REPORT TO THE CONGRESS

Better Management Needed Over Decisions To Start Full-Scale Development Of Minor Weapons Systems B-163058

Department of Defense

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

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

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

This is our report on the need for better management over decisions to start full-scale development of minor weapons systems.

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

Copies of this report are being sent to the Director, Office of Management and Budget; the Secretary of Defense; and the Secretary of the Navy.

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Comptroller General
of the United States

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ABBREVIATIONS

DOD	Department of Defense
GAO	General Accounting Office

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

BETTER MANAGEMENT NEEDED OVER DICISIONS TO START FULL-SCALE DEVELOPMENT OF MINOR WEAPONS SYSTEMS B-163058

D I G E S T

WHY THE REVIEW WAS MADE

A crucial step in creating any new military weapons system is the decision to go ahead with full-scale, or engineering, development. This is that final step before a system enters production. The decision leads inevitably to committing, irrevocably, large sums of money.

It is important that sufficient experimental work--particularly testing high-risk subsystems and components--be performed before full-scale development begins, to more easily identify and resolve technical problems before extensive systems-engineering takes place. Otherwise, problems can surface unexpectedly in the final development stage and can lead to cost overruns, schedule slippages, and performance compromises, as prior General Accounting Office (GAO) reports have shown.

In recent years congressional attention has focused on problems in meeting cost, schedule, and performance targets established for major weapons systems. The Department of Defense (DOD) has responded by emphasizing the importance of testing hardware and other controls during the development process.

As noted by the Blue Ribbon Defense Panel, more money is committed to the far more numerous "minor" weapons systems. These are systems which involve less than $50 million of research and development funds or $200 million of procurement funds. Therefore GAO was particularly interested in seeing how well DOD was managing decisions to start full-scale development on these "minor" systems.

GAO reviewed 15 Navy programs--mainly those not categorized as "major"--which had passed through the crucial decision point and which are now in varying stages of development, production, or use. (See app. I.)

FINDINGS AND CONCLUSIONS

Experimental work had not been performed sufficiently for most of the 15 programs before full-scale development was started. As a result, serious technical problems frequently occurred during full-scale development and caused cost growth, schedule slippage, or shortfalls in performance.

In turn, this forced the Navy to compromise its plans for meeting the equipment needs of its forces. Although premature full-scale development was not the only cause of later problems, it appeared to be the most prevalent cause and the one having the most far-reaching effect. (See p. 11.)

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Impact of premature initiation of full-scale development on cost, schedule, and performance targets

Development cost increased 50 percent or more for six of 10 programs and ranged from 16 to 213 percent. (See p. 12.)

In nine of 12 programs, completion of full-scale development had to be extended more than 1 year. Program slippage for these systems ranged from 4 to 51 months. (See p. 13.)

Serious technical problems were evident in nine of 15 programs. Redesign or modifications had taken place or were planned for six of the nine because of technical problems in areas which had not been proved feasible through experimental testing before full-scale development was begun. (See p. 14.)

When cost or schedule limits were significantly exceeded or when performance was significantly degraded, decisionmakers often were forced into undesirable compromises--e.g., redesigning or modifying equipment at additional cost, diverting funds from lower priority programs, improvising risky shortcuts, or canceling or cutting back development programs. (See p. 16.) Examples follow.

--Before starting full-scale development, the Navy had neither built nor tested experimental devices to prove out the concept for new microelectronics designed for its Sparrow III Airborne Intercept Missile 7F. Failure of the system to pass operational tests later led to redesigning about 67 percent of the missiles' guidance electronics at additional cost. (See p. 16.)

--After Zero Antiaircraft Potential missiles had been produced, operational evaluation revealed serious reliability problems that normally would be identified through experimental testing. The problems proved so serious that the program was eventually canceled--after $28 million had been sunk into it. (See p. 15.)

--Needed experimental work was not performed in several technical areas for the Integrated Helicopter Avionics System. As full-scale development proceeded, serious technical problems arose which delayed the program 3 years. This slippage caused the Navy to cancel two of the three major components of the system because the remaining service life of a helicopter--for which the system was designed--no longer justified costly installation of the full system. (See p. 18.)

In addition, when program delays occur during full-scale development, risky shortcuts--e.g., starting production while development is in process--are sometimes taken to bring completion dates back in line. Often, these shortcuts not only fail to speed up the program but also usually add to the development-production cost, as shown in a prior GAO report (B-163058, Nov. 19, 1970). GAO believes that pressures to resort to shortcuts would be lessened if more emphasis were placed on exposing technical problems

through experimental work before full-scale development is begun. (See p. 17.)

Reasons for premature approval of full-scale development

Navy decisionmakers approved full-scale development in some instances even though development plans indicated that experimental work had not been completed. This premature approval was attributed either to unwarranted confidence that the equipment would perform as required or to an expressed urgent need for the equipment. (See p. 22.)

In the case of the canceled Zero Antiaircraft Potential missile, the development plan clearly stated that technical risks were "high" for certain components and "medium" for others. Yet the go-ahead for full-scale development was justified on the basis of an urgent need in Southeast Asia. (See p. 25.)

Development plans for other programs might have misled the decisionmakers in that the plans indicated that no significant technical risks were expected. For example, the development plan for the Integrated Helicopter Avionics System indicated only that "risks were low" and failed to point out that experimental work had not been performed in certain vital technical areas. (See p. 23.)

For still other programs, development plans rationalized erroneously that risks were low on the assumption that technical concepts had been proved on systems in use. For example, the development plan for the Sparrow missile indicated that proposed technical concepts were in use on existing equipment but failed to point out that performance requirements for some of the major components were beyond anything that had been previously demonstrated. (See p. 24.)

AGENCY ACTIONS AND UNRESOLVED ISSUES

DOD's Director of Defense Research and Engineering stated that recent changes in DOD and Navy policies and procedures, summarized below, had been designed to correct such defects as those revealed in the report.

--Establishing the Defense Systems Acquisition Review Council to review major programs at key decision points.

--Introducing the Development Concept Paper.

--Increasing attention throughout DOD to test and evaluation responsibilities.

--Paying additional attention to reducing risks, before approval for full-scale development is granted, through more emphasis on prototyping and hardware development and through testing, rather than reliance on paper studies.

The first two actions apply only to major systems and, if implemented properly, should lead to improved management of such systems. GAO noted that a proposed new directive--DOD Directive 5000.2--would require these actions and Secretary of Defense approval earlier in the development process for major systems. Most systems discussed in this report, however, do not meet the DOD dollar requirement for such actions.

With respect to increased emphasis on testing and evaluation responsibilities and other efforts to reduce risk, provided by new DOD Directive 5000.1, the former DOD Directive 3200.9 appeared to be even stronger in its emphasis on, and more specific in its requirements for, justifying full-scale development. Yet sufficient experimental work was not always performed, as illustrated by this report.

DOD Directive 3200.9--in effect at the time that full-scale development decisions were made for 14 of the 15 systems discussed--specified prerequisites for starting full-scale development and required that experimental work be performed to a degree sufficient to demonstrate that technical risks did not exist or had been reduced to a reasonable level. In contrast, new DOD Directive 5000.1 provides merely that "development risks have been identified and solutions are in hand."

The recent actions should lead to improved management of major weapons systems; however, GAO believes this emphasis provided by the new policies will not in itself overcome the problems cited for minor systems.

RECOMMENDATIONS OR SUGGESTIONS

GAO recommends that the Secretary of Defense require key dicisionmakers to verify and certify that sufficient experimental work has been completed before they approve full-scale development of minor systems or justify in writing any exceptions. In addition, GAO recommends that the Secretary of Defense apply spot checks and other management-by-exception techniques to assure that the principles specifically applicable to major systems are applied also to the far more numerous and, in total, more costly "minor" systems.

MATTERS FOR CONSIDERATION BY THE CONGRESS

Recent legislation requires the Secretary of Defense to submit annual reports, beginning in 1973, on operational testing and evaluation for each weapons system for which procurement funds are requested. This should assist in identifying new systems entering production prematurely.

The decision to begin full-scale development, however, is even more fundamental because it "opens the door" and commits funds and loyalties to future systems. A yearly average of 25 Navy systems--individually budgeted projects--entered full-scale development from 1968 to 1971.

GAO suggests that the Congress require from the Secretary of Defense--along with his initial request for full-scale development funds for new "systems"--a statement to the effect that

--all necessary experimental work has been performed and the proposed system is ready for full-scale development or

--authorization of full-scale development is essential even though all prescribed conditions have not been met, in which case the statement should give the reasons for the decision and the identifying areas where experimental work has not been completed.

CHAPTER 1

INTRODUCTION

The Department of Defense (DOD) develops and procures weapons systems and other equipment to maintain military efficiency and combat readiness. In discharging its responsibilities, DOD has adopted policies designed to establish realistic and appropriate time, cost, and performance goals. To meet these goals, DOD policies provide that equipment development and procurement follow a defined sequential process whereby appropriate levels of authority evaluate and approve each phase of the process as it is completed before work in the next phase can be started.

In a normal sequence, concepts for new equipment evolve from exploratory development effort. In the next phase, which DOD refers to as advanced development, subsystems and other prototype devices are built and tested to determine whether equipment can be made to work and meet military requirements. After advanced development is completed, specific performance requirements are established and full-scale development, also called engineering development, is authorized.

The purpose of full-scale development is to build one or more testing models which are used to determine the extent that new equipment meets performance requirements, can be mass produced, and can be operated by combat personnel. If these objectives are met, the equipment is approved for service use and may be mass produced.

Full-scale development usually involves large sums of money and commits DOD to design specific equipment to meet an operational need. In this respect, the former Deputy Secretary of Defense stated during hearings before the Committee on Appropriations, House of Representatives, in March 1971:

> "The initial decision to go ahead with a particular program is the most important decision of the program. If this decision is wrong, the program is doomed to failure. The decision I mean is the decision to go ahead with full-scale development.

> To make this decision right generally will require that the program be kept in advanced development long enough to resolve the key technical uncertainties, and to see that they are matched with key operating requirements before the decision to go ahead is made."

In July 1971 DOD issued a new policy directive--DOD Directive 5000.1--setting forth, in part, the basis for initiating full-scale development. The new directive, although specifically applicable to major systems, states that the same management principles apply to all programs. The directive--unlike former DOD Directive 3200.9 which it replaced--does not specify in detail the prerequisites for initiating full-scale development but provides only that "development risks have been identified and solutions are in hand."

DOD Directive 3200.9--in effect at the time that full-scale development decisions were made for 14 of the 15 systems discussed in this report--provided that certain conditions be met before full-scale development could be authorized, including "accomplishment of *** experimental hardware efforts under Exploratory and Advanced Development." In experimental work, devices were to be built and tested in the laboratory or under controlled conditions to determine the extent that technical principles were sound and that equipment would be reliable and provide acceptable performance.

The degree to which such experimental work was performed was left to the technical judgment of the developing activities. Experimental work, however, was to be sufficient to demonstrate that technical risks did not exist or had been reduced to a reasonable level. The degree of technical risk was to be identified so that alternative actions could be taken to avoid, resolve, or minimize potential problem areas. The policy emphasized that:

"Projection into Engineering Development [note 1] of anticipated developmental achievement will be permitted only when sufficient quantitative results have been obtained, in laboratory or experimental devices, to allow such projections with a high confidence."

For fiscal year 1971, the Navy budgeted approximately $532 million for equipment in full-scale development prior to production and about $730 million for full-scale development of equipment already in production. In November 1971 the Navy had 135 programs in full-scale development prior to production and 27 programs in production concurrent with full-scale development.

Because of the importance of the decision to enter full-scale development, we reviewed those events leading up to that decision. We selected 15 Navy development programs--mainly systems not categorized as major systems--which passed through this decision point and which are now in various stages of their life cycle. (See app. I.) Because of the emphasis in recent years on so-called major systems, we were particularly interested in seeing how well decisions were being made for the far more numerous and, in total, more costly "minor" systems. In this regard, the Blue Ribbon Defense Panel stated in its July 1970 report to the President and the Secretary of Defense that, although Defense management emphasis is heavily focused on major systems, the far more numerous "minor" systems account for about three times the level of spending.

We examined DOD and Navy policies and procedures for acquiring weapons systems and ancillary equipment, specific operational requirements, technical development plans, proposed technical approaches, development contract files, and related documents. We also interviewed responsible officials in the Washington, D.C., area, at the Naval Air Systems Command, the Naval Ordnance Systems Command, the Naval Ship Systems Command, the Naval Electronic Systems Command, the Naval Material Command, and the Office of the Chief of Naval Operations.

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[1]The terms "engineering development" and "full-scale development" are synonymous.

In reviewing the programs, we compared original cost estimates with current estimates and compared actual schedule and performance achievements with planned goals, to determine, insofar as possible, the impact of decisions to initiate full-scale development on cost growth, schedule slippages, and performance targets. To show the impact of these decisions--which can be seen only in follow-on years--we selected systems which had passed through these decision points and which are now in varying stages of their life cycles.

CHAPTER 2

IMPACT OF STARTING FULL-SCALE DEVELOPMENT BEFORE COMPLETING EXPERIMENTAL WORK

DOD cost, schedule, or performance goals were not achieved in most programs that we examined, primarily because experimental work was not performed sufficiently before full-scale development was started. In some cases experimental hardware had neither been built nor tested to prove that required performance of certain components or subassemblies was feasible.

We believe the lack of adequate experimental work resulted, to a large extent, in the technical problems which later surfaced and caused cost, schedule, and performance goals not to be met. The failure to meet these goals has caused the Navy, in turn, to compromise its plans for meeting the equipment needs of its forces.

IMPACT ON PLANNED PROGRAM GOALS

To some extent, cost, schedule, or performance goals were not met for nearly all of the 15 programs examined. Development cost growth of 10 programs for which cost growth could be estimated ranged from 16 to 213 percent. Schedule slippage ranged from 4 to 51 months for 12 programs for which data were available. For nearly every program, technical problems later surfaced--ranging in seriousness from a few defective components on some systems to major technical difficulties affecting whole systems on others. In some instances, the problems were so serious that parts of the program were curtailed. Although premature full-scale development was not the only cause of later problems, it appeared to be the most prevalent cause and the one having the most far-reaching effect.

Cost growth

We compared original cost estimates with current estimates or actual costs for 10 of the 15 programs. Insufficient planning data precluded us from computing the cost

growth for the remaining five programs. Because most original development plans did not contain planning estimates for production, training, and support costs, our comparisons dealt only with development costs and should not be construed as being indicative of increases in total program costs. The extent of development cost growth for the 10 programs was as follows:

Name of system	Percent of cost growth
A-6 Trail Road Interdiction Multisensor	69
Zero Antiaircraft Potential Missile	25
Fuel Air Explosive Weapon	51
Sparrow III Airborne Intercept Missile 7F	127
Satellite Communications Terminal	213
Minesweeping and Clearance System	25
Ships Self-Contained Navigation System	16
Rocket Assisted Projectiles	39
Versatile Avionics Shop Test	195
5-Inch 54 Lightweight Gun	163

Premature full-scale development appeared to be the principal cause of cost growth for seven of these 10 programs. In nearly every case, technical problems--in areas where experimental testing had not been undertaken--occurred during full-scale development and corrective action involving additional cost and time had to be undertaken. Two examples follow.

Versatile Avionics Shop Test

The Versatile Avionics Shop Test is a computerized network of testing devices planned originally to provide repair shop testing facilities for 70 to 85 percent (now 45 to 50 percent) of the avionics equipment in a typical carrier air wing. When full-scale development was started, experimental work--although planned by the Navy--had not yet been undertaken on a number of testing and analyzing components.

After a model of the system had been nearly completed during full-scale development, it was found that computer capacity was inadequate, that various components were inadequate in capacity or number, and that the system as a

whole was larger than desired. At this point the Navy elected to start full-scale development on an improved version of the system. The redesign was the main reason for the $20.3 million increase in development costs--a 195-percent increase over the original estimate of $10.4 million.

Sparrow III Airborne Intercept Missile 7F

The Sparrow was required to have capabilities and performance beyond what had previously been demonstrated either in experimental work or in service use. In the final testing stages of the development model, several components failed to perform as required. Extensive redesign was then undertaken to resolve deficiencies. This problem was the main reason for an increase in development costs from $25.4 million to $57.6 million.

Schedule slippages

In our comparison of original milestones with the actual dates or latest estimates, we generally used the dates for completion of operational evaluations because they normally represent the completion of full-scale development. Because original planning estimates or latest estimates were not available in all cases, we could determine schedule slippage for only 12 of the 15 programs. The extent of slippage for these 12 programs was as follows:

Name of system	Slippage in months
A-6 Trail Road Interdiction Multisensor	22
Minesweeping and Clearance System	33
Ships Self-Contained Navigation System	39
Rocket Assisted Projectiles	12
Versatile Avionics Shop Test	41
5-Inch 54 Lightweight Gun	28
Fuel Air Explosive Weapon	19
Basic Point Defense Missile	4
Sparrow III Airborne Intercept Missile 7F	51
Integrated Helicopter Avionics System	36
Satellite Communications Terminal	9
Zero Antiaircraft Potential Missile	15

For six programs which experienced schedule slippages, the same technical problems which required redesign during full-scale development involved areas in which experimental work had not been performed before full-scale development was started.

Ships Self-Contained Navigation System

One of the longest delays--39 months--involved the Ships Self-Contained Navigation System. The system is an inertial navigator which accepts position update information from external navigational aids. It is designed to provide ships with a navigation system independent of shore aids and not susceptible to intentional interference.

After full-scale development was underway, serious technical problems involving software occurred. Software was not mentioned in the development plan, let alone assessed for technical risk and state of the art. Subsequently, technical evaluation reports during full-scale development revealed reliability problems involving the software. For example, a June 1970 report--after more than 4 years of full-scale development effort--recommended design modification to eliminate the "critical reliability problems" and to make the system suitable for fleet use. A September 1970 report pointed out that the mean time between failures for the system was only about one-fourth of the required minimum.

Although the Navy attributed the delays to problems in resolving security, in awarding a contract, and in reaching a joint agreement with Germany, we believe technical problems with the software also significantly contributed to these delays. In our opinion, the technical problems might have been identified and avoided if, on the basis of experimental work, the technical risk had been assessed before full-scale development was initiated.

Performance shortcomings

Serious technical problems were evident in nine of the 15 programs that we reviewed. Redesign and modification had taken place or were planned for six of the nine programs because of technical problems which occurred in areas which had not been proved feasible through experimental testing before full-scale development was started.

An example of a system which incurred serious technical problems follows.

Zero Antiaircraft Potential Missile

The Zero Antiaircraft Potential weapon is an unguided, high-velocity, air-to-ground missile which utilizes a large number of small tungsten darts in place of an explosive warhead to destroy targets. As its name implies, it is to be used chiefly against antiaircraft sites.

Although little experimental hardware testing had been performed before full-scale development began, the development plan indicated that technical risks for some components would be "medium"--a term not defined by the development plan or Navy instructions. Rationale for this assessment was not given. Technical risks for the rocket engine were labeled "high." This assessment was based on the anticipated short development time frame rather than on results of experimental testing. Existing documentation indicated that the system was being developed on an accelerated basis to meet urgent needs in Southeast Asia.

During full-scale development, several design characteristics were changed by the Navy as a "compromise between the technically possible and theoretical results." The weapon was operationally tested after program slippage exceeded 1 year and after associated costs increased. Because of a number of component reliability problems--including engine reliability problems and dart scattering problems--the system did not pass the operational evaluation. These problems normally would be identified through experimental work--for example, demonstrating the feasibility of launching darts at the desired high velocity.

The Navy project officer informed us that technical problems revealed by the operational evaluation were so serious and so hard to overcome that the Navy had decided to cancel the program. By the time the performance problems were recognized, missile systems (including systems used in the operational evaluation) had been manufactured and $28 million had been spent on the program.

ADVERSE EFFECTS RESULTING FROM COST GROWTH, SCHEDULE SLIPPAGES, OR PERFORMANCE SHORTCOMINGS

When cost or schedule parameters are significantly exceeded or when equipment performance is significantly degraded, decisionmakers are forced to take remedial action. In selecting a course of action, the decisionmakers generally are confronted with a choice of alternatives, each of which compromises some aspect of overall DOD objectives. These alternatives include (1) improving equipment design, (2) diverting funds from lower priority programs, (3) improvising shortcuts, or (4) canceling or cutting back the program.

Improving equipment design

When equipment does not perform as desired, design improvements are often necessary at additional cost to bring performance at least up to an acceptable level. This situation is illustrated by the following case.

Sparrow III Airborne Intercept Missile 7F

At the time full-scale development was started on the Sparrow missile, the Navy had not built and tested experimental devices to prove that the new microelectronics which it was designing into the missile would function as required. During operational testing, technical problems occurred which were so serious that the missile system was not approved for service use. To correct the problems, about 67 percent of the electronic components were redesigned at additional cost.

Diverting funds from lower priority programs

When remedial action is required to correct design problems or to overcome delivery schedule delays, it may be necessary to divert funds from development programs with lower priorities. When only minor problems are involved, small amounts of funds can be siphoned from each of several lower priority programs so that none are seriously impaired. However, when cost growth problems are extensive, lower priority programs may be severely cut back or even canceled. An example follows.

MK-30 Antisubmarine Warfare Mobile Target

Full-scale development of this low-priority program was severely curtailed because of continual underfunding. This underfunding occurred during a period characterized by massive cost growth of major weapons programs. To compensate for the lack of sufficient funds, testing was pared considerably and completion of full-scale development was delayed.

Although the program has been severely curtailed, there appears to be no move to cancel it, presumably because of the military need. The target is a sophisticated, self-guided, torpedolike underwater vehicle designed to simulate an attacking submarine so that submarine detection devices can be tested and exercised and so that crews can be trained in detection proficiency and torpedo practice without using actual submarines. The program was initiated because of the adverse cost, safety, and availability factors associated with using actual submarines.

Improvising shortcuts

When program delays occur during full-scale development, shortcuts may be attempted to bring completion dates back in line. These shortcuts may take various forms. All of them have the common objective of expediting the development-production process--but they often result in unduly compressing development and test objectives and in sacrificing equipment reliability and maintainability requirements.

One way of attempting to meet original delivery dates is to begin production during full-scale development. In our report to the Congress entitled "Adverse Effects of Large-Scale Production of Major Weapons Before Completion of Development and Testing" (B-163058, Nov. 19, 1970), we concluded that concurrent development and production generally does not result in earlier delivery of acceptable equipment but usually adds to the development-production cost. In that report we discussed five major weapons systems which had been developed and produced before the testing and evaluation of development models had been completed. We found that, in practically every instance, operational testing uncovered deficiencies and reliability problems which degraded

planned equipment performance and which necessitated costly design changes to eliminate the problems and to bring performance up to an acceptable level.

We believe the need for resorting to shortcuts such as concurrent development and production would be lessened by placing greater emphasis on completing necessary experimental work and on resolving technical problems before full-scale development is started.

Canceling all or part of the program

In some instances, there may be no choice except to cancel or curtail the program because of problems that otherwise might have been avoided had necessary experimental work been performed prior to starting full-scale development. Two examples illustrate this condition.

Integrated Helicopter Avionics System

The Integrated Helicopter Avionics System is a computerized network of sensors, displays, and controls designed to provide vertical assault-type helicopters, such as the CH-53, with an all-weather navigation capability. It is also designed to enable the aircraft to operate in all types of weather at high-cruise speeds and to navigate safely at low altitudes over completely obscured and unfamiliar terrain.

The decision to initiate full-scale development appeared to be based on studies indicating that equipment concepts were feasible and that little technical risk was involved. Our evaluation of these studies, however, revealed that needed experimental work apparently was not performed in a number of technical areas. In addition, a Navy audit report on the contractor's proposal for full-scale development stated that:

> "The task contemplated by this contract is considered to be extremely difficult. It is apparent that in many instances the company is advancing the state of the art." [i.e., undertaking experimental work.]

As full-scale development proceeded, serious technical problems arose which caused cost growth and a 3-year program slippage. The problems involved an essential component which could not be made to work. The system was introduced into the fleet in 1969, almost 3 years later than planned. Program slippage was so serious that it caused the Navy to delete requirements for two of the three major components of the system--the reason being that remaining service life of the CH-53 helicopter no longer justified costly installation of a full system.

Approximately $33 million had been expended on the development of a system which apparently will see only limited use. The Navy reported, however, that technologies developed for the program would be used in a new avionics system for the follow-on medium assault helicopter.

Minesweeping and Clearance System

This system generally is a combination of nine major subsystems, each of which performs an independent function, such as navigation or detection. Three of the subsystems are not required on all ship applications. Development plans showed that experimental work had not been performed on the navigation portion of the system before full-scale development began. According to the Navy, the subsystem's feasibility was proved during successful shipboard tests of an earlier development model, although this information was not revealed by the development plan. That feasibility had not been fully demonstrated was illustrated by later problems and by the stated purpose of prototype testing during the full-scale development stage, as shown below.

A test report on the navigation subsystem revealed that the purpose of the test was to demonstrate feasibility of automatically steering a minesweeping ship along a prescribed track with an acceptable degree of accuracy. "Demonstrating feasibility" is experimental work which should be done before beginning full-scale development.

Subsequently, during final testing of the development model, reliability and technical problems arose. A development cost growth of 25 percent was experienced, and the program slipped approximately 3 years. As a result, development

of the navigation subsystem was canceled and the desired performance capability of the Minesweeping and Clearance System was severely affected.

CHAPTER 3

REASONS FOR PREMATURE APPROVAL OF FULL-SCALE DEVELOPMENT

According to Navy procedures, experimental work should be performed to a sufficient degree to demonstrate the feasibility and practicality of concepts which are to be incorporated in equipment. Moreover, the procedures state that full-scale development should not include experimental work and that performance requirements for operational equipment should not be greater than performance that has been experimentally demonstrated.

To assure that these requirements are fulfilled, the procedures provide that the extent to which experimental work has been completed be specifically described in the development plan. Moreover, the development plan is required to elaborate on all prescribed conditions which have not been completed before full-scale development is started. Approval of the development plan at the Navy decisionmaking level (generally an Assistant Secretary) authorizes full-scale development to begin.

The Navy describes the development plan as the principal vehicle for conveying essential technical information to all levels of management and regards the plan as the principal source of information on which to base key decisions in the life of a development program. Because development plans greatly influence decisions to start, stop, or continue programs, Navy procedures require that the information provided in them be clearly stated, relevant, accurate, and complete.

For 11 of the 15 programs that we reviewed, the decisionmakers approved full-scale development despite the fact that development plans indicated--either explicitly or implicitly--that experimental work had not been performed on certain technical aspects of the proposed equipment. Available information indicated that the decisionmakers had approved full-scale development because they were confident that the equipment would perform as required without any problems or because there was an urgent need for the equipment.

APPROVAL DECISIONS BASED ON UNWARRANTED CONFIDENCE IN PROPOSED SYSTEMS

In our review of 11 programs where full-scale development began prematurely, we reviewed decisionmaking documentation to assess the rationale underlying the decisions. Our analysis showed that the decisions were based on unfounded optimism; on misleading information; or on an erroneous belief that, because technical concepts had been proved on systems already in operational use, the risk was low. Some programs fell into more than one of these categories.

Unfounded optimism

Navy procedures require that information in the development plan be used to determine whether all prescribed conditions have been met before full-scale development is authorized.

We found that full-scale development had been approved and started on some programs even though the development plans clearly indicated that experimental work had not been performed in major technical areas. Two examples follow.

Versatile Avionics Shop Test

The development plan and other pertinent documents for this system clearly indicated that experimental work had been only partly undertaken. Although experimental devices had not been built and tested, specific operating requirements had been established.[1] Moreover, although the development plan elaborated on the experimental work which had to be performed in full-scale development, it indicated that technical risks in development were low. Serious technical problems later surfaced during full-scale development. (See p. 12.)

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[1]By the end of advanced development, the feasibility of attaining a specific end-item should have been determined by examining experimental test results at least on a subsystem basis. The specific operating requirements are established on the basis of demonstrated feasibility.

Minesweeping and Clearance System

Similarly, the development plan for this system included statements which indicated that experimental work was incomplete. For one of the major subassemblies, for example, a statement was made that "If the technical risks are overcome, no major problems are foreseen for installation and use." For other major subsystems, potential problems were discussed but no explicit assessments of technical risks were made. We believe that, as a whole, the development plan for this system did not provide assurance that prescribed conditions for full-scale development had been met. Nevertheless, the decisionmakers approved this program for full-scale development--but later problems resulted in cancellation of one subsystem which seriously affected the entire system. (See p. 19.)

Misleading information

Navy procedures provide elaborate requirements for preparing development plans to eliminate the possibility that misleading or incomplete information could cause decisionmakers to approve full-scale development prematurely. Nevertheless, we believe misleading information on several programs had a bearing on the decision to approve full-scale development.

Integrated Helicopter Avionics System

A formal analytical study of this system was made by the development contractor to verify that all conditions for approving full-scale development had been met. This study, although implying that experimental work had not been undertaken in certain technical areas, concluded that developmental risks were low and recommended approval of full-scale development. The development plan, which summarized results of the analytical study, stated only that technical risks were low and failed to point out that experimental work in certain vital technical areas had not been performed. The consequences of the resulting decision to go ahead with full-scale development were discussed on page 18.

Ships Self-Contained Navigation System

This system's development plan did not indicate whether experimental work had been satisfactorily performed or whether the prescribed conditions for starting full-scale development had been met. Moreover, neither technical risks nor the software problems which later caused program slippage were mentioned. (See p. 14.)

Belief that technical concepts had been proved on systems already in service use

To prevent costly design problems in full-scale development, Navy procedures state that proposed systems' performance requirements should not be greater than performance that has been experimentally demonstrated. When proposed designs involve technical concepts which have not been proved feasible through experimentation, those design features are said to be beyond the state of the art.

Development plans on some programs stated that prescribed conditions for starting full-scale development were met because technical concepts had been proved for existing equipment. No mention was made of the fact that performance requirements for the proposed systems were beyond what had previously been demonstrated, either in the laboratory or in service use. Following is an example.

Sparrow III Airborne Intercept Missile 7F

The development plan for this missile indicated that technical risks were minimal because the technology was within the state of the art and because the technical concepts involved were in use for existing equipment. The performance requirements of some major components, however, were beyond anything that previously had been demonstrated. For example, the type of microelectronics required in the proposed system had never before been designed into a missile. Later failure led to costly redesign in this area. (See p. 13.)

Our examination of development plans for other programs showed that anticipated low risks likewise were based incorrectly on the rationale that technical concepts had

been proved for systems in use. These programs included the A-6 Trail Road Interdiction Multisensor, the Minesweeping and Clearance System, and the Ships Self-Contained Navigation System.

APPROVAL DECISIONS BASED ON URGENT NEEDS

Navy procedures prescribe several conditions which must be met before full-scale development can be authorized. There are no provisions in these procedures permitting the waiver of any conditions because of urgent needs. We found, nevertheless, that full-scale development had been started on several projects because of "urgent needs"--even though the development plans indicated that experimental work had been incomplete or had not been undertaken in a number of areas. Such decisions often backfired.

Zero Antiaircraft Potential Missile

The development plan for this missile indicated that technical risks were "high" on some components and "medium" on others. Nevertheless, full-scale development was approved and initiated. The basis given for this decision was that the proposed system was urgently needed in Southeast Asia. Later problems led to eventual cancellation of the program.

Satellite Communication Terminal

The Navy wanted this system--a set of shipboard communications equipment--at the earliest possible date so that it could use a satellite while it was still operational. The development plan stated that technical risks were expected to be minimal because a similar terminal already was in existence and because the selected contractor was experienced in "production of shipboard radars." The development plan did not indicate the degree of experimental work which had been performed up to that time. These conditions, in our opinion, did not afford an adequate basis for accepting the technical risks involved in developing the proposed system. As a result of the premature full-scale development, the reliability and maintainability of the system later proved deficient in operational use.

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Urgency also motivated the Navy to prematurely start full-scale development of two other programs--the MK-36 Destructor, an air-deployed mine system, and the Fuel Air Explosive Weapon, a bomb device. In each instance, major technical problems occurred after full-scale development started.

CHAPTER 4

CONCLUSIONS, AGENCY COMMENTS, AND RECOMMENDATIONS

CONCLUSIONS

The decision to go ahead with full-scale development is probably the most important step in the life of any military system because it opens the door to large sums of money for development and production from which there may be no turning back. Thus it is important that sufficient experimental work--particularly the testing of high-risk subsystems and components--be performed before full-scale development is started. In this way, potentially significant technical problems are more likely to be identified and resolved before extensive systems engineering takes place. Otherwise, unexpected problems can surface later and lead to cost overruns, schedule slippages, and performance compromises. This, in turn, can jeopardize plans for meeting the equipment needs of using forces.[1]

Because our review of 15 Navy systems indicated a need for increased management scrutiny over this crucial decision point, we suggested in our February 1972 draft of this report that the Secretary of Defense require decisionmakers to verify and certify that experimental work has been completed before full-scale development is approved. We suggested also that the Secretary require coordinating organizations to validate information contained in development plans and to determine whether sufficient information for decisionmaking purposes is being provided.

AGENCY COMMENTS AND OUR EVALUATION

The Director of Defense Research and Engineering commented on our draft report on behalf of the Secretary of Defense. (See app. II.) DOD contended that the report--covering 15 Navy systems which had entered full-scale

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[1]See also our prior reports to the Congress on major systems--"Status of the Acquisition of Selected Major Weapon Systems" (B-163058, Feb. 6, 1970) and "Acquisition of Major Weapon Systems" (B-163058, Mar. 18, 1971).

development from 1963 to 1968--predated important changes in DOD and Navy policies and procedures which are designed to cure defects of the sort revealed in the report. DOD suggested that we acknowledge the following steps taken to tighten the whole defense acquisition process.

--Establishing the Defense Systems Acquisition Review Council to review major programs at key decision points.

--Introducing the Development Concept Paper.

--Increasing attention throughout DOD to test and evaluation responsibilities.

--Paying additional attention to reducing risks, before approval for full-scale development is granted, through more emphasis on prototyping and hardware development and through testing, rather than reliance on paper studies.

It is true that the full-scale development decisions represented by our examples were made 4 to 9 years ago. To show the impact of those decisions--which can only be seen in follow-on years--it was necessary to select such systems. We believe the issues are relevant today because management practices--particularly for minor systems--have not really changed.

The first two cited actions apply only to major systems and, if properly implemented, should lead to improved management of such systems. We noted that a proposed new directive--DOD Directive 5000.2--would require these actions and Secretary of Defense approval earlier in the development process for major acquisitions. Most systems discussed in this report, however, do not meet DOD's "dollar threshold" for such actions.

With respect to increased emphasis on testing and evaluation responsibilities and other efforts to reduce risks (provided by new DOD Directive 5000.1), we noted that former DOD Directive 3200.9 appeared even stronger in its emphasis and more specific in its requirements for justifying full-scale development--yet sufficient experimental work was not always performed. DOD Directive 3200.9--in effect at the time full-scale development decisions were made for 14 of

the 15 systems discussed--specified prerequisites for starting full-scale development and required that experimental work be performed to a sufficient degree to demonstrate that technical risks did not exist or had been reduced to a reasonable level. In contrast, new DOD Directive 5000.1 provides merely that "development risks have been identified and solutions are in hand."

The recent actions should lead to improved management of major weapons systems; however, we believe this emphasis provided by the new policies will not in itself overcome the problems cited for minor systems.

More detailed Navy comments--included as an attachment to DOD's reply--pertained mainly to our calculations of cost growth and schedule slippage or to statements on technical problems related to the specific systems. Because they were lengthy and because the Navy did not take exception to the basic issues, the comments were not included in the final report--but, to the extent appropriate, changes have been made to the body of the report to reflect the comments.

RECOMMENDATIONS

We recommend that the Secretary of Defense require formal certifications--or justifications in writing for any exceptions--by key decisionmakers as a further incentive to discourage premature initiation of full-scale development of minor systems. In addition, we recommend that the Secretary of Defense apply spot checks and other management-by-exception techniques to assure that the management principles which are specifically applicable to major systems are also applied to the far more numerous and, in total, more costly minor systems.

MATTERS FOR CONSIDERATION BY THE CONGRESS

Recent legislation requires the Secretary of Defense to submit annual reports, beginning in 1973, on operational testing and evaluation for each weapons system for which procurement funds are requested. This should assist in identifying new systems entering production prematurely.

The decision to begin full-scale development, however, is even more fundamental because it "opens the door" and commits funds and loyalties to future systems. A yearly

average of 25 Navy systems--individually budgeted projects--entered full-scale development from 1968 to 1971.

We suggest that the Congress require from the Secretary of Defense--along with his initial request for full-scale development funds for new "systems"--a statement to the effect that

--all necessary experimental work has been performed and a proposed system is ready for full-scale development or

--authorization of full-scale development is essential even though all prescribed conditions have not been met, in which case the statement should give the reasons for the decision and the identifying areas where experimental work has not been completed.

APPENDIXES

DEVELOPMENT STATUS AND PROBLEMS

Name of system	Status as of 12-31-71: In full-scale development	In production	In operational use
Satellite Communications Terminal	(a)		
Minesweeping and Clearance System		Partially	Partially
MK-36 Destructor		X	X
Ships Self-Contained Navigation System	(a)		
Rocket Assisted Projectiles		X	X
Versatile Avionics Shop Test	X	X	
5-inch 54 Lightweight Gun	X	X	
Mark 30 Antisubmarine Warfare Mobile Target		X	X
A-6 Trail Road Interdiction Multisensor	X		X[e]
Zero Antiaircraft Potential Missile			
Basic Point Defense Missile		X	X
Sparrow III Airborne Intercept Missile 7F	X	X	
Integrated Helicopter Avionics System		Partially	
Integrated Light Attack Avionics System	Terminated during development		
Fuel Air Explosive Weapon		X	X

[a]Development is completed. The Navy does not plan to produce or use this system.

[b]Lack of available data precluded a determination of schedule and cost variances.

[c]Could not be determined.

[d]Lack of comparable milestones precluded a computation of schedule slippage.

[e]The development model is being operationally tested by fleet personnel in Southeast Asia.

[f]Development cost figures were not broken down by projects for this program.

Adverse program deviations		
Development cost growth (percent)	Program slippage (months)	Development problems
213	9	During operational use, reliability and maintainability were found to be deficient. Consequently, these systems were removed from the ships and were modified.
25	33	Reliability deficiencies and technical problems which arose during testing resulted in the cancellation of two subsystems which were required to complete the system; therefore, the system as a whole never completed development.
(b)	(b)	Technical difficulties were encountered during operational testing, and the equipment was subsequently modified.
16	39	There were serious design problems with computer software.
39	12	Rocket motor reliability which was found to be deficient during testing was corrected through redesign and modification.
195	41	Technical inadequacies became known after full-scale development had been initiated. This resulted in designing a completely new model of the system.
163	28	Changes in cost and schedule appeared to be mainly attributable to major equipment changes made midway in the program. The changes resulted from requirement changes.
(c)	(d)	The system failed to meet certain performance requirements during testing, and it appears that the system will be modified.
69	22	The system was still in testing and evaluation, and results were not available.
25	15	During testing, rocket engine reliability was found to be deficient and there were dart-scattering problems. The problems were so serious that the program was canceled. In all, about $28 million had been expended on the program.
(f)	4	Operational testing disclosed several serious performance deficiencies.
127	51	Technical problems involving microelectronics arose during full-scale development. This resulted in a major redesign.
(c)	36	Serious technical problems occurred during full-scale development, which caused program slippage and deletion of two major system requirements.
(c)	(c)	Technical problems were encountered during full-scale development.
51	19	Several major technical problems occurred during concurrent full-scale development and production.

APPENDIX II

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

19 APR 1972

Mr. Harold H. Rubin, Deputy Director
Technology Advancement, Procurement
and Systems Division
U.S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Rubin:

This response is made on behalf of the Secretary of Defense to your letter of Feb 9, 1972 which forwarded your draft report, "Need to Complete Experimental Work Before Starting Full-Scale Development of Military Equipment," (OSD Case #3414), for our comments.

The draft report covers 15 Navy equipment development programs which entered full-scale development during the period from 1963 to 1968. This period pre-dates important changes in DoD and Navy weapon system acquisition policies and procedures which were designed to cure defects of the sort revealed by the review. The establishment of the Defense Systems Acquisition Review Council (DSARC) for review of major programs at key decision points, the introduction of the Development Concept Paper (DCP), and the increased attention throughout the DoD to test and evaluation responsibilities, represent significant improvements over the situation that existed when the subject programs entered full-scale development. Also, additional attention has been given to risk reduction prior to approval for full-scale development through more emphasis on prototyping and hardware development and test rather than relying on paper studies.

Generally, the draft report does not, in our view, take adequate note of the recent DoD policies and procedures. It is suggested that these policies and procedures be given additional emphasis in the report to indicate that the DoD has taken steps to tighten the whole defense systems acquisition process. It is suggested that some words like the following be included in both the "Conclusions" chapter as well as in the "Digest."

"Since approval for full-scale development was given on the programs addressed in this report, the DoD has made changes to its policies and procedures which should largely alleviate the problems discussed. Under these new policies and procedures, a review of the status of major programs by the Defense Systems Acquisition Review Council (DSARC) is conducted prior to transition to full-scale development. Authority for the commencement of this program phase is contingent on Secretary of Defense approval, based upon the advice of the reviewing body. The primary governing document for these programs is the Development Concept Paper (DCP). It is written to define program issues, including plans, performance parameters and areas of major risk. Once approved it represents an agreement between OSD and the DoD component concerned. The DCPs which reflect the Secretary of Defense decision regarding the commencement of full-scale development contain a complete synopsis of experimental work to date. As part of risk reduction, the DoD is now emphasizing the need for more prototyping and hardware development and test rather than paper studies."

The Department of the Navy has made comments on the specific programs discussed in the draft report. These comments are attached for your consideration in the final report.

We appreciate the opportunity to provide comments on the draft report and will be pleased to provide additional information as required.

Sincerely,

for John S. Foster, Jr.

Enclosure

APPENDIX III

PRINCIPAL OFFICIALS OF THE DEPARTMENT OF DEFENSE AND THE DEPARTMENT OF THE NAVY RESPONSIBLE FOR THE ACTIVITIES DISCUSSED IN THIS REPORT

	Tenure of office	
	From	To
DEPARTMENT OF DEFENSE		
SECRETARY OF DEFENSE:		
Melvin R. Laird	Jan. 1969	Present
Clark M. Clifford	Mar. 1968	Jan. 1969
Robert S. McNamara	Jan. 1961	Feb. 1968
DEPUTY SECRETARY OF DEFENSE:		
Kenneth Rush	Feb. 1972	Present
Vacant	Dec. 1971	Feb. 1972
David M. Packard	Jan. 1969	Dec. 1971
Paul H. Nitze	July 1967	Jan. 1969
Cyrus R. Vance	Jan. 1964	June 1967
Roswell L. Gilpatric	Jan. 1961	Jan. 1964
DEPARTMENT OF THE NAVY		
SECRETARY OF THE NAVY:		
John H. Chafee	Jan. 1969	Present
Paul R. Ignatius	Sept. 1967	Jan. 1969
Charles F. Baird (acting)	Aug. 1967	Sept. 1967
Robert H. B. Baldwin (acting)	July 1967	Aug. 1967
Paul H. Nitze	Nov. 1963	June 1967
Fred Korth	Jan. 1962	Nov. 1963
CHIEF OF NAVAL OPERATIONS:		
Adm. Elmo R. Zumwalt, Jr.	July 1970	Present
Adm. Thomas H. Moorer	Aug. 1967	June 1970
Adm. David L. McDonald	Aug. 1963	July 1967
Adm. George W. Anderson	Aug. 1961	July 1963

DEPARTMENT OF THE NAVY (contd.)

CHIEF OF NAVAL MATERIAL:					
	Adm. J. D. Arnold	Oct.	1970	Present	
	Adm. Ignatius J. Galantin	Mar.	1965	June	1970
	Vice Adm. William A. Schoech	July	1963	Mar.	1965
	Vice Adm. George F. Beardsley	July	1960	June	1963

Copies of this report are available from the U. S. General Accounting Office, Room 6417, 441 G Street, N W., Washington, D.C., 20548.

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