economy of the HLH will be made but will be subject to even further refinement on the basis of results of the component development program. If the critical component development is a success, this should permit a decision to be made whether or not to proceed with full-scale development.

3. HARPOON

The HARPOON missile is a good example of the Navy's thoroughness in defining the performance characteristics required of a system. The potential enemy threat and the mission profile of a new missile to meet this threat were defined by the Chief of Naval Operations in June 1969. He specified certain restricting design characteristics. For example, the missile range required and the range desired were specified. The maximum weight of the missile to be launched from a ship and from an aircraft was given. The requirement also specified that the missile have an all-weather capability, i.e., be able to hit a target under specified adverse weather conditions.

For a year, the Navy conducted numerous studies to determine how best to meet the requirement. The aerodynamic qualities of various missile designs combined with different kinds of propulsion systems were studied to ascertain whether the desired range could be obtained. Additionally, the reasonableness of the weight limitations was verified and studies were conducted of subsystems to find out if an effective missile could be made within the limitation. The adequacy of the size of the warhead, which is one of the factors having a direct bearing on the weight, was tested by blowing up a number of obsolete ships.

Problems in selection of a seeker with all-weather capability were anticipated. Different kinds of seekers were tested in flight before the kind of seeker desired was identified. These studies and tests provide reasonable assurance that the requirements can be met before proposals are solicited from contractors.

B. Inadequate application of criteria

LAMPS

Although performance characteristics of the LAMPS have been under study since early in its development, the Navy has had difficulty in agreeing on the gross takeoff weight of the helicopter.

The significant factor contributing to this difficulty is the fact that the program has been managed by various committees within the Office of the Chief of Naval Operations and had no consistent sponsor to guide and control it. Naval committee representatives have varying vested interests in the program and, as a result, agreement has been delayed on major questions such as the gross take-off weight of the LAMPS helicopter.

Committee representatives from one organization within the Navy were pressing for a heavier helicopter. In their opinion, a light aircraft would not have the desired mission capability. Representatives from another organization wanted a light helicopter because it would fit on the DE-1052 class ship and would be available to the fleet sooner. Controversy centered around the question of whether the deck of the DE-1052 was strong enough to support the helicopter.

Although the Deputy Chief of Naval Operations (Air) requested data on the maximum deck strength of the DE-1052 early in the LAMPS program, testing of the deck for maximum allowable landing weight was not accomplished until 2½ years after the LAMPS program was started. The tests occurred in November 1970, shortly after the Deputy Chief of Naval Operations (Fleet Operations and Readiness) succeeded the Deputy Chief of Naval Operations (Air) as the official primarily responsible for the LAMPS.

The Navy's long delay in specifying the weight of the helicopter will result in a significant delay in delivery of the LAMPS to the fleet.

Obtaining assurance of feasibility of performance requirements

The probability of a technically successful development depends upon an assessment of the availability of proven technical knowledge required to build the item(s), by identifying design risk areas and assessing the likelihood of resolving them early in the development process. Feasibility of performance requirements is usually assessed as a part of conceptual studies and confirmed during the validation phase. Entering into full-scale development without establishing design feasibility can result in attempts to achieve unrealistic technical progress within a specific test and schedule plan. Positive identification of these design risk areas will permit the program manager to facilitate the system development process by bringing his resources of men and money to bear upon critical elements and streamline the development schedule.

Following are some examples of instances where criteria for obtaining assurance of feasibility of performance requirements were adequately applied and some where they were not.

A. Adequate application of criteria

1. AEGIS missile system

In the cases of the AEGIS missile system, a group of highly qualified people from the Navy and industry performed a risk analysis as part of a comprehensive missile system study. In evaluating results, the Navy directed a laboratory model to be constructed and tested to demonstrate the feasibility of high-risk components before proceeding further with development. Added assurance that the system was technically feasible was obtained through an independent evaluation.

The successful demonstration of the highest technical risk component has been established as the first critical milestone in the current engineering development contract.

2. Heavy Lift Helicopter (HLH)

The HLH is planned to lift heavy loads over short distances in support of combat missions and peacetime operations. The HLH is planned as an improvement in lift capability over present transport and flying crane aircraft, and has no counterpart in the current Department of Defense inventroy.

The development approach for the HLH differs from many major system acquisitions in that the early phase of the acquisition process includes development of critical hardware in contrast to paper studies.

The Army has identified high-risk components for immediate development effort. If the critical component development is a success, full-scale development can proceed.

3. F-14 Aircraft

The F-14 aircraft is composed of three basic subsystems; namely, avionics, propulsion, and airframe. The potential risks in developing each subsystem were studied and analyzed by the Navy before proposals were received from interested bidders. The Navy analysis indicated that the risks associated with the avionics and propulsion subsystems were low because these subsystems had been developed for use on another aircraft. For example, the engine to be used on the F-14 was available and was tested on the ground in a simulated F-14.

The airframe was considered a normal development risk although various potential problems were identified. Plans were developed to resolve potential problems including identification of possible backup items which could be used to provide an interim capability, if required.

The Navy also used risk analysis in considering the reasonableness of the contractors' proposals. Therefore, when the Navy entered the development and production contract, risk had been minimized. Identification of program risk also enabled the project manager to more adequately monitor development of the airframe.

4. Airborne Warning and Control System (AWACS)

In the AWACS, the high-risk area was identified as the overland radar, the extent of which will be determined by building and testing actual hardware. Actual demonstration that the AWACS, including the overland radar subsystem, will work as intended is stipulated as a condition of continuing development.

Two competing overland radar systems will be developed, and a fly-off competition with AWACS configured aircraft held, to demonstrate their respective merits and detect shortcomings. If a successful system is demonstrated, the AWACS program will be allowed to begin the remainder of the full-scale development program.

B. Inadequate application of criteria

1. DRAGON

The DRAGON weapon system was approved for full-scale development before essential technology was available to correct major system limitations. At that time, the development of a required night sight was not believed to be within the state of the art. Other technical risks (i.e., friendly electronic interference and enemy countermeasures) had not been assessed as thoroughly as was possible.

Several DOD review groups, while acknowledging major system difficulties and performance limitations, recommended an accelerated development schedule for limited production of the system. Operational need was stated as a basis for these recommendations.

Demonstrated DRAGON performance has not met requirements contained in the Army's Qualitative Materiel Requirement. This problem comes from failure to properly assess high technical risks, and from granting approval to proceed prior to the resolution of risks. This is contrary to DOD rules.

2. Short Range Attack Missile (SRAM)

The feasibility of developing the motor required for SRAM was not adequately considered before commencement of full-scale development. The missile motor represented a high-risk area that neither the Air Force nor its contractors adequately evaluated during the contract definition phase.

After award of the full-scale development contract, the contractors concluded that the rocket motor required to meet design and performance contract specifications was beyond the state of the art. The Air Force now estimates that the rocket motor planned for production will have a total impulse less than expected at the time of the development contract award. Performance was thus compromised. Development of the rocket motor delayed completion of system development several years and raised costs as well.

3. C-5A aircraft

Similar to the SRAM program experience, the C-5A program encountered technical difficulties which were appraised but which may not have been adequately recognized at higher levels during the validation process. These technical problems proved difficult and costly to resolve and caused cost growth and schedule slippages.

In the case of the C-5A, the development schedule also was unrealistic. At the outset it was overly optimistic with no allowance for setbacks in the development program.

Cost-effectiveness determinations

Cost-effectiveness studies are one accepted means of selecting a system. They are particularly useful during concept formulation of a weapon program. Systems selected for consideration should include equipment already in inventory and should specify the degree to which such systems provide needed mission capability.

A cost-effectiveness study considers the need that a system is supposed to fill, the alternative technical solutions that are available to meet that need, technical performance characteristics of each alternative, cost associated with each possible solution, and criteria for choosing among alternatives. The overall study should emphasize significant issues to clarify merits of alternative systems. Also, the analysis should be updated when changes in basic assumptions occur. Updating ensures continuing cost effectiveness of the system selected by allowing for changes in threat, technological advancement, or desired level of defense.

GAO's examination was limited to the questions whether (1) the military service had fulfilled a requirement that cost-effectiveness studies be performed, (2) studies had been made of competing equipment systems, (3) each study was evaluated, used, and became part of the competing weapon program records, and (4) realistic equipment operating environments and personnel training levels were included as conditions for performance of the equipment end-item.

Cost-effectiveness studies provide a measure for evaluating changes as the program proceeds and for making continuing trade-offs between cost and performance. With such studies, we have a technique by which balance can be maintained between cost and performance. Without such studies, ill-advised program decisions affecting performance and schedules can seriously jeopardize program cost estimates.

Following are some examples of instances where criteria for performing cost-effectiveness studies were adequately applied and some where they were not.

A. Adequate application of criteria

1. DD-963

The program for development and production of new destroyers (DD-963) to replace World War II ships was initiated in August 1966. In September 1967, the Office of the Chief of Naval Operations completed a study comparing the cost and antisubmarine warfare effectiveness of the DD-963 class destroyer with alternatives. Formal approval to enter contract definition for the DD-963 was granted in February 1968.

The scope of the DD-963 cost-effectiveness study included a comparison of existing, modernized, and new design destroyers. Results of the DD-963 study showed that the DD-963 could provide antisubmarine warfare effectiveness with substantially fewer ships at a lower life-cycle cost, and at approximately the same total investment cost as any alternative ship.

The DD-963 study relied heavily upon previous studies for such things as postulation of threat and estimate of differences in effectiveness among the various antisubmarine warfare components used on the competing ships. Since our review did not encompass earlier studies, we did not determine reasonableness of the assumptions used in the DD-963 study regarding these or other significant aspects of the cost-effectiveness question. Nevertheless, our limited review has shown that the Navy (1) prepared the DD-963 cost-effectiveness study early in the acquisition process, (2) considered a number of alternative systems in DOD's inventory, and (3) apparently selected the most cost-effective alternative.

2. AEGIS

A cost-effectiveness study of the AEGIS Advanced Surface Missile System was made in early 1965. The principal characteristics of the missile system recommended for development at that time were essentially the same as those currently approved for development of what is now called the AEGIS system. In that study, comparisons were made of the performance of various individual systems in a wide variety of tactical situations and of alternative combinations of systems providing for the defense of specific naval forces. Alternative systems evaluated included existing Navy missile systems, aircraft equipped with air-to-air missiles, and several versions of the AEGIS system.

Costs of alternatives considered included development, investment, and annual operating costs. The cost and effectiveness of alternatives were compared. The conclusion showed the AEGIS system to be superior in cost effectiveness to the alternatives. Although a formal updated cost-effectiveness study was not prepared, the Development Concept Paper submitted to the Defense Systems Acquisition Review Council following receipt and evaluation of contractors' proposals, compared the cost and effectiveness of alternate systems against various threats.

Although we did not question validity of basic assumptions, we believe methods used in this study conform to acceptable cost-effectiveness-study practices.

3. Armored Reconnaissance Scout Vehicle (SCOUT)

A cost-effectiveness determination was made by comparing threat, mission, and effectiveness analyses with schedule, cost, and feasibility studies. By providing seven different firms with such data as scope of work, description of the system, vehicle design, etc., various concept designs were submitted. These designs were consolidated with in-house effort, and the results were furnished to a research firm. In addition, Army research organizations supplied auxiliary data on threat analysis. In the assessment of design, cost, and combat effectiveness (parametric design/cost-effectiveness study), the research firm analyzed (1) effectiveness evaluations of nine concept vehicles and eight reference vehicles in computer simulations of representative missions and (2) life-cycle costs of each of the 17 candidate systems. The comparisons of effectiveness required evaluation of the candidate vehicles in different threat and geographical environments as well as in the performance of two different types of mission--security and reconnaissance.

B. Inadequate application of criteria

1. A-X aircraft

The Air Force cost-effectiveness studies for the A-X aircraft considered only the A-1J, A-7D, A-37B, F-4C/D, and the improved OV-10. These are all Air Force fixed-wing type aircraft. Such possible candidates as the Army's AH-56 Cheyenne helicopter, the Marine's AH-1J Cobra helicopter, and the Marine's Harrier--a vertical/short takeoff and landing aircraft--were not covered in the studies. Also excluded is a more expensive version of the A-X which incorporates an all-weather capability.

2. A-7D aircraft

The Air Force recommended, on the basis of cost-effectiveness studies of existing DOD-wide competing systems, the procurement of a slightly modified version of the Navy's A-7 in-production aircraft to fulfill its need for close ground support missions and interdiction in future years.

Subsequent to these studies and DOD's approval of the procurement, major configuration changes in avionics invalidated initial plans and contributed to the Air Force procurement of a more sophisticated and expensive aircraft. The average unit weapon system cost increased about 110 percent between DOD's approval in November 1965 and June 30, 1970. These changes also contributed to delay in establishing firm detail specifications and attaining delivery schedules. We were informed by Air Force personnel that the cost effectiveness of the A-7D was not revalidated to determine if the aircraft was still cost effective after these changes were made when compared with competing existing systems.

The principal management weakness in administering this program was failure to give formal recognition in the management process to the effect of these changes. Such recognition would have subjected the revised A-7D plan to the same basic decision-making process as the initial plan, including a valuable cost-effectiveness comparison of the changed A-7D configuration with other DOD systems.

3. A-7E aircraft

Similarly, the Navy A-7 aircraft program began with the Navy A-7A version, which was developed to fulfill the requirement for light attack aircraft with increased range and load carrying capability to replace the all-weather A-4E. This A-7A was subjected to the full-scale development cycle. The next Navy version, the A-7B, was basically the same as the A-7A except for a different engine which provided increased acceleration and decreased takeoff distance.

In developing the "E" version, the Navy started with its existing "B" version and developed a significantly improved light attack aircraft. The Specific Operational Requirement (SOR) for this aircraft has not been changed. However, the improved avionics system and engine of the A-7E represent significant advances in the military capabilities over the A-7B, one being increased bombing accuracy. Like the A-7D above, the cost effectiveness of the ultimate A-7E configuration was not validated.

Stability of the program and its relationship to other programs

Effective pursuit of program objectives requires stability of priority and of allocation of all critical resources in combination with clarity and consistency of program direction.

The discipline imposed by OSD and the service secretaries upon the military services' weapon acquisition organizations has helped to bring about a more orderly management process. The rather long period of time required for acquisition has been broken down into logical stages. Comprehensive criteria have been established for an acceptable proposal for a program to advance from one stage such as the conceptual phase to the next. Detailed OSD direction has been given to the military services on all aspects of procurement, such as "make-or-buy," national priorities and defense materials systems, and small business set-aside.

The rigorous structuring and close management control mentioned above do not address the question of need for, and priority of, a specific weapon acquisition program relative to others. That process of determination and execution of the relative need/priority is accomplished principally through the formulation of budget and is reconsidered annually for each weapon program, in each appropriation involved, with consequent instability permeating all program direction.

The impact of instability is illustrated by the reduction in capability experienced by the Defense Satellite Communications System and its associated earth terminals. In another USAF mission area, the bomber air defense system, in which provision was made to systematically develop, procure, and deploy the system components in a preplanned, well-organized manner, the principal components are the OTH-B radar, AWACS, F-15 air superiority fighter, or an as yet undetermined interceptor fighter. For two system components (OTH-B & AWACS), the initial operational capability (IOC) dates do not coincide and the full operational capability dates bear no relation to one another. *An overall acquisition management plan, with provisions for integration and coordination of mutually interdependent weapons required for mission performance, and an interrelated air defense testing* *program to evaluate accomplishment of continental air defense would ameliorate this condition.*

The establishment of a comprehensive priority system for weapon acquisition programs is an involved process. This is particularly true for weapon systems which fall outside the category of "Strategic 1A" programs, (generally "super-systems" such as the ABM, POSEIDON, and MINUTEMAN for which high-level attention is readily available). Application of the ranking to other weapon acquisition programs is even less formal and specific.

At present, there is a DOD-wide priority system which allocates certain scarce resources among the competing needs of the individual ongoing acquisition programs. *This priority system is deficient in two respects; it is not uniformly applied within each of the services (although it is reasonably well applied to conflicting needs between programs which are in different services) and it tends to deal only with certain limited categories of resources (such as materials which are in short supply) and ignores the more critical resources such as overall funding and personnel.*

Within the military departments, some sort of priority ranking system does exist; its value has not yet been proven. *We believe that the development of a comprehensive DOD-wide priority system is a first step toward alleviating an important part of the difficulty we found in DOD's management procedures.* Of course, an indisputable priority is established weapon system by weapon system through the annual budget review cycle. These budget-derived priorities, however, are not converted into a DOD-wide comprehensive priority rating which would also determine each program's relative priority for <u>all</u> critical resources. Also, insofar as we can see, there is no effective connection between these budget decisions and some longer range view which contrasts each potential acquisition against a master plan of overall mission requirements and available or developing capabilities of all the services.

The Office of the Secretary of Defense has recently implemented a new approach to analyzing the plans for a weapon in terms of the relevant military mission category such as "land warfare." This analysis, which includes identification of major issues, is to provide the Secretary of Defense with a broad overview of each mission category. It also is intended to provide guidance for weapon acquisition to military departments and agencies which develop the programs for equipment to improve military effectiveness. Additional objectives of the procedure are to eliminate competing systems, phase out obsolete equipment, identify deficiencies in capabilities of the forces, establish performance characteristics needed, and set schedules for carrying out guidance. It is expected that the analytical procedure will raise and resolve major issues inherent in and between mission categories. Although this procedure appears to satisfy many of the essentials of an overall priority system, it is still in its infancy.

Subsystem development phasing and interfacing

The constituent subsystems of a weapon system must be available and compatible or system development will not be successful.

When a weapon program includes development of a subsystem with high technical risk, the weapon program is susceptible to slippage. When the subsystem development is out of phase with the development of the overall system, that system may be compromised in either schedule or performance, or both.

The mismatch of subsystems with the parent system appears to occur most frequently when responsibility for development of parts of the system is divided among two or more project managers. The difficulty is compounded when a subsystem is common to more than one weapon system yet separately managed.

Specific provision must be made to ensure that development and acquisition of the subsystem will coincide with technical requirements of each of the weapon systems for which it is to be used. The same considerations of phasing and interfacing are applicable to a weapon system such as SRAM which must work in conjunction with systems such as the B-52, B-1, and FB-111 bomber aircraft.

The increasing complexity of weapon systems has necessitated increasingly detailed, close control over design, development, and production of the system by the program manager. He must give informed technical and administrative direction to ensure that proper provision is made for control of development phasing and interfacing. He must require performing organizations to (1) identify and document the functional and physical characteristics of the weapon system and its subsystems, (2) rigorously control changes to those characteristics, and (3) record and report all pertinent aspects of the progress of system components and any changes to them. This quality of direction and control by the program manager is necessary to achieve integrity and continuity of design for technical performance, producibility, operability, and supportability of the overall system.

To reiterate, developing subsystems must be kept in phase with one another to make sure they will work together and will be available when needed, or cost growth and schedule slippage will generally occur. Imbalance in development of subsystems can also cause shortfalls from performance objectives for the weapon system; that is, delay in the achievement of, or incompatibility among, constituent subsystems of the weapon, or related weapons, may impair performance of its mission.

Following are some examples of instances where criteria were adequately applied and some where they were not adequately applied in subsystem development phasing and interfacing.

A. Adequate application of criteria

F-15/B-1

The F-15 and B-1 programs incorporate management concepts intended to guard against or minimize the effects of pitfalls which have been encountered in other major acquisition programs, through use of *total system responsibility* and *demonstration milestone provisions*. A "total system performance responsibility" clause has been incorporated in the F-15 contract, which makes the airframe contractor responsible for integration of the complete weapon system as well as for all actions necessary to ensure that the total weapon system will meet performance requirements set forth in the system specification. In essence, the Government looks only to the airframe contractor for satisfactory performance of the aircraft and does not become involved in any problems concerning the engine or the subsystems. Contractor-to-contractor relationships necessary to fulfill interface plan commitments are set forth in associate contractor agreements between the prime contractor and his associate contractors. A similar approach has been incorporated into the B-1 program wherein the airframe and engine contractors are working on an associate contractor basis, but the airframe contractor has total system integration responsibility.

Under the demonstration milestone provision, planned dates for accomplishment of specified technical milestones are established. The Air Force will determine whether the contractor has satisfactorily accomplished the milestones. The accomplishment of the milestone is contractually tied in with Government allocation of production funds. Failure to meet a milestone may result in a delay in the funding of a production increment, a delay in exercise of the option to which the demonstration milestone relates, or a partial allotment to sustain minimum production at the Government's option. Any schedule adjustments due to delays will be made with no change in initial target cost or ceiling price. None of the milestones were scheduled to be accomplished at the time our review was completed.

B. Inadequate application of criteria

1. CHAPARRAL/VULCAN

The CHAPARRAL/VULCAN air defense system was produced and deployed without the Forward Area Alerting Radar System (FAARS) which, coupled with other significant performance limitations, resulted in the system's providing limited air defense capability.

When limited production of the CHAPARRAL and VULGAN systems was approved in November 1965 and March 1966, respectively, the Army had not designed or developed the military characteristics for the system's radar, even though it had determined in 1965 that existing systems could not be modified to fulfill the radar's mission. Production of the radar was authorized in 1968, though earlier testing indicated that it did not meet performance requirements. When technical difficulties arose, radar production was stopped in July 1969. This resulted in the deployment of the CHAPARRAL/VULCAN system without FAARS. The present system requires the operator's visual detection and identification of enemy aircraft and his judgment that they are within range.

2. AN/BQQ-2 integrated sonar system

The AN/BQQ-2 integrated sonar system is a complex system designed for installation and use aboard nuclear attack submarines. The accomplishment of the sonar and submarine projects is the responsibility of different project managers in the Naval Ships System Command. Successful accomplishment entails integrating the two systems at a predetermined point in time.

Performance and physical characteristics of the two systems had been identified, but development and production schedules for the two systems were out of balance. The sonar was acquired under an accelerated program to permit delivery at the predetermined time that a ship would be ready to accept it. This precluded an orderly design, development, and production of the sonar system and resulted in technical problems. Technical problems delayed delivery of the sonar system. The sonar delay resulted in a disruption of Navy shipbuilding schedules and in cost growth.

The problem experienced with the sonar system development phasing and its ultimate interfacing with submarines was magnified because each weapon system had its own project management.

The Navy has now established a ship project directive system which provides ship acquisition project managers with procedures for directing management actions of secondary managers to ensure proper integration of the total shipbuilding program. Thus, definitive tasking, scheduling, and funding for all support elements is effected. This policy should help significantly to prevent the situation described in the AN/BQQ-2 sonar example.

3. P-3C aircraft

Development interface and subsystem phasing problems were encountered in the P-3C program because the technical feasibility of certain subsystems planned for the program had not been fully proven when the development program was approved. For instance, a succession of three different versions of the acoustic signal processor has been attempted since program approval. The last of these, the one now included in the program, is known as DIFAR. The decision to incorporate the DIFAR processor gave additional capability to the P-3C, but it made the problem of interfacing and phasing of development more difficult because the processor was still under development and was not available until about a year after P-3C deliveries began. The result has been a stretch-out in P-3C testing and the delivery to the fleet of aircraft short of desired equipment. This equipment had to be backfitted as processor production caught up with need.

Continuous trade-off between cost and performance

As early as preparation of a design is completed for the weapon system, the program manager should initiate the iterative process of examining each proposed change in capability for the weapon against its associated costs. His analysis should include estimates of technical feasibility of the design features of the proposed change, probable impact on the logistics and schedule, and cost of the capability in relation to military need.

A continuous trade-off between performance and cost during the acquisition process will keep all elements in balance.

Flexibility during development is important. The Deputy Secretary of Defense has stated that

> "The cost of developing and acquiring new weapon systems is more dependent upon making practical trade-offs between the stated operating requirements and engineering design than upon any other factor."

He has stated further that

> "trade-offs must be considered not only at the beginning of the program but continually throughout the development stage."

Budget constraints have forced trade-offs of the nature described and have ensured continuing implementation of this philosophy.

Following is an example of an instance where criteria for trade-offs between cost and performance were adequately applied.

A. Adequate application of criteria

F-15 aircraft

The Deputy Secretary of Defense advised the Air Force in September 1969 that production funds for the F-15 program would be limited and that acceptable performance cost trade-offs must be determined so that F-15 costs would be within the approved program. The Air Force began a cost reduction study based on assumptions that the F-15 engine and airframe would be unchanged and that the development phase would begin as originally scheduled. The study produced savings which brought the program within funding constraints while retaining an acceptable operational and growth capability. The largest cost reductions were realized in avionics. Such changes as reducing range and ground map requirements for the radar, reducing redundancy in computation, reducing communications and navigation requirements and equipment, and a decrease in the amount of initial spares were effected. The estimated unit cost of production was reduced about $1.5 million per aircraft. Provisions were retained in the aircraft to permit the reinstatement of some hardware items at a later date, if feasible.

Additional trade-off studies of the F-15 have been made to meet Air Force needs more economically since the award of the development contract. The Air Force plans to continue its review of the F-15 program throughout the development phase for possible reductions in cost, weight, and complexity.

TECHNICAL ASSESSMENT

One of the results we observed of DOD's efforts to improve its weapon system acquisition process was the increased use of test results to anticipate specific technical difficulties.

The conduct of specified tests and use of their results under current management concepts are incorporated into recent acquisitions programs, such as the F-15 and B-1 aircraft programs. Clarification of assessment of technical development is part of the implementation of total system responsibility; of milestone demonstration; and of thresholds for cost, schedule, and technical performance.

Technical feasibility studies pinpoint technical high-risk areas. Special emphasis is now being given to minimizing these risks, and special testing is used to monitor planned progress.

Tests are a valuable means of assessing subsystems and system design progress. Test results also provide a comparison of actual progress with the planned progress.

Test results provide management with information on which to base decisions such as to modify a design approach or to change basic system development plans. The results of successful tests also can be used to curtail design efforts when sufficient confidence is gained to support a decision to proceed with production or to accept hardware for operational use. With inadequate data from test results, judgments of this kind become more subjective and susceptible to a greater degree of error. Omission of tests can result in the production of hardware that does not meet requirements.

Following are some examples of instances where criteria for technical assessment were adequately applied and some where they were not.

A. Adequate application of criteria

1. DRAGON missile

The Army's technical development test plan for the DRAGON missile has demonstrated that DRAGON's performance has not met established requirements for reliability and single-shot kill probability. Additional technical problems were also revealed through testing.

Test results that the Army is using may influence plans to let a limited production contract prior to completion of all service tests.

2. Improved HAWK missile

High-risk areas in technical objectives of this missile, for which extraordinary management action was required, were identified in November 1968. At that time the Improved HAWK system entered an engineering test/service test program. The test program was scheduled to continue through 1971. Flight tests were halted in December 1969 because a component failed to function properly. This component was modified and additional test objectives were prescribed. An 18-month development program was instituted to develop another component as an alternative. In early 1970, flight testing was resumed but only limited success was obtained in meeting the objectives. Conclusive data have not been obtained on flights against low-altitude targets, maneuvering targets, high-speed targets, long-range targets, and electronic countermeasure environments.

To decide whether a production contract should be awarded for FY 1970 and FY 1971, the project manager had a risk analysis performed. Completed in April 1970, the analysis included an evaluation of technical, cost, and schedule data on the Improved HAWK system. A component was assessed as a high-risk item. To minimize this risk, modifications to the component were proposed. After evaluation of these modifications, other performance risks, and increased costs that would be incurred by delaying procurement, the project manager recommended the immediate award of a production contract.

3. MAVERICK missile

Production options included in the contract for MAVERICK development were to be exercised before scheduled completion of tests conducted by the contractor. Additional provisions afforded the Air Force opportunity to delay exercising production options for 420 days, upon payment of stipulated standby costs. This option period extends through the scheduled completion of contractor testing and almost to the midpoint of military service testing. The Air Force decision to use this option period, and thereby delay commencement of production until a substantial portion of Air Force-controlled demonstration test results are known, indicates that it is moving toward the DOD position of "fly before you buy" and is gathering more test data before committing a weapon system to production.

B. Inadequate application of criteria

1. SRAM

Some degree of subjective evaluation must often be exercised in evaluating test results and that fact must be made clear to decisionmakers. This has not been the case in the SRAM program.

Major milestone decisions which involve advancing an acquisition program to its next phase must be based on broad information about actual accomplishments as compared with planned accomplishments. Test programs are devised to provide that information. The SRAM flight test program has fallen somewhat below the ideal in that extrapolations of test results have been used.

Extrapolations of the SRAM flight test results include adjustments for conditions, such as the interim rocket motor, atmosphere, winds, launch altitude, launch speed, and missile weight. Adjusted test data based on technical extrapolations, engineering assumptions, and various other adjustments for simulation and probability analysis do not conclusively demonstrate SRAM/carrier aircraft actual capabilities. *Such test results demonstrate only calculated capabilities.* Test data based on accomplishment more closely resembling actual mission conditions would provide a reliable gauge for top management to judge the performance and progress of a testing program.

2. AN/BQQ-2 sonar system

When planned test programs are abrogated, even for a good reason such as an overriding urgency to deploy, the effectiveness of the product is compromised. For example, the attack submarine program required that the AN/BQQ-2 sonar system components be installed at a specified time during a submarine shipbuilding schedule.

The current version of the AN/BQQ-2 sonar system was designed to provide a given improvement in reliability and a larger improvement in maintainability over a prior version of the sonar system. Reliability and maintainability demonstration tests were not conducted on the first few production systems. The Navy followed this course of action because it felt the chances for success to be good since the current system is a follow-on to previously designed and tested systems. The first production system was delivered before the production acceptance test was completed.

The schedule demands of the shipbuilding program for the nuclear attack submarines required delivery of the sonar systems before complete testing to preclude delaying the ship construction program. However, this should not be a justification for skipping the required testing.

The system delivered required changes to meet requirements. It is easy to see that program decisions which ignore test results are apt to escalate costs.

3. <u>M60 tank</u>

The M60A1E2 is a modified version of the M60A1 tank--currently the Army's standard battle tank. The E2 version was to have had a redesigned turret incorporating the SHILLELAGH weapon system. The SHILLELAGH was already under development; and, in this case, the objective was to adapt it for use on the M60A1 tank and to provide, at an early date, a tank having a missile-firing capability. Development of the M60A1E2 began in 1964; although early testing of prototypes had disclosed major deficiencies, the Army in 1966 authorized full-scale production of the tank before sufficient testing had been accomplished to validate the design, despite advice of qualified testing and user agencies.

Technical difficulties occurred during production which should have been detected in the testing program. The technical problem which caused the greatest concern and prevented deployment of the tank was the inability to stabilize the turret. This was a basic design fault that caused the tank's gun to move erratically, making it extremely difficult to deliver effective firepower. Premature decision to enter production brought delivery of 300 tanks and 243 turrets and components for which extensive modification is needed to satisfy the user's requirements.

ORGANIZATION FOR PROGRAM MANAGEMENT

Managing the acquisition of complex weapon systems has evolved into one of the principal activities of the military services. It is quite different from other procurement and receives special attention in the military services. Weapon system management is the process of planning, organizing, coordinating, evaluating, controlling, and directing contractors and participating organizations to accomplish system program objectives.

The program management approach to weapon acquisition is a distinct departure from the services' traditional method of establishing functionally oriented organizations to carry out well-defined, repetitive or continuous, long-term tasks. This approach requires the program manager to establish management arrangements among his organizations, other military organizations, and various contractors to efficiently coordinate their efforts to accomplish program objectives.

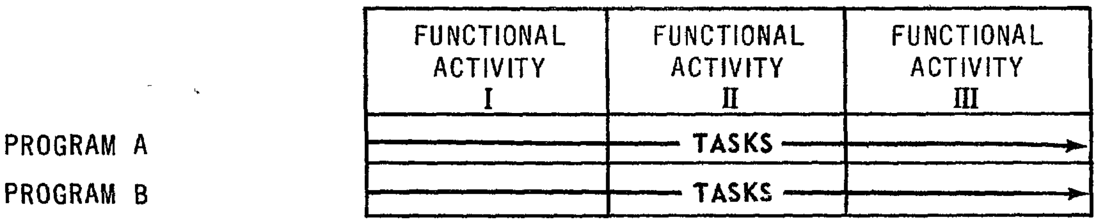
A variety of program management organizations have been established. They range from a large, self-sufficient office to an austerely staffed focal point which operates on the matrix principle and which must draw all specialized support from the functional organization to which it is attached. These are illustrated in figure III.

The self-sufficient program office is organized and structured to operate by itself without having to rely on functional organizations for technical and administrative support. Conversely, the program office operating on the matrix principle relies on functional organizations to perform such tasks as research, development, logistics planning, procurement, inspection, and supply and maintenance.

There are advantages and disadvantages associated with both the self-sufficient program office organization and the functionally oriented (matrix) organization. The advantages of one organizational structure tend to be the disadvantage of the other and vice versa; e.g., a matrix organization fosters greater specialization with less technical duplication but makes coordination and communication more difficult. A self-sufficient program structure fosters coordination and communication but makes specialization more difficult, and some technical duplication becomes inevitable.

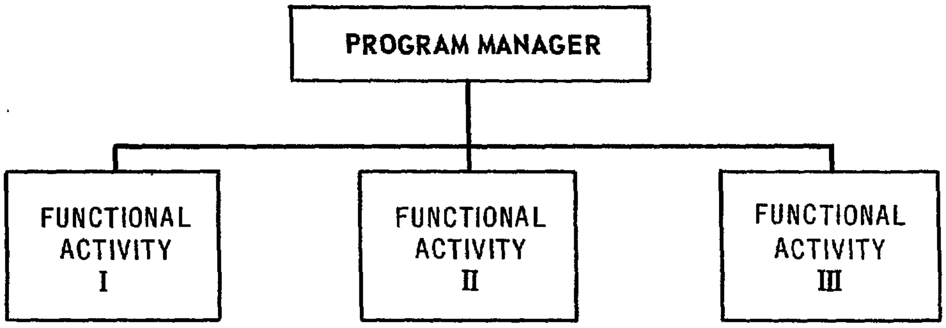
FUNCTIONAL MANAGEMENT ORGANIZATION

NO PROGRAM OFFICE ESTABLISHED
INCLUDES PERMANENT AND CONTINUING SPECIALIST STAFFS



PROGRAM MANAGEMENT ORGANIZATION

PROGRAM OFFICE ESTABLISHED
PROGRAM OFFICE STAFF ASSIGNED FOR THE DURATION OF THE ACQUISITION
INCLUDES SPECIALIST STAFFS REQUIRED FOR PROGRAM ACCOMPLISHMENT



MATRIX ORGANIZATION

INTERFACING OF PROGRAM AND FUNCTIONAL MANAGEMENT ORGANIZATION
MANAGEMENT OF CORRELATED ACTIVITIES OF FUNCTIONS AND PROGRAMS

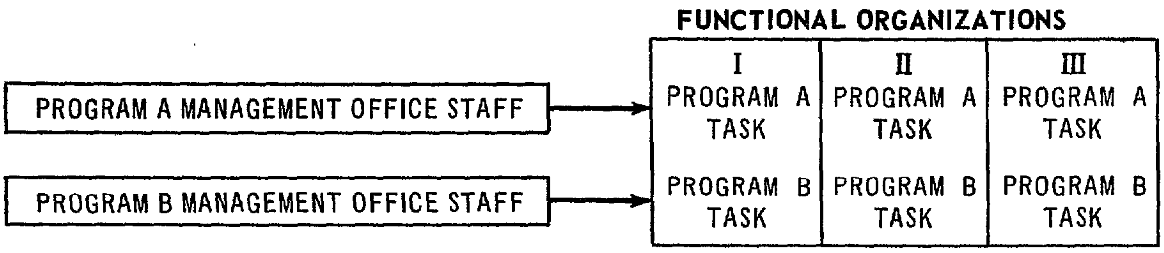


FIGURE III

In large part, the Air Force acquisition programs are in self-sufficient organizations, while the Navy projects are matrix oriented; and Army projects are organized somewhere between the other two.

Under its matrix concept, the Navy has provided only 14 people for its F-14 project manager's organization. Another 92 people are assigned to the functional organizations within the Naval Air Systems Command. They are identified with the F-14 program but they do not work directly for the project manager. Under this arrangement, there is need for considerable coordination between the organizations. The functional personnel associated with the F-14 program may or may not work exclusively on this program. Conflicts for their time must be negotiated on a case-by-case basis. We are informed that priority of work assignments on the F-14 project has not been a problem, but the potential for trouble obviously exists.

In contrast, the Air Force F-15 program manager, with 243 staff members, essentially has a self-contained organization. All the functions necessary to manage the development program are manned by personnel directly responsible to the program manager, and work assignment priority can be handled by him.

Organizational "layering"

One of the most troublesome features of the present program management structure is difficulty in obtaining decisions. It seems to us that the most likely cause of this problem is that decisionmaking layering is not commensurate with organizational layering. In general, the military services have not deemed it wise to place the project manager high in the organization because of some practical considerations, such as the large number of project managers and the need for them to work directly at lower levels of the organizations. However, the effect has been to preserve levels of review authority which do not have clear roles in the process of formulating decisions.

Most of the decisions that the project manager does not make himself are made at the highest levels of the service or by OSD. Between the project manager and top management are a large group of organizational units whose commanders attempt to keep themselves informed about a particular weapon system and study and deliberate on pending programs to recommend some course of action. As a rule, they have no direct approval powers. They can delay or stop a project but cannot make decisions to proceed, change direction, provide money, or take other positive action.

Military service organizations for weapon system acquisition are shown in the simplified charts on pages 53, 54 and 55. These charts do not show the many subdivisions that become involved or the special ad hoc panels and committees which inevitably arise in the weapon system acquisition process. All these organizational units, panels, and committees impact heavily on the project manager. His program may be delayed or stopped while matters are being studied or while decisions are being made, or his program may proceed without timely decisions.

In the Army, for instance, any significant decision that the project manager cannot make usually is made at the highest levels of the Department or in OSD. With respect to these decisions, the primary role of the project manager is to make recommendations or to work with other groups that make recommendations. Recommendations go through the normal chain of command; i.e., the Commanding General of the Commodity Command, to the Commanding General of AMC, to the Army staff. To formulate recommendations though, it is necessary to coordinate a number of functional groups. These include functional groups within the project managers' organizations (i.e., the Commodity Command) as well as organizations outside the Command, such as Conarc and CDC. *The essential task of these groups is to help formulate a recommendation, but their decisionmaking function is limited to agreeing or disagreeing with it. Once the recommendation is made, there are a number of functional groups at the AMC and DA staff levels (about a dozen at DA staff alone) who can influence the decision. The contribution of all these groups is much the same. They can either agree or disagree with the recommendation made.*

The inevitable result of this process is the scheduling of repetitive meetings, briefings, and studies in an attempt to reach agreement on the recommendation to be made. Supplying information to numerous groups can be almost a full-time job for the project manager. During 1969, one project manager spent about two thirds of his time conducting 166 briefings and from January to August 1970 participated in 62 additional briefings. From January 1969 through July 1970, another project manager participated in 124 briefings. Many of the briefings involved levels below the top headquarters' staff, but the most important function of those participating was to recommend.

In another instance of extensive layering, several reviews of a program were conducted between September 1969 and April 1970, including an in-depth review by several boards and committees at all levels. *Of particular importance was the requirement that briefings for decisionmaking groups be previewed as many as 20 to 30 times before presentation to an action-taking body. The project manager spent a large part of his time participating in these reviews.*

ARMY ORGANIZATION FOR ACQUISITION

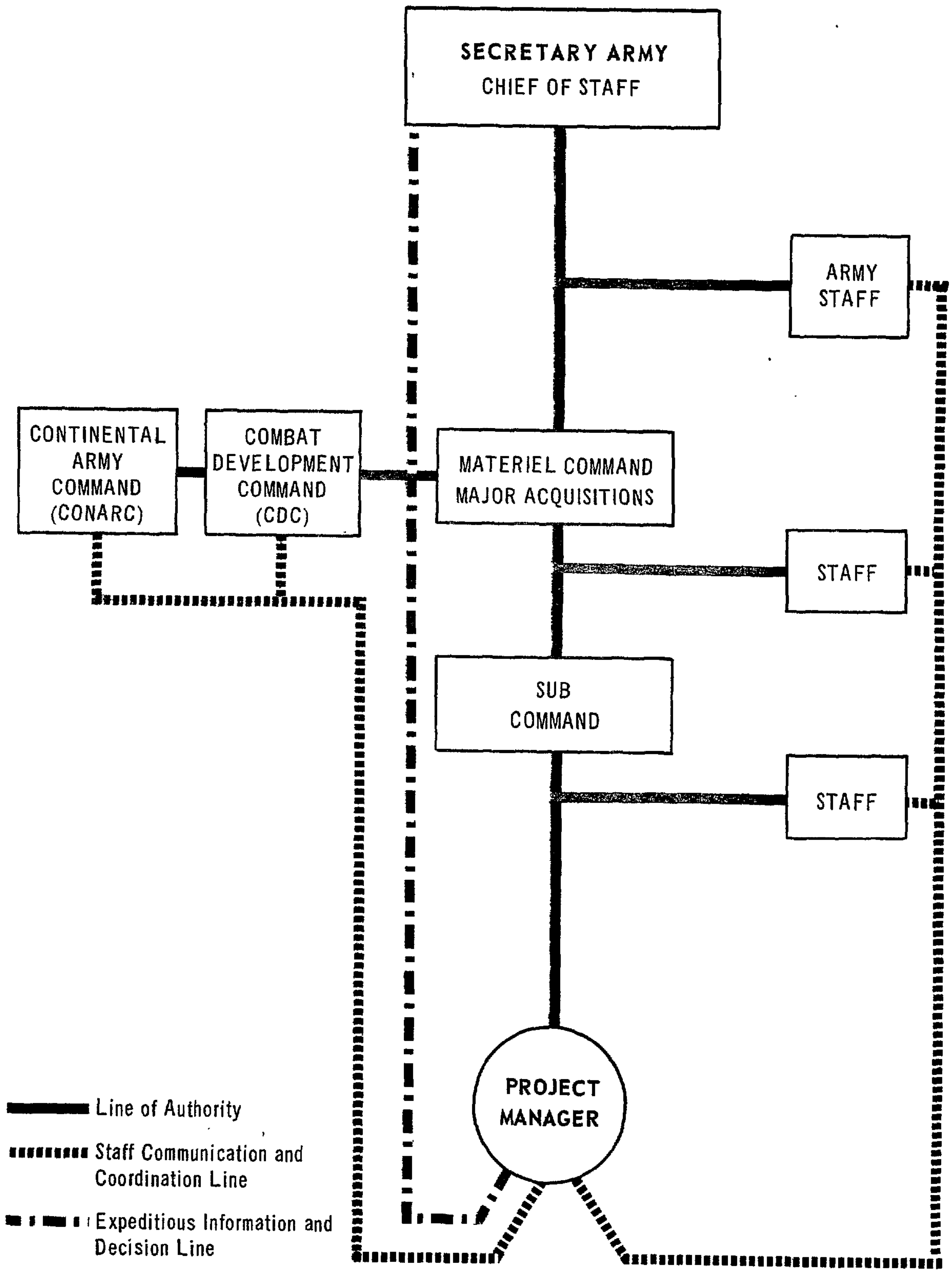


FIGURE IV

NAVY ORGANIZATION FOR ACQUISITION

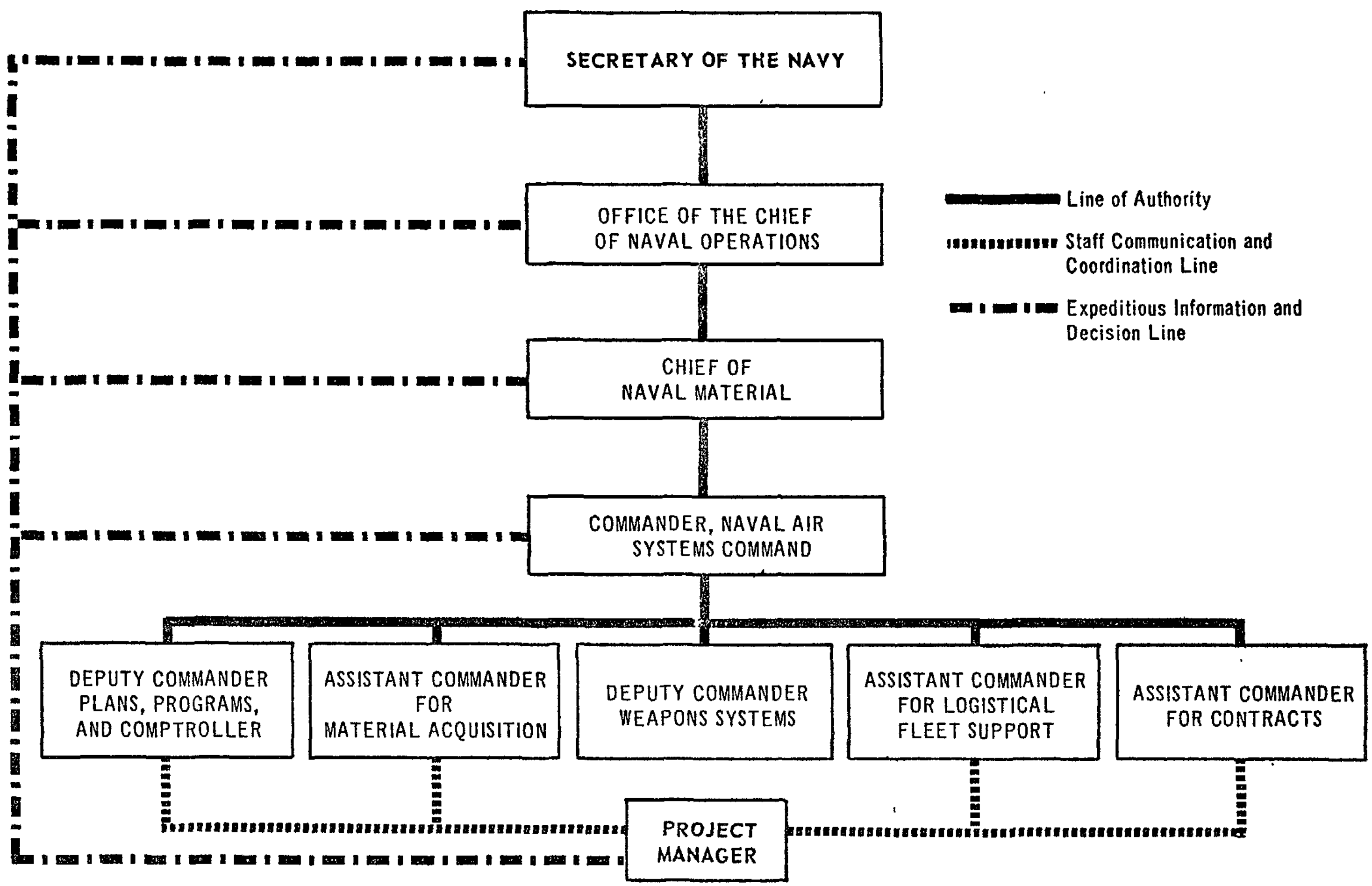


FIGURE V

AIR FORCE ORGANIZATION FOR ACQUISITION

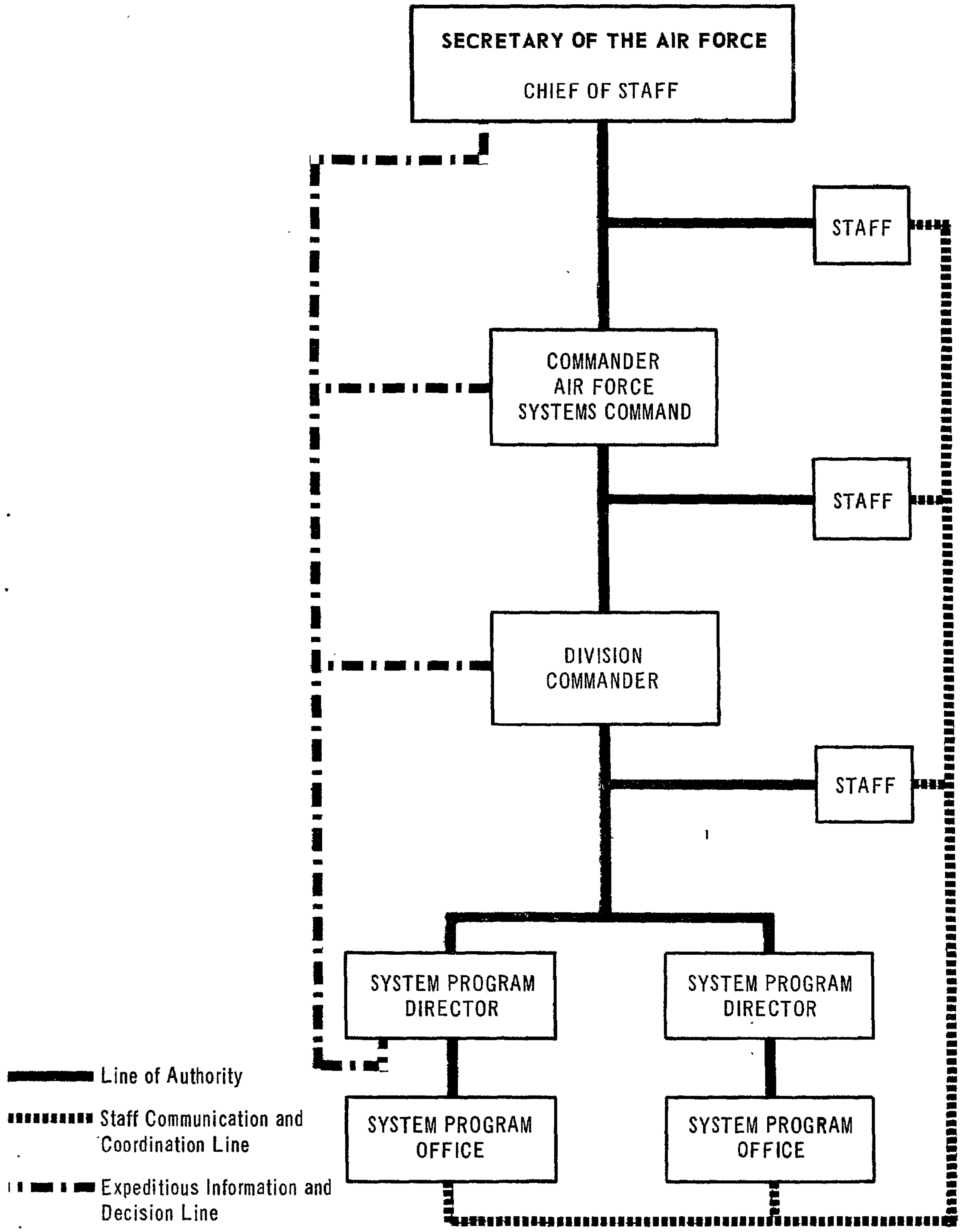


FIGURE VI

DOD-proposed action on acquisition management problems

The Deputy Secretary of Defense frequently has cited many of the problems in the organization and procedures for managing weapon system programs. He has stated that:

1. Program managers must be given authority to make decisions on major questions relating to the program, both in the conceptual phase and in the full-scale development phase.

2. Program managers must be given more recognition opportunity for career advancement in all the services, and good managers must be rewarded just as good operational people are rewarded.

3. People in program management must be experts in that business and must be assigned to a given program long enough to become effective.

4. The overall structure of the program management function in all services needs to be appraised. Changes must be made to reduce the numerous layers of authority between the program manager and the service secretary.

CHAPTER 3

SYSTEM COST EXPERIENCE

Estimates of probable cost to develop major weapon systems are required at various points in the development cycle.

The initial estimate against which all program costs are originally considered is the "planning estimate."

The planning estimate is a formal estimate of cost anticipated in acquiring a system in the quantities needed. It is prepared prior to the initiation of the formal acquisition cycle and usually serves as a basis for the first appropriation request. The planning estimate is prepared by a military department and is approved by the Secretary of Defense.

The planning estimate is followed by an estimate of the cost to develop the system. The "development estimate" is a refinement of the planning estimate and is established during the period in which preliminary design and engineering are verified or accomplished and contract and system management planning are performed. This period frequently extends over a period of one year.

A third estimate, the "total cost estimate," is intended to be a current objective statement of the cost to be incurred in acquiring the total approved program. This estimate is adjusted for increases or decreases in quantities, as well as for cost changes due to inflation, change in scope, capability increase, and program stretch-out.

An estimate also is prepared to disclose costs which are related to the maintenance, operation, or improvement of a weapon system rather than its acquisition cost. Examples are replenishment of spare parts, modifications, component improvement, and common ground equipment. Projected operating costs are not included in this latter kind of estimate.

Nine of the 70 systems we reviewed had just entered the development process. Their status precluded preparation of precise estimates. A summary of program cost estimates for the remaining 61 systems is shown in the table below.

The estimated cost for these 61 systems increased some $33.4 billion from the cost anticipated by the planning estimate to the current estimate of cost through program completion.

About one third of this increase, or $9.5 billion, represented the difference between the planning estimate and the development estimate. The remainder of the increase, $23.9 billion, was due to changes in quantities to be acquired and to a combination of such things as engineering changes, revisions to correct estimates, and provisions for economic inflation.

Cost Estimates as of June 30, 1970

Number of systems	Planning estimate	Development estimate	Cost changes (note a)		Current estimate through program completion	Total cost (note b)
			Quantity	Other		
	(millions)					
Army (14)	$14,869.8	$14,437.3	-$1,420.3	$ 3,308.4	$ 16,325.4	$ 17,197.6
Navy (32)	31,516.7	34,867.7	9,265.2	9,168.6	53,301.5	56,335.9
Air Force (15)	37,247.2	43,830.6	-4,632.4	8,220.2	47,418.4	51,896.8
Total (61)	$83,633.7	$93,135.6	$3,212.5	$20,697.2	$117,045.3	$125,430.3

[a]The cost changes shown represent the difference between the development estimates and the reported current estimate through program completion.

[b]Includes additional procurement costs.

GROWTH IN PROGRAM COST ESTIMATES ABOVE PLANNING ESTIMATES*

*Adjusted for Quantity Changes

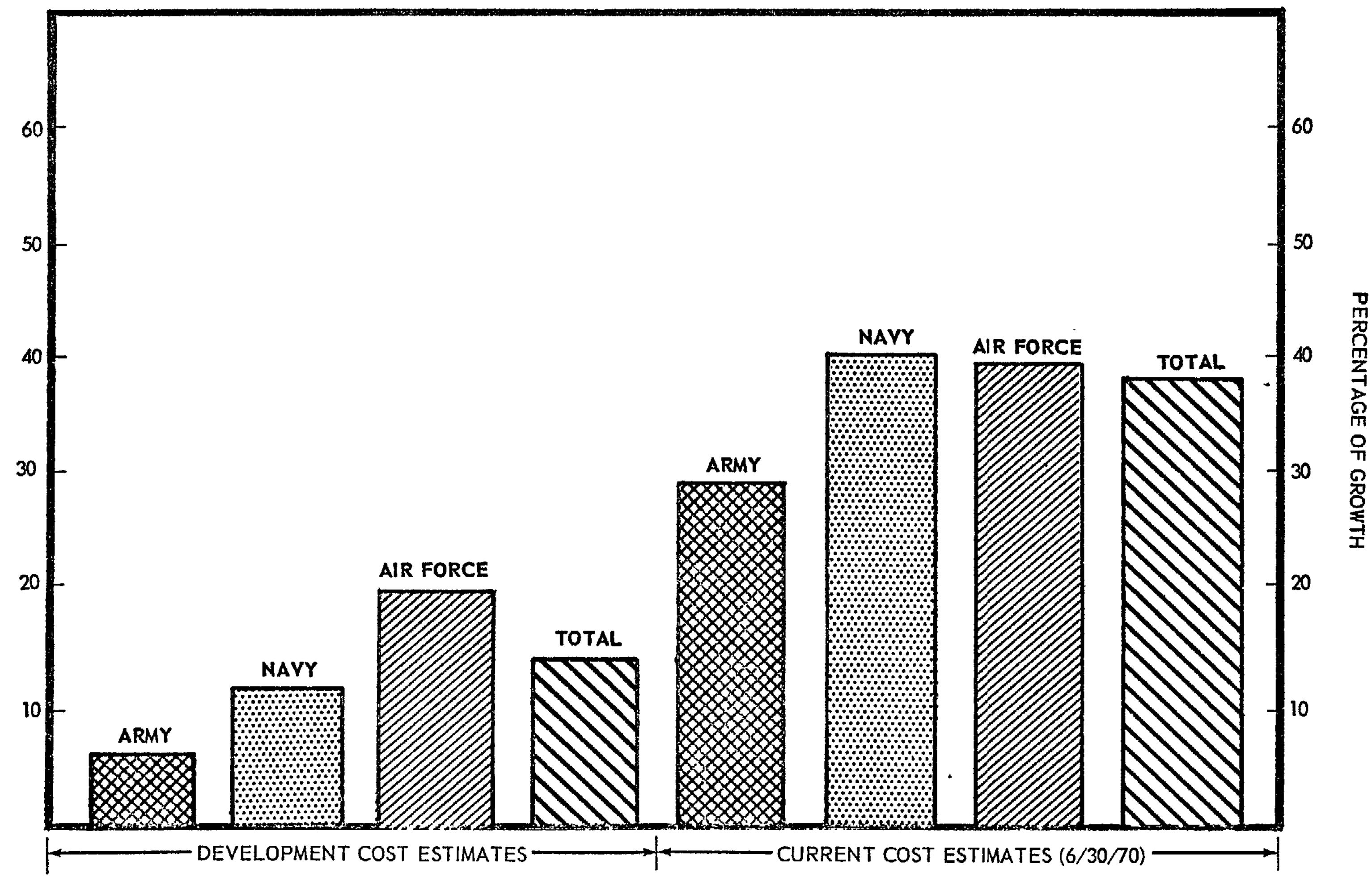


FIGURE VII

The foregoing chart (figure VII) shows that current estimates through program completion have grown 40 percent in comparison with planning cost estimates for these programs.

Cost growth may result from such things as unanticipated development difficulties, faulty planning, poor management, bad estimating, or deliberate underestimating. However, it is important to recognize, in any analysis or discussion of cost growth, that not all cost growth can reasonably be prevented and that some cost growth, even though preventable, may be desirable. For instance, unusual periods of inflation may result in cost growth. Changes in technology may make it possible to incorporate modifications that result in an overall increase in the effectiveness of the system. Such cost growth cannot always be anticipated, particularly where a weapon system is in development and production over long periods of time.

We stated in our February 6, 1970, report (B-163058) that data were unavailable from which to make any specific identification of program cost estimate variances.

We have suggested that DOD give increased attention to the problem of identifying:

1. Cost growth factors that are not entirely controllable by DOD, such as *inflation*, or those factors that may even be desirable and may be expected to continue, such as *upgrading system performance*.

2. Items that are basic causes for cost growth and could be *eliminated or reduced considerably by appropriate and effective DOD action*.

DOD has made a good start toward accomplishing the intent of our suggestion. Nine categories of cost variance have been established for use in the Selected Acquisition Reporting system (SAR), and program managers have attempted to quantify the impact of cost variances on their programs. Although the precision of these quantifications cannot be completely verified, segregations being made can now be used to focus attention upon areas where improvements can be made.

ANALYSIS OF COST CHANGES AS OF JUNE 30, 1970

The analysis of cost changes on the 52 weapon systems for which SAR data are available is shown in the table below. There has been a net increase in total cost of about $23,980 million. Quantity increases have amounted to about $12,600 million. Decreases in program quantities have amounted to about $10,216 million. Other changes such as engineering, schedule, and economic changes in the 52 weapon programs have amounted to about $21,597 million.

Analysis of Cost Changes as of June 30, 1970

Type of cost change	Army	Navy	Air Force	Total
	(millions)			
Quantity change:				
Increase	$1,371.1	$11,105.5	$ 122.3	$12,598.9
Decrease	-3,098.8	-1,760.5	-5,357.1	-10,216.4
Net	-1,727.7	9,345.0	-5,234.8	2,382.5
Other changes:				
Engineering changes	489.3	463.8	3,119.4	4,072.5
Support "	155.2	-57.7	1,268.5	1,366.0
Schedule "	462.1	1,308.7	844.7	2,615.5
Economic "	550.5	1,156.0	2,307.9	4,014.4
Estimating "	1,312.8	3,356.9	1,509.5	6,179.2
Sundry "	-12.7	553.1	544.3	1,084.7
Unidentified "	-	2,264.9	-	2,264.9
Total	2,957.2	9,045.7	9,594.3	21,597.2
Total	$1,229.5	$18,390.7	$4,359.5	$23,979.7
Number of systems	12	29	11	52

QUANTITY CHANGES

The approval of phase II of the SAFEGUARD system accounts for $1,365 million of the $1,371.1 million quantity increase reported by the Army. Three of the Army programs did not reflect any change in the number of units to be acquired. However, seven systems reflected decreases in program costs totaling more than $3 billion due to reductions in the number of units to be acquired. The largest of these decreases involved the SAM-D ($1.8 billion) and the MBT-70 ($600 million). We were informed that many of these reductions were the result of a review by the Department of the Army of its priorities for weapon systems, which was made because of impending budget reductions, and the establishment of the Army's eight highest priority systems.

Analysis of the 29 Navy systems for which data were available shows that 10 systems reported no change in quantities; nine systems reported increased costs totaling $11.1 billion (due to an increase in planned procurements), and 10 systems reported decreases totaling $1.8 billion. The largest part of the increase involves three ship programs totaling more than $7 billion. Included in this amount is $1.6 billion for 20[1] additional DD-963's, raising the total for this program from 30 ships to 50. Another large part of this increase comes from two aircraft programs totaling more than $3 billion.

The Air Force reported only a relatively small increase in cost due to quantity, mostly related to the SRAM. Two systems, the F-15 and B-1, reported no change in quantity. Seven systems reported reduced costs due to quantity decreases, totaling $5.4 billion. Of this amount, $4.4 billion involved the F-111, the FB-111, and the C-5A and $600 million involved the AWACS.

Instances of reductions in units acquired, in all services, were offset by increases in other costs for the weapon. Cost growth is obviously a significant reason for reducing the number of units to be acquired in all the services.

---

[1] We were informed in August 1970 that these 20 ships were not considered a firm program.

ENGINEERING CHANGES

An alteration in the established physical or functional characteristics of a system is called an engineering change. Incomplete descriptions of initial performance specifications and changes required to bring system performance up to expected standards have resulted in substantial need for engineering changes. Of the $4 billion dollars in engineering changes reported by the three services, about $3.1 billion was accounted for by the Air Force for the F-111, the C-5A, and the MINUTEMAN programs. Engineering changes totaling $1.8 billion were required to bring the F-111 and C-5A to expected standards, and $730 million involved changes in the MINUTEMAN to upgrade the system to meet an increased threat.

SUPPORT CHANGES

Support changes involve such items as spare parts, ancillary equipment, warranty provisions, and Government-furnished property/equipment. Relatively small amounts of money were reported in this category for the Army and Navy systems. Support changes in the Air Force amounted to about $1.3 billion and represented an increase in initial spares for the C-5A ($230 million) and the F-111 ($258 million).

SCHEDULE CHANGES

Schedule changes reflect adjustments in the delivery schedule, completion date, or some intermediate milestone of development or production. Cost increases of $2,615 million were reported as being due to schedule changes. Of this amount, $947 million involved three Navy aircraft programs (EA-6B, P-3C and A-7E); $260 million involved the SPARROW missile; and $747 million involved the F-111. The largest portion of the increase ($460 million) in Army programs is accounted for by the SAFEGUARD, SAM-D, MBT-70 and the LANCE.

For reporting purposes, identifying such schedule adjustment is probably important. GAO findings indicate that such adjustments are only indicative of other fundamental problems. Schedule changes, as such, are not a primary cause of cost growth.

ECONOMIC CHANGES

Economic changes reflect the influence of one or more factors in the economy. Included are specific contract changes deriving from economic escalation as well as changes in quantity--changing program estimates to reflect a revised economic forecast or changing actual contract quantities.

We were informed by the Assistant Secretary of Defense (Comptroller) that the treatment of anticipated economic escalation in various reports was neither consistent nor uniform within or between services. To rectify these discrepancies, OSD stipulated on June 30, 1970, that the September 30, 1970, SAR reports forecasting future price levels were to be based on a table of percentages.

We have not evaluated this table, however, we believe that there are no reliable indexes on which to base estimates of inflation.

ESTIMATE CHANGES

Estimate changes in a program or project cost are due to corrections in the initial estimate.

The principal estimate change reported on Army systems was $944 million for the SAM-D missile. The Army's justification for this change in estimate was:

> "*** The total estimate is based on analysis of our previous programs, deriving cost estimating relationships based on the actual growth experience of cost estimates for earlier missile programs, at comparable stages of development.
>
> Specifically, the estimating techniques anticipate unforeseen changes in requirements, performance characteristics, program slippages, funding availability, and quantities produced in specific years. The order of magnitude of those changes actually experienced on previous programs has been used to estimate the magnitude of these costs. While we have calculated the costs based on past

experience, we have also taken steps to seek to prevent the causes of cost growth from occurring on the SAM-D Program. As such, if our efforts are successful, the SAM-D will not require the total funds derived from extrapolating the actual experience of earlier programs. ***"

Two programs in the Navy account for most of its reported changes. The Mark 48 torpedo cost estimate was increased $2,500 million to correct a series of underestimates which had been prepared from incomplete data. The new estimates projecting production costs were prepared by using the actual prototype costs incurred. The $300 million estimating change on the Poseidon program corrected a series of overestimates and underestimates--an aggregate of smaller sums.

Three programs account for most of the reported estimating changes from the Air Force. The F-111 aircraft program reported price increases of about $670 million over earlier estimates on the contracts of numerous contractors involved in the program.

The SRAM cost estimate was increased $398 million due to underestimation of the costs of development tasks involved, while the C-5A aircraft cost estimate was increased $301 million by the Air Force to rectify contractor underestimates for producing this aircraft.

UNIDENTIFIED CAUSES FOR COST CHANGE

Summary data showing a cumulative variance analysis and the variance analysis changes since the last reporting period were either not provided or were incomplete for 15 Navy systems. For this reason, cost changes in Navy systems totaling $2,264.9 million could not be specifically allocated. We have been told by the Navy that cost changes will be allocated and shown in the December 31, 1970, SAR.

SAR SYSTEM

As we reported to the Congress in February 1970, the SAR system represents a valuable management tool for measuring and monitoring the progress of major acquisitions. DOD has tried to improve the format, content, and data in the SAR.

Although our review of the June 30, 1970, SAR confirmed that improvements were made during the last year, some improvements still were needed.

SAR does not (1) contain a summary statement regarding overall acceptability of the system for part or all of its mission, (2) show the status of major system components being separately developed, nor (3) reflect the current status of program accomplishment. Separate development could result in significant costs if the major system component encountered development problems that adversely affected the entire weapon system's performance.

Waivers of major milestone criteria, with an explanation of the attendant risk therefrom, are not highlighted or discussed in the summary section of SAR.

CHAPTER 4

SYSTEM SCHEDULE EXPERIENCE

Our review of the efforts of the military departments to correctly estimate initial delivery dates for about 50 weapon systems indicates that, on the average, the weapon systems experienced 33 percent schedule slippage. Average cost growth of these systems was approximately 30 percent.

The following charts show the percentage of schedule slippage by commodity class of weapon systems (figure VIII) and the percentage of cost growth (figure IX).

The schedule percentages were determined by comparing the time originally estimated for reaching the initial operational capability date (initial delivery dates of the systems to the military departments) from the beginning of the acquisition cycle with the current estimate (as of June 30, 1970) of the same period.

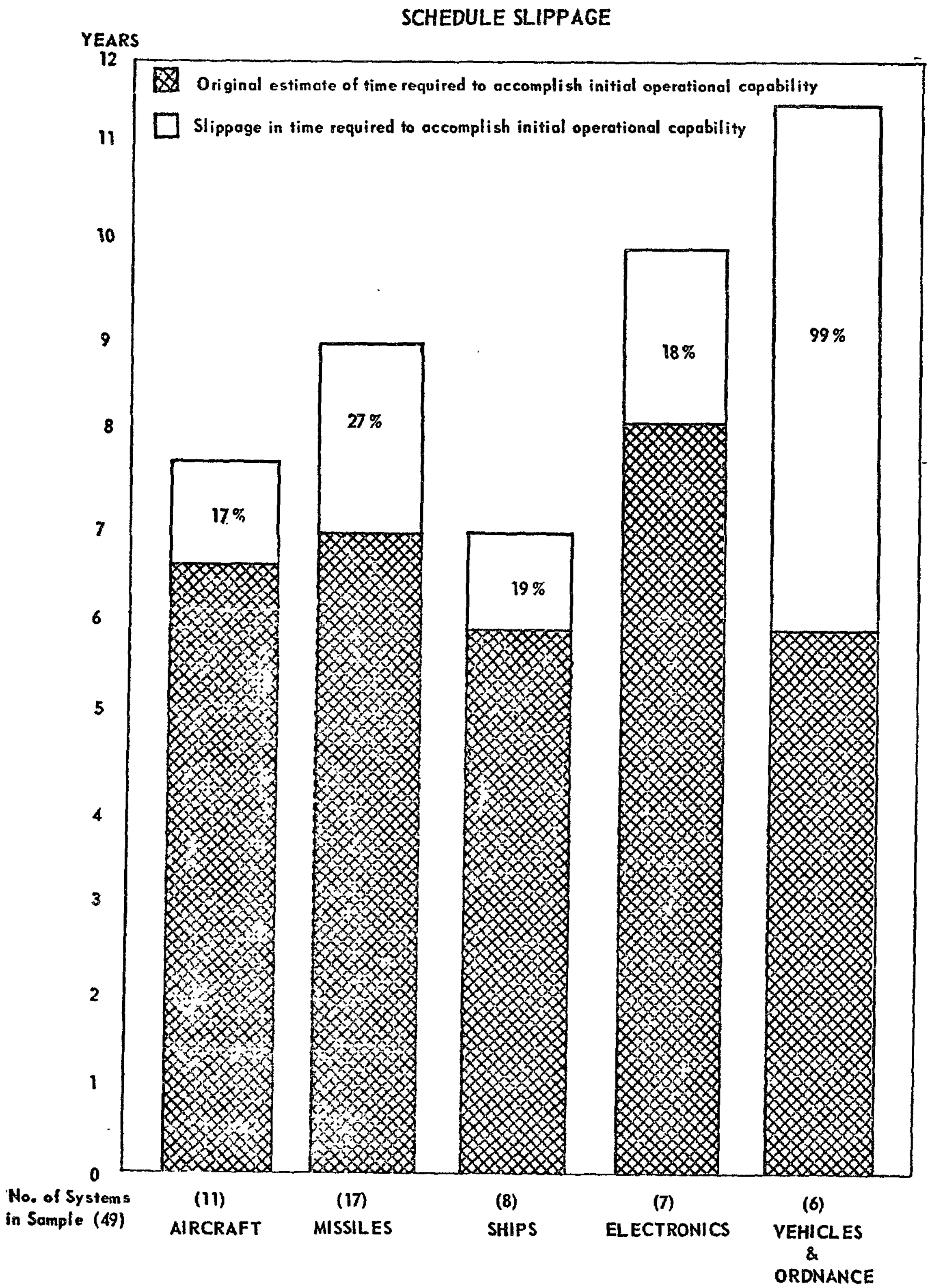

SCHEDULE SLIPPAGE
YEARS
12
11
10
9
8
7
6
5
4
3
2
1
0
Original estimate of time required to accomplish initial operational capability
Slippage in time required to accomplish initial operational capability
17%
27%
19%
18%
99%
No. of Systems in Sample (49)
(11) AIRCRAFT
(17) MISSILES
(8) SHIPS
(7) ELECTRONICS
(6) VEHICLES & ORDNANCE

FIGURE VIII

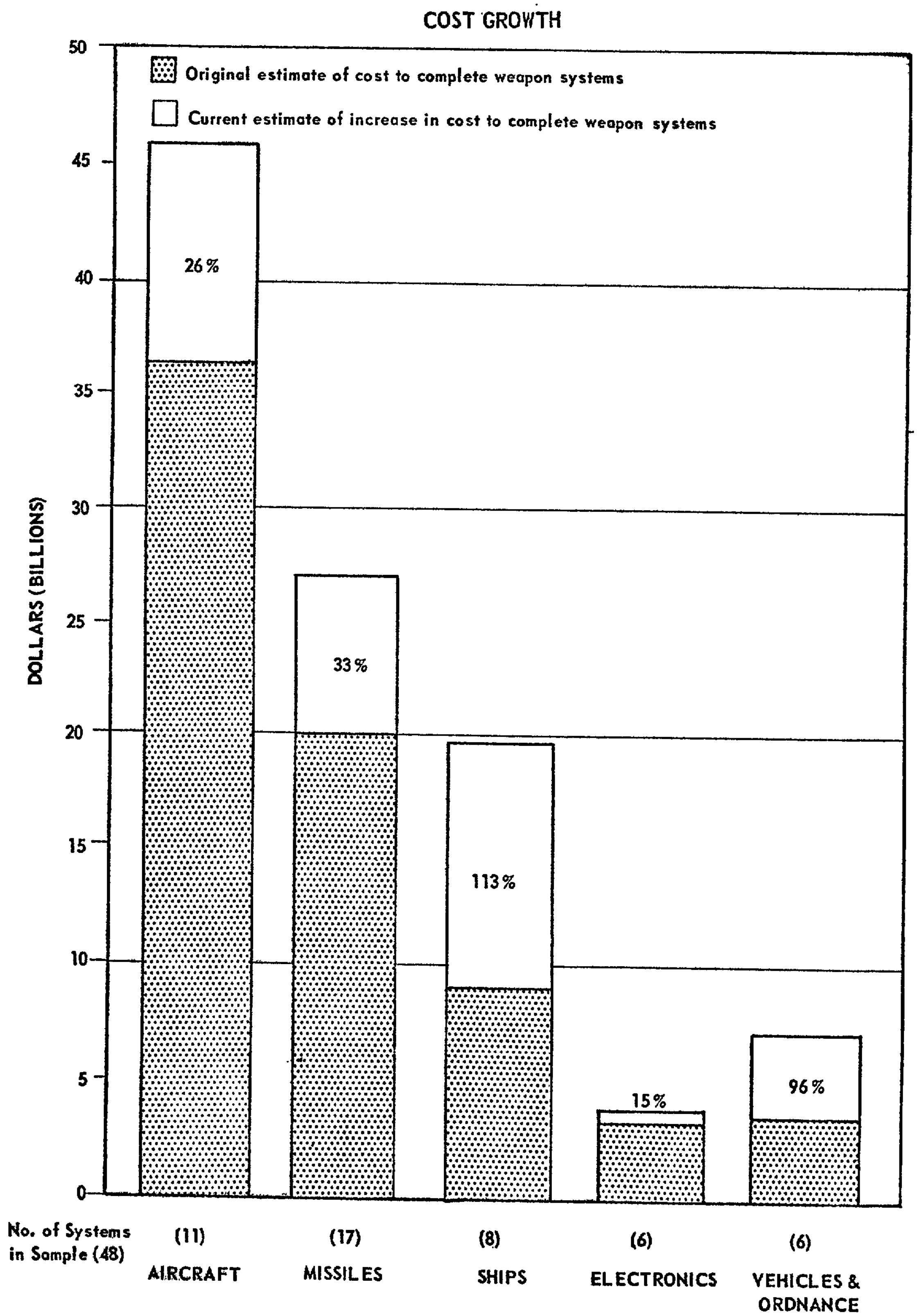

COST GROWTH
Original estimate of cost to complete weapon systems
Current estimate of increase in cost to complete weapon systems
DOLLARS (BILLIONS)
50
45
40
35
30
25
20
15
10
5
0
26%
33%
113%
15%
96%
No. of Systems in Sample (48)
(11)
(17)
(8)
(6)
(6)
AIRCRAFT
MISSILES
SHIPS
ELECTRONICS
VEHICLES & ORDNANCE

FIGURE IX

CHAPTER 5

GENERAL OBSERVATIONS, CONCLUSIONS AND RECOMMENDATIONS

In the last several months, the Office of the Secretary of Defense and the military services have been engaged in a substantial effort to resolve problems identified as adversely affecting the acquisition of major weapon systems. These problems include compromised performance, delayed availability, and increased costs. Generally, the more recent weapon programs are characterized by a slower development pace and more conservative procurement practices than those of earlier periods. Because many of these programs are in early stages of acquisition, physical evidence of the success of changed concepts is not yet available for assessment; but the outlook is brighter. Troublesome problems remain to be solved, particularly in selection of and assignment of priorities to weapons for development and in organizational matters.

The statement of the Deputy Secretary of Defense in September 1970 before the Committee on Government Operations, House of Representatives, on organizational and other problems related to new weapon systems development and acquisition, leads us to conclude that he has accurately appraised the problems and the actions needed to resolve them. The actions he proposes are basic, but their implementation will not be easy because they involve changes in traditional concepts and management practices that are firmly implanted in DOD.

Programs are under way in the military departments to improve the acquisition process. For example, AMC started a comprehensive improvement program on October 1, 1969, called PROMAP-70. Among this program's 52 objectives are improved definition of requirements, analysis of technical risk, upgraded selection criteria, and stabilized tours for officers assigned to project management, as well as improved coordination and conduct of tests. The Army has informed us that results already obtained in this program have shown substantial progress in application of these improvements to current programs. An important consideration in our future reviews will be an assessment of the success of these improvement programs.

General observations on the matters we have studied, conclusions we have drawn from that review, and our recommendations, follow.

A. Identification of need for and relative priority of individual systems

The clear identification of a new weapon's mission is probably the single, most fundamental task that must be completed before the development process can begin. Our study of the history of a fairly large sample of weapon systems, however, leads us to conclude that the function of deciding which weapons will be developed is not yet being done with the degree of effectiveness that this important function warrants.

Seemingly, the entire structure of the military service and OSD are involved in this process, in one way or another, and the long and imprecise process of defining and justifying and of redefining and rejustifying a weapon system, through many layers of involvement, invariably has delayed decisions and has extended stated availability dates by years.

The cumulative effect of the involvement of many different organizational units in the decision to justify and then to proceed with development is the root cause of long delays in development decisions. Almost every weapon system we studied showed some substantial degree of uncertainty as to whether, when, or in what form the weapon should be developed.

In addition to clarifying and improving the initial decision process (which is now going on in the DOD), establishing a mechanism which defines the priority position of a weapon program in relation to its competitors is equally important. *We believe that the development of a comprehensive DOD-wide priority system is a first step toward alleviating a part of the difficulty we observed in obtaining weapon systems development decisions and toward incorporating stability into programs.*

Our study revealed an emerging effort, initiated within OSD during the summer of 1970, and termed "a new concept." It is intended to provide the Secretary of Defense with a broad overview of each mission category, including identification of major issues. Although this effort appears to embody many of the essentials of an overall priority system, it is still in its infancy.

> Recommendation--The Secretary of Defense should make every effort to develop and perfect the DOD-wide method--now in its early stages of development--designed to be followed by all military services for determining two things: First, what weapon systems are needed in relation to the DOD missions. Second, what the priority of each should be in relation to other systems and their missions.

B. Definition of performance characteristics and assessment of technical risks

In the last several months, persistent problems in defining performance characteristics of weapon systems and in determining technical feasibility for achievement have been receiving extensive attention at both OSD and the military service levels. On the basis of our study of recent weapon systems procurement, we see many encouraging signs that these problems are being abated.

Extensive efforts are being applied, early in the process, to identifying high-risk design areas and to constructing and testing actual hardware to demonstrate feasibility of high-risk components before proceeding with further development. Similarly, current use of the demonstration milestone provisions in development contracts limits the Government's financial commitment pending a system's demonstrated performance.

C. Standards for and consistent use of cost-effectiveness studies

We saw wide variation in the quality of preparation and follow-through given to cost-effectiveness determinations supporting weapon systems acquisition decisions.

The variations in quality may be due to evolving methodology for, and use of, cost-effectiveness studies. *There is no evidence that DOD criteria for judging the adequacy of cost-effectiveness studies are being applied.*

We are convinced that the lack of clear guidelines for the preparation and application of cost-effectiveness studies has resulted in misunderstanding of their purpose, has contributed significantly to diversity in execution by the military services; and has lessened the value of cost-effectiveness studies to the entire acquisition process.

> Recommendations--The Secretary of Defense should require that (1) cost-effectiveness studies meet certain standards (including the identification of which weapon system and which considerations should be included in such studies) and (2) cost-effectiveness studies be updated at each point where a major program alternative is considered.

With regard to the latter recommendation, we noted that instructions now require cost-effectiveness studies to be prepared at major decision points in the program. These decision points are validation, full-scale development, and production.

D. Subsystem development phasing and interfacing

A major problem recurring in the weapon systems acquisition process is the compromise of system performance that occurs when a principal element of the system follows a development cycle not compatible with that of the primary system. *This incompatibility occurred most frequently when the responsibility for the development of the parts of a system was divided among two or more project managers. The results were imbalance in time-phasing of subsystems in some weapon programs and incompatibility of technical interfaces in others.*

We believe that the program manager authority should cover all technical effort on all principal elements of the weapon. Whenever a principal element is common to more than one weapon system, specific steps must be taken to ensure its development and acquisition in order to meet the technical specifications required by each of the major systems which will employ it. One way of handling that might be to give authority over the element to the manager of the more crucial major system.

E. Assessment of technical performance

In weapon programs we examined which were well along in the acquisition process, were finishing development, or were in production, we noted that assessment of progress against the development program was hampered by lack of early test results from technical high-risk areas. When technical problems are revealed by testing, there have frequently been aspects that had not been formally identified as technically risky early in the program and therefore had not been given the special attention needed during development. Some programs have encountered such serious technical problems that degradation from required performance has been accepted.

More sharply defined technical risk analysis with special emphasis applied to technical high-risk aspects of the new weapon system should give the military services a means of evaluating development progress earlier, and more accurately, than is presently possible.

In recently initiated weapon programs, we found that special care is being taken to identify the high-risk components and to fabricate them for testing in laboratory models before proceeding with development of the complete weapon system. We believe that this is a step in the right direction.

F. Organization and procedures

In our judgment, one of the most important unresolved problems in the management of major acquisitions is the problem of organization. The problems arising from establishment of need, for instance, are related to organizational deficiencies.

The essence of the problem appears to come from attempts to combine the specialized roles of major weapon systems acquisition management into more or less historical military command structure organizations. Because of this, there usually are a large number of organizational units not directly involved in the project which can only negatively influence it. In the Army and the Navy and to a lesser extent in the Air Force, project managers are part of organizations, whose basic missions are considerably broader than the managers' missions, with which organizations they must compete for resources.

As a matter of fact, each military service alters traditional organization patterns when faced with managing major programs. Although not recognized as a super program, inherent organizational problems of the F-15 program were successfully overcome by the program's having been placed in the organization in such a way that the privileges of substantial military rank could be exercised as a means of bypassing organizational layers. The value of this reorganization is that the project manager has been given stature and authority so as to be unencumbered by normal frustrations produced by cooperation with the functional organizations.

Each of the services has begun to upgrade the rank of project managers. But military rank alone will not accomplish what OSD and the military services are trying to do.

In our opinion, lessons learned from organizational changes in structure for the super programs can aptly be applied to the whole subject of weapon systems acquisition. It may be impractical to treat each of the large number of projects now under way in the military departments in a similar manner. But, it occurs to us that, ideally, there should be a direct relationship between the way weapon systems requirements are categorized (strategic deterrent, land warfare, ocean control, etc.) and the organizational structure needed to acquire them. Such an arrangement would facilitate grouping related weapon systems in "packages" of common mission and would permit putting together an acquisition organization of appropriate size and stature to handle the expanded concept. We believe that eventually program management will evolve along mission lines.

There are other alternatives, but whichever is chosen must clearly provide for someone to be in charge, to have clear authority to make decisions, and to have full responsibility for the results. The Deputy Secretary of Defense recognizes that correction of this problem is fundamental to any real improvement and has stated that he plans to pursue it aggressively.

> <u>Recommendations</u>--The Secretary of Defense should place greater decisionmaking authority for each major acquisition in a single organization, within the service concerned, with more direct control over the operations of weapon system programs and with sufficient status to overcome organizational conflict between weapon system managers and the traditional functional organization.

G. <u>System cost experience</u>

Our analysis of the estimated costs to develop 61 major weapon systems which are prepared at various points in the development cycle shows that the current estimates through program completion have grown 40 percent in comparison to the planning cost estimates for these programs.

Cost growth may result from such things as unanticipated development difficulties, faulty planning, poor management, bad estimating, or deliberate underestimating. However, it should be realized that not all cost growth can be reasonably prevented, for instance, cost growth resulting from inflation. Further, some cost growth may even be desirable, for instance, incorporation of technological changes that improve the system effectiveness.

Regarding our observations made last year, we found that DOD had made a good start toward developing data that specifically identifies the variances in program cost estimates for systems reported under the SAR system. We observed, however, that on 15 Navy systems the causes for cost change were either not provided or were incomplete.

DOD also has acted to improve the format, content, and data in the SARs. Our review confirmed those improvements made during the last year. We found, however, that some improvements still are needed.

Recommendations--The Secretary of Defense should ensure that the SARs (1) contain a summary statement regarding the overall acceptability of the weapon for its mission, (2) recognize the relationship of other weapon systems complementary to the subject system, and (3) reflect the current status of program accomplishment.

APPENDIXES

SCHEDULE OF PROGRAM COST DATA

AS OF JUNE 30, 1970, AND ARRANGED BY

ACQUISITION PHASE AND MILITARY SERVICE

	Planning estimate	Development estimate	Cost change: Quantity	Cost change: Other	Current estimate	Additional procurement costs	Total costs
	(millions)						
CONCEPTUAL PHASE (9) (note a)							
VALIDATION/RATIFICATION (4):							
Army:							
None	-	-	-	-	-	-	-
Navy:							
DLGN 38	769.2	769.2	3,210.8	1,510.3	5,490.3	-	5,490.3
SSN-688	1,658.0	1,658.0	2,376.0	245.7	4,279.7	-	4,279.7
Air Force:							
AX	1,025.5	1,025.5	-	-	1,025.5	-	1,025.5
OTH-B (note d)	100.9	100.9	-	3.9	104.8	-	104.8
ENGINEERING AND/OR OPERATIONAL SYSTEMS DEVELOPMENT (57):							
Army:							
Cheyenne (note b)	125.9	125.9	-	76.2	202.1	-	202.1
Shillelagh	357.4	357.4	-18.1	156.5	495.8	25.8	521.6
SAFEGUARD	4,185.0	-	1,365.0	389.0	5,939.0	-	5,939.0
DRAGON	382.2	404.2	-232.7	75.9	247.4	37.4	284.8
SAM-D (note c)	4,916.8	3,989.0	-1,791.4	1,215.9	3,413.5	82.4	3,495.9
LANCE	586.7	652.9	-	108.2	761.1	90.4	851.5
TOW	410.4	727.3	-300.1	248.1	675.3	33.3	708.6
Improved HAWK	573.3	573.3	-79.8	210.8	704.3	107.2	811.5
M-60 AIE2	162.1	202.6	-15.8	172.5	359.3	16.5	375.8
MBT-70	2,126.5	2,091.4	-602.4	336.7	1,825.7	293.3	2,119.0
Sheridan Tank (note f)	422.5	375.6	-13.1	93.4	455.9	31.6	487.5
Sheridan Ammunition	370.1	370.1	-125.2	105.9	350.8	-	350.8
GAMMA GOAT	69.1	163.9	6.1	16.9	186.9	11.7	198.6
CHAP/VULCAN	58.2	58.2	387.2	78.4	523.8	138.8	662.6
TACFIRE	123.6	160.5	-	24.0	184.5	3.8	188.3
Navy:							
S-3A	1,763.8	2,891.1	-	42.7	2,933.8	20.6	2,954.4
F-14	6,166.0	6,166.0	2,036.1	77.0	8,279.1	294.4	8,573.5
EA-6B	689.7	817.7	-50.7	291.6	1,058.6	31.5	1,090.1
P-3C	1,294.2	1,294.2	971.1	285.7	2,551.0	59.0	2,610.0
A-7E	1,465.6	1,465.6	-385.3	494.4	1,574.7	91.7	1,666.4
AN/SQS-23	157.1	170.5	-82.7	144.5	232.3	50.8	283.1
AN/SQS-26	95.7	88.8	-	30.8	119.6	-	119.6
AN/BQQ-2	126.9	179.0	-	86.2	265.2	33.5	298.7
DIFAR	178.5	414.1	97.0	46.9	558.0	(e)	558.0
VAST AN/USM-335	49.8	57.5	-26.6	22.5	53.4	1.4	54.8
VAST AN/USM-247	241.1	312.0	-182.2	282.6	412.4	77.3	489.7
PHOENIX	370.8	677.4	642.3	181.2	1,500.9	11.0	1,511.9
CONDOR	356.3	441.0	-220.9	131.3	351.4	1.9	353.3
POSEIDON	-	4,568.7	-243.6	790.2	5,115.3	1,740.2	6,855.5
Standard ARM	180.3	241.6	-10.4	-20.2	211.0	17.2	228.2
Sparrow E	687.2	740.7	-459.8	11.7	292.6	32.5	325.1
Sparrow F	139.8	453.6	114.7	489.9	1,058.2	26.3	1,084.5
Standard	313.2	-	-7.0	34.0	340.2	468.1	808.3
Mark 48 Mod 0&1	720.5	714.0	488.9	2,554.3	3,757.2	28.2	3,785.4
LHA	1,380.3	1,380.3	-	47.5	1,427.8	8.2	1,436.0
CVAN-68	427.5	-	-	116.7	544.2	-	544.2
CVAN-69	519.0	-	-	-	519.0	-	519.0
DE-1052	1,285.1	1,259.7	-	167.9	1,427.6	(e)	1,427.6
SSN-637	-	2,515.8	-	397.3	2,913.1	-	2,913.1
SSN-685	100.8	151.7	-	23.4	175.1	-	175.1
DLG modernization	698.8	698.8	-	153.4	852.2	-	852.2
AMTRAC	324.4	328.5	-129.8	-12.6	186.1	10.0	196.1
DSRV	100.2	143.7	-41.3	101.9	204.3	30.6	234.9
DD-963	1,784.4	2,581.2	1,595.4	-	4,176.6	-	4,176.6
AEGIS (note g)	388.0	427.6	-	13.0	440.6	-	440.6

	Planning estimate	Development estimate	Cost change Quantity	Cost change Other	Current estimate	Additional procurement costs	Total costs
	(millions)						
ENGINEERING AND/OR OPERATIONAL SYSTEMS DEVELOPMENT (57) (continued):							
Air Force:							
B-1	8,954.5	10,107.8	-	-	10,107.8	392.9	10,500.7
F-15 (note h)	6,039.1	7,355.2	-	1.2	7,356.4	763.7	8,120.1
C-5A	3,423.0	3,413.2	−736.2	1,631.6	4,308.6	285.7	4,594.3
F-111 A/C/D/E/F	4,686.6	5,505.0	−2,581.3	3,456.6	6,380.3	960.3	7,340.6
FB-111	1,781.5	1,781.5	−1,043.3	468.7	1,206.9	231.6	1,438.5
A-7D	1,379.1	1,379.1	−282.6	303.1	1,399.6	173.5	1,573.1
AWACS	2,656.7	2,661.6	-	-	2,661.6	126.0	2,787.6
MAVERICK	257.9	383.4	−73.6	33.8	343.6	8.0	351.6
TITAN III	932.2	814.1	-	373.8	1,187.9	(e)	1,187.9
SRAM	167.1	236.6	118.3	735.8	1,090.7	590.9	1,681.6
Minuteman II	3,014.1	4,254.9	4.0	207.5	4,466.4	583.2	5,049.6
Minuteman III	2,695.5	4,673.8	−37.7	999.1	5,635.2	362.6	5,997.8
777 COMSAT	133.5	138.0	-	5.1	143.1	-	143.1

[a]Comparative cost data not available for systems in this phase.

[b]The Cheyenne costs represented research and development costs only. The production contract was terminated on May 19, 1969. Due to pending litigations, the Army's liability was unknown.

[c]Army officials advised us that, while the SAM-D had gone through contract definition, contract award had been limited to advance development.

[d]Cost data as of August 31, 1970, for the OTH-B.

[e]Data were not available for inclusion.

[f]The DOD considered this as an annex to the Sheridan vehicle and not a weapon system itself.

[g]Research and development costs only.

[h]The original Development Concept Paper No. 19 dated Sept. 28, 1968, contained a preliminary planning estimate for lower quantity of F-15's as $5,137 million.

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D C. 20301

22 JAN 1971

Mr. C. M. Bailey
Director, Defense Division
United States General Accounting Office
Washington, D. C. 20548

Dear Mr. Bailey:

This letter is in response to the request of Mr. Hassell Bell of your organization for informal comments on GAO draft report "The First Report on the Continuing Evaluation of the Acquisition of Major Weapons Systems" (OSD Case #3219).

I know that you appreciate the extremely limited time the DoD had to review this report. However, in recognition of the equally limited time which Mr. Bell indicated the GAO has to meet its commitment for submission of the report to the Congress, we have done our best to prepare a general reaction to it. Because of the nature and importance of this subject, we will want to examine the final report further in a more thorough and logical fashion. It would be appreciated if your report to the Congress could indicate the fact that the DoD has not had sufficient time to make such a review.

We have reviewed the draft report and believe that your recommendations address important aspects of the weapon system process. We agree in particular that we have not yet solved some of the organizational problems and we will see that your report is made available to the Services and OSD offices which are working on those problems.

We do appreciate the recognition that you give to the DoD efforts to improve its management of weapon systems acquisition, and we know that you realize we are giving considerable time and attention to further improvements.

As you know, we are carrying on comprehensive evaluations of this management problem here in the Department. GAO reviews, such as this, will be of benefit to us, particularly by giving us an independent review and evaluation of our options. We are pleased to assist you by providing these informal comments on the draft report. We will forward more detailed comments after we have made a more thorough evaluation of the report, if you feel that would be helpful.

Sincerely,

for John S. Foster, Jr.